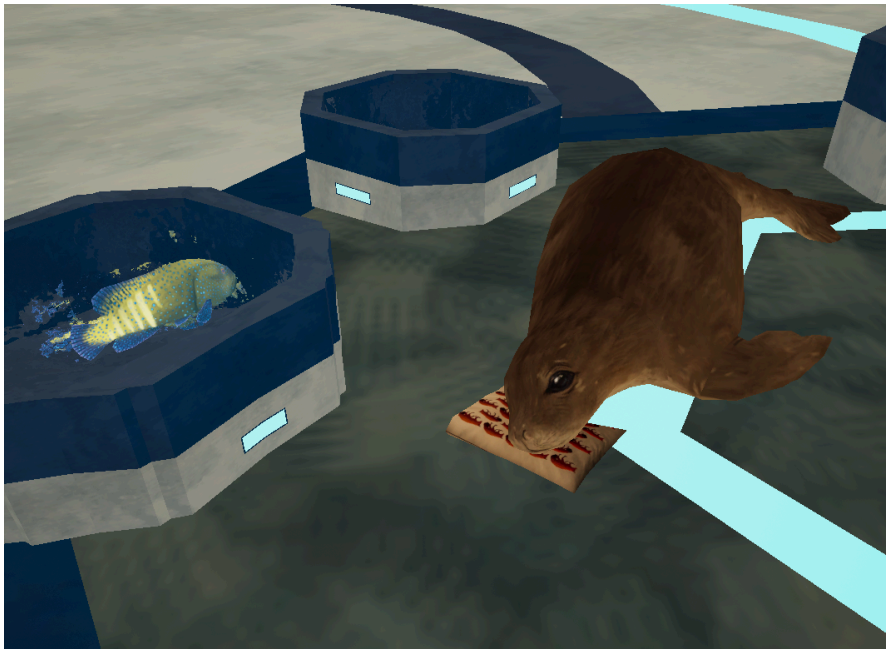
ECOLOGY: SEAL OF DISAPPROVAL

Teacher Guide for Classroom Storyline Use



NGSS STANDARDS

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4: Construct an argument supported by evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

PREREQUISITE KNOWLEDGE

- Students understand how to make a food web and what it represents
- Students understand the difference between a food web and a food chain
- Students understand that symptoms have causes

OVERVIEW

Captain Nenson is worried: Ronan, a Hawaiian monk seal who lives in the Pacific Ocean biodome, is acting ill and will not eat. He needs the player's help to figure out what's wrong with her.

ANCHORING PHENOMENON

This storyline is grounded in the phenomenon of biomagnification within ecosystems, using microplastics.

Guide updated: 08/23/2019

TABLE OF CONTENTS

ABOUT THIS GUIDE

This guide is made to help teachers implement the Tyto Online hands-on science video game within their classrooms, supporting their Next Generation Science Standards (or similar state versions).

If you do not yet have an account, please head to https://www.tytoonline.com/ to sign up!

CONTEXT WITHIN NGSS

This storyline fits into the NGSS at three different standards. This guide will examine each of these, beginning with standard MS-LS2-3, which reads:

Develop a model to describe the cycle of matter and flow of energy among living and nonliving parts of an ecosystem.

Science and Engineering Practices	
Developing and Using Models Develop a model to describe phenomena.	*Students study maps and charts and create a food web to explain phenomena.*
Disciplinary Core Ideas	
LS2.B: Cycle of Matter and Energy Transfer in Ecosystems Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	*Students observe how a pollutant can make its way through an entire food chain, even though only one organism is consuming it firsthand. Students must understand which species depend on the others for survival to correctly diagnose the problem; one species is unaffected because it does not share a food chain with the affected species.*
Crosscutting Concepts	
Energy and Matter The transfer of energy can be tracked as energy flows through a natural system.	*Students model a food web and observe the digestive process in this sequence, which shows the flow of nutrients and energy through both the ecosystem and the seal's system.*

This storyline also fits into the standard at MS-LS2-4, which reads:

Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Science and Engineering Practices	
Engaging in an Argument from Evidence Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	*Students create several arguments over the course of this storyline, as they develop more advanced understandings of the problem. This includes using empirical evidence and reasoning to argue what is making the seal sick, how it is spreading, drawing conclusions about how it's happening, and even arguing for a solution to the problem by the end of the storyline.*
Disciplinary Core Ideas	
LS2.C: Ecosystem Dynamics, Functioning, and Resilience Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	*This storyline relies upon students' knowledge and investigation of an ecosystem with many different niches and roles.*
Crosscutting Concepts	
Stability and Change Small changes in one part of a system might cause large changes in another part.	*Students realize during the course of the investigation that the underlying problem is microscopic, yet has a ripple effect throughout the entire ecosystem (even for components that are far removed from the initial problem.)*

This builds upon elementary standards relating to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

This storyline also fits into the NGSS at standard MS-LS2-5, which reads:

Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Science and Engineering Practices	
Engaging in an Argument from Evidence Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	*This storyline closes with students researching and comparing solutions to the problem they've identified over the course of the storyline. They use criteria such as ecosystem health and cost to evaluate the various proposed, competing solutions.*
Disciplinary Core Ideas	
LS2.C: Ecosystem Dynamics, Functioning, and Resilience Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. **LS4.D: Biodiversity and Humans** Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary) **ETS1.B: Developing Possible Solutions** There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary)	*Students model a food web and observe the digestive process in this sequence, concluding that while nutrients and energy are passed/recycled from prey to predator, microplastics cannot be recycled via the digestive process, leading to a bottleneck within the energy transfer system.* *In this storyline, students also evaluate competing design solutions against criteria to determine which should be chosen.* *This storyline does not explore the human resources that are impacted by the ecosystem being impacted, however. This would be a strong area for extension activities, and we cover it in our climate change storyline in Weather & Climate, "So Long and Thanks for All the Fish!"*
Crosscutting Concepts	
Energy and Matter The transfer of energy can be tracked as energy flows through a natural system.	*Students model a food web and observe the digestive process in this sequence, which shows the flow of nutrients and energy through both the ecosystem and the seal's system.*

This builds upon elementary standards relating to developing, using, and revising models to test, describe, and predict more abstract phenomena and design systems.

Relevant NGSS Links

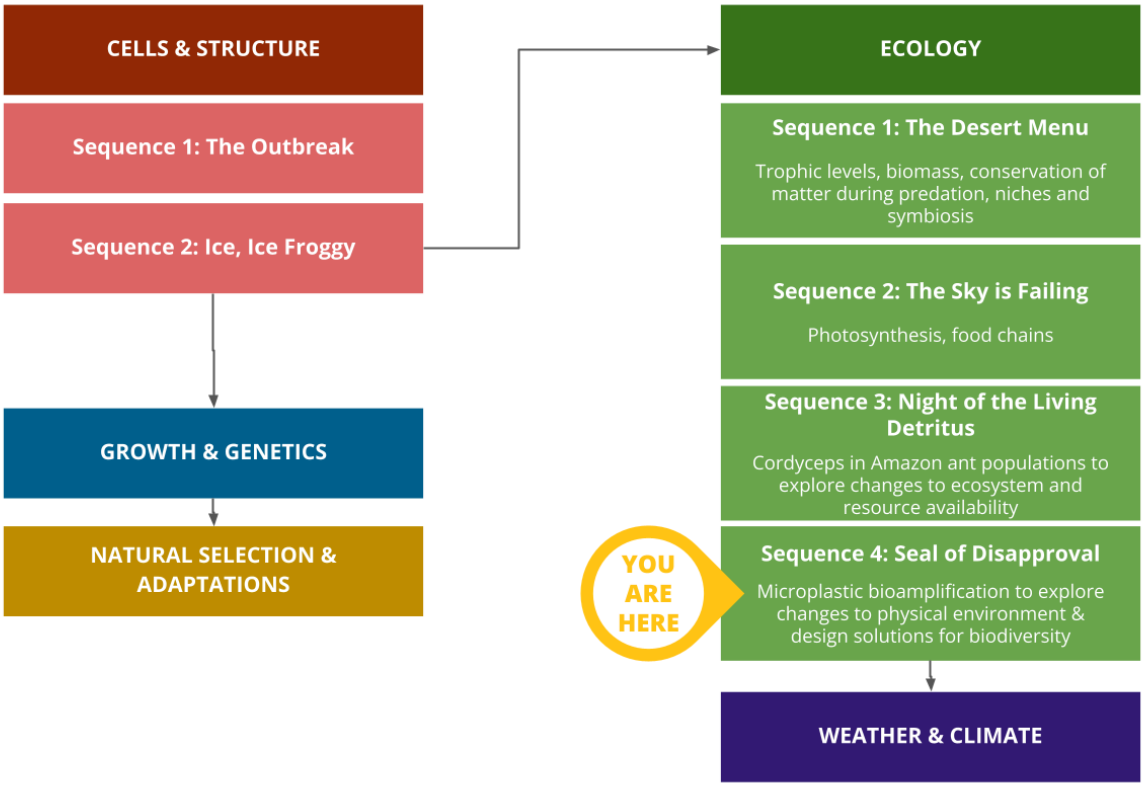
https://www.nextgenscience.org/pe/ms-ls2-3-ecosystems-interactions-energy-and-dynamics

https://www.nextgenscience.org/pe/ms-ls2-4-ecosystems-interactions-energy-and-dynamics

https://www.nextgenscience.org/pe/ms-ls2-5-ecosystems-interactions-energy-and-dynamics

CONTEXT WITHIN TYTO ONLINE

Seal of Disapproval is the final storyline in our ecology curriculum. Its in-game prerequisite is the preceding storyline, *Night of the Living Detritus*. It unlocks the Weather and Climate module.



STORYLINE FLOW

STORYLINE IN-CLASS SUPPORT

Vocabulary

Biome	Ecology	Ecosystem
Eco-Friendly	Prey	Predator
Symptom	White Blood Cell	Red Blood Cell

- Printable vocabulary cards: access on Google Drive

Summary Table

- Completed summary table: access on Google Drive
- Blank summary table worksheet, “My Thoughts” & “Class Thoughts”: access on Google Drive
- Blank summary table worksheet, “My Thoughts” only: access on Google Drive

Other Supplementary Resources

- Scaffolded Reasoning Prompt (students write their reasoning for every individual argument): access on Google Drive
- Combined Argument Writing Prompt (students write their reasoning after completing all arguments): access on Google Drive
- The Observe-Wonder-Learn (OWL) Board Instructional Routine padlet (make a copy): access student recording sheet on Google Drive

QUICK GUIDE

ARGUMENT BUILDER ANSWERS

Correct claim: Ronan ate something that made her sick.

Could an infection be what's making Ronan ill?

- Ronan's blood does not show an elevated white blood cell count AND Ronan has no external injuries THEREFORE Ronan does not appear to have an infection

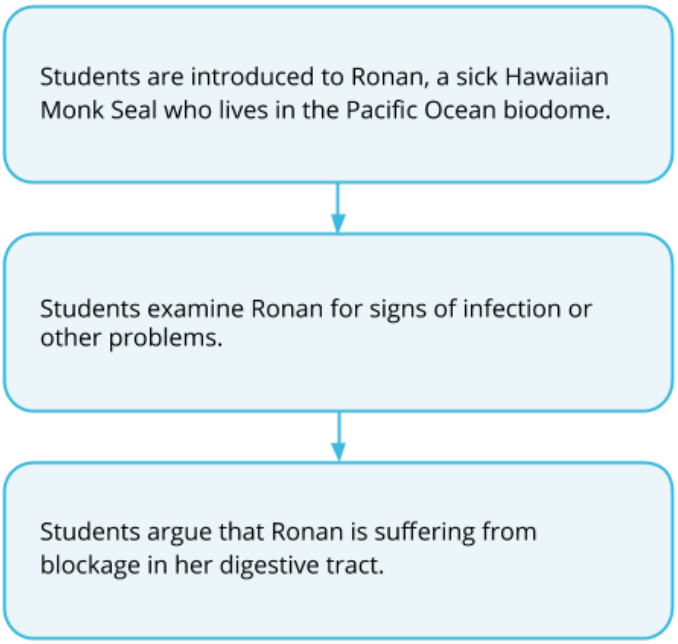
What do you think is wrong with Ronan, and why?

- Ronan is not eating AND the ultrasound showed an unidentified mass in Ronan's stomach THEREFORE Ronan's digestive system is blocked

Anchoring Phenomenon

Why is Ronan the seal sick?

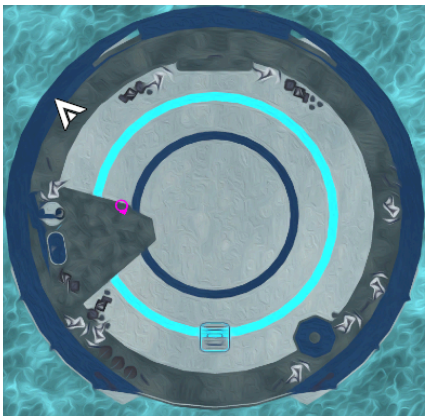
Quest Progression



Transition to Next Quest

Players have determined that Ronan is ill because of something she ate. Since Ronan only eats live fish from the biodome, Captain Nenson wonders if the peacock groupers have an illness that they've passed to Ronan.

COMPLETE WALKTHROUGH

Quest-Giving Character	Location
 Captain Bait Nenson	 Head to the Pacific ocean biodome via any transit center.

Narrative Flow

1. Captain Nenson introduces players to Ronan, a Hawaiian monk seal. Unfortunately, Ronan is not feeling well today, and the captain is worried. Captain Nenson asks the player to examine Ronan.
2. Players perform an ultrasound on Ronan's stomach, check her skin for lesions, and do a blood test to determine whether she has an elevated white blood cell count. Her blood test and skin appear normal, but the ultrasound shows an unidentified mass in her stomach.
3. Players argue that Ronan is feeling sick because of the mass in her stomach, and Captain Nenson agrees.

QUICK GUIDE

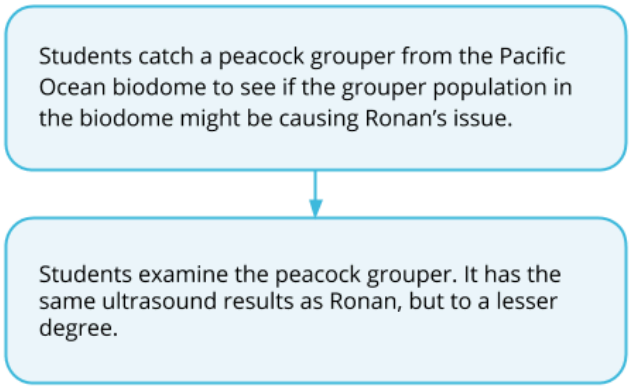
HINTS:

- At this point, students are still collecting data about what is happening. This may be a good time to have a discussion about how vets and doctors diagnose illnesses.
- Try saying:
  - Ask me two questions about this storyline that you are wondering about.
  - How do you think doctors figure out what is wrong with a patient?
  - How are doctors also scientists?
- A student may correctly point out that the quest ignores corals. However, since corals are not a part of the seal's food chain, we did not include the effects of microplastics on corals in this quest.

Anchoring Phenomenon

Players investigate Ronan's food supply and find that the same particles in Ronan's stomach are in the peacock groupers' as well.

Quest Progression



Transition to Next Quest

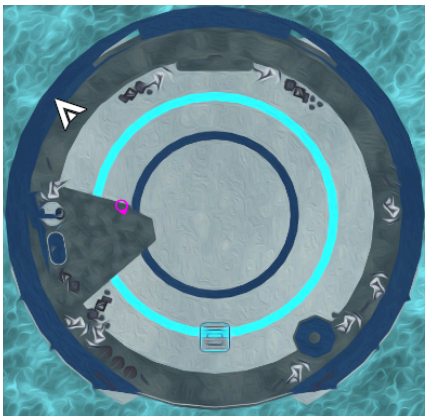
Having found unidentified matter in the stomachs of both Ronan and a random peacock grouper, Captain Nenson wonders how far into the food chain the particles have permeated.

COMPLETE WALKTHROUGH

Quest-Giving Character

Captain Bate Nenson

Location



This quest takes place in the Pacific Ocean Biodome, accessible from any transit center.

Narrative Flow

1. Players go underwater to catch a peacock grouper.
2. Players perform an ultrasound to see if its stomach also contains the unidentified matter found in Ronan's stomach. (It does.)
3. Captain Nenson decides that a larger-scale investigation must be done to see how many other organisms have been affected by these mysterious particles.

QUICK GUIDE

ARGUMENT BUILDER ANSWERS

Correct claim: The inorganic matter is being spread via predation.

How is the inorganic matter being spread, and why don't sea turtles appear to be affected?

- Groupers eat agile chromis and seals eat groupers WHILE sea turtles only eat sea grass THEREFORE the inorganic matter is present in the fish and seals, but not in the turtle

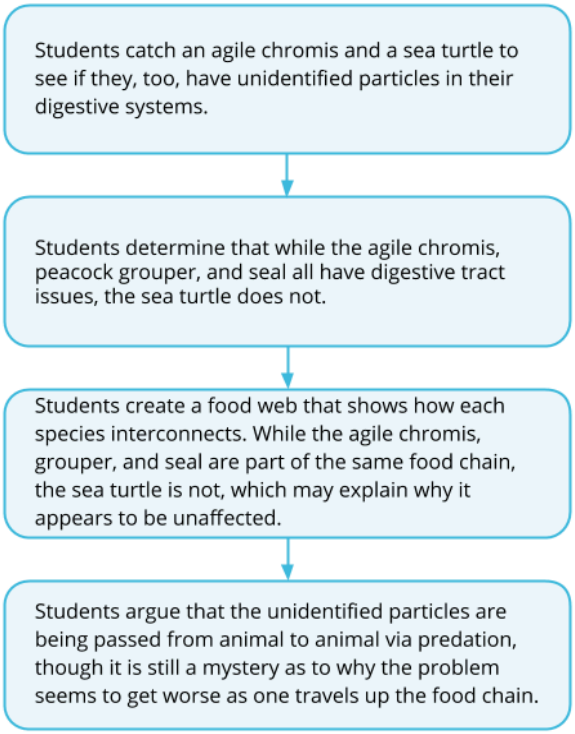
What trends did you notice when you looked at the amount of inorganic matter present in each organism?

- Seals have the greatest amount of inorganic matter WHILE agile chromis have the least amount of inorganic matter THEREFORE as consumer level increases, pollutant level increases

Anchoring Phenomenon

Why do some animals have unidentified matter in their stomachs, while others do not?

Quest Progression



Transition to Next Quest

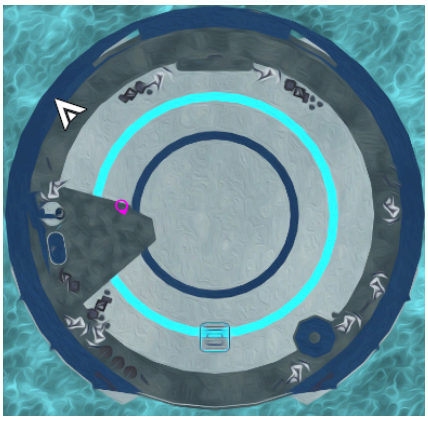
Players have now established that the unidentified particles are being spread via predation, since only animals within the same food chain are affected. Nenson now needs to understand how the particles are making their way into the food chain in the first place, and why the effect seems to compound itself as one works their way up.

COMPLETE WALKTHROUGH

Quest-Giving Character

Captain Bate Nenson

Location



This quest takes place in the Ocean biodome, accessible from any transit center.

Narrative Flow

1. Players collect an agile chromis and a sea turtle from the reef, then bring them back up to the boat for examination.
2. To determine how the food chain functions in this biodome, Captain Nenson asks the player to create a flowchart tracking the flow of matter. (This chart only contains relationships between consumers.) Players can consult their Analyzer for clues about which animals eat which.
3. Players perform a Picture Click task, determining that while the agile chromis, seal, and grouper all have unidentified particles in their stomachs, the sea turtle does not.
4. Players argue that the particles are present only in the stomachs of animals because they are being spread via predation, and the particles are absent from the sea turtle's stomach because the agile chromis is the point of entry (and sea turtles do not consume agile chromis.)

QUICK GUIDE

ARGUMENT BUILDER ANSWERS

Correct claim: Ronan can't digest the inorganic matter in her stomach, which makes her feel full without providing any nutrition.

Why do you think that some of the fish was digested, while some parts remain trapped in Ronan's stomach?

- When Ronan eats a fish, the organic parts of the fish are digested and absorbed into her body HOWEVER the inorganic matter is not absorbed into Ronan's body BECAUSE/AND the inorganic matter does not contain any nutrients

Loss of appetite was one of Ronan's symptoms, yet she gobbled up that peacock grouper as quick as anything! Why didn't she feel like eating *before* she vomited?

- Ronan only felt well enough to eat after vomiting the mass from her stomach BECAUSE Ronan's stomach feels full when it is full of inorganic matter

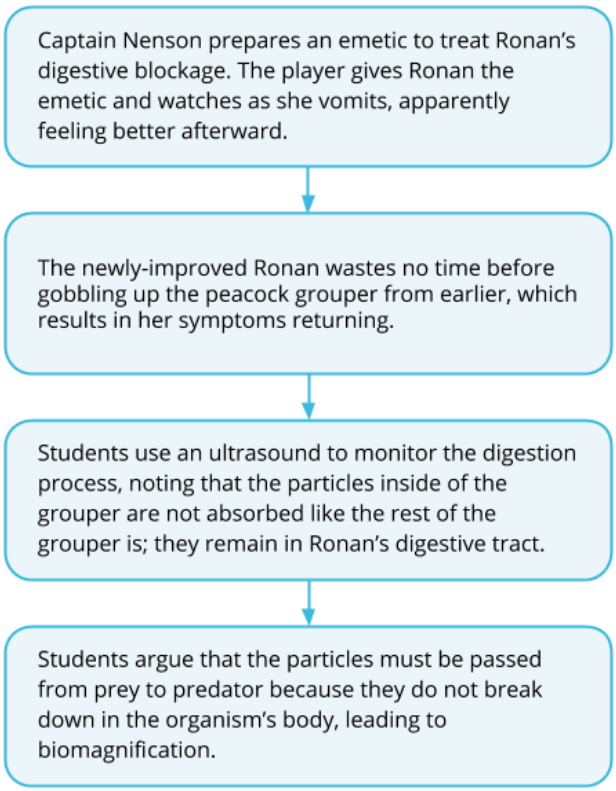
HINTS:

- Note that the digestion sequence happens much more quickly in the game than in real life.

Anchoring Phenomenon

Why is the unidentified matter in Ronan's stomach making her ill?

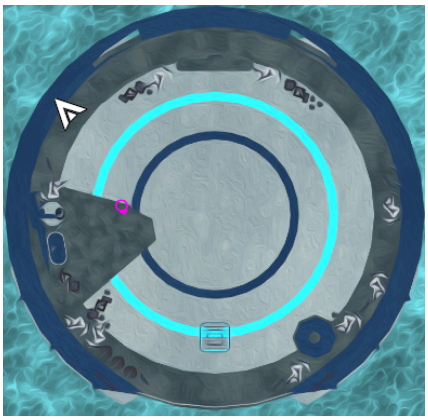
Quest Progression



Transition to Next Quest

Players now understand that the particles in Ronan's stomach are indigestible, leading to a buildup that makes her sick. Players also see that the particles are blue in color.

COMPLETE WALKTHROUGH

Quest-Giving Character	Location
 Captain Bait Nenson	 Head to the Ocean biodome for this quest.

Narrative Flow

1. Captain Nenson is confident that since the problem appears to be in Ronan's stomach, making her throw up might solve her health problems. Players feed an emetic to Ronan, which makes her vomit. Ronan immediately feels much better.
2. Players take a sample of the vomit and see that it contains inorganic particles that are blue in color.
3. Captain Nenson asks the player to scan Ronan again to make sure that all of the particles made their way out of Ronan's stomach, but Ronan surprises everyone by lunging for the peacock grouper that was caught in an earlier quest! Ronan immediately feels sick again, as we established that the fish was full of the same particles that made Ronan sick in the first place.
4. Players scan Ronan again to watch as she digests the fish. They observe the organic matter being broken down and absorbed into Ronan's body, while the inorganic matter is neither absorbed nor broken down.
5. Players explain how they think these inorganic particles are affecting Ronan's health.

IN-CLASS EXTENSIONS

After finishing *Our Fate is Seal* would be a great time to take a break from Tyto to do some real world explorations of Ronan's illness. The following suggested activity allows students to explore the mechanism behind bioamplification.

Suggested Hands-On Experiments

Bioamplification Lab - students see the mathematical mechanisms of bioamplification.

- Materials needed: print-outs, writing utensils, cups, M&Ms or 2 colors of bingo chip or other small item
- https://blogs.cornell.edu/cibt/labs-activities/labs/biomagnification-lab-todd-shuskey/

QUICK GUIDE

ARGUMENT BUILDER ANSWERS

Correct claim: Particles of inorganic matter are falling from the boat. The agile chromis mistake them for zooplankton and eat them.

Where are the particles of inorganic matter coming from?

- Inorganic matter was only found in sand and water samples taken from beneath the boat BECAUSE/AND the particles are originating from the boat itself

Why is Ronan experiencing the worst effects of the pollution when she's the furthest removed from the source?

- Accumulation of the inorganic matter increases as you make your way up the food chain BECAUSE the particles of inorganic matter do not break down during digestion as normal food does

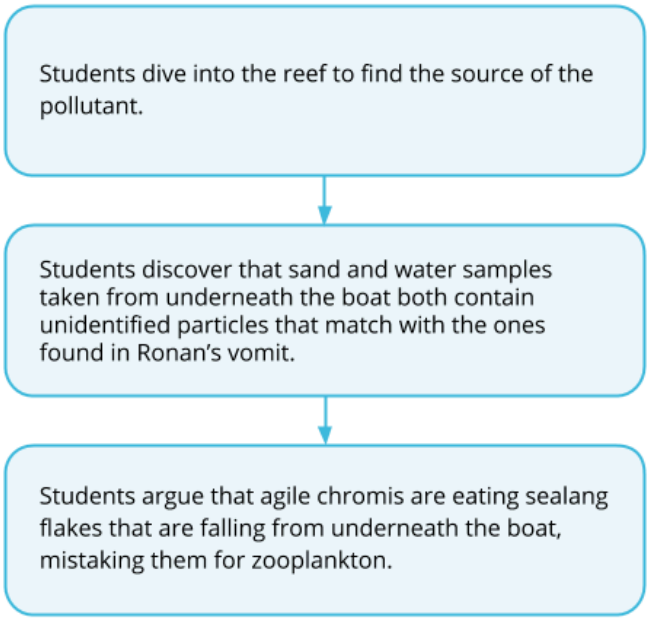
How do the particles get into the food chain in the first place?

- Agile chromis are eating the particles of inorganic matter as they fall from the boat BECAUSE zooplankton are the same size as the particles of inorganic matter AND agile chromis eat zooplankton

Anchoring Phenomenon

Where are these particles coming from?

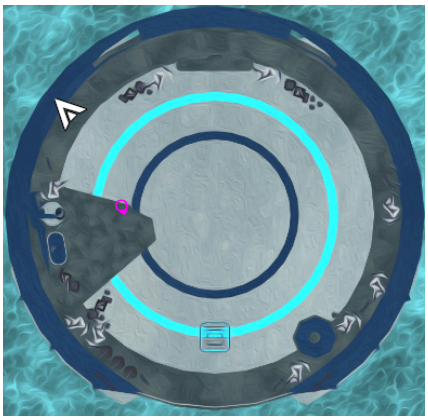
Quest Progression



Transition to Next Quest

Now that students have identified the source of the pollution, they must decide how to stop more particles from making their way into the water.

COMPLETE WALKTHROUGH

Quest-Giving Character	Location
 Captain Bait Nenson	 This quest takes place in the Ocean biodome.

Narrative Flow

1. Players travel back to the reef to take samples of water and sand.
2. Players examine the water and sand samples and find the same particles that were in Ronan's vomit, but only in the samples taken from beneath the boat upon which much of the storyline content has been taking place.
3. Players argue that the boat is the source of the pollutant.

QUICK GUIDE

ARGUMENT BUILDER ANSWERS

Correct claim: The current sealant must be scraped off the boat and replaced with a new sealant that will not flake off in the water.

Doing nothing looks like the cheapest option to me. What do you think about it?

- After 1 year, doing nothing will be the cheapest option HOWEVER in 15 years, doing nothing will be the most expensive option AND doing nothing will likely lead to the extinction of the Hawaiian monk seal, if not other species

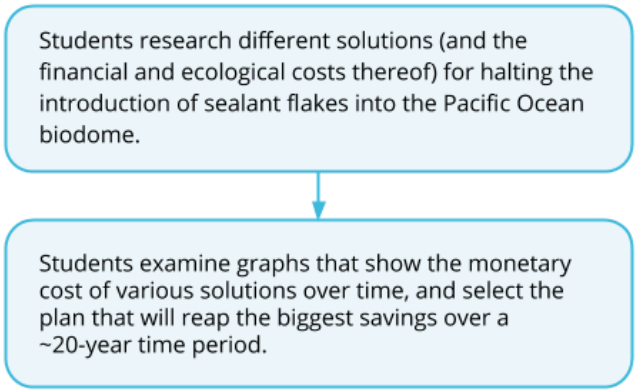
Why do you think we should scrape the hull and re-seal it? It's the second-most expensive option!

- Scraping the hull will cost $120,000 up front, but will only cost $50,000 every 5 years to maintain THEREFORE in 15 years, the least amount of money will have been spent on scraping and re-sealing the hull

Anchoring Phenomenon

How can we solve this issue in a financially and ecologically sustainable way?

Quest Progression



Transition to Next Quest

Players have identified the problem and solution.

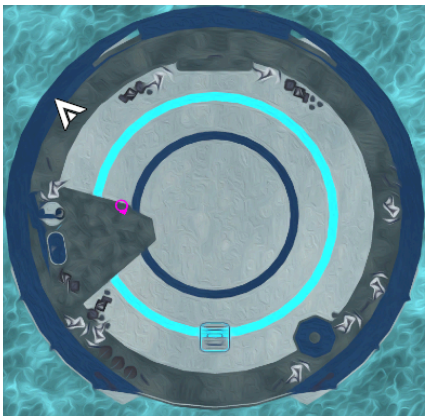
This concludes the Seal of Disapproval storyline. This storyline unlocks the Weather & Climate module within the game.

COMPLETE WALKTHROUGH

Quest-Giving Character

Captain Bait Nenson

Location



This quest takes place in the Ocean biodome.

Narrative Flow

1. Players perform research to see their options for addressing the issue of sealant particles flaking off of the boat and into the water.
2. Players argue that over time, scraping the current boat's hull and re-sealing it with a higher-quality sealant will be the most economical option, and will lead to the best outcomes for the biodome residents.

IN-CLASS EXTENSIONS

After finishing this storyline it would be good to take some time away from Tyto investigating real world connections to this content. The following resources support this by allowing exploration of potential next steps for Dr. Nenson, and research related to current solutions to the problem.

Suggested Hands-On Challenge

Water Cleaning Engineering Design Challenge - students work on their engineering and prototyping skills to create a prototype solution for Dr. Nenson's clean up efforts. Students should brainstorm in small groups and draw up a design. Students should then present their designs to each other.

If there is time, building the solutions and testing them with water "contaminated" with small pieces of plastic would be an ideal extension approach.

- Materials needed: paper, writing utensils, various maker supplies;
- *If prototyping:* cardboard, plastic bottles, netting, plastic bins and water with small bits of plastic to filter, or anything else that students may find useful. Students may need to be able to bring materials from home to experiment.

Suggested Online Resources

Microplastic Clean-up Efforts - students spend time reading and researching current efforts being used to try to clean up microplastics on Earth. The following links are a good place to start, but students should also be encouraged to search further and evaluate other resources they find.

- https://www.hawaii.edu/news/2019/05/07/uh-hilo-microplastic/
- https://www.pbs.org/newshour/science/this-new-nanotech-could-help-clean-up-earths-microplastics

To help this storyline fully address the standards, students should also understand how the ecosystem provides services to humans, and therefore how something like microplastics can impact them if not solved within an ecosystem.

Suggested Hands-On Activity

Human Impact of Microplastics - students can read this article from Scientific American about how microplastics have seeped into oil, fish, and air, and pose a risk to human health.

- https://www.scientificamerican.com/article/from-fish-to-humans-a-microplastic-invasion-may-be-taking-a-toll/

Students could then be assigned groups to create presentations about what people can do about this! What can you, as a middle schooler, do to protect yourself? Or create fewer microplastics that contribute to the problem. There are many areas of impact, so students could even be assigned different areas to create a Guide to Creating Less Microplastics, such as different groups researching what you can do to reduce your creation of microplastics from:

- Your clothing and laundry (ex: types of clothing that release more or less);
- Your eating and drinking (ex: reducing single-use plastic);
- Your hygiene (ex: not using washes with microbeads);
- Your daily habits and shopping (ex: shopping local, reusable bags).

Career Connections

Career	Description	Requirements
Marine Biologist	Marine biologists study and assess the health of marine ecosystems. They may specialize in the study of a particular organism or class of organism, or may study abiotic factors such as climate change and pollution.	• Bachelor's degree in biology or marine biology • Advanced degree (masters or PhD) in marine biology to conduct research
Veterinary Technician	A veterinary technician helps veterinarians at a clinic. Veterinary techs provide support during exams and clinical procedures, take samples, and administer medications.	• Composure in stressful situations involving animals • High school diploma and completion of at least a two year vet tech program.
Veterinarian	Veterinarians spend their days treating and curing sick animals, as well as keeping healthy animals healthy with routine examinations and preventative treatment. Veterinarians choose a specialty, which can include pets, large domestic animals, or exotic animals.	• DVM in veterinary medicine • Bachelor's degree in biology, or a related field • Composure in stressful situations involving animals
Materials Scientist	Materials scientists work in many varied fields, including environmental engineering. They work to solve problems with existing materials, and may work on projects such as developing new sensors or strengthening building materials in places which are prone to natural disasters.	• College Diploma • Masters or Doctoral degree for research and teaching positions
Environmental Engineer	Environmental engineers work to protect people from adverse environmental effects like pollution or natural disasters, as well as work to improve the environment overall.	• College Diploma • Internship with Environmental Engineering Firm (often)
Environmental Lobbyist	Environmental lobbyists work on behalf of organizations and special interest groups to influence laws pertaining to the environment. Lobbyists work to persuade legislators to pass laws that will protect the environment, and to reject initiatives that may harm it.	• Bachelor's degree in environmental science or a related field • Law degree (preferred)