Dive to Survive

ACTIVITY TIME

1 hour 20 mins

LEARNING OUTCOMES

- Describe and explain the diving ecology of an arctic marine animal.
- Explain how tidal currents affect sea ice habitats and influence the animals that live there.
- Use the concepts of trigonometry to solve applied problems.

OVERVIEW

WHY?

To understand the factors involved in eider duck feeding, from dive angle to differing ocean currents.

WHAT?

- How eider ducks dive to the seafloor to find food
- How ocean currents affect arctic animals like eider ducks
- How to use the Pythagorean theorem and law of cosines

HOW?

- Pre-discussion questions
- Watch a video about eider ducks
- Discuss prior knowledge
- Watch video footage of eiders diving
- Complete worksheet
- Post-discussion questions

CONTENTS

PREPARATION

MATERIALS

- Calculator
- Protractor
- Stopwatch/timer

RESOURCES

Dive Video #1
Video of Eider duck diving for worksheet Part 1
https://arcticeider.com/links/dts8

Dive Video #2
Video of Eider duck diving for worksheet part 2
https://arcticeider.com/links/dts9

Eider Studies Video
A special feature from the film People of a Feather which touches on how eiders survive in a harsh climate
https://arcticeider.com/links/dts1

IMAGE 1 Common Eider, Mitiq ᒥᑎᖅ ᐊᒪᐅᓚᒃᔭᐊᖅ, Somateria mollissima (S. DesRoches)

BACKGROUND

Some populations of the Common Eider duck live in the Arctic through the winter. These eider ducks depend on areas of open water in the sea ice where they can dive down and feed on seafloor invertebrates such as mussels and urchins. Despite the freezing winter temperatures, some areas in Hudson Bay remain ice free during the Arctic winter. Sections of open water in an ocean of ice are called **polynyas**, while long cracks in the sea ice are called **flaw leads**. These are truly the oases of the Arctic as they allow a number of animals to access food as well as marine mammals to access breathing air.

IMAGE 2 It takes between 20 and 30 eider skins to make a traditional eider parka. (J.Heath)

Part of the complex Arctic food web, eider ducks are an important resource for Arctic foxes and snowy owls. They are also harvested by Inuit on the Belcher Islands for both food and clothing. See the Resources section for a video showing how eider parkas are made.

Diving beneath the waves may come naturally to a duck, but factors such as strong ocean currents and water depth mean an eider rarely executes a perfect straight-down dive. By adopting a certain **dive angle**, a duck can compensate for the water conditions to successfully reach its prey. Strong currents keep the water from freezing, but also increase the difficulty of diving as the ducks have to swim into the current to reach the food on the bottom. Using underwater video, researchers can determine how long it takes the ducks to get to the bottom in different currents, estimate their dive angle and follow individuals hunting for mussels and sea urchins on the seafloor.

VOCABULARY

Abiotic: Non-living elements of the environment (antonym of biotic).

Flaw lead: Cracks in sea ice sheets that open up due to wind and often freeze over again.

Oasis: (oases pl.) Provides habitat for animals; contains an isolated feeding ground and/or shelter.

Polynya: An area of open water surrounded by sea ice; often remains open throughout the winter.

Dive Angle: The angle at which an eider duck dives down to the bottom relative to the surface of the water.

Physiological: Relates to a living thing's health or normal functioning.

Ecological: Deals with the relationships between groups of living things and their environments.

Tidal Ebb: when the tide is going out.

Tidal Flood: when the tide is coming in.

PRE-DISCUSSION QUESTIONS

1. Why would researchers want to investigate the feeding behaviour of eider ducks?

2. What are some of the **abiotic**, **ecological**, and **physiological** factors that you think could influence the diving behaviour of eider ducks?

Biotic factors

Physiological factors

Biotic ecological factors

WORKSHEET

Eider ducks at the ice edge have to dive down to the seafloor to get food. Strong ocean currents keep the water from freezing but also increase the difficulty of diving. Underwater video allows researchers to determine how long it takes the ducks to reach the bottom in different current conditions, while depth profilers tell us how deep the water is.

PART 1

1. Watch Dive Video #1 (pg. 2) and record the time it takes for the eider duck to reach the seafloor

   (A) Distance to bottom: _______________

   (B) Time to bottom: ________________

2. With the freeze frame from the video, use a protractor to estimate the dive angle of the eider in relation to the surface of the water.

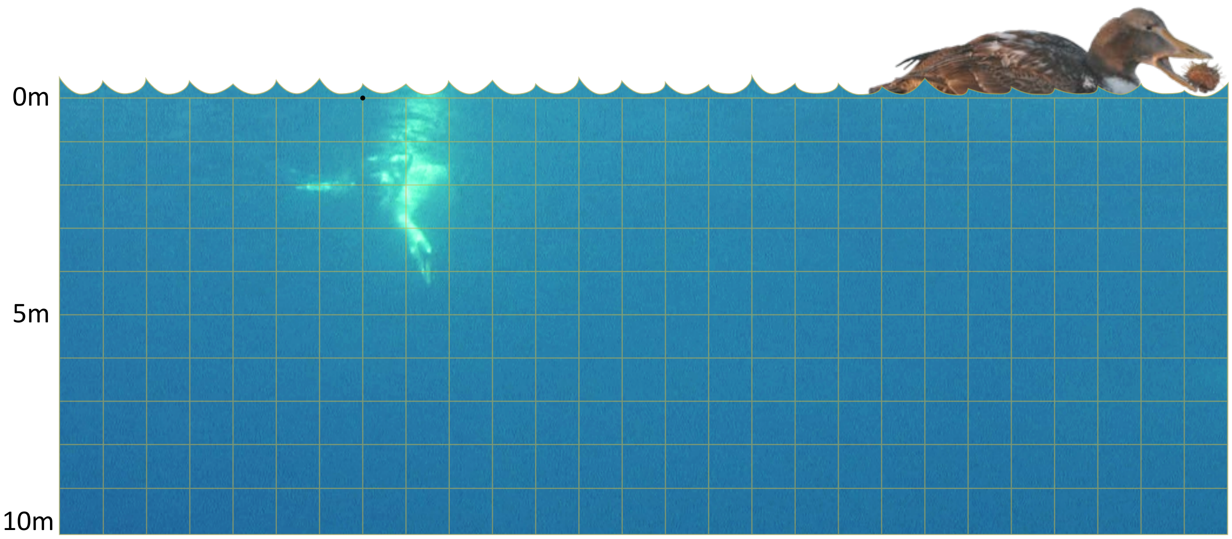

FIGURE 1 Estimate the eider duck's dive angle using a protractor.

3. Using the information you gathered from the dive video, draw a right triangle on *Figure 2* that includes:

   (A) The depth of the water

   (B) The trajectory (path) that the eider takes to reach the bottom, and

   (C) The dive angle

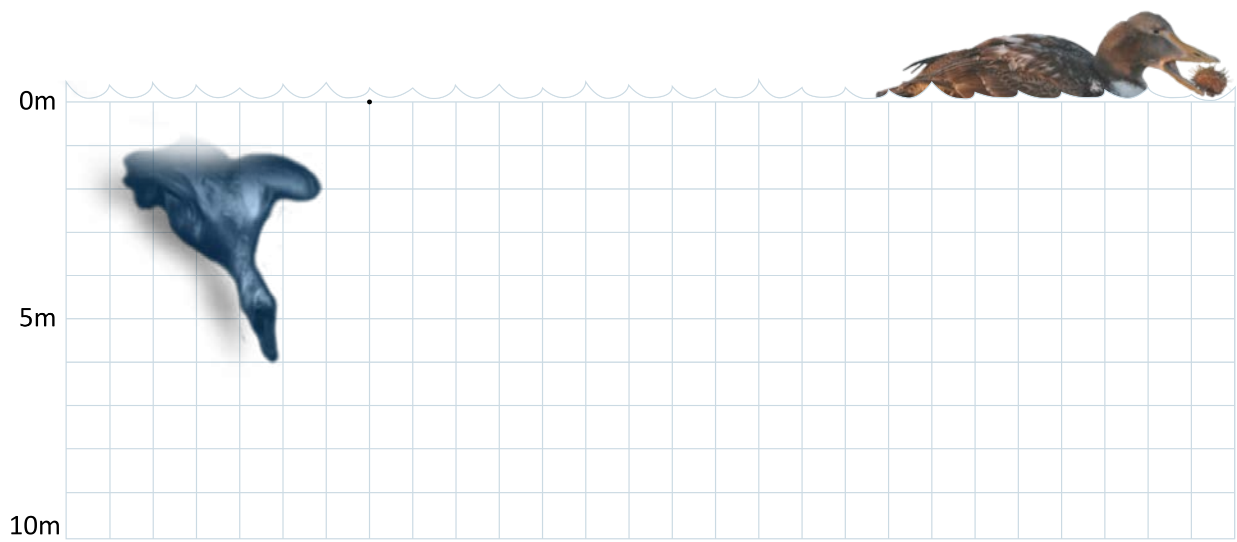

FIGURE 2 Draw a labeled diagram of the eider duck's dive.

4. Use the dive angle and the distance to the seafloor to calculate the actual dive distance (trajectory) the eider duck travels. Use trigonometry to solve the right triangle. Label your diagram on *Figure 2* appropriately with the answer.

$$hyp = \frac{adj}{cos\theta} =$$

5. Using the distance of the dive trajectory and the amount of time it takes the eider to reach the bottom to help you, calculate the velocity (speed) of the diving eider.

$$v_{speed} = \frac{distance}{time} =$$

6. Because you know the depth and trajectory distance, you can now use Pythagorean theorem to find out how far the eider has moved against the current in relation to the sea floor (the 3rd side of the triangle).

$$c^2 = a^2 + b^2$$

$$hyp^2 = adj^2 + opp^2$$

7. The research team has filmed the same eider diving later in the day at a different place in the polynya. The eider dives at a 25º angle and it takes 10 seconds to reach the bottom. Draw a new diagram and repeat questions 3-6 to determine:

   A. The dive distance
   B. Velocity, and
   C. The distance travelled in relation to the sea floor.

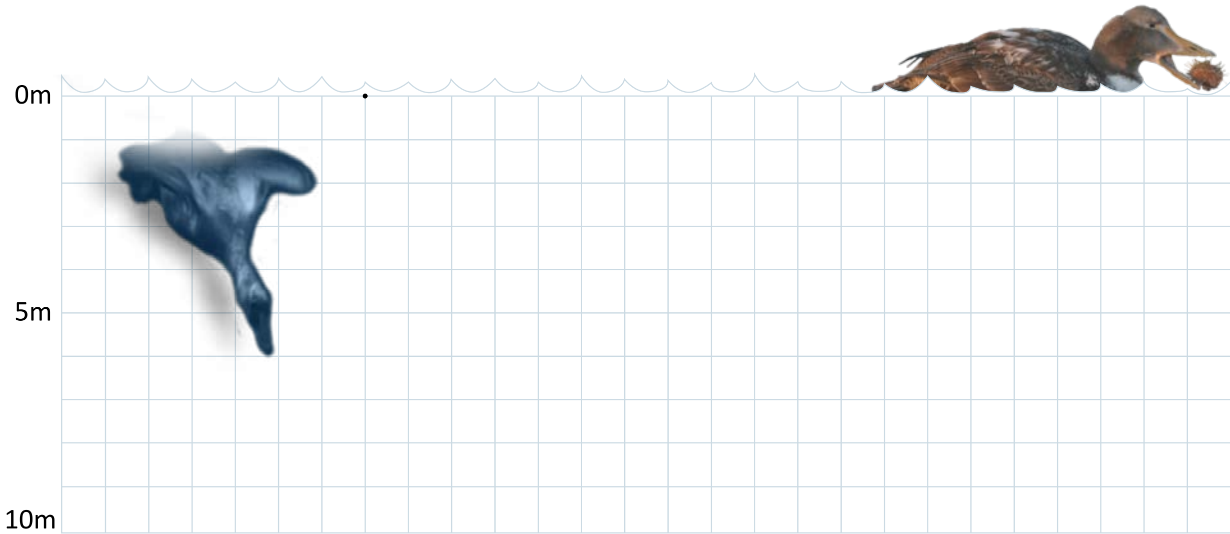

FIGURE 3 Draw a labeled diagram of the eider duck's dive at a 25˚ angle..

$$hyp = \frac{adj}{\cos\theta} =$$

$$v_{speed} = \frac{distance}{time} =$$

$$c^2 = a^2 + b^2$$

$$hyp^2 = adj^2 + opp^2$$

PART II

Powerful tidal currents keep many polynyas and flaw leads open thereby providing critical habitat for marine birds such as eider ducks. However, currents also work against the birds when they dive to the seafloor in search of food. In very fast currents, the eider ducks get out of the water, rest on the ice edge, and wait for the tide to slacken (slow down). Over a tidal cycle, currents at some polynyas range from 0 m/s to over 1.5 m/s during peak **tidal ebb** (when the tide is going out) or **tidal flood** (when the tide is coming in). This is faster than some rivers!

Eiders swim directly into oncoming currents when they dive. If the current is moving against them at 1.0 m/s, an eider duck has to swim at that same velocity just to stay in once place! The velocity at which an eider duck swims to the bottom is called its observed velocity, the speed at which it moves relative to an observer.

8. Watch the Dive Video #2 (pg. 2). Record both how long it takes the eider duck to reach the bottom and the velocity of the current recorded by the current meter.

   A. Dive time: ________________

   B. Current Velocity: __________

9. Calculate the observed velocity of the eider as it dives.

$$v_{speed} = \frac{distance}{time} =$$

10. To help visualize what effect the current has on the eider's dive, draw two arrows (force vectors) indicating the direction and observed velocity of the eider and the direction and velocity of the current.

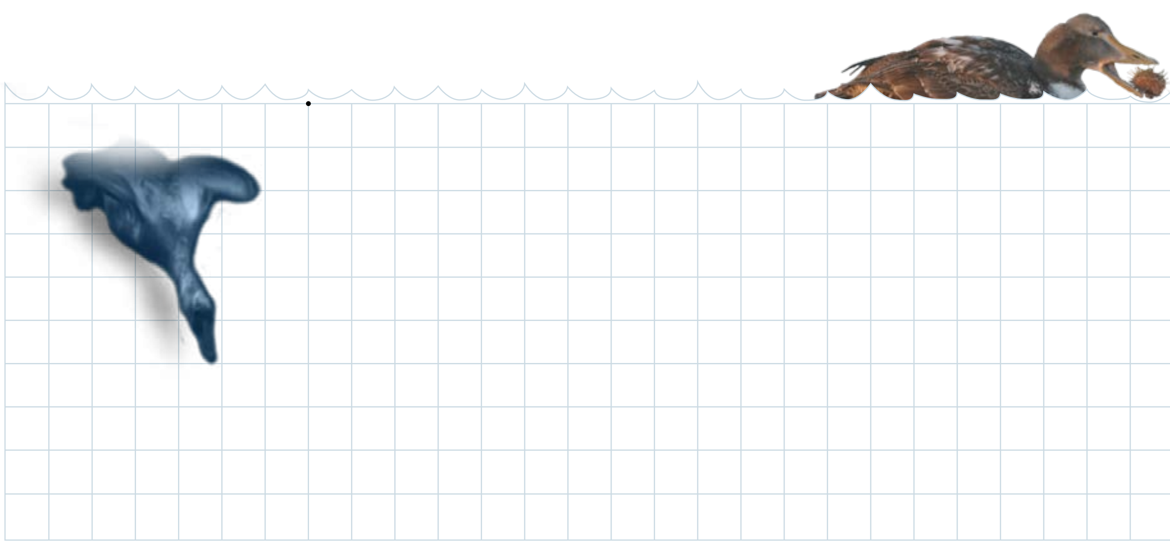

FIGURE 4 Draw two force vectors for $V_{observed}$ and $V_{current}$ to represent the eider duck's dive.

To actually reach the bottom, the eider duck can't just swim downwards. If it did, it would be pushed back by the current and might even get pushed under the sea ice. When an eider dives it is both swimming in a downwards direction towards its food at the bottom of the polynya and in a forward direction into the oncoming current. The effective swimming speed of the bird is determined by both the speed at which the duck swims down and the speed of the current.

11. Redraw the force vector arrows from question 2 and using a dotted line, indicate the approximate direction of the combined forces. Label the dashed line $V_{effective}$ for effective velocity.
12. If $V_{observed}$ is the velocity that we recorded from viewing the duck, what does $V_{effective}$ tell us?

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13. Would you expect the $V_{effective}$ to be greater or less than the $V_{observed}$? Why?

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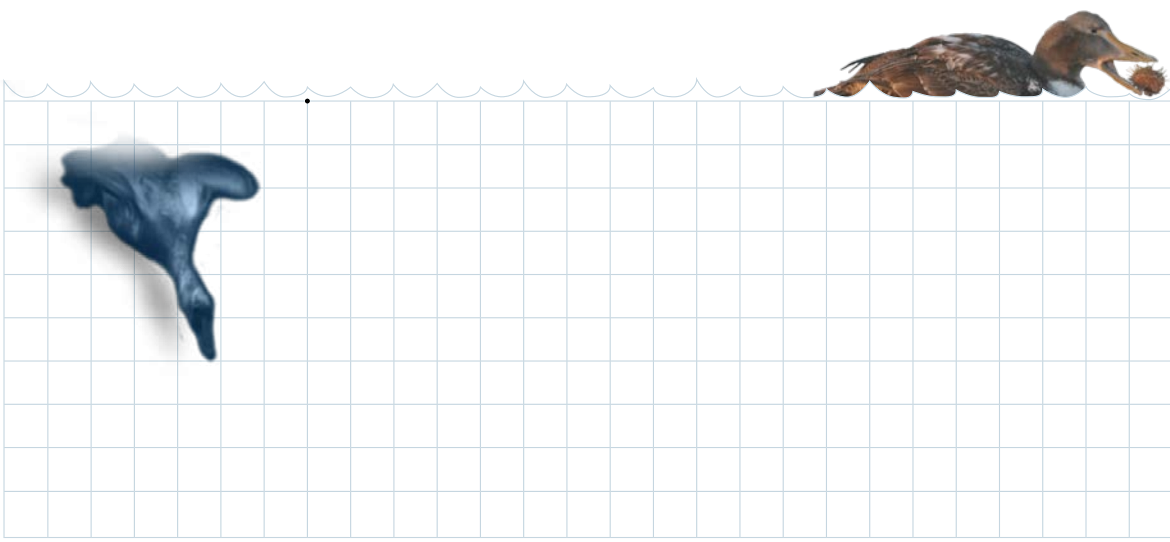

FIGURE 5 Draw a force vector diagram with $V_{effective}$ as a dotted line.

14. Now redraw this force vector as a right triangle and solve for $V_{effective}$.

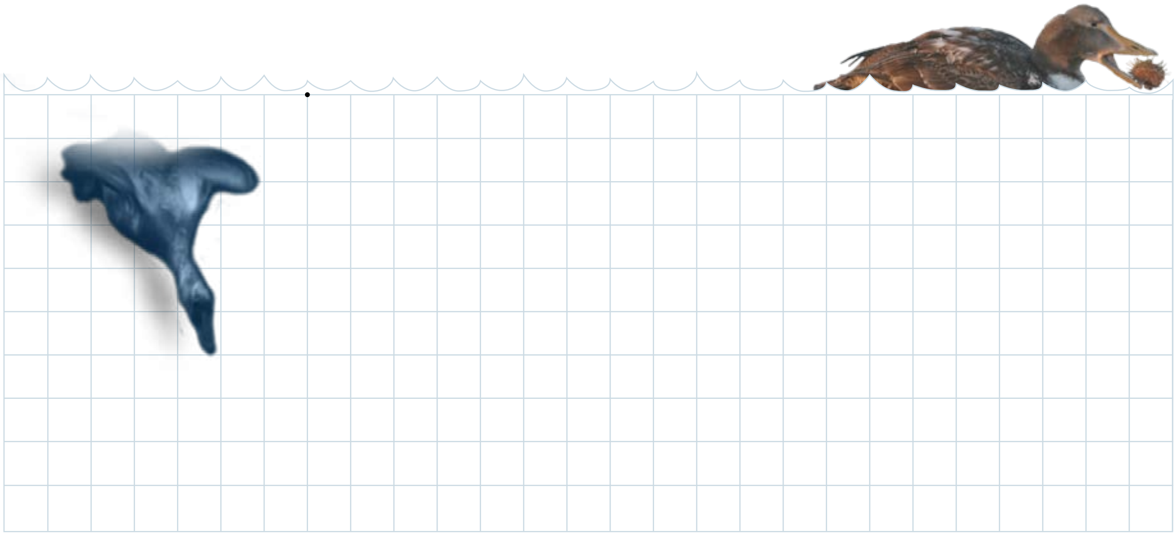

FIGURE 6 Draw a force vector diagram as a right triangle and solve for $V_{effective}$.

$c^2 = a^2 + b^2$

Throughout the tidal cycle, even though the strength and speed of the current may change, the effective swim velocity and the rate at which eider ducks flap their wings, remains relatively constant. Thus, when the current increases, the time and the number of times a duck has to flap its wings to get to the bottom increases.

15. Using what you have learned, if the current increased to 1.0 m/s, how long would it take for the eider to reach the bottom? *Hint: you already know the effective velocity.*

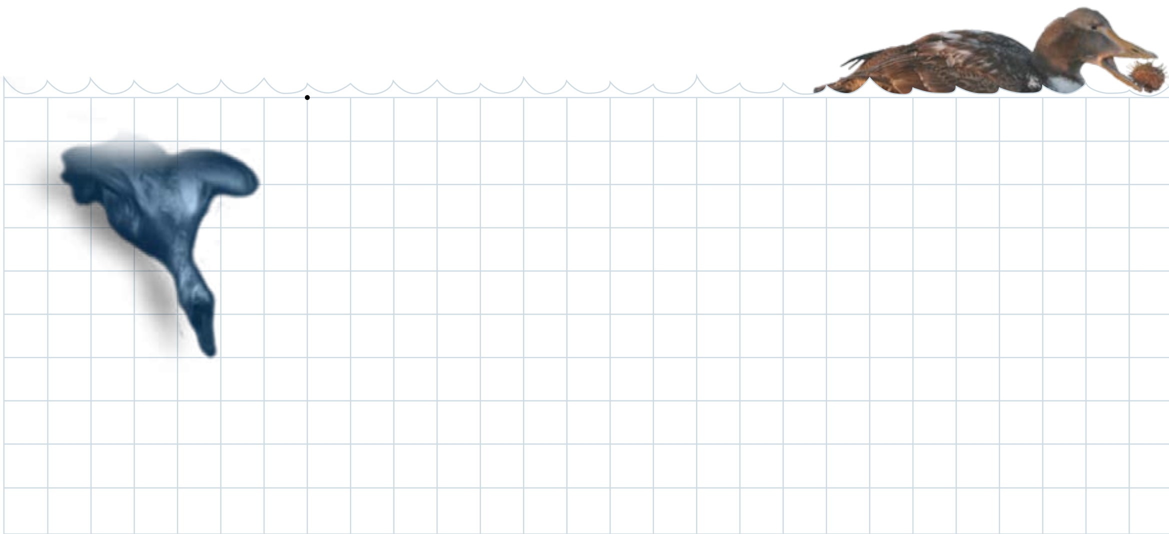

FIGURE 7 Redraw the force vectors as though the current has increased to 1.0 m/s.

$$c^2 = a^2 + b^2$$

16. What happens to the observed velocity when the current speed increases and why?

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POST-DISCUSSION QUESTIONS

PART I

1. What does changing the dive angle mean for how far the eider dives and where it ends up on the seafloor?

2. Why might an eider change the angle at which it dives? What are possible consequences of this change?

3. Why do we gain from researching how eiders dive?

PART II

4. How does walking on a windy day compare to how eider ducks have to dive for food when there is a current?

5. Why do eider ducks dive into the current?

6. If you were an eider, what would be the factors you would consider when trying to decide how and when to dive to the bottom to eat?