Shark Cart
Aquarium of the Pacific

This activity outline was developed for use in a variety of informal venues. By design, it provides the content, pedagogy and strategy necessary for implementation by both the novice and experienced informal educator. It is expected that this outline will be adapted and improved upon by the user. We welcome your feedback!

Synopsis of the Activity
Visitors learn about the diversity of shark feeding adaptations and diet by interacting with shark artifacts. Shark teeth are the focus of the activity, but shark senses, anatomy and conservation may also be discussed.

Audience
The whale cart will target visitors of all ages. Themes can be modified easily with age appropriate concepts. Suited for small groups of participants.

Setting
Open areas on the floor easily visible to visitors.

Activity Goals
Learners will examine a variety of shark artifacts and gain an understanding of shark diversity through the investigation of shark feeding adaptations.

Concepts
- There are many different kinds of sharks and rays.
- Different sharks have different types of teeth.
- Shark teeth are adapted for eating different kinds of prey.

Ocean Literacy Principles
5. The ocean supports a great diversity of life and ecosystems.
    d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

Materials
All materials are housed on or within a large rolling cart:
- Fabricated Great White Shark Jaw
- Bull Shark Jaw
- Mako Shark Jaw
- Zebra Shark Jaw
- Ray Jaw
- Pictures of sharks
- Models of sharks (optional)
- Megalodon tooth (optional)

Preparation and Set-up
Bring the cart to the activity location and place the items on top of the cart. Be sure to set the jaws apart from the photos and arrange them randomly.

Guiding Questions
What do you notice about these items? How do they feel?
What do you think sharks eat?
What do you think a shark with pointy teeth would eat? What is your evidence?
What are some differences between these teeth and the others?
What do you think a shark or ray with flat teeth would eat? What is your evidence?
How do you think humans might be connected to sharks?
How can someone like you help protect sharks?

Activity Description

Introduction: Invite guests to come explore the shark cart. Because the scale of some of the objects is quite impressive, using artifacts like the white shark jaw or the megalodon tooth might be of interest. Also, noting the diversity of teeth could help gain guest interest. For instance, you could say, "Have you ever seen a shark tooth the size of your hand? Do you think all sharks have teeth like that? Come over and find out."

Free exploration: Invite them to view and interact with the shark artifacts. Allow them to gently touch and handle the artifacts. As visitors freely explore, ask them questions about their observations of the artifacts to encourage them to think about the composition of the objects, the biology of the organism, and the use of the body part.

Suggested questions:
- How do they feel?
- What do you notice about them?
- How are they similar to each other?
- How are they different from each other?
- What is your evidence?
- What is this jaw made of? How about the teeth? Are there parts of your body that are made of the same kinds of materials? What are they?
- How might this item help the animal survive?

Key ideas to address in this conversation:
- Sharks are fish in the class Chondrichthyes, which also includes rays, skates, and chimeras.
- All members of this class have cartilaginous skeletons; cartilage is the same dense but flexible connective tissue that is found in human ears and noses.
- There are over 400 species of sharks alone which encompasses are large diversity of body sizes, morphologies and adaptations.

Form, Function, and Feeding: Let visitors know that, similar to other animals, sharks' teeth offer a lot of information about what sharks eat. Invite visitors to take a closer look at the different teeth, and challenge them to figure out what the shark might eat based on

the size and shape of the teeth. Remember to encourage visitors to explain and provide evidence for their ideas. Consider sharing pictures of the different sharks with visitors so that they can recognize the size of the predators in relation to the teeth. Encourage visitors to ask questions and talk with others in their group.

Suggested questions:

- What similarities do you notice about these teeth/jaws? (size, shape, features, composition)
- What differences do you notice about these teeth/jaws? (size, shape, features, composition)
- Based on what you observe in the jaws and teeth, what do you think this shark eats? What is your evidence?
- How do you think this shark captures its prey? What is your evidence?
- How do you think this shark eats its prey? What is your evidence?
- Do you think other animals have similar adaptations? Do your teeth say much about what you eat? What is your evidence? (The same could be asked of other aquarium animals; guests could be directed to exhibits to make observations.)

Key ideas to address in this conversation

- There is a large diversity of sharks with an equally large diversity in feeding adaptations. Shark teeth can be big or small, sharp or blunt, serrated or smooth.
  - Serrated teeth can be used like knives to cut up larger prey items, like marine mammals or large fish.
  - Pointy teeth can be used to grasp foods, but may not be appropriate for cutting up prey.
  - Many animals with sharp pointy teeth swallow their prey whole (and are therefore limited by the size of their gape.)
  - Flat teeth are used for crushing prey, especially those with hard shells, such as mollusks and crustaceans.
- One thing that all different types of teeth have in common is that they are exchangeable throughout the entire life.
  - The teeth of a shark are attached to the skin covering the jaw, and are arranged in multiple rows. Behind each tooth there are several new ones waiting to be used. Some sharks change their teeth randomly while others change the entire row at the same time. The teeth are embedded in the gums but not attached directly to the jawbone, as in other fishes.
  - The exchange of teeth goes on the entire life and for some species it has been estimated that they use as many as 30,000 teeth during their lifetime.
  - The jaws are not firmly fixed to the braincase, but instead loosely connected. This loose attachment allows sharks to widen their mouth and extend the upper jaw so they can engulf large items of food and even whole animals.
  - Most sharks only use the first one or two rows of teeth in the front, but some species use as many as eight rows at the same time. The rows that are not in use lie with the teeth bent back in the gums and wait for their turn. Each new tooth is slightly larger than the tooth it replaces.

- This discussion of form and function in teeth is especially important to help dispel the myth that sharks are maneaters. Most shark attack incidents are a case of mistaken identity.

Related Activities/Extensions/Modifications
Shark Conservation: Sharks are misunderstood animals that play an important role in the balance of the ocean ecosystem. Visitors that understand shark feeding adaptations can be directed to other places in the ISEI to see sharks and to appreciate their value in ecosystem function, engineering, design, and tourism.

Additional Resources
http://www.sharkology.com/index.html

Background
Vocabulary

- Predator - any organism that exists by killing and eating other organisms
- Prey - an animal hunted or seized for food
- Cartilaginous - having a skeleton composed either entirely or mainly of cartilage, such as vertebrates of the class Chondrichthyes, which includes the sharks, rays, and skates
- Cartilage - a firm, elastic, flexible type of connective tissue of a translucent whitish or yellowish color
- Adaptation- structure or behavior that helps an organism to survive

Sharks and Rays: Sharks, rays, and ratfish are referred to as cartilaginous fishes. These animals have a skeleton of cartilage, which is less dense than bone and allows them to conserve energy while swimming. While a cartilaginous skeleton makes them lighter, sharks are still more dense than the surrounding seawater and will sink if they stop swimming. Many people believe that if a shark stops swimming it will not be able to breath and will die. This is only true for a small percentage of sharks. Many sharks have adaptations that allow them to breathe while lying motionless on the ocean floor.

Shark teeth: A shark's teeth are made of enamel and dentine. They are the only hard part on a shark and the only part that readily becomes a fossil. A shark's teeth are set in rows and are replaced constantly as they fall out. A shark may lose and re-grow 30,000 teeth in a lifetime.

Great White: Great White sharks can grow to be 22 feet long, although they are more often less than 20 feet. White sharks have serrated, triangular teeth that act like knives. Young Great White sharks prey primarily upon fishes. Larger Great Whites eat marine mammals, turtles, sea birds, and large fishes. While these sharks have been known to bite people, attacks are largely viewed to be a case of mistaken identity. A shark may bite a surfer or a scuba diver because they resemble a seal or sea lion. Usually, after the initial bite the person is spit out and the shark swims away.

Bull Shark: Bull sharks have thick triangular teeth that are serrated to tear large prey into bite-sized pieces. Like most sharks, Bull sharks typically prey on other fish, but turtles, birds, marine mammals, and carrion are also on the menu. Amazingly Bull Sharks have the ability to swim into freshwater. They have been found hundreds of miles up rivers and there is even a landlocked population of Bull shark in Lake Nicaragua.

Mako Shark: Mako sharks are one of the fastest fishes in the sea. They use their sharp pointy teeth not to tear, but to grasp and swallow their prey whole. They typically eat open ocean fishes like mackerels, tunas, and even other sharks.

Zebra Shark**:** A Zebra shark is black with white bars while a juvenile and loses this coloration gradually as it grows. As an adult, zebra sharks actually have spots. The teeth of this shark are small and pointy and help them to grasp small fishes and crustaceans.

Ray: Not all rays are stingrays. While some rays possess a sting many others do not. The sting is used only in self-defense and not to capture prey. Rays are dorso-ventrally flattened (i.e., like a pancake) and their mouths are located on the ventral side of their body. They typically have flattened teeth to crush and eat hard-shelled invertebrates, often eating those that live in the sediment.

Teeth and jaws (from http://www.sharkology.com/teeth.html)
A shark tooth can be big or small, sharp or blunt, serrated or smooth. The shape of the teeth is an adaptation to what the animal eats. Flat teeth are useful to crush mollusks and crustaceans, while sharp teeth are more adapted to rip chunks of flesh out of a prey. One thing that all different types of teeth have in common is that they are exchangeable throughout the entire life. The teeth are attached to multiple rows in the jaws. Behind each tooth there are several new ones waiting to be used. Some sharks change their teeth randomly while others change the entire row at the same time. The teeth are embedded in the gums but not attached directly to the jawbone, as in other fishes.

The teeth are actually enlarged and modified placoid scales and just like our teeth, they consist of an outer enamel layer and an inner pulp. Most sharks only use the first one or two rows of teeth in the front, but some species use as many as eight rows at the same time. The rows that are not in use lie with the teeth bent back in the gums and wait for their turn. Each new tooth is slightly larger than the tooth it replaces. The older the shark gets and the more it grows, the larger its teeth gets. The size of the teeth of the same individual can vary depending on where in the jaw the tooth is. However, some species have all teeth in the same size.

The exchange of teeth goes on the entire life and for some species it has been estimated that they use as many as 30,000 teeth during their lifetime. The jaws are not firmly fixed to the braincase, but instead loosely connected. This loose attachment allows sharks to widen their mouth and extend the upper jaw so they can engulf large items of food and even whole animals.

Ref: Hickman CP, Roberts LS and Larson A (2000), Animal Diversity, McGraw-Hill

Higher Education, USA -- Springer VG and Gold JP (1989), Sharks in question: the Smithsonian answer book, Smithsonian Institution Press, Washington, D.C. London

Skeleton (from http://www.sharkology.com/ske.html)

The skeleton of sharks is to a large extent made out of cartilage, unlike other vertebrate's skeletons, which are made out of bone. Cartilage is a type of connective tissue composed of cells called chondrocytes suspended in a matrix of protein. The parts of the skeleton that are in need of extra support, e.g. jaws, vertebrae or gill arches, are built up by calcified cartilage. The calcified cartilage is harder than normal cartilage due to deposits of calcium salt. Often, the appearance of calcified cartilage and bone is very similar, and differences are apparent only after the tissues have been specially treated and examined with a microscope. The main difference between bone and cartilage is that bone is composed of osteocytes instead of chondrocytes. The cartilaginous skeleton of the modern shark is something that probably has evolved from a bony skeleton, which means that the previous ancestor of today's sharks had a skeleton made out of bone. There is no reason to believe that having a cartilaginous skeleton is disadvantageous. On the contrary, cartilage is less dense and more elastic than bone, providing advantages of buoyancy and flexibility. Because cartilage and other soft parts decay rapidly, it is rare to find complete or even nearly complete fossil remains of sharks. This is one reason why evolutionary relationships of sharks are so difficult to trace. Often teeth, scales, spines or vertebrae are the only parts remaining in fossils, and from these parts alone, it is very hard to figure out what the entire shark looked like.

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