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Elasmobranchii: A Survey Study on the Impact of Our Everyday Choices in Marine Environments

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I. Acknowledgements

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II. Abstract

Oceans cover two-thirds of our total planet surface area, ignoring the significance of depth, and even so, humans affect and change the ocean daily. This change is not often intentional or conscious, but rather is usually indirect. The hypothesis that humans do not consider how their actions affect the ocean unless they are educated on the subject matter and/or live within 25 miles of a coastline was examined through two survey studies. The purpose was to observe actions that affected the ocean and see if there were any trends with participants knowing which actions were positive for the ocean or negative for the ocean. These activities were put into context by being tied to elasmobranchs. These organisms are found in a wide variety of habitats and are well known, but not usually given attention in regards to conservation efforts. This highlights how our actions affect all organisms rather than just flagship species. Looking at the survey results and patterns in the data reveals that individuals did not know as much about conservation or the effects and magnitude of their actions unless they lived within 25 miles of a coastline, studied a life science and/or worked at an aquarium or other marine education facility. If there was knowledge of the effect of actions, there was little correlation between whether or not these actions were done and the known effect they have on the ocean.

III. Introduction

Humans constantly affect and change the ocean both physically and chemically. Recently, there has been more attention paid to our actions that make our environmental footprint smaller, but the oceans are often forgotten in this fight. Most people focus their attention on terrestrial environments because of human habitation and the impact we have here is easier to see. We know more about outer space than something that makes up ⅔ of our own planet, so how can we take care of something we know very little about? Either way, the ocean supplies us with most of our trading routes, food supply, energy and medicine sources, so it needs to be on our radar.

The main objective of this study was to address this lack in attention toward the ocean, highlight that it exists, and offer suggestions on how to better protect the ocean. A sample of people ranging in age, geographic location, and academic interest were questioned about their daily activities and if they were conscious of the effect of their actions on the ocean itself. Their general attitudes and opinions about the ocean were also examined. This information was then used as a baseline for small and manageable suggestions on what changes can be made in one's life to keep the ocean healthy and as close to its original, natural state. Elasmobranchs were used in a case study to make a direct tie between human action and their effect on marine life.

Elasmobranchii is a subclass of Chondrichthyes that encompasses all sharks, superorder Selachimorpha, and rays, superorder Batoidae. Chondrichthyes are fish that have a cartilaginous skeleton, as compared to Osteichthyes, which are fish that have skeletons made of bone (Bonfil, 1994). The other subclass of Chondrichthyes is Holocephalii, which include Chimaeras, or ratfish, and elephant fish. Elasmobranchii have been chosen as the focus of this study because there is more known about their biology than Holocephalii, and the general public is more cognizant of sharks and rays than Chimaeras

(Figure 1). See Table 1 for more detailed classifications. Elasmobranchii are an ancient and very successful group of organisms that have been documented to be on Earth since the Devonian era, 419.2 MYA (Bonfil, 1994). Figure 2 elaborates on the species richness around the world.

Sharks and rays have very acute senses, which aids in their successful lifestyle and their ability to coexist with other fish. Stingrays rely heavily on their sense of touch, smell and electroreception to assist in their ability to hunt for prey. Sharks utilize similar senses but with different organs, such as the Ampullae of Lorenzini. These are small pores at the front of their heads that detect changes in temperature and pressure, as well as close proximity to prey. Both sharks and rays, like many other species of fish, rely on their lateral line. This structure runs from their head to their tail on both sides of their bodies to assist in detecting movement of water and therefore, the location of other fish around them (AGT, 2003). Elasmobranchii have representatives in all types of environments, which includes freshwater (Bonfil, 1994).

Elasmobranchii have free amino acids in their circulatory systems and muscular systems, which help regulate intracellular osmoregulation. This refers to their chemical, specifically salinity, composition and assists their ability to adapt to rapidly changing conditions, such as those found along coastlines (Boyd et al., 1997). Elasmobranchs have internal fertilization and are either oviparous (eggs are laid and development occurs outside of female's body), ovoviviparous (eggs remain, develop and hatch inside female's body), or viviparous (no shell around the egg that develops inside the female's body and then females give live birth) (AGT, 2013; White and Summerville, 2010).

Stingrays are well known, but they are not often considered a flagship species. Flagship species are usually the focus of conservation efforts because they have qualities that attract interest from people. Examples include the polar bear, killer whale, and sea otter. Stingrays are important because they are in the middle of the food chain. Being predator and prey, food chains can collapse without their presence. They are also ecologically significant because they move large quantities of sand around, a process known as bioturbation, when they search for prey. This mixes up nutrients in the benthic zone. Their meat and skin are valuable for food and medicine, and they are important for ecotourism, a large source of income for tropical countries (Elston, 2014).

Sharks are apex predators and are, unfortunately, famous for the wrong reasons. Social media and the film industry have shaped them to be vicious killers that prey on humans when really, they are severely threatened by our actions and do not hunt humans. Shark attacks occur due to reckless behavior and misjudgment on the shark's behalf, such as thinking that a person on a surfboard is a seal, a natural prey of a large shark (AGT, 2013).

These organisms face many problems. This study focused on bycatch from many different kinds of fishing methods, coastal development and coastal habitat destruction, toxic run off and plastic debris as forms of water pollution, ocean acidification and temperature increase due to global climate change, and touch tanks in aquariums as well as ecotourism. Dulvy et al. (2014) estimate that approximately ¼ of Chondrichthyes are threatened on a global scale.

My hypothesis is that people do not necessarily think about the ocean and its inhabitants unless they live within roughly 25 miles of a coastline, have studied a life science, and/or have worked at an aquarium or other marine education facility. Otherwise, it is very easy to separate ourselves from the ocean in our day to day lives.

IV. Literature Review

Unsustainable Fishing

Humans have been dependent on seafood as a source of food and other nutrients and valuables for thousands of years. Unfortunately, with recent increases in technology, the fishing industry is booming and the fish populations are suffering. Fishing technology has surpassed the species' ability to grow and reproduce at a rate that keeps up with the amount of fish that are being taken from the ocean. To make matters worse, often times the fish of interest is not the only organism taken out of the ocean or affected by the fishing actions.

Bycatch is defined as animals that are accidentally caught in fishing gear and are tossed back into the ocean because they offer no value to the fishermen. These animals are usually injured when tossed back into the ocean and therefore cannot function to their best ability, or worse they die from the stress of being caught and tossed back. Bycatch can occur from both passive fishing gear and active fishing gear. Passive gear requires no effort on the behalf of the fishermen, while active gear does require physical effort. Bycatch is not to be confused with non-target catch, which is when an animal that was not the original target is still kept and sold anyway.

Accidental catch of organisms can damage ecosystems, food webs, populations, and species existence as a whole. Keeping track of bycatch is ambiguous and complex. The terminology used and species identification is not universal, as well as the standards that fishermen are expected to uphold. Fishermen do not want to report all bycatch for fear of stricter fishing regulations, including the use of more specific fishing methods, which are usually more expensive and not as efficient as non-specific fishing gear.

In 1990, the International Whaling Commission (IWC) called for a Symposium and Workshop on the Mortality of Cetaceans in Passive Fishing Nets and Traps. This meeting emphasized the need for improvement and more attention toward the problems related to bycatch by showing a global summary of bycatch numbers. The meeting also called for increased efforts towards collecting bycatch data so the problems can be properly addressed. Bycatch is due to unspecific fishing methods, which are fishing methods that include large nets that catch anything in their path (Smolowitz, 1997). There are many different kinds of unspecific fishing methods, but the ones that have been cited as the most detrimental are trawling (Shepherd and Myers, 2005; AGT; Smolowitz, 1997), dredging (Smolowitz, 1997), longline hook gear (Shepherd and Myers, 2005; AGT; Piovano et al., 2010; Beerkircher et al., 2002; Mandelman et al., 2008) and gillnets (Smolowitz, 1997; McKinnell et al., 1998).

Trawling utilizes active fishing gear that consists of a large mesh net being dragged either across the seafloor or through the water column (Smolowitz, 1997). Bottom trawling can be detrimental to habitats, since bottom trawl nets usually have heavy wooden beams that sink into the sand as they are pulled across the sea floor. The dragging of the wooden beams damages all benthic habitat components in its path, as well as uprooting and collecting any benthic organisms hiding in the sand. The nets can also catch rocks, which hit and injure the animals that are caught, decreasing their chances of survival if they are bycatch. Shepherd and Myers (2005) relate critically low elasmobranch numbers to trawling activity in the Gulf of Mexico. They observed a top-down effect of top predators being accidentally caught and killed, allowing lower trophic level organisms to overpopulate due to the decreasing size of elasmobranchs that would otherwise control their numbers through predation.

Dredging is similar to trawling in that both utilize active fishing gear dragging the net through the ocean, but dredging scrapes and rakes the seafloor (Smolowitz, 1997). Dredging is more detrimental to habitats and benthic organisms because it digs deeper and uproots larger amounts of sediments. This fishing method disrupts all aspects of the benthic environment. Dredging is also used as a way to dig up sediments that can be transported to shore to help build ports and docks.

Longline fishing consists of a long main floating line with many hooks that hang down (Smolowitz, 1997). These hooks catch anything that swims into them, and are pelagic passive fishing gear. The floating line can be thousands of feet long and is left at sea. Often, if the line is set out to catch for many days, it is anchored to the seafloor so it does not drift into the high seas. Longlines have been cited to catch elasmobranchs at very high rates (Piovano et al., 2010; Beerkircher et al., 2002; Mandelman et al., 2008), as well as birds, sea turtles, and cetaceans (Francis et al., 2001). When larger animals are caught, they suffer from trauma, dangerous wounds, and entanglement. Piovano et al. (2010) observed elasmobranchs as the most frequently caught organism in a sample of long lines in the Mediterranean sea, and Beerkircher et al. (2002) observed similar results off the coast of the Southeastern USA. Both studies showed that stingrays had a low mortality, while sharks had a very high mortality. Sharks were more often killed because pelagic sharks need to swim constantly to pump water over their gills (Mandelman et al., 2008).

Another kind of dangerous pelagic, passive fishing gear is drift nets, also known as gill nets. These consist of one side of the net floating at the surface of the water while the other side simply falls into the ocean, creating a wall of mesh netting. These can also be attached to the seafloor for stability. Both are left in the water column to catch anything that swims by and then the nets are retrieved later. These nets are frequently used because of their low effort and high catch rates, but very dangerous because of entanglement possibilities, and if they are lost at sea they sweep through collecting anything in their path. When a gill net is lost at sea, it is referred to as ghost fishing. Animals caught in gill nets get dangled and often die from the stress of trying to detangle, or end up drowning. Ghost fishing is especially dangerous because the dead animals already caught act as bait that attract more animals to the netting (Kim et al., 2016). Shark catch rates in ghost nets are extremely high, similarly to long line hooks (Smolowitz, 1997).

The bycatch and non-target catch situation is still not well understood, especially in regards to elasmobranchs. Many species are hard to identify, and often their identify is generalized (Piovano et al., 2010), meaning that the species is left out and a stingray is simply “stingray.” To make matters more confusing, many elasmobranchs have market value because of a specific part of them rather than the whole organism. Often these parts include fins and liver oils, so these are cut off/out of the animal and the rest of the carcass is thrown back into the ocean unaccounted for (Dulvy et al., 2014). This kind of fishing is unsustainable in that the animals can no longer thrive and therefore, reproduce. If too many organisms are removed, dramatic top-down effects can be observed from the decline of a major member of the food web and environment (Shepherd and Myers, 2005).

Elasmobranchs are very sensitive to overfishing pressures for many reasons. First, they have a slow generation time, meaning that they are not reproductively mature until a later age than some other animals. Many elasmobranchs have low fecundity and therefore, low reproductive potential. Because they are the tops of their food chains, their population numbers are comparatively low. They also tend to have very specific habitats and niches, especially shallow water species. Their maximum body size is important to consider because this correlates to their rate of population increase. Maximum body size also relates to a species chance of survival. The larger the organism, the more threatened it is. This is interesting though because usually with terrestrial conservation, efforts tend to favor larger species. For marine life, shallowness of a species and the narrowness of their depth range increase their risk levels as well. With that said, geographic range does not generally relate to the extinction risk of a marine animal, since fishing happens all over the world (Dulvy et al., 2008) (Figure 3).

Most fishing of elasmobranchs occurs in Asia and the Indo-Pacific, and more targeted animals are shallow water benthic species rather than high seas pelagic species (White and Sommerville, 2010). Indonesia is a big elasmobranch fishing hub, with many species thought to be already extinct or critically endangered in the surrounding waters (Dulvy et al., 2014; White and Sommerville, 2010). Unfortunately, sharks and rays have a relatively low economic value as a whole animal, so they are given less attention when it comes to conservation-oriented research (Bonfil, 1994).

The most popular market products include shark fins (Bonfil, 1994, AGT, 2013) and stingray gills (Dulvy et al., 2014) and liver oils (Dulvy et al., 2014; Alava et al., 1997). Stingrays also hold market value because they can replace other kinds of seafood, such as scallops. They taste similarly but sell for a cheaper price (AGT, 2013). Elevated extinction rates of sharks and rays is a function of exposure to fishing mortality and their intrinsic habitat sensitivity, meaning that many species cannot move from one place to another simply due to fishing pressure. This was phenomenon was observed with the yellow stingray, *Urobatis jamaicensis*, off the coast of Florida (Ward-Paige, 2010). Recently, fewer yellow rays have been observed as a result of shifting environments due to fishing pressures. They were at high risk because of their proximity to the shore.

Another example of an elasmobranch that is the target of a fishery market is the coastal manta ray, *Manta alfredi* (Alava et al., 1997; White and Sommerville, 2010; Dulvy et al., 2014). These organisms are not found in the high seas but are still relatively close to the shoreline. They are fished using harpoons, but are often found as bycatch in gillnets. The prized possession are their gill rakers, the horn shaped cephalic fins on the sides of their mouths that help with feeding (Dulvy et al., 2014). They are fished in high numbers off the coasts of South Asian and Indo-Pacific countries for food and medicinal purposes. Not a lot of information is known about these animals to begin with, which makes their fishery market even more dangerous. The International Union for Conservation of Nature and Natural Resources (IUCN) Red List states that 46% of known species of rays are data deficient. This is one of the highest percentages of data deficiency for any taxon (Dulvy et al., 2014).

Decreasing the amount of bycatch, let alone the amount of fishing in general, can be a delicate and challenging process due to the size and importance of the fishing industry. Because there is such a high and growing demand for seafood, many fishermen are against restrictive regulations that would result in less total catch per fishing trip. Not only that, but also many sustainable fishing methods have problems of their own, for example using a lot of oil or a lot of manpower. The biggest problem with bycatch, specifically, is that it is not all recorded. Since the oceans are vast, the rates of illegal fishing are assumed to be very high and recorded bycatch is to be taken lightly (Smolowitz, 1997).

Simply stopping the use of unsustainable fishing methods is one answer, but as previously mentioned this comes with it's own consequences. Another possibility includes fishing licenses and better management. This could include offering incentives and rewards for better fishing behavior and catching methodology. Advancing technology may lead to better fishing methods. This research coincides with a greater push for and support toward fishing companies to start using these methods instead of the less sustainable ones (Smolowitz, 1997). Also, fishermen could simply take steps that increase the chance of survival of the bycatch animal, such as freeing them from the fishing gear before bringing them aboard the ship in the first place (Smolowitz, 1997).

One example of a technological breakthrough is the Turtle Excluder Device (TED). These nets are found in trawling gear and are used to help reduce the amount of sea turtles, and other larger animals, that get swept into trawling nets. The TEDs offer a way for the larger animals to escape if they are caught. So fishermen can still use a low-effort fishing method, such as trawling, while also reducing their amount of large organism bycatch. The mechanism works by having a grid of bars at the neck of the net, with an opening next to them. Small animals pass through the bars and are caught in the net while larger animals, like sea turtles, hit the bars and are ejected through the opening in the net. While this method is not foolproof, NOAA has approved this technology, and if installed and used correctly, it has been cited to help reduce the amount of large animal bycatch recorded (NOAA, 2015).

Studies have been conducted looking at TEDs and elasmobranch bycatch. An et al. (2014) researched a shrimp-trawling fishery, which was very dangerous for the elasmobranch populations in the area. When the trawl nets had TEDs, there was a 96% decrease in the amount of stingrays caught, and 80% decrease with the amount of sharks caught. The amount of shrimp lost ranged from 2-38%, showing that the more sustainable fishing method was not detrimental to that fishing industry. Another possible solution to decrease the amount of bycatch caught with trawling gear is to have grid separators with horizontal bars at the back of the nets. This prevents the catch of flat finned fish, such as stingrays, because they can slide through the bars (An et al., 2014).

Dredging can be adjusted by conducting research on the optimal mesh size for the specific fishery, as well as looking into how big the spaces between the bars should be for the specific fishery (An et al., 2014). The bars at the back of the nets need to be heavy enough to sink, but light enough so they do not dramatically dig into the sediments. More research also needs to be conducted on what areas can be dredged. This would refer to benthic habitats that are less fragile due to having fewer fauna that could be uprooted and therefore destroyed (An et al., 2014; Smolowitz, 1997).

Ward et al. (2008) conducted a study looking at the material that the longline hooks were attached to, specifically comparing nylon monofilaments to wire filaments. Monofilaments are a single line, rather than the wire filaments, which were thicker and braided together. This means that the nylon was easier to handle and manipulate, could stretch and not break, and it sinks slower than wire so it is harder to lose a hand on it. The nylon is also easier for larger predators to chew through if they are caught on the longline. Therefore, catch rates of larger species were much lower for the nylon hooks rather than the wire hooks. As expected, there were high levels of hooks bitten off of the nylon monofilaments, meaning that many large animals were caught as bycatch, but were able to escape and swim away. Interestingly enough, tuna, the animal of interest that is fished with long lines, were seen to have higher catch rates with the nylon rather than the wire. Ward et al. (2008) hypothesized that this was due to the nylon being thinner than the wire and less shiny and startling. There were increased rates of gear loss with the nylon, due to the biting and the ability for it to break, but Ward et al. (2008) argue that the higher catch of tuna balanced this out.

With gillnets, simply increasing the mesh size of the net and decreasing the span of the fishing season have been shown to result in less bycatch (An et al., 2014). However, recent technological breakthroughs offer another possibility. Kim et al. (2016) has conducted preliminary work on biodegradable gillnets. These are intended to degrade after a certain amount of time, which reduces the possibility of ghost fishing if the net is lost at sea or purposefully discarded and abandoned. Other nets are not biodegradable and instead, continue to sweep the ocean indefinitely. This net is made of 82% polybutylene succinate (PBS) and 18% polybutylene adipate-co-terephthalate (PBAT). This has been cited to biodegrade after 1.5-2 years in either soil or salt water. The material itself is both very flexible and resilient as far as biodegradable materials go, which is beneficial for a fishing net.

The breakdown process is completed by microorganisms, and results in low-molecular-weight monomers and dimers. These are then finally mineralized into CO_2 and H_2O. That final process would take 3-4 years, but by then animals that are caught could most likely escape the fishing gear because it is not as resilient as it was before the biodegrading process began. At first, nylon nets had more strength and resilience and so, a biodegradable net would suggest to have lower fishing efficiency. These preliminary strength and resilience tests were done in a simulation lab. However, when the two nets were compared in the field, fishing for yellow croaker, Kim et al. (2016) found that the biodegradable nets caught almost the same amount (98.6%) as the nylon nets. The biodegradable nets also caught fewer juveniles than the nylon nets, which is valuable when considering population sizes and wanting to preserve juveniles until they can reach reproductive maturity and keep a population size stable. Larger organisms also offer a higher economic value than smaller organisms, which adds to the value of the biodegradable net. The biodegradable net also had less bycatch both in total number of bycatch organisms and specifically in regards to the most threatened bycatch organism (Chub mackerel). The biodegradable net started to degrade after 24 months, due to marine organismal activity, but also if the net is made and then not used for some time, it can start to biodegrade before used for fishing. Therefore, this is just the beginning of biodegradable netting exploration, but offers a viable solution to the detrimental problems seen with pelagic gill nets.

Coastal Development: Beaches, Marshes and Mangroves

Many elasmobranchs rely on coastal habitats for either part of their life, their entire life, or rely on the habitat for a source of food. Unfortunately, of all marine environments, humans have the highest impact on coastal habitats but this is where many species can be found (refer to Figure 2). Coastal habitats and the coast geology itself is divided up into many zones. The first zone of importance is the neritic zone, which in this study is defined as the water column and seafloor beginning at the intertidal zone and extending until the end of the continental shelf at a depth of 200 meters. This zone encompasses regions where light can touch the seafloor. Extending into the high seas, the photic zone or epipelagic zone is how far light can go into the water column, usually the surface to a depth of 200 meters. Highly mobile species are found here because of the potential for very productive photosynthesis and primary producers (White and Summerville, 2010).

Landward, the section of the ocean prior to the intertidal zone is what we generally call a beach. Beaches have many subdivisions of their own, but for this study the term "beach" will refer to the land between the intertidal zone and dunes, cliffs, or the edge of terrestrial vegetation, depending on the beach topography. This zone includes the backshore. Beaches are found all over the world and consist of loose material, usually sand and gravel that have accumulated due to wave action. The material and composition of a particular beach depends on the geographical location of the land and the surrounding environment. Beaches are dynamic environments due to the constant wave action and changing tides. Waves hit beaches at an angle, which carries sand up and down the coast. River action and storms also change and affect beach topography. In the USA alone, several hundred thousands of pounds of sediment get moved around each year (Brown and MacLachlan, 2002) (Figure 4).

One of the biggest problems facing beaches today is increased rates of erosion due to human interference of sediment travel. Specifically, humans interfering with wave action and river flow for the sake of increasing real estate property value and tourist attraction. Erosion is defined as the gradual breakdown or destruction of an object by a natural force, most often water (Keller, 2012). Rivers offer a main mode of transportation and trade for landlocked states and countries, so they are often damned and irregularly shifted to make boat travel easier. This practice has downstream effects where sediments that would usually build up coastlines cannot anymore because they are being shifted from their natural direction. Sediments are usually propelled at high velocities due to this river construction and end up in the deeper ocean. Wave action will continue to take sediments away from the coastlines, so rates of erosion here are dramatically increased (Keller, 2012).

Some of the steps taken to try and secure beaches and keep them economically prestigious include sea walls, breakwaters, groins, and jetties. Sea walls are synthetic non-decomposable structures that are parallel to a coastline and meant to reduce wave action that hits the beach and removes sediments. Instead of successfully calming wave action, the structures actually reflect the waves back at the coastline and thus increase the rate of erosion (Keller, 2012). Breakwaters protect small parts of the shoreline from waves. They are usually utilized in harbor construction in that they create a small protected area of calm water. They are successful in calming wave action, but again, lead to irregular beach shape and erosion rates (Keller, 2012).

Groins, on the other hand, are perpendicular to the coast and are meant to trap sand that moves in the lateral direction previously described. They do result in the deposition of sand on the lower edge of the groin, but the upper side sees dramatic erosion since the waves hit at an angle (Figure 5**)**. One possible solution for this would be beach nourishment, where sand is taken from another part of the sea floor, usually deep depths past the edge of the continental shelf at 200 meters, and used to fill in the upper part of the groin. Therefore, beach sediments will continue to deposit and flow around the end of the groin and fill in the other side. But, this could still be dangerous to the environment since it requires deep sea dredging (Brown and MacLachlan, 2002).

Jetties are constructed in pairs at the mouths of rivers to stabilize the channel. This process reduces sediment build up and wave action to make boat travel easier to accomplish. Again, the reduction of sediment build up leads to uneven beaches and high rates of erosion, which is not beneficial for the river as a whole. Beach erosion can lead to more damage by storms and more damage to valuable property and coastal infrastructure (Keller, 2012; Brown and MacLachlan, 2002).

Beaches are also threatened by oil spills (Brown and MacLachlan, 2002; Keller, 2012; Jonker et al., 2006), dune modifying (Brown and MacLachlan, 2002), and driving vehicles on the beach front (Brown and MacLachlan, 2002; Keller, 2012). The oil collects on the exposed sand and can harm both habitats and the organisms living on the beach. Artificial dune supplementing and dune destruction can have severe effects on sand transport and storm surge protection (Keller, 2012). Driving vehicles on the sand can damage natural sand movement and topography, which in turn damages important habitats as well as nests buried under the sand (Keller, 2012).

Sea cliffs can also be sites of high rates of erosion. This erosion usually accompanies increased amounts of industrialization, which weaken the stability of the cliff itself (Brown and MacLachlan, 2002). Another problem with sea cliffs is waste management. If directed over the edge, the waste itself carves away the cliff boundary. One solution would be directing waste management through pipe systems to expel waste at the bottom of the cliff face. Similarly, agricultural processes at the top of sea cliffs lead to an increased rate of erosion due to watering and using pesticides (Brown and MacLachlan, 2002).

Salt marshes and mangrove forests are two other coastal habitats that are equally as threatened as beaches, but get less attention because of their lower economic value due to their odors and treacherous geography. They have little tourist attraction and building real estate is almost impossible without uprooting a majority of the habitat flora. However, marshes and mangrove are very productive shallow ecosystems. Both are home to complex food webs and often act as nurseries for elasmobranchs and other large fish due to their shallow water and the many hiding places the physical structure of the habitats have to offer (Snelson et al., 1988; AGT, 2013; White and Sommerville, 2010; Jirik and Lowe, 2012; Wallman and Bennett, 2006; Kajiura and Tricas, 1996; Steven and McLoughlin, 1991; Sulikowski et al., 2007; Keller, 2012).

Marshes are salt water, coastal habitats, with lots of organic matter due to a very intricate and nutritious cycle of growth and decay that includes a lot of microorganismal activity. The changing tides benefit the depth and cycle of nutrients. Marshes consist of various grasses and reeds that have adapted for very salty conditions (Hansen and Rattray, 1996). These are supported by deep layers of mud and peat, which act as both a large source of organic matter and carbon and a filter for ocean water. Marshes also house many food sources for elasmobranchs, so often hunting takes place in the deeper waters right outside of this habitat (White and Sommerville, 2010; Wallman and Bennett, 2006; Simpfendorfer and Milward, 1993; Ley et al., 1994; Odum and Heald, 1972). The depth of the water is seasonal and dependent on the tides. Marshes are often found at the mouth of river systems (Snelson et al., 1998), and can be found at any latitude (NOAA, 2015). These ecosystems are not to be confused with an estuary, which is defined as having wood plants, while marshes do not (Hansen and Rattray, 1996).

Mangroves are plants found in the intertidal zone of tropical environmental coastlines, between 32-38 degrees latitude. In America, they are most famously found along the Florida coast. The plants have exposed roots and offer many places of protection for juveniles and smaller organisms. There are at least 50 species of mangroves that have all adapted to salty water, low oxygen levels, and exposure to intense climates such as wind, high precipitation rates, and wave action (DEP, 2015; AGT, 2013). The roots of the mangroves also hold sediment together and help decrease the rates of coastal erosion (Keller, 2012). They use pneumatophores, which are small projections from the roots that go above the surface to help the plants obtain necessary amounts of oxygen. Even with these adaptations, the trees grow very slowly, and are very sensitive to temperature fluctuations and chemical imbalances (DEP, 2015). Mangrove forests, like marshes, have a high organic matter content and thus are very nutritious and support a wide variety of life. Recreational and commercial fisheries would collapse without mangroves present.

Marshes and mangrove systems are very similar in construction and purpose, the biggest difference is where they are found and congruently, what species of organism are found there. They both act as nurseries, protect land from storm surge and erosion, offer food sources for a plethora of organisms, and filter and cycle salt water nutrients. They are also very sensitive environments that are greatly threatened by similar human interactions.

Many species of stingray, such as Atlantic stingrays (Wallman and Bennett, 2006), yellow stingrays (Snelson et al., 1988), and round rays (Snelson et al., 1988; AGT, 2013) use mangroves and marshlands as either nurseries or for most of their life cycle (White and Sommerville, 2010). Mangroves are especially popular for stingrays because they tend to prefer warmer climates (White and Sommerville, 2010; Wallman and Bennett, 2006; AGT; Kajiura and Tricas 1996; Snelson et al., 1988) and in the specific mangrove latitude range, the water is shallower in the summer months, making it harder for predators to enter the habitat (Snelson et al., 1988; White and Sommerville, 2010; Kajiura and Tricas, 1996).

Sharks also give birth during the summer, warmer months of the year (Steven and McLoughlin, 1991; Sulikowski et al., 2007). If oviparous or ovoviviparous, the sharks utilize bays and other coastal areas in order for their young to develop without being preyed upon (Simpfendorfer and Milward, 1993; Feldheim et al., 2002; Castro, 1993). There is still a large amount of mystery as to how viviparous sharks reproduce and protect their young. Some species of shark have been documented to return to the same nursery every reproductive cycle, such as lemon sharks (Feldheim et al., 2002; Hueter et al., 2005) nurse sharks (Hueter et al., 2005) blacktip reef sharks (Mourier and Planes, 2013) and scalloped hammerhead sharks (Duncan et al., 2006). A nursery for both stingrays and sharks is defined as a space where there are pregnant females, free-swimming newborns, and juveniles (Castro, 1993).

Stingrays generally tend to prey on bivalves, anemones, amphipods, clams and worms (AGT, 2013; Veras et al., 2009; Summers, 2000). These are frequently found in coastal systems, and if the stingray uses the coastal habitat for a majority of their life cycle, they are the apex predator there (White and Sommerville, 2010). Because these are such productive environments, there is an abundance of food so elasmobranchs can coexist with other species of fish and other elasmobranchs (Simpfendorfer and Milward, 1993; Ley et al., 1994). Sharks also act as apex predators if they inhabit the coastal zone for most of their lifetime, and if not, they spend a large amount of time right outside of the shallow water and wait for juvenile fish to swim into deeper water (Odum and Heald, 1972; White and Sommerville, 2010). Coastal sharks tend to feed on small fish and shrimp, and some have been documented to eat crabs (Johnson-Restrepo et al., 2005).

Even though salt marshes and mangroves are imperative for the success of many species of aquatic life, as well as the protection of human life and resources, they do not get the attention they deserve. NOAA estimates that about half of the world's mangroves have been lost and will continue to be destroyed at a rate of ~1% of mangrove plants per year, to make room for artificial land construction that is more beneficial to support infrastructure such as ports, harbors, houses and tourism retreats. This development results in habitat loss, increased rates of CO_2 being released into the atmosphere from being stored in mangrove soil and marsh peat layers, and increased levels of pollution in the parts of the habitat that remain. They are also threatened by aquaculture development, due to the waste that those systems produce. The flora and fauna that exist in coastal, dynamic environments are delicate and niche-specific, meaning that if one habitat is destroying, relocating is usually very challenging if not impossible.

Water Pollution: Chemical and Physical

The ocean has a very specific chemical and physical composition, and many species of animal are hypersensitive to habitat changes. Water pollution can be defined as when something synthetic and/or toxic is added to the ocean and causes a harmful biological, chemical or physical change. Chemical pollutants affect the ocean water composition and in turn can affect animals and habitats, while physical pollutants cause a direct and palpable injury or other negative consequence to an animal or habitat. For example, chemical would be liquid waste or pesticide runoff, physical would be trash and lost fishing gear.

There are higher concentrations of both physical and chemical pollution along the coastline, since that is where human activity is at its highest concentration. Unfortunately, coastal species are greatly affected because they have more specific niche requirements, as previously discussed. With that said, pollution can and does make it's way into the high seas, as seen with recent research on the five Plastic Gyres in all five oceans, the biggest being the Giant Pacific Gyre between California and Hawaii. The EPA (2015) states that water pollution is both waste that is dumped into the ocean itself as well as waste that is dumped on land that then washed into the ocean.

Chemical runoff and toxins are very dangerous to the biological functioning of organisms, and can be categorized into three groups: runoff, spills, and waste. Runoff is when liquids and chemicals are dumped on land, and because of precipitation and watering, they end up in the ocean. This is referred to as nonpoint source pollution, because it is impossible to point out the exact spot where the pollutant originated. Instead, the origin is generalized, which makes attacking the problem a little bit harder. Runoff can accumulate from agricultural land and urbanized areas. Land dedicated to agriculture is often frequently plowed and treated with pesticides. Plowing dramatically increases rates of erosion and the soil not utilized gets washed into the nearest system of water, usually a stream or river that leads to the ocean (Keller, 2012). Same with pesticides: when there is high rainfall or watering activity, the pesticide that did not seep into the ground gets washed away into the nearest body of water (Keller, 2012; Brady et al., 2006). Manure can also contribute to runoff problems from farmland. There is a big runoff problem with the Mississippi River, which begins in the midwest where a large percent of America's agricultural activity takes place. Forty-two% of rivers in the US are poorly regulated and have poor water quality (EPA, 2015; Keller, 2012).

Brady et al. (2006) conducted a study examining organophosphate (OP) pesticides, also known as diazinon pesticide, and compared it to a pyrethroid pesticide esfenvalerate, a hydrophobic pesticide that therefore, should hold onto soils better than the OP pesticide and if used, reduce the levels of runoff that resulted in phosphorus and nitrogen toxins. A complete understanding of environmental impact of the esfenvalerate is still not fully understood, so there is still hesitation with switching completely to this kind of pesticide, but it is progress to know which are less toxic and result in less runoff and waste. Brady et al. (2006) also call for less dormant spraying, which is when pesticides are applied during non-growing months to protect the buds and sprouts from insects. This is dangerous because many agricultural areas require well-drained alluvial soils and therefore, close proximity to a river, so spraying pesticide on loose soil results in high rates of runoff.

Runoff occurs in urbanized areas simply due to the large use of pavement. Oils, waste, and other chemicals have nowhere to go on the pavement, so they get washed down drains, which end up in marine environments with heavy amounts of rain.

Spills in this case refer to thousands of gallons of oil being dumped into the ocean at once. Three different kinds of oil affect marine life: lubricating, gas, and crude oil (Jonker et al., 2006), and Franco et al. (2006) found varying concentrations of PAH compounds along beaches whether or not there were recent spills in the congruent ocean. Usually, oil spills are the dramatic release of liquid petroleum hydrocarbon from either an oil tanker or an oilrig itself. Famous oil spills include the Exxon-Valdez in 1989 which released 235 million gallons of oil, the Deepwater Horizon BP oil rig explosion in 2010 which released 210 million gallons of oil, but the largest oil spill in history was due to the Gulf War off the coast of Kuwait in 1991 which released a range of 240 to 360 million gallons of crude oil as an attempted military protection strategy (NOAA, 2015; Piatt et al., 1990; Atlas, 1995; Keller, 2012). A large percentage of the oil burns off when it reaches the surface, and vacuums on rescue ships can usually clean up another large percentage, but millions of gallons still sink to the bottom of the ocean or get washed to shore and collect on beaches. More research is being conducted on long term effects of oil spills, which do not seem as drastic as the immediate effects and necessary clean up efforts.

Waste disposal refers to hazardous waste, trash, and sewage. Sewage collects in rivers and gets carried into the ocean in a similar manner as runoff (Ozdilek et al., 2006). Sewage has also been cited to collect on beaches (Walker et al., 2006). Synthetic organic compounds are a large part of waste, which accumulate from power plants and other industrial activities that usually are based on coastlines. Synthetic organic compounds usually do not break down easily once in the environment and are produced in huge quantities without understanding their full effect (Keller, 2012). One frequently found compound is organotins, which are toxic compounds found in antifouling paint. Mearns et al. (2009) cited these to cause reproductive abnormalities in elasmobranchs.

Ballast water is another big concern with marine pollution and more specifically, the natural structure of food webs. Large cargo ships take up ballast water after they drop off the cargo as a way to maintain a constant weight and stay balanced. When they get to another port to pick up more cargo, they release this ballast water because they are taking up so much more weight. Microorganisms and juvenile organisms are usually taken up in this ballast water so when it's released in a new port and thus new environment, these microorganisms can take over and become invasive species. Recently, ships are trying to dispose of ballast water while out at the open sea, but sediment is also taken up and usually not disposed of so that gets transported to the new port. There has also been some investigations into the use of biocide MNB (Piazza et al., 2006; Faimali et al., 2006), biocide hypochlorite (Gray et al., 2006), or an ozone treatment (Herwig et al., 2006; Oemcke and van Leeuwen, 2006), which can kill microorganisms in the ballast water before it is released.

These different forms of chemical pollutants can affect fish and the environments in many biological ways. Stingrays have been cited to adapt to different salinities very well, since many species inhabit brackish water along the coastline during reproductive months (Boyd et al., 1977), but they cannot necessarily adapt to different chemicals that are synthetic and toxic. Johnson-Restrepo et al. (2005) looked at muscle tissues of a variety of fish to observe levels of polybrominated diphenyl ethers (PBDE) and polychlorinated biphenyles (PCB). PBDEs are synthetic organic compounds that are used as additive flame-retardants, so they are found in couch and chair cushions, carpet padding, curtains, and mattresses. PCBs are used as dielectrics and cooling fluids for electrical equipment. Both compounds are also found in computer monitors and other related electronic appliances, television sets, and computer cases. PCBs were banned in the US due to their toxicity and carcinogenic properties, but are still found in organisms today.

Atlantic stingrays had an average level of 41.5 ng/g PBDE (nanograms of PBDE per gram of muscle tissue. In 1 gram there are 1x10^9 nanograms) and 592 ng/g PCB. Spiny dogfish and Atlantic sharpnose shark were also tested and both had very high levels of PCB, 790 ng/g and 5520 ng/g respectively. Freshwater fish had even higher levels of toxins, as did organisms at the coast, further emphasizing that coastal organisms are the most threatened by human activity. A very interesting part of this study was that a bull shark had 77.6 ng/g PBDE and 6440 ng/g PCB when first tested, but then 10 years later, the same individual bull sharks were tested again and their levels skyrocketed to 1630 ng/g PBDE and 71200 ng/g PCB. This meant that the animals were not excreting any of the toxic materials but instead accumulating more as time went on.

Johnson-Restrepo et al. (2005) also attribute this dramatic increase to a process called bioaccumulation, which is also supported by many other studies (Whitcare, 2009; Doucette et al., 2006; Schaffer et al., 2006). Bioaccumulation is the process of organisms taking in more toxic compounds than they break down or excrete, and that these toxins travel up food chains so higher trophic level organisms have higher relative concentrations of toxic compounds than lower trophic level. So, the concentrations in sharks having a doubling time of 2-3 years also implies that as they continued to eat contaminated food, the toxins in their food built up in the bull shark (Johnson-Restrepo et al., 2005).

Bioaccumulation often occurs from algal blooms (Doucette et al., 2006). Algal blooms occur when there are high concentrations of nutrients are in a condensed area of water, so algae reproduction dramatically increases and the water is taken over, so to speak, by these organisms. This process is referred to as eutrophication. The nutrients can come from runoff and improper waste management and usually contain the toxic levels of phosphorus and nitrogen previously mentioned. Schaffer et al. (2005) showed a direct link between sharks becoming sick and an algal bloom due to the microorganism *Pseudo-nitzchia australis*, which produces a toxin domoic acid (DA). Sharks have a molecular target for DA, so when they consumed fish that had eaten *P. australis,* and therefore had DA in their system, the sharks accumulated very high levels of DA that they were unable to excrete at rates that could keep their systems in check.

Eutrophication is not usually toxic to humans. The bigger concern is the presence of toxins in the fish that humans consume, resulting in a case of bioaccumulation with humans being the final organism of the food chain. There are about 40 potentially dangerous and toxic microalgae (Zingone et al., 2006), but most algal blooms are caused by cyanobacteria, which are generally harmless to humans (Mearns et al., 2009). The algal blooms can damage shellfish harvest and other shallow benthic organisms of interest for farming (Bill et al., 2006). The other big problem with eutrophication is that the algae are in such high numbers that they block sunlight from entering the water and reaching the plants below, so many organisms die due to this lack of light and the amount of dead organic matter increases. Decomposer organisms use high levels of oxygen in order to breakdown this organic matter, and so more animals die due to the lack of oxygen (Mearns et al., 2009). Due to large amounts of run off, there is a serious eutrophication problem at the mouth of the Mississippi River. It has become a dead zone because decomposers are using so much oxygen and the algae block so much sunlight from reaching the bottom where larger photosynthesizing plants are found. Aquaculture processes are also greatly damaged (Keller, 2012; Mearns et al., 2009).

Physical pollutants tend to cause more physical harm to organisms. These are most often plastics and other trash that does not break down in the ocean. Plastic can be ingested or the animals can get entangled in it (Ceccarelli, 2009). Many animals get tangled in lost fishing gear and fishing gear debris, which is mostly mesh netting, lines, and some hooks (Ceccarelli, 2009; Mearns et al., 2009). Shipbreaking yards are detrimental to the marine debris issue. These yards do not have the right materials or safety measures to control how large ships are broken down, so the huge cargo ships are just ripped apart and cut using blowtorches. Lots of dangerous gases are released, and it remains a big human rights issue today (Mearns et al., 2009; Gwin, 2014). Frequent physical pollutants that have been cited to either be entangling animals or within their digestive tract include packaging tape (Hofmeyer et al., 2006), vinyl plastics and woods (Lee at al., 2006) and lobster and crab trap lines (Seitz and Poulakis, 2006).

The Giant Plastic Gyres is where a lot of this trash collects. Woods Hole Oceanographic Institution in Massachusetts discovered the largest gyre in the Pacific in 1972. A gyre is a large, wind-driven, circular current system that has a quiet center. Plastics are carried there by these currents, and then settle in the quiet center where they break down into microplastics, which can be 0.5cm in diameter and only caught using a plankton net (Kaiser, 2010). Micro-plastic materials include thermocol, styrofoams, nylon, transparent plastics, colored plastics, glass wool (Reddy et al., 2006), fast food packaging, and plastic bottles and their respective caps (Mearns et al., 2009). The Pacific Gyre is this quiet epicenter where microplastics have a 6:1 ratio to zooplankton by weight and this ratio is true for an area that is twice the size of Texas (Kaiser, 2010). The long-term effect of these microplastics is still being looked into, but the argument could be made that when the microplastics settle on the seafloor, they could be consumed by smaller, lower trophic level organisms and begin the process of bioaccumulation if the microplastic is toxic.

Similarly to the situation with bycatch, most studies on marine pollution do not emphasize what kind of plastic debris or chemical compound they are talking about. Non-point source pollution also makes addressing the problem harder. Pollution could have a large impact of the fishing market industry, and the information that has been cited is likely an understatement. Some have called for a monitoring program towards plastic debris (Ceccarelli, 2009), but the concern of the plastic and toxins already in the ocean gets little attention.

Global Climate Change

Global Climate Change refers to when levels of carbon dioxide, CO2, and other greenhouse gases, such as methane and nitrous oxide, increase to a point where they begin to trap sun radiation in Earth's atmosphere. When the gases are trapped in the atmosphere, the temperature of Earth's surface increases (Keller, 2012; AGT, 2013). Polar ice caps are melting, resulting in rising sea levels that displace coastal organisms and habitats. More water also increases the rate of erosion because of the ability of wave action to go higher on the shore, past the usual intertidal zone. Increasing levels of CO2 is dangerous for both the temperature and the chemical composition of the ocean.

Many organisms such as corals are sensitive to temperature gradients and cannot make necessary adjustments. Corals are animals found in already warm climates that cement to the benthic surface, creating shelter for a wide variety of life, including many species of Elasmobranchii. They rely on a symbiotic relationship with zooxanthellae algae, and are very sensitive to changes in the surrounding water, such as temperature and pH. Zooxanthellae are unable to adjust to changes in the water and die when stressed. Corals cannot survive without zooxanthellae algae, so unstable water conditions results in a process known as coral bleaching. The microorganisms are what give the coral their color, so without them the corals become white. Coral reefs are some of the most productive environments in the world, so without healthy corals, animals need to relocate. Coral reefs are also shallower habitats, so they warm up faster (Booth and Beretta, 2002; AGT, 2013).

The ocean acts as a carbon sink, meaning that a large percentage of atmospheric CO_2 goes into the ocean and reacts with the other nutrients in the water. There is a marine carbon cycle that is delicate and easily disrupted. The cycle consists of two independent parts: the solubility pump and the biological carbon pump. The solubility pump refers to the fact that CO_2 is more soluble in cooler water, which in the general ocean is deeper water. ⅔ of the CO_2 that enters the ocean ends up at deeper depths (Riebesell and Tortell, 2011). The biological carbon pump has two components, one is the sinking of dead organisms that increase levels of CO_2 in the deep oceans as they are broken down by decomposers, and the other is a carbonate counter pump that refers to the formation of calcium carbonate, $CaCO_3$.

$CaCO_3$ is one of the most commonly used materials to build external skeletons and shells. The best conditions for $CaCO_3$ formation is high pH and high carbonate ion concentration, but increasing levels of CO_2 decreases the pH and carbonate ion concentration. Therefore, increasing the amount of CO_2 in the ocean means that the energetic cost of obtaining enough calcification increases, and usually organisms just have lower levels of $CaCO_3$ rather than exerting extra energy to obtain enough $CaCO_3$. The increasing CO_2 concentration and fluctuating acidity and chemistry is referred to as ocean acidification (Figure 6).

The ability to obtain $CaCO_3$ shifts depending on the organism and its metabolic pathways (Langer et al., 2006). If organisms have less $CaCO_3$, their skeletons and shells are weaker and incomplete, making them more vulnerable prey (Riebesell and Tortell, 2011; AGT, 2013). At first, this would seem beneficial for elasmobranchs because they feed on many shelled organisms, so if they had a weaker shell, it would make for an easier meal. Unfortunately, without a proper external shell and skeleton, often the $CaCO_3$-dependent organisms do not grow to adulthood and elasmobranchs end up with less food because the shelled organisms die before they can reproduce or grow to a size that would act as a substantial energy source (AGT, 2013; Orr et al., 2005).

Increased levels of CO_2 also affect photosynthetic primary producers. Photosynthetic species use CO_2 as their organic carbon compound to produce energy. Species with good and efficient carbon-concentrating mechanisms (CCMs) are less sensitive to increases in CO_2 levels in the ocean. They are able to respond to the increased CO_2 and have it not damage their metabolism. Because species vary in their metabolic processes, rising CO_2 levels shift the relationships between phytoplankton and other photosynthetic primary producers as some become more successful than others in regulating their CCM (Rost et al., 2009). This changing pH also affects how efficiently these plankton can acquire organic forms of nitrogen and phosphorus (Millero, 2009). The CO_2 and following chemical reactions change the concentrations of organic nutrients in the ocean water (Riebesell and Tortell, 2011). On a higher trophic level, fish have been cited to have behavioral changes and dysfunctions, such as detecting where predators are (Dixson et al., 2011; AGT, 2013).

Aquariums and Ecotourism

Aquariums and ecotourism activities offer ways for humans to get a first hand account at what the ocean is and are helpful tools in calling for more conservation efforts. Studies have shown that visitors do leave aquariums with more knowledge on the animals, the ecosystems, and what they can do in order to help preserve the ocean (Adelman et al., 2000; Yalowitz, 2004). Ecotourism allows visitors see first hand accounts of the array of life in the ocean. Without concrete knowledge and first hand accounts, it is challenging to put effort into something that is so vast and unknown as the ocean. With that said, there is a lot of debate as to whether or not aquariums and ecotourism are humane, and if they do more harm than good to the aquatic life.

Aquariums are facilities that exhibit marine and freshwater animals in synthetic habitats as a way to educate people on marine biology and conservation. Aquarium tanks range in size and space, and the needs of animals are often times questioned. Larger animals get the most attention from the media, specifically cetaceans. These animals draw in large crowds and attention, but they are also harder to keep healthy in small, contained environments. The most recent example is the documentary "Blackfish" and following critique on SeaWorld's Orca Whale exhibit and show.

Many aquariums also have touch tanks, where visitors can hold and feel animals ranging from snails and crabs to sharks and stingrays. Touch tanks are beneficial when visitors remain calm and follow instructions on proper handling technique. It is also important that touch tanks do not offer the chance for visitors to feed the animals, since in the wild it has been observed that if stingrays and sharks are fed by tourists, the animals associate the tourists with food and this disrupts natural foraging behavior and their ability to survive without human interaction (Orams, 2002).

Aquariums are important stations for research, rescue and rehabilitation efforts, conservation awareness, and community outreach. Aquariums often sponsor and support research efforts to gain more understanding of aspects of the ocean, which in turn leads to better understanding of how humans affect the ocean and what we can change in order to preserve marine life and try to fix mistakes. Along these lines, many aquariums sponsor rescue and rehabilitation programs for sea turtles and marine mammals. These animals range from endangered to critically endangered (IUCN, 2015), and also tend to get beached for a number of reason, including drops in temperature due to changing seasons and confusion with migration patterns and related illnesses. Pollution and following illnesses also result in many marine mammal strandings, as well as pups who get stranded from their mothers (AGT, 2013). Conservation awareness is a part of many aquariums and marine education facilities today, as the animals are used as examples and tools to emphasize why the ocean is important and why humans should care about it (AGT, 2013). The conservation messages often coincide with the exhibits themselves, but also with community outreach programs and connections with schools and after-school care programs.

One debate with aquariums is whether or not the animals should be captive bred or caught and taken from the wild. Captive breeding is beneficial because it does not disrupt the natural population numbers in the wild. There are many complex breeding programs with larger animals, such as penguins. Aquariums also feature invasive species and are used as a way to keep the animals alive but remove them from habitats that they could greatly harm. Illegally traded animals are also featured in the safety of aquariums. Many believe that aquariums are still too small and hindering natural life cycles and processes, such as keeping these animals away from sunlight, is wrong and should not be done even with the educational benefits. This remains true even with aquariums that have an Association of Zoos and Aquariums (AZA) accreditation and their recognition and approval.

Ecotourism is similar to aquariums in that they offer first hand accounts and interactions with marine life, but visitors go directly into the natural habitat. This is usually done with snorkeling and SCUBA diving, and another popular attraction is shark cage diving. Although very cool experiences, ecotourism is more complicated because of the access and ability to damage natural habitats. Often, codes of conduct are not followed correctly for tourists to have the "ultimate" experience, and this can be detrimental to both the animals and the habitats (Quiros, 2007; Semeniuk et al., 2009). Ecotourism has been cited to disrupt natural feeding and foraging behavior of animals due to humans dislocating them (Shackley, 1998; Semeniuk et al., 2009), humans themselves giving food to the animals (Vianna et al., 2012; Orams, 2002), and physical destruction of the habitat (Newsome et al., 2004; Semeniuk et al., 2009). Aquariums and ecotourism are very successful education tools and make the ocean more personable, but only if they are done correctly and respectfully.

V. Materials and Methods

Literature Review

Extensive literature review on science journal articles and review articles was completed for this project. All conclusions about how humans could affect the ocean were drawn from these studies as well as previously learned information from two internships at the New England Aquarium in Boston, Massachusetts, and classes taken during a semester abroad in Townsville, Australia (Invertebrate Biology: MB2080, and Marine Conservation Biology: MB3200). The AGT (2013) manual referenced is the Visitor Educator guidelines used for the two internships at the aquarium.

Through research and these two personal experiences, the conservation topics of interest and focus became unsustainable fishing and the problems related to bycatch, coastal development and habitat disturbances specifically toward marshes and mangrove forests, water pollution, global climate change and it's many affects on the ocean, and tourism and aquariums. There was curiosity towards whether or not others would know about these conservation topics if they did not work at an aquarium, study a science, or perhaps live close to a coastline and therefore have the ocean on their radar more so than someone who lives farther away from a large body of water.

Survey and Analysis

Both surveys were submitted to the IRB at Connecticut College for approval. Both surveys were first edited by the IRB, and then second drafts were submitted for final approval. Data was collected using Survey Monkey for the first survey and Qualtrics for the second survey. Data was analyzed using Microsoft Excel and SPSS software.

For the first survey, questions were identified that would highlight participant's knowledge about conservation topics, summarize what they did frequently, and how often they thought about the ocean in regards to what actions they did frequently. All of this was then tied back to elasmobranchs. The survey consisted of 12 questions (Appendix I) and was distributed through e-mail and Facebook until 200 responses were obtained.

The second survey was created as a response to the results from the first survey. The 9 questions were formed based on what was missing from the first survey and what needed more clarification (Appendix II). Therefore, the second survey focused less on actions completed and more on the participant's attitude about and opinion toward the ocean, as well as aquariums and how they relate to ocean conservation. This survey was also distributed through email and Facebook and capped at 165 responses due to time restraints and challenges towards obtaining complete surveys. Most correlation analysis was completed after removing responses that did not answer Question 9 due to technical difficulties with the sliding bar mechanism. Therefore, a majority of correlation analysis was done with a total of 126 participants.

Data was consolidated and divided with the assistance of Ariana Buckenmeyer (Connecticut College Class of 2019). Data was divided and to focus on participants who worked at an aquarium, the four different distances for proximity to a coastline, how participants responded to yes or no questions, and if participants studied a life science (Aerospace, Animal Behavior/Wildlife Conservation, Athletic training, Behavioral Neuroscience, Biological Sciences, Biochemistry, Biomedical Engineering, Botany, Chemistry, Ecology, Environmental Studies, Geography, Global Health, Human Development, Marine Science, Nursing, Physics, Pre-medicine, Psychology, Public Health, Science Communication, Therapeutic Recreation). The text answers were converted into numerical categories for analysis (Table 2).

Reverse scoring was used for the actions that had negative effects on the ocean including "driving a car", "gardening with fertilizer", "using a boat", "participating in ecotourism", "eating fish", "visiting the beach", "using plastic water bottles", and "using plastic bags." For the second survey, how often one went to the aquarium and the question of whether or not those who live 25+ miles away from a coastline have a negative effect on the ocean were reverse scored (Table 2).

Data was analyzed to find the correlation between different questions as well as any correlation between an action done (how often…) and the believed effect on the ocean (what effect…) that that effect has. Percentages of different answers were also analyzed. The second survey correlations of interest can be referred to in Table 5. Test analysis was organized and observed for all open response questions. For the final open-ended question in the second survey, numerical values were subjectively given to every response for the sake of statistical analysis (Table 2).

IV. Results

First Survey

Most participants do not think about the effects of their actions on the ocean, as there was no correlation observed between how often one did something and what affect that action has on the ocean. However, if the participants were educated in life or physical sciences and/or have worked at an aquarium, they were more likely to know more about the conservation issues facing our ocean as well as adjust their actions to better benefit marine life.

With all 200 participants, there was neither correlation nor significance observed between actions completed and whether or not they thought about the ocean when doing them ($r=0.120$, $p=0.090$). As in, if participants thought an action was good for the ocean, they did not do it often. If participants thought an action was bad for the ocean, this did not prevent them from doing it often. Refer to Figure 6 for how often each action was done. With that said, when prompted explicitly if participants thought about the ocean during their daily activities, 40% of participants said yes. So, participants did not actively think about how an action would affect the ocean before or after doing the action itself, but do acknowledge that the ocean is considered throughout the day.

If participants know about the included conservation topics, refer to Appendix 1, they will think about the ocean throughout the day. Correlation is strong and significant between what participants know and if they answered “yes” to thinking about the ocean in their decision making (further referred to as Question

10) (r=.501, p<0.001). Sixty-eight% of these participants work or have worked at an aquarium and/or study a life or physical science.

There was some significant correlation between whether or not participants answered yes to Question 10 and whether or not they knew the conservation topics (r = 0.503, p <001). Similarly, there was some significant correlation between whether or not participants answered yes to Question 10 and whether or not they thought that their actions affected stingrays (r = 0.358, p<0.001). This correlation did not increase when just looking at participants who have worked at an aquarium or other marine education facility (r = 0.317, p = 0.052). If participants knew about conservation topics, they knew that their actions affected stingrays (r=0.357, p<001).

Of the total participants, 20% worked at an aquarium or other marine education facility. When looking at this sample of data, there is correlation between what participants do everyday and if they explicitly think about the ocean (r = 0.613, p < 0.001). This relationship is not seen with the 80% of participants who have not worked at an aquarium (r = -0.037, p=0.43). Similarly, participants who work at an aquarium know more about conservation topics (r= 0.479, p<0.001). When just looking at participants who had worked at an aquarium, there was a significant negative correlation between how close they lived to a coastline and what actions they thought affected stingrays (r=-0.427, p=0.007).

Eighty-five % of participants who knew about 80-100% of the conservation topics either work or have worked at an aquarium or study a life or physical science. (Figure 7A and 7B). Sixty-one % of participants who said that 80-100% of the daily activities questioned affected stingrays either work or have worked at an aquarium or study a life or physical science (Figure 8A and 8B).

With looking at the participants who lived close to a coastline (combined location categories 1 and 2), there is a significant correlation between whether or not they worked at an aquarium and if they knew 80-100% of conservation topics ($r = 0.523$, $p<0.001$). There is a significant correlation between how often they did the questioned actions and if they answered "yes" to Question 10 ($r = 0.501$, $p<0.001$). There is a significant correlation between if they answered "yes" to Question 10 and for what they believed affected stingrays ($r = 0.538$, $p<0.001$). There was also a significant correlation between what conservation topics they knew and how close they were to a coastline ($r = 0.464$, $p<0.001$). When looking at just participants who lived farther from a coastline (combined location categories 3 and 4), there were no significant correlation results.

Of the 40% of participants that said "yes" to Question 10, 58% mentioned avoiding plastics, 59% mentioned being conscious of what gets poured down the drain, 24% avoided seafood, 14% mentioned that they keep track of their general water usage, 47% mentioned recycling and using reusable materials, and 61% mentioned being aware of what they throw away.

When comparing how often participants completed specific actions and what effect they believed these actions had on the ocean, no combination of responses were correlated. Therefore, there were no specific actions that were completed with the ocean in mind. With that said, for many questions explicitly about the effect of them on the ocean, a majority of participants answered correctly if it was beneficial for the ocean or not. For percentages, for Question 9 the answers "very positive" and "somewhat positive" were combined, and "very negative" and "somewhat negative" were combined (Figure 9).

There were seven actions that were good for the ocean and a majority of participants knew they were good for the ocean. For asking where a fish came from at a meal, 63% answered that this was good for the ocean. Interestingly, 26% answered that this had no effect on ocean conservation. Eighty-four% of participants knew that paying attention to what got poured down the drain could be beneficial for the ocean. Seventy-three% said that biking was beneficial, but 24% said no effect. Eighty-one% answered that communicating with a local government is beneficial for the ocean, and 82% said that eating locally grown food was beneficial for the ocean. Ninety-two% knew that recycling had positive effects on the ocean, and 90% knew that using reusable water bottles was beneficial for the health of the ocean.

There were two actions that are beneficial for the ocean that a majority of participants did not say were good for the ocean. For whether or not going to an aquarium was beneficial for the ocean, 30% said somewhat positive, 27% said no effect. The complications with this question are later discussed. Interestingly, this question had the highest correlation between those doing it and knowing it was beneficial for the ocean (r=0.3097). Seventy-three% said that using public transportation was not beneficial for the ocean.

There were six actions that were considered bad for the ocean that participants also listed as bad for the ocean. Ninety-two% of participants knew that driving had negative costs on the ocean, even though this is second most popular action done in participant's days. Therefore, the correlation between how often it is done and its effect on the ocean is practically zero (r=0.0374). For eating fish, 69% said this had a negative effect on the ocean, and for gardening with fertilizer 77% of participants. Eighty-one% listed using a boat as having a negative effect on the ocean, and 89% for using not reusable plastic water bottles. Ninety-three% of participants said that using a plastic bag was bad for the ocean, but there were generally equal percentages for how often participants used them. Less than once a week was 29%, once a week was 31%, and a few times a week was 29%.

There were two questions that were considered bad for the ocean that a majority of participants did not get correct. Participating in ecotourism did not have a majority answer. Twenty-nine% of participants checked "Not Sure," implying a problem with the vocabulary word for why a majority of participants said this was not bad for the ocean. Visiting the beach also did not have a majority answer, with 27% saying "No Effect."

Second Survey

For the second survey, 38% of participants had taken the first survey. Fourteen % of participants had worked at an aquarium or other marine education facility, and 38% of participants study a life science (refer to Materials and Methods). The question asking if people who lived far away from a coastline, further referred to as Question 7, had a positive effect on the ocean was frequently skipped, most likely due to technical difficulties. Therefore, when analyzing most of the data, participants who did not have an answer for this part of Question 7 were deleted from analysis. Therefore the total number of participants for a majority of the analysis was 127.

There were a variety of responses for Question 5, what is the first thing you think about when you think of the ocean (Figure 10). A majority of answers were aquatic/marine life itself, characteristics of the water, the size of the ocean, and the beach. The first anthropogenic response was trash/pollution with 8 responses, including participants who did not have an answer for part of Question 7. Interestingly, most of the responses were regarding the ocean itself and it's morphology, rather than human influences and interactions.

This is true even though many participants checked that the ocean is important for human use in a variety of ways, Question 6. "The beach" had the highest number of support with 97 participants, followed by recreational activities at 90 participants. "Food resources" had 86 participants, "energy resources" had 67 participants, and "mineral resources" had 42 participants. For "Travel purposes," 55 participants said that they care about the ocean for this reason. With that said, "conserving the Earth as a whole" was the top response with 119 participants. Supporting the ocean because it's "cool and mysterious" was one of the most popular responses with 75 participants (Table 3). The percent of participants who checked off each reason were divided into those who study a science and those who do not, live close to the coast or do not, and who work at an aquarium and who do not (Table 4).

There were 14 participants who had another reason to care about the ocean that was not included in the checklist. Twelve of these participants wrote down their reasoning. Five participants included the want to conserve marine life, including one who mentioned that they find aquatic life fascinating while another described how there has been a loss of marine species and biodiversity. Two participants wrote that they care about the ocean because it has organisms that produce a large percentage of the Earth's oxygen, that humans need in order to survive. Two participants simply just care about the ocean as a whole. Unique responses were that the ocean carries an important history of kidnapping people that we do not talk about often, one participant grew up on the water and feels as if it is part of his/her identity, and one states that the ocean acts as a natural infrastructure for trade.

When observing correlation, there were only 15 participants who both worked at an aquarium/marine education facility and studied a science. Therefore, all results were not significant due to the small sample size. With that said, this group had the highest average answer for if aquariums are connected to conservation, further referred to as Question 9, with 4.53. Therefore, these participants agreed that aquariums do connect with aquariums, with the exception of only one participant who did not answer 5, yes, and instead 2, no, leading to the average to be lower than 5 (refer to Materials and Methods).

Data was analyzed with all participants, just those who studied a science, just those who lived within 25 miles of a coastline, just those who lived 25miles away or farther from a coastline, and just those who had worked at an aquarium or other marine education facility. Means and standard deviations can be observed in Table 5, while correlations can be observed in Table 6. All questions were done with the

127 participants that had values for both parts of Question 8. The results for Question 9 with all participants are also included (Figure 11).

When comparing the checklist answers from Question 6, there were some that had significant correlation, higher than R = 0.500 or -0.500, meaning that participants who checked one often checked the other. Answers "food resources" and "energy resources" and "mineral resources" were all significant to each other, in that food and energy, food and minerals, and energy and minerals were all positively correlated (R = 0.595, p<0.001; R = 0.504, p<0.001; R = 0.537, p<0.001). Answers "I like the beach" and "recreational activities" were positively correlated (0.497, p<0.001). "Learning something from an aquarium" and "learning something from the media" had positive correlation as well (R = 0.574, p<0.001). Other significant correlations involving Question 6 can be observed in Table 6.

VII. Discussion

<u>Result interpretation – First Survey</u>

My hypothesis was correct in that people who either live close to a coastline, study a science, and/or work at an aquarium or marine science education facility do know more about ocean conservation as well as think about the ocean more than those who do not fall into one of those three categories. However, most participants have a solid understanding as to what is bad and what is good for the ocean. They just do not necessarily make decisions that follow through with these understandings, or perhaps do not think that their individual actions will change anything. No conclusions can be made as to why people make the actions that they do, but rather information can be assessed and conclusions can be inferred depending on trends seen in survey responses. The choice to have few open response questions was to make sure that I could have a larger participant pool, even though open response questions would have given me the most valuable data.

Fifty-three % of participants studied science, which makes sense because this kind of survey was probably more attractive to people who were interested in the subject or already had previous knowledge about the ocean, marine conservation, or both. There was a large amount of correlation when solely looking at the participants who lived closer to an ocean, and no correlation for those who lived farther away. This shows that location does influence one's knowledge as well as how much they would think about the ocean. Therefore, more effort would need to be taken to reach out to landlocked states and citizens in order to help them understand that even if they are thousands of miles away from a coastline, their actions are still influential to the general wellbeing of an ocean habitat.

Answers from Question 8 and Question 9 were compared and no correlation was found for any pairing. With that said, often participants understood what was good and what was bad for the ocean even if these two questions did not correlate. Therefore, because there were a lot of correct answers but no correlation, the same participants who knew what was good or bad for the ocean were simply not completing the tasks that had the more beneficial effect or avoiding actions that had a negative effect. Just because the participant has knowledge of what an action can do doesn't mean that the correct action is completed. This further proves my hypothesis that we do not think about the ocean nearly enough.

When only looking at participants who had worked at an aquarium, there was a significant negative correlation between how close they lived to a coastline and what actions they thought affected stingrays ($r=-0.427$, $p=0.007$). These responses support my hypothesis that people who live closer to a coastline will think about the ocean more than people who live farther away, since this negative correlation implies an inverse relationship between location and conservation knowledge towards stingrays (Table 2).

Another big impact on conservation and individual's environmental footprint is access to resources and socioeconomic status. Biking is better than a car, but what if someone works an hour away from where they live because living farther from a city is cheaper? They won't bike because it would be too much time and energy. Bikes are also an investment and can be expensive. Boats are also a very expensive investment and only apply to people who live closer to a body of water. Eating locally grown food, unfortunately, takes more effort to find and often is more expensive. Buying reusable water bottles and reusable grocery bags, again, is an investment.

Every action questioned about can affect the ocean and stingrays, as well as be modified for the sake of both. The smallest actions, even if they do not directly affect the ocean itself, can influence the general morphology and chemistry of the ocean, which in turn affects stingrays and sharks.

Driving a car vs. biking and public transportation: Running an automobile emits CO_2 into the atmosphere. As previously described, the ocean acts as a carbon sink so a large percentage of this emitted CO_2 gets absorbed into the ocean and reacts with the hydrogen atoms present. Most stingrays and some benthic shark species rely on prey that have outer shells or exoskeletons, such as bivalves and crustaceans. If these shelled organisms cannot grow because there is a lack of bicarbonate present in the ocean, then the sharks and stingrays that consume them do not get as much of a meal. The prey does not grow completely and therefore, the energy used in order for the sharks and stingrays to hunt them is not replenished when they get the prey.

Sharks and stingrays are sensitive animals and have trouble adapting to changing water conditions, such as an increase in acidity. More CO_2 in the water has been cited to affect a fish's ability to navigate and distinguish friend from foe (Nilson et al., 2012). Therefore, biking as an alternative mode of transportation that does not emit CO_2 into the atmosphere saves the ocean from dangerous chemical changes. Similarly, using public transportation means that it is one automobile for many passengers, rather than every passenger having their own CO_2-emitting automobile. Both modes of transportation reduce the amount of CO_2 in the atmosphere and therefore the amount of CO_2 in the ocean that can damage a stingray or shark's internal biology and/or their food.

So when 24% of participants say that biking does not have an effect on the ocean, it is true that there is no direct effect, but choosing to ride a bike instead of a car means less CO_2 is being emitted into the atmosphere. The same is true for public transportation. A majority of participants understood that both are good alternatives.

Using fertilizer: Fertilizer used on gardens gets washed away into nearby water sources or is absorbed into the groundwater. Both lead into larger bodies of water and eventually collect at the mouth of these large water systems, rivers, in the ocean. This is an especially important problem for participants who farther from a coast because these areas tend to be not only at a high elevation but where most agricultural activity is found. Therefore, any fertilizer or other agricultural chemical is used; it naturally flows downstream until sea level. The simplest solution is to limit the amount of fertilizer used, or look into natural fertilizing agents such as composting.

When fertilizer ends up in the ocean, it usually remains in high concentrations along the coast due to currents and wave action. Elasmobranchii who inhabit coastlines are greatly affected by the algae that grow using the fertilizer nutrients and resulting eutrophication process. Because there is the highest concentration of eutrophication near the coast, there is less oxygen in the waters that have algal blooms from too many chemical pollutants. Less oxygen results in increased mortality of life or the organisms have to find a way to relocate and for many coastal organisms endemic to specific conditions, relocation could be a very difficult challenge. In summary, the use of fertilizer results in run off, the process of the chemicals flowing into and entering the water systems, which collects along coastlines attracting the growth of algae and thus eutrophication, less oxygen present for Elasmobranchii which leads to increased rates of mortality (Doucette et al., 2006; Schaffer et al., 2005; Mearns et al., 2009).

Paying attention to what goes down the drain: All drains lead to the ocean, eventually. This means that anything poured down a drain as a way to dispose of it can end up in the ocean and polluting the habitats it first encounters, which are usually coastal systems. Similarly to the problems with run off, if contaminants are poured down the drain, they can result in toxic environments for stingrays and sharks. It is recommended that if something is dangerous to be poured down a drain to look into alternative disposal methods. Disposal methods of hazardous materials vary depending on location and the material itself.

One big problem recently has been the large use of plastic microbeads in facial washes, body soaps, and toothpastes. These microbeads are advertised as beneficial for exfoliation of the skin, but once in the ocean they clog pores of corals and are toxic when consumed by fish. Because they are made of plastic, they do not decompose. The amount of microbeads entering waterways was enough to cover 300 tennis courts, and one average microbead is 5 millimeters long (Rochman et al., 2015). In late 2015, President Obama signed a bipartisan bill banning microbead production and distribution in the USA and hopes that this is enacted by mid-2017. Rather than inhibit the companies that have products with microbeads, the hope is that cosmetic companies look to using different resources (Shaver, 2016). One solution is to use natural exfoliates that do not contain plastic, and instead choose exfoliates that can decompose into harmless compounds once in waterways.

Trash and plastic: Microbeads are just the beginning of the plastic problem in the ocean. Plastic in many different forms ends up in the ocean and on beaches in a variety of ways. Once this plastic is in the ocean, it flows with currents. Due to the Earth's rotation and wind patterns, there are major currents that result in giant gyres throughout the major oceans. There are 5 gyres, and the plastics end up in these and come to a general stand still in the eye of the gyre, which does not spin. The plastics break down into their main building block: microplastics, which can be smaller than microbeads. The gyre in the north Pacific is the largest source of microplastics and is twice the size of the state of Texas (Kaiser, 2010).

Most marine debris is not biodegradable and instead, continues to accumulate at the surface and then slowly sink to the sea floor. Plastics affect elasmobranchs in all parts of the ocean, whether in their original shape or as microplastics. If consumed, they accumulate in stomachs and can make organisms very sick or lead to death. Not only can plastic particles be consumed by elasmobranchs on the coast or in pelagic zones, but also the plastic can cause external injuries and lead to entanglement. For many species of shark, it is imperative that they continue to swim in order to have water pass over their gills. They do not have a mechanism to pump water through their gills, so if they are injured or entangled and cannot swim properly, they cannot survive.

Plastic water bottles and caps are two of the largest components of the microplastic problem, so using a reusable water bottle results in less plastic water bottles that end up in the ocean. Reusable water bottles are a more sustainable resource. The same is true for using reusable grocery bags instead of plastic bags, and washing plastic dishware if plausible. Recycling is another very important process in reducing the amount of plastic in the ocean. The process of recycling is taking waste materials and converting them into usable materials or products.

Communicating with local body of government: All aspects of conservation biology have a greater effect in larger numbers. One way to increase numbers for certain conservation motifs is to communicate with legislation representatives and push for better regulations in regards to marine and greater environmental conservation. For example, change policies, such as microbead production, to protect what gets put into the ocean and better manage what gets put into the ocean. This refers to sediment dumping, chemicals, trash, liquid waste, and beach and coastline development to name a few. This can also be related to management of fisheries and the fishing equipment used to try and limit the amount of bycatch. The EPA and the DEP have forums where citizens can comment and contribute ideas for legislation.

Using a boat: If not managed properly, boats can be very dangerous for marine life. Motors can cause deadly injuries to fish and marine mammals as well as rip up habitats if boats go too shallow. Ballast water from boats can release organisms into new environments that result in invasive species that disrupt the natural food chain. Juvenile organisms get sucked into the ballast water systems and released into the new environments when ballast water is released. The new organisms do not have natural predators in the new habitats, so they can eat all of the food resources or take up all of the natural habitat space and result in displacing stingrays and sharks in the process (AGT, 2013). The bottom of boats can also be home to barnacles and juvenile organisms that have benthic life stages, so when they mature and become free swimming they enter the new habitat and can have similar effects as the ballast water organisms (AGT, 2013). Boat owners also have to be careful where they take their boats and in what season because boats can easily scare off animals during mating season or injure newborns. For stingrays, mating season is in the fall when beach recreational activities are most popular (Snelson et al., 1988; White and Sommerville, 2010; Kajiura and Tricas, 1996). All boats are not bad for the ocean per say, it greatly depends on the machinery and pollution levels of the boat, whether or not it has a motor to begin with, and how it is driven and the safety measures the driver takes.

Ecotourism: In regards to elasmobranchs, ecotourism is the process of divers or tourists interacting with stingrays or various species of shark in their natural habitat. This can range from simply viewing them from afar to feeding and touching the animals. One of the biggest problems with this is that the animals then associate humans with food (Newsome et al., 2004; Orams, 2002). So the next time they see something resembling a human they will expect it to have food for them and this can lead to the human getting injured, which doesn't help the reputation of these animals. The other drawback from human feeding is that the animals then become dependent on humans for food and this hinders their natural way of surviving (Newsome et al., 2004; Orams, 2002). In proper ecotourism, it is important to give the animals space or respond to them as if your hand was simply another fish.

With sharks, besides diving, two of the biggest cases of ecotourism are cage diving with Great Whites and feeding whale sharks in Australia. Studies have shown that humans do have an influence on whale shark behavior especially when diving and feeding them (Quiros, 2007; Davis and Banks, 1997). Whale sharks were observed to swim away from tourists if there was a majority of touching (Quiros, 2007), but also approach the tourists if there was feeding available as part of the tourist experience (Davis and Banks, 1997).

Cage diving with Great White Sharks has been harder to draw conclusions from since it is only recently being actively looked into, especially because there has been a dramatic increase of cage diving in just the past ten years. With that said, Bruce and

Bradford (2013) observed changes in behavior of sharks in that they were found to spend more time in the areas where cage diving occurred even though these were not habitats that the Great Whites spent time in often before the cage diving began. Their study begins to suggest that there are potentially dramatic long-term effects in shark residency that should be considered in future conservation efforts and cage diving tourist attractions.

Visiting the beach: Pristine beaches are some of the top tourist attractions, and great amounts of human interference and energy are necessary to keep them considered quality tourist attractions. Unfortunately this interference can greatly damage the habitats, which are important for both the coastal life and the environmental benefits of healthy beaches, such as storm surge protection. Many species of stingray inhabit the shallow waters of the coastline, so people swimming and entering the water can scare them away or injure them. Elasmobranchs get some of their worst reputations from interactions with humans in coastal waters because they get scared or confused and end up injuring beach-goers. One way to prevent startling the animals, which could result in injury and continuation of negative reputations, is to shuffle your feet once you enter the water. Elasmobranchs have magnetic fields that they use to sense when food is nearby, so by shuffling your feet it acts as a sign that you are there and they would swim away without being startled or accidentally stepped on (AGT, 2013).

If sharks are present near beaches, that is a sign that the habitat is healthy because it means that their prey, seals, are in healthy numbers which in turn means that the fish those seals eat is in healthy numbers, and so on (Barbaros and de Costa, 2008). Unfortunately, because of attacks and sometimes resulting in deaths, sharks have received bad reputations and invoke a sense of fear. Humans are not a natural prey for sharks and attacks are due to sharks mistaking humans for prey or bite as defense mechanisms. That is why there have never been any cases of sharks consuming humans, just bites. Unfortunately, shark attacks have triggered shark culling events and long lining as a way to keep them away from beaches (Koch and Johnson, 2007). Sharks have longer generation times and therefore are delicate species, and are also important top predators whose numbers need to be protected.

Respecting the beachfront itself is also important for the sake of elasmobranchs. Shallow coastal waters are important and specified habitats, so actions that pollute the beaches and/or lead to increased rates of erosion can continue to destroy elasmobranch habitats and displace both the animals themselves and their prey. Respecting natural landforms is also important to keep the coastline as a whole protected.

Asking where a fish at a meal came from: Knowing where fish came from is one of the easiest ways to confirm that one is supporting sustainable fisheries rather than unsustainable ones. Knowing that the fish was caught with the least amount of environmental damage and bycatch possible means that natural food chains are still supported while you still get a good meal. Elasmobranchs or bivalve meat is sometimes used as replacement fish in fast foods restaurants or places where the exact kind of fish is kept vague. Also actively avoiding meals that are threatened species, such as Chilean Sea Bass or Shark Fin Soup, means that the locations that are more sustainable get more consumers and more profit while those that are not sustainable get less consumers and less profit. It is reward for good behavior.

Sustainable fish can be establishment specific, or species specific. The Monterey Bay Aquarium has created a phone application, Seafood Watch, that tracks sustainable fish species and offers suggestions of fish to eat instead of ones that are threatened or more generally fished in negative ways. Another option to support sustainable fishing is to look towards eating what is known as “trash fish.” These are species that are not as popular but can taste just as good if not sometimes better than the popular species of fish. That way, other options for food are more supported giving the species that are threatened time to repopulate and rejuvenate (AGT, 2013).

In this study, eating fish was considered a negative impact on the ocean even though it is in reality vague and could be either good or bad depending on the fish itself. It depends on where the fish came from and what species of fish it is, as well as how specifically it was processed. This action was considered negative because most popular species of fish are overexploited and the assumption was taken that most participants do not ask where their fish came from when they sit down for a meal. This assumption was one of the errors to consider in this study and is further discussed on page 52.

There are sources of error for this survey study that need to be accounted for and acknowledged. The first being that data was frequently transferred and reorganized for different analysis and interpretation purposes, and perhaps some data could have been mixed up in the process. Since a majority of activities, specifically 12 of the 17, on average were done "less than once a week," my data might not be conducive to highlight the everyday actions that participants do that affect the ocean. For my areas of interest, I would have wanted a bigger data set to make up for this. If creating the survey again, I would have created different time frames or perhaps found a way to account for only actions that were done more frequently. This question took the longest for format because of what time frame I wanted to use and focus this specific survey on. Unfortunately, some questions needed different time frames than others, and this varies for each participant as well. One possible solution could have been having participants order the actions by the ones they do the most to the ones they do the least.

Upon looking at the survey results, a few more questions arose. The first being to directly ask which questions were completed with the ocean in mind and having this be a check box system rather than open ended. The second being why participants concluded a certain decision on what effect an action has on the ocean. This would have helped elaborate which answers were more confidently checked off than others. Explicitly asking if participants ask where fish came from when they buy it would have also led to more specific and conclusive analysis.

For the statistical analysis, bias had to be made in regards to actions that were negative for the ocean or positive for the ocean because if they were negative, reverse scoring had to be applied. Unfortunately, some questions came across as vague and the survey analysis highlighted this confusion. Vague is defined by the questions not being written specifically and with greater detail and therefore they could have been interpreted in many different ways. When I was designing the survey, I did this on purpose to see what participants think of first, but the data that resulted from the vague questions is missing the elaboration and explanation for what participants thought of first. There are too many possibilities for their reasoning to be assumed and determined by the responses to Questions 8 and 9. Having more questions would have made my survey longer and more time consuming, potentially deterred participants from completing the survey. So although more questions, especially free-response questions, would have been very beneficial, there is the potential that less participants would have taken they survey and I would have had a smaller data set to work with.

As previously stated, eating fish was vague and could have been understood in a variety of ways. Fish have been a natural prey of humans for many years, so from a marine environmental conservation standpoint, the physical act of eating a fish is not necessarily a bad thing. The catch is to confirm that the fish being consumed is sustainably caught and processed. The species of fish also has to be accounted for. But none of these factors were explained in the survey.

Visiting the beach is a very general statement in that many actions could occur once a participant is on the beach itself. Whether or not visiting the beach is beneficial to the ocean depends on what the participant does there. Destroying sand dunes, littering, injuring and displacing marine life, changing natural coastlines are all negative actions towards general ocean conservation, while relaxing, swimming, avoiding the more sensitive areas, supporting the natural formations of the beach, cleaning up after oneself are all positive actions towards general ocean conservation.

Using a boat is vague because the kind of boat was not specified. A sailboat has a very different effect on the ocean than a large cruise ship with ballast water, or a motorboat driven by someone who is intoxicated. So when considering boats, it is important to take into consideration the kind of boat being used and the way that the boat is being driven and used itself.

The physical act of going to an aquarium does not directly help elasmobranchs and greater ocean conservation, but what you learn about at an aquarium can influence conservation efforts. Since marine science is not something we learn about often, aquariums are entertaining places to learn about the ocean as well as how to live a better life for the sake of marine life. Therefore, going to the aquarium depends on what the visitor takes away and what they actually change in their personal life. Aquariums also are usually NGOs and use their money to support research opportunities, rehabilitation programs for endangered species and educational programming outside of the aquarium facility.

However, some participants might argue that going to aquariums is very bad because it supports the captivity of animals that do not thrive in the small spaces of an aquarium. By taking wildlife out of the ocean, an aquarium is in fact harming conservation. If there are touch tanks, the animals could be physically harmed if the visitors do not follow regulations correctly. On the other hand, touch tanks offer up close and personal, and safe, opportunities for visitors to experience marine life, something that is usually hidden and/or not encountered frequently.

This debate was therefore incorporated and very explicit in the second survey. The first survey barely scraped the surface as to the effect that aquariums have and the perspectives of visitors towards marine education facilities. The other questions were not incorporated into the second survey because they were too specific and would not do justice to the study as a whole without responses to the other questions of the first survey. Meanwhile, aquariums are a separate subject matter.

Lastly, it is important to point out that information regarding where participants were born and where they went to college/university, if they did, was not included in analysis of results. This was not the focus of this particular study, which instead highlighted the question of generally how far away a participant is from a coastline. However, there is the possibility that geographic region or location could have an influence or trend for each question and this could be part of a future study. Do people live near a coastline because they like the ocean? Or does ending up near a coastline, for any other reason, make one more likely to care about the ocean? These questions regarding the causation behind how participants responded to the survey cannot be answered with the data provided.

Result Interpretation – Second survey

Participants on average said that those who live farther than 25 miles away from a coast have a more negative effect on the ocean than a positive effect. The average for all data was low for having a positive effect, meaning that less believed that people far away from a coastline could have a positive effect. The average for all data for negative effect was lower, and because this question was reverse scored, this means that on average many participants thought that people have a negative effect on the ocean if farther from a coast.

Those who study science had lower means for both, meaning that they on average believed that people far away had even less of a positive effect and even more of a negative effect on the ocean.

Interestingly, those who live farther away had the highest value for negative effect, meaning that the average was less negative than the other groupings. Those who live closer to a coast had the highest value for positive effect, meaning that the participants who lived close to a coastline believed that those who live far away could have a positive effect on the ocean. Those who worked at an aquarium had the lowest average value for positive effect.

The reasoning behind these results cannot be determined from this study, but rather an assumption can be made that those who are closer to the coastline and/or work at an aquarium are simply better educated on the subject matter. These participants understand and see the results of positive actions. Those who live farther away from the coastline could be less educated in the subject matter simply because they do not interact with a coastline on a daily basis and therefore do not know how they could positively impact the ocean since most actions have indirect effects.

Expectedly, those who work at an aquarium had the highest average for the last time they went to an aquarium. Otherwise, averages were pretty close and showed that participants did not go to an aquarium often or had not been to one recently.

The average for Question 9 for all data that had both answers for Question 7 can be translated as Depends, if using the same numerical analysis for individual participants. Divisions ranged from Depends to Yes, with working at aquariums being almost unanimous for Yes (1 participant difference), and closer to coastline being the lowest with 3.70 (Maybe/Depends). Looking at Question 9 including all participants, the means were higher for all data, those who study science, and those who live closer to a coastline. Means were lower for those who live farther away and have worked at an aquarium. These values are more realistic for this question because n is higher and the missing value in Question 7 does not influence this question's response. So those who worked at aquarium is not as unanimous when there are more participants.

In Table 5, there were many significant results that did not have a high correlation coefficient. The ones that were above 0.500 or -0.500 are the only ones focused on since this shows that there is a relationship rather than a significant slight relationship.

For all data divisions, those who worked at an aquarium said that they pursue opportunities to learn about marine science. This means that those who actively want to learn about marine science likely want to pursue it as a career, meanwhile those who do not actively seek out opportunities to learn about marine science do not work at an aquarium. Interestingly, there was not strong correlation between the last time participants went to an aquarium and if they pursue opportunities to learn about marine science. So if one does pursue opportunities, that doesn't necessarily mean going to an aquarium. Or, participants do not go to an aquarium often but do not necessarily avoid learning about marine science and could do so in other ways.

Those who live farther away from a coastline learned about marine science from an aquarium if they worked at an aquarium, while there was no significant correlation for those who live closer to a coastline. This could imply that those who are closer to the shore learn about a reason to care about the ocean in other ways rather than just an aquarium, adding to my hypothesis that those who live on a coast likely think about the ocean more so than those who live farther away.

Looking at correlations mostly revealed information about those who work at aquariums and it's no surprise that those who work at aquariums likely also said that they pursue opportunities to learn about science, the ocean was their top priority, and that they care about the ocean because of something they learned about from an aquarium.

Looking at the percent of participants that checked off specific reasons revealed interesting trends in the data. Study a science or not were contrasted, live close and live far were contrasted, and whether or not one had worked at an aquarium was contrasted. The only participant who said that they do not care about the ocean did not study a science, lived farther than 25miles from a coastline, and had not worked at an aquarium. The percentages for the answer "I do, but it's not a priority" were highest for not study a science, live far away, and not work at an aquarium. The second highest for it's my top priority, following those working at an aquarium, was study a science.

Mineral resources, which are usually hard to obtain form the ocean and usually come with negative consequences to the conservation of the ocean, had the lowest percentage for those who worked at an aquarium. Travel purposes was highest for those who live close to a coastline. All divisions had at least 50% of participants caring about the ocean for food resources. Energy resources was the highest for those who study a science, the assumption being that those who study a science are more likely educated in this subject matter.

Besides those who work at an aquarium, those who study a science had the second most participants say that they pursue opportunities to learn about marine science, 25%. Meanwhile, 9% of 109 participants who did not study a science pursue opportunities to learn about marine science, and only 6% out of 143 who do not work at an aquarium pursue opportunities.

Interestingly, the top percent of participants who said that others say they should care about the ocean did not work at an aquarium, which was expected, but then also those who study a science and those who live close to the coastline also had high percentages, respectfully. Perhaps this is due to their being pressure to care about the ocean if it is related to their field or close to where they live. Recreational activities was all above 50%, with study a science being the highest with close to 70% of participants, same with the beach.

To be expected, “cool and mysterious” had a majority of those who worked at an aquarium and was lowest for those who do not study a science. It was also low for those who live close to a coast, perhaps again because they care about the ocean for other reasons or don’t think it’s mysterious because they are around it often. Fifty% of those who are far away said it was cool and mysterious, which could be enough to conclude that those who are farther away know less but are still interested in marine science.

As expected, live close, work at aquarium and study science had the most for something learned at aquarium. Not many participants for any division checked off something learned from media. Earth as a whole had high percentages for all divisions, and made this the most answered option overall.

The correlations between answers in Question 6 revealed some interesting patterns. Food, energy, and mineral resources are all materialistic products that are made and sold for a profit. These are very beneficial for trade and sometimes necessary for a successful way of life. They offer financial stability for thousands of individuals, but at the same time there is a lot of call for increased control and management over trade goods. The second significant correlation was enjoying the beach and recreational activities, which makes sense because most recreational activities involving the ocean also involve the beach. Lastly, the positive correlation between learning something from the media and something from an aquarium suggest that participants either learned from both sources or did not learn something from either option. Specifically, participants were either fascinated by something they learned from both sources or did not think that either source offered interesting information.

Similarly to the first survey, there are errors for this study that need to be addressed and accounted for in understanding the results. The first again being that data was constantly transferred and reorganized, so it is possible that some values got mixed up in the process. One question missing from the study could have been how do you learn about marine science if at all? This would highlight where participants access educational information if at all and what areas of society could be utilized further. One respondent left out their geographic location, but their data was included anyway. Therefore, this had the potential to skew results if the blank was present in some analyses and correlations, which it could have been during the data moving and editing. Lastly, if the survey were to be distributed again, I would split up the answers it's cool and mysterious because these can be two different connotations and descriptions of the ocean, and imply two very different aspects of the ocean and its inhabitants.

The second survey was completed to highlight participant's views on aquariums and offer more insight into what people think about the ocean and why the ocean and marine life are important and something to care about. The first survey focused on actions, but the second survey highlighted perspectives to these actions and alluded to why participants completed the actions they did even with the knowledge they have.

Similar survey studies have been completed in regards to aquarium visitors and their before-and-after experiences and perceptions (Adelman et al., 2000; Yalowitz, 2004). However, no known surveys have been completed that look at the day-to-day life of individuals and how their ideas of the ocean come into play in regards to a specific organism. Some studies have looked at specific regions and others have asked about specific conservation topics.

Pendleton et al. (2001) looked at participant's use of beachfront property as well as their perceptions on environment quality, both coastal water and air, in the Los Angeles

County. This was sponsored by Heal the Bay and their main result focused on the idea that most LA resident's perceptions on coastal water quality were from media and other factors rather than water quality educational campaigns. There were similarly worded questions that looked at frequency of actions taken as well as open ended questions for specific and individual responses. The study was interested in looking into whether or not people's perceptions of conservation were similar to the recorded levels of pollution seen in LA's waters. Roca et al. (2009) conducted a similar study in Costa Brava, Spain.

Connell et al. (2006) looked at students in middle school in two separate Australian cities to see where there were gaps in their education on environmental conservation. Two surveys were completed for each condition, 12 months apart from each other. This time gap observed a year's worth of education influence, and the study itself points at direct topics that need addition or renewed organization. Palmgren et al. (2004) looked more specifically at public perceptions of carbon dioxide collecting and settling in the ocean.

VIII. Conclusion

In conclusion, those who take initiative to have the ocean and marine science be a part of their daily life, are interested in it, or grew up with the ocean have more incentive to fix it. These are participants who either live closer than 25 miles to a coastline, study a life science, and/or work or have worked at an aquarium or other marine education facility. This does not mean that all of those participants who do not fit into these three categories therefore do not care about the ocean and marine life, but rather that they are less likely to have incentive to change their actions and to know how to do so.

A majority of all participants knew what actions harmed the oceans natural state, as well as which actions could benefit marine life and their way of being, specifically in regards to elasmobranchs. With this said, there was no correlation with this knowledge and the specific actions completed by participants, highlighting that for most participants, just because they know their action is bad for the ocean does not mean that they will not complete said action.

Participants care about the ocean for a variety of reasons and only 1 participant did not care about the ocean at all. There was also a wide range of opinions on aquariums and whether or not they are beneficial to ocean conservation. On average, participants believed that it depends on the aquarium facility itself, the aquarium's specific message, and the research and rehabilitation efforts taken by that specific aquarium. In regards to whether or not those who live farther than 25 miles from a coast can affect the ocean, there was not a lot of confidence in this effect being positive. Rather, more participants on average believed that these residents had more of a negative effect if any effect at all.

This study is unique in its specific connections of human activity to the ocean through the use of a specific group of organisms. Therefore, the study goes farther than addressing one specific conservation topic that broadly affects marine life and instead, addresses a range of topics that affect specifically elasmobranchs. This study is also unique in addressing how those who live far away from a coastline can still affect the ocean. Survey studies like this one could be used for specific areas, as explained by some of the other surveys highlighted.

Towns and states could look at the results to see where people connect with the ocean and use these connections as motivational tools for drawing attention to conservation efforts. Using these surveys to find out where participants are missing information, or where they are passionate, are two methods for conservation efforts to have the greatest effect and results. Either the movements are targeted towards education of the public, or they are targeted at the aspects of the ocean that participants are most passionate about and therefore would be eager to complete. For example, using the results from this study, targeting beach health for the sake of recreational activities, or relating it to conserving Earth as a whole.

The main goal would be to find ways that those participants who do not study a life science, work at an aquarium, or live close to a coastline could connect to the ocean. There are still other reasons they checked off caring for the ocean and using the right angle can reach huge achievements rather than pushing for efforts that offer no valuable connection or interest. Future use of these kinds of surveys could use more specific geographical locations to make the survey and further conservation movements more personal and successful.

IV. Figures and Tables

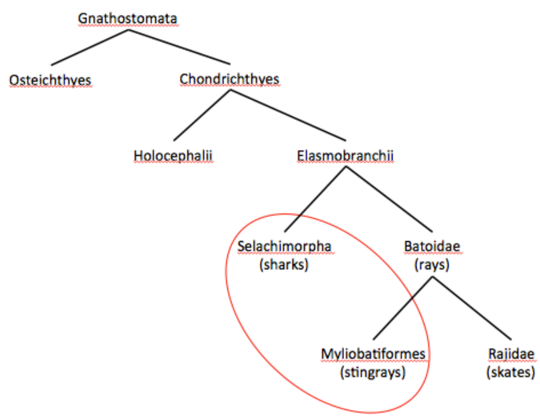

Figure 1 General classifications beginning with the superclass Gnathostomata, jawed fishes. The two circled groupings, superorder Selachimorpha and order Myliobatiformes, are the organisms this study focuses on.

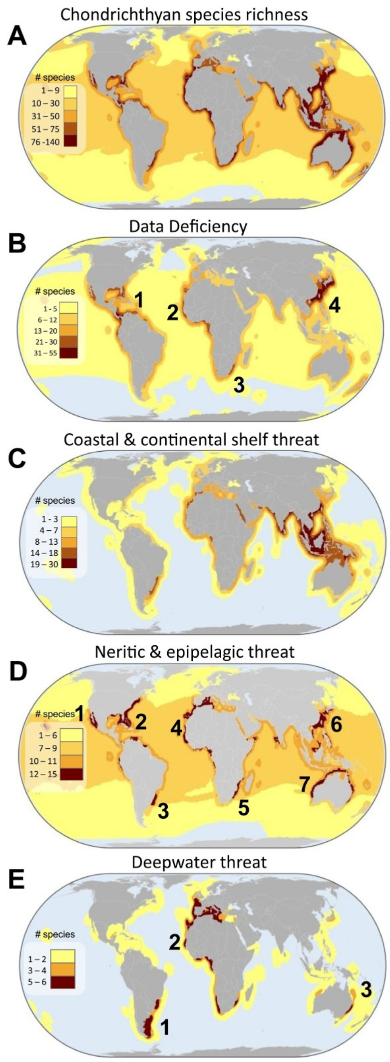

Figure 2 (A) Map of Global Chondrichthyan Species richness, showing that more are found in warmer waters and coastal habitats (B) Shows areas that are the most data deficient, points 1 and 4 overlap with where Chondrichthyan species richness is high. This is dangerous because if there is not enough data, then the proper number to be fished is unknown and populations can become greatly threatened (C) coastal threat is highest in the South Pacific, which overlaps with one of the areas of highest species richness (D) pelagic threats are still related to coastal environmental damages (E) Deepwater threats are also related to coastal threats (Dulvy et al., 2014)

Super order	Suborders	Family	Subfamily/ Genera	Common Name	Pelagic (as adults)	Benthic (as adults)	Cold water	Warm water	Freshwater	Deep ocean	Rely on coastal environments
Shark (Selachimorpha)											
	Carcharhiniformes			Ground Sharks							
		Carcharhinidae		Requiem sharks (Tiger Sharks, Bull Sharks)	X	X		X			X
		Hemigaleidae		Weasel sharks	X		X				
		Leptochariidae		Barbeled houndsharks		X		X			X
		Proscylliidae		Finback catsharks		X	X				
		Pseudotriakidae		False catsharks		X	X				
		Scyliohinidae		Catsharks		X	X				X
		Sphyrnidae		Hammerhead sharks	X			X			
		Triakidae		Houndsharks		X		X			X
	Heterodontiformes	Heterodontidae		Bullhead Sharks		X		X			X
	Hexanchiformes			Hexanchiforms							
		Chlamydoselachidae		Frilled sharks		X				X	
		Hexanchidae		Cow sharks		X				X	
	Lamniformes			Mackerel sharks							
		Alopiidae		Thresher sharks	X			X			
		Cetorhinidae		Basking shark	X			X			
		Lamnidae		Mackerel sharks (Great White, Mako)	X		X	X			X
		Megachasmidae		Megamouth shark		X				X	
		Mitsukurinidae		Goblin shark		X				X	
		Odontaspididae		Sand sharks		X		X			
		Pseudocarchariidae		Crocodile shark	X			X			
	Orectolobiformes			Carpet Sharks							
		Brachaeluridae		Blind sharks		X		X			X
		Ginglymostomatidae		Nursh sharks		X		X			X
		Hemiscylliidae		Bamboo sharks		X		X			X
		Orectolobidae		Wobbegong sharks		X		X			X
		Paraschylliidae		Collared carpet sharks		X		X			

	Rhincodontidae	Whale shark	X		X				
	Stegostomatidae	Zebra shark		X		X			X
Pristiophoriformes	Pristiophoridae	Saw shark		X				X	
Squaliformes									
	Centrophoridae	Gulper sharks	X	X				X	
	Dalatiidae	Kitefin sharks						X	
	Echinorhinidae	Bramble shark		X		X		X	
	Etmopteridae	Lantern sharks						X	
	Oxynotidae	Rough shark						X	
	Somniosidae	Sleeper sharks		X	X			X	
	Squalidae	Dogfish sharks		X				X	
Squantifiniformes	Squatinidae	Angel sharks		X		X		X	
Rays (Batoidae)									
Sting Ray (Myliobatiformes)									
	Hexatrygonidae	Sixgill stingray		X		X		X	
	Plesiobatidae	Deepwater stingray/Giant stingray				X		X	
	Urolophidae	Stingarees		X		X			
	Urotrygonidae	American Round stingrays		X		X			X
	Dasyatidae								
	Dasyatis			X		X			X
	Himantura	Whiptails		X		X			
	Makararaja					X	X		
	Neotrygon	Maskrays		X		X			
	Pastinachus	Cowtail		X		X			
	Pteroplatytrygon	Pelagic	X			X			
	Taeniura	Ribbon Tail		X		X			
	Urogymnus	Porcupine		X		X			
	Potamotrygonidae	Freshwater stingrays				X	X		X
	Gymnuridae	Butterfly stingrays		X		X			
	Myliobatidae								
	Myliobatinae	Eagle stingrays		X		X			
	Rhinopterinae	Cownose stingray		X		X			
	Mobulinae	Manta stingray		X		X			
Skates (Rajidae)									
	Rajinae	Hardnose skates	X	X	X				X
	Arhynchobatinae	Softnose skates	X	X	X				X

Table 1 Detailed classification of Elasmobranchii, including species Latin name, common name, if they are a pelagic species or benthic species, found in cold water or warm water, if they are a freshwater species or deep ocean species, and if they rely on a coastal habitat in any capacity.

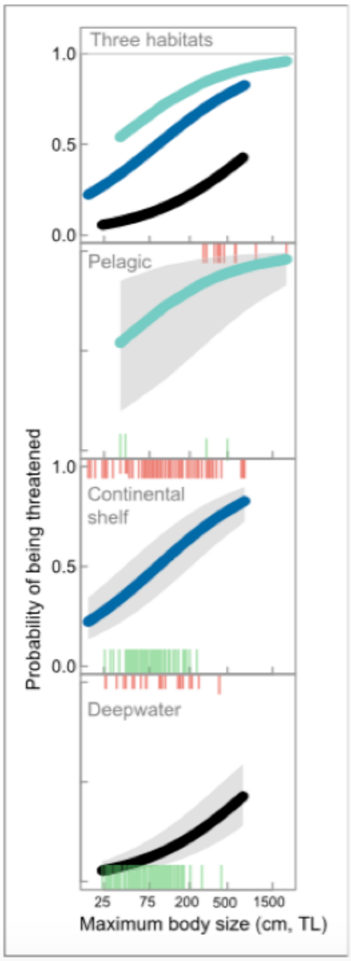

Figure 3 The function of maximum body size related to risk of extinction in 3 different habitats (the larger the animal the higher the risk, the shallower the animal the higher the risk). Continental shelf = coastal and <200m, deepwater refers to all areas of the ocean that are deeper than 200m. This is not species specific, so this does not take into account Maximum Sustainable Yield (MSY) and specific life cycles. (Dulvy et al. 2008)

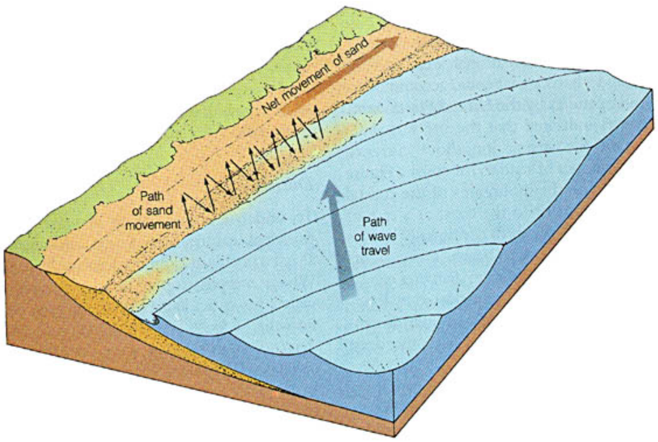

Figure 4 Depiction of wave action and how it effects natural sand movement and erosion along coast lines.

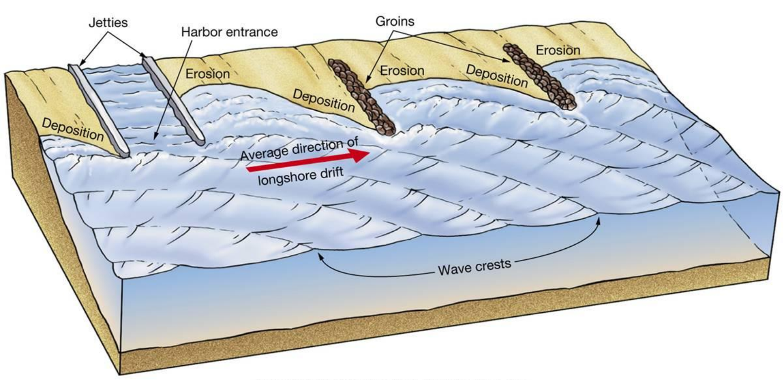

Figure 5 Depiction of how groins lead to irregular beach formation and the updrift, here labeled longshore drift, gets deposition while the lower side of the groin gets eroded away due to wave action. This image also shows how jetties have a similar erosion/deposition effect.

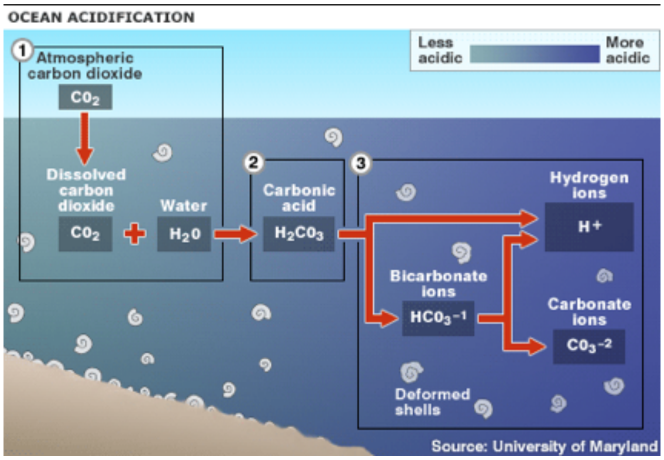

Figure 6 Depiction of the ocean acidification chemical reaction and why an increase in CO2 leads to a decrease in the amount of readily available calcium carbonate.

Question	Answer	Numerical Value
For most of the year, how close do you live to a coastline?	very close (coastal-5 miles away)	1
	relatively close (5-25 miles away)	2
	relatively far away (25-50 miles away)	3
	far away (50+ miles away)	4
Please indicate roughly how often you do the following activities	less than once a week	1
	once a week	2
	few times a week	3
	once a day	4
	more than once a day	5
	N/A	0
What effect do the following activities have on the ocean and marine life?	very negative effect	1
	somewhat negative effect	2
	no effect	3
	somewhat positive effect	4
	very positive effect	5
	not sure	0
All yes or no question	yes	1
	no	0
When was the last time you went to an aquarium?	I work at one	1
	last week	2
	in the past month	3
	in the past 6 months	4
	>in the past 6 months	5
	I've never been to one	6
Do you think supporting aquariums helps ocean conservation?	N/A	0
	I don't know	1
	No	2
	Maybe	3
	Depends	4
	Yes	5
All questions asking participants to check off	Checked response	1
	No response	0

Table 2 All questions for both survey 1 and survey 2 that were converted into numerical values for statistical analysis. Only the last question was a subjective numerical system, otherwise the statistics softwares generated the other numerical systems. The only yes or no question that was different than a 1 or 0 system was in the second survey. Qualtrics transposed Question 3 of "Have you ever worked at an aquarium or other education facility?" to 1 being yes and 2 being no.

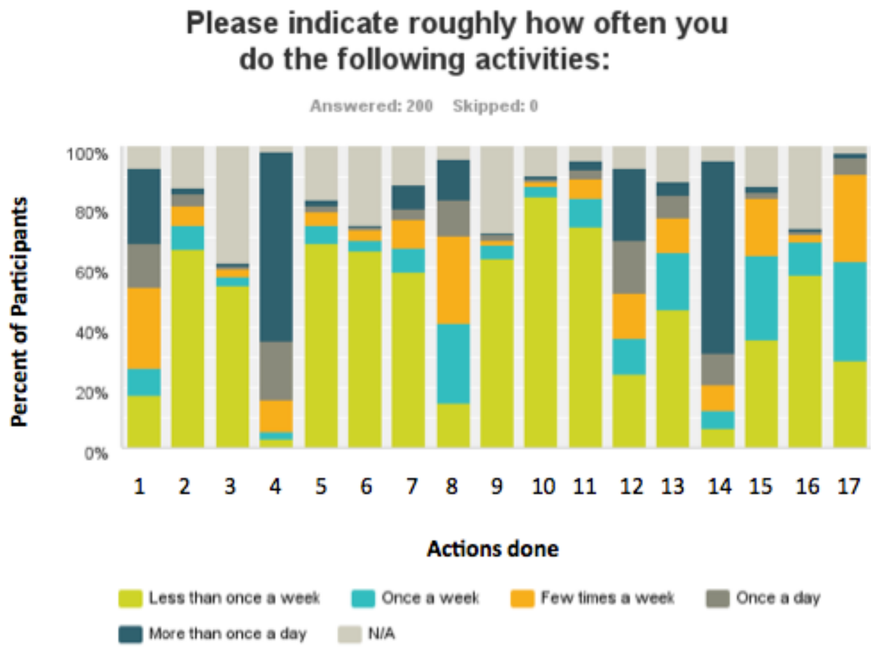

Figure 6 Results for Question 8 of the first survey. Chart produced by Survey Monkey. Actions are as follows: 1) Drive a car 2) Bike 3) Garden with fertilizer 4) Remember to recycle 5) Communicate with a local governing body for a cause 6) Use a boat 7) Use public transportation 8) Eat locally grown food 9) Participate in ecotourism 10) Go to an aquarium 11) Visit the beach 12) Pay attention to what gets poured down the drain 13) Use plastic (not reusable) water bottles 14) Use reusable water bottles 15) Eat fish 16) Ask where fish at a meal came from 17) Use a plastic bag

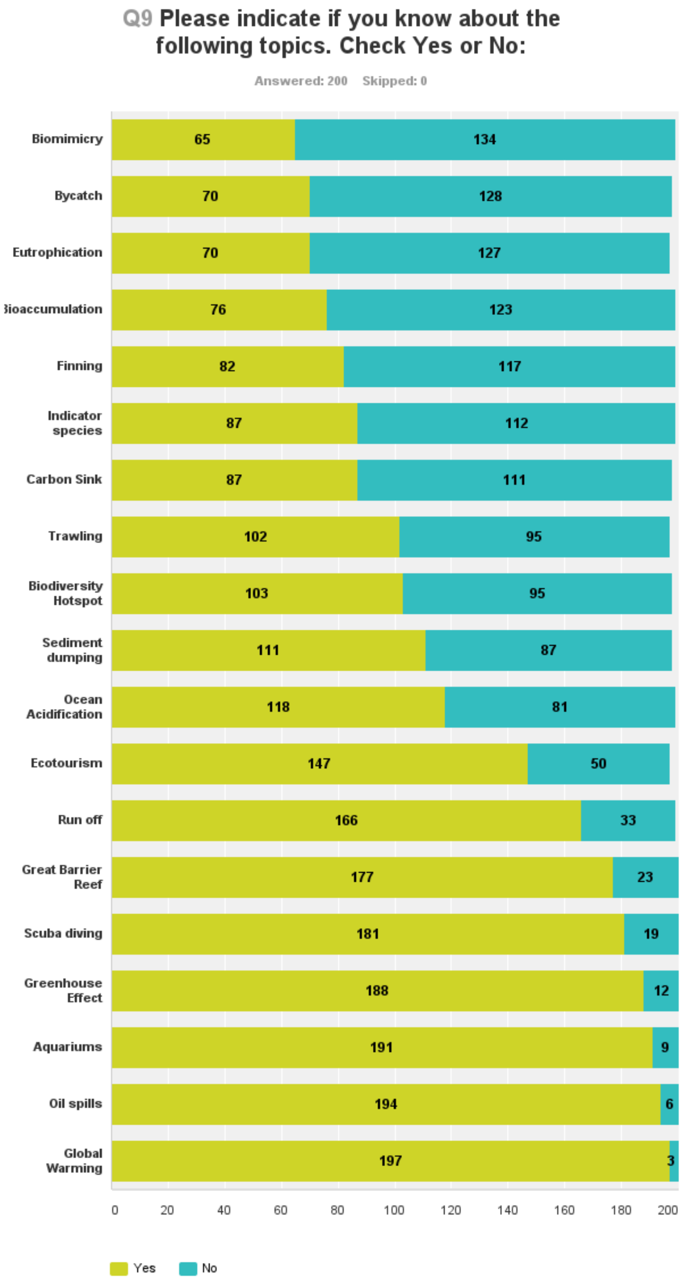

Figure 7A The number of participants that knew each conservation topic is in green, and the number of participants that did not know that conservation topic is in blue. Chart was produced by Survey Monkey.

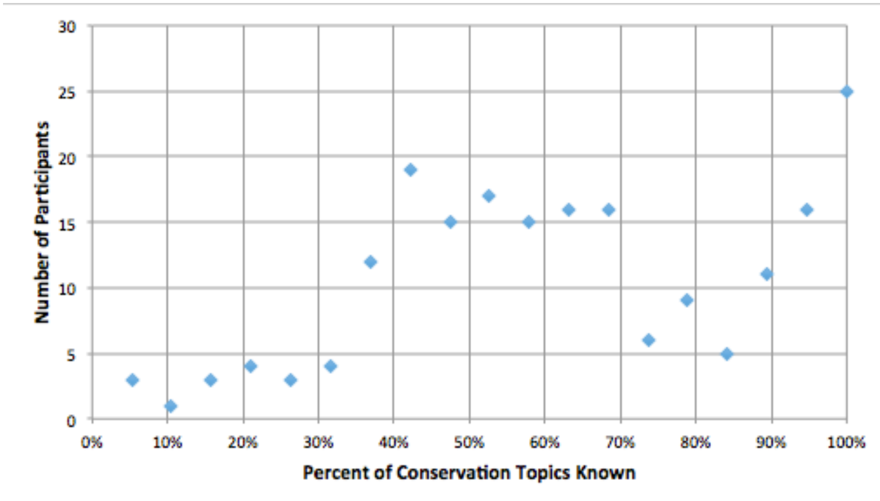

Figure 7B The number of participants who knew a specific percentage of the conservation topics. There were 25 participants who knew 100% of the conservation topics questioned, and 3 participants who did not know any of the conservation topics questioned.

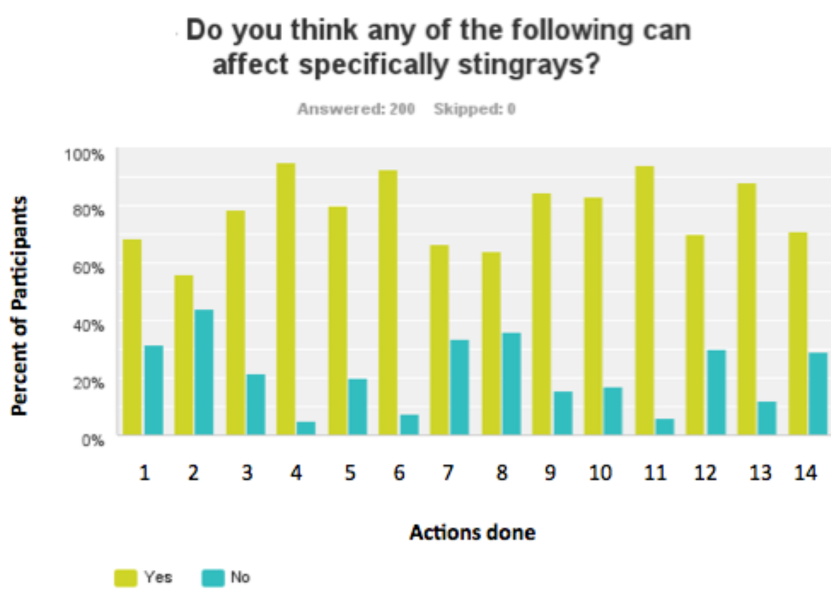

Figure 8A Results for Question 11 of the first survey. Actions done are as follows: 1) Driving a car 2) Biking 3) Deciding to garden with or without fertilizer 4) Remembering to recycle 5) Communicating with a local governing body 6) Using a boat 7) Using public transportation 8) Eating locally grown food 9) Participating in ecotourism 10) Going to an aquarium 11) Paying attention to what gets poured down the drain 12) Visiting the beach 13) Using a reusable water bottle 14) Asking where fish at a meal came from. Chart was produced by Survey Monkey.

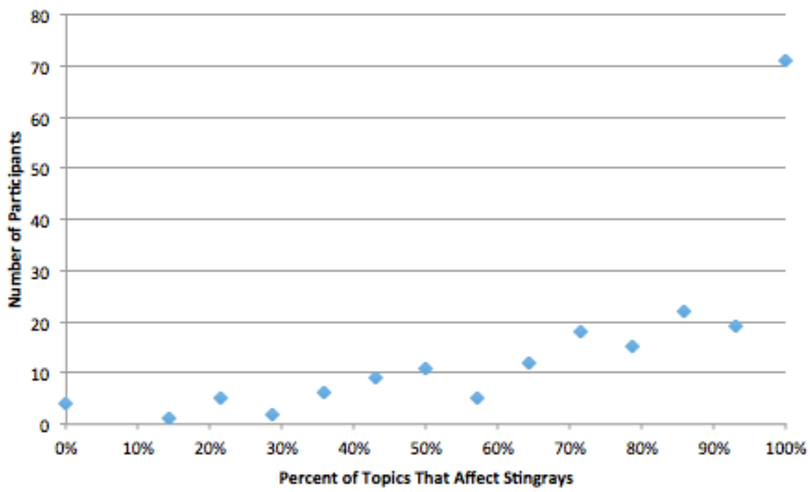

Figure 8B The number of participants who knew a specific percentage of topics in Figure 8A affected stingrays. Five participants said that none of the actions affected stingrays, while 74 participants said that 100% of actions affected stingrays.

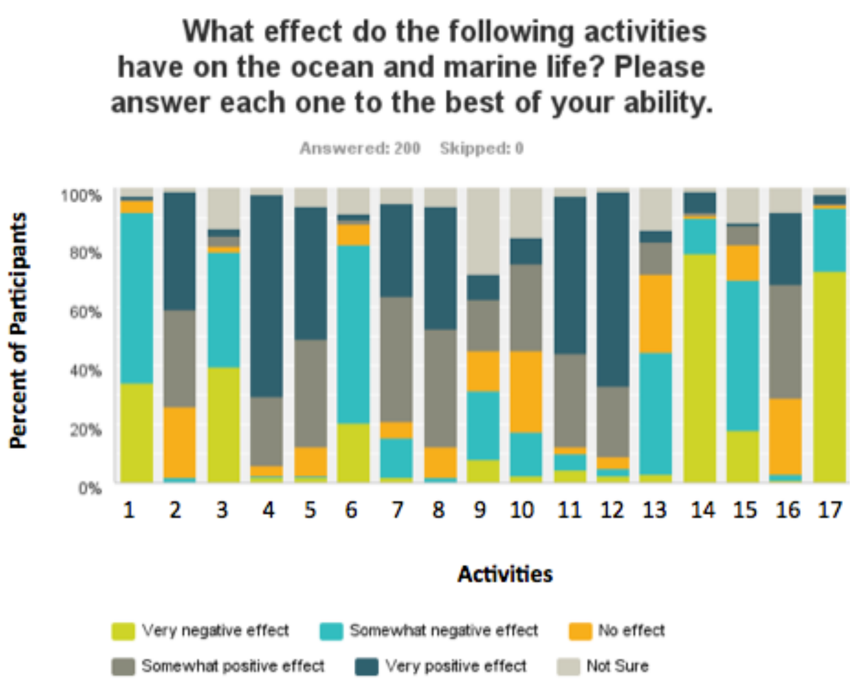

Figure 9 Results for Question 9 of the first survey. Chart was produced by Survey Monkey. Activities are as follows: 1) Driving a car 2) Biking 3) Gardening with fertilizer 4) Remembering to recycle 5) Communicating with a local governing body for a cause 6) Using a boat 7) Using public transportation 8) Eating locally grown food 9) Participating in ecotourism 10) Going to an aquarium 11) Being careful about what gets poured down the drain 12) Using reusable water bottles 13) Visiting the beach 14) Using plastic (not reusable) water bottles 15) Eating fish 16) Asking where fish at a meal came from 17) Using a plastic bag

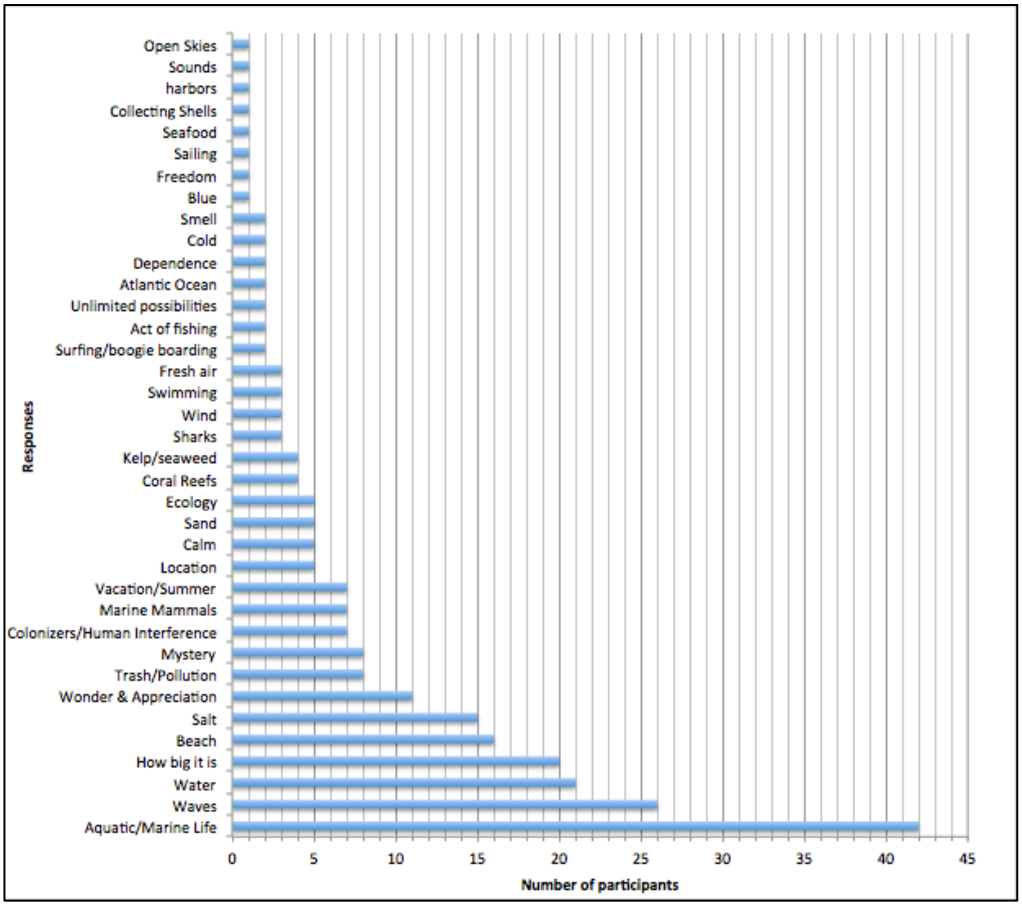

Figure 10 Question 5 of second survey. Written responses were grouped depending on relatedness and similar word choice.

Response	Number of participants who checked this answer	Percent of participants who checked this answer
I don't	1	0.61%
I do, but it's not a priority	49	29.70%
It's my top priority	13	7.88%
Food resources	86	52.12%
Energy resources	67	40.61%
Mineral resources	42	25.45%
Travel purposes	55	33.33%
I pursue opportunities to learn about marine sciences	25	15.15%
Others say I should care about the ocean	8	4.85%
Recreational activities	90	54.55%
I like the beach	97	58.79%
It's cool and mysterious	75	45.45%
Something I learned about from an aquarium/marine education facility	32	19.39%
Something I learned from the media	22	13.33%
I care about working towards conserving Earth as a whole	119	72.12%
Other	14	8.48%
	Total: 165	

Table 3 Results for Question 6 of the second survey with the possible answers in the checklist, the number of participants who checked each specific reason, and the percent value out of all participants questioned.

	n	I don't	I do, but it's not a priority	It's my top priority	Food resources	Energy resources	Mineral resources	Travel purposes	I pursue opportunities to learn about marine sciences	Others say I should care about the ocean	Recreational activities	I like the beach	It's cool and mysterious	Something I learned about from an aquarium/marine education facility	Something I learned from the media	I care about working towards conserving Earth as a whole
Study Science	63	0%	24%	16%	60%	56%	33%	41%	25%	6%	68%	67%	57%	35%	19%	78%
Do Not Study Science	102	1%	33%	3%	47%	31%	21%	28%	9%	4%	46%	54%	38%	10%	10%	69%
Live Close	109	0%	33%	6%	51%	42%	26%	36%	14%	6%	57%	61%	43%	18%	15%	76%
Live Far	55	2%	21%	13%	54%	38%	25%	29%	18%	2%	50%	54%	50%	21%	11%	64%
Worked at Aquarium	22	0%	9%	30%	61%	48%	17%	22%	70%	0%	52%	65%	61%	52%	22%	78%
Do Not Work at Aquarium	143	1%	33%	4%	50%	39%	27%	35%	6%	6%	55%	57%	43%	14%	12%	71%

Table 4 Breakdown of Question 6 in regards to the percent of participants that checked off each answer per division of data. The divisions were looking at studying a science or not, living close to a coastline or not (further referred to in the survey as living far from a coastline, >25miles), and working at an aquarium or not.

	All Data	Just Participants Who Study Science	Just Participants Who Live Closer than 25miles to a Coastline	Just Participants Who Live Farther than 25 miles to a Coastline	Just Participants Who Have Worked at an Aquarium/Marine Science Education Facility
	n = 126	n = 52	n = 79	n = 46	n = 18
Question 7, Answer 1 Positive Effect	4.48 (2.465)	4.04 (2.266)	4.61 (2.356)	4.35 (2.635)	3.94 (2.532)
Question 7, Answer 2 Negative Effect	3.66 (2.511)	3.31 (2.414)	3.48 (2.385)	3.98 (2.736)	3.78 (2.734)
Question 8: Last Time Went To An Aquarium	2.31 (0.675)	2.38 (0.661)	2.27 (0.674)	2.39 (0.682)	3.00 (0.840)
Question 9: Aquariums Connected to Conservation?	3.87 (1.544)	3.92 (1.440)	3.70 (1.604)	4.22 (1.381)	4.50 (0.924)
	n = 165	n = 61	n = 110	n = 56	n = 22
Question 9: Aquariums Connected to Conservation?	3.90 (1.521)	3.95 (1.465)	3.78 (1.576)	4.09 (1.405)	4.36 (1.293)

Table 5 Mean values for Questions 7-9 with standard deviations in parenthesis. Sample size for each division was included. Question 9 was included both with and without those participants who did not include Answer 2 for Question 7.

Two Variables Compared for Pearson's Correlation and Significance	All Data	Just Participants Who Study Science	Just Participants Who Live Closer than 25miles to a Coastline	Just Participants Who Live Farther than 25 miles to a Coastline	Just Participants Who Have Worked at an Aquarium/Marine Science Education Facility
	n = 126	n = 52	n = 79	n = 46	n = 18
Question 2 and Question 7, Answer 1	R = -0.107 p=0.236	R = -0.182 p=0.195	R =-0.103 p=0.368	R = -0.220 p=0.142	R = -0.269 p=0.280
Question 2 and Question 7, Answer 2	R = 0.160 p=0.075	R = 0.095 p=0.502	R = 0.227 p=0.044	R = 0.099 p=0.511	R = 0.273 p=0.274
Question 3 and Question 6, Answer 3	*R = -0.327 p<0.001	R = -0.246 p=0.078	R = -0.171 p=0.132	*R = -0.388 p=0.008	
Question 3 and Question 6, Answer 8	*R = -0.635 p<0.001	*R = -0.613 p<0.001	*R = -0.634 p<0.001	*R = -0.623 p<0.001	
Question 3 and Question 6, Answer 13	*R = -0.395 p<0.001	*R = -0.429 p=0.002	R = -0.270 p=0.016	*R = -0.569 p<0.001	
Question 3 and Question 9	*R = -0.419 p<0.001	*R = -0.469 p<0.001	*R = -0.475 p<0.001	*R = -0.355 p=0.016	
Question 6, Answers 3 and 8	*R = 0.522 p<0.001	*R = -0.553 p<0.001	*R = 0.372 p=0.001	*R = 0.623 p<0.001	R = 0.439 p=0.069
Question 6, Answers 3 and 13	*R = 0.456 p<0.001	*R = -0.542 p<0.001	*R = 0.379 p=0.001	*R = 0.578 p<0.001	*R = 0.495 p=0.037
Question 6, Answers 8 and 13	*R = 0.530 p<0.001	*R = -0.607 p<0.001	*R = 0.539 p<0.001	*R = 0.537 p<0.001	R = 0.403 p=0.097
Question 6, Answer 8 and Question 8	*R = 0.302 p<0.001	R = 0.271 p=0.052	*R = 0.368 p<0.001	R = 0.201 p=0.180	R = 0.289 p=0.245
Question 6, Answer 8 and Question 9	R = 0.184 p=0.040	R = 0.218 p=0.120	R = 0.196 p=0.084	R = 0.122 p=0.415	R = 0.394 p=0.106
Question 6, Answer 13 and Question 8	R = 0.220 p=0.013	R = 0.128 p=0.365	R = 0.206 p=0.068	R = 0.241 p=0.107	R = -0.140 p=0.581
Question 6, Answer 13 and Question 9	R = 0.169 p=0.059	R = 0.238 p=0.090	R = 0.274 p=0.015	R = -0.045 p=0.765	R = 0.190 p=0.449
Question 7, Answers 1 and 2	R = -0.182 p=0.041	R = -0.038 p=0.789	*R = -0.345 p=0.002	R = 0.035 p=0.818	R = -0.087 p=0.732
Question 8 and Question 9	R = 0.092 p=0.307	R = 0.299 p=0.031	R = 0.111 p=0.329	R = 0.002 p=0.989	R = 0.227 p=0.364
	n = 165	n = 61	n = 110	n = 56	n = 22
Question 8 and Question 9	R = 0.115 p=0.143	R = 0.259 p=0.044	R = 0.159 p=0.096	R = -0.001 p=0.994	R = 0.214 p=0.340

Table 6 Correlation (R) values and significance values for the different correlations of interest for Survey 2. R values with a * indicate significant calculations in regards to a 0.01 level of a two-tailed Pearson correlation test. These were calculated with SPSS software. Refer to Appendix II for Questions. The second correlation between Question 8 and Question 9 was conducted including those participants who did not answer the second part of Question 7. There are 4 empty boxes under "just participants who have worked at an aquarium or other marine education facility" because Question 3 asked if the participant had worked at an aquarium or other marine education facility, so this was not included for this division because all participants were the same.

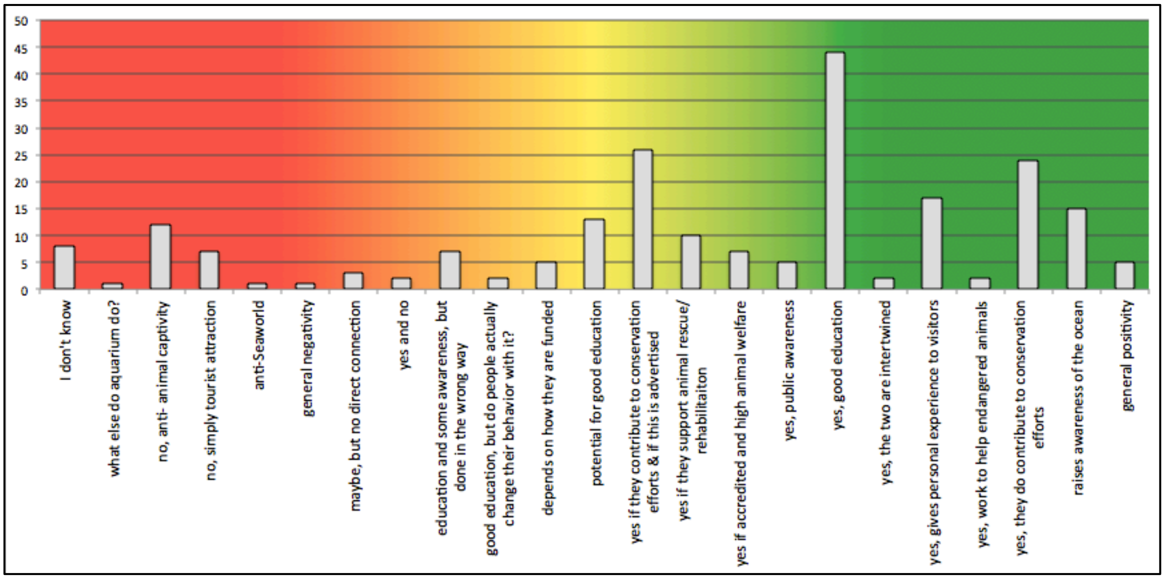

Figure 11 Responses to Question 9 of the second survey, grouped by relatedness. The left answers surrounded by red are those that do not believe aquariums relate to ocean conservation, while the right-most answers are those that do believe that aquariums relate to ocean conservation. Answers in the middle were subjectively ordered from negative to positive.

Appendix 1: Survey 1

Page 1: Consent Form
Page 2: Information about participant:

- What is your hometown and state? Please indicate the country if not the USA.
- What town and state is your college/university in? If not in college, please write "N/A"
- Please write your main areas of study and/or your field of employment
- How old are you?
- Most of the year, how close do you live to a body of salt water? Use your best judgment. Very close (coastal-5 miles away), relatively close (5-25 miles away), relatively far away (25-50 miles away), far away (50+ miles away)
- Have you ever worked at an aquarium or other marine educational facility? Yes or no

Page 3: Please indicate if you know about the following topics. Check Yes or No.

- Ocean acidification
- Trawling
- Run off
- Greenhouse effect
- Indicator species
- Scuba diving
- Global warming
- Carbon sink
- Bioaccumulation
- Ecotourism
- Bycatch
- Finning
- Eutrophication
- Great Barrier Reef
- Sediment dumping
- Oil spills
- Biodiversity hotspot
- Aquariums
- Biomimicry

Page 4: Please indicate roughly how often you do the following activities: Less than once a week, once a week, few times a week, once a day, more than once a day, N/A

- Drive a car
- Bike
- Garden with fertilizer
- Remember to recycle
- Communicate with a local governing body for a cause
- Use a boat
- Use public transportation
- Eat locally grown food
- Participate in ecotourism

- Go to an aquarium
- Visit the beach
- Pay attention to what gets poured down the drain
- Use plastic (not reusable) water bottles
- Use reusable water bottles
- Eat fish
- Ask where fish at a meal came from
- Use a plastic bag

Page 5: What effect do the following activities have on the ocean and marine life? Please answer each one to the best of your ability and by clicking on either: very negative effect, somewhat negative effect, no effect, somewhat positive effect, very positive effect, not sure.

- Driving a car
- Biking
- Gardening with fertilizer
- Remembering to recycle
- Communicating with a local governing body for a cause
- Using a boat
- Using public transportation
- Eating locally grown food
- Participating in ecotourism
- Going to an aquarium
- Being careful about what gets poured down the drain
- Using reusable water bottles
- Visiting the beach
- Using plastic water bottles
- Eating fish
- Asking where fish at a meal came from
- Using a plastic bag

Page 6:
When making daily decisions, are any actions completed with the ocean in mind? Yes or no

If answered Yes in the previous question, please write in which daily activities and elaborate how they affect the ocean and its inhabitants

Do you think any of the following can affect stingrays? Yes or no

- Driving a car
- Biking
- Deciding to garden with or without fertilizer
- Remembering to recycle
- Communicating with a local governing body
- Using a boat
- Using public transportation

- Eating locally grown food
- Participating in ecotourism
- Going to an aquarium
- Paying attention to what gets poured down the drain
- Visiting the beach
- Using a reusable water bottle
- Asking where fish at a meal came from

Page 7: Debriefing Form

Appendix II: Second Survey

Page 1:
Informed Consent Document

Page 2:
Please write your main areas of study and/or your field of employment: Text box

Most of the year, how close do you live to a body of salt water? Use your best judgment.

- Very close (coastal-5 miles away)
- Relatively close (5-25 miles away)
- Relatively far away (25-50 miles away)
- Far away (50+ miles away)

Have you ever worked at an aquarium or other marine educational facility? Yes or no

Did you take the first survey in Fall 2015 that focused on conservation topics, what you do in your daily life, and stingrays? Whether yes or no, you may proceed with the rest of the survey. Yes or no

Page 3:
What's the first thing you think of when you think about the ocean? Text box

Page 4:
Why do you care about the ocean? (check all that apply)

- I don't
- I do, but it's not a priority
- It's my top priority
- Food resources
- Energy resources
- Mineral resources
- Travel purposes
- I pursue opportunities to learn about marine sciences
- Others say I should
- Recreational activities
- I like the beach
- It's cool and mysterious
- Something I learned about from an aquarium/marine education facility
- Something I learned from the media
- I care about working towards conserving Earth as a whole
- Other (textbox)

Page 5:

Do you think people who live 25+ miles away from the ocean can have a negative effect on it? Sliding bar scale 0-10

Do you think people who live 25+ miles away from the ocean can have a positive effect on it? Sliding bar scale 0-10

Page 6:
When was the last time you went to an aquarium?
- I work at one
- Last week
- In the past month
- In the past 6 months
- > the past 6 months
- I've never been to one

Do you think supporting aquariums helps ocean conservation? Please explain.
Textbox

Page 7:
Debriefing document

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