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Biogeography

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The Biogeography of *Carcharodon carcharias*

 Biogeography is the study of a species geographic distribution and how they got there. The biogeography of great white sharks “*Carcharodon carcharias”* is extensive and relatively less researched when compared to other species due to the common misperception of these beautiful creatures as vicious, blood-thirsty, killers.Through further research of *Carcharodon carcharias* current geographic distribution,it can be hoped to find a better understanding of an essential part of our oceans ecosystem and to help clear up misconceptions regarding the image surrounding this species. Also, further research could lead to more possibilities for conservation as *Carcharodon carcharias* are listed as vulnerable for their conservation status.

 In order to begin taking steps toward the conservation and protection of *Carcharodon carcharias* we need to first find when and where these creatures are breeding and where the juveniles dwell. The same idea can be seen implemented with the conservation of sea turtles where conservationists protect hatching sea turtles from predators from attacking them allowing more turtles to escape into the ocean. When identifying where *Carcharodon carcharias* are giving birth it first must be known that *Carcharodon carcharias* have a gestation of 18 months. This results in an annual migration pattern for mature females one study shows (Domeier,2013). The beginning of life for a white sharks starts with four phases, an offshore gestation phase, a coastal pupping phase, a pre-aggregation phase where white sharks are begin their journey from the coast of Mexico to Guadalupe Island, and an aggregation phase where the mature females come together at Guadalupe Island (Domeier,2013). When examining the phases of the great white shark it is easier to understand them as a cycle instead of phases. The baby sharks are conceived offshore and then birthed on the coast of Mexico and North America where they then make their way to Guadalupe Island and when they arrive they are mature adults, all within a two year period.

A relating study tagged six juvenile white sharks in the eastern Pacific ocean in order to better understand the behavior of white sharks but more importantly the habitat preferences for the juveniles (Weng, 2007). These habitat preferences included temperature, foraging, and depth preferences for the juvenile sharks. When averaging the temperatures that the juveniles stayed in for the duration of the study it can be concluded that juvenile white sharks prefer areas with average temperatures between 16 and 22 degrees celsius. The foraging habits of these juveniles showed that the juveniles would continually rise to the mixed surface area in order to feed and after would drop in depth. The scientists completing this experiment also conducted stomach check in order to see the the diet that the juveniles were living on and their main prey items included Pacific sardines, king salmon, white seabass, and striped bass (Weng, 2007). These details of the life of juvenile white sharks can help us protect this species by allowing us to identify and observe the areas where the sharks are most likely to be in their most vulnerable time.

After a brief understanding of the conception and lives of juvenile white sharks the next step in conservation is to understand the next phase in a great white sharks life. Once these beautiful creatures reach adulthood migration patterns start to emerge. When looking at tagged great whites in the Pacific it can been seen that these sharks have a philopatric tendency in their migration patterns (Jorgensen, 2009). This means that the sharks have a tendency to return to a particular area. Another study showed possible natal homing when looking at great whites tagged off the coast of South Africa and Australia (Bonfil,2005). Another study on Pacific great whites also showed the same philopatric tendency when observing sexually matured sharks off the coast of Guadalupe Mexico (Domeier, 2008). All three studies had the exact same results, these sharks are in a continuous loop of going from offshore to coastal areas mainly to find foraging areas. The main reason that these sharks are going from offshore to coastal areas is seasonally based. Another study looked at the mitochondrial DNA (mtDNA) of 97 white sharks around Australia. After the samples were taken they were genotyped with six nuclear-encoded microsatellite loci of eastern and southwestern coasts . This study resulted in the identification of population subdivision of a fine spatial scale and that mainly females showed philopatric behavior but also some male whites sharks did also (Blower, 2012). The philopatric tendencies of these sharks can help with conservation efforts by identifying where these sharks are being tagged, how many sharks are being/ have been tagged in an area, and how long it takes for these sharks to return resulting in a possible timeline where agencies that want to protect these beautiful creatures may patrol these areas for poachers.

One study took look at large scale movements and diving behavior of *Carcharodon carcharias*. In April of 2005 four great whites were tagged with pop-up archival tags off the coast of New Zealand in order to identify how far and how deep these sharks were swimming (Bonfil, 2010). Unfortunately one of the tags release prematurely leaving only three to collect data. The data collected however showed large scale movements of up to 3000 kilometers and depths of up to 900 meters during large movements. When these sharks weren’t in the process of large scale movements they tended to stay about one meter around the surface but with occasional dives down to around 100 meters. These movements and depths were attributed to prey availability and migration patterns (Bonfil, 2010). The time and place of these large scale movements and average depths can help us with conservation in the idea that if more and more of these sharks and tagged and more knowledge is obtained then we can better predict the movements of the animals to possibly use measures to better protect this species.

One of if not the main driving force for the migration habits and distribution of *Carcharodon carcharias* is seasonal changes. These seasonal changes can affect the sharks distribution, feeding habits, and habitat use. When examining great whites tagged in the north western Atlantic ocean, the sharks tended to show specific migration patterns along the coast in regard to the season changes and the amount of prey available (Curtis, 2014). These sharks tagged in the north western Atlantic ocean showed an annual migration pattern that went north and south along the coast. During the summer months great whites in this area tended to be located off the coast of north east United States where their prey options are extensive. It is also shown however that a large number of great whites had a tendency to hunt grey seals off the coast of Massachusetts. Once the temperature starts to decrease and the fall season starts the emerge the great whites started moving south toward Georgia and Florida. This is due to the preference of warmer waters. The other reason for this migration is to locate foraging areas around this area (Curtis, 2014). In this case these greats whites that were documented seemed to have a difference when compared to great whites in the Pacific as these great whites. The Atlantic great whites had a tendency to stay primarily along the coast instead of going to offshore pelagic waters. These results can help us better protect this species by allowing us to identify migration highways and foraging areas so that we may better understand that habits of great whites.

Another method for understanding *Carcharodon carcharias* is the use of stable isotope analysis (SIA). In this experiment scientists extracted dermal and muscle tissue samples from 53 great whites which were biopsied to obtain the sample. These samples were then tested for isotope values of nitrogen and carbon. These results show different concentrated areas of white sharks diets and migration patterns. These results also showed that great whites had a higher foraging average in coastal areas and that offshore if mainly for migration purposes (Carlisle, 2012). This method can be used alongside with electronic tagging in order to understand the trophic ecology and migration patterns over a period of time and help with conservation projects due to the ever increasing knowledge gained from these different experiments.

One study done in 2002 stated that the niche for white sharks is actually greater than what was previously believed. The scientists used pop-up archival tags on six great whites which were caught off the coast of central California in order to collect sample of temperature and depth. It was concluded that when the sharks were on the shore they all seemed to have a similar preference toward depth and temperature (Boustany, 2002). The expanded niche for the great whites in this experiment went from the previously believed depth of 30 meters to a new depth of 75 meters and a temperature low of 16 degrees celsius to a new low of 10 degrees celsius (Boustany, 2002). These new findings can help us better conserve this species because these results can allow us to set up new experiments at these locations.

All of the findings in these studies are essential to the understanding and protection of one of nature's most important predators. It is our job to protect these creatures in order to keep the ecosystem intact and to help preserve our oceans. These results of location, depth, temperature, genetics, seasonal distribution, and feeding habits can help us better care for and protect these beautiful animals.

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