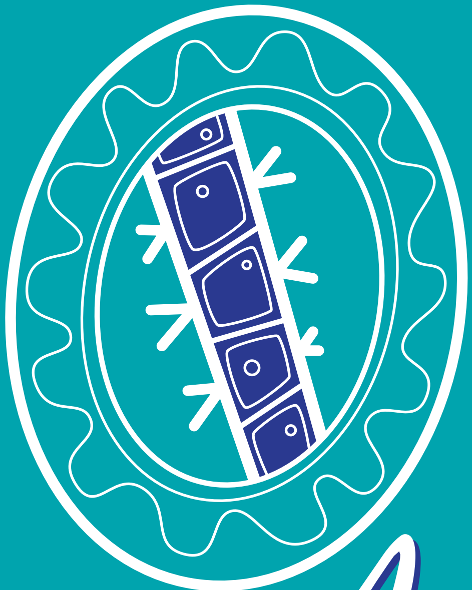

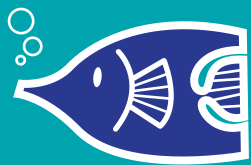

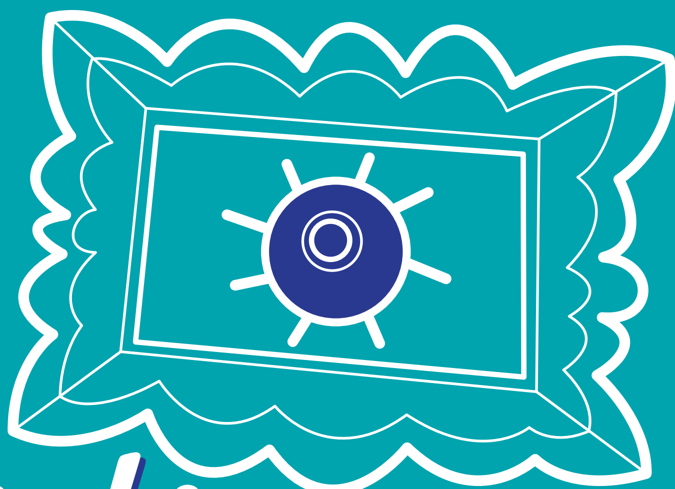

The Artistic Oceanographer Program

Encouraging ocean science literacy through multidisciplinary learning

By Sheean T. Haley and Sonya T. Dyhrman

Oceans are essential to life on Earth. Covering almost two-thirds of the planet, the oceans house nearly 80% of all life, regulate weather and climate, provide 50% of the planet's oxygen production, and serve as a critical source of food and transportation for a large portion of the human population. Despite their significance, the oceans are often not incorporated into K–12 educational curricula. In fact, ocean sciences are underrepresented at most levels and rarely appear in curriculum materials, textbooks, assessments, or standards.

As a result many adults are poorly informed on the importance of the ocean for global ecology and human society. In response to the general lack of ocean literacy, the U.S. Commission for Ocean Policy submitted its recommendations for strengthening the nation's awareness of the importance of the oceans as part of a coordinated and comprehensive ocean policy to the President and Congress in September 2004. The Commission noted that a key component in increasing public awareness of the role oceans play is through diverse educational opportunities, starting at a young age, and focused on the marine environment and ocean issues. Fortunately, the marine environment and oceans are inherently interesting to children, making them excellent teaching tools for engaging students in basic science.

Introducing the oceans to young students in a classroom setting is helped by their natural curiosity about the world around them. This attitude was the motivation for the development of the Artistic Oceanographer Program (AOP), designed to engage elementary school students (fifth graders) in ocean sciences and to illustrate basic fifth-grade science and art standards with ocean-based examples. The program combines short science lessons, hands-on observational science, and art and focuses on phytoplankton, the tiny marine organisms that form the base of the marine food web. The science and art portions of the project mesh well with existing fifth-grade education standards for our state (Massachusetts) and align with the Essential Principles and Fundamental Concepts of ocean literacy, as defined by a consortium of scientists and educators and written in accordance with the National Science Education Standards.

The AOP can be implemented in a variety of ways, but we typically divide the lessons into four days (one hour per day) of activities. We describe three days of lessons here, and the fourth is featured online (see NSTA Connection). Each day begins with a brief lesson with PowerPoint slides. These slides provide bullets of information and images to enhance our discussion. This is followed by a laboratory segment. The learning outcomes for each activity are described below. Piloted in 2006 in a fifth-grade class in Falmouth, Massachusetts, the AOP has been integrated into existing curricula for the past three years for an increasing number of fifth-grade students.

Day 1: Introduction to the Oceans

We begin by leading students through an introduction to the oceans. Student participation is encouraged and the talk is kept engaging by asking and answering questions during the lesson and by keeping it brief (about 15 minutes). The content focuses on ocean characteristics, food webs, and primary productivity.

We start the science lesson by discussing ocean characteristics. This includes information related to the portion of Earth's surface covered by ocean, the average depth of the ocean, the importance of the oceans, and the

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incredible diversity of life in the ocean. Ocean life faces some very different challenges compared to life on land. Some common questions that students ask that convey their interest include: Where is the deepest point in the ocean (Challenger Deep in the Mariana Trench in the Pacific Ocean)?; Is there life at the bottom of the ocean (Yes)?; What is the largest animal in the ocean (Blue whale)?.

Next, we describe and compare food webs in the ocean with those on land, establishing an understanding of phytoplankton and seaweeds as the base of marine food webs and plants (e.g., grass, trees, etc.) as the base of terrestrial food webs. We generally start by asking students, "What did you eat today?" Students typically respond with what they've had for breakfast. We then ask, "Are these things plants or animals?" We have the students piece together a terrestrial food web, based on the components of their breakfasts (e.g., Where does cereal come from? What does a pig or cow eat? What is an animal that eats pigs or cows?). We use this discussion to transition to the marine environment. Students use their knowledge of a land-based food web with plants at the bottom and large predators at the top to help them construct a marine food web (e.g., phytoplankton at the bottom and whales at the top).

As much of the focus for the AOP is on microscopic phytoplankton, the first laboratory segment begins with an introduction to microscopes and their use. At the end of the discussion, we present a few graphics about the use of microscopes. We focus on what microscopes are and why they are used, the parts of a microscope, and how to use a microscope. This is a necessary lead-in to Day 1's laboratory component, as most of the students have not used a microscope.

Students receive nametags with a different microorganism commonly found in the water in our area, denoting their "Team." For example, Team Diatom's nametags feature a picture of a diatom, a unique microscopic marine organism that makes its cell walls out of silica. Using the organism on their nametags, students sort themselves into their lab teams around each of six microscopes borrowed from a high school.

To help students learn how to use microscopes correctly, an adult volunteer assists each team. If your students do not already have experience using microscopes, and volunteers are not available, extra time helping them become familiar with microscope use before this lesson is advisable.

We keep the groups small to facilitate equal use of the microscopes. Each group receives several "everyday" items to look at under the microscope. These include thread, feathers, flower petals, scraps of newspaper, and different types of hair (e.g., pet hair, human hair). We find it useful to start with items with which students have familiarity. Students have 30 minutes for the hands-on portion of Day 1. The learning outcomes are to:

- Know how much of the Earth is covered with water.
- Know several reasons why oceans are important to life on Earth.
- Know what a food web is and know its typical structure in the ocean.
- Understand how a microscope works.
- Operate a microscope.

Day 2: Introduction to Plankton

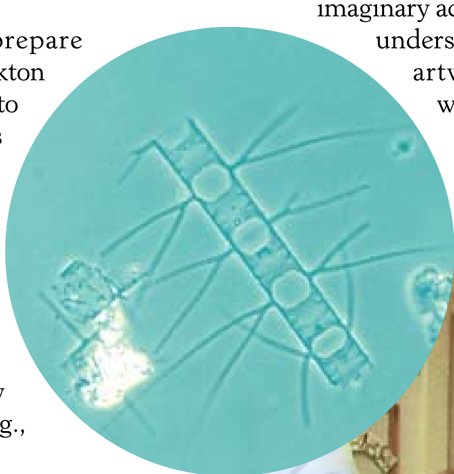
The oceans contain a large fraction of all life on Earth, and most of this life is barely visible without the aid of a microscope. These *plankton* are the microscopic organisms that, even if capable of some movement, are ultimately at the mercy of the ocean currents. Measured in microns, they are often more than 1/10th smaller than the diameter of human hair. Plankton include *phytoplankton* and *zooplankton*. These organisms are very abundant in the ocean. Phytoplankton, despite its diminutive size, forms the base of the marine food web and is the primary food and energy source for the ocean ecosystem.

We begin Day 2 by providing the students with another short lesson focused on plankton. The lesson provides students with a basic understanding of phytoplankton, including a discussion of some of the different types, their abundance in the ocean, and their form and function (e.g., shapes, sizes, and color). The form and function of phytoplankton explains their ability to adapt to life in the ocean, which necessitates staying afloat and close to the sunlight for photosynthesis and avoiding predation. Phytoplankton have adaptations, such as long spikes, bristles, and spines, to help them stay afloat in the water and to deter predators.

We show many images of different types of phytoplankton so students will know what to look for during their laboratory investigation with the microscopes. An excellent source for images is the book *Sea Soup: Phytoplankton* by Mary M. Cerullo (1999).

For the laboratory portion of Day 2, students separate into their Teams from Day 1. Teams receive several prepared slides of phytoplankton (e.g., diatoms and dinoflagellates, a type of phytoplankton that can move with the use of a whip-like protrusion called a flagella) as well as several culture tubes of live phytoplankton which the students use to prepare their own microscope slides (see Internet Resources). Plastic microscope slides and coverslips were used instead of glass to avoid potential safety concerns.

First, we demonstrate how to prepare microscope slides from live phytoplankton cultures. Then, we encourage students to look at as many types of phytoplankton as possible and to draw their observations (e.g., shape of the phytoplankton; presence or absence of spikes, spines ,or bristles to help them float; and presence or absence of movement) in a notebook. Students have 45 minutes for the hands-on portion of Day 2. The hands-on segment reinforces several of the key concepts introduced during the lesson (e.g., phytoplankton color, size, and shape).



The learning outcomes expected for Day 2 are to:

- Learn about some of the different kinds of phytoplankton and their abundance.
- Understand the importance of different phytoplankton shapes, sizes, and colors for adapting to life in the ocean.
- Operate a microscope.
- Examine prepared and live phytoplankton samples under different magnifications (4× and 10×)
- Draw the organisms observed in a notebook.

Day 3: Create Your Own Phytoplankton

On the third day, we review the types of organisms the students observed the day before as well as some of their adaptations. During this short discussion period, we ask students to recall the types of phytoplankton they observed the day before and what types of adaptations (e.g., spines to help them float or avoid predation) help these organisms survive in the ocean. Next, we ask the students to invent their own phytoplankton, giving it a unique name and adaptations that they think will help it survive in the ocean. The students receive black construction paper and oil pastels to design their new creature, as this combination yields a vivid image. In our case, the art teacher instructed the students to use colors that would contrast with the black paper and were shown examples where the picture was filled in with bold lines and shapes.

This art project provides students with a creative exercise for synthesizing and reinforcing what was presented in the science lessons and in the lab on previous days. This activity also meets fifth-grade art standards for the representation of objects in two dimensions from imagination.

Some examples of creative adaptations that students gave their phytoplankton for staying near the water's surface (thus near sunlight) and deter predators included water wings, bubbles, inner tubes, spines, spikes, and solar panels. Although these are imaginary species with some imaginary adaptations, they do suggest a conceptual understanding of survival in the ocean. The artwork created by the students, along with a description of the program, is then displayed at various public locations, such as the local public library, observatory, and even Starbucks!

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The learning outcomes for Day 3 are to:

- Develop ideas for the work by synthesizing the information and making preliminary sketches.
- Create a two-dimensional representational artwork from direct observations and imagination.
- Label the adaptations given to the "new" organism for its survival.
- Provide a scientific name (genus and species) for the "new" organism.
- Explain the utility of the adaptations, either through a creative writing exercise or through a short presentation to the class.

Future Oceanographers

The primary assessment used during the program was the art component in which students were asked to draw a unique and new phytoplankton species with adaptations that they thought would help the organism survive in the ocean. Students created imaginary species with both true to life and some imaginary adaptations, suggesting a conceptual understanding of survival in the ocean.

The AOP has had several positive outcomes. First, based on feedback from students, the program effectively piqued their interest in the oceans. Nearly 100% of the students reported that they wanted to learn more about the ocean. Moreover, most students pointed to hands-on activities, particularly the use of microscopes, as being their favorite part of the program. For many students, this program provides the first opportunity to use a microscope, preparing them for later use in upper grades.

With these positive outcomes, this program is not only a local step in encouraging ocean science literacy at an early age but also serves as a model for the genesis of similar programs. The success of the AOP stems from four key elements. First, it incorporates a partnership between scientists and teachers. Scientists who receive federal funding for their research are often obligated to engage in outreach, to satisfy the terms of the grant. Therefore, scientists often want to partner with teachers, and this relationship can be valuable. Scientists can engage in local outreach and teachers can gain access to a pool of resources that may not have otherwise been known. Second, the AOP uses the oceans as a teaching tool. The oceans are good model systems for education since many general science concepts can be explained using ocean-based examples and the oceans are inherently interesting to children. Third, the AOP integrates different disciplines into the teaching approach, engaging students and helping to reinforce concepts. Lastly, the AOP is successful because it is a low-cost program. We have provided this program for as little as $250, although it can certainly be scaled up and made more elaborate.

At this juncture, the AOP is designed to partner ocean scientists with teachers in a fifth-grade classroom, but as highlighted above this general approach could easily be adapted to partnerships with freshwater scientists or implemented by teachers independently.

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Grades 5–8

Content Standards

Standard C: Life Science

- Structure and function in living systems
- Populations and ecosystems
- Diversity and adaptations of organisms

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

NSTA Connection

Read about the fourth activity, an exploration of algae in our daily lives, at *www.nsta.org/0904*.

We continue to offer this program for several classes of fifth graders, and we have developed a handbook for use by scientists and teachers to implement the program in their area. For a free copy of the handbook, please contact the authors directly. ■

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Acknowledgment

We wish to sincerely thank Patricia Keoughan and Amy Maseda (Morse Pond School, Falmouth, Massachusetts) for sharing their classrooms with us. We also thank Dr. Andrew Juhl (Lamont Doherty Earth Observatory, Palisades, New York) and the many WHOI volunteers who have helped with the AOP. Funding from the Woods Hole Science and Technology and Education Partnership (WHSTEP), the US Environmental Protection Agency (EPA), the National Science Foundation (NSF) Biological Oceanography Program and the Center for Microbial Oceanography: Research and Education (CMORE) made the AOP possible.

Resource

Cerullo, M.M. 1999. *Sea soup: Phytoplankton.* Gardiner, ME.: Tilbury House Publishers.

Internet Resources

Carolina Biological Supply
www.carolina.com
Fisher Scientific
www.fishersci.edu
Ward's Natural Science
www.wardsci.com