

# **Earth Space Science: Eclipses and Tides**

Middle School

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# Anchoring phenomenon:

Fish pen anchors of the Cooke Aquaculture fish farm failed near Cypress Island, Wa from high tide and currents on August 20th, 2017. Thousands of Atlantic Salmon escaped into the Pacific Ocean. Cooke Aquaculture claimed the solar eclipse that occured on August 21, 2017 caused abnormally high tides and currents that destroyed the pens but it will help clean-up the environmental hazards this accident created.

# Essential question about phenomenon/for unit:

Do you agree with Cooke Aquacultures claim that the fish farm failed from abnormal conditions caused by the Solar Eclipse?

# **Big Idea:**

The Earth-Sun-Moon motion is cyclic resulting in predictable lunar phases and eclipses. Gravitational forces exerted on the Earth is a result of mass and distance which cause cyclic ocean tides

# Scientific explanation:

The Earth-Sun Moon System & Eclipses

The moon revolves around the Earth in a predictable orbit approximately once a month (29 days). The moon is always receiving solar energy (light) from the sun, and 50% of the moon's surface receives this energy. In other words, half of the moon is always in light, the other in dark. From space, this view would be clear. However, as seen from the Earth's surface, some, all or none of the moon's "light-side" can be seen, depending on where the moon is in its orbit. These different perspectives are known as the moon's (or lunar) phases.



As the moon crosses directly between the Earth and sun (i.e. enters a new moon phase), a solar eclipse may occur. From Earth's perspective, the moon is blocking the solar energy. However, a solar eclipse does not happen each month when the moon enters its new phase.

The moon's orbital plane is not in line with the Earth's orbital plane as it (the Earth) revolves around the sun. The orbit of the moon is tilted approximately 5 degrees relative to the Earth's orbital plane. Because of this tilt, the Earth-sun-moon system is



### rarely in a direct line. Tides

Objects with mass experience the force of gravity. The pull of gravity is present between all parts of the Earth-sun-moon system. The force of gravity depends on the mass of the objects in the system and the distance between. For instance, the force of gravitational attraction between the Earth and the moon is  $2.0 \times 10^{20}$  Newtons. This force is  $3.6 \times 10^{22}$  N between the Earth and the sun. The attractive force is stronger in this latter case because of the sun's enormous mass.

These attractive forces, or tidal forces, influence ocean tides on the Earth. It's important to note that although the force of attraction between the sun and Earth is greater (which is why the Earth orbits the sun, not the moon), the moon is in such close proximity to the Earth that it's tidal force is more



"concentrated" and has a greater impact on our tides. The sun influences the Earth's tides as well, but it's gravitational force is not as "concentrated."

When the moon is in line with the Earth and sun, both during the new and full phases, the tidal forces combine to create relatively higher tides. These are known as spring tides. When the moon is 90 degrees from the Earth-sun line, during the first and third quarters, the sun's gravitational force counteracts the moon's, resulting in relatively "lower" high tides. These are called neap tides. It's important to note that tides are not just influenced by the position of the moon, but also by the geology of the Earth; it's "nooks and crannies."

# <u>The Salmon Spill</u>

Cooke Aquaculture claimed that the tides were "exceptionally high" on the days leading up to the August 21, 2017 solar eclipse, and that these exceptional tides put too much pressure on the fish pens, causing them to break. Again, solar eclipses do happen when the moon is in line with the Earth and sun during a new moon phase. This does result in a spring tide, which can be relatively high. However, by looking at the tide charts for that area on the day of and the days leading up to the eclipse, there is no evidence that the tides were "exceptionally higher" that weekend. In fact, there were higher tides earlier that summer. The difference between high and low tides on a tide chart indicate tidal current intensity. The greater the difference between the high point/tide and low point/tide, the greater the tidal current.

After further investigation, officials learned that the particular pen that broke on August 19 was scheduled for repair. Cooke delayed those repairs, and the pen ultimately broke under normal tidal conditions. In short, it was an engineering problem, not a naturally caused disaster alone.

Standard	PE	DCI	ССС
ESS1-1	Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons	ESS1.A: The Universe and Its stars: Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. ESS1.B: This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of the Earth across the year.	Patterns
PS2-4	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects	PS2.B Types of interactions: Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass - e.g., Earth and the sun	Systems and system model

# NGSS Performance Expectations addressed in this unit:

# Summary Table of Activities in Unit

Activity	Learning Target (Color code 3-dimensions: Blue = SEP; Orange = DCI, Green = CCC)	Evidence Students Could Gain/Key Learning	Connection to explain part of the phenomena
Activity 1: Anchoring Event & Initial Model Read an <u>article</u> and watch a <u>video</u> about the salmon spill event	To use observations from Earth on 8/14/17, 8/20/17, and 8/21/17 to model celestial orbits of the same dates	A fish farm's net broke and hundreds of thousands of Atlantic Salmon escaped.	The farm is blaming the eclipse and high tides for the net's breaking.

Using a tide chart, predict how the tides will impact a fish pen and model how a moon phases viewed from Earth would be viewed from space			
Activity 2: Modeling Eclipses	To model the ESM system to display the orientation of solar bodies resulting in an eclipse	Solar eclipses occur when the moon blocks the Sun's solar radiation and only occur during a New Moon. Lunar eclipses occur when the Earth blocks the sun's solar radiation and only occur during a Full Moon. Eclipses occur infrequently due to the moon's orbital plane at a 5 degree tilt in relation to the Earth's orbital plane	An eclipse occurred on August 21st and Cooke Aquaculture blamed this event for the destruction of its fish pens that broke on August 20th
Activity 3: Lunar Phases with Oreos Modeling ESM stages leading up to an Eclipse (Alternative: "Phases of the Moon Wheel")	To connect how solar radiation causes lunar phases through the lens of Oreos and relate lunar phases to eclipses	The moon revolves around the Earth and reflects the Sun's solar radiation. The moon's Day-time is what is observed on Earth as the moon revolves around Earth every 29 days, and our human perspective changes so we see different phases of the moon. From the solar perspective, one can perceive the positioning of the Sun Earth Moon to explain how the phases occur and their frequency. During a solar eclipse, the SEM position is always during a New Moon (A lunar eclipse can only	The moon's orbital path and plane is necessary to explain the orientation of Earth Sun Moon leading up to the solar eclipse. It was a Waning Moon August 19th, New Moon Aug. 20th and 21st.

		occur during a Full Moon) and the moon blocks the sun's solar energy from certain parts of the Earth's day time.	
Activity 4: Reading Tide Charts Analyze 8 tide charts of different days but same location Extension: Theorize the reason for daily High and Low tides	To read and interpret tide chart of individual days to identify high and low tides, tidal currents	Each day, there are two high and low tides. The difference in high and low tides determine Tide Current; the greater the difference, the greater the current Extension: The frequency of daily high and low tides (every 12 hrs) occur as a result of the Earth's quick daily rotation (24 hrs) and the moon's slow rotation (29 days). The highest tide in a specific place is when the moon is directly in front or behind the Earth. Low tides in a specific place is when the moon is perpendicular to the Earth.	The high and low points in tides determine tidal currents which caused the fish pen to break.
Activity 5: Tide Charts and Lunar Calendar https://tidesandcurrents. noaa.gov/tide_predictions .html?gid=1415 https://www.calendar-12 .com/moon_calendar/201 7/august	To compare tide charts and lunar calendar to identify tidal patterns indicated in crest and trough differences	The New and Full moon correlate to the greatest difference in high and low tide. Quarter moons correlate to smaller differences in high and low tide.	An eclipse only occurs during a New and Full moon. This alignment of gravitational factors relate to greatest tidal currents of the month
Activity 6: Factors of gravity Gravity 'Just-in-time' notes and demonstration	To identify the factors influencing tides: Mass, Distance, Tidal bulge, and Line-up of E-S-M	The Sun/Moon/Earth gravity is due to its mass. The pull of gravity on an object decreases with greater distance. The	Gravitational effects of the Sun and Moon are greatest when they are aligned during a New or Full moon. The tide differences are

(Gravity field on a blanket) Interpreting ESM model of tides	To label and describe parts of an ESM model of tides.	distance between the Earth and Moon is shortest and the effects of gravity are most influential. The Sun's distance is further from Earth and its effects are minimal on tides. When The gravitational effects of the Sun and Moon increase when they align and cause greater tidal bulges. The gravitational effect on Earth tides from the Sun and Moon will lessen as the two objects become unaligned; it is weakest when they are perpendicular to the Earth.	greatest during this time. If the Sun and Moon are aligned during a full moon or new moon, then the gravitational pull will be greatest on the high and low tide everywhere on Earth at different times of the day. The Sun and Moon were aligned during the eclipse since it was a New Moon and the tide heights were greatest on August 20th.
Activity 7: Tide charts across the Sound Groups identify control variables they want to compare and present their findings to support or reject Cooke Aquaculture's claim. They must defend their choice in control variables www.deepzoom.com	To identify trends in tides of different days, months, years, or locations. (choose one as a control variable)	Comparison of tide charts require identifying the high and low tides to determine the tidal current. There are multiple ways of comparing tide chart across multiple references such as time and location. For a comparison of data, a control variable must be maintained to be used as reliable evidence. Patterns are consistent and can be used to predict future conditions.	Upon the comparison of tide chart high and low tides, it will be clear there was no extreme differences to warrant Cooke Aquaculture's claim. There are other occurrences of more extreme tidal currents in their region; areas around the fish pens did not experience extreme tides the same day. The ecological fault lay in the hands of Cooke Aquaculture due to their failure to prepare for frequent tidal currents.
Activity 8a: Build a safer fish pen (Engineering project)	To engineer a solution to reduce chances of a fish pen failure given specific criteria and constraints	Identifying how the environment determines design of a fish pen to reduce the chances of fish release. Experience the engineering process to	The fish pen failed structurally from regular tidal currents resulting in the release of thousands of non-native Atlantic Salmon

		identify a problem, draft a solution, test, redesign, etc.	into the Puget Sound
Activity 8b: Socratic seminar for fish farming Stakeholders (Fish farm CEO, Indigenous tribal council, WA DNR, WA Senators, Anglers, Grocery store, Consumer)	To take the role of different stakeholders to argue for or against the use of fish farms	Social, economic, and ecological perspectives must be addressed to determine best course of action on fish farming practices.	Cooke Aquaculture's ecological catastrophe is impacting current regulations and future choices in Washington State.

# **Model Template**

### Part 1



### Part 2



### Initial Model Examples

(\*Note: The student initial models were based on a model scaffold that was more open-ended and with less scaffolds in order for students to not feel like they "have to" include things this early in the unit. Additionally students added to their initial models throughout the unit based on what they learned.)



### **Example Summary Table questions**



### **Student Summary Table example**





(Note: Animal Husbandry was excluded in this Unit Bundle; it is recommended to use as an added extension)

### **Final Model Student Examples**







**Additional Unit-Related Documents** 

- Introduction article
- Introduction YouTube Video about catching Atlantic Salmon
- <u>Washington State Dept. of Natural Resources</u>
- <u>Follow-up article after Activity 8</u>
- <u>Activity 4 Tide Charts</u>
- Activity 5 Tide Charts
  - <u>Link #1</u>
  - <u>Link #2</u>
- <u>Activity 7 Tide charts across the Puget Sound</u>
- <u>PHET Simulation on Gravity</u>