WORLD AQUARIUM CONSERVATION & SUSTAINABILITY TOUR

INFORMATION PACKET

60 MINUTE TOUR (10 minutes per realm)
The crux of the matter:
"According to the Millennium Ecosystem Assessment (MEA, 2005), the world's oceans and coasts are highly threatened and subject to rapid environmental change. Major threats to marine and coastal ecosystems include: (i) land-based pollution and euthrophication; (ii) overfishing, destructive fishing, and illegal, unreported and unregulated (IUU) fishing; (iii) alterations of physical habitats; (iv) invasion of exotic species; and (v) global climate change."

1. Realm: The Water Cycle
The Water cycle is a circular process: evaporation… condensation… precipitation… and collection. This cycle of life provides the basis for most living things on the terrestrial part of the planet. Understanding that freshwater makes up less than one percent of the available water on the planet, some people have said that water is more precious than gold. Evaporation is when the sun heats water in rivers or lakes or the ocean and turns it into vapor or steam, which leaves river, lake or ocean and goes into the air. Water vapor in the air is cooled and changes back into liquid, forming clouds. This is called condensation. Precipitation occurs when more water condenses than the air can hold. The clouds become heavy and water falls back to the earth in the form of rain, hail, sleet or snow. When water is released back to earth as precipitation, it may fall back into other bodies of water or it may end up on land. When precipitation falls onto land, it will either soak into the earth or become part of the "ground water" that plants absorb or it may run over the soil and collect in the rivers, lakes, or oceans where the cycle begins again.
Emphasize the fact that toxic substances like alcohol which, prior to their evaporation, kill everything in the site in which they are located and get left behind on Earth in ecosystems.

Climate change, rising atmospheric carbon dioxide, excess nutrient inputs, and pollution in its many forms are fundamentally altering the chemistry of the ocean on a global scale. Major observed trends include a shift in the acid-base chemistry of seawater, reduced subsurface oxygen both in near-shore coastal water and in the open ocean, rising coastal nitrogen levels, and widespread increase in mercury and persistent organic pollutants. Most of these perturbations, tied either directly or indirectly to human fossil fuel combustion, fertilizer use, and industrial activity, are projected to grow in coming decades, resulting in increasing negative impacts on ocean biota and marine resources.

-Water Conservation
Water is the most abundant liquid on Earth. 71% of Our Earth's surface is water *and constitutes 60-70 of the living world.*

There is exactly the same amount of water on earth now as there was when the dinosaurs hung out at the local pond millions of years ago. The water keeps going around and around. It evaporates from rivers, lakes, and oceans. The vapor from this forms clouds in the sky, then it returns to earth again as rain or snow. This process is called "The Water Cycle" making it seem endlessly renewable.

So why worry?
Actually, only 1% of the world's water is usable to us.
About 97% is salty sea water, and 2% is frozen in glaciers and polar ice caps;
The remaining 1% percent of water is present in rocks as groundwater;
And Less than 0.01% is present in rivers and lakes![1]
Thus that 1% of the world's freshwater supply is a precious commodity necessary for our survival

-Change in Ocean Currents

Deep-water formation is just what it sounds like: As the Atlantic's surface waters travel north they become cooler and denser, so that by the time they reach the Arctic they are cold enough to sink to the ocean bottom. The sinking water pulls warm surface waters like the Gulf Stream north, which in turn leaves a void that pulls deep, colder water south. If global warming inhibits the formation of deep water, the flows across the Greenland–Scotland Ridge should slow. Ocean and atmosphere are inextricably linked. As global climate change alters wind, precipitation and temperature patterns worldwide, ocean currents will reflect these changes in often unpredictable ways. For example, increasing wind speeds arising from larger land-ocean temperature differences may drive stronger upwelling which will change near shore ecosystems and may cause hypoxic dead zones in some areas. Another key factor that influences ocean currents is the density of seawater. Both temperature and salinity contribute to seawater density, thus local changes in temperature and the magnitude of freshwater inputs from rivers and streams can alter near shore ocean currents. Changes in the direction and strength of nearshore currents can have profound impacts on near shore ecosystems by altering the transport / retention of contaminants, nutrients, and the marine larvae that sustain populations along the coast.

-Point Source Pollution

Definition – Identifiable inputs of waste that are discharged via pipes or drains primarily (but not exclusively) from industrial facilities and municipal treatments plants into rivers, lakes, and ocean.

-Non-Point Source Pollution

Definition - water pollution affecting a water body from diffuse sources, such as polluted runoff from agricultural areas draining into a river, or wind-borne debris blowing out to sea. Nonpoint source pollution can be contrasted with point source pollution, where discharges occur to a body of water at a single location, such as discharges from a chemical factory, urban runoff from a roadway storm drain, or from ships at sea.

States report that nonpoint source pollution is the leading remaining cause of water quality problems. The effects of nonpoint source pollutants on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries, and wildlife.

It is believed that Point Source and Non-Point Source Pollution are the causes of the Dead Zone in the Gulf of Mexico and other places. Aquatic and marine dead zones can be caused by an increase in chemical nutrients (particularly nitrogen and phosphorus) in the water, known as eutrophication. These chemicals are the fundamental building blocks of single-celled, plant-like organisms that live in the water column, and whose growth is limited in part by the availability of these materials. Eutrophication can lead to rapid increases in the density of certain types of these phytoplankton, a phenomenon known as an algal bloom. Although these algae produce oxygen in the daytime via photosynthesis, during the night hours they continue to undergo cellular respiration and can therefore deplete the water column of available oxygen. In addition, when algal blooms die off, oxygen is used up further during bacterial decomposition of the dead algal cells. Both of these processes can result in a significant depletion of dissolved oxygen in the water, creating hypoxic conditions. Dead zones can be caused by natural and by anthropogenic factors. Use of chemical fertilizers is considered the major human-related cause of dead zones around the world. Natural causes include coastal upwelling and changes in wind and water circulation patterns. Runoff from sewage, urban land use, and fertilizers can also contribute to eutrophication.

Notable dead zones in the United States include the northern Gulf of Mexico region, surrounding the outfall of the Mississippi River, and the coastal regions of the Pacific Northwest, and the Elizabeth River in Virginia Beach, all of which have been shown to be recurring events over the last several years.

The dead zone occurs naturally, but human activity is making it much worse by allowing tributaries to become overfilled with some nutrients while those tributaries lack in other key nutrients. Nitrogen (in saltwater) and phosphorus (in freshwater) are the nutrients that contribute most to algal blooms. A lack of silicon in the water limits the growth of **diatoms**, a helpful type of algae. A major contributing factor to dead zones is when water becomes **stratified** -- warm, fresh water settles on top of colder, saltier water. This stratification limits the aeration of deeper waters as algal blooms settle to the bottom and decay.

2. Realm: Rivers of the World

-Sustainable Seafood

Seafood is sustainable when the population of that species of fish is managed in a way that provides for today's needs without damaging the ability of the species to reproduce and be available for future generations.

One of the ways to achieve sustainability in fisheries is through aquaculture. Aquaculture is fish farming within a body of water. Aquaculture, or fish farming, sounds like a great solution to the ever-increasing pressures on our ocean resources. And it can be a useful alternative. Today, half of our seafood comes from farms. People are raising fish, shrimp and oysters like farmers raise cattle and chickens. But the ecological impact of fish farming depends on the species chosen, where the farm is located, and how they are raised.

As a society, we can create sustainable aquaculture that limits habitat damage; prevents the spread of disease and non-native species; and minimizes the use of wild fish as feed.

Aquaculture Issues:

Wild fish: Many of our favorite fish are themselves fish eaters. When we farm these carnivores, we need lots of wild fish to feed them. On average it takes over three pounds of wild fish to grow a pound of farmed salmon. Alternative feeds are being developed to reduce this dependence on wild fish. But the best solution may be farming shellfish and non-fish eaters like tilapia and catfish.

Pollution & disease: When fish are farmed in open net pens, byproducts are released directly into the environment. This includes fish waste, uneaten food, disease, parasites, pesticides and antibiotics that can be harmful to the environment. In contrast, "closed" systems collect and manage these byproducts and have less impact.

Escapes: Each year, millions of fish escape from aquaculture operations, and their impacts aren't known. These escapees compete with native fish and, in the worst case, may interbreed with them—changing forever the gene pool of the native species. Reducing the use of open systems can help. Silver carp and bighead carp were imported from China in 1973 to improve water quality of aquaculture ponds (initially in Arkansas). Asian carp were introduced to the United States in the early '70s to control algae in catfish farms in the South. Floods washed the Asian Carp into the Mississippi River in the 1980s. They've worked their way upriver ever since. The carp thrive in the Illinois River, a tributary of the Mississippi. Reproducing populations of these four species are now present in the Upper Mississippi River System. They are steadily moving towards the Great Lakes.

Habitat damage: Farm location is important. Rich coastal waters have been polluted by open net pen farms and hundreds of thousands of acres of coastal mangrove forests have been lost by conversion to shrimp ponds. Protecting important habitats and the species that rely on them for survival are key to sustaining the oceans.

Management: The aquaculture industry is growing quickly. Innovative practices as well as careful oversight are needed to reduce impacts on the environment and ensure a sustainable future.

-Tropical Fish Trade - sustainability

Billions of people throughout the world rely on fish as a primary source of protein, particularly in developing countries with rapidly expanding populations. Worldwide, fish provide over 2.6 billion people with more than 20% of their animal protein. The world's fisheries generate over US$130 billion annually, and contribute significantly to the economies of many countries. Even where fisheries are not important on a national level, they can be critical for regional employment, where entire communities of small-scale fishermen rely on fishing as their primary source of income. In the Tamil Nadu region of southeastern India, one third of the population depends on the sea for their livelihood, and average incomes declined by 50% when false trevally (the most valuable local fish) suffered a sharp decline blamed partly on climate change. Worldwide, over 38 million people earn an income by fishing or raising fish, and if activities associated with

fisheries production are included, fisheries support over 200 million people. In industrialized countries, recreational fishing also provides a large source of income.

Impacts include changes in rainfall and evaporation that alter lake levels and river flow, changes in ocean and wind currents, and increases in mean sea level. But even based on the effects of temperature alone, it seems likely that fish will become smaller and harder to find, and valuable cool and cold water species will begin to be replaced by more adaptable (and often less valuable) warm water fish.

Large, commercial fleets, who have the means to get to fish stocks, may not be as strongly affected as local, small-scale fishermen, who will have to adapt their gear and methods, travel further, and fish longer to continue providing enough food for their families and local markets.

The most impacted fish are:
-polar marine fish
-freshwater fish that are geographically isolated
-coral reef fish

-Amazon River Conservation

Aquarium fish keeping is an industry worth US$ 250 billion (Rana 2008), involving more than 120 countries (Dey 2008) and over 1 billion individuals of over 4000 freshwater and 1400 marine species (Whittington & Chong 2007). Freshwater species make up 90% of the trade as they are the most popular and widely kept aquarium pets worldwide. Even though a majority of fish entering the global freshwater aquarium pet trade are produced in aquaculture far from their native waters, wild fisheries are still locally important in the extant species ranges (Tlusty et al. 2008), especially in the biodiversity rich regions of Asia, South America and Africa, and are critical to the development and functioning of local economies.

For example, in the Rio Negro region of Amazonas, Brazil, ornamental fishery is responsible for approximately 70% of the revenue for the municipality of Barcelos and nearly 1,000 families are involved directly in the fishery (Tlusty et al. 2008). Similarly in neighbouring Peru, close to 10,000 people were earning at least some income from collecting fish for the aquarium trade (Moreau & Coomes 2007). In Africa, collection and export of freshwater ornamental fishes from the rainforest streams is an emerging activity especially in Guinea and Cameroon. Of the eight million people who live in the Lower Guinea forest, twenty percent are more or less fulltime fishers and another seventy percent (mostly women and children) fish seasonally (Brummet 2005). Over 100 people were known to have been directly employed and an additional 350 benefited indirectly from the aquarium fish collection and trade in Malawi during the early nineties (Grant 1995).

Project Piaba:

The World Aquarium helped to start Project Piaba to combat the problem of overfishing ornamental species within the Amazon River Basin. Project Piaba has been working solidly for many years (1989-2009) on research to promote the sustainable harvest of aquatic resources that will ensure the survival of both the Amazonian rainforests and its human inhabitants. Significant progress has been made during this time, but much more baseline data are required before firm resource management strategies can be formulated. The next phase of Project Piaba aims to generate data relating to a wide range of issues, from population of species diversity, to the function and structure of the ecosystem, and to develop measures that will help improve the livelihood of the riverine people. The ultimate goal is to promote a viable fishery at commercially and ecologically sustainable, and to help reduce environmentally destructive land use and rural-to-urban migration in the Rio Negro basin.

Aquatic ecosystem and resources of the Amazon basin are the predominant basis of sustainability for the rainforest. Fishes are frequently overlooked in more publicized conservation or development projects in the Amazon despite the enormous diversity of fishes (over 3,000 species) and the socio-economic importance of the fisheries. Food fishes comprise the principal component of the Amazonian diet (67 kg/ capital/ year). The ornamental fish trade is also of economic importance to local fisherfolk and in the worldwide market.

More than 20 million live fishes are exported from the region annually for the Amazonas State economy and in excess of $100 million in worldwide retail value. The mid-Rio Negro basin is the primary fishing grounds and the municipality of Barcelos is the principal trading post where trade in ornamental fishes now contributes over 60% of the local revenue.

A single species, the cardinal tetra (*Paracheirodon axelrodi*) constitutes over 80% of the total export from the Rio Negro basin. Natural fluctuations in fish populations, fish mortality rate during capture and transport, and market demand are the main constraints on the fisherfolk subsistence. As adaptation to the extreme fluctuations in Amazon ecology, many ornamental fishes have a short life cycle (1-2 years) and high fecundity that allow their populations to sustain the ornamental fishery.

Though the ornamental fish stocks are very hardy, they are sensitive to long term environmental disruptions. In order for the ornamental fishery to thrive, the entire aquatic ecosystem must be intact and functional. It may be possible through proper application of fishery management procedures to provide local people with incentive to preserve the integrity of their aquatic ecosystems and their cultural and terrestrial environment as well.

To develop an appropriate management strategy, a firm understanding of the ecosystems and sociocultural perspectives of the ornamental fishery are essential. It will also require that fisherfolk, exporters/importers, to the distributors and retailers to understand their place in this important industry. Furthermore, locally controlled ornamental fishery and trade practices are fundamental to the long-term sustainability of a quality livelihood in the region.

Since 1989, faculty and students of the Universidade do Amazonas (UA) and National Institute of Amazonia Research (INPA) have studied aquatic biodiversity, collected baseline data on ornamental fishery and socioeconomic aspects of riverine communities in the Rio Negro basin. We have concluded that the ornamental fishery in the region is manageable; it is the basis of protecting Amazon rainforest. We have already built sound scientific base and community network to implement an effective management of the fishery.

For the next phase of the Project Piaba, we intend to deepen the areas of research to include genetic diversity of fishes, habitat/stream gradient, ecosystem function, shipping and handling of live fish, fish pathology, and the trade processes. We have chosen the cardinal tetra as the principal indicator species for the Project. We will apply our research results to develop techniques for fish husbandry and help fisherfolk to produce quality fishes of the region. We will also expand our information database and make them accessible to broader user groups.

3. Realm: Sand Castle Beach and Structure, Color & Function

- Desertification

Desertification is the degradation of land in arid, semi-arid, and dry sub-humid areas due to various factors: including climatic variations and human activities. A major impact of desertification is reduced biodiversity and diminished productive capacity, for example, by transition from land dominated by shrublands to non-native grasslands. For example, in the semi-arid regions of southern California, many coastal sage scrub and chaparral ecosystems have been replaced by non-native, invasive grasses due to the shortening of fire return intervals. This can create a monoculture of annual grass that cannot support the wide range of animals once found in the original ecosystem

-Eat Lionfish Campaign/Invasive species

Invasive Species: An "invasive species" is defined as a species that is

1) non-native (or alien) to the ecosystem under consideration and

2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health..

Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

- Invasive species threaten native species. Exotics have contributed to the decline of 35-46% of imperiled species in the United States.
- In agricultural landscapes, invasive plants, herbivores and parasites outcompete crops for soil and water resources, reduce crop and forage quality, and poison some livestock species.
- Invasive species on US agricultural and rangelands cost over $54 billion annually.
- Introduced organisms degrade resources, such as national forests. Current estimates of annual losses and damages from forest pests and pathogens in the U.S. reach $4.2 billion.
- Recreational and commercial fisheries are also vulnerable to the threat of invasions. European green crabs negatively impact oyster, clam and crab fisheries on the Pacific coast.
- Aquatic invasive species, such as the zebra mussel, clog lakes and waterways and adversely affect public water supplies, nuclear power plants, irrigation, water treatment systems, recreational activities, and shipping.
- Invasive pathogens may also directly affect human health. West Nile virus arrived in the United States as recently as 1999. In 2003, 4200 people were infected, resulting in 284 deaths.
- Hybridization with exotics can alter the genetic makeup of native species. Cultivation of genetically
- modified organisms provides a special case of such risk. When GMOs interbreed with wild relatives, their DNA becomes part of the gene pool of natural populations. Long-term consequences are not
- known.

Eat the Lionfish Campaign: Lionfish (native to the Western Pacific) have invaded the waters of the Caribbean and are quickly multiplying along the East Coast from Florida through the Carolinas, devouring native reef fish as they go. According to some scientists, **the lionfish invasion has the potential to be the "most disastrous marine invasion in history**," decimating commercially-valuable fish populations and wreaking havoc on our vulnerable coral reef ecosystems.

According to a recently released NOAA report, one of the only viable methods for controlling these predators is to encourage a market for them. Professional tasters have ranked the fish high for taste and texture, and a recent pilot project which brought the fish to several top New York and Chicago restaurants proved very successful. The eating of lionfish has become a grass-roots cause in some local areas, and several restaurants in the US and the Caribbean are serving up the fish whenever they can.

NOAA's National Centers for Coastal Ocean Science, who have conducted extensive lionfish research, have conceived an "Eat Lionfish" campaign that builds upon the original New York/Chicago pilot project. Top chefs in five cities will be hosting tasting events in 2010. NOAA will be working with them to develop press for the event that brings attention to the threat of lionfish and which highlights eating lionfish as a method of conservation and protection for our coral reefs. The media campaign will include not only pitches to major print outlets but also to television producers for The Food Network and The Travel Channel.

The intent is not to develop a fishery for the lionfish but to consume it out of existence in Caribbean and American waters. Given what we know about the worsening lionfish crisis, we feel that we would be negligent if we did not provide leadership on this issue. While fishermen, seafood wholesalers and restaurants are already demonstrating interest in bringing lionfish to market, we hope to serve as an additional catalyst in this effort. We anticipate that the main lionfish supply will be coming from the Bahamas and from parts of the US where the lionfish population is more established, such as North Carolina.

There are no existing regulatory impediments to selling lionfish commercially in the US. Currently there are no federal regulations concerning the landing and sales of lionfish; however, state regulations concerning diving and commercial licensing do apply. Similarly, there are no specific regulations concerning the importation of lionfish for human consumption into the US except those associated with all species, such as safe handling requirements, etc. As the result of our efforts, FDA has agreed to add *Pterois volitans*--the red lionfish--to the list of species approved for commercial sale under the name "lionfish".

4. Realm: Prehistoric Alley

-Global Warming and Effects

EFFECTS OF GLOBAL WARMING ON FISH:

Fish can be impacted in the following ways: cells, organ systems, the whole organism, reproduction, behavior, pollutant interactions, ecology and population dynamics, physiological function, protein metabolism, stress, muscle function, cardiovascular performance, embryonic and larval development, pollutant stress, growth rate, wild fish stocks, growth rage, physiology, and biogeography.

- **Metabolic changes:**

Fish are more sensitive to temperature than many animals because they cannot maintain a constant body temperature like we do – in most cases, their body is exactly the same temperature as the water they are swimming in. Different species can live in very cold or very hot water, but each species has a range of temperatures that it prefers, and fish can't survive in temperatures too far out of this range. If there is not enough food, all of a fish's available energy goes to fueling its high metabolism, and less energy is available for growth and reproduction. Rainbow trout grow significantly more slowly when their water temperature is raised only 2°C and food is also limited due to fluctuation in plankton levels. To make matters worse, fish may not have enough oxygen to breathe as the water grows warmer. Fish filter oxygen from the water they are swimming in, but the saturation amount of oxygen dissolved in water decreases as temperatures rise. So many fish need more oxygen to support their elevated metabolisms, but may not be able to get it from the warmer, oxygen-poor water around them. Also, the warmer temperatures affect the metabolism of the planktonic level to increase numbers and increase in respiration further lowers oxygen levels which also varies at different times of the day significantly.

- **Reproductive changes:**

Warmer water fish tend to mature more quickly, but the cost of this speedy lifestyle is often a smaller body size. Fish raised in warm water end up smaller than their peers raised at cooler temperatures. Many fish will also have less offspring as temperatures rise, and some may not be able to reproduce at all.

- **Geographical changes:**

Naturally, when fish find themselves in hot water, they head out in search of cooler locales, but this can leave other animals with few options. When fish in the Gulf of Mexico moved deep in 1993, 120,000 seabirds starved to death, most likely because they could not dive deep enough to catch their relocated prey (World Wide Fund for Nature, 2005).

- **Invasive species:**

As cool and cold water species decline or move poleward, fish that don't mind the heat will become much more common. Many areas have been colonized by new species as water has warmed in the last few decades, and invasions are likely to increase such as with tilapia, goldfish, carp and other species. Newly arrived species can wreak havoc in a number of ways, such as competing with native fish for food and spawning habitat, devouring the eggs and juveniles of native fish, while larger predators prey on native adults or even by bringing in new disease into an area with an otherwise healthy population.

- **Removal of ocean water layers:**

Some of the carbon in our oceans sinks to the benthic level and is consumed in the seafloor. When an animal dies, it sinks to the seafloor where it feeds decomposers and other organisms, thereby releasing carbon dioxide and other nutrients. Ocean currents bring this cold deep, nutrient-rich ocean water in the seafloor to the surface. This "upwelling" is necessary for keeping phytoplankton alive.

Evidence has shown that the surface layers of the ocean hold nitrogen-fixing cyanobacteria, which supply 50% of the nitrogen required for phytoplankton to live. The enormous food web in the oceans that depend on phytoplankton makes phytoplankton *the* most important primary producer. It is unique among primary producers for growing at the fastest rates, with doubling times from hours to days depending on the conditions. Because of its prodigious rate of growth, phytoplankton population also determines carbon balance in the oceans, which will impact on climate change.

For phytoplankton to thrive there must be an appropriate supply of nutrients. Also, the water must not be too warm, or too acid. All these conditions are deteriorating on account of global warming, bringing the prospect of a collapse in the marine biota and ecosystems. When the ocean surface water warms, it essentially becomes "lighter" than the cold, dense water below, which is loaded with nutrients. This process effectively separates phytoplankton,

which are responsible for about half of the photosynthesis on Earth, in the surface layer-which needs light for photosynthesis-from the nutrients below them, which they also need for growth, thereby decreasing the natural productivity of the ocean. Shutting down the North Atlantic Deep Water "pump,", which tends to be bring nutrients in abyssal plain to the ocean's surface, would be disastrous.

- **Disease and toxins:**

As water warms up, many parasites and microbes that cause fish diseases grow faster and become more virulent. Parasites in cooler climates are more likely to survive the winter and produce multiple generations of offspring each year, so more fish may become infected. And as harmful microbes and parasites become stronger and more numerous, fish whose immune systems are already stressed by warm water, low oxygen, and crowding, become even more susceptible to diseases and parasites. As warmer water increases the toxicity of pollutants, and as fish pump more water through their gills to meet increased metabolic needs, they also collect more pollutants.

-Coral culture and global water rise

Coral reefs are one of the most impacted ocean habitats from global warming. As water levels rise due to the melting of glaciers, corals are greatly impacted due to their reliance upon sunlight to produce food through the zooxanthellae in their bodies. Such water depth changes could cause coral die-off and bleaching.

The first requirement for active coral reef development and growth is light (Nybakken 1993). If corals are unable to get enough light (whether due to increased water turbidity and the increased suspended sediment clouding the water column, or due to a dramatic and rapid increase in water depth), they stop growing and eventually die (Nybakken 1993). Light is necessary to promote photosynthesis within the corals symbiotic zooxanthallae. Light also enhances oxygen production, which stimulates the coral metabolism and leads to increased calcium carbonate deposition and therefore coral reef growth.

Coral dependence on light and ocean temperature are just two variables on a list of potential stresses to reef ecosystems. Corals possess numerous mechanisms for acclimatization and adaptation to various stresses including diverse reproductive strategies, flexible symbiotic relationships, physiological acclimatization, habitat tolerance, and a range of community interactions (NOAA). However, once weakened, their systems become more vulnerable as additional stresses are added. It is when multiple stresses occur at the same time - as is almost always the case in natural systems - that coral reefs are in danger of severe, long-standing damage and perhaps fatality. Corals are slow growing organisms, and when destruction occurs, it takes upward of 25 years to repair and rebuild even the smallest coral colonies (Nybakken 1993).

A rise in sea level will cause reef ecosystems at the depth limit of coral growth to experience diminished light conditions that will no longer sustain this growth and will most likely result in death (Hoegh-Guldberg 1999). Corals that currently exist at these depths are expected to go extinct with rising sea levels. In addition to corals living at their physiological depth limit, slow growing coral species are also susceptible to the negative consequences brought by sea level rise as they will be unable to grow fast enough to keep pace with rising ocean levels (Hoegh-Guldberg 1999). When coupled with other stresses coral reef systems will be under in association with rising waters (increased water temperatures, and possibly reduced salinity), the ability of reefs to keep up with rising sea levels will be greatly diminished (NOAA). If coral growth rates are reduced by general environmental stresses, then the rise in sea level that is expected under even moderate global climate change projections will present additional and perhaps insurmountable challenges for coral reef communities in the future (Hoegh-Guldberg 1999). For example, computer model simulations have demonstrated that coral reefs in the Caribbean will be unable to keep up with the predicted rates of sea level rise (Graus 1998). As these reefs become deeply submerged, dependent human populations will feel multiple severe consequences.

5. Realm: DiSalvo Curiosity Classroom

-Biodiversity Awareness & Sustainable Living Practices

Biodiversity is a natural insurance policy against climate change. Many individual studies have examined the evidence for recent biological changes in relation to measured climatic changes. These studies give us a very high confidence that global climate change is already impacting biodiversity in the following ways:

1. Changes in distribution
2. Increased extinction rates

3. Changes in reproduction timings
4. Changes in length of growing seasons for plants
5. Shifting migration ranges of insects and animals
6. Modified flowering and fruiting cycles

In a study of general marine biodiversity, scientists have made the first global map of the biodiversity of the oceans for more than 11,000 marine species, from tiny shrimp-like creatures to whales, building on 6.5 million records from the Census for Marine Life and other databases. Of all the factors they looked at to explain why some regions had more or fewer types of creatures, the only factor that consistently explained the patterns for the 13 groups of marine life they studied was temperature.

In light of the already measured effects of global warming on the ornamental fish trade and fisheries productivity, it is recommended that a further set of actions be taken for protection and preservation of aquatic biodiversity, food security and the environment:

1. Prediction of localized effects of global warming for rapid recovery.
2. Appropriate coastal protection such as mangroves, fishing quotas, and MPAs, etc.
3. Measurements of productivity with rubrics for changes.
4. Evaluation of coral species with the intent to create living ARKS in aquaculture conditions for later re-implantation or implantation in new areas based upon temperature, water quality and other conditions.
5. Surveillance for invasive species.
6. Measurement of water quality: chemical and biological indicators.
7. Appropriate protection for preservation of production relative to local, regional and national food security issues.
8. Cut carbon dioxide emissions
9. Invest in clean energy – most of the carbon dioxide comes from electricity generation (37% worldwide).

LOCAL ADAPTIVE RESPONSES:

- Purchase Organic Foods - As much as 40% of energy used in the food system goes towards the production of artificial fertilizers and pesticides. A 22-year study conducted by the Rodale Institute determined that organic farming operations use 30% less energy than conventional farms.
- Purchase Sustainable Products - 52% of the world's marine fish stocks are fully exploited, 16% are overexploited and 7% are depleted (FAO 2005). The northwest Atlantic cod stocks off eastern Canada once sustained one of the world's largest fisheries, and supported livelihoods for many generations of Newfoundlanders. The cod are now considered "commercially extinct," so the cod fishery was closed down in 1992 to protect the remaining overfished stocks. The devastating result – 20,000 people involved in fishing and shore-based activities lost their jobs.
- Change in cultivation time in anticipation of changed monsoon (rains) pattern
- Rainwater harvesting and storage: ponds and canals
- Construction of mud-barrages around the island to protect it from incursion of saline water
- Reforestation activity (mangroves) on the mud barrage to make it durable
- Alternative livelihood options for proper substitution of certain livelihood activities like baby prawn/ shrimp catches, timber smuggling etc.
- Capacity building activity through scientific and organizational intervention in support of their indigenous adaptation efforts.
- Monitor food security locally and take actions accordingly

6. Realm: Sharks!

-Ocean Conservation: Fisheries Practices

The oceans supply us with food, help regulate our climate, and supply a livelihood for millions of people. Just as important, we depend on the oceans for recreation and renewal. But our seas are not the infinite bounty they appear to be. Today, no part of the oceans remain unaffected by human activities. And among the many factors influencing our ocean ecosystems, none has a greater impact than fishing.

Humans have been fishing the oceans for thousands of years. But over the past five decades technology has allowed us to fish farther, deeper and more efficiently than ever before. Scientists estimate that we have removed as much as 90 percent of the large predatory fish such as shark, swordfish and cod from the world's oceans. In 2003, the Pew Oceans Commission warned that the world's oceans are in a state of "silent collapse," threatening our food supply, marine economies, recreation and the natural legacy we leave our children.

Wild Seafood Issues:

Overfishing: Simply put, we're removing fish from the ocean faster than they can reproduce. More boats on the water and more effective fishing practices have worked together over the last 60 years to shift the advantage to fishermen. Decades of overfishing have driven fish populations to levels so low that recovery, when possible, is a long-term proposition.

Illegal fishing: Experts estimate that illegal, unreported or unregulated fishing—sometimes called pirate fishing—accounts for a quarter of the world's total catch of wild fish. Many fisheries that may otherwise be sustainable ignore and violate regulations, leading to overfishing.

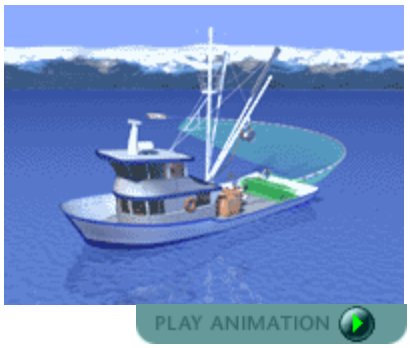
Habitat damage: The habitat that fish need to survive can be destroyed by some types of fishing gear, for instance when large nets or trawls are dragged along the seafloor, sweeping up everything in their paths.

Bycatch: The process of bringing a fish to market can be messy. Large nets and longlines intended for one species often catch others by mistake. Fish, sea birds, turtles and marine mammals are included in this "bycatch," and are usually thrown back dead or dying.

Management: Worldwide, regulation of the fishing industry is weak, non-existent or not well-enforced. Rules intended to deal with overfishing, illegal fishing and the related issues of bycatch and habitat damage are ignored, and species like tuna that travel long distances are not managed consistently over their range.

Fishing Methods

Pole/troll fishermen use a fishing pole and bait to target a variety of fish, ranging from open ocean swimmers, like tuna and mahi mahi, to bottom dwellers, like cod. Pole/troll fishing is environmentally responsible and a good alternative to pelagic longlining. Unlike pelagic longlines, which catch sharks, marine mammals, sea turtles and seabirds as bycatch, pole/troll fishermen have very low bycatch rates.



Purse seining establishes a large wall of netting to encircle schools of fish. Fishermen pull the bottom of the netting closed—like a drawstring purse—to herd fish into the center. This method is used to catch schooling fish, such as sardines, or species that gather to spawn, such as squid. There are several types of purse seines and, depending on which is used, some can catch other animals (such as when tuna seines are intentionally set on schools of dolphins).

Gillnetting uses curtains of netting that are suspended by a system of floats and weights; they can be anchored to the sea floor or allowed to float at the surface. The netting is almost invisible to fish, so they swim right into it. Gillnets are often used to catch sardines, salmon and cod, but can accidentally entangle and kill other animals, including sharks and sea turtles.

Longlining employs a central fishing line that can range from one to 50 miles long; this line is strung with smaller lines of baited hooks, dangling at evenly spaced intervals. Longlines can be set near the surface to catch pelagic fish like tuna and swordfish, or laid on the sea floor to catch deep dwelling fish like cod and halibut. Many lines, however, can hook sea turtles, sharks and seabirds that are also attracted to the bait. By sinking longlines deeper or using different hooks, fishermen can reduce the bycatch problem.

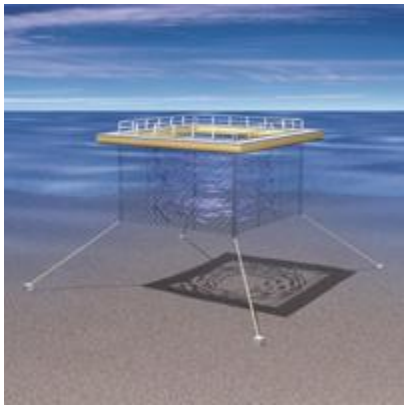
Trawls and dredges are nets towed at various depths to catch fish or shellfish. Trawl nets, which can be as large as a football field, are either dragged along the sea floor or midway between the floor and the surface. Trawlers catch fish such as pollock, cod, flounder and shrimp. Bottom trawling can result in high levels of bycatch. Dredging involves dragging a heavy frame with an attached mesh bag along the sea floor to catch animals living on or in the mud or sand; catches include scallops, clams and oysters. Dredging can damage the sea floor by scraping the bottom and also often results in significant bycatch.

Traps and pots are submerged wire or wood cages that attract fish with bait and hold them alive until fishermen return to haul in the catch. Traps and pots are usually placed on the ocean bottom, often to catch lobsters, crabs, shrimp, sablefish and Pacific cod. They generally have lower unintended catch and less sea floor impact than mobile gear like trawls.

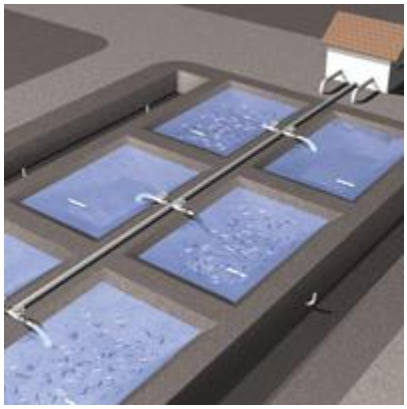
Harpooning is a traditional method for catching large fish—and it's still used today by skilled fishermen. When a harpooner spots a fish, he thrusts or shoots a long aluminum or wooden harpoon into the animal and hauls it aboard. Harpooners catch large, pelagic predators such as bluefin tuna and swordfish. Harpooning is an environmentally responsible fishing method. Bycatch of unwanted marine life is not a concern because harpoon fishermen visually identify the species and size of the targeted fish before killing it.

Trolling is a hook-and-line method that tows fishing lines behind or alongside a boat. Fishermen use a variety of lures and baits to "troll" for different fish at different depths. Trollers catch fish that will follow a moving lure or bait, such as salmon, mahi mahi and albacore tuna. Trolling is an environmentally responsible fishing method. Fishermen can quickly release unwanted catch from their hooks since lines are reeled in soon after a fish takes the bait.

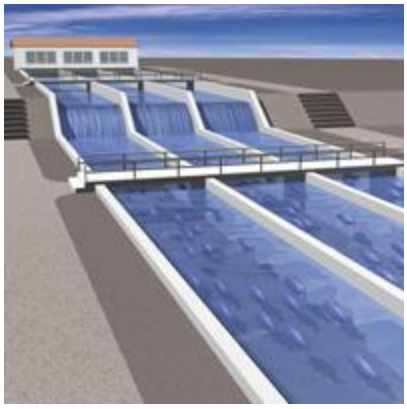
Fish Farming (Aquaculture)



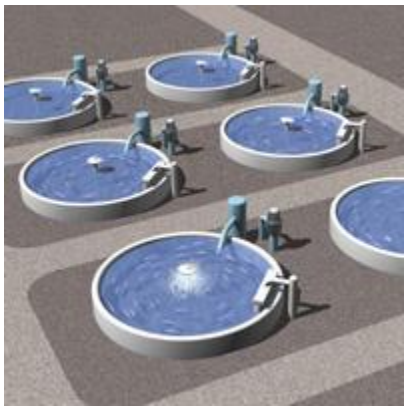
Open net pens or cages enclose fish such as salmon in offshore coastal areas or in freshwater lakes. Net pens are considered a high-impact aquaculture method because waste from the fish passes freely into the surrounding environment, polluting wild habitat. Farmed fish can also escape and compete with wild fish for natural resources or interbreed with wild fish of the same species, compromising the wild population. Diseases and parasites can also spread to wild fish living near or swimming past net pens.



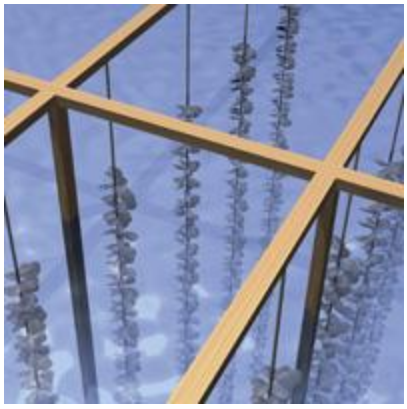
Ponds enclose fish in a coastal or inland body of fresh or salt water. Shrimp, catfish and tilapia are commonly raised in this manner. Wastewater can be contained and treated. However, the discharge of untreated wastewater from the ponds can pollute the surrounding environment and contaminate groundwater. Moreover, the construction of shrimp ponds in mangrove forests has destroyed more than 3.7 million acres of coastal habitat important to fish, birds and humans.



Raceways allow farmers to divert water from a waterway, like a stream or well, so that it flows through channels containing fish. Farmers usually treat the water before diverting it back into a natural waterway. Some governments require strict regulation and monitoring of on-site and nearby water quality. In the U.S., farmers use raceways to raise rainbow trout. If untreated, wastewater from the raceways can contaminate waterways and spread disease. Farmed fish can potentially escape and compete with wild fish for natural resources. Escaped fish can also interbreed with wild fish of the same species, putting the health of the wild population at risk.



Recirculating systems raise fish in tanks in which water is treated and recycled through the system. Almost any finfish species such as striped bass, salmon and sturgeon can be raised in recirculating systems. Recirculating systems address many environmental concerns associated with fish farming—fish cannot escape, and wastewater is treated—but they are costly to operate and rely on electricity or other power sources.



Shellfish culture means that farmers grow shellfish on beaches or suspend them in water by ropes, plastic trays or mesh bags. The shellfish farmed using these methods—oysters, mussels, and clams—are filter feeders and require only clean water to thrive. Filter feeders can actually filter excess nutrients out of the water, but farming shellfish in high densities in areas with little current or tidal flow can lead to the accumulation of waste. Also, historically, some shellfish culture has been responsible for the introduction of exotic species that can sometimes out-compete native species for natural resources.

-Shark slide (activity)

-On back door, show pump diagram and describe how we keep the pump room closed to keep heat within the Aquarium and open the door to let heat out during the summer

-Talk about the Aquarium's change to LED Lighting which reduces our energy usage

45-60 MINUTES OF HANDS-ON ACTIVITIES

A. FEEDINGS (20 minutes)
    a. Emphasize vegetation animal feedings (i.e. Amazon, tortoises, sloths)
    b. If you must feed fish to an animal, use tilapia only
    c. We want to emphasize sourcing animal food locally and/or sustainable seafood
B. TOUCH ANIMALS (20 minutes)
    a. Bull Snake
    b. Anteater
    c. Stingrays
    d. Other touch animals different from the 2-3 hour tour)
C. ACTIVITIES (10 minutes)
    a. Shark Slide (see above)

GIVE-AWAYS

1. Small Aquatic Plush toy
2. Seafood Watch card
3. Comprehensive brochure
4. Activity card (Top 10 Things to Do to Stop Climate Change)

WORLD AQUARIUM CONSERVATION & SUSTAINABILITY TOUR

KEY POINTS

60 MINUTE TOUR (10 minutes per realm)

The crux of the matter:
"According to the Millennium Ecosystem Assessment (MEA, 2005), the world's oceans and coasts are highly threatened and subject to rapid environmental change. Major threats to marine and coastal ecosystems include: (i) land-based pollution and euthrophication; (ii) overfishing, destructive fishing, and illegal, unreported and unregulated (IUU) fishing; (iii) alterations of physical habitats; (iv) invasion of exotic species; and (v) global climate change."

1. Realm: The Water Cycle
The Water cycle is a circular process: evaporation… condensation… precipitation… and collection. This cycle of life provides the basis for most living things on the terrestrial part of the planet. Understanding that freshwater makes up less than one percent of the available water on the planet, some people have said that water is more precious than gold. **Emphasize the fact that toxic substances like alcohol which, prior to their evaporation, kill everything in the site in which they are located and get left behind on Earth in ecosystems.**

Climate change, rising atmospheric carbon dioxide, excess nutrient inputs, and pollution in its many forms are fundamentally altering the chemistry of the ocean on a global scale. Major observed trends include a shift in the acid-base chemistry of seawater, reduced subsurface oxygen both in near-shore coastal water and in the open ocean, rising coastal nitrogen levels, and widespread increase in mercury and persistent organic pollutants. Most of these perturbations, tied either directly or indirectly to human fossil fuel combustion, fertilizer use, and industrial activity, are projected to grow in coming decades, resulting in increasing negative impacts on ocean biota and marine resources.

-Water Conservation
Water is the most abundant liquid on Earth. 71% of Our Earth's surface is water *and constitutes 60-70 of the living world.*

So why worry?
Actually, only 1% of the world's water is usable to us.
About 97% is salty sea water, and 2% is frozen in glaciers and polar ice caps;

-Change in Ocean Currents
As global climate change alters wind, precipitation and temperature patterns worldwide, ocean currents will reflect these changes in often unpredictable ways. For example, increasing wind speeds arising from larger land-ocean temperature differences may drive stronger upwelling which will change near shore ecosystems and may cause hypoxic dead zones in some areas. Another key factor that influences ocean currents is the density of seawater. Both temperature and salinity contribute to seawater density, thus local changes in temperature and the magnitude of freshwater inputs from rivers and streams can alter near shore ocean currents. Changes in the direction and strength of nearshore currents can have profound impacts on near shore ecosystems by altering the transport / retention of contaminants, nutrients, and the marine larvae that sustain populations along the coast.

-Point Source Pollution
Definition – Identifiable inputs of waste that are discharged via pipes or drains primarily (but not exclusively) from industrial facilities and municipal treatments plants into rivers, lakes, and ocean.

-Non-Point Source Pollution

Definition - water pollution affecting a water body from diffuse sources, such as polluted runoff from agricultural areas draining into a river, or wind-borne debris blowing out to sea. Nonpoint source pollution can be contrasted with point source pollution, where discharges occur to a body of water at a single location, such as discharges from a chemical factory, urban runoff from a roadway storm drain, or from ships at sea.

States report that nonpoint source pollution is the leading remaining cause of water quality problems. The effects of nonpoint source pollutants on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries, and wildlife.

It is believed that Point Source and Non-Point Source Pollution are the causes of the Dead Zone in the Gulf of Mexico and other places. Aquatic and marine dead zones can be caused by an increase in chemical nutrients (particularly nitrogen and phosphorus) in the water, known as eutrophication. These chemicals are the fundamental building blocks of single-celled, plant-like organisms that live in the water column, and whose growth is limited in part by the availability of these materials. Eutrophication can lead to rapid increases in the density of certain types of these phytoplankton, a phenomenon known as an algal bloom. Although these algae produce oxygen in the daytime via photosynthesis, during the night hours they continue to undergo cellular respiration and can therefore deplete the water column of available oxygen. In addition, when algal blooms die off, oxygen is used up further during bacterial decomposition of the dead algal cells. Both of these processes can result in a significant depletion of dissolved oxygen in the water, creating hypoxic conditions. Use of chemical fertilizers is considered the major human-related cause of dead zones around the world. Runoff from sewage, urban land use, and fertilizers can also contribute to eutrophication.

Notable dead zones in the United States include the northern Gulf of Mexico region, surrounding the outfall of the Mississippi River.

. Nitrogen (in saltwater) and phosphorus (in freshwater) are the nutrients that contribute most to algal blooms. A lack of silicon in the water limits the growth of **diatoms**, a helpful type of algae. A major contributing factor to dead zones is when water becomes **stratified** -- warm, fresh water settles on top of colder, saltier water. This stratification limits the aeration of deeper waters as algal blooms settle to the bottom and decay.

2. Realm: Rivers of the World

-Sustainable Seafood

Seafood is sustainable when the population of that species of fish is managed in a way that provides for today's needs without damaging the ability of the species to reproduce and be available for future generations.

One of the ways to achieve sustainability in fisheries is through aquaculture. Aquaculture is fish farming within a body of water. Aquaculture, or fish farming, sounds like a great solution to the ever-increasing pressures on our ocean resources. And it can be a useful alternative. Today, half of our seafood comes from farms. People are raising fish, shrimp and oysters like farmers raise cattle and chickens. But the ecological impact of fish farming depends on the species chosen, where the farm is located, and how they are raised.

As a society, we can create sustainable aquaculture that limits habitat damage; prevents the spread of disease and non-native species; and minimizes the use of wild fish as feed.

Aquaculture Issues:

Wild fish:

Pollution & disease:

Escapes: Asian carp were introduced to the United States in the early '70s to control algae in catfish farms in the South. Floods washed the Asian Carp into the Mississippi River in the 1980s. They've worked their way upriver ever since. The

carp thrive in the Illinois River, a tributary of the Mississippi. Reproducing populations of these four species are now present in the Upper Mississippi River System. They are steadily moving towards the Great Lakes.

Habitat damage:

Management:

-Tropical Fish Trade - sustainability

Billions of people throughout the world rely on fish as a primary source of protein, particularly in developing countries with rapidly expanding populations. The world's fisheries generate over US$130 billion annually, and contribute significantly to the economies of many countries. Even where fisheries are not important on a national level, they can be critical for regional employment, where entire communities of small-scale fishermen rely on fishing as their primary source of income.

A single species, the cardinal tetra (*Paracheirodon axelrodi*) constitutes over 80% of the total export from the Rio Negro basin.

Though the ornamental fish stocks are very hardy, they are sensitive to long term environmental disruptions. In order for the ornamental fishery to thrive, the entire aquatic ecosystem must be intact and functional.

3. Realm: Sand Castle Beach and Structure, Color & Function

- Desertification

Desertification is the degradation of land in arid, semi-arid, and dry sub-humid areas due to various factors: including climatic variations and human activities. A major impact of desertification is reduced biodiversity and diminished productive capacity, for example, by transition from land dominated by shrublands to non-native grasslands. For example, in the semi-arid regions of southern California, many coastal sage scrub and chaparral ecosystems have been replaced by non-native, invasive grasses due to the shortening of fire return intervals. This can create a monoculture of annual grass that cannot support the wide range of animals once found in the original ecosystem

-Eat Lionfish Campaign/Invasive species

Invasive Species: An "invasive species" is defined as a species that is

1) non-native (or alien) to the ecosystem under consideration and

2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health..

Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

Eat the Lionfish Campaign: Lionfish (native to the Western Pacific) have invaded the waters of the Caribbean and are quickly multiplying along the East Coast from Florida through the Carolinas, devouring native reef fish as they go. According to some scientists, **the lionfish invasion has the potential to be the "most disastrous marine invasion in history**," decimating commercially-valuable fish populations and wreaking havoc on our vulnerable coral reef ecosystems.

Top chefs in five cities will be hosting tasting events in 2010. NOAA will be working with them to develop press for the event that brings attention to the threat of lionfish and which highlights eating lionfish as a method of conservation and

protection for our coral reefs. The media campaign will include not only pitches to major print outlets but also to television producers for The Food Network and The Travel Channel.

4. Realm: Prehistoric Alley

-Global Warming and Effects

EFFECTS OF GLOBAL WARMING ON FISH:

Fish can be impacted in the following ways: cells, organ systems, the whole organism, reproduction, behavior, pollutant interactions, ecology and population dynamics, physiological function, protein metabolism, stress, muscle function, cardiovascular performance, embryonic and larval development, pollutant stress, growth rate, wild fish stocks, growth rage, physiology, and biogeography.

- **Metabolic changes:**

Fish are more sensitive to temperature than many animals because they cannot maintain a constant body temperature like we do – in most cases, their body is exactly the same temperature as the water they are swimming in. Different species can live in very cold or very hot water, but each species has a range of temperatures that it prefers, and fish can't survive in temperatures too far out of this range. To make matters worse, fish may not have enough oxygen to breathe as the water grows warmer.

- **Reproductive changes:**

Warmer water fish tend to mature more quickly, but the cost of this speedy lifestyle is often a smaller body size. Fish raised in warm water end up smaller than their peers raised at cooler temperatures. Many fish will also have less offspring as temperatures rise, and some may not be able to reproduce at all.

- **Geographical changes:**

Naturally, when fish find themselves in hot water, they head out in search of cooler locales, but this can leave other animals with few options. When fish in the Gulf of Mexico moved deep in 1993, 120,000 seabirds starved to death, most likely because they could not dive deep enough to catch their relocated prey.

- **Invasive species:**

As cool and cold water species decline or move poleward, fish that don't mind the heat will become much more common. Many areas have been colonized by new species as water has warmed in the last few decades, and invasions are likely to increase such as with tilapia, goldfish, carp and other species. Newly arrived species can wreak havoc in a number of ways, such as competing with native fish for food and spawning habitat, devouring the eggs and juveniles of native fish, while larger predators prey on native adults or even by bringing in new disease into an area with an otherwise healthy population.

- **Removal of ocean water layers:**

Some of the carbon in our oceans sinks to the benthic level and is consumed in the seafloor. When an animal dies, it sinks to the seafloor where it feeds decomposers and other organisms, thereby releasing carbon dioxide and other nutrients. Ocean currents bring this cold deep, nutrient-rich ocean water in the seafloor to the surface. This "upwelling" is necessary for keeping phytoplankton alive.

Evidence has shown that the surface layers of the ocean hold nitrogen-fixing cyanobacteria, which supply 50% of the nitrogen required for phytoplankton to live. The enormous food web in the oceans that depend on phytoplankton makes phytoplankton *the* most important primary producer. It is unique among primary producers for growing at the fastest rates, with doubling times from hours to days depending on the conditions. Because of its prodigious rate of growth, phytoplankton population also determines carbon balance in the oceans, which will impact on climate change.

For phytoplankton to thrive there must be an appropriate supply of nutrients. Also, the water must not be too warm, or too acid. All these conditions are deteriorating on account of global warming, bringing the prospect of a collapse in the marine biota and ecosystems.

- **Disease and toxins:**

As water warms up, many parasites and microbes that cause fish diseases grow faster and become more virulent.

-Coral culture and global water rise

Coral reefs are one of the most impacted ocean habitats from global warming. As water levels rise due to the melting of glaciers, corals are greatly impacted due to their reliance upon sunlight to produce food through the zooxanthellae in their bodies. Such water depth changes could cause coral die-off and bleaching.

Coral dependence on light and ocean temperature are just two variables on a list of potential stresses to reef ecosystems.

A rise in sea level will cause reef ecosystems at the depth limit of coral growth to experience diminished light conditions that will no longer sustain this growth and will most likely result in death.

5. Realm: DiSalvo Curiosity Classroom

-Biodiversity Awareness & Sustainable Living Practices

Biodiversity is a natural insurance policy against climate change. Many individual studies have examined the evidence for recent biological changes in relation to measured climatic changes. These studies give us a very high confidence that global climate change is already impacting biodiversity in the following ways:

A. Changes in distribution
B. Increased extinction rates
C. Changes in reproduction timings
D. Changes in length of growing seasons for plants
E. Shifting migration ranges of insects and animals
F. Modified flowering and fruiting cycles

In a study of general marine biodiversity, scientists have made the first global map of the biodiversity of the oceans for more than 11,000 marine species, from tiny shrimp-like creatures to whales, building on 6.5 million records from the Census for Marine Life and other databases. Of all the factors they looked at to explain why some regions had more or fewer types of creatures, the only factor that consistently explained the patterns for the 13 groups of marine life they studied was temperature.

LOCAL ADAPTIVE RESPONSES:

- Purchase Organic Foods
- Purchase Sustainable Products -

6. Realm: Sharks!

-Ocean Conservation: Fisheries Practices

The oceans supply us with food, help regulate our climate, and supply a livelihood for millions of people. Just as important, we depend on the oceans for recreation and renewal. But our seas are not the infinite bounty they appear to be. Today, no part of the oceans remain unaffected by human activities. And among the many factors influencing our ocean ecosystems, none has a greater impact than fishing.

Humans have been fishing the oceans for thousands of years. But over the past five decades technology has allowed us to fish farther, deeper and more efficiently than ever before. Scientists estimate that we have removed as much as 90 percent of the large predatory fish such as shark, swordfish and cod from the world's oceans.

Wild Seafood Issues:

Overfishing:

Illegal fishing:

Habitat damage:

Bycatch:

Management:

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-Anteater
-Stingrays
-Other touch animals **(different from the 2-3 hour tour)**

ACTIVITIES (10 minutes)

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