Back to Nature: Jellyfish Lake Program

Teacher's Guide

Palau

Coral Reef Research Foundation

https://coralreefpalau.org/

crrfpalau@gmail.com

© Coral Reef Research Foundation

2022.03.01

Team Members

Gerda Ucharm

Sharon Patris

Kaylee Giramur

Amber Sky Skiwo

Carlos Manuel

Lori Colin

Table of Contents

About Coral Reef Research Foundation & the Marine Lakes Project

The Coral Reef Research Foundation, or CRRF, is a research facility located on Malakal Island across from Kings Minute Mart and next door to NECO Marine Dive Shop. CRRF was started in 1991 by a group of marine scientists dedicated to research and education on coral reefs and other tropical marine environments. CRRF is a non-profit organization in both the U.S. and Palau. CRRF does scientific research to acquire the knowledge needed to understand and make intelligent decisions related to conservation, climate change and resource management.

Our current marine lakes research program began in 1999 after the strong El Niño/La Niña event that caused the Golden jellyfish population to disappear. Overall, the program emphasizes the origins, ecology, and evolution of marine lakes, including how their species vary through time, and how climate change impacts the lakes. CRRF is the only research facility in Palau that studies the marine lakes.

There are more than 55 marine lakes in Palau and they are all unique and different from one another. The majority of these lakes are concentrated in the Rock Island Southern Lagoon of Koror State, a UNESCO World Heritage Site. Of all the marine lakes in Palau, CRRF monitors 18 once a year and 3 once every quarter. This monitoring program includes documenting the temperature, salinity, oxygen, pH, and chlorophyll of the lake water from surface down to the bottom of the lake. CRRF also documents the population of the Golden jellyfish in Jellyfish Lake every quarter. There are also temperature-logging instruments that are deployed in 18 lakes. Studying temperature, salinity, oxygen and pH have been identified to be an essential part of the lake study. All of these physical parameters contribute to the health and reproduction cycle of the unique sub-species of *Mastigias papua etpisoni* that is endemic to Jellyfish Lake. Documenting and studying these variables can help us to understand how we can protect the lake for future generations. For more information see: **https://coralreefpalau.org/research/marine-lakes/**.

CRRF also runs a tower weather station (TWS) on Ngeanges Island. Its location, isolated from obstructions (e.g. tall manmade structures), reduces the effects of large land masses on weather observations and provides more accurate information on marine conditions for comparisons with other areas. The weather conditions monitored by the tower station closely approximate those occurring at Jellyfish Lake, only 5 km away from the station. The TWS has been running since 2007, and has recently gone online. Live hourly data from this station can be viewed at **https://weather.coralreefpalau.org/**

PROGRAM FUNDING

Acknowledgements

This field education program is a success because of the generous help and advice from numerous agencies, as well as individual people in Palau. The Coral Reef Research Foundation and its team would like to express our deepest gratitude to the grantors, the GEF Small Grants Programme and the New Zealand North Pacific Development Fund, for supporting the program's development and implementation for school year (SY) 2020–2021, and Canada Fund for Local Initiatives for program support in SY 2021-2022, and funds to institutionalize it within the Ministry of Education (MOE). We would also like to thank the Ministry of Education for working with us in planning and executing the program. Within MOE, we would like to give special thanks to former Minister Sinton Soalablai SY 2020-2021, Chief Raynold Mechol, Chief Magaria Tellei, Specialist Debbie R. Nagata and Specialist Sarah Sugiyama. We also thank all the schools, principals, teachers and parents for making this program possible. Lastly, we thank the hundreds of students for taking part in this program. We are very proud of all of you and we hope that you will use this as a window into a deeper appreciation of your home and a stepping stone toward future careers. You will be the leaders of Palau one day, and we are confident that you will protect and preserve our small islands for all the generations to come.

The Coral Reef Research Foundation would also like to thank Paddling Palau and its staff for assisting with our field trips. Special thanks are due to NECO Marine for accommodating our trips. Our partners at the Koror State Government, Koror State Legislature and the Koror State Department of Conservation and Law Enforcement are thanked for permitting us to implement the program in one of their most unique resources, Jellyfish Lake. Our intention is that the program can be continued annually to expose our children to the beautiful natural resources that we have, as well as educate them on how to preserve, conserve and protect these unique areas of biodiversity in Palau.

Welcome and Description

The Back to Nature: Jellyfish Lake program aims to foster environmental stewards who actively engage and work on protecting and conserving our natural environment. This program helps young people to connect to nature, increasing their appreciation and knowledge of the natural world that will encourage youth to advocate for changes that will protect and conserve our environment.

This particular program focuses on Jellyfish Lake, to foster a sense of ownership and increase knowledge of Jellyfish Lake. Why Jellyfish Lake? Jellyfish Lake is a unique marine environment that is special to Palau; it is home to millions of a unique Golden jellyfish found nowhere else in the world. Sadly, more tourists than our own students have visited and explored Jellyfish Lake. For this reason, we have created the program to ensure that students get the chance to visit and explore the lake, feel that connection to this special place, and foster a passion and desire to protect the lake.

We started the Back to Nature: Jellyfish Lake program in early 2020 with the goal of taking all students from 6th and 8th grade in Palau to Jellyfish Lake for an educational experience. After some Covid-19 delays, we went into full operation by June 2020, starting with a teacher's training session to introduce the program. With the help and coordination of Palau's Ministry of Education, public and private school principals and teachers, in August 2020 we began our schedule to take all 6th and 8th graders to Jellyfish Lake for the school year (SY) 2020–2021. By the end of the 2020–2021 academic year, a total of 739 participants, including teachers, students, and chaperones from 21 schools, and 2 organization groups, had been through the program. The program continued in SY 2021-2022 and reached 270 6th graders, in addition to teachers, chaperones and parents.

The Back to Nature: Jellyfish Lake program reached students from Kayangel to Hatohobei, for two consecutive years, SY 2020–2021 & SY 2021-2022, covering all elementary schools in Palau and additional groups and high schools:

- **868 students**: 426 males, 442 females
- **73 teachers** from public and private schools
- **19 elementary schools**: 17 public schools, 2 private schools
- **4 high schools**: 1 public school, 3 private schools
- **2 organizations**: Ebiil Society Camp, Heirs to Our Oceans

This lesson plan and information packet was created by the Coral Reef Research Foundation to help the teachers of Palau conduct the Back to Nature: Jellyfish Program with their students. It has been used on students from 3rd grade through high school, and is easily adapted. The packet will help teachers through the three stages of the program, and includes an example Field Trip Application (Appendix 1):

> **Introduction**: On Day 1, provide useful background information that will give students a general overview of Jellyfish Lake and prepare them for the field day.
> **Field Day**: On Day 2, guide students in learning through hands-on activities in Jellyfish Lake.
> **Wrap Up**: On Day 3, help students synthesize the information they have learned, analyze the data they have collected, and present their work to their classmates.

We hope through this program, our youth will have fun learning about Jellyfish Lake, science and climate change.

Connecting the Back to Nature: Jellyfish Lake Program and Palau Ministry of Education Curriculum

When we developed the Back to Nature Program, we aimed to align the program with the Palau Ministry of Education curriculum so that the program can enhance the student-learning experience. Overall, the Back to Nature: Jellyfish Lake program aligns with the Palau Ministry of Education curriculum learning standard of **Science Practices**. Throughout the year on the academic quarter system, the program aligns with specific learning targets and performance indicators in the 1st and 2nd quarters.

LEARNING STRAND: SCIENCE PRACTICES

Standard	Ministry of Education Objective	Back to Nature: Jellyfish Lake
Standard SP Science Practices The ways that scientists ask questions about the natural world, get and analyze data, develop explanations, and communicate their evidence-based scientific knowledge.	4-6, 7-8.SP.1 Obtain information, ask science questions, and plan investigations.	Day 1: Lesson 1–4 Students take notes of and ask questions on the presentation given by the teacher. Presentations also provide the steps and plans for investigations and activities.
	4-6, 7-8.SP.2 Get, analyze, and interpret data.	Day 2: Lesson 1–4 At Jellyfish Lake, students collect data at different stations. They also review their data through short answers to questions provided. Day 3: Lesson 1–4 In the classroom, students further analyze and interpret data through group work and by answering the guideline questions. They will also use graphs to evaluate and present their data.
	4-6, 7-8.SP.3 Make, evaluate, and communicate conclusions	Day 3: Lesson 1–4 Students evaluate and communicate their conclusions through oral presentations to the class and, if assigned by teacher, through report writing.

The Back to Nature: Jellyfish Lake Program aligns with certain objectives of the different learning strands and targets for each quarter. Here we outline the learning targets and performance indicators students reach by completing the Back to Nature: Jellyfish Program.

Grade 6 - First Quarter: Life Sciences

6.LS.3 Investigate local environments and research other kinds of island environments to describe, classify, and compare the biodiversity of animals in these environments.

> **6.LS.3a** Classify animals in Palau environments as vertebrates, invertebrates, sponges, cnidarians, worms, mollusks, arthropods, echinoderms, amphibians, fish, reptiles, birds, and mammals.
>
> **6.LS.3b** Compare and contrast the biodiversity of animals in different Palau environments.

6.LS.4 Analyze the organism adaptation that help the populations of different organisms to be successful in their environments.

> **6.LS.4a** Define adaptation as a feature or behavior of a species that makes it possible for organisms of that species to survive in their natural environment.

Grade 6 - Second Quarter: Earth and Space Science

6.ESS.1 Compare and contrast ecosystems in different biomes with each other and with Palau environments.

> **6.ESS.1a** Using examples from Palau and very different kinds of environments, distinguish between the biotic and abiotic parts of ecosystems.
>
> **6.ESS.1b** Using examples from Palau and very different kinds of environments, correctly use the terms habitat, community and populations in describing ecosystems.
>
> **6.ESS.1d** Compare and contrast Palau environments and organisms with environments and organisms in world biomes.

Third Quarter and Fourth Quarter aligns with **Science Practices**

<u>Other subjects</u>

Because the field day (Day 2) takes the entire school day, the program will cover a number of different subjects during the day. During the field day, students will be able to learn and use the following scientific skills:

Mathematics: Students will apply math skills in recording and graphing data.
Social Studies: Students will learn about the geography, weather and climate events of Palau.
English: Students will practice English writing skills by writing a report assigned by the teacher.
Palauan: The presentation will be in Palauan, and students will learn of an important natural resource to Palau.
Health: Students will learn about safety rules and safe boat and water practices.
Physical Education: Students will be hiking and swimming throughout the day, giving them healthful physical exercise.

Grade 8 - First Quarter: Life Sciences

8.LS.2 Represent abiotic and biotic interactions in ecosystems, and predict how changes may affect organism populations.

> **8.LS.2a** Compare and contrast abiotic factors in different Palau environments with each other and with abiotic conditions in very different environments.
>
> **8.LS.2b** Observe and gather information about local ecosystems, and use scientific terms (e.g., habitats, niches, commensalism, producer, predator, consumer, decomposer) to communicate the interactions of the organisms with the environment and with each other.
>
> **8.LS.2d** Based on observations and/or information gathered from reliable sources, create a representation of a Palau ecosystem food web and use the representation to communicate the ecosystem flows of matter and energy.
>
> **8.LS.2e** Predict how different changes to the ecosystem would affect different populations of organisms, and use evidence to explain the predictions.

Grade 8 - Second Quarter: Earth and Space Science

8.LS.3 Explain how natural selection can result in changes to a species over long periods of time.

> **8.LS.3a** Using local ecosystems as examples, describe biodiversity as the variety of species living in a particular environment.
>
> **8.LS.3b** Use the example of a specific species (e.g., brown bear, peppered moth) and the concept of natural selection to explain how a species changes over generations as a result of changing environmental conditions.
>
> **8.LS.3d** Explain that as an environment changes, populations of an organism that is adapted to the environment must either change to be become better adapted to the new conditions, move away from the changed environment, or become extinct.

Third Quarter and Fourth Quarter aligns with **Science Practices**

<u>Other subjects</u>

Because the field day (Day 2) takes the entire school day, the program will cover a number of different subjects during the day. During the field day, students will be able to learn and use the following scientific skills:

Mathematics: Students will apply math skills in recording and graphing data.
Social Studies: Students will learn about the geography, weather and climate events of Palau.
English: Students will practice English writing skills by writing a report assigned by the teacher.
Palauan: The presentation will be in Palauan, and students will learn of an important natural resource to Palau.
Health: Students will learn about safety rules and safe boat and water practices.
Physical Education: Students will be hiking and swimming throughout the day, giving them healthful physical exercise.

LESSON PLANS

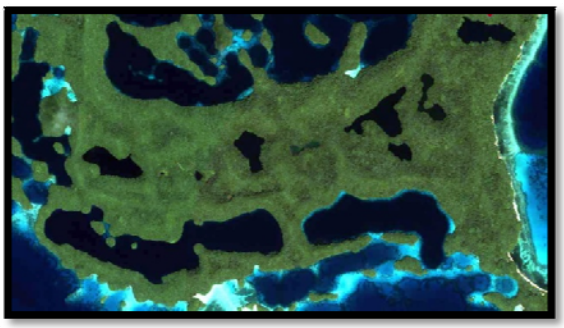
Day 1 – Introduction to Back to Nature Program and Marine Lakes

This first day of the program is held in the classroom where students will watch a Power Point presentation (Appendix 2: Back to Nature-Jellyfish Lake Powerpoint Presentation). Through the presentation, students will learn about the Jellyfish Lake environment and the unique organisms that are found in the lake. They will also hear about climate change and other threats to Jellyfish Lake and its Golden jellyfish. Toward the end of this unit, students will learn about the different scientific tools and methods they will be using during the field trip to Jellyfish Lake. This part of the program can be covered in one class period, or divided into more than one class, depending on the teacher's preference.

	LESSON	OBJECTIVES	MOE Objectives	STANDARDS
Lesson 01	**Marine Lake Habitat, Formation, and Types of Organisms**	Students will be able to do the following: -I can explain why Jellyfish Lake is important. -I can identify two threats to the health of Jellyfish Lake. -I can classify marine organisms to phylum level. -I can identify four methods used during the field trip.	Science Practices: -Obtain information, ask science questions, and plan investigations.	-Obtain and compare information about a scientific topic from different sources. -Ask questions that can be investigated and predict reasonable outcomes based on patterns, such as cause and effect relationships. -In planning an investigation, identify variables and ask questions about what would happen if a specific variable is changed.
Lesson 02	**Threats to Jellyfish Lake: Climate Change and Visitor Impact**			
Lesson 03	**Scientific Method and Tools**			
Lesson 04	**Classification System**			

Lesson 01: Marine Lake Habitat, Formation, and Types of Organisms

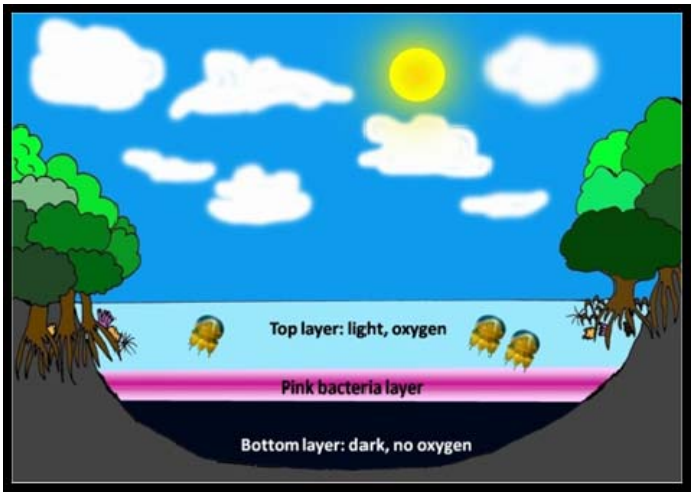
Background Information



A marine lake is a body of seawater that is completely surrounded by land. Thousands of years ago, sea level was much lower than today and all of Palau that is lagoon today was dry land. The marine lakes formed when sea level started rising and filled low spots with ocean water. As sea level rose, the sea

and marine organisms made their way through open tunnels, cracks and crevices in the rock islands as the low lying areas or depressions filled with sea water. These filled depressions became marine lakes, numbering over 50, with some still connected to the lagoon while others became more isolated.

Palau has three types of marine lakes: stratified, mixed and transitional. Marine lakes can vary due to the types of connections they have with the surrounding lagoon. Some lakes are directly connected to the lagoon through large tunnels you can swim through. Other lakes are **isolated** with indirect connections to the lagoon through tiny tunnels and cracks.



The first type of lake is **stratified**, or **meromictic**, and is like a layer cake. The layers are water, separated from each other by differences in density. Stratified lakes usually have small tunnels and cracks. They will have an indirect and limited connection to the lagoon, and so are isolated from the ocean. High ridges of land will also surround most stratified marine lakes, and the surrounding land will slow down the wind blowing across the lake. These geographical characteristics contribute to the lack of mixing in the lake, which causes the water in the lake to stratify and oxygen to deplete at some depth. The top layer of the lake's water usually has oxygen, whereas the bottom layer lacks oxygen (anoxic). A pink bacteria layer is usually found at the interface, or boundary, of these two different layers of water. Because stratified lakes have a limited connection to the ocean, the timing and tidal range (or difference between low and high tide) in the lake are different from the ocean.

The biological community in stratified lakes has similarities to those of mangrove habitats, but some of the species are unique to these lakes. Some species are new to science, and still need to be described and given scientific names. In a stratified lake, dissolved oxygen is found only in the upper layer of water, and this is where all the organisms live because they must have oxygen to survive. The pink layer is thin, its color coming from pink bacteria in the water. Below it is the zone where no oxygen occurs, due to decomposition of living matter.

In contrast, the **mixed or holomictic lakes** have large tunnels that directly connect to the surrounding lagoon. This characteristic, along with lower lying ridges and more exposure to wind, contributes to the mixing of the water column. These lakes will have oxygen from the surface to the bottom of the lake. They have a uniform water column; temperature and salinity levels are the same from surface to the bottom and animals are able to move throughout the lake,

as well as in and out of the lake through the tunnels to the lagoon. As a result, mixed lakes have a similar community to the lagoon, with corals, sponges, and sea squirts that are common to the lagoon. The direct tunnels allow water to go into and out of the lake with the tides, so the lakes experience a very similar tidal cycle as the surrounding lagoon.

Transitional lakes are those that can be either mixed or stratified depending on the mixing by winds and other weather patterns. Generally they have small tunnels, but through exchange with the lagoon they can sometimes be mixed under the right weather conditions. Transitional lakes can have communities similar to both lagoon and mangrove habitats.

Vocabulary

Biology - the study of living organisms, divided into many specialized fields that cover their morphology, physiology, anatomy, behavior, origin, and distribution.
Habitat - the natural home or environment of an animal, plant, or other organism.
Holomictic or mixed lake - a lake that has a uniform temperature, salinity and density from top to bottom, with dissolved oxygen in the water at the lake's bottom. Mixed lakes have large, open tunnels that connect them to the surrounding lagoon.
Isolated - separated from other places with little communication.
Meromictic or stratified lake - a lake with layers of water, like a layer cake, that do not intermix due to density of the water. Stratified lakes have small indirect cracks and crevices that cause a delay in the lake's tidal cycle.
Transitional Lake - a lake that can be mixed or stratified depending on the wind mixing and other weather patterns.

Materials

For teachers

- Laptop computer
- Presentation
- Internet connection

For students

- Notebook
- Pen or pencil

Classroom Activities

- 15 minute long presentation on the program and marine lakes formation
  - Purpose of the program
    - To enhance knowledge of marine lakes and other local resources
  - Lake Formation
  - Types of marine lakes
    - Stratified or meromictic lake
    - Mixed or holomictic lake
    - Transitional lake

- Compare and contrast the lake temperature-salinity-oxygen (TSO) profile between stratified, mixed and transitional lakes
- Compare and contrast organisms between stratified, mixed and transitional lakes

Thinking Corner

1. How are marine lakes different from Ngardok Lake in Melekeok?
2. What conditions can cause transitional lakes to become mixed? stratified?
3. How old do you think marine lakes are? How old are the rock islands?

Lesson 02: Threats to Jellyfish Lake: Climate Change and Visitor Impact

Background Information

Jellyfish Lake is an excellent example of an area important for its biodiversity. **Biodiversity** is the variety of all living things. It is most famous for its Golden jellyfish, which is a unique subspecies found nowhere else in the world. Jellyfish Lake also has many other species, particularly along its sides, that make up a community unique to this specific lake. However, the lake is threatened by humans, through **visitor impact**, and **climate change**. Visitors affect the lake through particular behaviors, such as leaving trash in the lake and damaging the jellyfish while swimming. Climate change is a long-term threat, through changes in average weather conditions such as temperature, rain, sunlight and wind over a long period of time.

The actions of visitors can negatively affect the lake, but perhaps the most important is visitors introducing **non-native species**. Non-native species are animals and plants that do not occur naturally in a particular place, and can become an **invasive species** that take over once introduced to a new place. Visitors can introduce non-native species when they bring rocks, shells, sand, and other things from the lagoon into the lake. Often, these rocks and shells will have tiny organisms living on them. Remember that Jellyfish Lake has been isolated from the ocean for thousands of years, and we need to maintain that isolation, otherwise the entire ecosystem in the lake can be disturbed so the jellyfish no longer survive. Other ways that visitors affect the lake is through **water pollution**, either through using sunscreen that contains chemicals toxic to marine organisms or by leaving plastic bottles, food containers, bags, and trash in the lake. Visitors can also tear and kill the jellyfish by swimming too vigorously.

Climate change can have a huge impact on marine ecosystems. We know that climate change can cause the lake's normal temperature range to gradually rise. If the lake's temperature increases

above the threshold level of 31.5°C (degrees Celsius), the population of the Golden jellyfish will decline. Drought, or when there is little to no rain, can also affect the salinity or salt content of the lake; these can have negative effects on the jellyfish population. In 2016, the Golden jellyfish population in Jellyfish Lake started to decline during an extreme drought as part of El Niño conditions. They continued to decrease, and the swimming form, the medusae, subsequently disappeared at the end of the El Niño when sea water temperatures rapidly increased over the temperature threshold. Changes in weather patterns and extreme climatic events like the 2016 El Niño can impact the lake and its Golden jellyfish population.

Vocabulary

Biodiversity - the variety of life in the world, or in a particular habitat or ecosystem.
Climate change - a change in average conditions such as temperature or rainfall in a region over a long period of time.
Invasive species - any kind of living organism that is not native to an ecosystem and causes harm.
Non-native species - an organism that does not occur naturally in an area.
Visitor impact - actions and behaviors of people that have an effect on the area that they visit.
Water pollution - the release of materials and substances, such as trash and sunscreen pollution, into bodies of water that degrades the quality of the water. When extreme, it makes the water unsafe for humans and other animals to drink or swim in.

Materials

For teachers
- Laptop computer
- Presentation
- Internet connection

For students
- Notebook
- Pen or pencil

Classroom Activities

- 10 minute long presentation on the importance of Jellyfish Lake to Palau and identifying threats to its health.
    - Important area of biodiversity
        - *Mastigias papua etpisoni*, the Golden jellyfish subspecies that is found nowhere else in the world
        - Organisms in the lake are hard to find in open ocean
        - New species discovered
    - Threats to Jellyfish Lake
        - Climate Change
            - Palau extreme drought in 2016
                - Warm sea temperature

    - Golden jellyfish population decline
- Visitor impact
    - Water pollution (trash & sunscreen)
    - Introduction of invasive species
    - Damaging jellyfish

Thinking Corner

1. How is Jellyfish Lake different from the coral reef? Other marine ecosystems?
2. If the Golden jellyfish disappeared in 2016 because of high temperatures, how do you think they came back? What needed to happen for the Golden jellyfish to return?
3. What are things you can do to protect Jellyfish Lake? The environment?

Lesson 03: Scientific Method and Tools

Background Information

The scientific method and tools are used to gather data and information about the world. We use the **scientific method** and tools to identify problems and seek solutions. In all research across the different science fields, scientists will conduct experiments according to the scientific method. The scientific method is a process that allows researchers to study a topic or problem, learn and gather information about that particular topic, and share what they learned. The scientific method consists of five steps: ask a question, gather information, form a **hypothesis**, test the hypothesis, and share the results.

In this lesson, students will learn how they will conduct their research and monitor the lake through four stations in Jellyfish Lake. On Day 1 in the classroom, students will focus on the first and second step, which is to make an **observation** with the information they get from the presentation (Appendix 2). After viewing the presentation, they will gather information and ask necessary questions that will lead to a hypothesis that can be tested during the field day in Jellyfish Lake. During the field day (Day 2), students will make a prediction and test their hypothesis and share their results during the wrap up (Day 3).

There are four stations during the field day. Station 1 is the "**Temperature**, **Salinity** & **Oxygen** (TSO) Profile Station" where students will use a YSI **water quality meter** to record temperature, salinity, and dissolved oxygen in the upper 15 meters of the lake. Students focus on the first 15 meters because that is where all living organisms are found in Jellyfish Lake. Station

2 is the "Pink Bacteria Layer Station" where students will use a **Nansen bottle** to sample the pink bacteria layer in the lake, usually found around 13-15 meters (Appendix 3:TSO Profile & Pink Bacteria Layer Datasheet). Station 3 is the "**Plankton** and Microscope Use Station" where students will catch plankton samples with a plankton net and look at them under the microscope. Station 4 is the "Scavenger Hunt Station" where students will be doing an invertebrate and vertebrate survey, determine the depth where they find organisms, identify the organism's color and **substrate**, and classify them to their phylum level (Appendix 4: Scavenger Hunt and Zooplankton Datasheet).

Vocabulary

Hypothesis - a prediction or educated guess that can be tested and can be used to guide further study.
Nansen bottle - equipment used to capture water samples from different depths below the surface.
Observation - the action or process of observing something or someone carefully in order to gain information.
Oxygen - the colorless odorless gas necessary for most life, a small amount which can dissolve in water, and constitutes 20% of air.
Plankton - microscopic drifting organisms, plants or animals, in the sea.
Temperature - the measure of heat that is measured with a thermometer and expressed in different scales (Celsius, Fahrenheit, Kelvin).
Salinity - the quantity of dissolved salt content in a volume of water.
Substrate - a surface or material on or from which an organism lives and grows.
Scientific method - a method of procedure or a process consisting of systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.
Water Quality Meter - instrument used to measure temperature, salinity, and oxygen in the water.

Materials

For teachers
- Laptop computer
- Presentation
- Internet connection

For students
- Notebook
- Pen or pencil

Classroom Activities

- 10 minutes presentation on scientific method and tools
  - TSO station

        - YSI water quality meter
    - Scavenger Hunt station
        - Depth line
        - Underwater camera
        - Field guide
    - Pink Bacteria Layer station
        - Nansen bottle
    - Plankton & Microscope Use station
        - Microscope
        - Concave slides and cover slip
        - Field guide
        - Zooplankton net and line

Thinking Corner

1. What do you think happens to temperature and oxygen as you go deeper in the water?
2. Which animal do you think will be easiest to find? Hardest to find? Why?
3. What do you think the pink bacteria layer will smell like?

Lesson 04: Classification System

Background Information

Classifying organisms is an important process that helps with identifying the different species and understanding their relationships with each other. It also allows us to measure the diversity (number of species) of living things as well as learn about similarities and differences between organisms. The **Linnaean classification system** is a method of classifying living things based on **morphology** (the structure, shape and size of an organism). Species are given a unique two-part scientific name, referred to as **binomial nomenclature**, consisting of the genus (first) and species (second) name. This system is very important as it helps us to categorize and identify

animals or plants and separate them from one another. It also helps us to understand the relationship between groups of plants or animals at different levels. In this lesson, students will learn to classify organisms found in the lake to their **phylum** level. It will help familiarize themselves with the kind of living organisms that can be found in Jellyfish Lake versus organisms found in the lagoon in coral reef environments.

Vocabulary

Binomial nomenclature - a system of nomenclature in which each species of animal or plant is given an identifying two part "scientific" name (genus and species). The name of this species is used by everyone in the world, no matter what language they speak.
Classification - to organize or arrange species in groups or categories according to shared qualities or characteristics.
Linnaean classification system - a method used to identify and classify living things based on their morphology.
Morphology - study of the size, shape, and structure of animals and plants and of the relationships of their constituent parts.
Phylum - a major principal taxonomic category that represents the major groups of plants and animals.

Materials

For teachers

- Laptop computer
- Presentation
- Internet connection

For students

- Notebook
- Pen or pencil
- Classification field guide

Classroom Activities

- 5 minutes on Classification System & organisms found in Jellyfish Lake.
  - Common name
  - Phylum
  - Genus & species
- 5 minutes on Q & A and practice using scientific tools.

Thinking Corner

1. Name a common type of reef organism (invertebrate) that is NOT found in Jellyfish Lake?
2. Other than morphology, what are other ways to classify (or find similarities or differences) between organisms?

Day 2 – Exploring Jellyfish Lake Using the Scientific Method and Tools

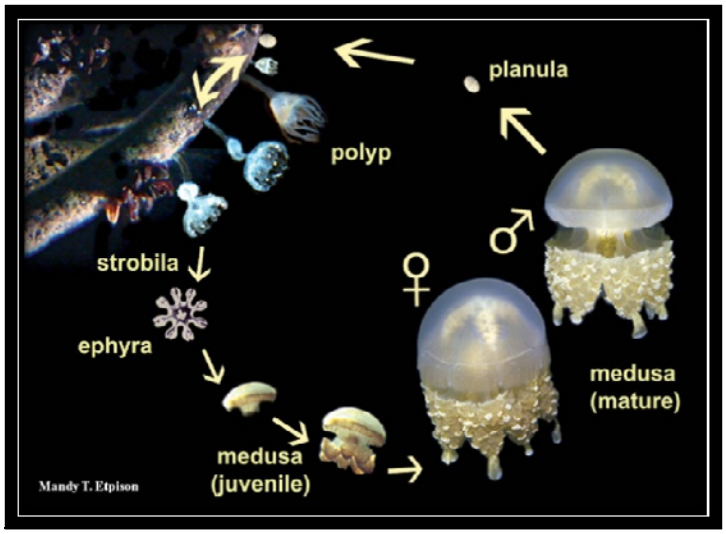
During the field day, which will take up a whole school day (8am - 2:30pm), students will cover a few steps of the scientific method such as gathering information, forming a hypothesis, and testing their hypothesis. After traveling by boat through the rock islands, students will arrive at Jellyfish Lake. On the dock, they will first go through the Golden jellyfish life cycle before the hike over the hill to the lake. There they will split into four (4) groups and complete the four study stations. The four stations are: (1) Temperature, Salinity & Oxygen (TSO) profile; (2) Pink Bacteria Layer; (3) Plankton and Microscope Use; (4) Scavenger Hunt for lake organisms. These groups will rotate stations, and each group will complete at least two stations, depending on time. After the activities in the lake, students will pack up and leave to a nearby rock island for lunch. Students should read the lesson plans for Day 2 (below) the night before to prepare for field trip.

	LESSON	PROGRAM OBJECTIVES	MOE OBJECTIVES	STANDARDS
Lesson 01	**Temperature, Salinity and Oxygen (TSO) Profile**	Students will be able to do the following: -I can practice observation skills, using my five senses and recording what I see, hear, smell, taste, and touch. -I can use the Nansen bottle to locate the pink bacteria layer in Jellyfish Lake. -I can compare and contrast living things in Jellyfish Lake. -I can identify the invasive sea anemone in Jellyfish Lake. -I can use a microscope to observe zooplankton in the field.	Science Practices: -Get, analyze, and interpret data. Life Sciences: -Investigate local environments and research other kinds of island environments to describe, classify, and compare the biodiversity of animals in these environments. -Analyze the adaptations that help the populations of different organisms to be successful in their environments.	-Make and record observations and/or measurements that can be used as evidence to explain a phenomenon. -Classify animals in Palau environments as vertebrates, invertebrates, sponges, cnidarians, worms, mollusks, arthropods, echinoderms, amphibians, fish, reptiles, birds, and mammals. -Compare and contrast the biodiversity of animals in different Palau environments. -Define adaptation as a feature or behavior of a species that makes it possible for organisms of that species to survive in their natural environment.
Lesson 02	**Pink Bacteria Layer**			
Lesson 03	**Plankton and Microscope Use**			
Lesson 04	**Scavenger Hunt for Lake Organisms**			

Lesson 01: Temperature, Salinity & Oxygen Profile (TSO Station)

Background Information

Temperature, Salinity and **Oxygen** (TSO) are important parameters to consider when studying Jellyfish Lake and organisms that reside in the lake. All three affect the numbers and distribution of Golden jellyfish found in the lake. For example, if temperature of the lake increases above 31.5°C (degrees Celsius) for a long time (weeks to months), then the number of the Golden jellyfish will decrease. Since life in Jellyfish Lake is only found in the upper 15 meters of the lake water, students will record their data from 0–15 meters to document how TSO changes with depth (Appendix 5: TSO Profile and YSI Manual).



Jellyfish have a life cycle with two stages: the **medusa** and the **polyp**. The polyp form lives on the side of the lake, and does not move. The medusa is the swimming form of the jellyfish. Male and female medusa release sperm and eggs. The egg is fertilized, and it develops into a swimming **planula** or larva. The larva has hair-like structures, or **cilia,** that help it to swim to the side of the lake where it attaches to the substrate (bottom or other object). The larva, now attached to the lake's side, will turn into a polyp. The polyp eventually starts to produce **ephyrae** or baby jellyfish that break free from the polyps and grow into free-swimming medusae.

When the lake becomes too warm (above 31.5°C), the medusa (or free swimming) stage will eventually disappear, but the polyps are more resistant to high temperatures and will survive on the sides of the lake. However, at those temperatures, the polyps will not produce any ephyrae or baby jellyfish. Instead, they go into a "resting" state. If the temperature of the lake continues to increase, then the Golden jellyfish will disappear as the older jellyfish die and no young ones are produced to replace them. Only when conditions go back to normal (lower temperatures) will the polyps start producing ephyrae and medusae again, resuming the cycle of life. This is how the medusae population is able to recover after they have "disappeared" from the lake for a long time.

Vocabulary

Cilia - hair-like structure surrounding a planula that helps it to swim.
Ephyra - a larval jellyfish, after it has separated from the strobila/polyp, or very tiny medusa (<0.5 cm). Ephyrae is the plural form.

Medusa - the swimming form of the jellyfish with an umbrella-shaped bell and oral arms. Medusae is the plural form.
Oxygen - the colorless odorless gas necessary for most life, a small amount which can dissolve in water, and constitutes 20% of air.
Planula - a free-swimming jellyfish larva, planulae is the plural form.
Polyp - the bottom-dwelling stage of the jellyfish life cycle found on the sides of the lake.
Salinity - amount of salt dissolved in a volume of water.
Temperature - the measure of heat that is measured with a thermometer and expressed in different scales (Celsius, Fahrenheit, Kelvin).

Materials

For teachers

- Bin
- Towels
- Underwater camera
- Water quality meter
- Floating chair (1)
- First aid kit

For students

- Clipboard with datasheet
- Pencils
- Mask, fins and snorkel
- Life jackets

Field Activities

- 40 minutes recording TSO and observe jellyfish
  - 10 minutes to give time for students to look at jellyfish as they swim from the dock to the station
  - 20 minutes to record TSO data from 0m down to 15m (Appendix 5)
  - 10 minutes to discuss how documenting TSO is important to the lake and the Golden jellyfish

- 5 minutes to pack gear and move to the next station

Thinking Corner

1. What depth in the lake has the highest temperature?
2. At what depths do marine organisms live in Jellyfish Lake?
3. What depth has the lowest salinity? Why?

Lesson 02: Pink Bacteria Layer

Background Information

Jellyfish Lake is a stratified lake, with three layers of water like a cake. The top layer of water has oxygen and the bottom layer has no oxygen. The thin middle layer is pink from a type of **bacteria**. Below the pink bacteria layer, hydrogen sulfide is present in the water. **Hydrogen sulfide** is a poisonous gas dissolved in the water that forms from the decomposition of living matter which has fallen into the lake and comes to rest on the bottom. High levels of hydrogen sulfide can kill most living things, so it is a good thing the hydrogen sulfide is trapped beneath the pink layer.

The students will be given a **Nansen bottle** (Appendix 6: Nansen Bottle Instructions), a device that is lowered on a line from the surface and used to capture water samples at different depths. They will use the Nansen bottle to locate the pink bacteria layer and note the smell and color of the water collected from different depths (Appendix 3).

Vocabulary

Bacteria - a tiny unicellular microorganism with a cell wall but lacking an organized nucleus. They are found almost everywhere, in large numbers and some types can cause disease.
Hydrogen sulfide - a colorless gas with the distinct bad odor of rotten eggs. It is poisonous.
Nansen bottle - a device that is lowered on a line from the surface and used to capture water samples from different depths.

Materials

For teachers

- Nansen bottle
- Inflatable chair
- Cross arm for the chair
- Fins, mask and snorkel
- Underwater camera

For students

- Clipboard with datasheet
- Pencils
- Mask, fins and snorkel
- Life jacket
- Underwater camera

Field Activities

- 40 minutes locating the pink bacteria layer
  - Learn how to use the Nansen bottle
  - Determine the range of depth you will sample
  - Students will take turns to drop the Nansen bottle and search for the pink layer
  - All students will smell and identify the color of the captured sample
  - Discuss why it's important to monitor the depth and thickness of the pink layer
  - Explain to students why the layer is there and why it smells
- 5 minutes to swim to the next station

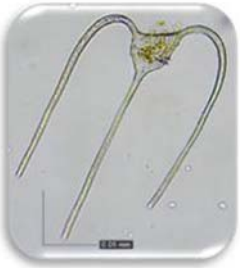
Thinking Corner

1. What makes this layer pink?
2. What makes the layer smell?
3. What other habitat smells like the pink layer?

Lesson 03: Plankton and Microscope Use

Background Information

There are two types of tiny plankton in Jellyfish Lake. The first, **zooplankton**, are tiny drifting animals, and the second, **phytoplankton**, are tiny drifting plants (microalgae). Phytoplankton are generally much smaller than zooplankton and are eaten by zooplankton for food. Both are essential parts of the Golden jellyfish **food web**. The



Golden jellyfish gets its food in two ways. Jellyfish use their oral arms to sting and eat zooplankton. They also get food through another type of microalgae that lives inside their tissue, called **zooxanthellae**. This algae produces food from sunlight through **photosynthesis**.

In this part of the lesson, students will collect samples using a **plankton net** (Appendix 7: Plankton Net Instructions and Features) with a very small mesh size of 80 **microns**. The net allows for water to filter through, leaving plankton trapped by the net and funneled into a bottle screwed to the end of the net. After about 3 tows with the plankton net, the students will have enough samples. They will bring samples to the dock where **microscopes** are set up in the ranger's station. Students will use the microscopes (Appendix 8: Microscope Instructions and Features) to identify plankton and draw what they see on their datasheet (Appendix 4). Students are also given a field guide (Appendix 9: Plankton Field Guide) that will help them to identify zooplankton and phytoplankton.

Vocabulary

Food web - a graphical model depicting the many food chains linked together to show the feeding relationships of organisms in an ecosystem.
Microscope - an optical instrument used for viewing very small objects, such as animal or plant cells, typically magnified several hundred times.
Micron - a very small unit of measurement, also known as micrometer. There are about 25,000 microns in an inch.
Photosynthesis - the way in which green plants and some other organisms use sunlight to produce food.
Phytoplankton - tiny drifting plants (algae) in the sea.
Plankton net - filter net with a very small mesh size of 80 microns used for collecting samples of plankton.
Zooplankton - tiny drifting animals in the sea.
Zooxanthellae - a golden-brown symbiotic, microscopic algae, or plant, present in the tissue of many marine invertebrates, such as corals and some jellyfish.

Materials

For teachers

- Inflatable chair
- Plankton net
- Plankton jars
- Microscope
- Plankton field guide
- Kim Tech wipes
- Slide and cover slip
- Pipette
- Filter and Tupperware
- Bin for rinsing
- 1 gallon fresh water
- Towel
- Underwater camera

For students

- Clipboard with datasheet
- Pencils
- Underwater camera
- Mask, fins and snorkel
- Life jacket

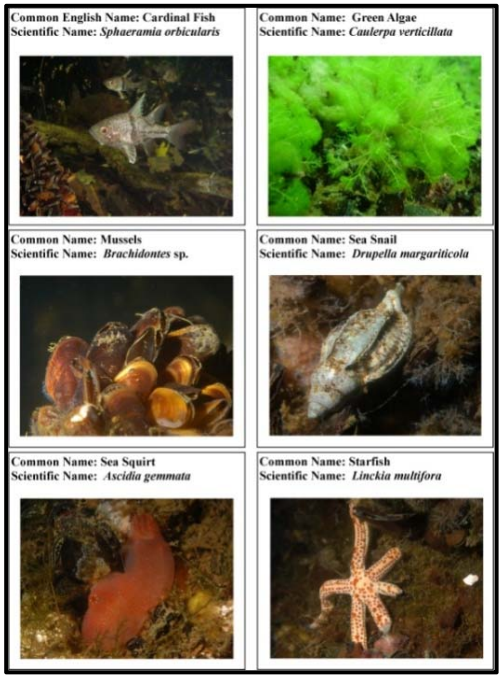
Field Activities

- 40 minutes on plankton and microscope use
  - 20 minutes collecting plankton samples
  - 5 minutes overview of importance of plankton and the Golden jellyfish food web
  - 15 minutes looking for them under the microscope, identifying and drawing plankton
- 5 minutes to get ready for the next station

Thinking Corner

1. Why is it important to study plankton in Jellyfish Lake?
2. How do phytoplankton get their food?
3. What do the Golden jellyfish in Jellyfish Lake eat?

Lesson 04: Scavenger Hunt for Lake Organisms



Background Information

The Linnaean classification system is a method used to classify living organisms based on their different characteristics. This system is very important as it helps distinguish different species among millions of living organisms. It also helps us to understand the relationships among groups of plants or animals.

As part of our marine lakes research, Coral Reef Research Foundation has conducted invertebrate surveys around Jellyfish Lake and other marine lakes to identify the different types of organisms found in the various lakes. Within Jellyfish Lake, surveys have been done to determine how much of the lake side (the percent cover) has been taken over by the invasive brown sea anemone, as well as other marine invertebrates living on the side of the lake.

In this activity, the students look for and identify different types of living things in a marine lake and document where they are found (Appendix 10: Scavenger Hunt Instructions). Students will be given a field guide (Appendix 11: Scavenger Hunt Field Guide) and a datasheet with a list of targeted organisms to look for in the lake (Appendix 4). For example, they will be asked to look for the **invasive** brown sea anemone and compare it with the lake's **endemic** white sea anemone. Students are required to determine the depth and substrate where each organism occurs, as well as their color and **phylum**. Students will also take photos of the organisms they find. This activity will allow students to explore the community of organisms living in the mangrove habitat of Jellyfish Lake.

Vocabulary

Endemic species - any living organism that is native and limited to a single defined geographical location, such as an island.
Invasive species - any living organism that is not native to an ecosystem and causes harm.
Phylum - a major principal taxonomic category that represents the major groups of plants and animals.

Materials

For teachers

- Underwater camera
- Field guide
- Depth line
- Mask, fins, and snorkel

For students

- Clipboard with datasheet
- Pencils
- Mask, fins and snorkel
- Life jacket
- Underwater camera

Field Activities

- 40 minutes scouting, identifying, and classifying lake organisms
  - Students will be given a list of organisms to look for in the lake along with their field guides
  - On their datasheet, they will take notes on each organism
    - Classify them to their phylum level
    - Determine the depth of organism
    - Identify color
    - Identify substrate
    - Photograph each organism for class reference
  - 5 minutes to prepare for the next station

Thinking Corner

1. What lake organisms are similar to those in the lagoon?
2. What was the smallest organism that you found?
3. Are there seagrass in Jellyfish Lake?

Packing and Leaving the Lake:

After two rotations to allow groups to complete at least two stations, everyone should meet back at the dock to prepare to leave. Teachers should collect datasheets, cameras, depth lines and field guides. Chairs should be deflated and packed. Kayaks should be put back on dock. Pack all other equipment.

Students should carry all their belongings, including their fins, mask, snorkel and life jackets out of lake. EVERYONE should check for trash or anything left behind and carry it out of the lake. Work together to make sure nothing is left behind, especially trash.

After all activities in the lake, everyone will leave to a nearby rock island for lunch:

- 30 minutes - 1 hour lunch break
- 30 minutes to swim, relax and process the information obtained from the lake activities
- Head back to Koror by 2:00 pm

Day 3 – Data Analysis and Presentation of Results and Conclusions

In this part of the program, students will cover the last step of the scientific method, which is analyzing data and sharing the results and conclusions. Now that the students have gathered the information and data, it's time to make sense of it. Data analysis is an important step of scientific surveys as it helps us to understand our results and draw conclusions based on our results. Data are analyzed and presented in the form of a presentation or printed report that is easy for the audience to understand. The students will graph their data and use photos to identify species.

Students will discuss with their group members and teacher about how to make informative statements with their data, so that everyone and anyone can understand what they did and why. After analyzing the data, each group will take turns going up to the front of the class to present their data to the class.

	LESSON	OBJECTIVES	MOE Objectives	STANDARDS
Lesson 01	**Analyze Temperature and Salinity Data**	Students will be able to do the following: -I can make informative statements based on my data and observations I collected during the field trip. -I can explain why Jellyfish Lake is	Science Practices: -Get, analyze, and interpret data -Make, evaluate, and communicate conclusions.	- Organize collected data in a table and/or graph that helps show a pattern of relationship -Use data to evaluate conclusion about causes and effects. -Use tables, diagrams and/or charts to communicate results of an investigation. -Communicate
Lesson 02	**Analyze Pink Bacteria Layer and Oxygen Data**			
Lesson 03	**Identify Plankton samples and Explain Food Web**			

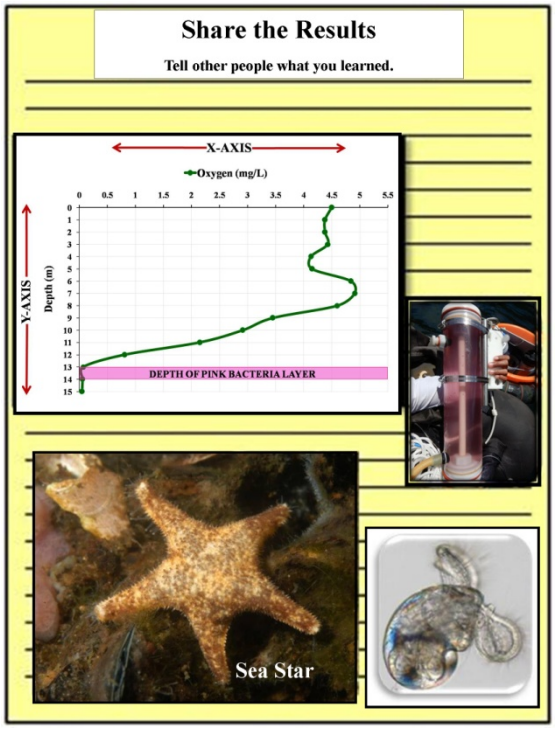
Lesson 04	**Identify Organisms to Phylum and Identify Common Species**	important. -I can identify ways to protect the environment.		investigation procedures, data, reasoning and conclusion orally and in written formats including various forms of media.

Lesson 01: Analyze Temperature and Salinity Data

Background Information

Temperature and **salinity** are monitored in Jellyfish Lake, because they affect the marine organisms, especially the Golden jellyfish population, in the lake. If water temperature is too high (over 31.5°C) for a long period of time (weeks to a month), the polyp stage of the jellyfish will stop producing baby jellyfish or ephyrae, leading to a decline in the jellyfish population. The Golden jellyfish medusa will also bleach; meaning the zooxanthellae that live in its tissue will leave the body of the jellyfish. Without the zooxanthellae, the jellyfish will look white or clear. It is not well understood if a bleached jellyfish can reproduce or not; however, it is very clear that warm water temperature does affect the polyps and the life cycle, and that is why it is important to document the lake's water temperature.

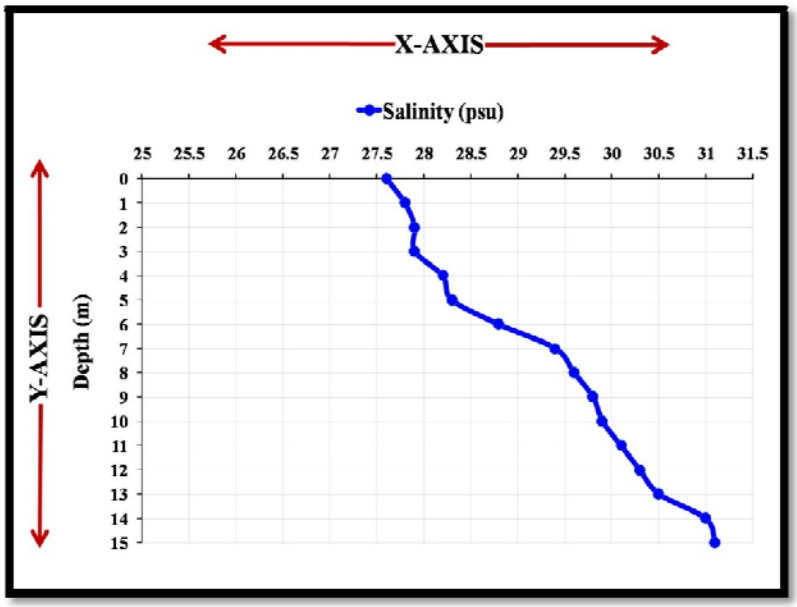
Studying the salinity of the lake will help us to understand how freshwater input, evaporation and mixing of the lake water can affect salinity. Salinity can affect marine life in the lake. We also study how local weather patterns, such as wind and rainfall, affect lake water temperature and salinity. If there is no wind to mix the top layer of water and no freshwater input from rainfall, both temperature and salinity can increase in the top layer of Jellyfish Lake.



Students will graph their temperature and salinity data using a line graph. Students can either use Microsoft Excel on a computer or graph paper. To graph their data, students should learn the parts of the graph. The **x-axis** is the horizontal line of the graph that displays the values of temperature and salinity. Numbers increase from left to right on the x-axis, with the minimum value on the left end and the maximum value on the right end of the x-axis. The **y-axis** is the vertical line that displays the depth of the lake. To match the lake depth profile, we put the x-axis at the top of the graph, and label the y-

axis with zero (0) at the top (representing the lake surface), increasing in number (depth) as you go down. The line graph will show how temperature and salinity changes as depth increases. As depth increases, does the temperature and salinity increase or decrease?

For their presentation, students should be able to explain parts of the graph (x and y axis), what the graph is showing and what the different numbers on the y-axis and x-axis represent. They should explain the pattern of temperature and salinity with depth—how does temperature and salinity change with depth? Students can use the review questions (Appendix 12: Review Questions for Each Station) to guide them in their presentation.



Vocabulary

Salinity - the quality or degree of being saline, the amount of salt in water.
Temperature - the measure of heat that is measured with a thermometer and expressed in different scales (Celsius, Fahrenheit, Kelvin).
X-Axis - is the horizontal axis of a graph that displays text labels and numerical values.
Y-Axis - is the vertical axis of a graph that displays text labels and numerical values.

Materials

For teachers

- Computer
- Projector
- Presentation
- Graph paper (if not using computer to graph)

For students

- Datasheet from field day
- Pen or pencil
- Photos from field day
- Review questions
- Graph paper (if not using computer to graph)

Classroom Activities

- 15 minutes discussion and analyzing data
  - Graph
  - Answer and discuss review questions
    - What is temperature?
    - What is salinity?

- How did you measure temperature and salinity? To what depth?
- Explain graphs (x-axis, y-axis, lines).
- Explain what is happening to temperature and salinity.
- Why are temperature and salinity important?
- Optional: Compare lake temperature and salinity to ocean.

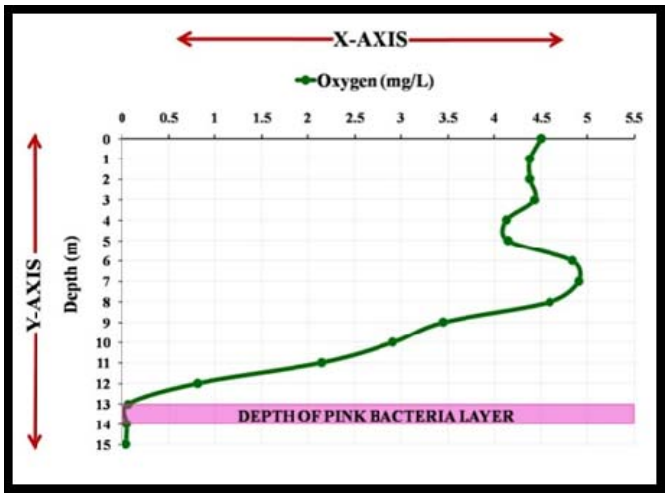
- 25 minutes presentation
- 5 minutes Q & A

Lesson 02: Analyze Oxygen Data and Pink Layer of Bacteria

Background Information

Nearly all life on Earth depends on **oxygen** for living. The levels of oxygen dissolved in the water determine where organisms live in Jellyfish Lake; most living things will be found in the upper layer of water that has oxygen. Living things can die in the lake when oxygen levels become too low. Below the **pink layer of bacteria**, there is no oxygen and only other types of **bacteria**. Instead of oxygen, there is **hydrogen sulfide** dissolved in the water, a poisonous gas produced by decomposing living things. It is the hydrogen sulfide that makes the lake water smell like rotten eggs. High levels of hydrogen sulfide can kill living things.

The pink layer is only an interface or boundary between the layer with oxygen and the layer without oxygen. It is there because it is a suitable habitat/depth for these particular bacteria, which gives the layer a pink color. Below the pink layer, it gets dark because the pink layer blocks light from reaching depths below. The pink layer and **anoxic** layer can move up or down with **density** changes in lake water. Over years, the pink layer has been as shallow as 8m and deep at 15m.



During this part of the lesson, students will join their group from the field day to discuss and analyze their data. Students will either be given a computer or graph paper to graph their oxygen data. If both are not available, they can use a white board to graph their oxygen data. Similar to the temperature and salinity graphs, the oxygen graph will be a line graph. The x-axis, or horizontal line, will represent oxygen. Values will increase from left to right, with the minimum oxygen level on the left end and the maximum oxygen level on the right end. The y-axis, or vertical line, will represent the depth of the lake. Values will decrease from top to bottom, with the minimum value (0m) at the top end and the maximum value (15m) at the bottom end of the y-axis. The x-axis will be at the top of the y-axis, crossing

the y-axis at 0m. The oxygen is graphed by connecting each data point that shows the oxygen level at each depth, and the results should show how oxygen levels change with depth.

After graphing their oxygen data, students can identify and highlight the depth of the pink bacteria layer within their oxygen graph. The depth of the pink layer, determined from the Nansen bottle collection, should match the depth where the oxygen level is zero (or close to it). There are also review questions (Appendix 12) that students should answer as these will help them to better understand and explain their data to their classmates.

When presenting data, students will define oxygen and explain what the y-axis and x-axis on their graph represent. They should explain the changes in dissolved oxygen with depth. Students will also show the depth where living organisms are found in the lake based on their oxygen graph. The students will also define the pink bacteria layer and describe the smell. It is important for students to point out the depth or thickness of the pink bacteria layer.

Vocabulary

Anoxic - absence of oxygen in a body of water.
Bacteria - a tiny unicellular microorganisms with a cell wall but lacking an organized nucleus. They are found almost everywhere, in large numbers and some types can cause disease.
Density - mass of a substance per unit volume; lighter water will float on top of heavier water.
Hydrogen sulfide –-a colorless gas with the characteristic bad odor of rotten eggs. It is poisonous.
Pink layer of bacteria - A layer of pink bacteria that usually forms in stratified lakes between the top and bottom layers of water in the lake.
Oxygen - the colorless odorless gas necessary for most life, a small amount which can dissolve in water, and constitutes 20% of air.

Materials

For teachers

- Computer
- Projector
- Graph paper
- White board
- Presentation

For students

- Datasheet from field day
- Pencil
- Review questions

Classroom Activities

- 15 minutes discussion and analyzing data
  - Graph
  - Answer and discuss review questions
    - What is Oxygen & why is it important?
    - How did you measure oxygen?
    - Explain graphs (x-axis, y-axis, lines).

- Explain the data line, what is happening to oxygen?
- Show where living organisms are, and where you would not find living organisms.
- What is the pink layer?
- What makes it pink?
- What makes it smell?
- At what depth did you find the pink layer?
- **BONUS:** Why is the smell only at a certain depth? What keeps it there?

- 25 minutes presentation
- 5 minutes Q & A

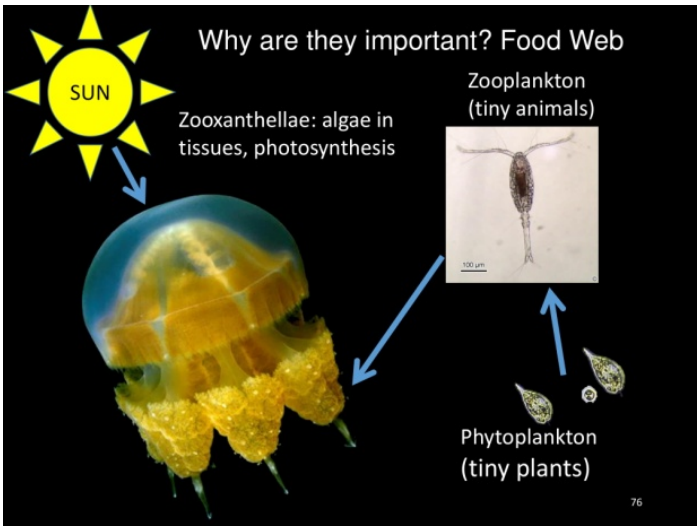
Lesson 03: Identify Plankton Samples and the Food Web

Background Information

Plankton in Jellyfish Lake

There are two types of plankton in Jellyfish Lake. There are **zooplankton**, which are tiny drifting animals. **Phytoplankton** are much smaller tiny drifting plants, which zooplankton feed upon. The zooplankton found in Jellyfish Lake are mostly copepods, but also include mussel and snail larvae. There are different types of phytoplankton in Jellyfish Lake, including a group called **diatoms** (such as *Chaetoceros* sp.) which are abundant. Both zooplankton and their prey phytoplankton are essential parts of the Golden jellyfish **food web**.

Food Web in Jellyfish Lake



The golden color of the Golden jellyfish comes from symbiotic algae (zooxanthellae) that live in their tissues. The zooxanthellae provide part of the food for the jellyfish through photosynthesis. Golden jellyfish also get some of their energy by capturing (using **stinging cells**) and eating zooplankton. The small zooplankton feed on the even smaller phytoplankton, which like the **zooxanthellae**, get their energy from the sun through photosynthesis. Both food sources are needed for the Golden jellyfish

and if just one food source is depleted, then that can affect the population of the Golden jellyfish.

During this last day of the class, students will join their group from the field day and organize their field photos of their samples taken through the microscope. While organizing their photos and drawings, students will need to identify their plankton and separate zooplankton photos and phytoplankton photos. Students will also be given the food web of the Golden jellyfish to review before presenting their data. Showing the food web to the class will make it easier for other students to understand how both types of plankton are important to the Golden jellyfish. There are also review questions (Appendix 12) for this exercise that students will need to answer and use as a guide to their presentation.

Vocabulary

Diatoms - single-celled algae that live in houses made of glass (a cell wall made of silica).
Food web - a graphical model depicting the many food chains linked together to show the feeding relationships of organisms in an ecosystem.
Phytoplankton - tiny drifting plants in the sea.
Stinging cells- specialized cells that contain the stingers and poison used to kill prey for feeding.
Zooplankton - tiny drifting animals in the sea.
Zooxanthellae - tiny plant-like organisms (microalgae) that live in the jellyfish tissue giving it its golden color.

Materials

For teachers

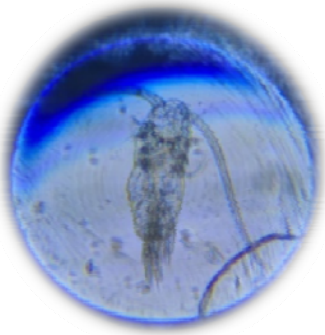
- Computer
- White board
- Presentation

For students

- Datasheet from field day
- Pen or pencil
- Review questions
- Photos from field day
- Food web

Classroom Activities

- 15 minutes discussion and analyzing data
  - Answer and discuss review questions
    - What is zooplankton?
    - What is phytoplankton?
    - How did you collect them? Describe the method.
    - What did you find using the microscope?
    - Why are plankton important?
      - Explain the food web.
- 25 minutes presentation
- 5 minutes Q & A



Lesson 04: Identify Organisms to Phylum and Identify Common Species

Background Information

Jellyfish Lake is an important area of biodiversity. While it does have some unique elements (such as the endemic Golden jellyfish) it also has some similarities to a mangrove habitat. Many of the organisms in the lake do not live in the open ocean. In Jellyfish Lake, you will find an invertebrate community of sponges, mussels, sea squirts and sea stars, and algae. However, unlike the reefs, there are no corals in Jellyfish Lake. The scavenger hunt is a good way for the students to identify and classify organisms that live in this type of marine environment and be able to compare them to familiar organisms on the lagoon coral reefs.

Classification is important because it helps students to learn and understand the features, similarities and differences between organisms. Classifying organisms is an important part of any biological survey and provides information to help the community or resource managers designate areas for conservation. For example, if a **threatened species** is identified within the study area, then the resource managers can close the area in order to protect that species. Other times, if species are identified to be abundant in only one particular area, then the area can be closed to protect that population.

In this lesson, students will join their group from the field day and organize their photos and field notes. Students will identify marine species found during the scavenger hunt; they should identify both the common names and phylum. Students are also given review questions (Appendix 12) that will help them to present data.

During the presentation, students will explain to their classmates their site study, what they did and what makes the survey an important part of the lake sampling. Students will also go through the list of their **targeted species** with photos from the field day. By doing this, the rest of the class will be able to see the photos as well as learn about the common name, phylum, genus and species for targeted organisms.

Vocabulary

Targeted species - chosen group of species for monitoring or to be studied.
Threatened species - species that can be endangered in the near future.

Materials

For teachers

- Computer
- White board
- Presentation

For students

- Field guides
- Photos from field day
- Datasheet from field day
- Pencil

Batstar, new species

Sea Star

Linckia multifora

Classroom Activities

- 15 minutes discussion and analyzing data
  - Answer and discuss review questions
    - What is the habitat like?
    - What did you find? Name the phylum and common name of organisms in your pictures.
    - Explain the phylum by describing what kind of animals are in those phyla?
    - What was the easiest to find?
    - What was the hardest to find?
    - Are there corals in Jellyfish Lake?
    - What gives the Golden jellyfish its golden color? Does the Moon jellyfish have the same color?
- 25 minutes for all four presentations (about 6 min/presentation)
- 5 minutes Q & A

Thinking Corner

1. What makes Jellyfish Lake unique?
2. Is monitoring useful? In what ways?
3. What can we do to protect Jellyfish Lake and our natural environments?

APPENDIX 1: FIELD TRIP APPLICATION

REPUBLIC OF PALAU

MINISTRY OF EDUCATION

BUREAU OF CURRICULUM & INSTRUCTION

Workshop Title: Back to Nature: Jellyfish Lake

Workshop Agenda:

1. Explore and learn about Jellyfish Lake & climate change using scientific tools and
    a. Documenting the temperature, salinity and oxygen of the lake water.
    b. Finding the depth and thickness of the pink bacteria layer in the lake.
    c. Using a plankton tow to collect plankton and identifying them under a field microscope.
    d. Surveying common organisms in the lake and identifying them down to the phylum level.
2. Observation of the lagoon habitat
    a. Visit a nearby beach for snorkeling.
    b. Compare the lagoon habitat to the lake habitat.
    c. Compare and contrast the lagoon organisms vs. lake organisms.

FIELDTRIPS REQUIREMENT

1. Cover Letter

A. The letter should be written on your school letterhead or has the name of your school at the top of the page.
B. The letter should indicate the date it was written and be addressed to the Chief of School Management.
C. The letter must be approved and signed by the school principal.
D. The subject should indicate that it is a field trip request.
E. The body of the letter should include:

1. Purpose of the field trip
2. Grade level or grade levels involved
3. Number of trip participants – Specify number of students teachers, parents and others
4. Date or dates and time or times of the field trip
5. Destination and description of area or areas and their significances
6. Affirmation of parents' consents to indicate that they give their children approval to participate in the field trip

F. Signature or signatures of the teacher or teachers involved in the field trip

2. **Lesson Plans:** Include copies of your lesson plans for core subjects for the fieldtrip.
   A. Lesson plans must be written on the MOE lesson plan template.
   B. Lesson plan must be aligned to the appropriate quarter learning targets.
   C. Lesson plan must be completely filled out.
   D. All activities in the lesson plan must be completed within a reasonable time after the trip.

3. **Schedule:** Include a schedule of activities during the trip.
   A. Your schedule should detail all activities during the entire day or days and times of the field trip.

4. **Trip Report:** Submit a report about your field trip within a week after the event had taken place.

   A. Briefly explain whether or not your goals and objectives were met.
   B. Report any specific incidents, accidents or occurrences that may have happened during the trip.
   C. If you received any donations from your state, other states, agencies, or individuals like food, supplies, or transportation etc., please include them in your report.
   D. Turn in your report to your school principal no later than one week after your field trip.
   E. Finally, send a copy of your field trip report to the Chief of School Management.

6. **Submissions and Approval of Field Trip Request:** The central office must receive your request at least **2 weeks prior** to the date of your field trip.

   A. The content area specialist will review your lesson plans for approval. In instances that lesson plans need improvement, the specialists will notify you with advice to consider.
   B. Transportation will be provided on availability on a "first come, first serve basis" and to the accordance of the existing rules.
   C. Arrangement for transportation will be made either by your school or the Chief of School Management upon the approval of the Chief of School Management.

REPUBLIC OF PALAU
MINISTRY OF EDUCATION

BUREAU OF CURRICULUM & INSTRUCTION

Sample cover letter

August 18, 2020

To	:	Chief of School Management Division of School Management
Thru	:	Principal _____ ABC School
From	:	Eight Grade Teacher ABC School
Subject	:	Field Trip Request

This is a field trip request for my 12 eight grade students and I to go explore **Jellyfish Lake** on September 25, 2020. We have been studying the Science learning target **(6.LS.3Investigate local environments and research other kinds of island environments to describe, classify and compare the biodiversity of animals in these environments**); therefore, I would like to extend this lesson to include a fieldtrip opportunity for my students to explore and understand the characteristics of Jellyfish Lake. As a teacher, I thought that a first-hand experience of the marine lake would enhance my students' knowledge and understanding of the marine environments of Palau.

Even though the main purpose of the trip is for **Science**, the other four core subjects will be incorporated during this trip in order to maximize the use of the trip. The lesson plans as well as the trip schedule, chaperon list, and transportation request are attachments of this letter for your review and approval.

I also have collected the signed parental consent forms for my students to participate in this trip that can be reviewed upon request.

Thank you very much for your attention on this matter and please contact me at the telephone number _____ for further information you may have regarding my request.

Sincerely,

Maria Joseph

Sample Field-Trip Schedule

Time	**Place**
8:00 am	Leave grounds of ABC School to NECO Dock, gather equipment and load boat
9:00 am	Leave NECO dock to Jellyfish Lake
9:30 – 10:00	Travel to Jellyfish Lake; hike over and get in the water
10:00	Begin stations
10:45	1st Rotation
11:30	2nd Rotation
12:15	Gather equipment, pack and hike out to the boat
12:45	Lunch at Ngermeaus Beach
13:30	Finish up and leave
14:30	Arrive ABC school

Sample Chaperon List

Chaperon	Title	Signature
Maria Joseph (cell ph: 779- 1516)	Eight grade teacher	
Andrew Michael	Parent	
Sandy Thomas	Parent	

APPENDIX 2: JELLYFISH LAKE POWERPOINT PRESENTATION

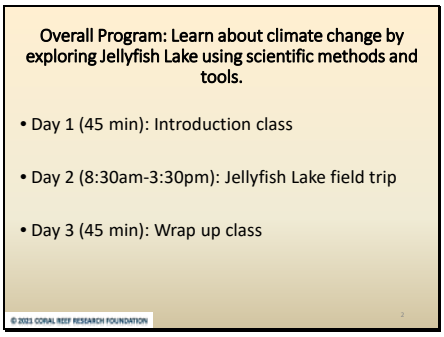
This Presentation has extra information that will help students better understand the geography of Palau. It has rock island formation as well as marine lakes formation. If the teacher feels like this information is too much, then it is okay to exclude these topics from the presentation and just focus on Jellyfish Lake and the Back to Nature Program. Otherwise, please make use of the entire presentation.

Slide 1

Side Notes for Teacher

The program started after the Coral Reef Research Foundation did a Jellyfish Lake awareness outreach to all 5th graders in Palau in 2016-2017. During that time, the CRRF realized that the majority of Palauan students have never been to Jellyfish Lake. CRRF then looked for funding and designed a program as an opportunity for Palauan students to explore Jellyfish Lake through scientific tools and methods.

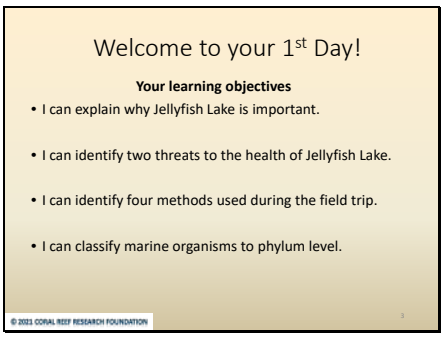
Slide 2



Side Notes for Teacher

The program aims to take all 6th - 8th graders of Palau to Jellyfish Lake, so that students can explore the lake and learn about climate change using scientific methods and tools. This is a 3 day program. The 1st is an introduction in the classroom, the 2nd day is a field trip to Jellyfish Lake to gather data, and the 3rd day is in the classroom where students will analyze and report their data.

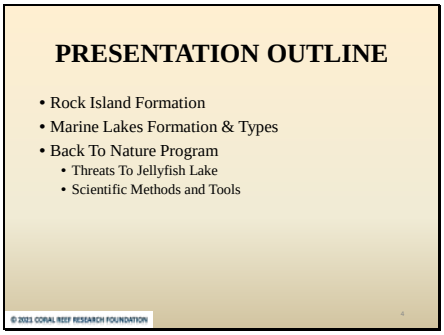
Slide 3



Slide Notes for Teacher

This is the first day of this 3 day program and your learning objectives for this day are…(read the objectives).

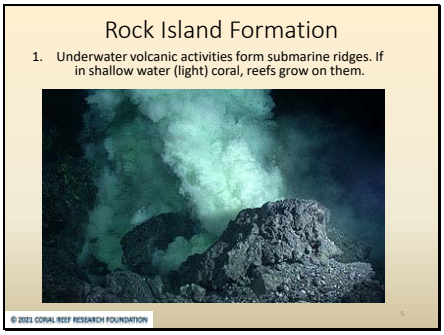
Slide 4



Side Notes for Teacher

This presentation will cover three topics: Rock Island formation, Marine lakes formation & Types, and the Back to Nature Program.

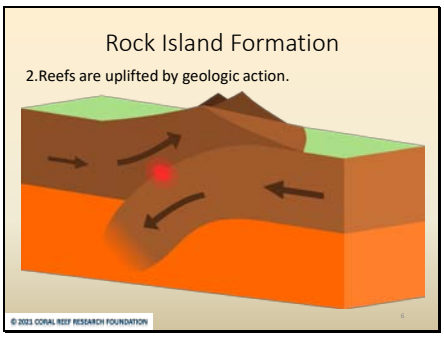
Slide 5



Side Notes for Teacher

Rock island formation begins with submarine volcanic activity forming ridges (the basement). When the ridges are uplifted into shallow water (where there is light) by tectonic activity, then coral reefs can start to grow on the basement, like icing on a cake. Over time the reef corals grow towards the surface, and build a structure made from coral skeletons. That is how coral reefs are formed.

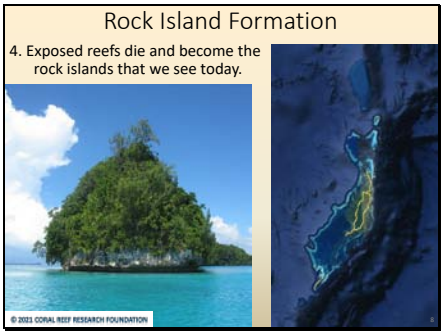
Slide 6



Side Notes for Teacher

During plate tectonic movement (when two plates are crushing against each other) or other geologic activity, the reefs growing on the basement rock are uplifted above the surface of the water, forming dry land made of old coral rock. Over time the barren rock will become a living rock island with trees and birds nesting. Plants and seeds can drift to the island or birds can disperse seeds that will then grow on this new island.

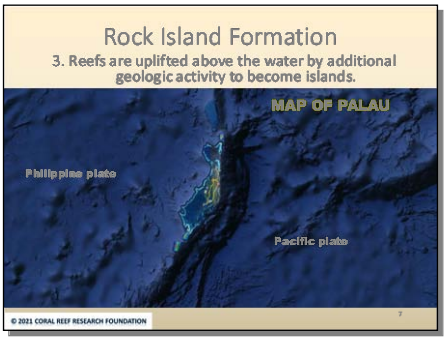
Slide 7



Side Notes for Teacher

Palau is an example of an island group formed on a submarine ridge, the Palau-Kyushu ridge. The ridge forms where the Pacific plate and the Philippine plate meet. The colliding plates caused the ridge, and any reefs growing on it, to be uplifted and raised above sea level. These uplifted reefs became what we call the rock islands today.

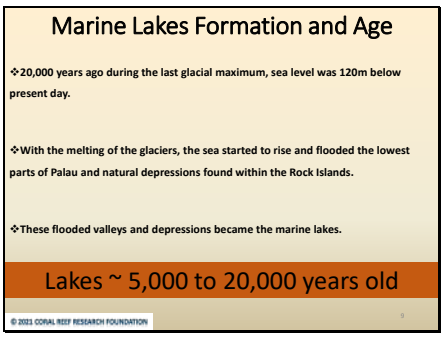
Slide 8



Side Notes for Teacher

The rock islands that you see today were submerged reefs a long time ago (25 million years).

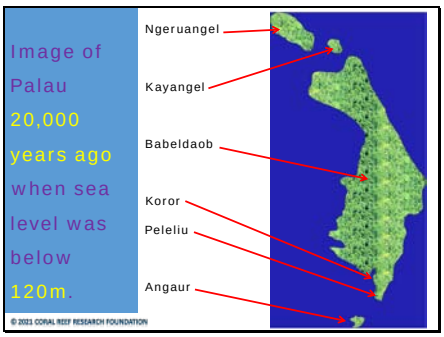
Slide 9



Side Notes for Teacher

Now that takes us to the marine lakes formation. So how did marine lakes form? About 20,000 years ago during the last glacial maximum (ice age), the sea level was about 120 meters below today's sea level. However, when the ice on land started to melt, the sea level began to rise as well. This flooded the lowest parts of Palau, filling up the hundreds of natural depressions found within today's Rock Islands. The water flooding into the island also carried eggs, larvae and juveniles of marine organisms into these lake depressions. These flooded valleys and depressions became the marine lakes that we see today.

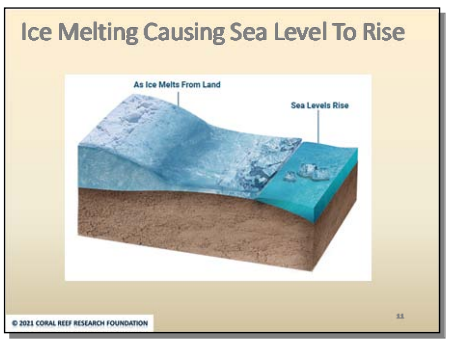
Slide 10



Side Notes for Teacher

Let us look closely at Palau 20,000 years ago. When the sea level was 120m lower than it is today, everything was dry land that today is shallow sea bottom. As a result, Palau had more landmass back then. Ngeruangel was a big island, almost as big as Babeldaob today. Kayangel was a single whole island, Koror and Peleliu were connected to Babeldaob and Angaur was bigger in terms of landmass compared to today.

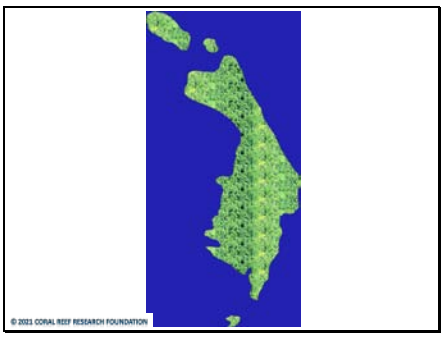
Slide 11



Side Notes for Teacher

This gif file here shows how the sea level changes due to ice melting. This is how the lowest parts of Palau flooded.

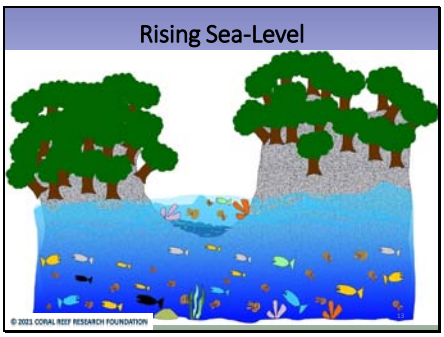
Slide 12



Side Notes for Teacher

This short gif file shows how water rose into the lowest areas of Palau as sea level rose. Seawater filled the lowest parts of Palau, starting with the natural dry depressions found throughout Palau. In the Rock island areas, water found its way through cracks and natural tunnels found beneath the islands and entered these dry depressions to cause them to become lakes. It also carried in the eggs and larvae of different marine organisms which became the permanent residents of the lakes that we see today. The rising sea caused islands to be separated by areas of water; Babeldaob, Koror and Peleliu became separate islands with lagoon waters in between. Kayangel had its lagoon fill and became a normal atoll.

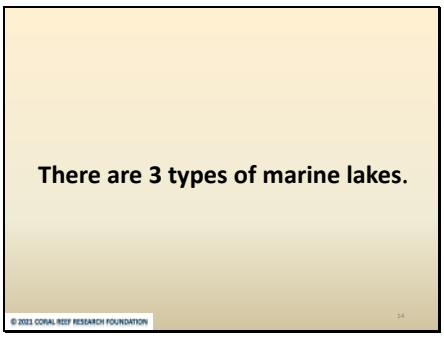
Slide 13



Side Notes for Teacher

This is a gif file of how lakes are formed during sea-level rise. As the water flooded (blue area) these dry depressions through small cracks and tunnels (black lines), it brought in larvae or eggs of organisms such as the Golden jellyfish that is found in Jellyfish Lake. Those that could survive in this newly isolated body of water became the permanent residents of the lakes that we see today.

Slide 14



Side Notes for Teacher

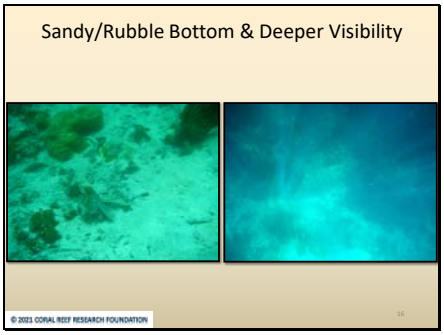
That is how marine lakes are formed, but are these lakes different? This question takes us to the three different types of marine lakes.

Slide 15

Side Notes for Teacher

The first type of lake that we will discuss is a holomictic or mixed lake. Holomictic or mixed lakes have big open tunnels that connect the lake to the surrounding lagoon. This allows for water exchange and organisms to move in and out of the lake, and also allows the lake to have a similar habitat to the surrounding lagoon.

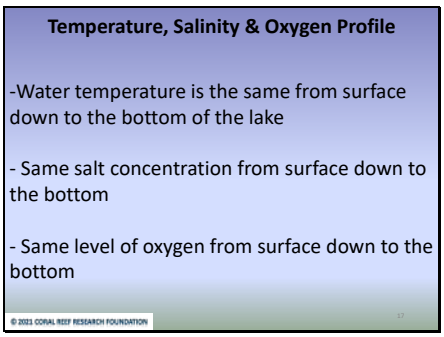
Slide 16



Side Note for Teacher

Due to the big open tunnels that connect the lake to the surrounding lagoon, the lake water is clear with bottom habitats ranging from sandy and rubble to a normal coral reef.

Slide 17



Side Note for Teacher

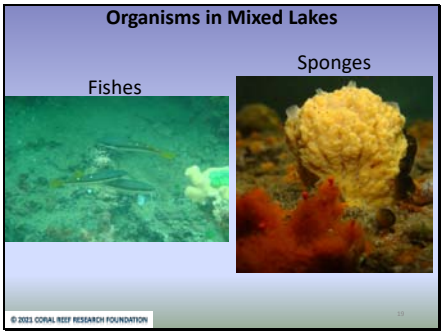
These big open tunnels also allow a mixed lake to have uniform profile, which coincides with the lagoon. This means that temperature is the same from surface down to the bottom as well as salinity or salt concentration. There is also oxygen all throughout the water column (surface to the bottom).

Slide 18

Side Note for Teacher

With big open surface tunnels, a mixed lake will experience a very similar tidal cycle to the surrounding lagoon. For example, if the high tide is at 4 PM in the lagoon, then it will be high tide in a mixed lake around 4 PM as well.

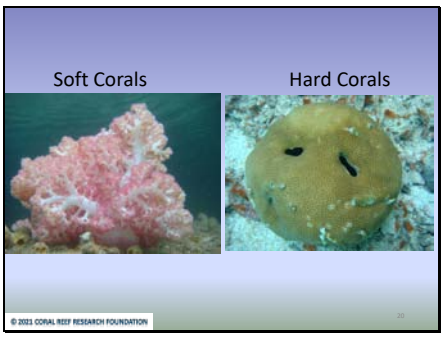
Slide 19



Side Note for Teacher

It also allows the lake to have the same organisms as the surrounding lagoon. You can find variety reef fishes and sponges.

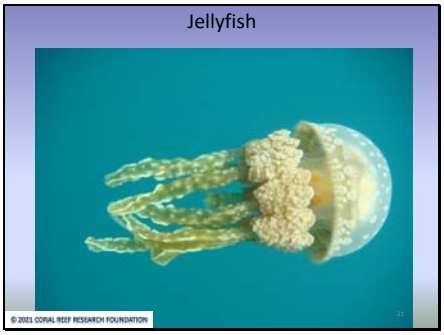
Slide 20



Side Note for Teacher

…as well as soft corals and hard corals.

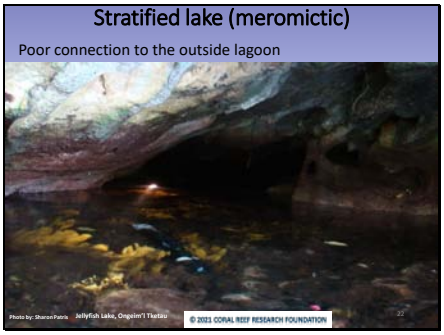
Slide 21



Side Note for Teacher

You can also find the lagoon golden jellyfish in a mixed lake. It is usually larger with long thick clubs compare to those that are found in a stratified lake.

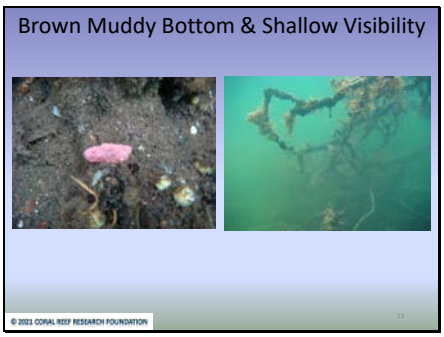
Slide 22



Side Note for Teacher

The second type of lake is a meromictic or stratified lake. Stratified or meromictic lakes have indirect connections to the surrounding lagoon. The connection between the lagoon and a stratified lake is poor due to the sizes of tunnels or cracks as well as the distance of the lake to the lagoon.

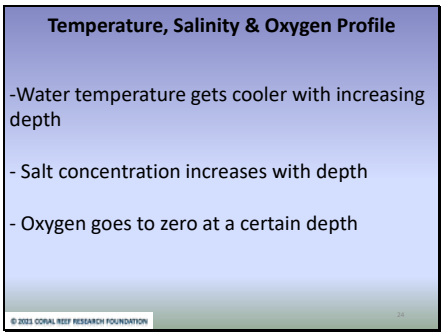
Slide 23



Side Note for Teacher

Due to its poor connection to the lagoon, a stratified lake is like a mangrove habitat with brown muddy bottom and very low visibility.

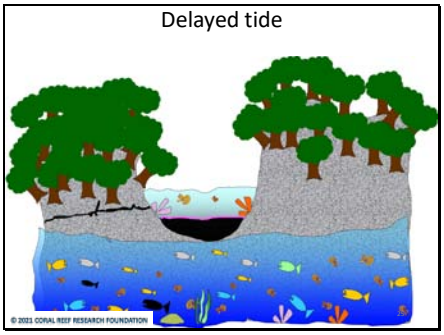
Slide 24



Side Notes for Teacher

Water in a stratified lake is almost isolated from the surrounding lagoon, which makes the water profile very different from the outside or a mixed lake. The temperature of the water gets cooler with increasing depth, salinity or salt concentration increases with depth. Oxygen in the water also goes to zero at a certain depth, and is replaced by hydrogen sulfide. It is poisonous; therefore, organisms in the lake are limited to the first few meters of the lake's water.

Slide 25



Side Note for Teacher

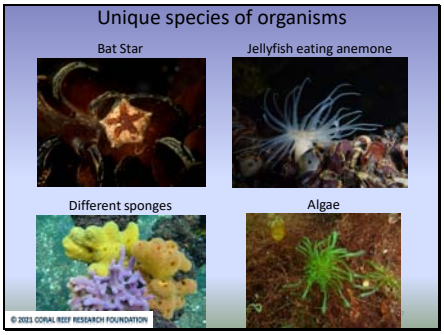
The indirect connection to the surrounding lagoon also causes a stratified lake to have a delayed tide compared to the lagoon. High tide in the lake will be later than high tide in the lagoon.

Slide 26

Side Note for Teacher

Since the lake is similar to a mangrove habitat, it is a favorable environment for crocodiles. They hang out and maybe nest in these lakes.

Slide 27



Side Note for Teacher

With poor connections, some organisms in stratified lakes are new species that can't be found in the lagoon. An example of a new species is the bat star on the top left corner of the screen. This is a bat star from Jellyfish Lake and has yet not been identified.

Slide 28

Side Note for Teacher

You can also find a variety of fishes often found in mangrove areas in a stratified lake.

Slide 29

Side Notes for Teacher

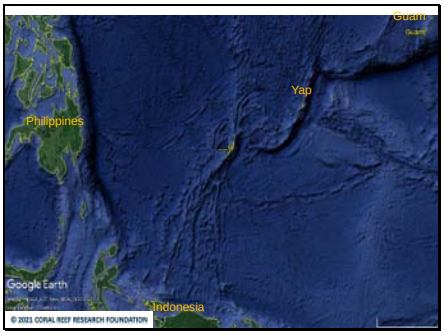
The last and third type of lake is a transitional lake. Transitional lakes are like a perfect blend of a mixed and stratified lake. It is called transitional because under certain weather conditions, it can be stratified or mixed. Organisms found in a transitional lake are a mixture between those that can be found in a mixed lake and stratified lake. When a transitional lake is mixed, it has higher visibility; however, when it stratifies then it will have lower visibility.

Slide 30

Side Notes for Teacher

That concludes the marine lakes introduction, so let us look at the Back to Nature: Jellyfish Lake program. This will prepare you for your field trip to Jellyfish Lake.

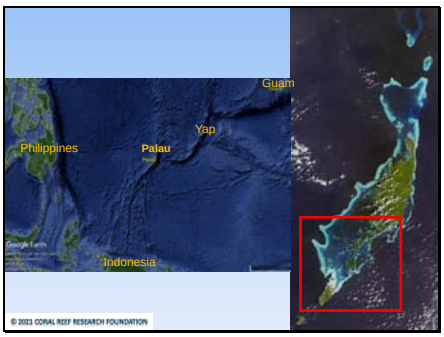
Slide 31



Side Notes for Teacher

We start off by looking at a map to see where Palau is. Palau is located between the Philippines, Yap and Indonesia.

Slide 32



Side Notes for Teacher

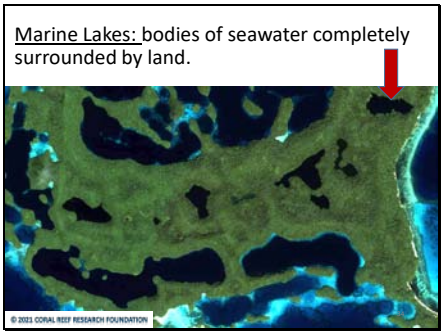
It is a small Pacific island, and when you get a closer look at Palau on a satellite picture, you can see Babeldoab, Koror, Peleliu and Angaur. And if we zoom even closer, we can see Koror.

Slide 33

Side Notes for Teacher

We can see Koror, the barrier reef, and the rock islands. But let's zoom even closer to this rock island.

Slide 34



Side Notes for Teacher

This is Mecherchar Island. In this island you can see bodies of seawater completely surrounded by land. These are called marine lakes. Point out which are considered marine lakes, and which are not. Marine lakes come in different shapes and sizes, some can be very large, some very small. Some are near the ocean, some far inland. Where do you think Jellyfish Lake is?

Jellyfish Lake is the one with red arrow.

Slide 35

Side Notes for Teacher

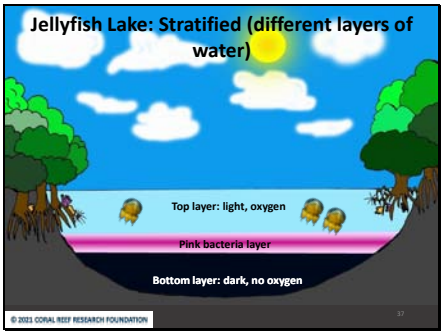
There are about 55 marine lakes in Palau, all of them are unique and different from the lagoon and each other, and about 5 of these lakes have Golden jellyfish. We will focus on Jellyfish Lake because that is where we will conduct our study. (Remind students where Jellyfish Lake is in this picture).

Slide 36

Side Notes for Teacher

Jellyfish Lake is what we call an isolated lake. It does not have a direct connection to the ocean. It has small tunnels where water goes in and out. The tide is a little different from the ocean because of the limited connection between the lagoon and the lake.

Slide 37



Side Notes for Teacher

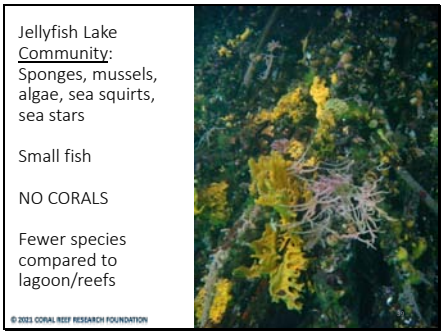
Jellyfish Lake is considered a stratified or meromictic lake. It is isolated and the lake is surrounded by high limestone island ridges. The bottom and top layer of the lake's water doesn't mix. The top layer has oxygen, where all the animals and plants live. There is a layer of pink bacteria that blocks out the light, and so the bottom layer is dark with no oxygen. Instead it has poisonous gas called hydrogen sulfide, and that is why scuba diving is not allowed in Jellyfish Lake.

Slide 38

Side Notes for Teacher

Due to the lake's isolation, Jellyfish Lake is similar to a mangrove habitat. In the lake you will find varieties of mangrove trees, brown or black mangrove mud, different species of mangrove clams and many other organisms that are found in mangroves.

Slide 39



Side Notes for Teacher

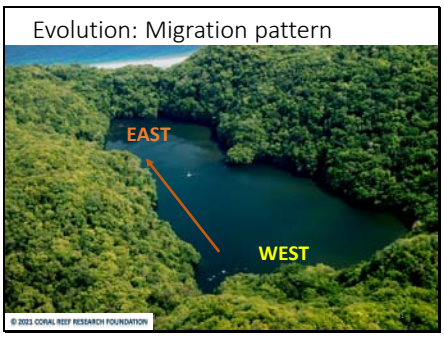
Some common organisms that you will find in Jellyfish Lake are sponges, mussels, algae, sea squirts and sea stars. There are some small fishes in the lake, but there are NO CORALS in Jellyfish Lake. However, there are few species that are similar to the lagoon or reef.

Slide 40

Side Notes for Teacher

What makes Jellyfish Lake so unique is the millions of jellyfish living in the lake. These are the Golden jellyfish, known as *Mastigias papua etpisoni*. This jellyfish, like the other jellyfish in the four other lakes, is named after a Palauan president. This one is named after President Etpison. As these jellyfish have been separated from the ocean and other populations of *Mastigias*, they have evolved and adapted to this particular lake habitat.

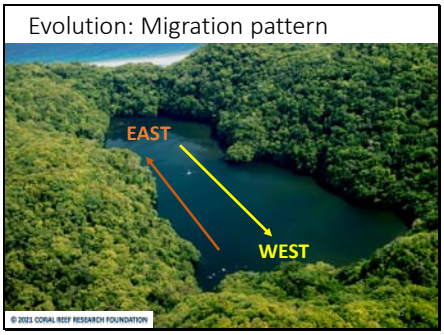
Slide 41



Side Notes for Teacher

One of the adaptations is their jellyfish migration pattern. You don't see this pattern in any of the other lakes. In the morning jellyfish will be swimming from the west towards the east, towards the rising sun.

Slide 42



Side Notes for Teacher

As the sun passes over at noon, the jellyfish swim towards the west. They swim in this pattern so that they can expose the symbiotic algae that live in their tissue to the sun. The algae is called zooxanthellae. It makes food from the sun through photosynthesis, and through this process it also provides food for the Golden jellyfish.

Slide 43

Side Notes for Teacher

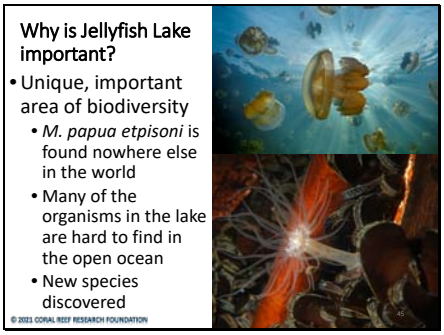
ADAPTATION TO THE ENVIRONMENT: At the edge, these jellyfish will stop at the shadow line to avoid their predator, the white sea anemone. They will not go into the shadow line, and this can cause the walls of jellyfish you find at the edges.

Slide 44

Side Notes for Teacher

It's behavior like this, and a few other genetic and morphological characteristics, that make this subspecies *Mastigias papua etpisoni* unique to Jellyfish Lake. You won't find them anywhere else in the world, or in Palau, except in this lake.

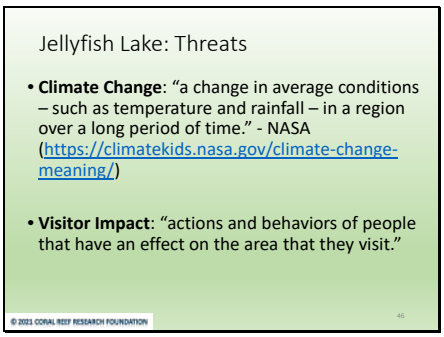
Slide 45



Side Notes for Teacher

This is why Jellyfish Lake is an important area of biodiversity. This Golden jellyfish is found nowhere else in the world, they're different from the other Golden jellyfish from the other four lakes and lagoon. Many of the organisms in the lake are hard to find in the open ocean. There have been new species discovered, like this white anemone. These are a few reasons why we should protect Jellyfish Lake, but there are threats to Jellyfish Lake.

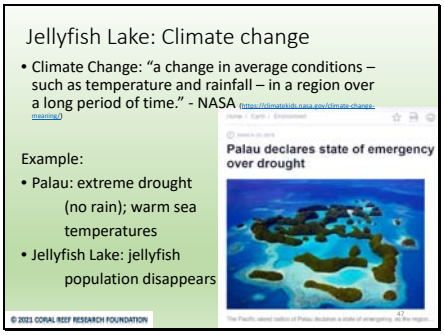
Slide 46



Side Notes for Teacher

Climate change is a "read definition". Visitor impact is "read definition"

Slide 47



Side Notes for Teacher

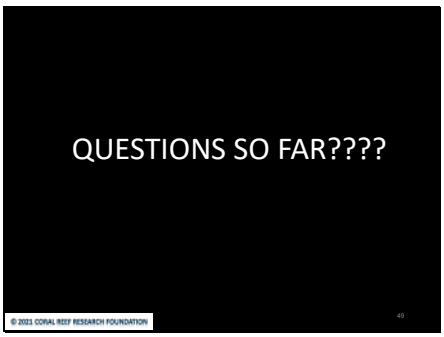
An example of what climate change can do is the extreme drought when Palau had very little rain in 2016. That is a change from what is normal, and it affected Jellyfish Lake. During this time, the jellyfish disappeared from the lake.

Slide 48

Side Notes for Teacher

Visitors can affect the lake through a number of ways. They can pollute the lake through trash and sunscreen pollution. They can introduce animals or plants that don't belong in the lake. An example is this brown sea anemone that was introduced by visitors. They can also damage the jellyfish, if they swim too rough around them.

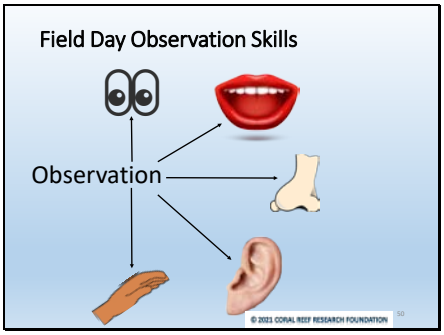
Slide 49



Side Notes for Teacher

That was the quick overview of Jellyfish Lake. Before we continue, does anyone have any questions?

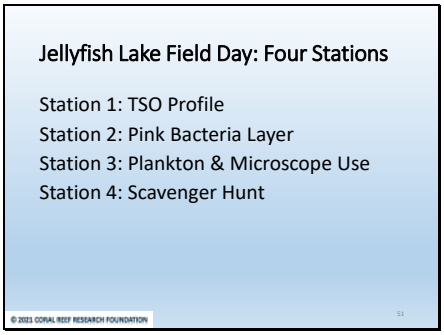
Slide 50



Side Notes for Teacher

For the field day, we will use our observation skills. Ask what are observation skills? What do you use to observe things? You use all five senses.

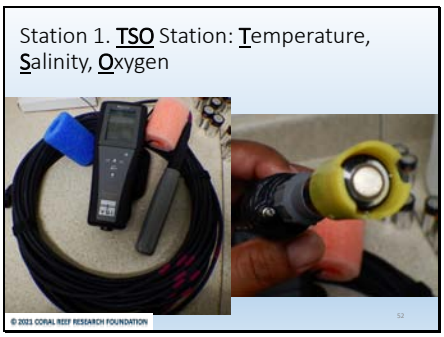
Slide 51



Side Notes for Teacher

During the field day, we will go through 4 stations. These 4 stations are: TSO Profile, Pink Bacteria Layer, Plankton & Microscope Use, and the Scavenger Hunt.

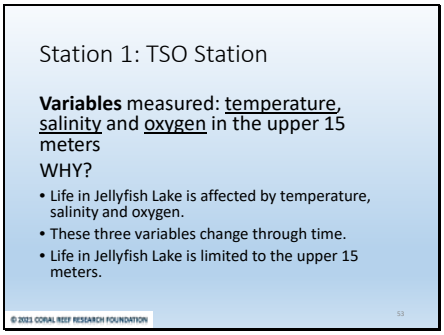
Slide 52



Side Notes for Teacher

TSO stands for Temperature, Salinity and Oxygen. At the profile station, you will be using a water quality meter to measure conditions of the lake water. The water quality meter has a display in the handheld, and on the sonde, or probe, there are sensors to measure different parameters.

Slide 53



Side Notes for Teacher

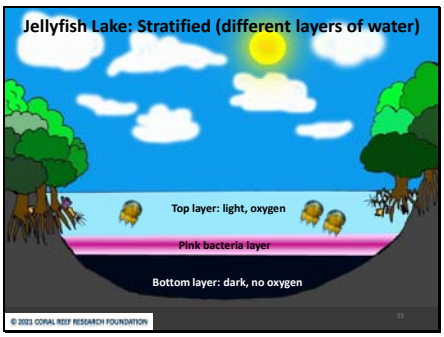
Using the water quality meter, you will measure temperature, salinity (how much salt is in the water) and oxygen in the upper 15 m. We measure these factors because life in Jellyfish lake is affected by these factors, and these factors change through time. Finally, we focus on 15 m because life is limited to the upper 15 meters of the lake's water.

Slide 54

Side Notes for Teacher

At station 2, you will use the Nansen bottle to find the pink bacteria layer. The rope of the Nansen bottle will have tape on it marking every meter. This is the layer of pink bacteria; it's a thick layer of millions of bacteria that are colored pink. Point out picture of pink layer. Explain: method of dropping with a weight called a messenger, and explain collecting samples of water by recording the smell and color at each depth.

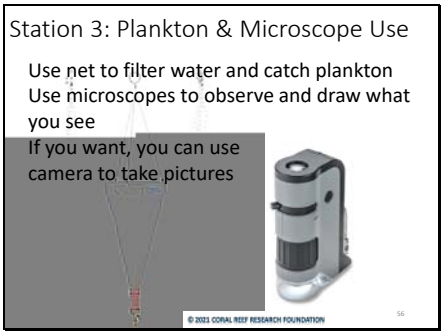
Slide 55



Side Notes for Teacher

Remind the student where the pink layer is.

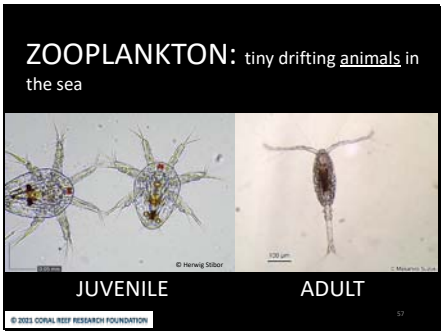
Slide 56



Side Notes for Teacher

Students will use the net to capture their plankton samples and bring them back to the dock. The net is made of mesh that is a certain size that allows water to pass through, but you catch particles in the water that are larger than the particular mesh size. At the dock, there will be a microscope area where students will identify their samples and they can also take photos with their cell phones. Once you identify your sample, you will draw an image of organisms that you see on your datasheet.

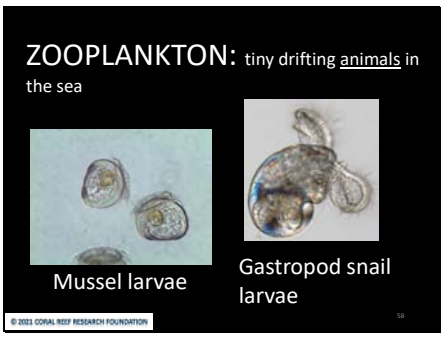
Slide 57



Side Notes for Teacher

Zooplankton is tiny drifting animals in the sea. Here are pictures of some zooplankton you will find in the lake. Left are juvenile copepods and right is an adult copepod.

Slide 58



Side Notes for Teacher

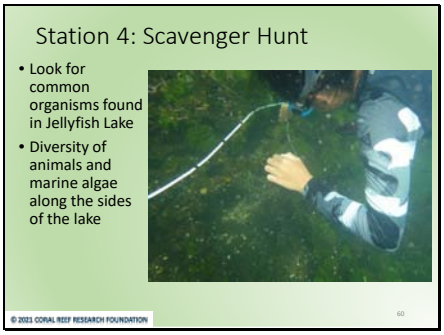
Here are pictures of other zooplankton you will find. There are also shrimp, crab and mussel larvae that you will find in the lake.

Slide 59

Side Notes for Teacher

Phytoplankton is tiny drifting plants in the sea. Here are pictures of some phytoplankton that you can find in Jellyfish Lake.

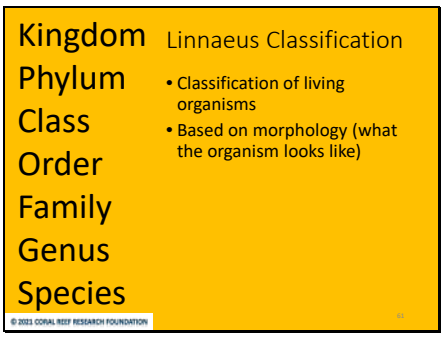
Slide 60



Side Notes for Teacher

For the Scavenger Hunt station, you will perform a survey of common organisms (invertebrate and vertebrate) that are found in Jellyfish Lake. You will be given a datasheet with list of the organisms; you will record the depth of each organism, substrate if any and color. You will also need to photograph each organism as well as identify them to phylum level.

Slide 61



Side Notes for Teacher

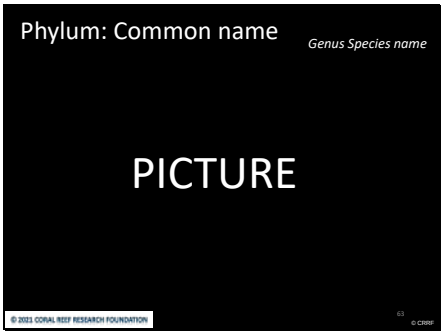
With this we will go through the Linnaeus Classification System. What is the Linnaeus Classification System used for? It is used to classify living organisms based on morphology or what they look like.

Slide 62

Side Notes for Teacher

We will use this time to go through the different organisms you can find in Jellyfish Lake. We will go through their phylum, common name, genus and species.

Slide 63



Side Notes for Teacher

The next couple of slides will be in this format, where you have the name of phylum followed by the common name. Then in small italics is the scientific name. And finally, the picture. Remember, a species name is made up of a Genus and species name, with the Genus part capitalized and both are in italics.

Slide 64

Side Notes for Teacher

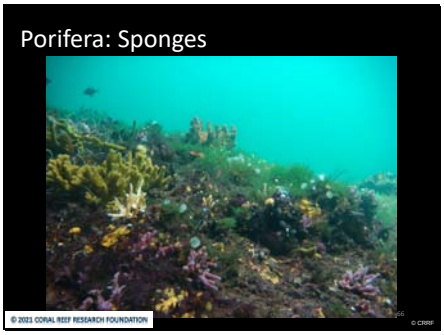
Here, Chlorophyta is the phylum that green algae belong to. Chloro means green and phyta means plants. This is an example of Chlorophyta found in Jellyfish Lake, and it's species name is *Caulerpa verticillata*. *Caulerpa* is the genus, and *verticillata* is the species.

Slide 65

Side Notes for Teacher

Sponges belong to the phylum Porifera. Por – is the root name that means porous, because sponges are porous (lots and lots of holes). Here is an example of one kind of sponge. The *Haliclona* sp. so, we know it's genus is *Haliclona*, but we have not identified its species. So instead we put sp. to indicate it has not been identified to species level.

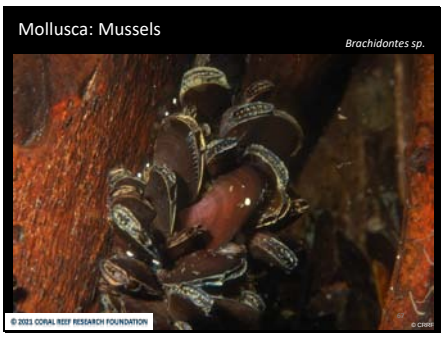
Slide 66



Side Notes for Teacher

Keep in mind that when we ask you to find a sponge, you will find many different kinds, and any one of them is okay to use for your scavenger hunt.

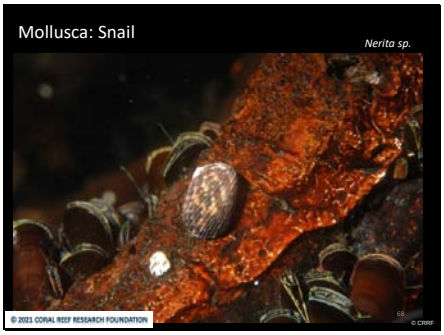
Slide 67



Side Notes for Teacher

Mollusca are a diverse group of animals, often with hard shells covering their soft tissue. In Jellyfish Lake you can find mussels and snails. These belong to the phylum Mollusca.

Slide 68



Side Notes for Teacher

Intertidal snail in Jellyfish lake.

Slide 69

Side Notes for Teacher

Another type of snail in the lake.

Slide 70

Side Notes for Teacher

On fallen trees underwater, you will see white stuff growing on branches.

Slide 71

Side Notes for Teacher

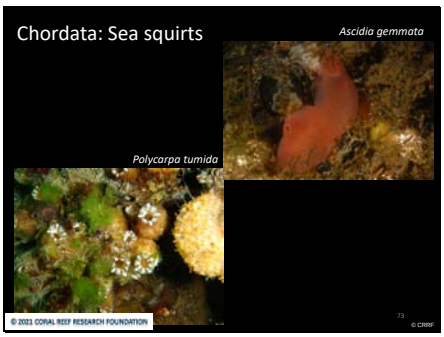
These are tube worms and they belong to the phylum Annelida. The animals live inside the hard, white outer layer. Notice we don't have a species name, as we have not figured out what species this is.

Slide 72

Side Notes for Teacher

Echinodermata – is a phylum of organisms with spiny skin like these sea stars here. Two of these sea stars are new species and have not been given a scientific name (Batstar on the top left and the seastar on the bottom).

Slide 73



Side Notes for Teacher

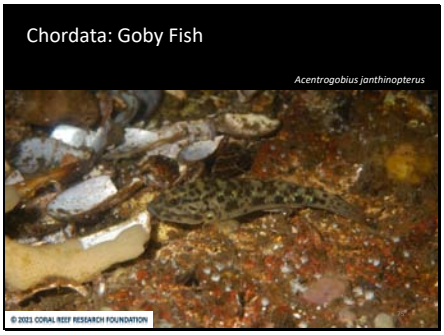
Sea squirts belong to phylum Chordata, the same as humans. Why? Because sea squirts have a nerve cord (similar to our spinal cord) when they are larvae. But the nerve cord disappears as they grow.

Slide 74

Side Notes for Teacher

Other organisms that fall under the phylum Chordata are fishes. In Jellyfish Lake you can find 3 different types of fishes. This one is a Cardinal Fish and it is a mid-water fish.

Slide 75



Side Notes for Teacher

You can also find gobies that like to hang out on the bottom.

Slide 76

Side Notes for Teacher

…and silversides, a schooling fish.

Slide 77

Side Notes for Teacher

The Cnidaria phylum is a group of animals that have stinging cells or cnidae. This is the white endemic sea anemone in Jellyfish Lake. It belongs to the phylum Cnidaria because it has stinging cells on its tentacles.

Slide 78

Side Notes for Teacher

These sea anemones don't belong to the lake, and they were carried in by visitors. They can be found all over the lake now, and you can tell the difference between this invasive sea anemone and the native one by color. The white one is native. This one has brown tentacles. It also belongs to the phylum Cnidaria.

Slide 79

Side Notes for Teacher

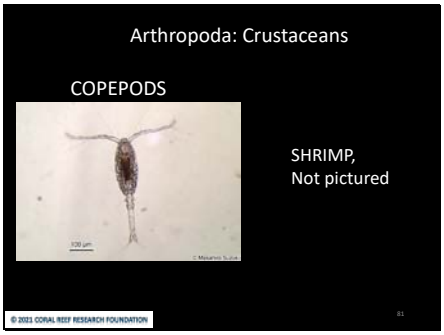
In the same phylum, Cnidaria, you will find two kinds of jellyfish. This one is the Moon jellyfish, it is completely white. It also has stinging cells.

Slide 80

Side Notes for Teacher

And the second one is the golden jellyfish.

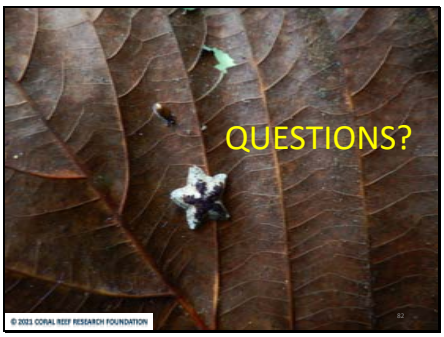
Slide 81



Side Notes for Teacher

Crustaceans belong to the phylum Arthropoda, and include the copepods that we see in our zooplankton net hauls.

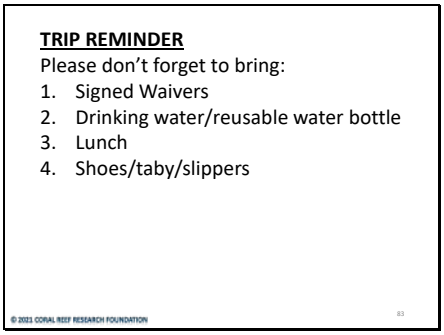
Slide 82



Side Notes for Teacher

This is the end of Day 1 presentation. Give a few minutes for students to ask questions. You can also ask questions regarding the classification system by asking them which phylum does the snail in the picture belongs to or the seastar.

Slide 83



Side Notes for Teacher

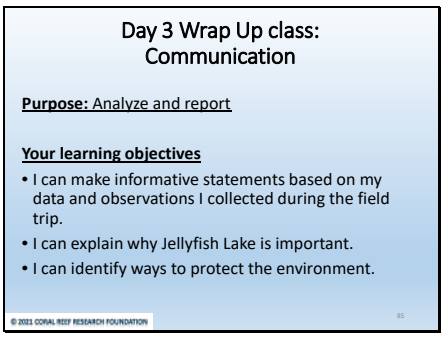
Remind students of the important things that they need to bring for the field day. Announce where the students will be dropped off and picked up for boat ride to Jellyfish Lake.

Slide 84

Side Notes for Teacher

Use this time for students to fit fins and sign out mask and fins.

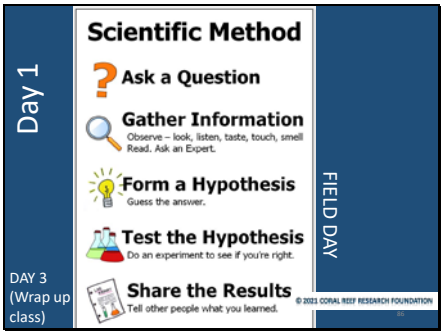
Slide 85



Side Notes for Teacher

This 3rd day is when we gather in our groups from the field day and work on our data and reports. Today's learning objectives are…

Slide 86



Side Notes for Teacher

On day 1 of Scientific method we covered
- Asking a question
- Gather Information

On day 2 (Field Day) we covered
- Form a Hypothesis
- and Test our Hypothesis

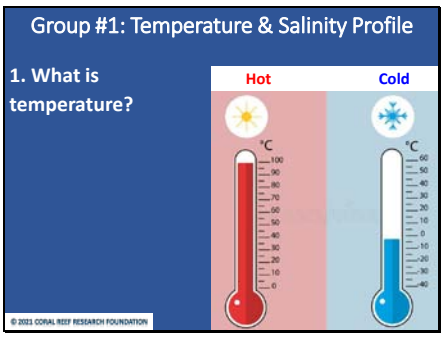
Now this last day we will
- Analyze our data and share the results

Slide 87

Side Notes for Teacher

Identify which groups did which stations. Student's presentation starts on the next slide, starting with group 1, 2, 3 and 4.
Use this time to discuss and analyze data with each group of students. Pass out review questions for each station to the students (see lesson 3 activities). Students will analyze data for the first station that they did (example: Group 1 did Temperature and Salinity first, so they will present graphs of Temperature and Salinity as well as answering the review questions).

Slide 88



Side Note for Teacher:

Introduce your group members, where did you go and what did you do. Example: Good morning and we are group 1. My name is Jane and my group members are Jelly, Moon and Snail. We went to Jellyfish Lake to measure and learn about temperature and salinity. I will talk about temperature first.

So what is temperature? Temperature is a measurement of how hot or cold something is.

Teacher: you can insert a group picture before this slide that can be used as an introduction picture.

Slide 89

Side Note for Teacher:

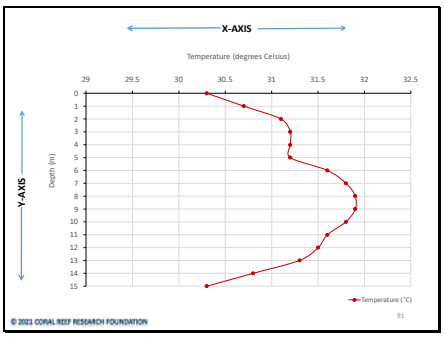
We used the YSI water quality meter to measure the water temperature in Jellyfish Lake.

Slide 90

Side Note for Teacher:

We sat on an inflatable chair so that the end of the instrument with a screen doesn't get wet and we lowered the other end of the instrument into the water. That is the end that measures the temperature and salinity. We wait 10 or 20 seconds for the numbers to be stable and then we record our temperature and salinity on our datasheet. We measured temperature and salinity at every meter from surface down to 15 meter.

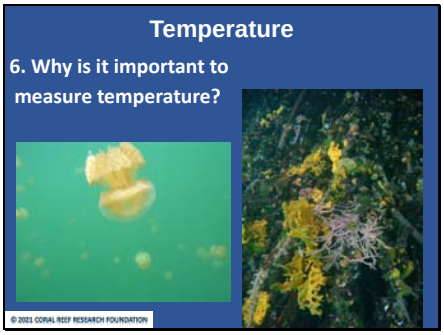
Slide 91



Side notes for Teacher: Review Questions

4. Explain the x-axis and y-axis.
5. What is the temperature doing?

Slide 92



Side notes for Teacher: Review Questions

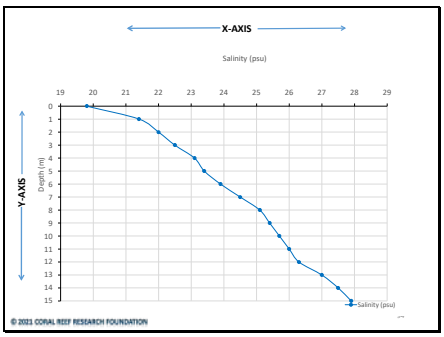
It is important to study temperature because organisms in Jellyfish lake like the Golden Jellyfish respond to temperature. If the water is too hot then the jellies can bleach or die, but if the water is cooler then they will reproduce more babies.

Slide 93

Side notes for Teacher: Review Questions

Salinity is the measurement of salt concentration in the water.

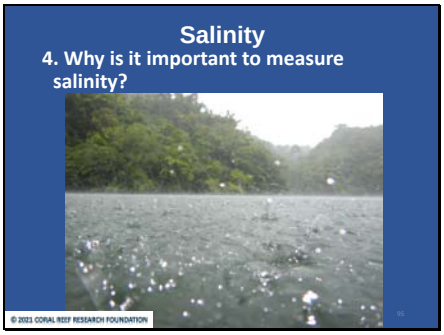
Slide 94



Side notes for Teacher: Review Questions

2. Explain the x-axis and y-axis.
3. What is the salinity doing?

Slide 95



Side notes for Teacher: Review Questions

It is important to study salinity because it tells us how much freshwater, or rain water, has entered the lake. For example, if there is a lot of rain then salinity decreases, if there is not a lot of rain then salinity can increase.

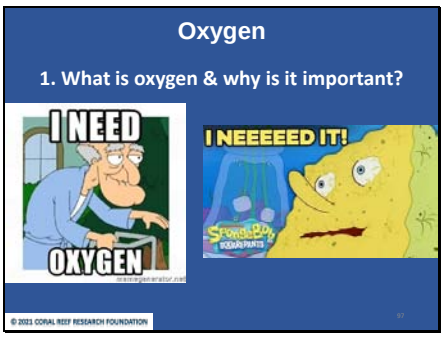
Slide 96

Side Notes for Teacher

Find a good picture of the kids working as well as the nansen bottle and use at the beginning of Group 2 presentation. Better if the students have a picture of pink-colored water in the nansen bottle.

This is where students introduce their group members and tell the class where they went and what they did. Similar to the Temperature presentation, but this is about oxygen and pink bacteria layer.

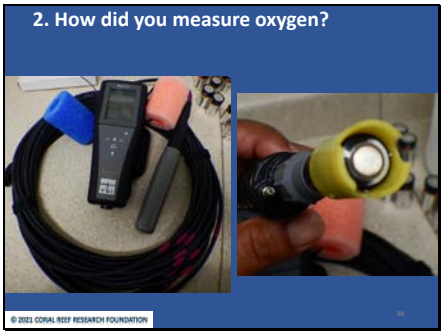
Slide 97



Side Notes for Teacher

Oxygen is the second most abundant gas on Earth. It is important because all life on Earth depends on oxygen for breathing and to be able to live.

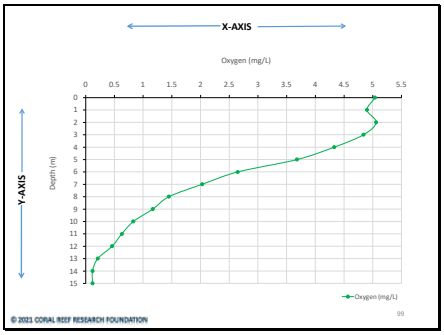
Slide 98



Side Notes for Teacher

Tell your classmates what instrument you used to measure oxygen (similar to Temperature and Salinity).

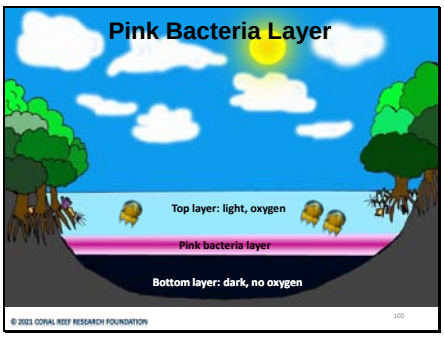
Slide 99



Side notes for Teacher: Review Questions

3. Explain graphs (x-axis, y-axis, lines).
4. Explain line – what is happening to oxygen?
5. Show where living things are, and where you would not find living things.

Slide 100



Side notes for Teacher: Review Questions

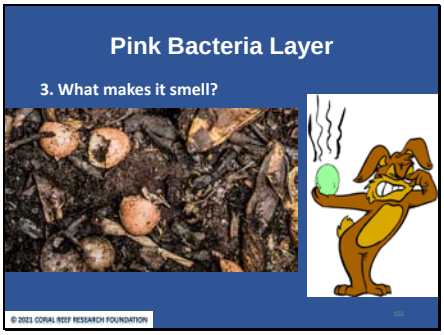
1. What is the pink layer?

Slide 101

Side notes for Teacher: Review Questions

The pink layer is pink because of the bacteria that lives in that layer. It is the bacteria that is pink, not the water.

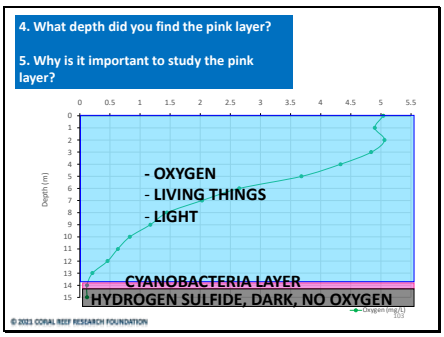
Slide 102



Side notes for Teacher: Review Questions

The smell of the pink bacteria comes from decomposed matter on the bottom of the lake like leaves, dead organisms and tree branches. When they decompose, then they release the smelly gas called hydrogen sulfide.

Slide 103



Side notes for Teacher: Review Questions

Show students where you found the pink bacteria layer. Use the oxygen graph as it will show depths and highlight the depth where you found the pink bacteria layer. Show students which depth had the strongest smell, the darker pink color and the lighter pink color. Where did you find the first clear water with a smell of hydrogen sulfide? Why is it important to study the pink layer? It helps us to know the depth of the hydrogen sulfide layer. It is important to know the depth of the hydrogen sulfide because it is poisonous to most living things, so if it gets shallow, then it can kill living organisms in the lake.

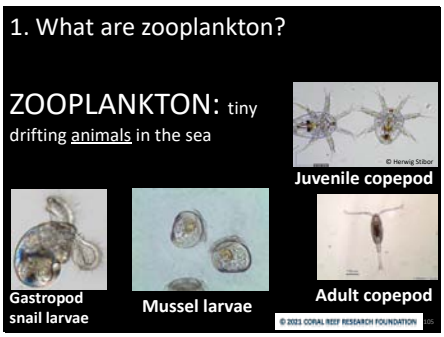
Bonus: Why is the smell only at a certain depth? What keeps it there?

Slide 104

Side Notes for Teacher

Insert zooplankton pictures from different groups: what did they find? Zooplankton/phytoplankton?

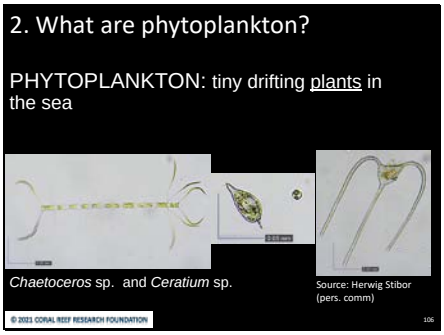
Slide 105



Side Notes for Teacher

Remind the class what zooplankton are and the type of zooplankton that can be found in Jellyfish lake. These are juvenile copepods (top right) and adult copepods bottom right). You can also find gastropod snail larvae and mussel larvae.

Slide 106



Side Notes for Teacher

These are phytoplankton found in Jellyfish Lake. Phytoplankton are tiny drifting plants in the sea.

Slide 107

Side Notes for Teacher

Insert photo of students working with the net.

How did you catch planktons? By towing a mesh net vertically in the water column and capturing planktons from 18 meters to the surface of the lake.

Slide 108

Side Notes for Teacher

After collecting our plankton samples, we brought it to the dock and looked at them under the microscope. After identifying our samples, we drew an image of the samples that we found/identified on our datasheet.

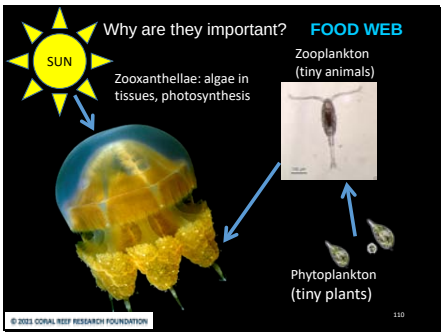
Slide 109

Side Notes for Teacher

Use photos from students if they did take pictures through the microscope. Otherwise use their drawing to show the types of plankton that they found.

Example: These are adult and juvenile copepods that we collected during the field trip.

Slide 110



Side Notes for Teacher

Why are plankton important? The Golden jellyfish has zooxanthellae, or tiny algae, in their tissues that use sunlight to make food through photosynthesis. The Golden jellyfish also has nematocysts, or stinging cells, on their oral arms that they use to capture their food which are tiny zooplankton in the water. Therefore, the Golden jellyfish gets it food in two ways: (1) through the algae in their tissues and (2) stinging and catching prey, or their food in the water. Golden jellyfish can sting, but the sting is so mild that people don't feel it unless they kiss the jellyfish. The food web includes phytoplankton (or tiny plants) which zooplankton (or tiny animals) eat. The Golden jellyfish eats the zooplankton.

Slide 111

Side Notes for Teacher

Select good pictures of the kids doing scavenger hunt and use one or two for their first slide.

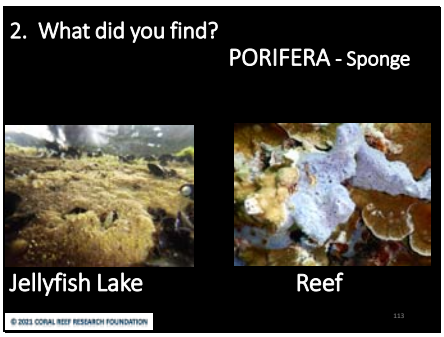
Slide 112

Side Notes for Teacher

1. What is the habitat like?
2. What did you find? Name the phylum and common name of the organisms you photographed.
3. Explain the phylum by describing what kind of animals are in those phyla.
4. What was the easiest to find?
5. What was the hardest to find?
6. Are there corals in Jellyfish Lake?
7. What gives the Golden jellyfish its golden color? Does the Moon jellyfish have the same?

For jellyfish questions, point out that there are many types of jellyfish in the ocean. The Golden jellyfish get their golden color from algae, similar to corals.

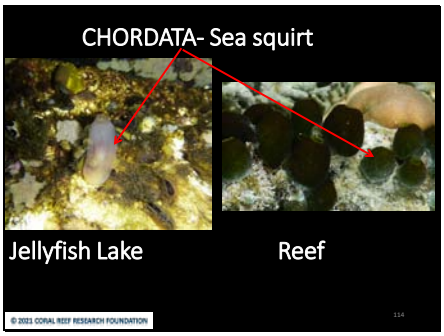
Slide 113



Side Notes for Teacher

Use arrows to point out sponges to make it easier for audience to identify what you are talking about. Do this for other organisms like algae and sea squirts, especially if your picture is a mixture of different organisms. Feel free to find similar reef organisms and use it for comparison, similar to what is shown on this slide.

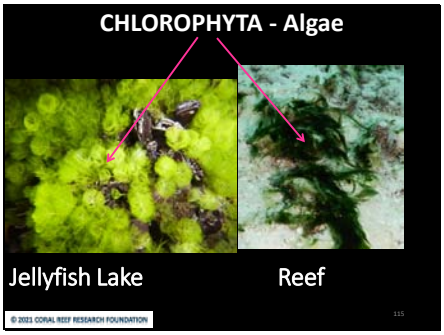
Slide 114



Side Notes for Teacher

What is the phylum for sea squirt?

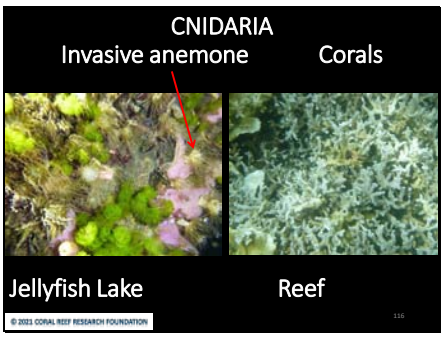
Slide 115



Side Notes for Teacher

What is the phylum for green algae?

Slide 116



Side Notes for Teacher

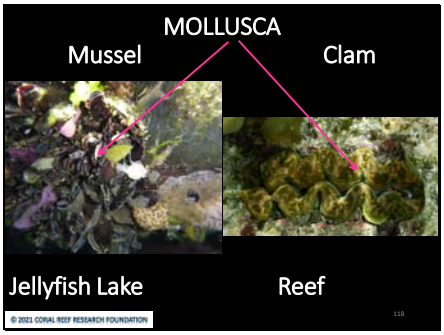
Describe the invasive sea anemone. You can also compare it to the endemic anemone based on color and size, or compare it to other Cnidaria found on the reef.

Slide 117

Side Notes for Teacher

Compare and contrast the invasive and native, or endemic, sea anemone.

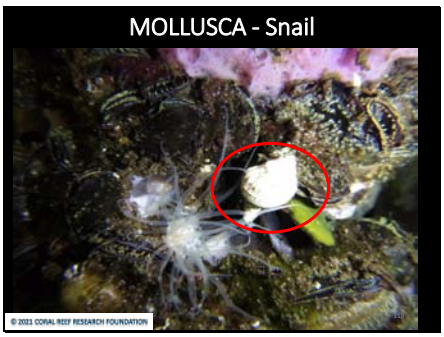
Slide 118



Side Notes for Teacher

What is the phylum for mussels? What reef organisms also fall under this phylum?

Slide 119



Side Notes for Teacher

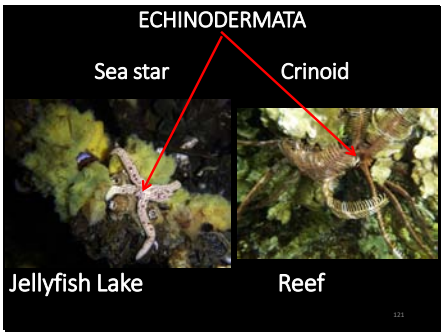
What is the phylum for snail?

Slide 120

Side Notes for Teacher

What is the phylum for Tubeworm? What other reef organisms belongs to this phylum?

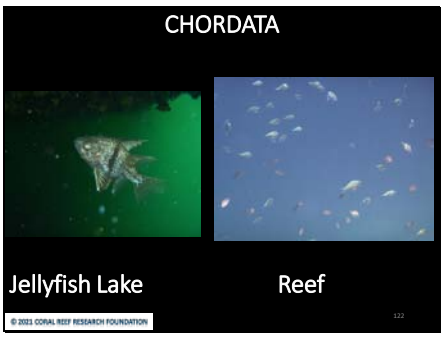
Slide 121



Side Notes for Teacher

What is the phylum for sea star? What other reef organisms fall under this phylum?

Slide 122



Side Notes for Teacher

What other fishes can you find in Jellyfish Lake? What is their phylum?

Slide 123

Side Notes for Teacher

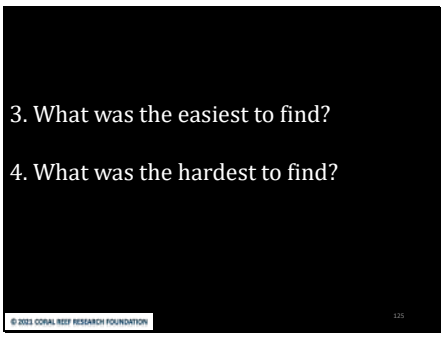
Describe the Golden jellyfish. What makes it golden? At what depth did you find it?

Slide 124

Side Notes for Teacher

Compare and contrast the Golden jellyfish and the Moon jellyfish.

Slide 125



Side Notes for Teacher

After your presentation ask your classmates if there are corals in Jellyfish Lake.

Slide 126

Side Notes for Teacher

Use this time for students to ask questions from the other groups or if they have more questions regarding their station. Discuss ways to protect the lake and how important the lake is.

A

APPENDIX 3: TSO PROFILE & PINK BACTERIA LAYER DATASHEET

TSO PROFILE			
Depth (m)	Temperature (°C)	Salinity (psu)	Oxygen (mg/L)
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

PINK BACTERIA LAYER NOTES							
	Smell		Color				
Depth (m)	Yes	No	Clear	Light Pink	Pink	Very Pink	Other

Answer the following questions based on the data that you have just collected.

1. What depth has the highest temperature?

2. What happens to the salinity as you go deeper in the lake?

3. What depth does oxygen go close to zero?

4. Based on the nansen data that you have just collected, what makes the water pink or light pink?

Notes:

APPENDIX 4: SCAVENGER HUNT & ZOOPLANKTON DATASHEET

Date: _____ Group#: _____ Camera #:_____

Group Members: _____

School:_____ Grade: _____

SCAVENGER HUNT					
Phylum	General name	Depth (m)	Color	Substrate	Note
☐ Mollusca ☐ Porifera	Sponge				
☐ Chordata ☐ Cnidaria	Sea Squirt				
☐ Chlorophyta ☐ Porifera	Algae				
☐ Echinodermata ☐ Cnidaria	Invasive Sea Anemone				
☐ Cnidaria ☐ Mollusca	Endemic Sea Anemone				
☐ Mollusca ☐ Porifera	Mussel				
☐ Chlorophyta ☐ Mollusca	Snail				
☐ Chordata ☐ Annelida	Tubeworm				
☐ Echinodermata ☐ Mollusca	Starfish				
☐ Chordata ☐ Porifera	Cardinal Fish				
☐ Cnidaria ☐ Chordata	Golden Jellyfish				
☐ Annelida ☐ Cnidaria	Moon Jellyfish				

ZOOPLANKTON DRAWING

APPENDIX 5: TSO PROFILE & YSI MANUAL

Keypad and Features

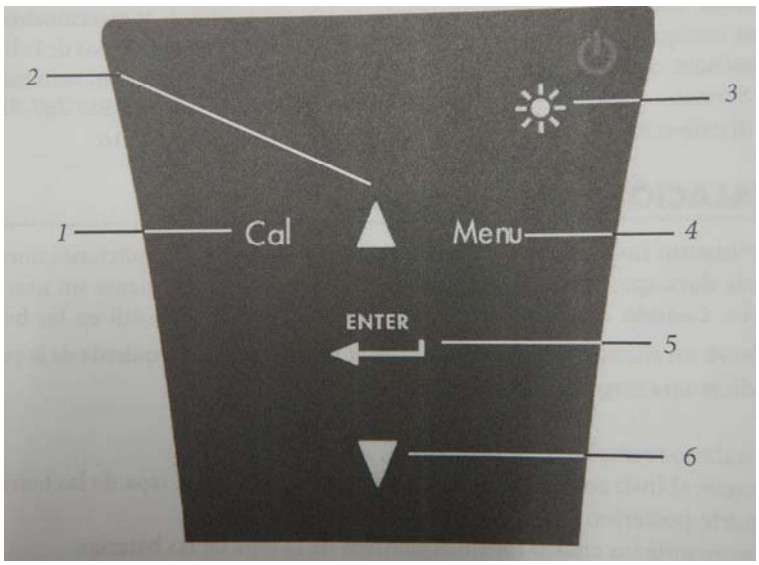


Figure 1: Keypad

Number	Key	Description
1		**Calibration** **DO NOT** USE THIS BUTTON OUT IN THE FIELD. Calibration is only done in the laboratory by CRRF staff.
2		**Up Arrow** Use to navigate through menus, to navigate through box options along the bottom of the Run screen and to increase numerical inputs.
3		**Power and Backlight** Press once to turn instrument on. Press a second time to turn backlight on. Press a third time to turn backlight off. Press and hold for 3 seconds to turn instrument off.
4		**Menu** Use to enter the System Setup menu from the Run screen.
5		**Enter** Press to confirm entries and selections.
6		**Down Arrow** Use to navigate through menus, to navigate through box options at the bottom of the Run screen and to decrease numerical inputs.

Table 1: Keypad description.

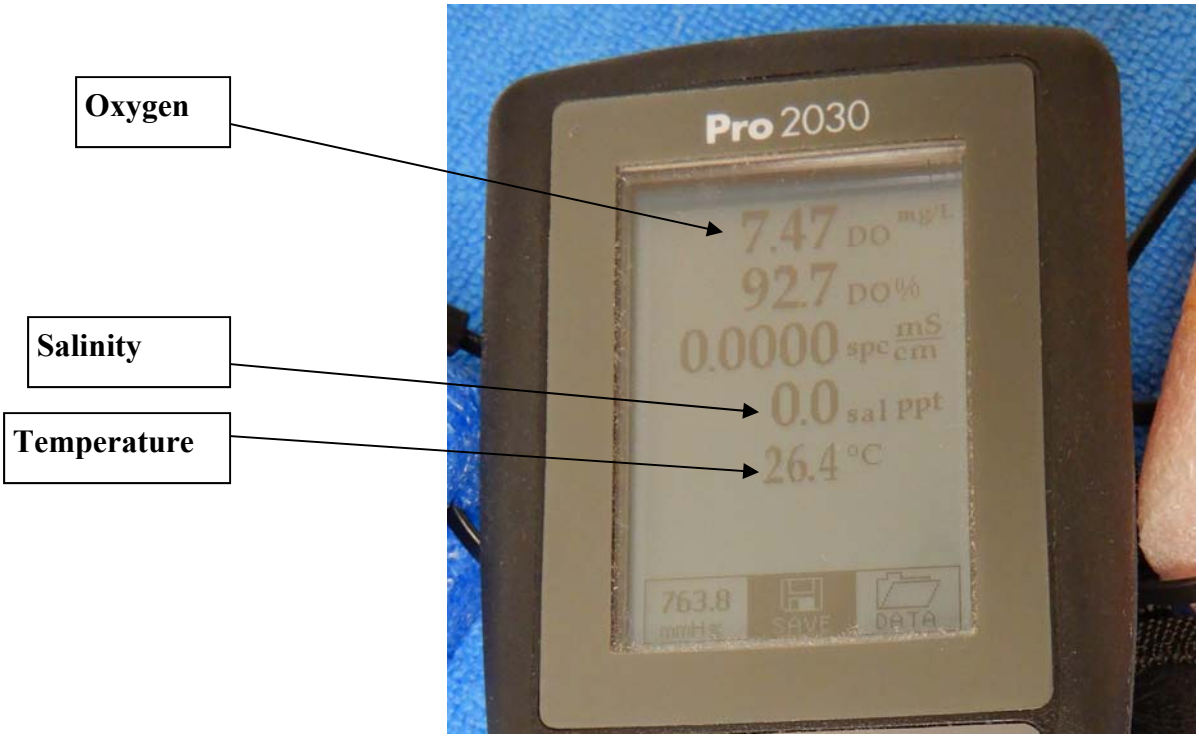


Figure 2: Run Screen

Figure 3: Handheld

Figure 4: Cable and sensor end

Figure 5: (left) Handheld keyed connector and (right) cable end

Figure 6: Sensor End with gray silicone storage sleeve.

Figure 7: Sensor End with deployment guard.

Salinity sensor (Black)

Oxygen sensor (Yellow)

Deployment guard (silver)

Figure 8: Yellow sponge to keep moisture in the storage sleeve when storing the instrument.

Figure 9: When coiling the cable for storage, make sure all tapes are aligned.

Figure 10: For storage, place the Handheld and the end of the sensor in the center of the coiled cable.

Packing the Instrument at the Lab for Field Day

1. Connect the Handheld Keyed Connector to the cable end (Fig. 5)
2. Make Sure the storage sleeve is attached to the sensor end (Fig. 6)
3. Wrap the Handheld in a small towel to protect the screen.
4. Placed the wrapped Handheld in a heavy duty clear plastic bag to keep it from getting wet. Do this even if it is sunny just in case it starts raining while you are in the field.

5. If you are going to pack the instrument with other things, make sure the whole unit sits on the very top of your backpack. It is highly recommend that the instrument gets its own backpack, to avoid damage to the screen as well as the whole instrument.

Unpacking the Instrument Out in the Field For Profile

1. Remove the Handheld from the plastic bag and remove the towel.
2. Set the towel in a dry place for later.
3. Put the Handheld back in the clear plastic bag and place the whole unit in a floating bin.
4. There are extra lines tied on the side of the floating bin;you will need to get one line and tie it through one of cable ties on the Handheld. This is to secure the sensor, so if something happens and you drop it, at least it will be easy to retrieve it.
5. **DO NOT** remove the floats on both sides of the Handheld, these floats keep the Handheld afloat if you drop it. It does not hurt to have a backup plan. ☺
6. Once you are at the profile station, leave the Handheld in the plastic bag and press the power button (Table 1, number 3). The Handheld should remain in the plastic bag in case it rains.
7. Remove the gray storage sleeve from the sensor end (Fig. 6) and place the sleeve in one of the pockets of the floating chair. **NOTE:** The storage sleeve **DOES NOT FLOAT**, so make sure it is in a safe place.
8. Lower the sensor end into the water to the first purple tape (0 meter mark) just above the salinity sensor (Fig. 7).
9. The sensor will need to warm up before you can start recording your data. Wait at least 2 minutes for all the numbers to stabilize then record or read out your Temperature, Salinity and Oxygen.
10. Oxygen takes a while to stabilize and sometimes it will move between a set of numbers (e.g. 5.41 to 5.48). When this happens you can use the average, so in this case it will be 5.44.
11. Once the readings are stable, you can start reading your data for 0 meter depth.
12. Since your datasheet starts with Temperature, Salinity and then Oxygen (TSO), it would be easier if you read the data in the same order. All your TSO readings are on the first main screen, so you won't have to press any button after you turn on the sensor. **NOTE:** THE SENSOR TURNS OFF AUTOMATICALLY AFTER 20 MINUTES. IF IT DOES TURN OFF BEFORE YOU ARE DONE RECORDING YOUR DATA, JUST SIMPLY TURN IT BACK ON AND REPEAT STEP 9 BEFORE RECORDING DATA.
13. Once you finish recording the data for 0 meter, you can move down to the next tape and do your 1 meter reading. Repeat this until you finish 15 meters.

Rinsing the Sensor After Profile

1. After each profile (0 meter to 15 meter), you will need to rinse the storage sleeve with fresh water. **DO NOT REMOVE THE SENSOR GUARD!**

2. Leave the yellow sponge (Fig. 8) in the sleeve and add water. Close the open end of the sleeve with your hand and shake it, once you are done pour out the water and make sure to squeeze the closed end of the sleeve where the yellow sponge is to get rid of the extra water soaked in the sponge.
3. Add more water into the sleeve and insert the end of the sensor into the sleeve and shake it gently.
4. Remove the sleeve from the end of the sensor and pour out the water from the sleeve. From this point on, the sensor should not touch any surface or the lake water if it's not in the storage sleeve (repeat step 3 and 4 at least 2 times). After the last rinse, you should pour out the water from the sleeve and without removing the yellow sponge, squeeze the closed end of the sleeve and turn it upside down to remove excess water from the sponge. You can now place the sensor end back into the sleeve and place it in the bin.

Packing the Sensor After the Profile

1. At the dock, put the bin on the dock next to your backpack and make sure the cable is not tangled up. If the cable is tangled then untangle it and wind the cable (see Fig. 9).
2. Remove the Handheld from the plastic bag and untie the security line from the Handheld.
3. Wrap the Handheld in a towel and place it back into the plastic bag.
4. Pack the instrument in your backpack. If you are using the same backpack for other gear, make sure the instrument sits at the very top of your backpack, meaning nothing should sit on top of the instrument.

At the Lab

1. **DO NOT SOAK THE HANDHELD IN THE SINK, IT IS NOT WATERPROOF.**
2. Unpack the instrument and soak the cable with sensor end in a sink tub with tub water. While the Handheld is attached to the cable, place it somewhere dry (sink top closer to the tub).
3. While the cable is soaking, rinse the sensor tip again (step 3 and 4 of the Rinsing the Sensor after Profile). Do this 2 times.
4. After rinsing the end of the sensor, place it back in the storage sleeve and place it on the sink top.
5. Rinse the cable well and place it next to the Handheld and sensor end. Place the sensor end in the center of the coiled cable.
6. Remove the Handheld from the plastic bag and unwrap the towel.
7. Use a clean, damp towel to wipe the Handheld to remove any salt or seawater.
8. Disconnect the end of the cable from the Handheld and place the Handheld in the center of the coiled cable next to the sensor end (Fig. 10).

APPENDIX 6: NANSEN BOTTLE INSTRUCTIONS AND FEATURES

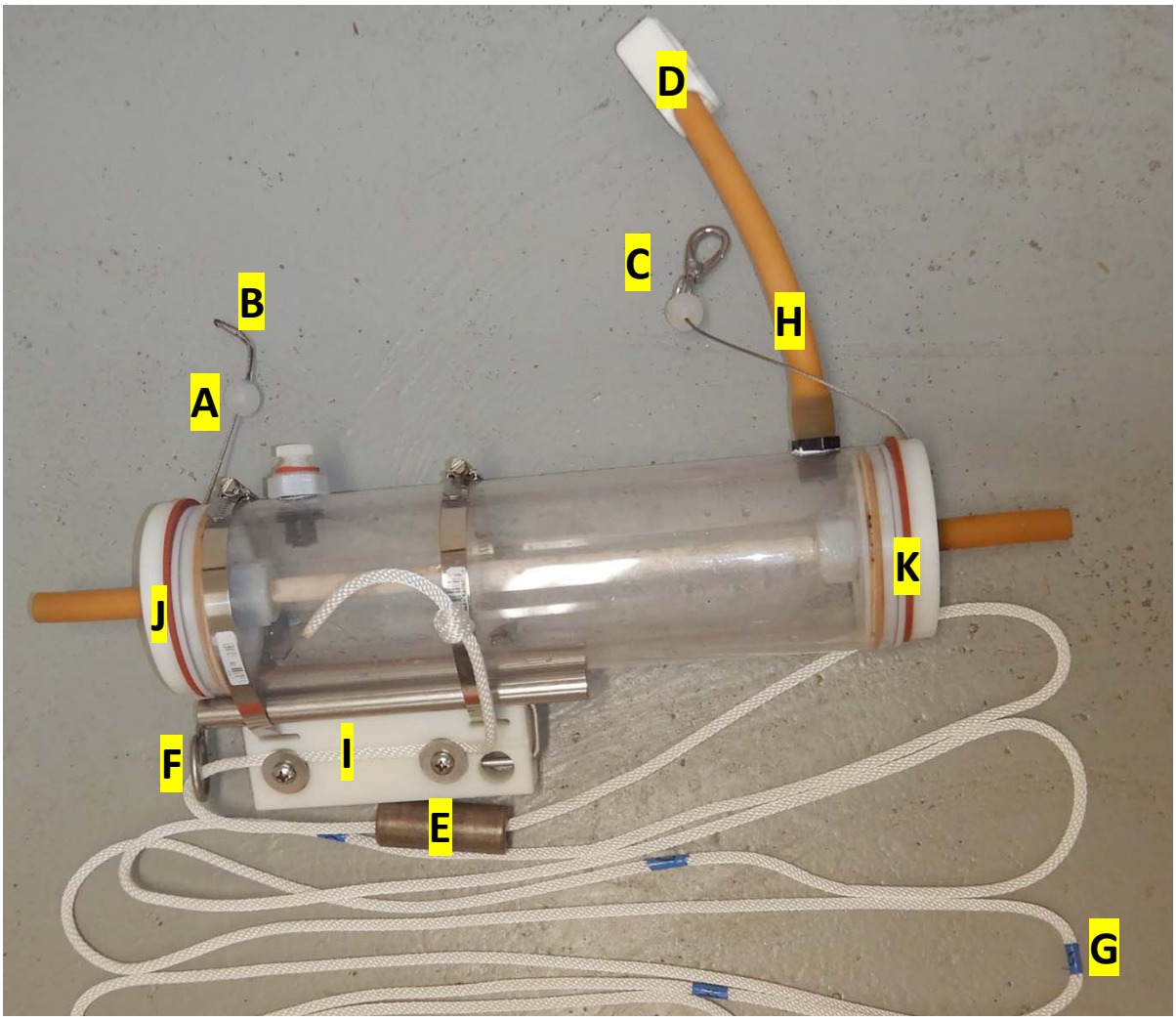


Figure 1. Important features of the Nansen bottle.

A. White plastic ball. B. Wire with loop end. C. Wire with clip end. D. Plastic clip for closing the drainage tube. E. Metal messenger. F. Top of the spring hook for locking the seals in place.	G. Tape markers for every meter. H. Drainage tube. I. White plastic with screw. Pull and lock the rubber seal on the side without screw. J. Seal near the spring. K. Seal near the drainage tube.

Figure 2. Top of the metal spring for locking the seals in place. Push this to open the hook end of the spring.

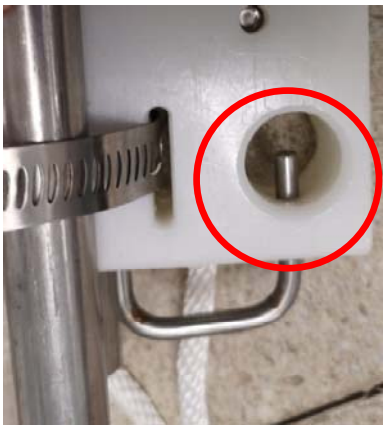


Figure 3. Spring end with hook. Put the wire with loop end through this hole and on to the end of the spring hook and release the spring.

Figure 4. Wire with loop end. This goes in first when you are securing the rubber seal to the spring.

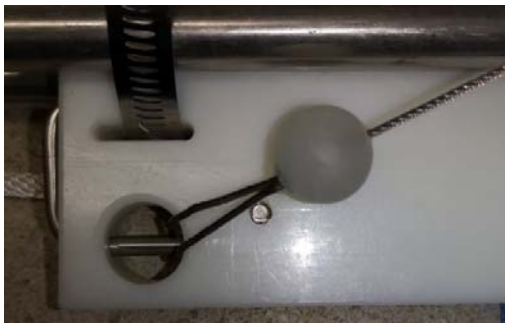


Figure 5. This is what it should look like once you hook the wire with loop end and release the spring.

Figure 6. Wire with clip end.

Figure 7. Wire with clip locked in place under the white ball of the wire with loop.

Figure 8a. Plastic clip for sealing the drainage tube. Push to close the tube.

Figure 8b. Pull the clip to open the tube and drain the samples.

Deploying the Nansen

1. Unpack the Nansen and place it in a bin with floats. Your bin should have at least 1 line tied off on the side. Use that line to secure the line spool for the Nansen to the bin.
2. Your floating chair comes with two or 4 lines tied off on the side. Use one to secure your bin to the chair.
3. Make use of the chair pockets and secure cameras, mask and other things you will need out in the lake. If you run out of room, make use of the extra lines on your chair.
4. Always make sure the white clip that closes the drainage tube (Fig. 8a) is closed before deploying the Nansen.
5. Once you are at your station, leave the Nansen in the bin and untie the line spool from the bin. Unwind the line from the spool until you get to the end of the line.
6. To keep the line from tangling, fold it neatly on one arm of the chair or on your lap.
7. Tie the spool back to the bin. The spool needs to be well secured at all times in case you drop the Nansen bottle.
8. When setting up the Nansen, make sure the seal near the drainage tube (Fig. 1K) is sitting on your lap and the seal next to the spring (Fig. 1J & Fig. 2) is facing upward. Before opening and locking the rubber seals in place, be sure that the white plastic that holds the spring (Fig. 1I) is facing outward, this will make it easier for you to pull out the seal and lock it in place.
9. With your left hand pushing down the top of the spring to open it (Fig. 2), use your right hand to pull the top rubber seal upward and then insert the wire with loop end (Fig. 4) through the end of the spring (Fig. 5) where you lock the seal in place.
10. Once you lock the first seal, lay the Nansen horizontal on your lap with the spring facing outward and pull the other wire with a clip (Fig. 6) for the second seal out and toward the end of the spring. This is the wire with a clip, NOT a loop. Clip the wire to the bottom of the white ball of the wire with loop (Fig. 7).
11. Once this is done, lower down the Nansen bottle to your preferred depth of sample. There are tape markers (Fig. 1G) on the Nansen line representing each depth. Once you are at your preferred depth of sample, wait until the line is straight down and you can feel the weight of the Nansen bottle. When you are ready, send down the metal messenger (Fig. 1E). This will release the spring lock, which will release the seals and lock the sample in the Nansen.
12. Pull up the Nansen to the surface and have the end with the drainage tube sit on your lap. Unclip the white plastic clip (Fig. 1D and Fig. 8b) at the end of the tube to release the water sample.

<u>APPENDIX 7:</u> PLANKTON NET INSTRUCTIONS AND FEATURES

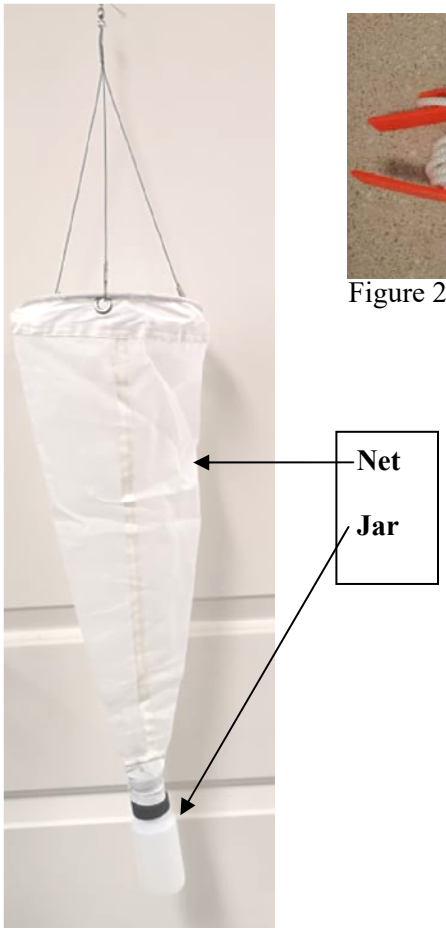


Figure 1. Plankton net with a jar attached to the end.

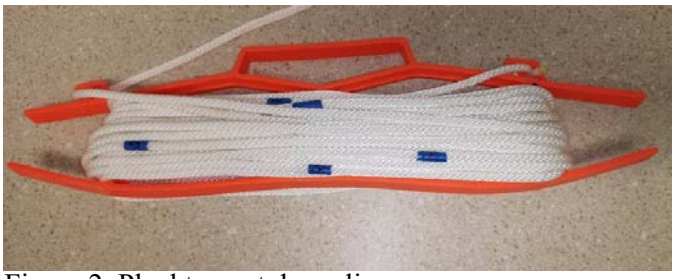


Figure 2. Plankton net down line.

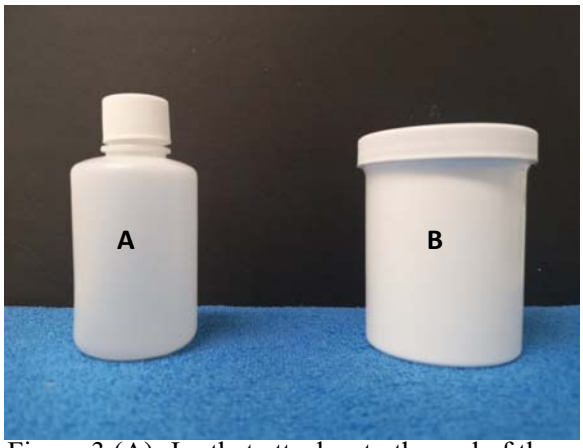


Figure 3 (A). Jar that attaches to the end of the plankton net. (B) Jar for holding samples.

Figure 4. Different sizes of filters for filtering different sizes of plankton. Left has larger mesh than the right one. Place the larger mesh over the smaller mesh and filter your samples.

Figure 5. Place filters in the small tupperware and pour your sample that's in the white jar through the filter. The bottom filter will catch your plankton samples.

Collecting Plankton

1. On the inside dock of Jellyfish Lake, tie the plankton down line (Fig. 2) to the plankton net (Fig. 1) and place both in your bin.
2. There should be at least 1 small line tied off on the side of your bin. Use that to secure the plankton net by tying it to the spool of the down line.
3. There are at least 2 small lines tied off on the side of your floating chair. Secure the bin for the net to your chair.
4. Once you are at the site, leave the net in the bin and untie the spool from the bin. Unwind your line until you reach the end and tie the spool back to the bin.
5. Screw the small jar (Fig. 1 and Fig 3a.) to the end of the net and drop the net.
6. Wait for the line to be straight and then start pulling up the net. You should pull at a rate of 0.5 seconds per meter. Do not pull really fast as the water will not properly filter through the net, instead it will displace your sample by pushing it out.
7. Once the net is at the surface, rinse the outside of the net by splashing seawater around it. This will rinse the samples from the side of the net into the jar at the end.
8. Carefully remove the jar from the end of the net and pour all your samples into the medium size white jar (Fig. 3b).
9. If you are satisfied with the amount of your samples, you can go back to the dock. Otherwise, repeat step 5 to 8. Two tows of samples should be enough.
10. At the dock, secure your chair to the side of the dock and make sure it does not get in anyone's way. Leave everything in the bin and take the white jar with samples and move to your microscope area.
11. At the microscope area, set the sample aside and rinse your hands in the bin with fresh water and wipe with dry towels.
12. Setup the filters by placing the filter with larger mesh on top of the one with smaller mesh (Fig.4).
13. Place the filters in the small tupperware and pour your sample over the filters (Fig.5).
14. The filter with smaller mesh will catch your plankton sample. Remove the filter with bigger mesh from the tupperware. If there is too much water in the small tupperware then you can spill some out. BE CAREFUL not to spill the sample in the filter with smaller mesh.
15. Place the filter with smaller mesh back in the tupperware that has some seawater. Add some freshwater into the tupperware to immobilize the plankton. Make sure water does not overflow as you will lose your samples.
16. Let the filter sit in the tupperware with mixture of fresh water and setup your microscope slide.

<u>APPENDIX 8:</u> MICROSCOPE INSTRUCTIONS AND FEATURES

Right Side

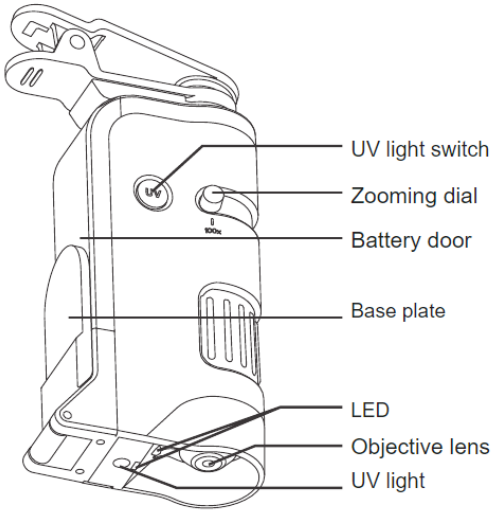


Figure 1. Features on the right side of the microscope.

Left Side

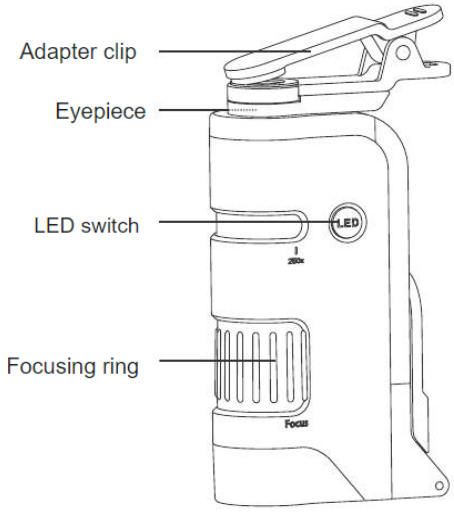


Figure 2. Features on the left side of the microscope.

Figure 3. Concave slide.

Figure 4. Attaching your phone's camera to the microscope.

Figure 5. This is what it looks like when your phone's camera is well aligned with the microscope eyepiece.

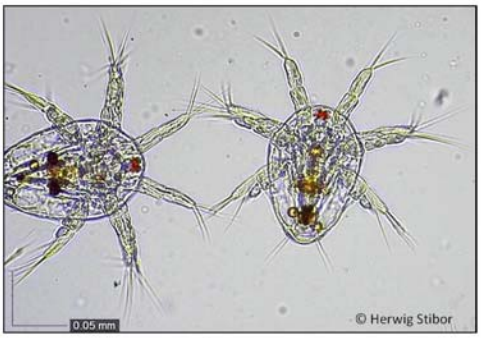
How To Setup The Microscope

1. Make sure your microscope is set to the lowest magnification by adjusting the zoom dial (Fig. 1).
2. Using the pipette, draw your sample into the pipette and place it on a concave microscope slide (Fig. 3), and cover it with a slide cover (cover slip).
3. Place the slide onto the base plate (Fig. 1) and gently close the plate. Make sure your microscope is standing upright as you are doing this.
4. Turn on your microscope by pressing the LED switch (Fig. 2).
5. Do not install your Adapter clip (Fig. 2) at this point.
6. Look through the eyepiece of the microscope (Fig. 2) and see if you can see anything.
7. If you can't see anything or it seems blurry, try adjusting the focus ring on your microscope (Fig. 2).
8. Once your microscope is in focus, gently and carefully move your slide around or side to side to look for different organisms.
9. Try your best to look for different organisms that you can find.
10. You can hook up the adapter clip (Fig. 2) for cell phone and use your phone to photograph your sample.
11. Do this by placing the adapter clip on top of the eyepiece and gently press it down to lock it in. You should hear a snapping sound when the clip is locked in to the eyepiece.
12. Press the end of the clip to open it and place your phone's camera in the clip (Fig. 4). Adjust it so that your phone's camera is well aligned to the eyepiece (Fig. 5).
13. Record what you see under the microscope by drawing images of the organisms you see on your datasheet. If you see 5 different organisms, then you will draw all 5 of them.
14. Once you are done, remove the slide from under the microscope and put it aside.
15. Bring the magnification down to 100x, if it's not at 100x, and turn off your microscope.
16. Use a dry towel to wipe your microscope and the adapter clip even if you don't see droplets on it.
17. Put your microscope in the provided plastic bag and put it in its box. Do the same for the adapter and place it in the same box as the microscope. The adapter always sits on top of the microscope.
18. Put the microscope in the tupperware and then move on to cleaning the slide. There is a separate tupperware for microscopes only.
19. Rinse off the slide and the cover slip with fresh water. Dry the slide and cover slip with a Kim wipe and place them back in their appropriate containers. There is one for the slides and a separate one for the cover slips.
20. Rinse your pipettes with fresh water, as well as the small tupperware for samples and the filter.
21. Pack the slide, cover, small tupperware, and filters in one medium size tupperware.
22. Pack the jars for samples in a bag and pack everything in your backpack.

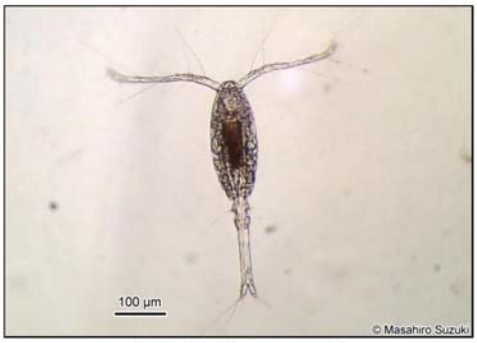
APPENDIX 9: PLANKTON FIELD GUIDE

PLANKTON _ IN JELLYFISH LAKE

ZOOPLANKTON: tiny drifting animal in the sea.



Juvenile Copepod

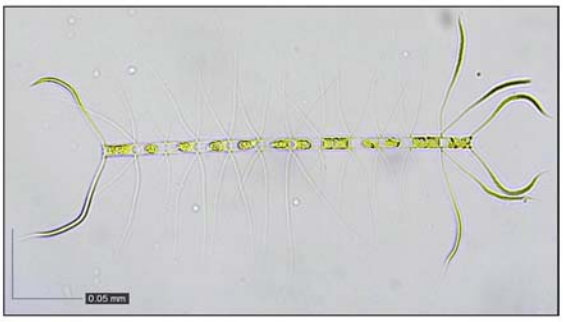


Adult Copepod

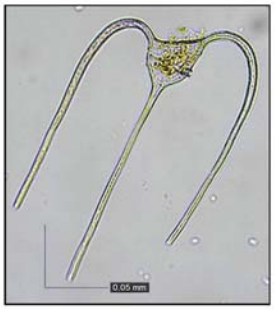
Mussel larvae

Gastropod snail larva

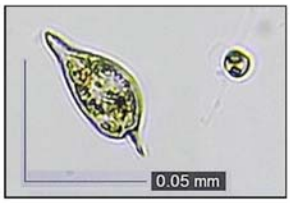
PHYTOPLANKTON: tiny drifting plant in the sea.



Chaetoceros sp.



Ceratium sp.



APPENDIX 10: SCAVENGER HUNT INSTRUCTIONS

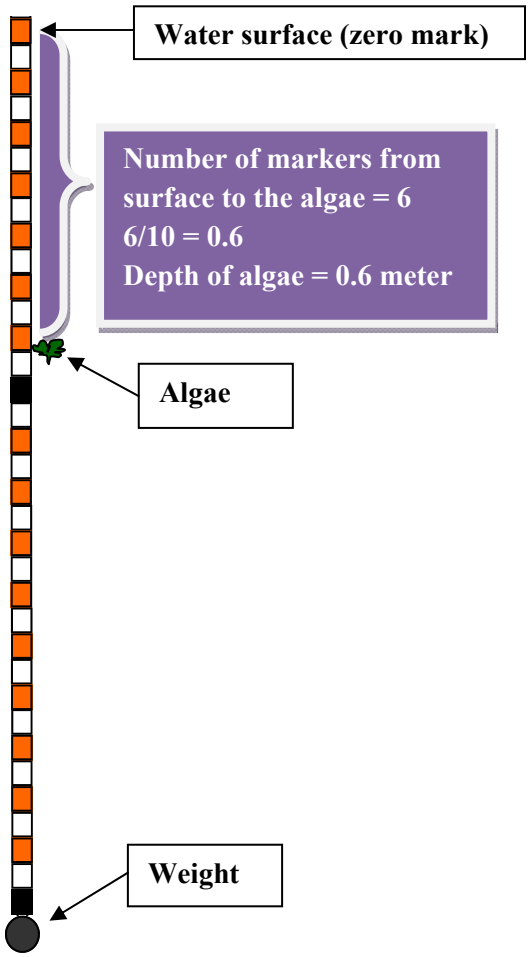


Figure 1. Use the first marker on the surfaces as your zero mark and figure out the depth of the organism.

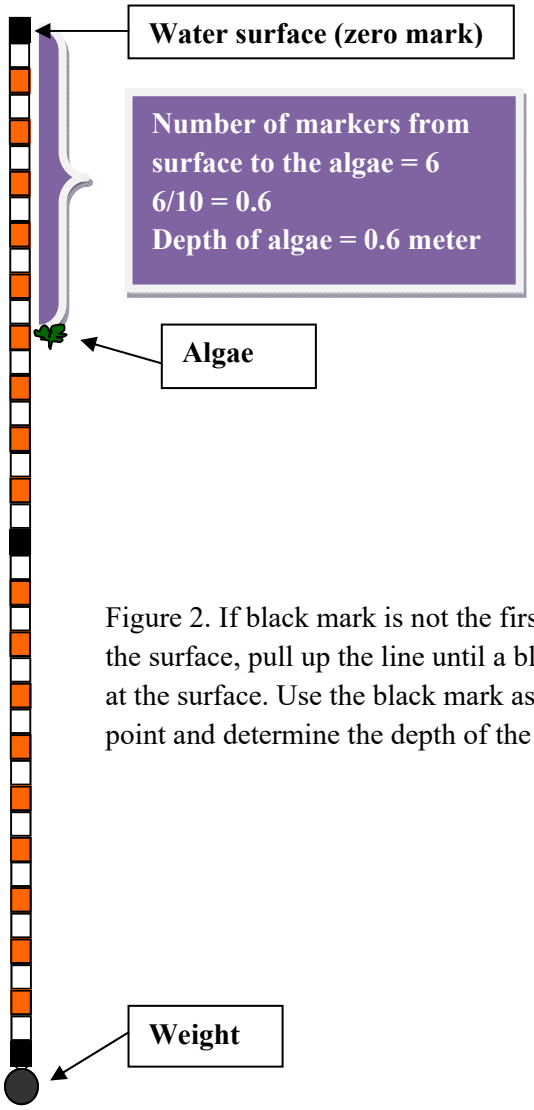


Figure 2. If black mark is not the first mark on the surface, pull up the line until a black mark is at the surface. Use the black mark as your zero point and determine the depth of the organism.

Depth Line Instructions

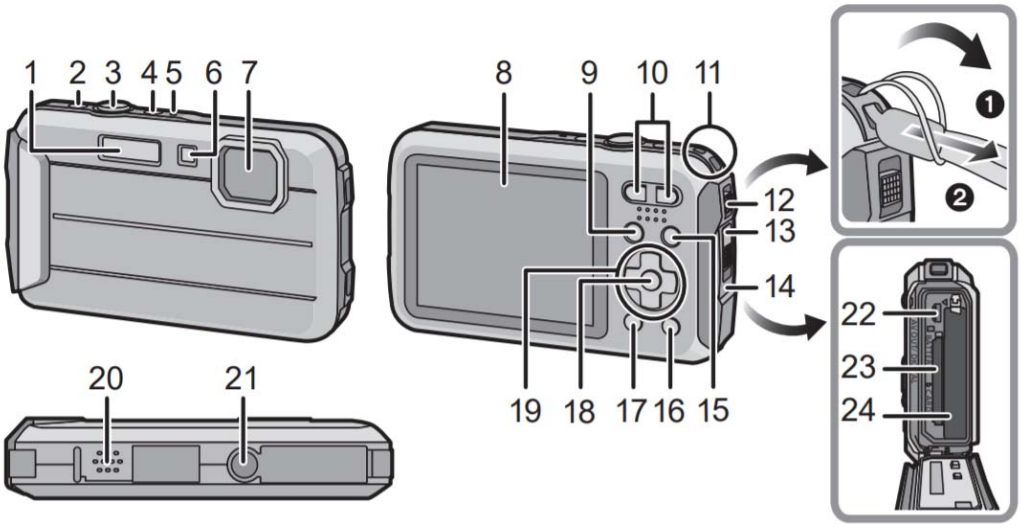
There are two ways to read the depth line.

1. Disregard the colors of the markers and use the first marker on the surface as your zero mark. Start counting from the second marker down until the last marker next to your targeted organism. Take the number of markers and divide it by 10 to find out the depth in meters (Fig.1).
2. If the first marker on the surface is orange, pull the line up until you have a black marker on the surface, this will be your zero mark. Now start counting the black markers until you reach the last marker near your targeted organism. If you counted 3 black markers

after the surface and 7 orange markers to reach the targeted organism, then the depth for that organism is 3.7 meters (Fig.2).

1. At the dock inside Jellyfish Lake, review the field guide and check mark the right phylum of each organism on the datasheet.
2. Place all clipboards, cameras and depth lines in the bin. Anything that does not float should stay in the bin if not in use. There are lines tied off on the side of your bin; use them to secure things that don't float.
3. Put on your snorkeling gear, including your life jacket and snorkel to the designated area of survey.
4. Divide tasks among your group members, that way everyone will contribute.
    a. Person to take pictures
    b. Person for depth line
    c. Person to record data
    d. Rest of the members will help each other looking for the organisms and describe to the person who is recording the data.
5. Look for all organisms on your list. It's easier to start with the first one you see. However, if you want you can start from the top of the list and work your way down to the bottom. Use your field guide for reference.
6. Using your underwater camera (Fig.3), take pictures of the organism first before you collect the other data. It is best to photograph the organism first when the water is still clear. Most of the time, people stir the bottom and that can mess up your pictures.
7. Take more than one picture just in case some pictures turn out blurry.
8. After taking pictures, unwind the depth line and let the weight sit on the bottom and the float floating (see instructions for depth line and Fig. 1 & Fig.2).
9. Your depth line is marked with 2 colors (orange & black). Black represents every meter and orange represents 0.1 meter.
10. Use these markers to figure out the depth of your organism and record it on your datasheet.
11. Determine the color of the organism and its substrate, if any, and note it on your datasheet.
12. Once you are done, you and your group will go to the dock and the rest of the members will copy data from the one who was recording data.
13. Double check that everyone's data are complete before you move on to the next station.
14. When you are done for the day, wrap your underwater camera in a dry towel and place it in a plastic bag.
15. When packing your cameras in the backpack, make sure that nothing heavy sits on the cameras. It is better if you pack the cameras in one of the small pockets of your backpack or on the very top of your backpack.

Names and Functions of Main Parts



1 Flash
2 Motion picture button
3 Shutter button
4 Camera [ON/OFF] button
5 Microphone
6 Self-timer indicator/ AF Assist Lamp/ LED light
7 Lens
8 LCD monitor
9 [MODE] button
10 Zoom button
11 Strap eyelet
- Be sure to attach the strap when using the camera to ensure that you will not drop it.

12 Release lever
13 [LOCK] switch
14 Side door
15 [▶] (Playback) button
16 [Q.MENU] button/[🗑/↩] (Delete/ Cancel) button
17 [DISP.] button
18 [MENU/SET] button
19 Cursor buttons
20 Speaker
- Be careful not to cover the speaker with your finger. Doing so may make sound difficult to hear.

21 Tripod mount
- A tripod with a screw length of 5.5 mm (0.22 inch) or more may damage this unit if attached.

22 [AV OUT/DIGITAL] socket
23 Card slot
24 Battery slot
- When using an AC adaptor, ensure that the Panasonic DC coupler (DMW-DCC10: optional) and AC adaptor (DMW-AC5PP: optional) are used.
- Always use a genuine Panasonic AC adaptor (DMW-AC5PP: optional).

Figure 3. Important features of the underwater camera.

DO NOT open the battery compartment out in the field.

DO NOT remove the float from the camera at all.

ALWAYS keep the camera in the bin if not in use.

<u>APPENDIX 11:</u> SCAVENGER HUNT FIELD GUIDE

Common English Name: Cardinal Fish
Scientific Name: *Sphaeramia orbicularis*

Common Name: Green Algae
Scientific Name: *Caulerpa verticillata*

Common Name: Mussels
Scientific Name: *Brachidontes* sp.

Common Name: Sea Snail
Scientific Name: *Drupella margariticola*

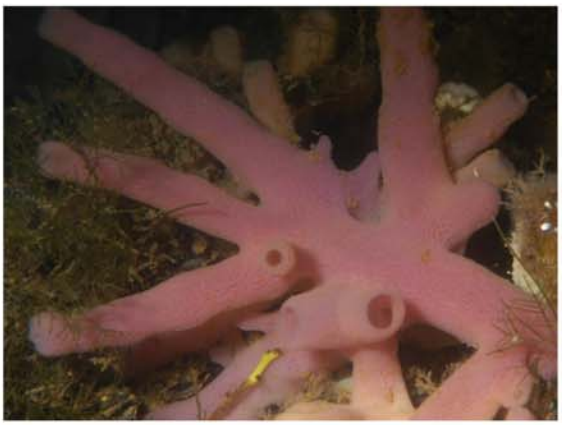
Common Name: Sea Squirt
Scientific Name: *Ascidia gemmata*

Common Name: Starfish
Scientific Name: *Linckia multifora*

Common Name: Endemic Sea Anemone
Scientific Name: ***Entacmaea medusivora***

Common Name: Invasive Sea Anemone
Scientific Name: ***Exaiptasia pallida***

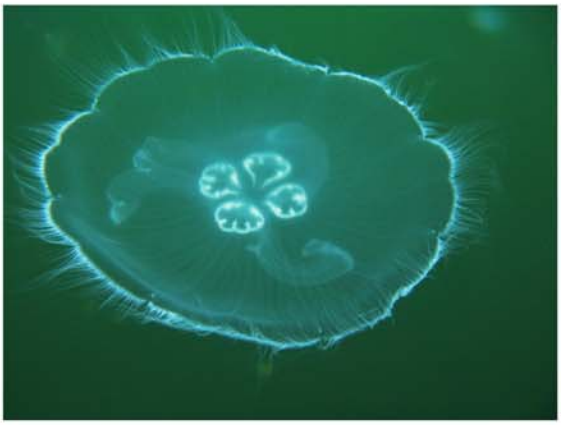
Common Name: Pink Tube Sponge
Scientific Name: ***Haliclona*** **sp.**



Common Name: Tubeworm
Scientific Name: Unidentified species

Common Name: Golden Jellyfish
Scientific Name: ***Mastigias papua etpisoni***

Common Name: Moon Jellyfish
Scientific Name: ***Aurelia sp.***



<u>APPENDIX 12:</u> REVIEW QUESTIONS FOR EACH STATION-

Back to Nature: Jellyfish Lake

I. Zooplankton

1. What is zooplankton?
2. What is phytoplankton?
3. How did you collect them? Describe the method.
4. What did you find using the microscope?
5. Why are plankton important? Explain the food web.

II. Temperature & Salinity Profile

1. What is temperature?
2. What is salinity?
3. How did you measure temperature and salinity? To what depth?
4. Explain graphs (x-axis, y-axis, lines).
5. Explain what is happening to temperature and salinity.
6. Why are temperature and salinity important?
7. Optional. Compare lake temperature and salinity to ocean.

III. Oxygen & Nansen bottle

1. What is oxygen? Why is it important?
2. How did you measure oxygen?
3. Explain graphs (x-axis, y-axis, lines).
4. Explain the data line – what is happening to oxygen?
5. Show where living organisms are, and where you would not find living organisms.

For Nansen

6. What is the pink layer?
7. What makes it pink?

8. What makes it smell?

9. At what depth did you find the pink layer?

Bonus: Why is the smell only at a certain depth? What keeps it there?

IV. Scavenger Hunt

1. What is the habitat like?

2. What did you find? Name the phylum and common name of organisms in your pictures.

3. Explain the phylum by describing what kind of animals are in those phyla.

4. What was the easiest to find?

5. What was the hardest to find?

6. Are there corals in Jellyfish Lake?

7. What gives the Golden jellyfish its golden color? Does the Moon jellyfish have the same color?