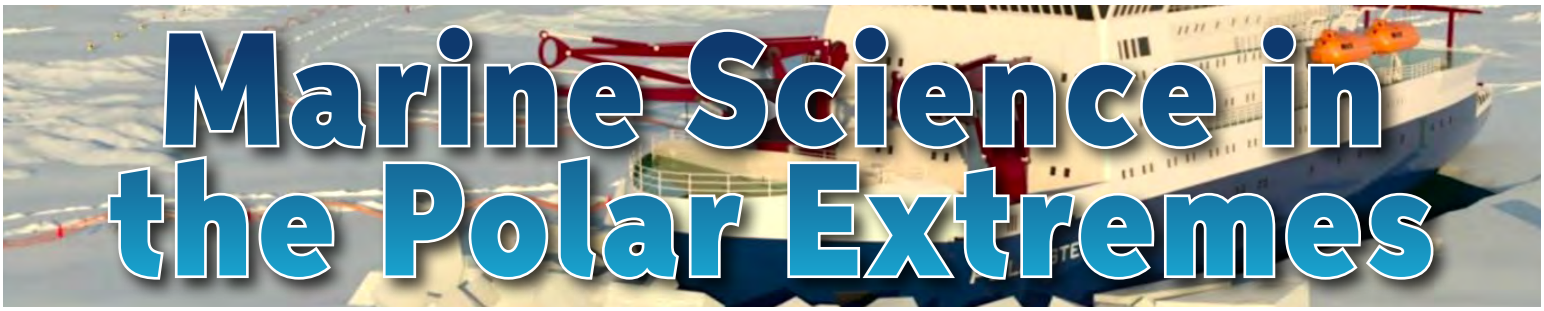
Flotsam & Jetsam

Winter 2021 massachusettsmarineeducators.org Vol. 49, No. 3



Marine Science in the Polar Extremes

MOSAiC

Multidisciplinary drifting Observatory for the Study of Arctic Climate

Embark on the largest polar expedition in history. In September 2019, the German research icebreaker ***RV Polarstern*** set sail from Tromsø, Norway, to spend a year drifting through the Arctic Ocean — trapped in ice. The goal of the MOSAiC expedition was to take the closest look ever at the Arctic as the epicenter of global warming and to gain fundamental insights that are key to better understand global climate change. Hundreds of researchers from 20 countries were involved in this exceptional endeavour. Following in the footsteps of Fridtjof Nansen's ground-breaking expedition with his wooden sailing ship Fram in 1893-1896, the MOSAiC expedition brought a modern research icebreaker close to the north pole for a full year including for the first time in polar winter. The data gathered will be used by scientists around the globe to take climate research to a completely new level. Led by atmospheric scientist Markus Rex, and co-led by Klaus Dethloff and Matthew Shupe, MOSAiC is spearheaded by Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) and was a $150 million project.

The ***RV Polarstern*** was commissioned in 1982 and is still one of the most advanced and versatile polar research ships worldwide. The ship usually operates 317 days on average every year, covering about 50,000 nautical miles per year. Between 1999 and 2001, the ship was completely overhauled and now contains the latest equipment and technologies available. It is capable of operating in the pack-ice zone, and owing to her double-walled steel hull and 20,000 hp engines can break through 1.5 meter thick ice and can ram through thicker ice. She is 118 meters long, 25 meters wide with a maximum displacement of 17277 tons. OA crew of 44 seamen operate the ship and about 100 **MOSAiC** researchers, technicians and crew were on board for each of the four legs of the trip. She also had on board various vehicles (helicopters, snowmobiles, Pistenbullies etc.).

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• INSIDE THIS ISSUE •

If you have difficulty accessing this journal, contact the editor at dimmick@esteacher.org . The next issue of *F&J* will be posted on the website on March 14.

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2021 MME Calendar

Check website and F&J for details.

WEDNESDAY, MARCH 10
MME Board Meeting

WEEK OF MARCH 15
High School Marine Science Symposium
Virtual Conference

WEDNESDAY, MAY 12
MME Board Meeting

MAY
Annual Meeting and Election of Officers

Please check the MME website for details as we get closer to these dates.

All MME Members are invited to Board Meetings, which will be virtual meetings. Please check with an MME officer for details.

The annual meeting will also be a virtual one again this year.

MME wishes Kathy Zagzebski good luck in her new position at Karen Beasley Sea Turtle Rescue and Rehabilitation Center, in Surf City, NC. We will miss your many contributions to MME, but know that NC will be gaining a person who has kept busy at NMLC.

Journey to the Top of the World with the MOSAiC Expedition

Carin Ashjian

"The ship is rumbling. Extremely loudly. The rumbling is punctuated by a sound like two pieces of Styrofoam rubbing together. Then there is scraping…screech! We are in the middle of a ridge that is building and the ice is moving along the side of the ship. We are "pinched". We are not breaking ice; it is breaking around us. So strange to hear the sound of ice breaking on a stationary ship!"

I wrote those words on April 14, 2020 as I was living and working on board the *R/V Polarstern* in the Arctic Ocean as part of the MOSAiC expedition. Earlier this year, during the onset of the COVID pandemic, I spent 4.5 months at sea in the Arctic as part of this massive, international expedition.

The Arctic is arguably feeling the impact of climate change more than any other region on earth. The central Arctic also is critically understudied, particularly during the winter. To predict future changes to the system in response to ongoing climate change, we need first to understand how the system works. The MOSAiC project ("Multidisciplinary drifting Observatory for the Study of Arctic Climate") was envisioned to better understand the impact of climate change on the marine system. The project was based on the German icebreaker *R/V Polarstern* that was frozen into the ice in the central Arctic Ocean in October of 2019 and allowed to drift with the sea ice for a year (until October 2020). Multiple instruments and sampling installations were established on the ice around the ship, many powered with electricity from the ship. MOSAiC is the largest Arctic expedition ever mounted, involving 20 supporting nations, including the US, and participating scientists from many other nations, multiple ships, aircraft, and many supporting personnel. It follows on in the tradition of Arctic drift of Nansen's Fram from the 1890s and the US-Canada SHEBA expedition of 1997-1998 but is much more comprehensive in scientific scope and complexity. One hundred people were on board for each of five legs.

The project is organized around 5 disciplinary teams: Atmosphere, Ice, Ocean, Ecosystem, and Biogeochemistry. I am a member of the ecosystem team. Our main questions focused on the seasonal cycles in the ecosystem, the connectivity of the ecosystem to other aspects of the system such as sea ice, and the impact of ongoing environmental change on that ecosystem. MOSAiC provided us with a unique opportunity to collect a comprehensive data set over a full annual cycle, something that is very difficult to achieve in an ice-covered ocean.

I was a participant on Leg 3. My leg was originally scheduled to run from mid-February to early April, with us leaving Norway in late January to sail to the *Polarstern*, frozen into the ice not far from the North Pole, on a Russian icebreaker, the *Kapitan Dranitsyn*. In the end, our leg lasted until early June when we transferred off of the *Polarstern* after the ship had left the ice and sailed to Kongsfjord in Svalbard.

As we went north from Norway on the *Dranitsyn*, we quickly lost daylight and plunged into the polar night and the temperatures became very cold, as cold as -40° Celsius. The going was very slow once we got into the ice, sometimes less than 5 miles per day. After some weeks, we began to wonder if we would ever reach the *Polarstern*; we were just crawling through the heavy ice. At one point, we heard that we might need to turn back so that the *Dranitsyn* would

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Carin Ashjian with her sampling gear on sleds that were used to drag gear out to the sampling tent. The Polarstern *is in the background.*

Photo by Serdar Sakinan

President's Message

Greetings all,

As I write this letter, good news seems to finally be on the horizon, as vaccine production ramps up and the first recipients may get a shot in the arm soon. We can only hope that all goes well and that the mountainous logistical challenges are overcome. With luck, many of us will have been vaccinated by the time I write the spring letter.

The MME Fall Conference (previously known as the Boston Harbor Educators Conference), held remotely, was a resounding success by any measure. Kudos to President-Elect Pat Harcourt and her team for all their hard work making this happen. In addition to including many diverse voices in marine science, this was the first conference I have ever attended that included an American Sign Language interpreter. We hope to make this a regular feature of MME conferences, remote or otherwise. I am proud that we can model this important offering for other organizations. And if you missed the conference, members can access them online. Look for a link in your email.

At this point we have already made the decision to hold our Annual Meeting and Conference virtually this year. Although we miss the mingling and important personal connections that in-person conferences offer, the virtual model does allow us to open our doors to participants, speakers and presenters who might not otherwise be able to attend. Planning is already under way, so look for updates in the early spring. The High School Marine Science Symposium is also going virtual this year, with a week-long offering of workshops and activities.

Finally, be sure to "like" our postings on the MME Facebook and Instagram pages. Share them with your friends! It's a great way to spread the word about our important work. As always, if you have any questions, ideas, comments or concerns please feel free to contact me directly at dpinkerton1019@gmail.com, or call/text me at (781) 718-5770. I am on Instagram and Twitter @ pinkerteach.

Warmest regards,

Don

Don Pinkerton, President

Solving the Antarctic Paradox: Towards sustained observations of change in the Southern Ocean ice pack

Ted Maksym, Associate Scientist with Tenure, Woods Hole Oceanographic Institution

As the wind blew snow across my face, I fumbled in the cold and darkness connecting sensors to the buoy platform I was installing into the sea ice. I heard the faint chirp of our under-ice robot – an autonomous underwater vehicle, or AUV – reassuring me that it was still on course surveying the ice beneath me. We were in the central Ross Sea, Antarctica in the austral winter of 2017, aboard the Nathanial B. Palmer, the National Science Foundation's flagship Antarctic research icebreaker. Or rather, not on board, as we were standing on sea ice, the thin veneer, only a few feet thick, that forms each year around the Antarctic. As I looked back to the ship, the faint glow of the Southern Lights in the sky above, I reflected on our solitude, and the improbability of where we were. We were hundreds of miles deep into the ice, and thousands of miles from civilization. This was the first winter trip into the Ross Sea in nearly twenty years. And I was deploying one of the first buoys capable of monitoring the seasonal evolution of the ice ever deployed in this region. And while our AUV was breaking new ground in our ability to measure the ice and ocean beneath it, we were only just scratching the surface. The Antarctic remains one of the least observed parts of the world's ocean, and is among the most important in determining our future climate.

Antarctic sea ice is one of the greatest seasonal events on earth. In winter Antarctic sea ice covers an area twice that of the United States. But in summer, it shrinks to 1/8th its size, leaving only a narrow buffer between the open ocean and the continent. In spite of its remoteness, it plays a critical role in Earth's climate. Including the broader, ice-free ocean to north, the Southern Ocean acts as the thermostat for the world – absorbing nearly half of the carbon dioxide we emit, and as much as 90% of the heat absorbed due to global warming. The ice caps the ocean, limiting the loss of heat in winter, and reflecting the sun's heat in summer. Winter ice growth produces cold, dense water which sinks near the Antarctic coast, while drifting ice transports fresh water northward. Together, these processes modify the global overturning of the World's ocean and the heat delivered to deeper waters. It also may play an important, but poorly understood role in buttressing Antarctic ice shelves from warm water and ocean waves. The decline of these ice shelves, which are formed from glacial ice draining from the vast Antarctic ice sheet, are critical in determining the rate of future sea level rise.

Despite its seemingly barren landscape, Antarctic sea ice is a also a critical habitat for a rich ecosystem. Antarctic krill, perhaps the most abundant species of animal on the planet, spends the winter beneath the ice. It forms the base of the Southern Ocean food chain, supporting penguins, numerous whales, and seals, including the crabeater seal – an ice-obligate species and the most numerous marine mammal on Earth.

But in contrast to Arctic sea ice, which has been retreating faster than forecast by climate models, Antarctic sea ice has been a conundrum. Since satellite measurements began forty years ago, the ice has increased slightly in extent, contrary to expectations. Then, suddenly, the ice retreated to a record low in 2016, from which it is only just recovering. Understanding this behavior has been the focus of much research over the past decade, with myriad candidate mechanisms proposed – both human-caused and natural. These include changes in the ozone hole, changing winds, freshwater from melting ice shelves and increased precipitation, and changes in ocean heat delivered to the ice. We now know much of the ice variability is wind driven, with the ice expanding northward or being pushed southward depending on the direction of the wind. But the ocean acts as an important feedback. In the Antarctic, the ocean is weakly stratified, so that warm water beneath the surface is easily stirred up. This upwelling heat is strong enough to keep the ice thin (often only a couple feet thick), and often strong enough to melt the ice from below, even in winter. In fact, in 2017 in the Weddell Sea, enough heat was stirred up to create an area of open water deep within the winter ice pack the size of Maine – a feature not seen since the 1970s. Changes in the upper ocean and how interactions with the ice either bring up this heat or sequester it below the surface will determine how much the ice may retreat, and how sustained those changes may be.

Is the ice just responding to natural variability in winds? Or will the ocean sustain the recent retreat of the ice? Will we finally see the sustained losses that have been predicted as the climate warms? Answering these questions requires direct measurements. We can

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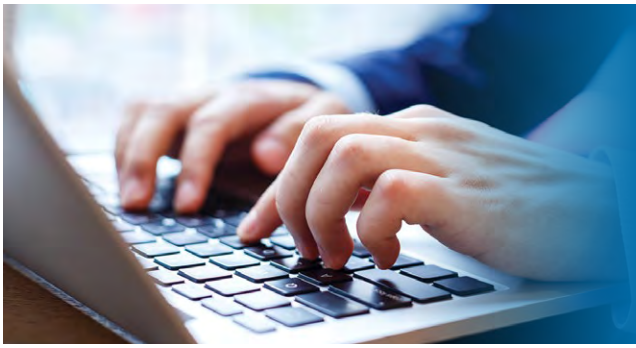


From the Editor's Desk

Recent issues of *Flotsam and Jetsam* have included articles on Sea Level Rise, Climate Change, Ocean Pandemics, and Seaweed Farming. This issue of *F&J* looks at Marine Science in the polar regions. Marine Science in the polar regions is not commonly thought of because it is too cold! Why study the polar regions, they are only ice, permafrost, polar bears and long dark periods with 24-hour darkness? Scientists have long noted that things are changing in the Arctic. Ships can sail across the top of the world during summer months, permafrost is melting, and ice is getting thinner yearly. In the Antarctic, huge pieces of glacial ice break off and form icebergs nearly as large as some of our smaller states floating in the southern oceans.

These events have a profound effect on global climate and are causing major changes around the globe. The Earth is warming, permafrost is melting, huge fires occur even in the arctic regions of Siberia, and the sea is warming. As more and more of this ice melts, the Earth's oceans are rising, and cities like Los Angeles, Miami, New York and Boston see the sea level rising as the water level increases.

At our board meeting in September, when I asked for ideas for the winter *Flotsam and Jetsam* the board suggested a unit dealing with the polar regions. This put me to work and led me to making contact at Woods Hole Oceanographic Institution through contact made by Grace Simpkins of the board, Alfred Wegener Institute in Bremerhaven, Germany, the Cooperative Institute for Research in Environmental Sciences, at the University of Colorado, and Colorado State University. After bouncing emails back and forth this issue is the result.

On page 7 you will find a large number of links to single lessons, full units, MOSAiC media, ArcGIS story maps, and Data Puzzles plus many, many more links from these sites. Many afternoons were spent talking with people in these locations. Level of activities are indicated as is difficulty of some activities.

CIRES is a partnership of NOAA and the University of Colorado Boulder. A Zoom conference with Curriculum Developers Lynne Harden and Jonathan Griffith was like opening a door to VAST amounts of information and contacts for this article. I would like to take time here to thank Lynne and Jonathan for their help. They are now at work developing curriculum materials using data gained on the MOSAiC expedition. Lynn put together page 7 of this journal and Jonathan worked on the MOSAiC Data Puzzles

Lynne and Jonathan both indicated in our Zoom call that *they would like to hear from teachers* who use any of the materials mentioned in that page. You can find their contacts on the CIRES page or drop a note to me and I will give you their e-mail addresses.

The MOSAiC project has brought back huge volumes of information and data as a result of the year floating within the Arctic ice. The data, specimens, samples and materials returned will be studied by the many dozens of scientists who worked on the project for years to come. This new data will allow us to more accurately represent key processes using Earth system models, and as a result, provide urgently needed and more reliable prognoses regarding climate developments, for the Arctic and beyond.

As we move into the new year, I hope it is a bit easier for you than the past months have been. I can't imagine the new problems and extra work that has been done as a result of our bout with this virus. I hope you have a successful winter-spring set of classes, and hope that you find some materials referenced in this issue useful in teaching about the polar regions and how they are related to climate science.

Howard

Howard Dimmick, Editor

Teach about climate science with the MOSAiC Arctic expedition

In September of 2019, the research icebreaker Polarstern traveled north into the Arctic where it was intentionally frozen into the Arctic sea ice. This was the beginning of the 2019-2020 MOSAiC (Multidisciplinary Drifting Observatory for the Study of Arctic Climate) research expedition. Over the next year, the Polarstern drifted almost continuously across the Arctic, allowing scientists to study all aspects of the Arctic climate system for a full seasonal cycle from research camps set up on the sea ice around the ship.

Why bring the MOSAiC expedition into your classroom?

What is happening in the Arctic is such a central piece of the global climate change story. The MOSAiC expedition is not only a compelling hook for teaching about the Arctic climate system, it also gives students the opportunity to see firsthand how scientists study it. From short 10-minute engagements, to immersive virtual reality experiences, to full-length units, there are a multitude of ways to bring MOSAiC into your classroom:

< 1 hour

MOSAiC Multimedia
- Browse the various MOSAiC media collections – videos, photos, even podcasts!
- https://mosaic.colorado.edu/media
- https://multimedia.awi.de/mosaic/

VR Experiences
- Immerse yourself in the Arctic with 360-degree MOSAiC **virtual reality experiences**.
- https://mosaic.colorado.edu/mosaic-virtual-expeditions

ArcGIS StoryMaps
- Immersive and visually-compelling stories about MOSAiC and the Arctic
- https://mosaic.colorado.edu/mosaic-arcgis-storymaps

Independent learning

Guided learning

MOSAiC Data Puzzles
- Bring authentic MOSAiC and Arctic data into your classroom with MOSAiC Data Puzzles!
- https://mosaic.colorado.edu/mosaic-data-puzzles

Arctic Activity Database
- Browse our extensive searchable database of MOSAiC and Arctic-related activities!
- https://mosaic.colorado.edu/activities

- In this unit, students explore the nature of science through the Fram and MOSAiC expeditions.
- https://cires.colorado.edu/outreach/resources/unit/exploring-new-and-old-arctic

- In this unit, students explore why the Arctic is warming twice as fast as the global average.
- https://cires.colorado.edu/outreach/resources/unit/arctic-feedbacks-not-all-warming-equal

> 1 week

mosaic.colorado.edu/education

CLASSROOM ACTIVITY

NEW MOSAiC Data Puzzles

Are you interested in using authentic Arctic and MOSAiC expedition data in your classroom? Look no further! MOSAiC Data Puzzles allow your students to analyze and interpret real Arctic data and develop skills in hypothesis testing, graphing, and more.

In The Teachers Guide include notes for the teacher, links to video presentations and background information for the teacher. Suggestions for student understanding checks are also included. Links to data visualizations and other MOSAiC Data Puzzles and units of material and individual lessons are given.

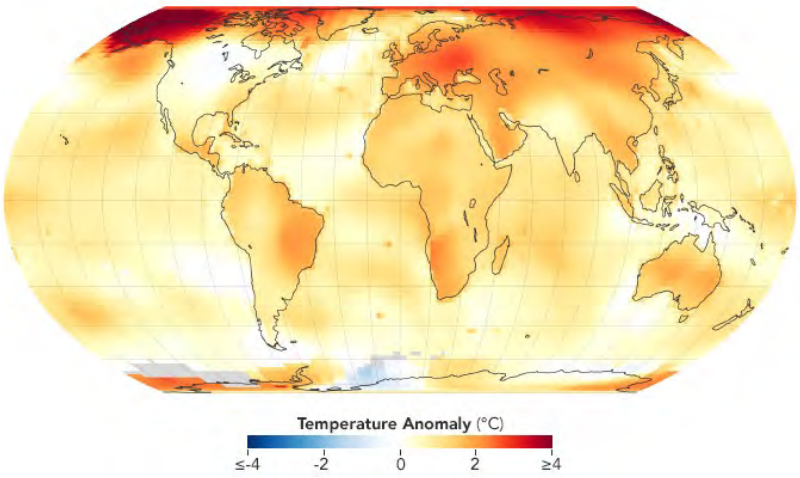
Connect your students to authentic datasets acquired as part of the 2019-2020 MOSAiC expedition with Data Puzzles, a free resource co-designed by MOSAiC scientists and curriculum developers. Data Puzzles provide middle and high school students with the details of research projects and related science concepts, as well as an authentic dataset for students to engage and puzzle with as they look for patterns and develop explanations about natural phenomena. Data Puzzles are connected to NGSS Earth's Systems standards and include a Teacher Guide and three student differentiated activities with Graph Type A being the easiest and Graph Type C the most challenging. Described and included below are two MOSAiC Data Puzzles, "On a Budget" and "To Reflect or Not to Reflect, That is the Question". Datasets provided in both Puzzles are included in our popular **"Arctic Feedbacks" curriculum**.

Want more? Check out our MOSAiC-inspired "Arctic Feedbacks" curriculum and/or **sign up** to receive **monthly Data Puzzles** directly to your inbox.

ON A BUDGET

Grade level: Middle/high school

Time: 1 class period



The Earth's energy budget describes the balance between the energy that is reaching the Earth from the Sun and the energy that is emitted by the Earth, which flows back out into space. In the simplest sense, if this energy budget stays balanced, Earth's temperature stays constant. Rising global temperatures over the past century indicate that Earth's energy budget is out of balance. This energy imbalance is not equal across Earth's surface as scientists have observed that the Arctic is heating up at a rate faster than the global average, a phenomenon known as Arctic amplification. Scientists studying Arctic amplification are seeking to answer the question, What can the amount of incoming sunlight and outgoing heat energy to and from the Arctic tell us about Arctic amplification?

Image (above) description: 2019 global temperature anomalies relative to the 1951-1980 mean. Image from NASA.

Featured Dataset(s) - Arctic incoming sun (shortwave) energy, Arctic outgoing heat (longwave) energy, Arctic temperature anomalies

Download the Materials

- **Teacher Guide**
- **Student Activity, Graph Type A** *(included in publication)*
- **Student Activity, Graph Type B**
- **Student Activity, Graph Type C**

REACH THE WORLD
Bringing the World into Classrooms

MOSAiC Expedition to the Arctic Ocean

Welcome to the MOSAiC Expedition to the Arctic Ocean! Reach the World has designed a journey outline with linked articles and sample activities to guide you. Use this suggested itinerary and take your students on a virtual exchange expedition that they'll never forget!

Want more, related learning resources? Feel free to use any of Reach the World's sample lessons and activities.

Questions? Please contact educators@reachtheworld.org.

FOUR-WEEK JOURNEY OUTLINE

Week #1: *Meet the explorers*

- Journal: "Four Months in the Arctic with MOSAiC"
- MOSAiC Content: "A Year Trapped in Arctic Ice" (Video)
  - MOSAIC Extension Content: "The Team Behind MOSAiC"
  - Sample Activity: KWL Chart

Week #2: *Living in the Arctic*

- Journal: "Indigenous Communities in the Arctic"
- MOSAiC Content: RV Polarstern and Ice Camp (Images)
  - Sample Activity: Pack Your Bags

Week #3: *Safety and survival*

- Communities Field Note: "Understanding the Arctic Winter"
- Journal: "Safety and Logistics in the Central Arctic"
  - Sample Activity: Design-Based Thinking - Prototyping Worksheet
    - Design a prototype for an innovation that helps keep MOSAiC crew members safe on their expedition

Week #4: *Scientific research on the MOSAiC Expedition*

- Nature Field Note: "Cold-Loving Critters: Animals of the Central Arctic"
- MOSAiC Content: "The Key to the Arctic Puzzle"
  - PBS Video: "Arctic Climate Perspectives"
  - Sample Activity: Experiment – How Does Melting Ice Affect Sea Level?

OPTIONAL: Live Video Conference with an Explorer

Would you like to schedule a live video conference between your students and one of the explorers from this virtual exchange expedition? Video conferences are optional and subject to classroom and explorer availability. Reach the World strongly recommends that classrooms review most expedition articles prior to scheduling a video conference. Educators will work with Reach the World and the explorer(s) to set a theme and/or topic for the event.

Ready to go? Please complete this form to schedule.

Examples of fun, engaging video call events:

- **Stump the Expert!** – Classrooms conduct research on the explorer's area of expertise and the explorer themselves. The students ask the explorer questions and gain a point if the explorer doesn't know/answers incorrectly, while the explorer gains a point if they answer the question correctly. *Ideal for all ages.*
- **Explore [Topic/Theme] Together** – Students and the explorer choose a topic related to the explorer's area of expertise. For the first five minutes, the explorer presents to the students. Then, for the next five minutes, the students present to the explorer. This can be repeated as many times as desired. *Ideal for middle and high school students.*
- **Student Show & Tell** - Students and the explorer choose a topic that is related to the explorer's area of expertise. The students conduct their own research before the video call and prepare presentations either individually or in groups. During the video call itself, students take turns presenting to the explorer. At the conclusion of the call, the explorer asks the students questions about their presentations. Ideal for all ages.

MOSAiC

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The mission of MOSAiC

MOSAiC aims at a breakthrough in understanding the Arctic climate system and in its representation in global climate models. **MOSAiC** will provide a more robust scientific basis for policy decisions on climate change mitigation and adaptation and for setting up a framework for managing Arctic development sustainably.

The Arctic is the key area of global climate change, with warming rates exceeding twice the global average (Figure 1) and warming during winter even larger. It is well possible that the Arctic ocean will become ice free in summer during the 21st century. This dramatic change strongly affects weather and climate on the whole northern hemisphere and fuels rapid economic development in the Arctic.

Future climate change projections for the Arctic are extremely uncertain with a factor of three uncertainty of projected warming by the end of this century – a much larger uncertainty than anywhere else on the planet (Figure 2).

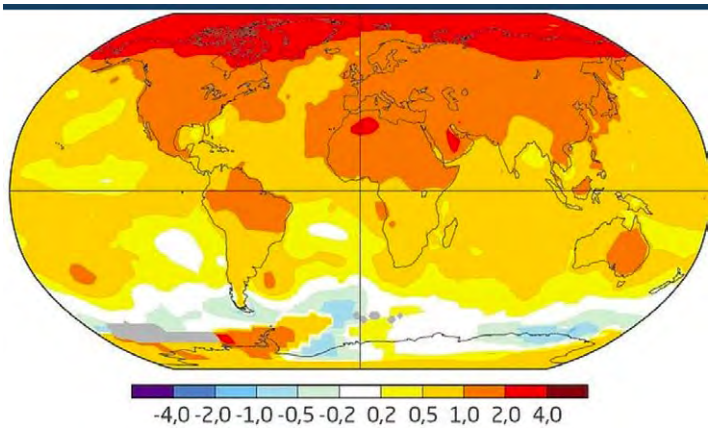


Figure 1. Near surface temperature changes 1970-2017
Graphic: NASA GISS, https://data.giss.nasa.gov/gistemp

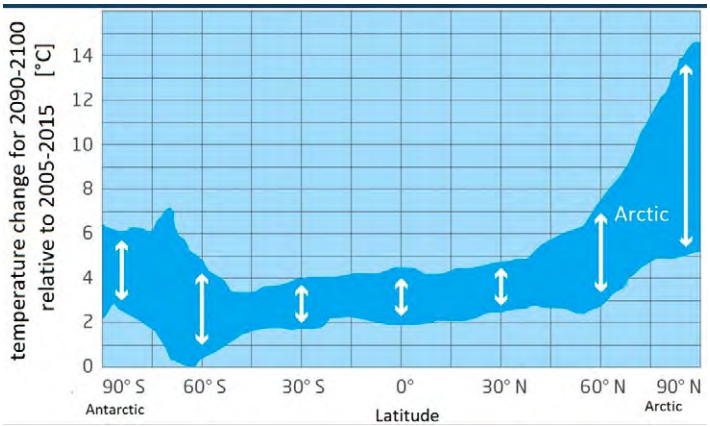


Figure 2. For the Arctic the uncertainties of climate models are much larger than for any other part of the planet. Here projections of the warming by the end of the century range between 5 and 15 degree Celsius among the different models, for the same rather pessimistic greenhouse gas emission scenario (RCP8.5) which is shown here.

Many processes in the Arctic climate system are poorly represented in climate models because they are not sufficiently understood. As long as we do not understand these processes, Arctic climate projections will not be robust.

The understanding of Arctic climate processes is limited by a dramatic lack of observations in the central Arctic, especially in winter and spring. During these seasons sea ice is so thick that even the best research icebreakers cannot penetrate into the Arctic and researchers have always been locked out.

The dramatic changes in the Arctic climate system and the fast retreat of Arctic sea ice strongly affect global climate. The inability of modern climate models to reproduce Arctic climate change is one of the most pressing problems in understanding and predicting global climate change.

MOSAiC sets out to investigate the heart of the Arctic climate system year-round – one of the largest uncharted areas in climate research.

MOSAiC – The key to the Arctic puzzle

The **MOSAiC** expedition will help us gain a better understanding of the evolving Arctic system. Over the course of the entire year-long expedition, including winter and spring, an international team of experts, with a vast array of large and small scientific instruments, will closely observe all the pieces of the Arctic climate puzzle – the atmosphere, sea ice, ocean, ecosystem, biogeochemical processes, and more – and put these together to develop a more complete understanding of how they interact and respond to change.

This new data will allow us to more accurately represent key processes using Earth system models, and as a result, provide urgently needed and more reliable prognoses regarding climate developments, for the Arctic and beyond.

The **MOSAiC** expedition's findings will also enable researchers to gain deeper insights into the feedbacks between the Arctic climate and the lower latitudes around the globe where most people live. More accurate Earth system models lead to better weather and sea-ice forecasts, which are essential for day-to-day planning, management of resources, transportation, and many other societally-relevant activities in the Arctic and at home.

MOSAiC's contribution to Arctic protection

Improved climate forecasts are also extremely important for the Arctic itself, since the overall warming and the loss of sea ice are changing the face of the Arctic region. Clear research findings, like those provided by **MOSAiC**, can offer a sound scientific basis for future political decisions regarding environmental protection, sustainable economic development,

The RV Polarstern in the Arctic Ice Field. The vessel was commissioned in 1982 and still is one of the most advanced and versatile polar research vessels.

and global cooperation around the Arctic. For example, retreating ice extent is modifying habitat for many species; understanding the impact of these changes will enable a better understanding, and management, of these systems with implications on ecosystems, food supplies, and more.

Furthermore, the thawing ice is making the Arctic increasingly interesting from an economic perspective. New shipping routes are opening up. Raw materials, like natural gas, crude oil and metals, which were previously buried under the ice, are becoming exposed, and new fishing grounds will become accessible. This means that clear framework conditions are needed to ensure the Arctic is developed sustainably. Setting these conditions requires a solid understanding of the Arctic climate and environmental systems. Only then will it be possible to have a well-founded political and public discussion on the basis of scientific findings. MOSAiC will help to provide that basis.

Published with permission from Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

Cold-Loving Critters: Animals of the Central Arctic

Jessie Creamean, Colorado State University

Algae are tiny plant-like organisms that look like shapes, such as small "blobs" or rods under a microscope. To the human eye, they can live in large communities that appear to be floating masses or filaments (fibers) of green, brown, and yellow under the sea ice. Copepods are larger than algae and most species look like tiny shrimp with red, brown, and clear bodies. They are part of the diet of the Polar cod, a narrow fish that has adapted to the frigid waters of the Arctic Ocean and can grow to 11 inches in length, but they are typically much smaller. Mammals, like ringed seals, eat Polar cod. These seals have a thick layer of blubber that enables them to live and swim in the Central Arctic. Arctic foxes are another type of mammal that have adapted to living on the sea ice. They can be brown, but near the North Pole they are fluffy and white. This helps them blend into their surroundings. And of course, there are polar bears! These large creatures have thick fur and fat layers to keep them warm and camouflaged while they travel over the sea ice and swim in the cold waters between ice floes.

How did I feel when I saw it?

When I was on the MOSAiC Expedition last fall and early winter, I saw clumps of algae in sea ice cores we collected, copepods in seawater samples, cod fished by some of the ecologists on board, and even polar bears. I was very excited to see all these animals, mostly because I am fascinated by how living beings can thrive in the cold and dark Arctic environment. I was warm in my thick parka jacket when I was working on the sea ice, but I could not last for more than several hours, while these organisms live here 24/7! Seals are one of their main sources of food!

What can harm this creature or plant? Are we worried about it?

These animals are part of the balanced and intricate food web of the Central Arctic. Most of them, aside from the polar bears, are food for an animal that is larger than them. The polar bears eat ringed seals. Cod are eaten by bears, seals, and foxes. Cod need to eat copepods and the copepods need to eat the algae. Although this may seem harmful to each induvial species, it is a part of nature and how these animals survive.

One unnatural thing that can harm all these animals is climate change and a warming Arctic. A warmer Arctic means less sea ice. All of these animals depend on the sea ice for food, shelter, and transportation. This means the sea ice is a crucial part of the Arctic ecosystem. If one animal, such as algae for example, does not have the sea ice to live in, trickling effects to larger animals cause the food web to be off balance. No algae means no food for the copepods, no copepods means no food for the cod, and no cod means no food for the seals, foxes, and polar bears. Without the sea ice, it would be very difficult for these animals to survive!

Journey to the Top of the World with the MOSAiC Expedition

continued from page 3

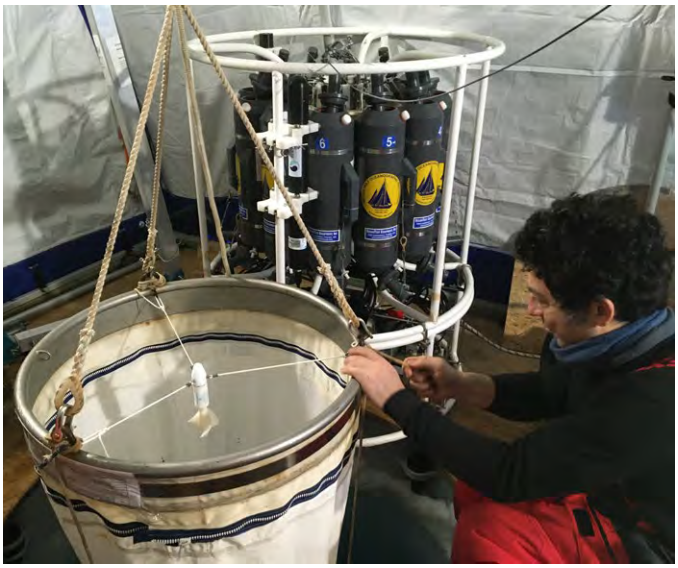
The R/V Polarstern in the ice.
Photo by Carin Ashjian

have enough fuel to get out of the ice and back to her home port; this was very stressful for us since we were all eager to work at the ice station. Fortunately, this didn't happen. Finally, on February 26, we saw the lights of the *Polarstern* in the distance. We arrived at our parking location a mile away from the *Polarstern* on February 28, a month after we left Norway. Because it was still polar night, we accomplished the transfer of equipment, supplies, and personnel between the two ships under the unrelenting lights of the ships, snow machines, and pisten bullies. On March 6, the *Dranitsyn* left with the Leg 2 science party and ship's crew, leaving my team to carry on the work at MOSAiC.

My particular scientific focus is on zooplankton, microscopic animals that float freely in the water and that are a key link in the food chain. My zooplankton work focused on WHO, WHAT, WHEN, and WHERE: Which types and species are present? Where are they, in shallow water, deep water, or near the ice? What are the seasonal cycles of abundance and age structure? What are they doing: are they actively feeding? Are they reproducing? What are they eating?

To collect zooplankton, we used plankton nets that we deployed through a hole in the ice. At first, we worked from the ship, using cranes and winches to lower the nets through a hole located next to the ship and covered by a heated tent when not in use, preventing the water in the hole from freezing over. Our first weeks were dogged by very cold days that prevented use of the cranes (they could not be used when it was colder than -30°C). Every day was a challenge: plans were made and then modified based on the temperatures. Then, after a couple of weeks when we were just comfortable with the sampling procedures, disaster struck: the very dynamic Arctic Ocean started to shear the ice and the ship moved and destroyed the sampling hole. After that, and for the next two months, we sampled with our nets at "Ocean City" – a tent in which there was a winch and a sampling hole in the ice. Each sampling day we packed up our stuff on sleds and trudged out across the ice floe, along "roads" marked by flags, to the Ocean City tent.

The ice remained dynamic for the remainder of the leg, with frequent rearrangements of the puzzle pieces surrounding our central ice floe on which many of the on-ice facilities are based.



Carin's colleague Serdar Sakinan with a plankton net suspended over the hole in the ice in the sampling tent. The net is about 10' long and most of it is in the water in this photo. The gray tubes on the rack in the background are used to sample ocean water at specific depths.
Photo by Carin Ashjian

Two dominant Arctic copepods, Calanus hyperboreus *(large) and* Calanus glacialis *(small) taken with a camera mounted on a microscope. The large copepod is approximately the size of an uncooked grain of rice.*
Photo by Carin Ashjian

The ship moved a little bit almost every day, sometimes snapping the massive lines anchoring her to the ice. The noise, particularly below decks where one of my labs was located, was eerie – rumbling and screeching as the ship shifted in the ice or was compressed when two massive pieces of ice pushed together.

During the transit north from Norway, we had seen twilight gradually increasing so the horizon was pink and purple during the mid-day. Venus hung huge (for Venus) and bright in the sky. When up, the moon glittered above us, illuminating the endless ice with a cool, blue glare. The sun first rose in mid-March and after a few days of night, remained above the horizon for the remainder of my time at MOSAiC; I did not see a sunset until transiting south to Germany in June. As spring progressed, the days were bathed in golden sunlight, weather was less stormy, and the air temperatures tended towards -15 to -10 °C, finally approaching freezing (0°C) in early May.

On board the ship, we worked in excellent laboratory facilities, using a microscope to pick individual zooplankton for experiments such as reproduction, respiration, and grazing rate determinations and for samples to be analyzed back on shore. Back home, we will measure the carbon and nitrogen content of individual copepods (a dominant type of zooplankton that are the size of an uncooked grain of rice or smaller and that are related to shrimp). With this information, and rates such as grazing, we can calculate how much carbon resides in the zooplankton pool of the ecosystem and how much is being transferred along links in the food chain. On my leg, we picked over 4800 individual copepods. During the length of the expedition, we collected thousands and thousands of samples that will take months to analyze back on shore.

Life on *Polarstern* was very comfortable. Three meals a day were served by a cheerful steward department. An automatic coffee machine dispensed coffee, espresso, cappuccino, café au lait, and amazing hot chocolate. The menu was varied, although potatoes were a constant. For Easter, we celebrated with three days of special events and meals. On Friday night, some of us gathered to listen to Bach's "Matthew's Passion". Saturday night we went out on the ice to enjoy fires that were lit in barrels sunk into the ice. On Sunday, we had a formal dinner at noon. The weather was gorgeous and clear. Twenty-five of us went on a 5 km hike out across the floe. Sunday night we had a barbecue, with the entire ship's complement gathering in a large lab with tables set up. Each person could select their items (different meats, fishes, vegetables) to barbecue and then go outside, into the -28°C weather, to grill over large charcoal grills set up on the deck.

Days seemed to flow together so that sometimes I barely remembered what I did two days earlier. Only the pattern of the meals kept us oriented to the day of the week; Friday was fish, Saturday was soup with homemade bread. Our schedule was ever changing; the environment seemed to conspire to prevent us from following a plan. Nonetheless, we sampled with our nets weekly. Once the nets came in, I worked at the microscope for several days afterwards.

When we left Norway in late January, the COVID pandemic was still just a nasty flu in Wuhan China. By mid-March, it had expanded into a global pandemic. On March 17, we learned that the flights that were to transport us home from MOSAiC in early April had been cancelled due to the pandemic. Time passed, beyond the end of our leg and we were still on board with no plans to leave. This was an extremely stressful period for us, as we continued to work while wondering when we would be able to leave and also worrying about family and friends back in the "real world". We could think of home but could not imagine what it was really like. Finally on April 24 a plan was announced by which we would sail from the floe on *Polarstern* in mid-May and rendezvous with two German research icebreakers in Svalbard to do the personnel exchange.

On the morning of May 14, we heard a dull rumbling and felt a quivering vibration as the *Polarstern* awoke from her slumber and came to life, bringing the main engines up to run in preparation for moving. For the past 10 days, we had been preparing for our departure from the floe to go south for the personnel transfer, re-fueling, and re-provisioning. Science activities were interspersed with preparations to complete our time here and to entrust the continuation of our work to our colleagues who will be replacing us. At the same time, the dynamic ice field continued to change our icescape in a very dramatic fashion. Because of this, and in preparation for leaving, we brought most equipment and instruments on board so that they would be safe while the ship was gone from the floe. On May 16, with our labs secure for sea, we departed from the floe, heading south to the ice edge and Svalbard.

We arrived in Kongsfjord, Svalbard on June 4, after two and a half weeks at sea battling through ice heavier than anticipated. As we sailed into the fjord, we marveled at a landscape of browns and dark gray. We watched eagerly for our first sight of the *R/V Sonne* and *R/V Maria S. Merian*, the two German research vessels that had traveled from Bremerhaven with our colleagues for the personnel transfer. As the *Polarstern* came alongside the *Merian*, we crowded the decks, watching across the narrowing divide to see the first new faces in 3 months and our friends and colleagues who were to replace us. We spent 4 days transferring gear, personnel, and knowledge to the oncoming science party and ship crew. Then the Leg 3 personnel were split

between the two ships for the transit, separating us for the first time since the end of January. On June 8, the three ships headed out of the fjord, the *Sonne* and the *Merian* flanking the *Polarstern*. At the mouth of the fjord, the *Polarstern* slowly turned to the north, heading to the ice to continue MOSAiC, while the other two ships set course for Bremerhaven, Germany.

We sailed south, through the Norwegian then North then Baltic Seas. As we sailed south, the decreasing latitude brought warmer days and, on June 11, our first nightfall since March. The days were long and lazy. Most of the time, the winds were relatively gentle and the seas low. The ship rolled gently, which was very lulling. People read and sat on the deck, looking out at the seas. In the evenings we gathered to watch the sun go down. It was not without trepidation that we looked to the days ahead when we would join the new world with so much to learn. It was hard to leave the protected cocoon of our small society, where the behaviors of a previous world still were the norm.

I arrived back in the US on June 16, after an amazing experience, to a sad new world. I had thought I would be the one with a surreal experience, living and working on a ship frozen into the ice, but in the end my life was totally normal and your lives back home had all changed.

About the Author

Carin Ashjian is the Chair of the Biology Department at Woods Hole Oceanographic Institution. She received her BA in Biology from Cornell University in 1982, and her PhD in Oceanography from the University of Rhode Island in 1991. She has spent extensive time in the Arctic at the SHEBA ice camp in 1997 and 1998, on multiple research cruises on icebreakers, and working from a small research vessel out of Utqiaġvik, Alaska. Her research has concentrated on biological oceanography, particularly on the ecology and distribution of polar zooplankton with a special focus on with a special focus on the impact of ongoing climate change on polar ecosystems.

Carin's participation in the MOSAiC project is funded by the US National Science Foundation. The continuation of the MOSAiC expedition through the global COVID pandemic was made possible by many supporting agencies and nations but most particularly by the efforts of the Alfred Wegener Institute, Helmhotz Center for Polar Marine Research in Bremerhaven Germany.

Link to an activity dealing with Sea Ice in the Arctic and Antarctic

GRAPHING SEA ICE EXTENT IN THE ARCTIC AND ANTARCTIC

https://scied.ucar.edu/activity/13146/print-all

Students create graphs of sea ice extent data for the Arctic and Antarctic, learning about both annual, seasonal cycles and longer-term trends. Visualizations complement the data analysis, allowing students to view animated maps of the data

Source UCAR Cnter for Science Education

TEACHERS SAVE THE DATE!

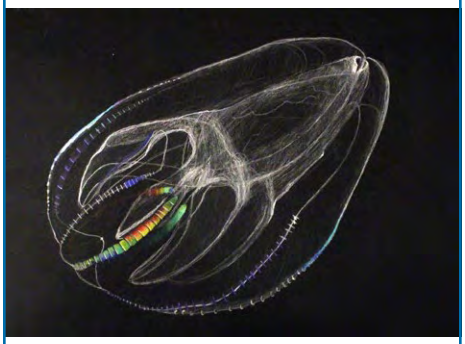
2021 High School Marine Science Symposium

THE WEEK OF MARCH 15

About the Event

The annual High School Marine Science Symposium will be going virtual this year! We invite you and your students join us for a week-long event where we bring together organizations from across Massachusetts to share their work to protect the ocean and paths to a career in marine science. Events will take place during the week of March 15 and will be specifically tailored to provide activities for students to complete during remote learning. Stay tuned for more information and registration details!

2019 Art Contest – Scientific Illustration – 3rd Place
Elizabeth C., gr. 8, Covenant Christian Acad., W. Peabody. *Copepods*



2018 Art Contest – Scientific Illustration – 6th Place
Eden McKenna-Bateman, gr. 11, Bourne HS. *Sea Gooseberry*

Collecting Scientific Samples

Location: Aboard *Polarstern* in the Central Arctic

Latitude/Longitude: 76.250577800000, -100.113952000000

Journal Entry:
Hi, I'm Dr. Jessie Creamean, and I'm a research scientist at Colorado State University in Fort Collins, Colorado. I recently returned from Leg I of the MOSAiC Expedition in the Central Arctic. During my several months aboard the icebreaker ship Polarstern, I worked with other scientists to collect thousands of scientific samples. These samples included sea ice, seawater, animals, snow and tiny particles of matter in the air called aerosols. My colleagues and I used (and continue to use!) a wide range of measurements to evaluate how these different components of the Arctic system might be linked.

So how do MOSAiC scientists actually collect samples?
Sea ice samples are collected using a special ice coring barrel and a battery-powered drill. Every week, somewhere between 50 and 100 ice cores are collected to measure properties like ice temperature, thickness, salt content, microbes (bacteria, algae, plankton), nutrients for the microbes, other particles and gases like methane and oxygen trapped in bubbles in the ice. The cores are collected as whole cores or cut up into sections to measure how things change with the depth of the ice.

The ice samples are then either stored and transported frozen, melted then frozen or melted and filtered to collect the material in the ice, sometimes at temperatures as low as -112 degrees Fahrenheit!

Seawater samples are measured for similar properties as the sea ice but are collected in tubes from cracks in the ice. We use a special seawater tap on the icebreaker, something called a CTD rosette, where the CTD stands for "conductivity, temperature, and depth". The CTD is connected to a heavy-duty cable that allows scientists to send it to the bottom of the ocean through a large hole in the ice where we can open special bottles at different depths to collect the water samples. These samples are split up unto sub-samples, and then stored frozen, filtered then frozen, or sometimes they are analyzed using equipment on the icebreaker.

Animals like fish, plankton, algae and crustaceans are collected using special fishing lines or nets that are sent hundreds to thousands of feet deep into the ocean. The fish are usually then dissected in laboratories on board the icebreaker then stored frozen, while the smaller organisms are separated by species then counted. Measurements on the animals include things like DNA and ecosystem population statistics.

Snow samples are collected several times a week from snow pits dug by scientists and by using special snow sample collecting tools. These samples are stored frozen on the icebreaker until they can be brought back to land, where they are sent to many laboratories to measure properties like snow crystal shape and size and to determine the presence of microbes and other particles. MOSAiC scientists regularly measure snow temperature, depth and the gases coming up from the snow.

Aerosol samples are collected using a special item of scientific equipment that is like a home vacuum cleaner. This equipment collects aerosol particles (or particulate material), and depending on the type of measurements, these samples are stored frozen or unfrozen at room temperature. These aerosol samples are then measured for their chemical and biological make up as well as the shape, size and quantity of particles and other properties relevant to climate.

The MOSAiC Expedition has worked very hard to put scientists in a position where they can collect all of this data, and the information that we learn from this data over the coming years will help improve our understanding of different aspects of the Arctic system and climate. All of these clues may help scientists answer the big question: Why is the Arctic changing so rapidly?

Solving the Antarctic Paradox

continued from page 5

see how much of the ocean is covered by ice from space, but it is difficult for satellites to measure how thick the ice is. And satellites cannot see the ocean below the ice. This is what motivated us to venture deep into the sea ice pack – to measure how the atmosphere, ice, and ocean interact to govern the amount of ice produced in winter. And on this trip, we would be making many measurements that have not been made here before. The buoy I was installing was one of a suite of platforms that would monitor the ice thickness and the upwelling ocean heat as the winter progressed, sending back data by satellite long after we were safely back home.

One of the real technological innovations on the cruise was our AUV. These robotic submarines are first programmed with a mission and then run autonomously, making measurements as they traverse their pre-programmed route until they return to the surface and are recovered. AUVs are fast becoming a workhorse in oceanography, particularly ocean gliders, an energy efficient vehicle that can operate alone at sea for a month or more. But navigating under ice has always been a challenge, since the vehicle cannot safely surface to get a GPS fix to determine its location. My team has used an AUV developed at the Woods Hole Oceanographic Institution (WHOI) that operates over relatively small distances from the ship and uses a network of acoustic beacons to determine its location and an acoustic modem to communicate with its operator on the ship should it run into trouble. We used this AUV to measure ice thickness with sonars mounted on the vehicle in great detail, obtaining orders of magnitude more thickness measurements than the traditional method of mechanical drilling. We are now using these measurements, along with coincident measurements we made on the ice surface, to help estimate sea ice thickness over the entire Antarctic from satellites.

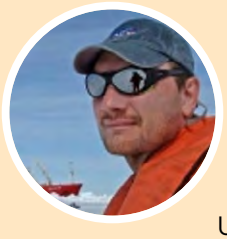
But that this was the first winter expedition in this region in 20 years highlights how hard it is to make observations in the ice-covered regions of the Antarctic. It is logistically challenging to mount a research expedition into the ice, and in the middle of winter, there are vast swaths of the Southern Ocean that simply cannot be accessed. And even when icebreakers do venture into the ice, their endurance is limited to only about two months at sea. This necessitates autonomous observations. But our buoys still require manned expeditions to deploy them. And while ours is the first cruise on which an AUV successfully operated under the ice in winter, it never ventured more than a kilometer from the ship. To observe how the ice-ocean system evolves seasonally, or over many years, and over large areas, we need drifting platforms that can be deployed each year, and vehicles that can traverse long distances over the course of multi-month missions.

These goals remain a challenge, but there has been significant recent progress. There is now routine deployment of profiling floats (drifting platforms that can move up and down through the ocean as they measure ocean properties and send that data home over satellite link when they surface) throughout the ocean. Some now are capable of operating under ice. Still, because of limited access to these regions, few floats make any observations under the ice each year. And direct observations of the ice, like those we did in 2017 remain rare. New kinds of drifting platforms, long-range drones, and new robotic vehicles offer promise to enable observational capability with limited or no manned presence. A recent effort led by oceanographers at the University of Washington and Lamont-Doherty Earth Observatory at Columbia University have used ocean gliders to make unmanned observations for many months under and around an Antarctic ice shelf. Work is also underway, at WHOI and elsewhere, to develop long-range, long-endurance vehicles that can autonomously explore under the sea ice to deliver sustained observations

The author deploying WHOI's Jaguar AUV on a mission under the Antarctic sea ice to measure its thickness.

throughout the year, without the need for ship-based support. The future of Antarctic oceanography requires coordinated international efforts for an observing system that includes vehicles, drifting platforms, ships and satellites.

As I stood on the ice, musing about the buoy I was deploying, and the robot beneath my feet, I thought back to my first Antarctic cruise, some twenty years earlier. Then we measured ice thickness crudely by drilling hundreds of holes through the ice. I thought about how far we had come technologically, but also how far we still needed to go if we were to be able to fully understand the fate of the ice.



About the Author

Ted Maksym is an Associate Scientist with Tenure at the Woods Hole Oceanographic Institution, in the Department of Applied Ocean Physics and Engineering. Ted received a B.Sc.E in Engineering Physics from Queens University in Kingston, Ontario in 1992. He received his Ph.D in Geophysics from the University of Alaska Fairbanks in 2001. Ted studies the physics of sea ice and its interactions with the atmosphere and ocean in both the Arctic and Antarctic. He has participated in nine research expeditions to the Antarctic and four in the Arctic. His most recent interests involve the use of autonomous vehicles under ice.

nsta

National Science Teaching Association

Given the continuing concerns around COVID-19, NSTA has made the difficult decision to postpone the in-person National Conference in Chicago, scheduled for April 8–11, 2021.

Very soon we will announce dates, topics, and new proposal guidelines for the NSTA Engage: Spring21 Virtual Event.

We know that postponing the in-person Chicago conference comes as an enormous disappointment to the many teachers and exhibitors who have been looking forward to the face-to-face 2021 annual national conference, but we know it's the right decision based on the information we have today.

We believe we can, and will, create a compelling professional learning experience next spring that will include everything you have come to expect from an NSTA conference, including featured keynotes and sessions, special science and education showcases, networking, exhibitions, and so much more.

For the past nine months, we have focused considerable attention and resources on helping science educators with the new challenges we all face. Someday soon we are looking forward to a gradual return to the status quo, when audiences will be comfortable convening in an in-person setting, and we cannot wait for that to happen.

National Marine Education Association

Meeting in person isn't happening this year, but the NMEA annual conference will live on! Stay tuned for information regarding NMEA's 2021 virtual event!

We are excited to announce that NMEA is re-imagining our conference experience and is planning to host a virtual conference event in 2021!

As a result of the COVID-19 pandemic, the hosts of the NMEA 2021 conference, Oceania, with the full support of the NMEA Executive Committee and the NMEA Board, have made the difficult decision to cancel the 2021 conference).

Several factors influenced this decision, including uncertainties around vaccine timing and distribution, our ability to safely host conference participants, and other limitations that would hinder our ability to put on a quality conference.

Although we will miss hosting you in Hawai'i next summer, we look forward to seeing you online at the virtual conference event!

Nov. 13, 2020 Marine Science in the News

Retreating Glacier Presents Landslide Threat, Tsunami Risk in Alaskan Fjord

Source NASA

Using NASA satellite imagery and software processing approaches, a group of geoscientists has discovered a landslide-generated tsunami threat in Barry Arm, Alaska, that will likely affect tourists and locals in the surrounding area in the next 20 years.

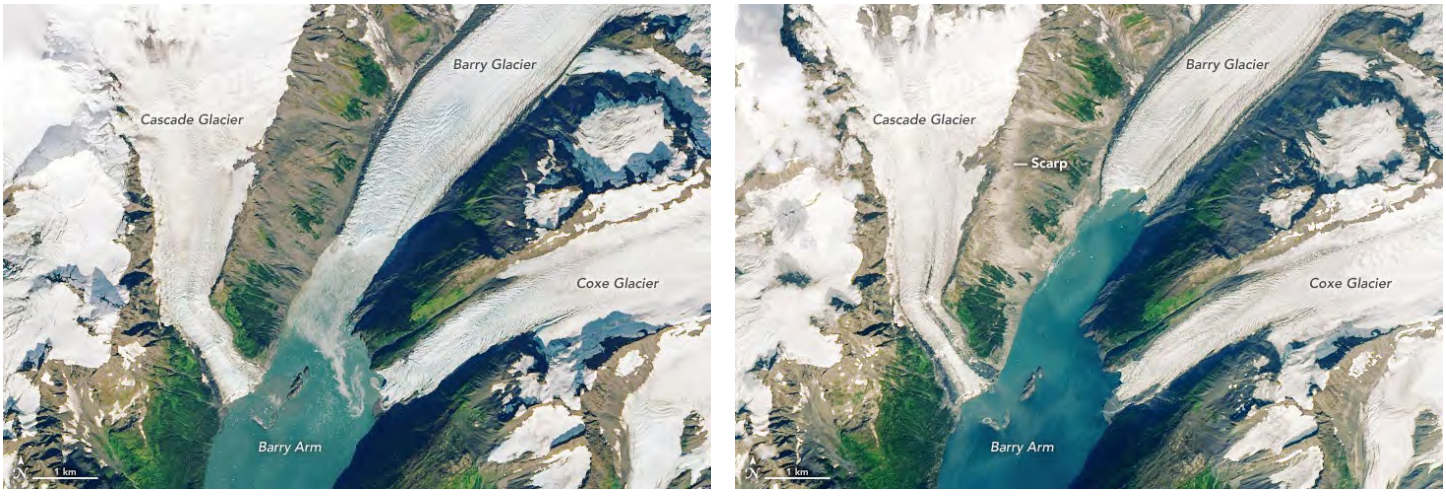
The Barry Arm Glacier has diminished rapidly in the last decade due to climate change, causing the surrounding terrain to become unstable. The researchers found that the mountainside near the Barry Arm Glacier has moved 394 feet (120 meters) over the seven-year period between 2010 to 2017. If that slow-moving landmass were to catastrophically fail – becoming what we typically think of as a landslide – it would fall 3,000 feet into the fjord below, sending tsunami waves toward nearby communities.

The researchers jumped into action after the discovery, writing an open letter to community stakeholders. The findings were published Oct. 29 in *Geophysical Research Letters*.

Chunli Dai, geophysics researcher at The Ohio State University in Columbus, worked with Bretwood Higman, geologist and co-founder of Ground Truth Alaska nonprofit, to analyze the slow-moving landslide near the Barry Arm Glacier. Their team tracked the landslide's horizontal movement using satellite imagery and measurements from NASA-U.S. Geological Survey's Landsat constellation, NASA's Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), ESA's (the European Space Agency) Sentinel-1, Planet Labs, and DigitalGlobe. As the longest-running Earth-observing satellite program, Landsat provided the researchers with an archive of satellite imagery that allowed the team to see how the Arctic surface in that area has changed over time. Data from the Polar Geospatial Center's ArcticDEM project were also used to measure the elevation of the glacier to see how its height has changed over the years.

Dai and her team developed new and innovative tools that confirmed the threat from the landslide near the Barry Arm Glacier. The tools are sensitive enough to enable the team to detect signals associated with volcanic eruptions, changes in the surface due to permafrost melting, and landslides. These tools sort through massive topographic datasets to detect subtle changes in the land's surface over time – acting as one step toward better preparation for hazards on the changing Arctic.

The new finding came out of a large project studying the topography of the Arctic surface and how that landscape is changing. The project uses ArcticDEM digital elevation models and is funded by the NASA Earth Surface and Interior (ESI) program. This project intends to use global, high-resolution



The unstable terrain that poses a landslide threat lies between the Cascade Glacier and Barry Arm Glacier, which has been steadily retreating over the last decade. The above satellite images show the glacier's retreat from 2013 (left) to 2019 (right). ***Credit:*** *NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey*

topographic measurements so that NASA may better understand natural hazards and changing environments, said Benjamin Phillips, lead for NASA's Earth Surface and Interior Focus Area. Partnering with the National Science Foundation, National Geospatial-Intelligence Agency, and others, NASA supports the development and distribution of new digital surface models of the globe, constructed from optical imagery acquired by the DigitalGlobe constellation.

As the Barry Arm Glacier retreats, 600 million cubic yards of rugged terrain that was once supported by the glacier is left unstable. During a landslide, rocks and debris act less like a collection of solids and more like a fluid. In the case of sudden landslide failure, this flow of rock and debris would likely fill the fjord, leaving several smaller lakes in place of the 450-foot deep body of water.

Barry Arm Fjord and the adjacent Harriman Fjord – 60 miles east of Anchorage on the southern coast of Alaska – are frequented by cruise ships, tour boats, fishing boats, kayakers, and hikers. Because of the immediate dangers posed by the potential the landslide and tsunami threat, Dai and the other scientists signed an open letter to local community stakeholders as soon as the hazard was identified so that they were aware of the implications that the landslide would likely generate a tsunami.

At the landslide's current elevation, its mass would trigger a tsunami with waves hundreds of feet tall in Barry Arm. Broader impacts of the tsunami include 30-foot waves hitting Whittier, Alaska. Prince William Sound may experience wave and current changes, and rock and debris from the landslide would be scattered in this area.

If the landslide were to fail all at once, the potential energy stored within the event is equivalent to a magnitude seven earthquake, nearly ten times greater than any of Alaska's largest tsunami-generating landslides in the last 70 years, said geoscientist Anna Liljedahl of Woods Hole Research Center in Homer, Alaska.

The resulting tsunami could travel up the opposite side of the fjord, harming wildlife, hikers and vegetation. Farther away from the source, bays throughout Prince William Sound act as amplifiers, meaning this tsunami would be less localized and more powerful even tens of miles from the source.

As a result of this discovery, the National Oceanic and Atmospheric Administration (NOAA), the agency responsible for tsunami alerts, is in the process of preliminary tsunami modeling. In early June, NOAA also assessed the fjord for wave height monitoring equipment, which could be installed and connected to their warning system network later this summer, said Liljedahl, who worked with Dai to assess the Barry Arm landslide threat.

Alaska's Division of Geological and Geophysical Surveys (DGGS) is also monitoring the Barry Arm region following the scientists' discovery. They completed an airborne lidar survey in mid-June to track the slide's movement and are working with the Alaska Earthquake Center to install a seismic station near the fjord that will help detect sudden landslide movements. Without new monitoring equipment, Whittier would only have 20 minutes warning to evacuate if the Barry Arm landslide were to suddenly fail.

"There are a lot of natural hazards that people in Alaska are used to – earthquakes, volcanoes, and fire hazards. We need to take that mindset and apply that to landslide-generated tsunamis," Liljedahl said.

In addition to current monitoring efforts, geoscientist Bretwood Higman said that having a GPS system on the landslide mass should be a high priority because it could give a better indication as to when the landslide will fail.

"Landslides sometimes accelerate just before they fail," he said. "If you have some way of measuring deformation – if we see something like that – we can say risk is much higher right now, let's get everyone out of the area."

The landslide's movement down the mountainside is strongly correlated to the nearby Barry Arm Glacier's retreat, as surrounding area becomes destabilized as the glacier melts. While a landslide-generated tsunami is not a certainty, knowledge of the risk informs the need to monitor and prepare for the possibility. "This is such a huge area and rare event, but the risk of it happening is just going up because we have this warming climate," Liljedahl said.

By Emily Fischer
NASA Contact: Sofie Bates
NASA's Earth Science News Team, Greenbelt, Md.

2019 Art Contest – Middle School – 4th Place
Derrek Y., gr. 7, Li Mao Art Studio, Houston, TX.
Humpbacks

Baleen Whales Expanding Their Range as Oceans Warm, New Study Shows

Jan Wesner Childs

Sei whale mother and calf. This study was the first comprehensive analysis of sei whale distribution throughout the western North Atlantic Ocean.

Photo: NOAA Fisheries

Several species of baleen whales are expanding their range and spending more time in northern latitudes, likely as a result of climate change, according to new research.

The study, published recently in the journal Global Biology Change, was authored by nearly three dozen federal, state and academic researchers from institutions in the United States and Canada including NOAA, Woods Hole Oceanographic Institute, New England Aquarium and the U.S. Navy.

The scientists analyzed undersea recordings of humpback, blue, fin and sei whales collected over a decade from 2004 to 2014, totaling 35,033 hours of whale sounds, according to a NOAA news release. The recordings were made by devices moored to the seafloor at nearly 300 locations spanning from the Caribbean Sea to western Greenland, and have been used for more than 100 other research projects.

That particular decade was selected because it coincides with shifts in climate in the Gulf of Maine, a key feeding ground for the whales, and distribution changes observed in numerous other species in the western North Atlantic Ocean around 2010.

Baleen whales are among the largest animals on earth, and are familiar for their famous "blow" as they quickly exhale and inhale when surfacing and submerging.

The analysis showed that the four species were all expanding their ranges from common feeding grounds like the Gulf of Maine, with fin, blue and sei whales spending more time in northern latitudes during the later years of the recordings. The change matches a shift in food sources, according to the researchers.

"The Gulf of Maine, an important feeding ground for many baleen whale species, is warming faster than most places in the world, resulting in changes in distribution not only of marine mammals and fish but also for their prey," Genevieve Davis, a senior acoustician at the Northeast Fisheries Science Center in Woods Hole, Massachusetts and lead author of the study, said in the NOAA news release.

Covering some 36,000 square miles off the coasts of Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia, the Gulf of Maine is one of the fastest-warming parts of Earth's oceans, according to NASA. Water temperatures there have increased three times faster than the global average over the past 30 years and seven times faster in the past 15 years, a rate higher than 99% of the total global ocean.

Humpback whales, meanwhile, were found to spend to more time across a broader range of locations than researchers previously thought.

The study, which built on previous research, was the first to show these particular whale species spread out across the western North Atlantic Ocean over long periods of time.

While the recordings tell researchers what whales are present at any given time, they can't tell how many there are.

"All four whale species were present in waters from the southeast U.S. to Greenland, with humpbacks also present in the Caribbean Sea. These four species were detected throughout all the regions in the winter, suggesting that baleen whales are widely distributed during these months," Davis said.

"A decade of acoustic observations have shown important changes over the range of baleen whales and identified new habitats that will require further protection from human-induced threats like fixed fishing gear, shipping, and noise pollution."

The Weather Company's primary journalistic mission is to report on breaking weather news, the environment and the importance of science to our lives. This story does not necessarily represent the position of our parent company, IBM.

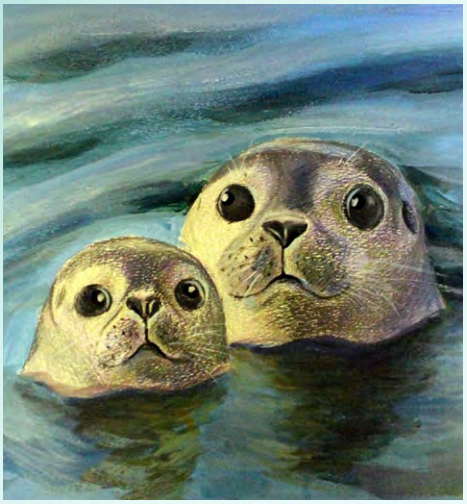
Massachusetts Marine Educators

Marine Art Contest 2021

Grades K-12
Deadline: May 7, 2021

THEME:
Illustrating the Biodiversity of Stellwagen Bank National Marine Sanctuary

Sponsors
Massachusetts Marine Educators, Stellwagen Bank National Marine Sanctuary, New England Aquarium, Ocean Genome Legacy Center-Northeastern University, Center for Coastal Studies, Whale and Dolphin Conservation, Woods Hole Sea Grant



Harbor Seals – Donna X., gr. 5, Li Mao Art Studio, Houston, TX

2021 Marine Art Contest

THEME: Illustrating the Biodiversity of Stellwagen Bank National Marine Sanctuary

DEADLINE: May 7, 2021

Massachusetts Marine Educators, Stellwagen Bank National Marine Sanctuary, and co-sponsors invite students in grades K-12 to participate in the 2021 Marine Art Contest. The theme is *Illustrating the Marine Biodiversity of Stellwagen Bank National Marine Sanctuary*. Contest sponsors encourage students to consider composing pieces that illustrate a representative species in its sanctuary habitat, show predator-prey relationships, or depict a sanctuary habitat with a diverse array of marine species.

REQUIREMENTS

- Make sure that all artwork depicts species that are found in Stellwagen Bank National Marine Sanctuary, which is located in the Gulf of Maine, just off the Massachusetts coast.
- Entries should be submitted as high resolution digital images – jpg or tif formats preferred but pdf will also be accepted.
- White, non-glossy paper is recommended — please be careful in scanning or photographing art to avoid glare.
- Original photographs may be submitted in the computer graphics division.
- If manipulating images from outside sources in the computer graphics division, please cite the source of the image.
- Include a scan of the entry form or type the entry information in the email text area: student's name, age, grade, school, school address, school phone number, teacher's name and teacher's email address. Write the common and/or scientific name(s) of the animal(s) in the artwork. Attach the artwork file(s) to the email.
- Please provide home address (for mailing awards, if selected), email of parent or guardian, and phone number for correspondence purposes. For all students under age 18, check the box or note that the parent approves submission of the entry.
- Students are limited to two entries. Submit each entry to stellwagen@noaa.gov

DIVISIONS

Elementary School: Grades K-4

Middle School: Grades 5-8

High School: Grades 9-12

Scientific Illustration: All Grades

Computer Graphics & Photography: All Grades

PRIZES

1st Place: $50 cash award, certificate

2nd Place: $30 cash award, certificate

3rd Place: $15 cash award, certificate

4th-6th Places: certificate

Additional prizes may be available. MME is working with local museums and marine institutions to acquire passes, posters, and other rewards.

Winning artwork will be shared on the NOAA Stellwagen Bank National Marine Sanctuary and MME websites and social media (including, but not limited to, Facebook, Instagram, and Twitter). MME and co-sponsors will have unrestricted use of all submitted artwork.

Please note that by sending your artwork to the stellwagen@noaa.gov email address, you are giving the contest sponsors permission to use the image for other purposes, such as websites and publications of the sponsoring organizations. Credit to the artists will be applied whenever any of the art is used.

Credit for students in elementary and middle school will include first name, last initial, age, grade, and school. For students in high school, the full first and last names will be used. If students do not want full names posted, please tell us in the entry email

See next page for a partial species list

FOR MORE INFORMATION:

www.massachusettsmarineeducators.org • stellwagen.noaa.gov • anne.smrcina@noaa.gov

781-738-2242 or 781-546-6007

2021 Marine Art Contest Partial Species List

This is only a partial list. There are many other species, particularly among phytoplankton, zooplankton, worms and other benthic invertebrates.

PHYTOPLANKTON
- Diatoms
- Dinoflagellates
- Blue-green algae

ZOOPLANKTON
- Arthropods – Copepods and other drifting crustaceans
- Chaetognaths – Arrow worms Cniderians Moon jelly, Lion's mane jelly
- Ctenophores –Beroe's comb jelly, Sea gooseberry
- Mollusk –Pteropod, Naked sea butterfly
- Larval fish and invertebrates

INVERTEBRATES

Sponges
- Finger and Branching sponges
- Breadcrumb and Bulbous sponges
- Chalice or cup sponge
- Common palmate sponge

Cniderians
- Moon and Lion's mane jellies
- Frilled and Bolocera anemones
- Northern red anemones
- Northern cerianthid
- Pom pom anemone
- Red soft coral
- Solitary hydroid
- Tubularian (pink-hearted) hydroids

Bryozoans (Spiral tufted bryozoan)

Mollusks
- Ocean quahog
- Northern horse mussel
- Sea scallop
- Northern moon snail
- Waved and Ten-ridged whelks
- Red-gilled nudibranch
- Short- and Long-finned squid
- Atlantic octopus

Worms
- Nemerteans (ribbon worms)
- Annelids (segmented worms)
- Clam and Fan worms

Brachiopods (Northern lamp shell)

Arthropods
- Rough barnacle
- Acadian and Hairy hermit crabs
- Jonah and Rock crabs
- Stone crab
- American lobster
- Northern pink and Sand shrimp
- Dichelopandalus shrimp
- Mysid and Skeleton shrimp
- Krill
- Horseshoe crab
- Isopods and amphipods

Echinoderms
- Forbes' and Northern sea stars
- Spiny and Smooth sunstars
- Horse and Badge stars
- Blood sea star
- Daisy brittle star
- Northern basket star
- Orange-footed cucumber
- Scarlet psolus
- Common sand dollar
- Green sea urchin

Tunicates
- Stalked sea squirt (Boltenia)
- Sea vase and Sea peach
- Northern white crust
- Sea grape

FISHES

Sharks
- Thresher shark
- Blue shark
- Shortfin mako shark
- White shark
- Porbeagle
- Basking shark
- Spiny dogfish

Skates
- Winter (big) skate
- Little skate
- Barndoor skate
- Thorny skate

Small, Schooling Prey Fish
- Northern sand lance
- Atlantic herring
- Atlantic mackerel
- Butterfish

Flounders
- Atlantic halibut
- American plaice
- Four-spot flounder
- Windowpane flounder
- Winter flounder
- Witch flounder
- Yellowtail flounder

Gadids (cod family)
- Atlantic cod
- Cusk
- Haddock
- Pollock
- Red and White hakes
- Silver hake (Whiting)

Silvery Swimmers (pelagic)
- Bluefish
- Bluefin tuna
- Striped bass

Demersal (seafloor) Dwellers
- Atlantic wolfish
- Sea raven Ocean pout
- Acadian redfish
- Longhorn, Shorthorn and Grubby sculpins
- Northern sea robin
- Cunner
- Black sea bass
- Goosefish (Monkfish)
- Snakeblenny

Unusual Shape
- Ocean sunfish
- Pipefish
- Hagfish
- Lumpfish

MARINE MAMMALS

Baleen Whales
- Blue whale (rarely seen)
- Fin whale
- North Atlantic right whale
- Humpback whale
- Sei whale
- Minke whale

Toothed Whales
- Sperm whale (rarely seen)
- Orca (rarely seen)
- Long-finned pilot whale
- Atlantic white-sided dolphin
- Common dolphin
- Harbor porpoise

Seals
- Harbor seal
- Gray seal
- Harp, Hooded and Ringed seals (rarely seen)

SEA TURTLES
- Kemp's ridley sea turtle
- Leatherback sea turtle
- Loggerhead sea turtle (rarely seen)
- Green sea turtle (rarely seen)

SEABIRDS

Alcids
- Razorbill
- Dovekie
- Atlantic puffin
- Common murre
- Thick-billed murre
- Black guillemot
- Great auk (extinct)

Gulls and Terns
- Herring gull
- Great black-backed gull
- Lesser black-backed gull
- Laughing gull
- Bonaparte's gull
- Ring-billed gull
- Iceland gull
- Glaucous gull
- Sabine's gull
- Black-legged kittiwake
- Least tern
- Roseate tern
- Common tern
- Arctic tern

Gannets and Cormorants
- Northern gannet
- Great cormorant
- Double-crested cormorant

Sea Ducks and Loons
- Common eider
- Long-tailed duck
- Black scoter
- Surf scoter
- White-winged scoter
- Great skua
- Common loon

Shearwaters, Storm Petrels and Albatrosses
- Great shearwater
- Cory's shearwater
- Sooty shearwater
- Manx shearwater
- Wilson's storm petrel
- Yellow-nosed albatross

Fulmars, Jaegers, Phalaropes
- Northern fulmar
- Parasitic jaeger
- Pomarine jaeger
- Long-tailed jaeger
- Red-necked phalarope
- Red phalarope

Art Credits: Cover –

- Naked Sea Butterflies by Grace Li, gr.10, Newton North HS (Scientific Illustration);
- Ocean Sunfish and Diver by Sophia S., gr.8, William Diamond MS, Lexington (Computer Graphics);
- Common Dolphins by Bohdan A., gr.6, Viz Art School, Northborough (Middle School);
- Atlantic Puffin with Fish by Jessica Wu, gr.11, North Quincy HS (High School);
- Sanctuary Scene by Charlotte R., gr.1, Antioch School, Fall River (Elementary School);

Humpback Breach by Michael G., gr.1, PS-89, NYC (Elementary School)

2021 Marine Art Contest

ENTRY FORM

THEME:
Illustrating the Marine Biodiversity of Stellwagen Bank National Marine Sanctuary

DEADLINE: May 7, 2021

Send DIGITAL entries to:
stellwagen@noaa.gov

MME Marine Art Contest
c/o SBNMS
175 Edward Foster Road
Scituate, MA 02066

Submission of this entry gives the sponsoring organizations all rights to use the artwork for non-commercial purposes, in products that serve to promote and publicize the contest, to educate the public about local marine species, and in online or traveling exhibitions of winning art. Any use of artwork will include credit to the student. Credit for high school art will include the student's full name. For grades K-8, students will be identified by school, grade, and first name/last initial only. All winning artwork and honorable mentions will be posted on the sanctuary website (selected artwork will also be posted to the MME website). Personal identifiable information on this form will be held securely and not released to any outside individual or organization.

☐ **Public School** ☐ **Private School** ☐ **Homeschool**
☐ **Art School** ☐ **Afterschool Program**
☐ **Individual** (Individual entries do not need teacher information)

Student Name_____

Age _____ Grade _____ School _____

TEACHER INFORMATION

Name_____

Phone #_____

Email _____

School Address _____

_____

Home Mailing Address (for mailing of prizes, if chosen, and contest correspondence)

_____

_____

PARENT/GUARDIAN INFORMATION

Name _____
(for questions related to contest entries)

Phone # _____

Email _____

☐ I hereby give permission for my child's artwork to be entered in the contest.

Name(s) of animal(s) pictured in artwork _____

_____