OCEAN NETWORKS CANADA

Ocean Sense
Program

Lesson 2

Module:

Waves of Knowledge

Time:

60 minutes

Learning pillars:

- Indigenous knowledge
- Ocean science

Grade & curriculum connection:

- **BC Science 8**
  "The theory of plate tectonics is the unifying theory that explains Earth's geological processes."

Created in partnership with:

Nuu-chah-nulth knowledge holders Darrell Ross Sr. (Tseshaht First Nation), Cliff Atleo Sr. (Ahousaht First Nation), and Tom Happynook Sr. (Huu-ay-aht First Nations)

A UNIVERSITY OF VICTORIA INITIATIVE

Science of Waves

Explore earthquakes by making two wave machines. Learn about seismic data by listening to Nuu-chah-nulth knowledge holders and examining Ocean Networks Canada's Earthquake Information and Messaging System (EIMS) 'land+seafloor' seismic network. Study the earthquake-tsunami connection.

Earthquakes and **tsunamis** are two types of major geological events. Earthquakes, caused by **tectonic activity**, create longitudinal **P waves** and transverse **S waves**; P waves arrive first. Since the occurrence of earthquakes cannot be predicted with complete certainty, Ocean Networks Canada has developed an earthquake information and messaging system using sensors to detect the P waves and issue a warning before the arrival of the damaging S waves.

Live data from ONC's 'land+seafloor' seismic sensor network is available for integration into the Canadian Earthquake Early Warning System. ONC does not issue public alerts. Depending on the **epicentre** of the earthquake, the sensor network provides up to a few seconds of notification which is enough to take some protective and preventive measures that can save lives, prevent injury, and protect infrastructure. Tsunamis occur as a result of major water displacement, and earthquakes are one cause of tsunamis. Indigenous knowledge holders have oral histories that tell of historic earthquakes and tsunamis and offer insights on mitigating risk.

Learning objectives

- Make observations aimed at identifying their own questions about the natural world.
- Communicate ideas, findings, and solutions to problems, using scientific language and representations.

Materials

- Computer with internet connection

- Projector, screen, and speakers
- Slide deck: **Waves of Knowledge (bit.ly/SlidesWOK)**
- Video: **Waves of Knowledge (bit.ly/VidWOK)**
- Video: **Responding to Waves (bit.ly/VidRTW)**
- Activity 2: *Two Wave Machines* and all materials listed therein

Teacher preparation

- Preload the slide deck: **Waves of Knowledge (bit.ly/SlidesWOK)**
- Prepare materials from the activity *Two Wave Machine*

Classroom instructions

Hook

1. Share slide 17 to launch a discussion of waves.

Step-by-step process

2. Share slide 18 to describe the types of waves, including the **S** and **P waves** that are associated with earthquakes.
3. Share slide 19 and 20 to detail the similarities and differences between S and P waves.
4. Share the video clip from *Waves of Knowledge* on slide 21 featuring Cliff Atleo Sr. (Ahousaht First Nation).
    a. Clip runs from 8:22min–9:13min within the video section entitled *Knowledge, observation, and experience: What can we learn?*
5. Discuss how P or S waves might give animals advance warning of an earthquake as shared by Cliff Atleo Sr.
6. Share slide 22 to review the similarities and differences between P and S waves.
7. Complete the activity *Two Wave Machines* using slides 23-25.
8. Share the video on slide 26 which describes Ocean Networks Canada's Earthquake Information and Messaging System (EIMS) 'land+seafloor' seismic network.
9. Discuss how EIMS relies on P waves to provide advance warning of an earthquake.
10. Share slide 27 referring back to the opening hook. Discuss if the wave pictured is more like a P or S wave.
11. Share slide 28 and 29 to discuss the connection between earthquakes and tsunamis.
12. Share the video clip from Responding to Waves on slide 30 featuring Tom Happynook Sr. (Huu-ay-aht First Nations).
    a. Clip shared is from 1:52min - 3:03min within the video section entitled How does community knowledge of the past inform resilience today?
13. Discuss how both data and Indigenous oral histories help us understand and prepare for major geological events such as earthquakes and tsunamis.

Modifications and adaptations

- Watch the entire videos, Waves of Knowledge and Responding to Waves.
- Conduct the activity Two Wave Machines as a demonstration.

Final remarks to the educator

P and S waves are waves that are generated from earthquakes. Further to this, the substrate and surrounding geography can impact how the waves travel. This is one reason that predicting the impact and size of earthquakes can be so difficult. A fault or boundary may move in such a way as to release energy but not cause major ground shaking. The reverse can also be true as well with smaller earthquakes having very damaging waves due to their proximity to people, places, and the surface.

One major complexity surrounding earthquake monitoring and response is determining how and when to alert people to take action. As mentioned, some earthquakes may create tsunamis or major ground shaking. Choosing who to alert and when can be a significant challenge as people need to be alerted to avoid loss of life, but not so frequently that they become complacent. If people are too frequently asked to take action that is unnecessary, they may end up ignoring important evacuation orders.

Assessment

- How does the science of waves help us to understand earthquake events?
- Why might a scientific understanding of waves be an incomplete representation of earthquakes' impacts on people, places, and things?
- How can demonstrations in controlled settings help us better understand waves in the natural world?

Extensions

- Investigate the additional types of waves in earthquakes.
- Explore how the sediment on the ground (e.g. sand, stone, water, clay, etc.) impacts how the P and S waves act.
- Investigate historic earthquakes and tsunamis.
- Watch the **Tsunami 11th Relative (bit.ly/Tsu11Rel)** documentary (26min) to explore the rich history of tsunami resilience on the Pacific West Coast.

Glossary

Earthquake Early Warning: An array of sensors deployed in an area intended to detect the earliest earthquake signals (shaking) and alert people of impending danger.

Earthquake Information and Messaging System: Ocean Networks Canada's real-time seismic sensor data from onshore and offshore sensors and available to be integrated with government organizations that issue public alerts in Canada and the United States.

Epicentre: The point on Earth's surface directly above where an earthquake originates; epicentres can be underwater or on land.

P waves: Primary or pressure wave; usually the first wave detected after an earthquake event; travels via longitudinal propagation.

S waves: Secondary or shear wave; usually the second wave detected after an earthquake event; travels via transverse propagation.

Seismic: Relating to earthquakes.

Sensor: A device that detects or measures a change in property, movement, or state.

Tectonic activity: Movement in Earth's tectonic plates which are pieces of the Earth's outer layer (lithosphere) and are the basis of tectonic plate theory.

References

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Activity 2

Two Wave Machines

Use simple materials to demonstrate P and S waves produced by earthquakes.

Module:
Waves of Knowledge

Lesson:
What Others Know

Learning pillars:
- Data exploration

Grade & curriculum connection:
- **BC Science 8**
  "The theory of plate tectonics is the unifying theory that explains Earth's geological processes."

Materials
- Computer with internet connection
- Projector and screen
- Slide deck: **Waves of Knowledge (bit.ly/SlidesWOK)**
- 1 slinky/group of students
- 6m duct tape
- 1 ruler/group of students
- 2 clamp stands
- 100 wooden skewers
- 200 gumdrops or pieces of plasticine

Teacher preparation
- Consider how best to construct the wave machine: constructed in advance of class or with student assistance.

Procedure
1. Distribute the slinkys and ask the students to demonstrate the P wave of an earthquake. Consider displaying slide 24 for their reference. If they need additional support, provide the steps below:
    a. Stretch a slinky between two people on a table.
    b. Have one person hold ~5 loops of the slinky and then release them all at once.
2. Reiterate how the slinkys' movements represent the key aspects of the P waves, including:
    a. The rings compress together in a longitudinal wave as the

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energy travels through the stretched slinky.

b. P waves can move through solids, liquids, and gases, therefore travelling quickly during an earthquake.

c. In earthquakes, P waves are called primary waves because they are the first type of wave detected.

3. Construct the wave machine (figure 1):
    a. On the floor or desks, lay out approximately 3m of duct tape, sticky side facing up.
    b. Centre the skewers across the tape leaving about 5 cm between each skewer.
        i. The skewers don't need to be perfectly centred, as the gumdrops can be used to adjust the weight of each skewer so it lays flat.
    c. Continue with this pattern until all the skewers are used.
    d. Lay another piece of tape directly over the tape to enclose the skewers.
    e. Stretch the wave machine under tension between the two table clamps so the skewers lay horizontally.
    f. Add the gumdrops or pieces of plasticine on each end of the skewers.
4. Ask the students how they might demonstrate the S waves of an earthquake using the wave machine. Consider displaying slide 25 for their reference. If they need additional support, provide the step below:
    a. Tap one of the skewers near one end so it moves vertically up and down.
5. Reiterate how the wave machine's movements represent the key aspects of the S waves, including:
    a. The skewers move in a vertical direction as the energy travels through them.
    b. S waves have the potential to cause damage to landscapes, buildings, and infrastructure in an earthquake.
    c. In earthquakes, S waves are called secondary or shear waves because they occur after the P waves.

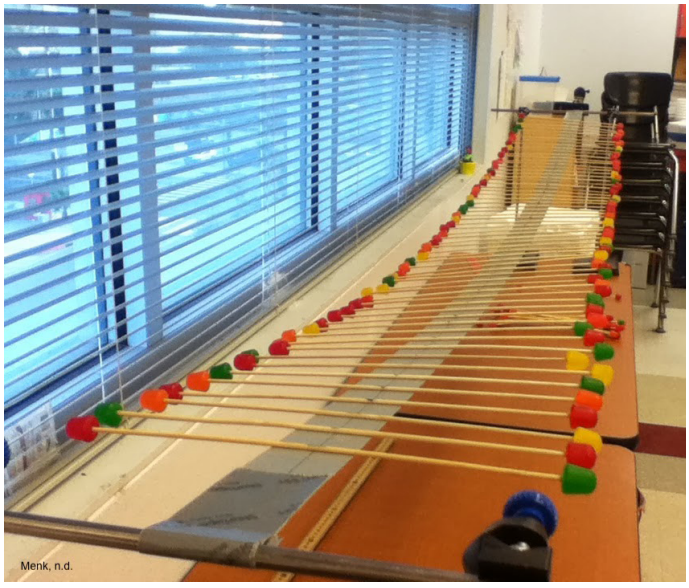

figure 1

Conclusion

Laboratory experiments give us a basis to explore the different mechanisms of waves while removing some of the variables, such as geological features and sediment composition, that might be in nature. Scientists study P and S waves to learn more about earthquakes; the epicentre, depth, and magnitude of an earthquake can be determined by analyzing the arrival time, the amplitude, and the type of seismic waves.