Educator Instructions - OET STEM Learning Module

Module Theme | Science
Pacing | | 1-3 class periods
Background Needed | basic understanding of currents, conversions, and calculating averages

Assessment | STEM Project & Task rubric provided

Materials/Resources

- Laptops, computers or tablets with Internet connection
- Calculators
- Printable California latitude/longitude map (Driftin Away Map template.png)

Overview

This learning module provides students with the opportunity to learn about and practice ground-truthing current models using oceanographic drifter data. Students will use a current simulator to predict a drifter's path and will compare the actual drifter track to various current models to compare accuracy.

Objectives & Learning Outcomes

- Students will practice the method of ground truthing a current model and understand its importance.
- Students will compute average hourly and daily distances in nautical miles.
- Students will convert nautical miles to miles.

Guiding Questions

- List 2-3 types of sensors that could be attached to a drifter, describe what kind of data they collect, and why the data is useful to scientists.

✓ Possible answers: temperature sensor: measures water temperature in the surface layer; barometers: measure atmospheric pressure which informs weather prediction; salinity sensors: to calibrate sea surface salinity; irradiance sensor: measure the intensity of sunlight in a location; anemometer: measures wind along the drifter path; ocean color radiometer: measures ocean color as a proxy for chlorophyll content and primary productivity- can indicate pollution levels

- Describe the difference between latitude and longitude. What are the units of measurement for these values?

✓ Possible answers: Latitude are invisible lines extending around Earth horizontally (East to West). A latitude measurement indicates how far north or south of the Equator an object is on the planet's surface. Longitude lines are invisible lines, also called meridians, running vertically (pole to pole) around the Earth used to measure how far east or west an object is from the Prime Meridian, a line through Greenwich, United Kingdom. Both measurements are angular distances measured in degrees. There are 360° of longitude, beginning at the Prime Meridian and 180° E or W to the International Date Line. Specific locations can be described as decimal degrees or as degrees (°), minutes (‘), seconds (“).

- What does GMT stand for? GMT is based on a 24-hour clock. If GMT is 18:12, what time does that represent on a 12-hour clock?
  - ✓ Possible answers: Greenwich Mean Time. The Prime Meridian location (0° longitude) runs through Greenwich, London, United Kingdom. This location was set as the standard time zone and baseline for measurement through international agreements. If GMT is 18:12, the time on a 12-hour clock is 6:12 p.m. Local time zones also count forward or backward from GMT time. The US East Coast time is GMT-5. The US West Coast is GMT - 8. Japanese national time is GMT +9

- What is/are the primary factor(s) that determine the direction of global surface currents?
  - ✓ Possible answers: Moving air masses set currents in motion, especially the major wind belts of the world. The Coriolis Effect, caused by the planet's rotation, plays a significant role in determining wind and current paths. Learn more about the Coriolis Effect from National Geographic Education [http://education.nationalgeographic.org/encyclopedia/coriolis-effect/].

- Describe another oceanographic tool (besides a drifting buoy) that can provide scientists with useful marine and atmospheric data.
  - ✓ Possible answers: Doppler flow meter measures currents by transmitting low-frequency sound signals through the water. The instrument measures the shift in frequency between the sound emitted and the returning sound after it is backscattered by particles in the water. This difference in the sound waves can help identify current movement. Moored buoys can be mounted with various meteorological sensors, satellite or radio transmitters and receivers, current meters, temperature and pressure sensors, sediment traps, and chemical sensors. Weather stations on land are also important sources of ground truth data to compare with oceanic sensors.

Activity/Tasks

Students will:

- Complete guiding questions and vocabulary to get better acquainted with the function of drifters and basic vocabulary
- Predict the pathway of an actual deployed drifter using current model data and a given starting point.
- Compare the actual pathway dataset to the predicted pathway to analyze the effectiveness of the models.
- Conduct analysis on a real-world drifter dataset, using an online program to determine the distance traveled in nautical miles.
- Calculate averages of the drifter's hourly and daily distances traveled.
- Convert nautical miles to imperial miles.
- Reflect on their learning and share additional related content with the class.

Links to Next Generation Science Standards

- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS 1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

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Links to Common Core Standards

- CCSS.ELA.LITERACY.WHST.6-8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to the task, purpose, and audience.
- CCSS.ELA.LITERACY.WHST.6-8.9: Draw evidence from informational texts to support analysis reflection, and research.
- CCSS.MATH.CONTENT .5.MD: Convert like measurement units within a given measurement system.
- CCSS.MATH.CONTENT .6.SP.5c: Summarize and describe distributions.

Define the following terms:

Students will be able to understand and use the following vocabulary:

1. Coriolis Effect
   ✓ An apparent force resulting from Earth's rotation, which causes particles in motion to be deflected from the path of the force acting on them. This deflection bends particles to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.
2. Current
   ✓ A physical movement of water. Currents are usually wind or tidally driven at the surface and driven by variable water density in deeper water
3. Eddy
   ✓ A circular movement of water on a small scale, often formed to the side of a main current. Students may be familiar with seeing eddies as small whirlpools, circling against the flow on the side of a river. Eddies form where currents encounter obstacles, deviate from clear boundaries, or flow past one another
4. GPS Unit
   ✓ A Global Positioning System transmitter, which signals to a global set of satellites to determine the location of the receiver. On drifters, GPS units are mounted in a waterproof casing.
5. Ground Truthing
   ✓ The process of collecting data locally on the ground to check measurements done by a remote scientific instrument, such as a satellite.
6. Gyre
   ✓ A large system of rotating ocean currents, associated with global-scale wind patterns. Gyres are caused by the Coriolis Effect and form in each major ocean basin. Gyres are important to understand as students explore more complex global current models and have recently become highly publicized as regions of the ocean where marine debris aggregates.
7. Latitude
   ✓ Invisible parallel lines extending around Earth horizontally (East to West) used to measure how far north or south an object is from the Equator on the surface of the planet.
8. Longitude
   ✓ Invisible lines running vertically (pole to pole) around the Earth used to measure how far east or west an object is from the Prime Meridian. Longitude lines are not parallel, but each line represents one arc degree along the Equator.

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Set The Stage!

A great way to introduce this module is to show a map such as the one here. Ask students the following questions for discussion:

1. What do the lines on the map represent?
2. If you were going to sail a boat between two countries, what kind of information would you want to know before you set sail?
3. How do you think scientists collect information on current patterns?
4. Why is it useful to scientists and the general public to have models of current patterns? What can they be used to predict?

Educator: Lesson Directions

✓ LESSON SET-UP | Teachers should implement their own grouping arrangement. It may be helpful to introduce the concepts of oceanographic tools, latitude and longitude, and calculating averages prior to the lesson.

- Online drifter resources:
  - Ocean Motion and Surface Currents (http://nautl.us/2e83jAG)
  - 2015 Drifter Tracks www.nefsc.noaa.gov/drifter/
  - http://neracoos.org/drifters
  - Oceanographic Standards for Drifter Design (http://nautl.us/2dJTWud)
  - High School Students Launch Research Drifters from *Nautilus* (http://nautl.us/2e81BiB)
  - http://studentdrifters.org
  - http://carthe.org/
  - Examples of Floats and Drifters (http://nautl.us/2dJW4Sq)
  - "How Lego Figures and Rubber Ducks Reveal Ocean Secrets" (http://nautl.us/2e867xN)
  - "Study Shows Drifter Data on Surface Currents Critical to Predict Pollutant Transport" (http://nautl.us/2e1SnFk)

Student: Lesson Directions

1. Determine student pairs or workgroup arrangements.
2. Complete guiding questions and vocabulary terms using online resources.
3. Complete student worksheets 1-7 using a tablet or computer and noted online resources.
4. Be prepared to share and discuss related content with classmates.

Extensions & Adaptations

Introductory |
For a basic activity introducing the process of ground-truthing using NASA data, refer to this website from the California Academy of Science https://www.calacademy.org/educators/lesson-plans/ground-truthing

Advanced Extension | Ask students to research the methods and technology used to develop scientific models like surface current models. Many factors and data sets must be compiled. Ask students to answer the question: if you were going to create a model of surface currents, what would the primary and secondary considerations you plan to take into account when developing your model? Students could also interview a STEM professional involved in the field (oceanography, computer modeling, remote sensing) and share the information with the class.
What Causes Ocean Currents? Story Map (http://nautl.us/2FSs3iy)

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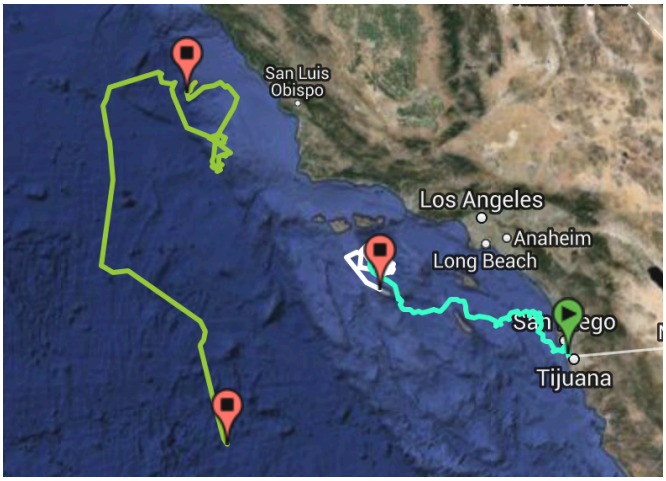
Answer Keys and Student Work Samples

- Worksheet 1 http://nautl.us/2dcO7kT
- Worksheet 2 http://nautl.us/2dcO88p
- Worksheet 4 http://nautl.us/2dWQlr0
- Worksheet 5 http://nautl.us/2e9R1cp
- Worksheet 6 http://nautl.us/2dLjTbk
- Worksheet 7 http://nautl.us/2dcPa4o

Student Worksheet Name:_____

Introduction | Drifting buoys, or ocean drifters, are important tools in collecting scientific data such as tracking marine surface and deep water currents, sea surface temperature, and sea level pressure. These modern-day "messages in bottles", while adhering to the same set of oceanographic standards for drifter design (http://nautl.us/2dJTWud), can vary in complexity and price depending on the materials used to construct them and the sensors they carry. Currently, there are more than 1,000 drifting buoys at sea, transmitting data to satellites and back to collecting centers, which can be observed online. Scientists use this data for a variety of purposes, such as tracking major ocean currents, predicting weather events and pollution spills, and ground-truthing existing current models. Ground truthing refers to the practice of comparing what we know to be true on the "ground" in terms of real-world measurement and comparing it to satellite measurements.

In oceanography, satellite measurements are used to create various models, such as predicting the pathways of ocean currents. Drifters can provide a scale of localized data in real-time, which can help dial in and calibrate what satellites are tracking on a larger scale over longer periods. This work leads to the creation of more accurate and precise models every year. The Nautilus Exploration Program has been deploying student-built drifters since 2014. In this module, you will hypothesize a drifter path given the starting coordinates and access to a current model, and practice ground truthing this model by comparing it to the actual path the drifter took over several weeks. In addition, you will learn how to convert nautical miles to miles and compute average hourly and daily distances using latitude and longitude coordinates.



The Google Earth image at right shows the tracks from four student drifters launched from aboard E/V *Nautilus* in 2015. The Nautilus Exploration Program has launched eight such drifters since 2014, which share data with the National Oceanic and Atmospheric Administration to improve existing current models.

Learning Goals:

- Understand the importance of ground-truthing current models using oceanic drifter data.
- Practice the method of ground truthing using an actual drifter dataset and various online current simulators and models.
- Compute average hourly and daily distances in nautical miles.
- Convert nautical miles to miles.

Procedure |

1. Complete guiding questions and define all vocabulary terms.
2. Follow the instructions on the worksheets to complete each task.
3. Complete follow-up questions.

Student Worksheet Name:_____

Helpful Resources:

- Drifters Provide Climate Data: http://nautl.us/1T0Wvqq
- WHOI: Currents, Gyres & Eddies: http://nautl.us/1oEN17o
- NOAA Currents: http://nautl.us/21nazzd
- What Causes Ocean Currents Story Map: http://nautl.us/2FSs3iy

Guiding Questions |

1. List 2-3 types of sensors that could be attached to a drifter, describe what kind of data they collect, and why the data is useful to scientists.

2. Describe the difference between latitude and longitude. What are the units of measurement for these values?

3. What does GMT stand for? GMT is based on a 24-hour clock. If GMT is 18:12 what time does that represent on a 12-hour clock?

4. What is/are the primary factor(s) that determine the direction of global surface currents?

5. Describe another oceanographic tool (besides a drifting buoy) that can provide scientists with useful marine and atmospheric data.

Student Worksheet Name:_____

Vocabulary |

1. Current:

2. Eddy:

3. Gyre:

4. GPS Unit:

5. Ground Truthing:

6. Latitude:

7. Longitude:

Voices in STEM |

Deanna Bergondo, PhD. Associate Professor, Department of Science, U.S. Coast Guard Academy

"As a professor in marine science at the U.S. Coast Guard Academy, I have been fortunate to have the opportunity to study and teach in the field of oceanography. I find oceanography to be such a fascinating field because of its interdisciplinary nature. In order to understand the complex ocean environment, you must integrate concepts from geology, physics, chemistry, and biology. I enjoy sharing my knowledge and enthusiasm for ocean sciences with new groups of students each year and watching them gain an understanding of intricate topics. To any student wishing to pursue a career in oceanography, I encourage you to focus your attention on science and mathematics courses."

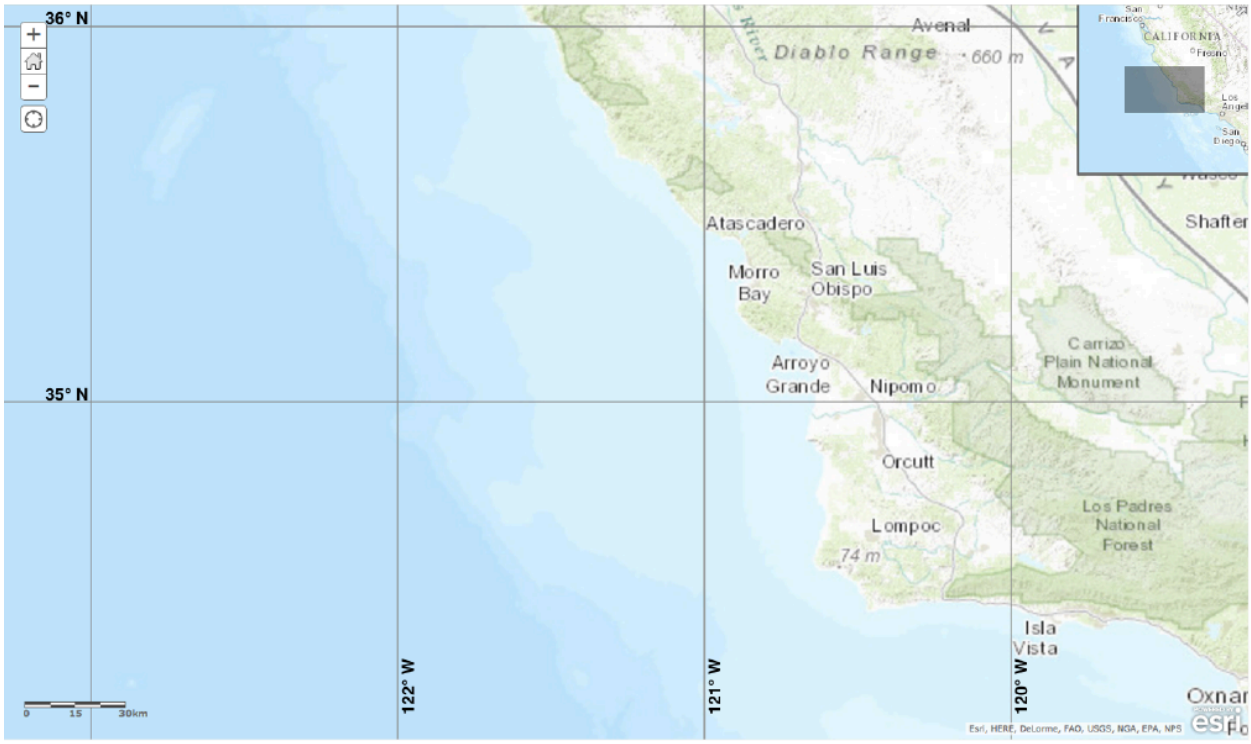
Student Worksheet Name:_____

Worksheet 1

Surface Drifter (Student) ID #158351221 Data

Predict the Drifter's Path…

On August 18th, 2015, a student-built surface drifter was deployed off E/V *Nautilus* off the coast of California at 122° W and 35.5° N. Use the current simulator (http://nautl.us/1qwcuRR) to plot 25 numbered, consecutive points on the map below showing where you think this drifter would track over the course of several days. This web model works best in a Firefox browser. Make sure to indicate the correct month and year (August 2015) when using the model. Plot your points on the map below. The starting location is 35.5° N, 122° W.



Student Worksheet Name:_____

Worksheet 2

Use this NOAA model to draw a second predicted pathway based on information from this website: http://las.pfeg.noaa.gov/oscurs/. In this website's data, degrees West longitude will have to be converted to degrees East. To do this, subtract the West longitude from 360°. Dates of travel are August 18, 2015, until September 14, 2015.

Take a screenshot of the predicted pathway and insert it here or create a sketch below.

Student Worksheet Name:_____

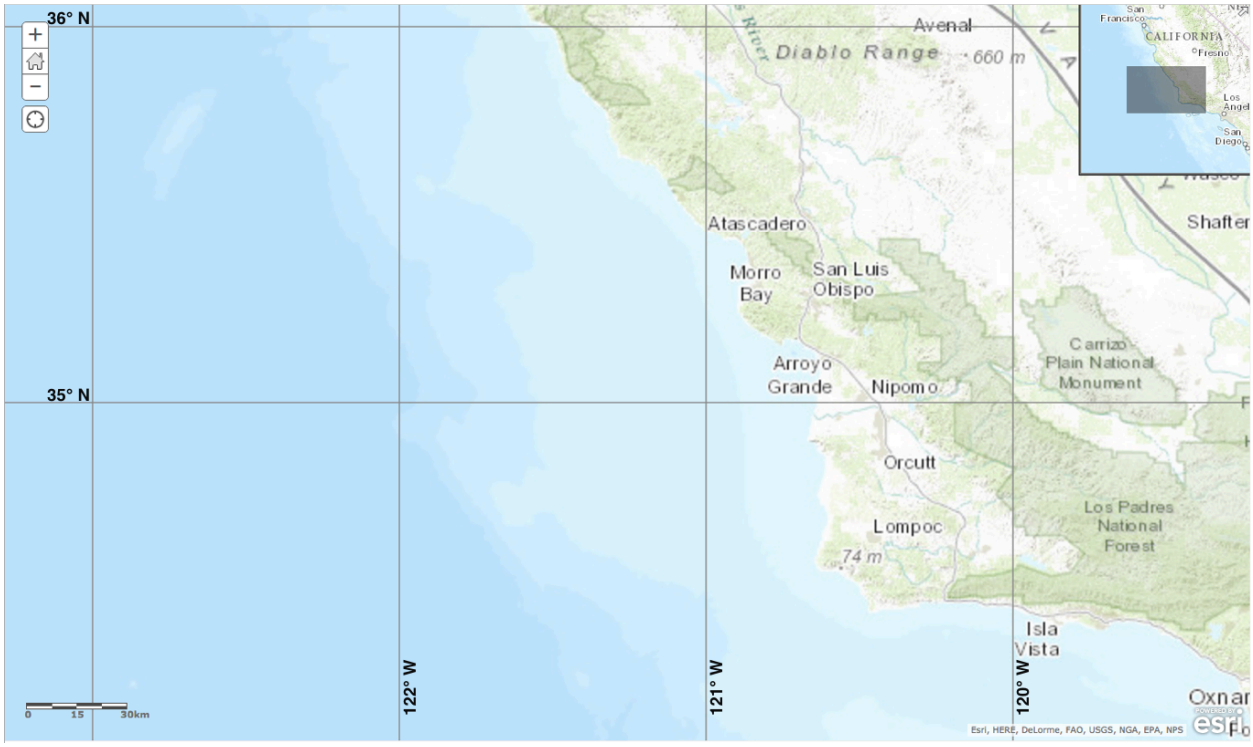
Worksheet 3

The following is the actual data taken from the drifter's GPS over the course of 28 days. Plot the points of the actual path traveled on the next page (worksheet 4).

Transmission Number	Date	Time	Latitude	Longitude
1	8-18–15	06:12 GMT	35.5° N	122° W
2	8-19-15	12:12 GMT	35.3° N	122.02° W
3	8-20-15	18:12 GMT	35.45° N	121.8° W
4	8-21-15	00:12 GMT	35.5° N	121.7° W
5	8-22-15	06:13 GMT	35.3° N	121.4° W
6	8-23-15	18:13 GMT	34.93° N	121.71° W
7	8-24-15	12:12 GMT	34.89° N	121.72° W
8	8-25-15	00:20 GMT	34.85° N	121.7° W
9	8-26-15	18:12 GMT	34.65° N	121.8° W
10	8-27-15	18:13 GMT	34.59° N	121.74° W
11	8-28-15	18:12 GMT	34.58° N	121.7° W
12	8-29-15	18:12 GMT	34.7° N	121.68° W
13	8-30-15	18:13 GMT	34.73° N	121.6° W
14	8-31-15	00:12 GMT	34.73° N	121.5° W
15	9-03-15	00:27 GMT	34.87° N	121.74° W
16	9-04-15	00:27 GMT	34.9° N	121.8° W
17	9-06-15	18:12 GMT	34.94° N	121.68° W
18	9-07-15	18:20 GMT	34.88° N	121.6° W
19	9-08-15	06:20 GMT	34.85° N	121.61° W
20	9-09-15	06:20 GMT	34.85° N	121.7° W
21	9-10-15	06:20 GMT	34.9° N	121.8° W
22	9-12-15	06:12 GMT	35.02° N	122.1° W
23	9-14-15	12:12 GMT	35.35° N	122.28° W

Student Worksheet Name:_____

Worksheet 4



Student Worksheet Name:_____

Worksheet 5

Answer the following questions about the differences and similarities between your proposed tracks and the actual drifter data.

1. Was one model more effective at predicting the drifter's path of travel? If so, which one and what factors do you think contribute to its higher level of accuracy?

2. How close was the predicted path to the actual path the drifter took? What factors do you think influenced any difference in the two paths?

3. Read this article about ocean currents: http://www.education.noaa.gov/Ocean_and_Coasts/Ocean_Currents.html. What ocean current did this student drifter end up in? Describe the direction of travel and other specific details about this current.

Student Worksheet Name:_____

Worksheet 6

Use this website (http://www.nhc.noaa.gov/gccalc.shtml) to calculate the distance traveled from one date to the next in nautical miles.

Date	Latitude	Longitude	Distance Traveled in Nautical Miles
8-18–15	35.5° N	122° W	N/A
8-19-15	35.3° N	122.02° W	
8-20-15	35.45° N	121.8° W	
8-21-15	35.5° N	121.7° W	
8-22-15	35.3° N	121.4° W	
8-23-15	34.93° N	121.71° W	
8-24-15	34.89° N	121.72° W	
8-25-15	34.85° N	121.7° W	
8-26-15	34.65° N	121.8° W	
8-27-15	34.59° N	121.74° W	
8-28-15	34.58° N	121.7° W	
8-29-15	34.7° N	121.68° W	
8-30-15	34.73° N	121.6° W	
8-31-15	34.73° N	121.5° W	
9-03-15	34.87° N	121.74° W	
9-04-15	34.9° N	121.8° W	
9-06-15	34.94° N	121.68° W	
9-07-15	34.88° N	121.6° W	
9-08-15	34.85° N	121.61° W	
9-09-15	34.85° N	121.7° W	
9-10-15	34.9° N	121.8° W	
9-12-15	35.02° N	122.1° W	
9-14-15	35.35° N	122.28° W	
Total Distance Traveled:			

Student Worksheet Name:_____

Worksheet 7

Use a calculator to help you solve the following problems using the drifter data from the previous page. Show all of your work in the space provided.

1. Average distance per day:

2. Average distance per hour:

3. One nautical mile is equivalent to 1.15078 miles. Choose one of the distances from the previous table in nautical miles and convert to miles.

Module Discussion |

1. Summarize why collecting data from oceanic drifters is useful to scientists.

2. Using this article as a reference (http://oceanmotion.org/html/gatheringdata/buoysanddrifers.htm), describe two ways technological advances have helped improve climate prediction models.

3. Research an interesting article about drifters or drifter data online and be prepared to share with the class during discussion. Provide the title and note the link for the article below.

STEM Project & Task Rubric

OBJECTIVE	CRITERIA			
	4 **Exemplary**	**3** **Commended**	**2** **Emerging**	**1** **Developing**
Knowledge & Understanding	Student consistently, correctly and thoroughly answers all questions. Uses an abundance of relevant vocabulary and is able to explain relationships within the content using examples. Can apply the content to other topics or real life.	Student is able to consistently answer most questions correctly. Uses an adequate amount of relevant vocabulary. Can explain relationships within the content and can apply content to other topics or real life.	Student is able to answer some questions correctly. Uses some relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.	Student is able to answer a few questions correctly. Inconsistently uses relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.
Content Organization, Methodology & Analysis	Student effectively organizes complex ideas, concepts, and information to make important connections and distinctions. This may include detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student is able to organize ideas, concepts, and information to make connections and distinctions. This may include mostly detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student attempts to organize ideas, concepts and information to make some connections and distinctions. Student is able to provide basic procedures, data tables, graphs, diagrams and/or analyses.	Student has difficulty organizing ideas, concepts and information to make connections and distinctions. Student is unable to provide basic procedures, data tables, graphs, diagrams and/or analyses.
Self-Directed Learner	Student is actively engaged in the learning process; consistently contributes to class discussions and asks clarifying questions. Seeks out and shares additional resources with the class or teacher. Advocates for his/her learning needs.	Student is engaged in the learning process. Often contributes to class discussions and asks clarifying questions. Advocates for his/her learning needs.	Student is inconsistently engaged in the learning process. Sometimes contributes to class discussions or asks clarifying questions. Inconsistently advocates for his/her learning needs.	Student is weakly engaged in the learning process. Rarely contributes to class discussions or asks clarifying questions. Rarely advocates for his/her learning needs.
Technological Tools	Use of digital resources is always appropriate for the task. Willing to learn and use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is appropriate for the task. Willing to use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is sometimes appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is rarely appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.
Collaboration Skills	Consistently works effectively and respectfully with a diverse group of learners. Actively checks with others for understanding and how he or she may be of help. Student listens when others speak and incorporates or builds off of the ideas of others.	Works effectively and respectfully with a diverse group of learners. Checks with others for understanding and how he or she may be of help. Student listens when others speak.	Sometimes works effectively and respectfully with a diverse group of learners. Sometimes checks with others for understanding and how he or she may be of help. Student listens when others speak.	Has difficulty working effectively and respectfully with a diverse group of learners. Rarely checks with others for understanding and how he or she may be of help. Student may talk over other students or does not listen when others speak.
Total Score: _____	**Comments:**			