We're excited to start going over these concepts with you and your students! This education plan was developed with both students and teachers in mind. The experiments utilize materials that most classrooms have or are not too expensive to get. It's a five-day crash course in the basic concepts of marine biology with the intent of helping students understand how they can work together or individually to save the ocean and its inhabitants. Knowing that marine biology is an ultra-specific and ever-evolving field, we did the hours of research for you so that this can be a fun experience for you as well. If your students are asking something that isn't included in this book, please reach out to us so someone on the education team here at Captain Dave's can help you get the resources or give your students some hints on reputable sources to do their own research.

We'll be asking them to learn *a lot* in a short amount of time so the following information is just a foundation that they can build on later (either in life or through their own research). Who knows...you might have a budding marine biologist on your hands! We also know that the pacing might be too intense. We tried to break it down in such a way that you can mix-and-match your lab book. While they'll get the most out of doing each experiment and then reading the "Diving Deeper" section, there's only so many hours in a day. If you want to pace the book differently, feel free to do so and let us know if you need any help shortening the lessons.

Day 1 - Oceanography

Objectives:

- Understand the shape and range of the ocean floor off the coast of California
- Learn how the seafloor impacts sea life
- Understand currents and gyres and how they impact sea life
- Discover the Pacific Ring of Fire

Experiments:

1. The Waves Experiment

This experiment is to help kids understand why the coastline looks how it does. There's a lot to be learned about the seafloor from the surface waves that we see on the beach. The ocean floor is a good indicator of what type of animals might be attracted to this area so understanding how to identify what type of ocean floor you're looking at is useful for marine biology to set the expectation.

- What do you think will happen if the water moves over different surfaces?
- What do you think will happen after you change the sea floor?

Waves in the water move a little differently than sound waves. The energy moves in two ways concurrently: descending counterclockwise circles. The wave at the surface (created in less dense water by the disturbing force that is usually wind) will have a wide circumference. As it moves down into the water, the circumference gets smaller and smaller until the energy dissipates. In the deep ocean, that means that (usually) waves will not break since by the time the energy hits the ocean floor it has either dissipated or is too small to push the wave up into a crest. At the shoreline where the ocean floor is closer to the surface, the energy hits the ocean floor and bumps the water up into the crest of the wave which then curls, breaks, or crumbles depending on the type of ocean floor it's moving over. California has a pitted, jumbled, scarred ocean floor because of the convergent tectonic plates that push against each other. That activity is what creates waves, ecosystems, and fun whale watching trips.

Wind is created by an inequality of surface temperature. The seasonal tilt of the earth towards the sun tells you when winds will be picking up. As the sun heats one section of the earth more intensely than another, that air gets warm, expands, becomes less dense, and rises. Cold air rushes to fill the void left by the warm air, thus creating wind. During the summertime in the Northern Hemisphere, the sun is more evenly exposed between the North Pole and the Equator which creates less temperature disparity which means less wind. During the winter time, the earth is less evenly exposed which creates stronger winds that create bigger, stronger waves. In the Southern Hemisphere, they have a more regular spread of heat throughout the year which means they have mediocre waves year round as compared to the seasonally phenomenal waves in places like California and Hawai'i.

So while the energy dissipates as it moves downward in the water, it can grow as it moves across an ocean basin. It can hook up with other, larger waves that were created by other, larger disturbing forces or it can be pushed by a particularly persistent disturbing force.

If your students are very interested in the idea of winter waves vs. summer waves, you can tell them to do some research on photos of specific beaches in the middle of summer compared to a photo of the same beach in winter. Crystal Cove in Newport is a great example. During the summer time, the sand is all on the berm (the sandy expanse leading up to the water) and the berm has next to no slope to it. During the winter time, the berm is steep with jagged little sand cliffs where the tide reaches its highest point and exposed rocks up and down the beach. The waves are a bit bigger and more powerful because they gain a bump from the sandbar that they created with all the sand that used to be on the beach.

Again, this comes back to the Pacific Ring of Fire creating that dynamic ocean floor for us. The water at the bottom of the ocean is cold because it gets no sunlight. It gains nutrients from coming into contact with the diatomaceous earth on the ocean floor. This ocean floor is rarely disturbed by wave energy so the organisms that die and eventually decompose and float to the bottom stay there. This diatomaceous earth basically becomes fertilizer for the water and helps it soak up nutrients. As upwelling occurs, it pushes that nutrient-rich water to the surface where it reacts with sunlight to form phytoplankton which then starts the whole food chain for more of the surface-dwelling marine animals.

THINK ABOUT THIS...

1. What role does the Pacific Ring of Fire play in the way waves are shaped?

The Pacific Ring of Fire has a high occurrence of earthquakes and a lot of tectonic activity. The convergent plates rub against each other to create a lot of variety on the ocean floor (submarine canyons, ridges, steep drop-offs, etc) so the waves have a lot of opportunity to get pushed up into different shapes.

2. If you're at the beach during summertime, will the waves be better for surfing or better for swimming? Why?

The waves will be calmer during the summertime, meaning they're better for swimming rather than surfing. Because the waves have less energy during the summertime, they don't pull as much sand off the berm (beach face) and they don't create a sandbar for the waves to form over.

3. Why is it important to understand what the ocean floor looks like? Could you use the same principles of understanding the nearshore ocean floor to understand the deep ocean floor?

Understanding what the surface water looks like gives you a basic (if not exact) idea of what the ocean floor looks like. If you know what the ocean floor looks like, you can give an educated guess as to what type of animals might call that place home. Using this idea, we can also map the deep ocean floor. Scientists actually use satellite images of ocean basins to map the deep ocean floor. Using algorithms to account for tidal bulges, the scientists can tell you where an underwater ridge, valley, or mountain most likely occurs by the different "resting" heights of the water.

2. The Gyre Experiment

This experiment is to show them how the water that we see doesn't just stay here. It's important to understand how the water moves around the Pacific Basin so that when we get to Day 3 and talk about pollution, they know why the garbage patch is forming and why it's a persistent problem and they start to get a base knowledge for pollution as a problem that starts on land.

- Where do you think each color will end up after departing from their assigned destination?
- **CAN WE DO THE SHEET WITH THE APPROXIMATE START POINTS FOR THE TEACHERS?**

Gyres seem simple but are fairly complicated. The gyre off the California coast (illustrated above) is comprised of four main currents which then feed into smaller currents. All these currents work together to create one gyre. They're controlled mainly by the wind belts (consistent wind) and the Coriolis Effect which makes things curve due to the earth's rotation and axis tilt. Everything is very delicate and works in concordance with each other. Without one piece, it would all stop working.

The Great Pacific Garbage Patch was first discovered by Charles Moore in 1997. He was sailing from Hawaii to California and ended up going through a giant patch of garbage floating on the ocean, a floating dump. For the most part, no one had considered what happened to trash and debris that ended up in the ocean. Though we already knew about gyres and the currents that made them up as well as the fact that there had to be a convergence zone, no one had considered that the trash ended up in the ocean and remained there as it decomposed. Organic materials (dead animals, plants, cardboard, etc) break down within a matter of months. Plastics are an entirely different story. They take hundreds, maybe thousands, of years to break down. The first piece of plastic ever made is still in existence.

Since the ocean is a concealing and harsh medium, the animals in it must adapt to its changes otherwise it means certain extinction. The trash pile didn't appear overnight, it took many years to grow to the size it currently is (about the size of Texas). So as more trash appeared, animals adapted to living in and around the trash.

Algalita based out of Long Beach is the foremost authority on the Great Pacific Garbage Patch. Their founder is Charles Moore and has since built a career on researching the trash pile and the potential ways to clean it up.

This is going to be a theme throughout the booklet. Right now, understanding marine biology centers around the idea of repairing years' worth of negligent damage humans have cause. It starts with small actions (throwing away trash, picking up trash, using a canvas bag rather than a plastic one, etc) and has a huge effect.

THINK ABOUT THIS…

1. Why is the water in California cold? Do you think the water in Japan is warm or cold? What about Hawaii? Why?

The water here is cold because of the California current which puts up chilly water above Alaska. If you follow the arrows of the currents in the gyre diagram, you'll see that the water that flows past Japan's coastline would be warm because it picks up warm water from the equator. The same idea goes with Hawaiian waters. The students may need a little hint as to Hawaii is BUT once they know about where it is, they can see that the California Current is also part of a smaller, sub-gyre that picks up warm water closer to the equator before flowing up and rotating back past Canada (picking up cold water again) and returning to be part of the California current.

3. Knowing that every ocean has a gyre, do you think there are other floating islands of trash? Why or why not?

There are other areas of floating trash! Anywhere that there is a convergence zone, marine debris will gather. You can divide your students into groups and have them research any of the floating garbage patches in the world. The most famous after the Pacific Garbage Patch are:

- Indian Ocean Garbage Patch
- North Atlantic Garbage Patch
- Mediterranean Sea Garbage Patch

Because we don't live next to these garbage patches, we did not include any information about them but if your students are interested, please feel free to introduce them to GarbagePatch.Net so they can learn more.

4. Why can't we just take the trash out of the ocean?

We can't take the trash out because it is too integrated into the ecosystem. Fish and birds now rely on the floating pile of garbage as a habitat. Add to this the idea that as the plastic breaks down, it turns into microplastics. These microplastics can range in size but can be about the same size as krill and phytoplankton (a main source of bait for a lot of ocean life). So to take out the microplastics as they mingle with krill and phytoplankton, you would need to remove the krill and phytoplankton as well which would majorly disrupt the food chain and cause the ocean to become a barren wasteland. The problem of the plastic is delicate. For more information, have the kids look up Algalita. The founder is also the man who discovered the garbage patch in the Pacific so the foundation is an authority on marine debris. As an added bonus, they're local to Southern California.

5. What can you specifically do to help keep trash outside of the ocean?

Hopefully this one won't require too much stretch of the imagination for the kids. The simple answer is "Reduce, Reuse, Recycle." You can ask them to be more personal and look at what *they* specifically can do to help keep our oceans healthy.

A Plastic Ocean Set Up:

This is a set up for Day 3. On Day 3, they'll look at these cups and see how the vinegar has corroded whatever they brought in (shells, bark, plastic, etc). Having them observe what the items look like before going into the vinegar and then write it down will help cement the idea that a higher acid content in the ocean has legitimate and visible effects on wildlife.

Day 2 - Species, Seasons, & Behaviors

Objectives:

-Learn about the local types of ocean animals
-Discover why the California coast is unique
-Understand how each species plays a role in the food chain

Experiments:

1. Echolocation Experiment

Not all whales have baleen though. Toothed whales have a “melon” on their head which is where they emit and receive their high frequency sounds and reflections. The bigger the melon, the better the echolocation. While it’s difficult for humans to work with echolocation, it’s easy for dolphins. The sense of echolocation is so sophisticated that dolphins can bow ride (ride the pressure wave at the front, or bow, of the boat) without ever hitting the boat. They can get within fractions of an inch of the boat and still know exactly how to be safe. To get them excited about going whale watching, you can pull up a video of being out on Manute’a, our catamaran with underwater viewing pods. They’ll be able to see how the dolphin come right up and look passengers in the face while the boat is still moving.

They emit a high pitched sound from their melon that travels out in front of them. The **melon** is found on the front of the whale’s head. It’s a mass of tissue where the high pitched sound used for echolocation is formed and concentrated. When that sound hits an object, it bounces back. The whale can then interpret this bounceback to determine what object is in front of them, such as a fish, a boat, or a diver. They use echolocation to “see” better underwater. If a fish is hidden behind kelp or buried in the sand, toothed whales can still find them with echolocation.

The toothed whales that can be found off of Southern California include common dolphin, bottlenose dolphin, Pacific white-sided dolphin, Risso’s dolphin, and sometimes pilot whales, sperm whales, and killer whales (orca). Some whales have a stronger sense of echolocation. The easiest way to tell the strength of their echolocation is by the size of their melon. The larger the melon, the stronger that whales’ ability to echolocate. For example, a sperm whale has a large melon which means there’s a lot more room for the sound to concentrate and bounce back making their sense of echolocation stronger than a common dolphin’s, which has a smaller space to concentrate and bounce back from.

Adult male toothed whales are larger than adult females. Some toothed whales are dimorphic (i.e. large dorsal fin and broad pectoral flippers for male killer whales) and some are not. One of the ways to tell the sex is the presence of a young calf with females and extremely large size for males.

Killer whales, pilot whales, false killer whales, pygmy killer whales, and melon-headed whales are actually members of the dolphin family. The beaked whale family consisted of 22

species and all of them are rare to see. They typically reside in deeper waters which are often out of range for regular 2-3 hour whale watching trips and are extreme divers, staying down for as long as an hour. Sperm Whales are the largest of all toothed whales, growing 50-70 feet in length. Other species of toothed whales include dwarf sperm whales, pygmy sperm whales, narwhals, and beluga.

2. Eat Like a Baleen Whale Lab

Baleen whales are filter feeders. The way they feed may seem crazy to kids so showing them with combs and cereal bits will help them visualize how a whale eats. After they filter the water out and have a mouthful of fish, the whale will use its tongue to shove any food in its mouth down its throat. It's important for kids to see that while whales are huge and could seem a little scary, they're gentle giants that feed on the smallest fish.

The different colors of the fruity pebbles represent how trash and microplastics are mixed in with the animals whales feed on. Try having students only filter a certain color of cereal. It is nearly impossible! Whales have no way of avoiding trash and microplastics in the ocean.

Mysticeti, or **baleen whales** do not have traditional teeth; they have baleen plates. Humpback, blue, Gray, fin and minke whales are all examples of baleen whales that live off of our coast. **Baleen plates**, commonly referred to just as baleen, are the hairy-looking plates that hang down from the upper jaw of a toothless whale. It is made out of similar material as your fingernails and hair. Their latin name, *mysticeti*, actually means "mustachioed" since the baleen makes whales look like they have a mustache. Baleen whales feed by taking up a mouthful of water and filtering out their food (i.e. small bait fish and krill) the same way you filtered out the water and kept the Fruity Pebbles in the cup.

Within baleen whales, there are further classifications like rorquals, (i.e. blue,fin, minke, humpback, sei and Bryde's whales) right and bowhead whales (Atlantic and Pacific right whales and bowhead whales), and Gray whales. For all baleen whales, females are larger than males. It can be difficult to tell the difference between males and females; one of the most obvious signs the presence of a young calf or the extremely large size for females.

THINK ABOUT IT…

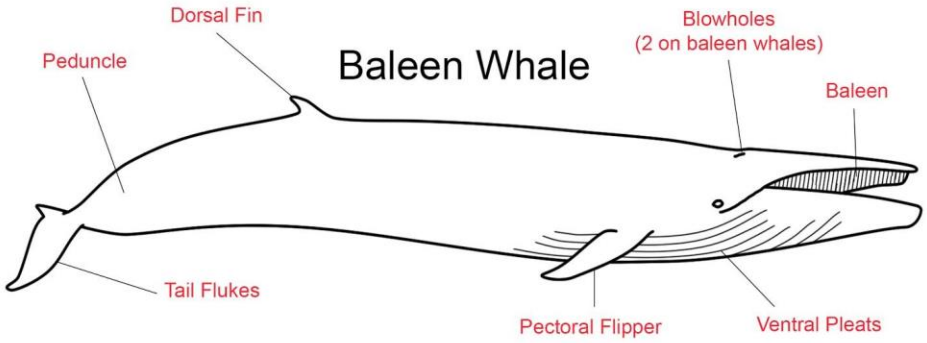
1. Knowing that baleen whales are filter feeders, do you think they can filter out the fish from plastic debris and water?

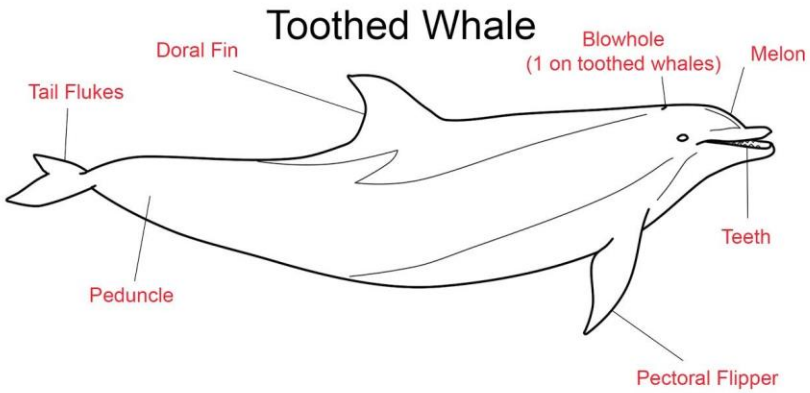
Since the focus of this book is marine biology with an emphasis on marine pollution, we'll be tying into marine pollution a lot. They cannot filter the fish from the plastic. The plastic breaks down to become microplastics that then integrate with the small krill/phytoplankton that whales gulp up. Because they're similar in size, the whales cannot filter the plastic from their bait.

3. Label the Whale Parts Activity

On Day 3, we'll be talking about basic anatomy during the entanglement sections. If we say "a whale with a fluke entanglement" it's important that the kids understand what the flukes are and why it's dangerous for them to be entangled.

Label the Whale Parts





4. Species Activity

Cetaceans have delicate social structures. Dolphins are given a “signature whistle” at birth- similar to how human parents give a name to their children. They use this signature whistle as they communicate throughout their lives. Even if a dolphin leaves for an extended period of time, the pod will greet them with their signature whistle upon their return. Understanding some of their behaviors will make it more fun for the kids while they’re trying to fill out their journals on Day 4. Since a lot of animals display distinct characteristics off Dana

Point, it will be easier for them when they're on the trip if they already know what they're looking for.

I. Common Dolphin:
   A. Migration/Range: Common Dolphin remain in Southern California waters year-round and are not migratory. The population here spans from Santa Barbara to San Diego. As a species, different populations of Long and Short-beaked Common Dolphin are across the world. They reside in subtropical and temperate waters.
   B. Diet: Common Dolphin feed on small baitfish, such as anchovies, sardines and other small schooling fish. They occasionally feed on small squid and other cephalopods. They only eat what they can swallow whole, so the organisms are roughly the size of an adult human's finger.
   C. Common Behaviors: Common Dolphins are highly social animals and can be found in pods ranging from 10 to 10,000 individuals. Most regularly seen behaviors include bowriding, porpoising and stampeding. Long beaks are more likely to bow ride (surf on the waves created by the front of the boat), although Short beaks also do this on occasion.

II. Bottlenose Dolphin
   A. Migration/Range: Bottlenose Dolphin remain in Southern California waters year-round and are not thought to be migratory. The population here spans from roughly Santa Barbara to San Diego. Coastal Bottlenose are commonly sighted year-round near the shore, often surfing in the waves near beaches. Offshore Bottlenose are most commonly sighted in the summer months, it is not known if they move into more tropical waters during the winter. As a species, Bottlenose are found across the world in temperate, subtropical and tropical waters.
   B. Diet: Bottlenose prey on a wide variety of organisms. Coastal dolphins tend to feed on fish and invertebrates that live near the bottom. Offshore dolphins eat pelagic and mesopelagic fish (i.e. croakers, sea trout, mackerel) as well as squid. Different populations around the world have developed some interesting hunting strategies- with both individual and cooperative methods.
   C. Common Behaviors: Most common behaviors for Bottlenose include breaching, porpoising, bowriding, tail slapping and pectoral flipper slapping. Behaviors vary between coastal and offshore populations. Coastal animals tend to be more shy of boats. They can be seen from shore, sometimes even surfing in the waves by beaches! Offshore Bottlenose more commonly approach boats and bow ride. They are also capable using their powerful muscles to launch themselves in a full-body breach! Sometimes multiple dolphins do this at the same time, creating an incredible "air show." Bottlenose dolphins can sometimes be aggressive towards other cetacean species (such as smaller dolphins and porpoises).

III. Blue Whale:
   A. Migration/Range: Blue Whales are found world-wide inhabiting both coastal and oceanic areas. As a species, they spend summer in colder water for feeding and winter in warm equatorial water for calving and mating. The population of Southern California comes area surrounding the Channel Islands (San Diego to Santa Barbara) to feed and migrates to Mexico and central America for the winter.
   B. Diet: Blue Whales are somewhat picky eaters and feed almost exclusively on krill (zooplankton invertebrates)- the largest animal in the world feeds on some of the smallest! Blues are occasionally known to feed on pelagic crabs as well. Adult Blue Whales consume 5-6 tons of food in a single day! Because of the s pecies large size, it is believed that Blues need feeding areas with particularly dense prey patches.
   C. Common Behaviors: Most baleen whales are solitary and tend to travel alone or in small temporary groups. Behaviors we often see from Blue Whales include fluking and lunge feeding. When going on a deep dive, Blues will lift their tail flukes up into the air. Sometimes we see them lunge feeding, where they surface at a high speed with an open mouth and spread their ventral pleats as water and krill accumulate in their mouths. It is extremely rare to see a Blue Whale breach- their large size makes it very difficult to breach.

IV. Gray Whale:
   A. Migration/Range: Gray Whales are highly migratory- they on traveling during most months of the year. The largest population in the world on the Pacific coast of North America. There is also a critically endangered population on the Pacific coast of Asia. There once was an Atlantic population as well, but they are now thought to be extinct due to whaling. The full migration route of the local population spans from the Chukchi Sea north of Alaska down to the lagoons of Baja California, Mexico. That is the longest migration of any known mammal- nearly 12,000 miles round trip!
   B. Diet: Gray Whales are bottom feeders- they feed on benthic amphipods (small shrimp-like animals) and mysids. that live in the sediment on the seafloor. When Grays feed, they often leave a trail of mud as they filter out these creatures.
   C. Common Behaviors: Common Gray Whale behaviors include fluking, snorkeling, breaching, pectoral flipper slapping and spyhopping. “Snorkeling” happens when Grays surface without a visible blow; this behavior indicates that they are trying to hide from predators. Killer Whales often prey on Gray Whales during the California leg of their migration (mainly in Monterey Bay). On the northbound migration, mother Gray Whales bring their calves in very close to shore- sometimes even in the surfline! Calves can become playful and curious, spyhopping to look around or breaching to play in the waves.

V. Harbor Seals:
   A. Migration/Range:
   B. Diet:
   C. Common Behaviors:

VI. California Seal Lion
   A. Migration/Range: Female California Sea Lions are seen in California year-round. Adult males and juveniles migrate to feed in northern waters spanning from central California to British Columbia.
   B. Diet: Sea Lions feed on over 50 species of fish and cephalopods. These range from octopus, squid, herring, anchovies and sardines. They can also be opportunistic feeders and eat salmon, lamprey and even small sharks!
   C. Common Behaviors: One of the most common places we find Sea Lions is on top of the buoys. Although they look lazy there, they are resting after grueling foraging out at sea. Unlike whales and dolphins, they need to come out of the water periodically. They also need to regulate their body temperature- sometimes they do this by thermoregulating (floating at the surface with their flippers sticking up out of the water). We can also see (and hear) them barking, as well as porpoising when they are traveling through the water at high speed.

Humpbacks are known as the “acrobats” of the whales. They tend to show the most surface behaviors out of all baleen whales, with breaches, pectoral flipper slaps, spyhops, peduncle throws, and cooperative lunge feeding. Their scientific name Megaptera Novaeanlgliae means “long winged from New England” for their uniquely long pectoral flippers. An Atlantic population of humpbacks migrates to New England, although humpbacks are found in all of the world’s oceans.

While there are many videos of orca predations on the internet, their hunting style is aggressive and calculated and can be disturbing for some of your students. If you want to show your students a video of whales feeding, try looking for humpbacks using their bubble-netting technique or lunge feeding.

This behavior is just one example of why humpbacks are so easy to fall in love with. They’re very inquisitive and will often go out of their way to explore different things (kelp beds, boats, abandoned fishing line, etc). This curiosity is often a delight for whale watchers and humpbacks will get extremely close to the boat to get a good look at it but is also the reason that

humpbacks are the whales most often identified in entanglements. Their curiosity may also be dangerous as humpbacks are frequently reported as getting too close to boats.

We mentioned offshore and coastal bottlenose here. While they're both bottlenose dolphin and they both live off our coastline, they're not the same group of animals and can't be lumped into together. Coastal bottlenose live and hunt no more than 1km from the shore. If you're sitting overlooking the ocean and you see a small pod of dolphin, it's most likely a family group of coastal bottlenose. Offshore bottlenose live and hunt anywhere from 1km to 65km away from the shore. These two groups do not mix (as far as we know) and there are no reported cases of the two inter-breeding.

THINK ABOUT IT…

1. Why do some whales migrate to warm water and cold water?

During the summer, colder water generally is rich with nutrients and "whale food" such as krill and baitfish. Baleen whales spend summer feeding and then migrate to warmer and shallower waters to give birth and raise calves. The warm water environment is more comfortable for young calves, plus this time they will be feeding on their mother's milk and don't have an immediate need for solid food.

2. If you went on a whale watching trip tomorrow, what type of animals would you have a chance of seeing? What types of behaviors could they be exhibiting?

This might be a challenging one for the students to answer so we'll break it down by month for you. Every single month will have common dolphin and sea lions so the month by month breakdown won't include those.

January-February: Bottlenose Dolphins, Pacific White Sided Dolphins, Risso's Dolphins, Fin Whales, Gray Whales, & Minke Whales. The dolphin will most likely be feeding as they move through the areas. The fin whales might also be feeding and the Gray whales will be migrating North & South. Those going North will most likely be going with their young and will be more playful and sticking close to shore while those going South will be more direct and moving in slightly deeper water. Students might also see Humpbacks, False Killer Whales, Orcas, Pilot Whales, Elephant Seals, Harbor Seals, Mola Mola, and a number of shark species.

March-May: Bottlenose Dolphins, Pacific White Sided Dolphins, Risso's Dolphins, Fin Whales, Gray Whales, Humpback Whales, & Minke Whales. The dolphin will most likely be feeding as they move through the area. Fin, Humpback, and Minke whales will be feeding while the Gray whales will be migrating mostly Northward at this point. There will be a higher chance of seeing cow/calf (mom/baby) pairs of Gray whales at this point and the calves will be pretty playful. Students could also see Blue whales, False Killer Whales, Orcas, Pilot Whales, Elephant Seals, Harbor Seals, Mola Mola, & a number of shark species.

June-September: Bottlenose Dolphins, Risso's Dolphins, Blue Whales, Fin Whales, Humpback Whales, Minke Whales, Sharks, & Mola Mola. The dolphin will be feeding as they move through the area. The whales will be feeding and playing in this area. Some will move through quickly and some will stay for several weeks. The sharks that are common during the summer months are Great Whites, Mako, and occasionally Hammerhead if the water is warm enough. The sharks moving through the area will be cruising and eating local bait fish & rays. Students might also see Bryde's Whales, False Killer Whales, Gray Whales, Orcas, Pilot Whales, Sei Whales, Pacific White Sided Dolphins, Elephant Seals, and Harbor Seals.

October: Bottlenose Dolphins, Risso's Dolphins, Blue Whales, Fin Whales, Humpback Whales, & Minke Whales. This is towards the end of the blue whale season so for the most part, they will be migrating or moving if not quickly then determinedly. The other whales will be feeding as they move through the area and some of them can be pretty playful. Students may also see Pacific White Sided Dolphins, False Killer Whales, Orcas, Pilot Whales, Sei Whales, Elephant Seals, Harbor Seals, Mola Mola, & a number of shark species.

November: Bottlenose Dolphins, Risso's Dolphins, Fin Whales, Humpback Whales, & Minke Whales. This is the more "in-between" season. The blue whale migration is mostly over and the Gray whale migration will be just starting so the trips are more variable in terms of baleen whales. The baleen whales and dolphin that we see will be moving through the area and feeding. Students may also see Pacific White Sided Dolphins, Blue Whales, False Killer Whales, Gray Whales, Orcas, Pilot Whales, Elephant Seals, Harbor SEal,s Mola Mola, & a number of shark species.

December: Bottlenose Dolphins, Pacific White Sided Dolphins, Risso's Dolphins, Fin Whales, Gray Whales, & Minke Whales. At this point the Gray whale migration should be beginning to pick up. Students will mainly be seeing solitary Gray whales migrating South as they head to the Baja Lagoons to mate and calf. They might also see a straggler Blue Whale, False Killer Whales, Humpback Whales, Orcas, Pilot Whales, Elephant Seals, Harbor Seals, Mola Mola, & a number of shark species.

Day 3 - Threats

Objectives:

- Understand how pollution is affecting animals & water
- Learn about how plastics break down and why
- Discover the difficulties surrounding entanglement and rescue

Experiments:

1. A Plastic Ocean

On Day One, the kids started this experiment to understand what a highly acidic ocean would look like. We might not be noticing the effects of pollution, but the ocean's inhabitants are. It can be easy on this day to get bogged down and think that there is no hope so it's important to stress that we now know what is happening so we can take steps to help. Plastic is a big deal and we want kids to be aware of how much single-use plastic they're using and whether or not it's ending up in the ocean, a landfill, or a recycling plant.

Plastic bags look very similar to a jellyfish when floating in the water. As they degrade, the stringy plastic resembles tentacles. Research done by universities around the globe but most noticeably by the University of Tokyo where researchers attached "crittercams" to the turtles. They discovered that turtles use sight more than smell or sound to identify food. Regardless if they accidentally ingest it or not, they waste valuable time and energy pursuing "prey" that won't actually sustain them.

A great teaching resource for this is going to be Algalita and the Ocean Conservancy, both of which have extensive information on the way plastic breaks down and starts to change the ocean environment. They have videos and photos of the effects of microplastics in the ocean and why it's such a problem. Algalita's founder is the man that discovered the floating pile of garbage and is the authority on the problem. At this point, it's important to note how things they view as "out of sight, out of mind" is impactful. A perfect example is a rubber sandal. Rubber soled shoes take approximately 100 years to degrade so even though you might forget about your lost flip flop at the beach, the ocean is dealing with it for another century!

CO_2 emissions come from a variety of different places. Part of what makes California such a great place for marine life to live is our clean(ish) air. Back in the 1940's, smog was so bad that the Los Angeles area would shut down for a day. These were called "smog events" and the newspapers likened these days to gas attacks as the density of the smog would cause burning eyes and throats, tissue damage, lung damage, etc. It took 4 years of aggressive smog events for some statewide clean air laws to be put into place but it wasn't until the 1970's that the federal government caught on and passed the Clean Air Act (CAA).

This is particularly important for California (for the aforementioned reasons) because at one point in the mid-20th century, the smog was so bad that some suggested we abandon the LA Basin altogether and households owned gas masks. All that smog had to go somewhere and

with about 30% of it ending up in the ocean, there were some pretty dire consequences, particularly for our reefs. Most students will think of a traditional coral reef if you mention the effect of ocean acidification on reefs but the nearest coral reefs (which thrive in warmer, tropical waters) are down in Baja California. Southern California (with our cold, California Current water) had intricate rock reef systems and kelp forests. All reef systems are particularly susceptible to a change in the ocean's temperature or CO_2 levels. Without reef systems (even though our natural topography supports a plethora of marine life) we would be starting to see more barren coastal waters.

So California's aggressive response to pollution combined with the CAA cleaned up our coastal waters despite the fact that we have 3 of the 5 largest commercial ports in the country plus smaller harbors and private ports dotting our coastline. These are not the only measures California took to protect its waters but this booklet is only so long. California is considered a leader in clean air initiatives throughout the country. At the point in California's history when smog was starting to significantly affect the ocean, we were still whaling, marine protected areas had not yet been set up, and commercial fishing was still a giant of industry just offshore so while the air quality certainly did not help the state of our ocean it wasn't the only factor in our near wasteland-esque coastal waters. The air contributed to murky waters, reef destruction, and poor feeding groups for marine life. Encourage your students to ask their parents or grandparents if they grew up in Orange or LA County. Some of them may remember the air quality of a few decades ago.

Oyster reefs are a pretty cool system to study. While oysters are usually directly linked to their role in the economy, their role in the ocean is much more important. Since they filter water, oyster reefs help clean up the water and keep it inhabitable for other marine animals. To give you an idea of previous oyster populations and their filtering abilities, it was estimated that historic oyster populations in Chesapeake Bay could filter all the water (about 18 trillion gallons) in the bay in 5 days. According to research done in 2011, pollution and overharvesting has reduced oyster reef populations by around 90% (Beck et al, 2011). Then jump to 2006-2008 and the oyster fisheries along the Pacific coast reported losing over 80% of their oyster larvae because the baby oysters could not develop and sustain shells due to the rising acidity of the water.

Oxybenzone is another of those human-made chemicals that started off promising but quickly became a hindrance. While it does help keep your skin safe from the sun's harmful rays, it also degrades coral and damages fish systems. Researchers found that oxybenzone in deodorant, sunscreen, and other personal hygiene items did negatively affect coral's ability to grow. National Geographic broke the news in 2008 and since then, sunscreens have been racing each other to be reef-safe.

1. What are some ways for you to reduce, reuse, and recycle in your everyday life?

We want to challenge the kids to start thinking about their individual impact on marine life. Ask them to really consider how they can reduce (can they stop using plastic straws, can they make sure they're recycling properly, etc), reuse (can they use a reusable bag when they go shopping, can they bring a reusable water bottle to school instead of buying a plastic one, etc), and recycle (are they actually recycling or just tossing their trash in any trash can). Everyone will *probably* have a different answer and some might need help. It's surprising how little, simple things can make the biggest impact. Make sure your students see how one small act (cutting

out plastic straws, using a reusable bag, etc) makes a HUGE difference. Once the students have come up with their own ideas, show them the Algalita page titled “The Solution”. It has a list of little ways you can make a difference.

2. What do you think will happen to the items you placed in the vinegar if you leave them there for another week? A month?

The longer your items stay in the vinegar, the more they will dissolve. If you left organic and plastic items in the vinegar, the biggest difference you’ll see is that the organic items will dissolve much quicker than the plastic items.

2. Entanglement Lab

Seeing an entangled whale is distressing for everyone involved but most kids don’t quite understand the scope of what an entanglement means. This lab should help get them ready to talk about entanglement and why it is a growing problem. Make sure they fully participate and adjust the times for the kids. This isn’t meant to shame kids for not being strong, it’s meant to show them that over time, entanglements get heavier and heavier. For cetaceans, the ropes and netting that entangles them also starts to collect barnacles, animal by-catch, and other debris so even as their muscles get tired from swimming with the entanglement, the animals is getting more and more weighed down.

Common ocean debris/pollution	Rank	Time to Decompose
Fishing Line	10	600 years
Aluminum Can	8	200 years
Paper Cup	5	6 months
Newspaper	2	6 weeks
Apple Core	4	2 months
Plastic Cup	9	400 years
Cardboard Box	3	2 months
Plastic Water Bottle	7	100 years
Disposable Diaper	6	50-100 years
Paper Towel	1	2-4 weeks

Ghost fishing is a serious problem. Old fishing nets are not profitable and therefore, an “out of sight, out of mind” attitude persists. Knowing this, various companies have attempted to find value in used fishing nets (recycling them into skateboards, bathing suits, etc) but these companies are few and far between. Algalita notes that there are floating islands of discarded fishing line and gear that stretch 80 feet across. These “islands” provide an environment for animals in the ocean. On one of their expeditions, they came across one such island that had a

population of reef fish living under its protection. The reef fish should not have been far away from the coast and would not have otherwise been in the open ocean if not for the floating fishing gear. As noted in the previous Diving Deeper, the plastic leaks chemicals as it degrades, so even as the reef fish are surviving in the open ocean, they are getting sick due to their habitat.

Not all cetaceans will die when they become entangled. Some will shake the entanglement off and become deformed, some will get the entanglement off but injure themselves in the process, and some will shake the gear off on their own and be okay. Some of your students might have seen “A Dolphin Tale” in which a bottlenose dolphin has to have its tail amputated due to an entangled crab fishing pot lines. The story is based on the real bottlenose dolphin named Winter who lives at Clearwater Marine Aquarium in Clearwater, Florida. The aquarium offers several live-camera angles of Winter’s tank and she’s a great example of both the devastating effect of ghost-fishing and marine animals’ resilience and ability to adapt.

Part of the issue is that the type of fishing gear that would keep whales safe would also enable poachers to take advantage of areas that are protected. California in particular has a large section of coast reserved as a “Marine Protected Area” which means that no fishing of any kind is allowed in that area. The type of buoys that don’t require a lot of line to be floating in the water are called “Pop Up Buoys” and they enable people to secretly place crab and lobster traps underwater in an MPA. Technology has not advanced enough to the point of accurately avoiding the problem of a pop up buoy being used for evil rather than good so they are still currently illegal according to the National Oceanic and Atmospheric Agency (NOAA).

Bart is a particularly wonderful whale to focus on for whale disentanglement. Not only was Bart entangled, but as the rescuers pulled the lines off of him, they found dead sharks, fish, rays, and even a sea lion being pulled along by Bart as well. However, Bart has a happy ending and the story of him coming over to say thank you actually happened. Capt. Dave’s experience with Bart ended with a successful disentanglement and a quirky whale interaction as compared to Lily, the whale Capt. Dave got famous for rescuing. While Lily is a great story of a Gray whale swimming into the harbor and asking us for help, it did not have a happy ending. With as daunting as this subject can be, we wanted to keep in mind that there is hope for success in conservation endeavors while still discussing the need to reexamine how we live so we can prevent the need for these endeavors in the future.

THINK ABOUT IT...

1. How does pollution affect marine animals? Give some specific examples for different species.

For this critical thinking, have your students pick one marine animal that they like learning about (shark, tuna, dolphin, baleen whale, rays, etc) and focus on three main questions:

- Marine debris in their diets (Are they filter feeders? Are there any cases of this species being found with large amounts of trash/debris in their systems?)
- Proximity to human-made debris (Are they coastal or deep sea dwellers? Are they affected by floating piles of trash, microplastics, or runoff from cities?)
- Acidification implications (Will rising acidity levels destroy their food source? Their habitat?)

Direct them to sites like Algalita, Ocean Conservancy, Oceana, National Geographic, universities with strong marine biology programs (Scripps, Cal State Long Beach, University of

North Carolina Wilmington, Cal State Monterey Bay, etc), or even reputable aquariums (Scripps, Ocean Institute in Dana Point, Aquarium of the Pacific, Georgia Aquarium, etc) to begin their research. If they're stumped or they want to discuss their chosen species at length, feel free to contact the education team here. If we don't know about that particular animal, chances are we'll know someone who does!

2. Knowing that ghost fishing is a significant problem, get together with a partner or a group and develop a solution. Once you do, split into two teams: for and against. If you're for the solution you developed, come up with a bullet point list of why it helps. If you're against the solution, come up with a bullet point list of why it isn't a good solution.

This one will require research as well. The good news is your students will most likely develop an idea that has already been thought of and proposed so there will be a lot of opinion pieces from fishermen, lawmakers, industry leaders, and scientists for why it would or would not help with ghost fishing. Some students might be uncomfortable with the idea of arguing against a solution to ghost fishing after reading through the diving deeper, answering question one, and watching Winter on the live camera. Innovations can't come about unless they are challenged and perfected at every turn. A simple solution to ghost fishing does not exist yet. While rescuing whales and dolphins is important, there are fishermen who depend on the current way things are done to make their livelihood. By challenging the solution, the students who are "against" it will be helping it become a legitimate way to eliminate ghost fishing.

Day 4 - Identification

Objectives:

- Discover the ocean
- Work on identification abilities

Field Guide:

Today should be an easy day for you. The captain and crew will be taking over on the mobile classroom. If you have any questions or the kids have questions, we'll be there to help. The most important thing is to remind the kids that they are taking on the role of marine biologist today. They get their own field guides to take notes in and draw pictures of the animals they see. Encourage them to list behaviors, number of animals, anything they think might be interesting. It's a good idea to remind them to be on the lookout for pollution too. If they see a balloon in the water or a piece of trash blowing away, remind them to make note of it. Responsible citizens will be the ones to save the ocean and being aware is the first step.

Today, we're going to be asking your students to ask the questions they've been wondering. We'll help them remember to ask questions, note observations that didn't make it into their official field guide, and develop a conclusion. Why did they see what they saw on the water? Were the sightings something we usually see this time of year or was it rare? Did they see birds? Trash?

Day 5 - Call to Action

Objectives:

- Go over any questions
- Reinforce the idea of reduce, reuse, recycle
- Come up with an action plan as a class

1. Reduce:

Try tracking how much trash you generate. Is there a way for you to generate less trash or to recycle more of the trash you do generate? Consider whether you have space to make a window garden or a small compost pile. What steps would you have to take to create that?

This is going to look different for each student since only they know what kind of space they have available for a garden or compost pile. The idea is just to get them thinking about the possibilities of reducing how much trash/plastic they buy. If you want, ask them to do a Zero Waste Challenge for a day or two. This will really open their eyes to how much single use plastic they use on a day to day basis!

2. Reuse:

Work together as a classroom to create a “Reuse” poster guide. What are some ways to reuse old items so they don’t end up in the ocean?

Have them get creative! Can they make an old t-shirt into a reusable shopping bag? What about bringing their snacks or lunches in reusable bags? Getting a reusable water bottle instead of single-use plastic water bottles?

3. Recycle:

Help out your parents, siblings, and friends by making a recycling chart! Give them an idea of what types of trash can be recycled and how to properly dispose of trash that cannot be recycled. Try using recycled materials to make your chart as an added bonus!

Most people just don’t know what they can recycle let alone how to recycle it! If your students don’t know, it’s an excellent opportunity for them to flex their research muscles. Making a chart or poster will help cement the information as well. Give them a jumpstart by pointing out that a majority of recycling companies don’t recycle the types of plastic that bottle caps are made of. Collect some bottle caps and use them to decorate your poster.