

1. Marine Diversity
  - a. This is a presentation meant to communicate the important aspects of marine biodiversity to school classes. It is by no means comprehensive but is a framework to understand the diversity of life in the oceans. The presentation is most appropriate for middle to high school groups. If you have any questions, suggestions or comments you can contact the author, Raphael Ritson-Williams at [raphswall@gmail.com](mailto:raphswall@gmail.com). Raphael is a PhD student at the University of Hawaii who studies coral reefs and is interested all aspects of evolution and biodiversity. He is funded by a STAR Fellowship Assistance Agreement # FP917660 awarded by the U.S. Environmental Protection Agency (EPA). This presentation has not been formally reviewed by EPA. The views expressed in this presentation are solely those of the authors, and EPA does not endorse any products or commercial services mentioned in this publication.
2. Categorizing Diversity
  - a. Biodiversity encompasses a huge range of different creatures. Just think about the difference among fish, birds, jellyfish and trees. Scientists use a hierarchal method to categorize diversity. The most broad of these categories are Kingdoms. Plants and Animals are two different Kingdoms, there are also multiple kingdoms for microbes. Within a kingdom organisms with a similar body plan are cataloged in the same phyla. Both of these cats are in the phylum vertebrata. You can see they are also in the same family, but are in different genera. However, much of our counting of diversity is at the most basic unit, the species. While scientists still argue about what is considered a species, most of us agree that two individuals that can make a viable offspring are in the same species. There are exceptions to this rule.
3. Understanding Marine Diversity
  - a. There are many different kinds of life under the surface of the oceans. While it is difficult for us to see and to document there is an amazing array of types of creatures. These range from tiny worms that crawl through the sand to huge whales that swim around the globe in their lifetime. While there are many species that live in temperate marine ecosystems, this presentation will focus on tropical diversity. The greatest accumulation of marine species is found in corals reefs, which are similar to tropical rainforests in the huge diversity they contain.
4. Coral Reef Diversity
  - a. Coral reefs are marine ecosystems found in clear, shallow tropical waters around the world, including Hawaii and Florida in the USA. Reefs provide habitat for diverse communities of animals and plants. Coral animals are the building blocks of these reefs. On a global scale corals can create huge reefs like the Great Barrier Reef, which is 1,600

miles long and can be seen from space. Coral reefs cover less than 0.1% of the ocean surface but they contain at least 25% of all marine species. In this photo (approximately one square meter) there are 6 different phyla; sponges, cnidarians, echinoderms, green algae, brown algae, red algae.

#### 5. Cnidarians: Corals' Cousins

- a. Coral colonies build reef habitats but what are they? Corals are animals. They are related to Portuguese man of war, jellyfish, soft corals, anemones, and zooanthids. All of these groups are classified in the phylum Cnidaria. Cnidarians have simple saclike bodies with tentacles surrounding their mouths. All cnidarians have microscopic harpoons (nematocysts) that they use to catch their food. Many cnidarians form partnerships with plants. The plant gets a safe place to live (inside the cnidarian) and the animal gets food from photosynthesis. This partnership is a type of symbiosis and is especially critical for corals that live in tropical waters where food is scarce.

#### 6. Coral Skeleton

- a. Of these related creatures, the hard corals are the only ones that produce a skeleton. These skeletons are basically "cups" of limestone that the coral secretes to protect itself and live in. The living creature is actually a very thin layer of tissue that covers this skeleton. The skeleton of coral colonies form limestone rocks (that are left there when the coral dies). These limestone skeletons are built by stacking coral cups on each other, rising towards the surface. In this way corals produce complex skeletons that are the structure of reefs. This is comparable to buildings in a city, the coral skeletons are the buildings. These buildings are critical habitat for a huge amount of biodiversity.

#### 7. Marine Plants

- a. There are many different types of plants that live on coral reefs. Marine algae include 4 phyla (Rhodophyta, Phaeophyta, Chlorophyta, Cyanobacteria). These plants are primary producers that convert sunlight to energy and are the foundation of food webs.
- b. The plant on the left of the slide is a green algae called *Halimeda tuna*. The brown algae on the right is called *Lobophora variegata* growing next to a red sponge.
- c. The plants are benthic organisms, meaning they are stuck on the bottom and can not escape predation, thus they often produce chemicals for defense, anti-fouling, anti-disease, etc. Many animals have evolved to eat specific plants, but when these herbivores are removed from overfishing or disease events the plants can replace corals and dominate reefs.

#### 8. Flowering Plants

- a. Flowering plants are quite common in terrestrial environments. These plants evolved on land, and a few species have evolved to live underwater. One of the marine flowering plants is seagrass. These

plants are important because they make seagrass habitat, which is a nursery ground for many fish and hosts a wide variety of plants and animals.

#### 9. Cyanobacteria

- a. Cyanobacteria are often called algae but are bacteria aligned in a filament that looks like a strand of hair. Clumps of cyanobacteria can grow rapidly and disrupt natural communities. They contain many chemical defenses and in the right conditions they can form a huge bloom and take over a reef. Cyanobacterial chemical defenses and natural products are showing great diversity and promise as potential medicines for humans.

#### 10. Sponges

- a. Sponges are considered very simple animals because they don't have different tissues made from specialized cells. However, sponges are ancient creatures and can dominate some habitats especially in the Caribbean. There are close to 10,000 known species of sponges in the oceans.

#### 11. Sponges on reefs

- a. Sponges are filter feeders and they help to keep the water clean. This is similar to an air filter, they eat bacteria and small plankton that are found in the water passing over reefs. They can be larger than a person and create important habitat for other creatures.

#### 12. Chemically defended habitat

- a. Many sponges are chemically defended. This means that fish and other predators typically don't eat them. This makes sponges a great place for other creatures to live. If fish don't eat sponges, then they will not eat these shrimp that can hide in the sponges. This symbiosis is especially important for the survival of the shrimp.

#### 13. Echinoderms

- a. Echinoderms means spiny skin. They are a diverse group of animals with approximately 7,000 species that include sea stars, sea urchins, sea cucumbers and crinoids. Even though many of these animals appear very different they all have radial symmetry. This is a tropical sea star that has radial symmetry making the five legs.

#### 14. Crown of thorns

- a. Sea stars are found in diverse habitats and can have 5-20 legs, but are typically predators. This sea star is called the "crown of thorns" star because of the spines that are all over its body. The crown of thorns star eats corals and so well studied because it has a strong influence on the diversity of corals on reefs. These stars can come in huge blooms (more than 10,000 individuals) where they are known to eat almost every coral in their path.

#### 15. Brittle stars

- a. Brittle stars are much more delicate than sea stars, this is a yellow brittle star hanging off of a red sponge. They have thin legs that often break if you try to grab them. Brittle stars often hide in rocks and only

come out at night. They are scavengers and can also filter food (plankton) out of the water as it floats by.

#### 16. Sea cucumbers

- a. Sea cucumbers are squishy tube like creatures that live on the bottom of the ocean. They range in size from as small as a pinky nail to the size of a loaf of bread. They eat bacteria, but consume sand and digest the bacteria off of the sand. You can think of these as the street cleaners of the ocean. They continuously clean the bottom of the ocean so that other organisms can live there.

#### 17. Crinoids

- a. Crinoids are relatively rare on most coral reefs and similar in appearance to brittle stars but with more legs. They have sticky cells on their legs and catch plankton and other floating material found in the water. Crinoids typically sit in one place and filter water but they can move. Some rare species of crinoids are stalked (resembling a sunflower) and these species do not move. Stalked crinoids used to be very common in the oceans but many species went extinct millions of years ago.

#### 18. Urchins

- a. Sea urchins have a hard shell referred to as a test that is typically the size of a baseball. This test is covered by sharp spines. Most sea urchins are herbivores and eat algae but they can scrape animals off of rocks while they are grazing. On coral reefs sea urchins are important herbivores that eat algae creating space for corals. This food web was disrupted in the Caribbean ocean in the 1980's due to a widespread disease that killed most of the dominant urchins. This created a shift in the community diversity of the reefs away from large corals to more fast growing algae.

#### 19. Molluscs

- a. Molluscs is a phylum that includes oysters, clams, squid, snails and slugs. There are 85,000 spp. of molluscs worldwide. All molluscs are bilaterally symmetrical with an open circulatory system housed in their body cavity surrounded by a thick skin called the mantle. Molluscs have a nervous system. They range from microscopic bivalves to giant squid that can be longer than 20 meters.

#### 20. Snails

- a. Snails make a shell that they can hide in, which is like carrying their home on their backs. Snails have a large well defined "foot" that they use to move around and grab their prey. Snails have a mouth with a radula (tooth), this radula has evolved many different functions in different species, from a harpoon in cone snails, a straw like structure in sap suckers, to a rasp in herbivores that lets them scrape food off of rocks.

#### 21. Opisthobranchs

- a. Opisthobranchs are a group of different species that are effectively snails without a shell, a slug. Some of these slugs are herbivores and

others are predators. Marine slugs are often brightly colored and are chemically defended since they don't have a shell. This coloration is an important visual cue of their toxicity and helps fish to learn and remember to avoid these toxic slugs.

## 22. Cephalopods

- a. Cephalopods include squid (on the left), octopus (on the right) and cuttlefish. Cephalopods are also molluscs but their shells are very reduced. These animals are predators and they are relatively intelligent. One of their adaptations is that they can change their skin color and texture, which helps them hide from predators.

## 23. Crustaceans

- a. Crustaceans are a diverse group of mobile creatures that includes over 67,000 species. These two orange crabs are hanging onto a soft coral at night, probably to catch plankton. Crustaceans are a type of arthropod, which is a hugely diverse group of animals that includes insects, crabs, shrimp, krill, copepods and others. Crustaceans typically have a hard outer skin called an exoskeleton. Since the exoskeleton is not flexible crustaceans have to shed it as they grow bigger, a process called molting. After they shed their exoskeleton, they excreting a soft shell and wait minutes to hours for the new shell to harden. Crustaceans include strange small animals and a variety of miniature parasites that are rarely studied. Copepods are a small crustacean that many people don't see but these are a huge component of the planktonic food web.

## 24. Crabs

- a. Crabs are one of the best known groups of crustaceans and can live on land, in freshwater and in marine environments. These animals have a short squat body and have two large claws. Crabs are opportunists, they will eat just about anything. Crabs are an important fishing industry for people. This is a tropical spider crab, it is related to the king crab from Alaska that they serve at restaurants.

## 25. Shrimp

- a. Shrimp are also important fisheries for people, and support an industry worth 50 billion US dollars a year. Shrimp are wild caught or farmed in many 3<sup>rd</sup> world countries. Both of these fishing methods cause harm, when fish are caught from the wild the nets catch a huge number of other creatures that are killed, called by catch. When shrimp are farmed their water becomes high in nutrients and is often dumped on the reefs causing algae to grow, outcompeting corals. Shrimp are typically long slender bodied crustaceans with very small claws. They have small legs and use swimmerets under their tail to swim through the water. Many shrimp live symbiotically with other animals including; sponges, ascidians, and cnidarians.

## 26. Lobster

- a. Lobsters are another crustacean that is an important fishery around the world. They have thick legs that allows them to walk but they also

have a large tail that they can flip to move rapidly to escape predators. They can have large claws (Maine Lobster) or no claws at all (Caribbean Spiny Lobster). Lobsters are also opportunists and will scavenge dead food from the ocean floor if necessary.

#### 27. Marine Worms: Polychaetes

- a. Worms is a catch bag of creatures and includes at least 4 phyla. They are an important and diverse group that play many roles in marine habitats.
- b. The polychaete in this photo is called a fire worm, it is a type of annelid. It has sharp spines on the edge of its body that can stick in your fingers like a splinter. This worm lives in the Caribbean and eats different species of corals.
- c. Nemertean (not shown) are commonly called ribbon worms. Many ribbon worms are parasites, but the marine species are predators that often contain paralytic toxins for prey capture. Most species look very similar to each other and so are difficult to categorize and distinguish.
- d. Nematodes (not shown) are commonly called round worms and are a diverse group of worms (over 25,000 species described) that live all over the planet. These are especially important in soil and can be the dominant organism found in the sediments in the deep sea. Most nematodes are poorly studied but some of the best studied species are parasites.

#### 28. Christmas tree worms

- a. This animal is called a Christmas tree worm, it is a type of annelid. Annelids are the most commonly seen worms, an earthworm is an annelid. Annelids are segmented worms that are diverse but difficult to distinguish species, so the number of species remains poorly understood. This Christmas tree worm doesn't look like a typical worm, it buries most of its body in a coral and then waves these structures in the water to filter plankton out of the water column.

#### 29. Flatworm diversity

- a. This is another phylum of worms, the flatworms. These are a diverse group of worms that are very poorly studied. Many flatworms are parasites and are often studied for their ability to regenerate, if you cut one in half another half will grow back. Some of the larger free living flatworms (such as the one in this picture) are brightly colored and predators of soft bodied animals like the ascidians.

#### 30. Ascidians

- a. Ascidians are commonly called sea squirts and are in the phylum Chordata. Ascidians include 2,300 species that are found all over the world, but mostly in marine systems and rarely in freshwater habitats. They are invertebrates but because they have a hollow nerve cord, they are thought to be an evolutionary link/ precursor to vertebrates. They are characterized by a tough outer skin that is called a tunic. Ascidians are stuck to the bottom and they use their siphons

to filter food out of the water. They do not have an escape mechanism from predators so are often chemically defended.

### 31. Colonial Ascidians

- a. Some ascidians like the ones shown here are colonial. Each individual ascidian is connected to others, making one large animal made up of many different individuals.

### 32. Solitary Ascidian

- a. The ascidians shown here are solitary they are the purple and yellow blobs. They live as one individual and can be as large as a fist. The incurrent hole on the top takes in water and the animal spits out filtered water through the hole on the side of the body. There is a species of shrimp that makes its home in these ascidians.

### 33. Fish

- a. Fish are vertebrates (phylum Vertebrata) that are commonly found in fresh and marine habitats. They have limbs and gills. Fish includes a diverse group of organisms (more than 33,000 species) that have many different adaptations for survival in an array of habitats. They are mobile and typically swim with their fins, but a few species like eels swim with their body motion. They are an important fishery and provide approximately 1/6<sup>th</sup> of all the protein people eat. The annual yield of fishing is approximately 150 million tons per year.

### 34. Symbiosis

- a. One of the main themes throughout this presentation is symbiosis. In the oceans many organisms survive in their habitat because they have evolved to live together. This is a critical evolutionary force that can provide food and habitat for many different types of organisms. This photo shows a clownfish, it relies on its anemone for a home. The anemone is a cnidarian that provides a safe place to live. The fish helps to catch food and keep the anemone clean, a critical symbiosis for the survival of these two types of animals.

### 35. The Balance of Food Webs

- a. Many animals serve a critical role in maintaining the natural balance of a habitat, such as these parrotfish that eat algae. It is really important that we don't overfish parrotfish or algae will overgrow reefs and restrict the ability of corals to survive. Another major theme in diversity research is that every species contributes to a balanced ecosystem. Maintaining diversity is critical for the proper functioning of food webs. We rely on many top predators, crustaceans and fish for food, if we kill the organisms at the bottom of the food web, the web will collapse and no longer provide humans with food.

### 36. Invasive Species

- a. In addition to maintaining the native species we need to restrict the introduction of novel species to an ecosystem. Invasive species are ones that are moved from their original home and introduced to a novel habitat. This often disrupts the balance of food webs and is a serious threat to habitats in both marine and terrestrial systems. The

lionfish shown in this slide is originally from the Pacific Ocean. It was introduced to the Caribbean around 2000. Lionfish are a voracious predator that will eat all different types of juvenile fish. This is a serious threat to Caribbean coral reefs because as the native fish decline the food web will be pushed out of balance.

37. What do we know?

- a. This presentation has exposed you to a variety of the creatures that live in the ocean. By no means is it everything that lives there, really this is just the tip of the iceberg. It is important that you realize that every creature has a role to play. While there are some weird and slimy things out there they all serve a purpose.
- b. Unfortunately we are in the middle of a mass extinction. Many marine species are dying in front of our eyes and we are doing nothing to stop this. Many of these extinctions are being driven by climate change. It is time to address the fundamental issue of how humans can live sustainably on this planet while ensuring we don't destroy the very ecosystems that we rely on.