Greenland Shark Lifespan and Implications for Human Longevity

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Greenland Shark Lifespan and Implications for Human Longevity

by

Holly C. Gates

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Dedication

I struggled to write the dedication for this thesis for a number of reasons. Primarily, it is simply far too difficult to summarize how eternally grateful I am for all of the help I have received in a mere paragraph or so. Countless people have played a role, no matter how minor, in supporting me throughout my time in the Honors College. This paper is the culmination of innumerable hours of work, sleepless nights, and many (many) cups of coffee. That said, there are a few people I would be remiss were I not to thank them expressly. Firstly, my family, who have supported me throughout my time at UAH with untold late night phone calls, care packages, and check-ins. My partner, Woody Sharp, who has been a steadfast support in the face of my ever shifting academic pursuits and shown me nothing but love and grace through it all. My thesis advisor, Dr. Magnuson, for taking the time to aid me in this endeavor. And finally, Emily Eichhorn, who has continually reminded me that I am worth more than my academic achievements and fully capable of anything I set my mind to.
Greenland sharks have been the subject of much discussion in the news following the recent revelation that they live for anywhere from 300-500 years. Following this discovery, interest in understanding what biological factors contribute to their lifespan has blossomed and as a result a number of different studies have been conducted that revealed new insights regarding the Greenland shark. Despite their age and size, Greenland sharks do not seem to suffer from cancer. Critically, understanding what keeps these sharks from dying of cancer is important as it could translate into more effective treatments for human cancers. Additionally, Greenland shark heart rate and blood pressure are both abnormally low, which could be another contributing factor to their longevity. Their basal metabolic rate is also extremely low, which might also contribute to their extensive lifespan. Understanding the effects of these qualities on lifespan will prove useful in the ceaseless efforts to extend human longevity.

This paper will explore existing research on Greenland sharks and delve into the implications each discovery may have for human longevity. It will also cover the importance of and dire need for conservation and protection for this species so that further research may be conducted.

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Image 1- Greenland Shark in the Uummannaq Fjord.²

Introduction

Greenland sharks are a species of sleeper shark found in northern Atlantic waters. For years, it was believed that calculating their age was impossible due to the lack of fin spines, hard tissues in their bodies, and growth bands in their vertebrae- all of which are traditionally used for determining age in many species of sharks. Approximations could be made using the size of the shark and the known growth rate of less than 1 cm per year, but recent breakthroughs in carbon dating has allowed for more accurate assessment of age. This is accomplished by analyzing the proteins in their eyes, which are formed at birth and do not degrade with age.³ It is now known that Greenland sharks live approximately 400-500 years, making them by far the longest living

vertebrate species. They are currently classified as near-threatened, with the majority of yearly deaths arising as a result of accidental capture in fishing trawls.

Understanding the biological factors that contribute to Greenland shark lifespan could have significant implications for human longevity. Important aspects to discuss include Greenland shark cancer rates, cardiovascular function, metabolic function, and the future of study in Greenland shark anatomy. It will also address methods with which these unique aspects of Greenland sharks could be applied to humans in an attempt to extend longevity.

**Cancer**

One in six human deaths worldwide every year can be attributed to cancer of some kind. This equates to an approximate value of ten million cancer related deaths per year. Research suggests that early detection and improvements in treatment are essential to the reduction of cancer mortality rate. There is also a considerable correlation between age and cancer rates in humans. As cancer is a disease of replication, it follows that an animal would be more likely to develop cancer as it gets older and larger, since this correlates to more cell divisions. However, vertebrates display similar cancer rates regardless of discrepancies in size and age. Understanding why this may be the case could offer insight into how the development of cancer in humans can be slowed or stopped. Despite how large they grow and their lengthy lifespan, Greenland sharks display significantly lower rates of developing and succumbing to cancer.

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5 Ibid.
7 Ibid.
8 Ibid.
10 Ibid.
Tumor suppressor genes and the hypertumor theory both offer explanations for this phenomenon. Understanding this trend is critical to the future of cancer treatment.

Tumor suppressor genes play an important role in preventing cancer in large vertebrates. As a larger animal will experience more cell divisions, it will have a statistically higher chance of one of those divisions developing a malignant mutation, and it takes multiple compounding mutations for cancer to develop.\(^1\) In spite of this, large vertebrates are not riddled with cancer. This is largely due to the work of tumor suppressor genes. Tumor suppressor genes work to slow down cell growth and initiate cell death at the proper time. Large vertebrates actually have higher proportions of tumor suppressor genes, which contributes to their cancer resistance.\(^2\) Heightened presence of tumor suppressor genes in the Greenland shark genome could contribute to their survival. As of now, there is not a whole genome sequence of the Greenland shark, so identifying genes of particular interest could prove complicated until the genome has been fully sequenced. That said, further work with tumor suppressor genes could be beneficial in the fight against cancer and in increasing the survival rate.

One such tumor suppressor gene, TP53, has been a subject of interest in recent years. TP53 codes for a protein, p53, that plays a critical role in tumor suppression, tissue homeostasis, and aging.\(^3\) Longer living organisms have specific amino acid substitutions in their TP53 DNA binding sequence that impact the function.\(^4\) Though no current data exists regarding the TP53...

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\(^5\) Ibid.
gene for Greenland sharks, their stance as the longest living vertebrate lends itself to the conclusion that it might have beneficial mutations on this gene. Developing a model for this gene could help identify which portions of the sequence are most impactful for longevity. A broader understanding of the TP53 gene pathway is critical in the next steps for cancer treatment. Mice bred to contain extra copies of the TP53 gene in their genome - mimicking the pattern seen in larger vertebrates - demonstrated an improved response to DNA damage and heightened cancer suppression.\(^{16}\) Currently, applying the expanded lethality of the TP53 gene on human subjects is the next step in developing new clinical treatments for cancer patients.\(^{17}\) One strategy of implementing beneficial mutations in cancer prone individuals would involve cultivating cells with these mutations in a vector, then injecting it in the individual in hopes of helping the individual encode for more copies of the TP53 gene.\(^{18}\) It will take more extensive research to fully apply this gene therapy to human subjects, but current studies in this field offer promising advances in cancer treatment.

Another explanation regarding the low rate of cancer deaths in Greenland sharks involves the hypertumor theory. This concept is an alternative explanation for the lower than anticipated cancer rates in large animals. It should be noted that significantly less research has been conducted in this field, but it is still an important theory regarding cancer suppression in large vertebrates. In its simplest definition, a hypertumor is a tumor of a tumor. Essentially, the more a tumor grows, the more likely it is to have a mutation that causes some of the cells to

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\(^{18}\) “FDA Has Approved Gene Therapy Products for Cancer, Rare Diseases.” U.S. Food and Drug Administration. FDA. Accessed March 5, 2023. [https://www.fda.gov/consumers/consumer-updates/how-gene-therapy-can-cure-or-treat-diseases#:~:text=When%20a%20gene%20therapy%20is,cell%20types%20in%20the%20lab.](https://www.fda.gov/consumers/consumer-updates/how-gene-therapy-can-cure-or-treat-diseases#:~:text=When%20a%20gene%20therapy%20is,cell%20types%20in%20the%20lab.)
essentially revolt against the original tumor, attacking it and stealing its resources. The cells of hypertumors fail to secrete sufficient tumor angiogenic factors to promote blood their own tumoral growth, instead hijacking the vascular system established by the tumor it came from. This theory might explain why large vertebrates, such as Greenland sharks, do not die of cancer at the expected rate. They may have tumors, but their size means it would take a larger tumor to kill them. As the tumor grows, the chances of it developing a hypertumor would increase, keeping the tumor itself in check. The likelihood of hypertumors is higher in larger vertebrates because a tumor has to grow to significant size before becoming fatal, whereas the fatality threshold is drastically lower in smaller vertebrates. For example, in a pika with a body mass of 0.15kg, a fatal tumor would weigh approximately 12 g, but a 70kg human would need a 1200 g tumor to be fatal. The reason hypertumors are not more common in smaller vertebrates is because they tend to die from their tumors before they have the chance to develop a hypertumor. That said, in a number of simulated scenarios, hypertumors were able to hold the tumor under the fatal threshold for years. This indicates that this may be a viable option for slowing the rate at which cancer progresses, which could offer subjects time to pursue further methods of treatment that they otherwise would not have.

Applying hypertumor theory to human subjects could work a number of different ways. One method would be adopting the strategy of hypertumors and developing a method of diverting blood flow away from the tumor, effectively destroying its nutrient supply. This is the idea behind embolization therapy, which involves injecting a substance directly into an artery.

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20 Ibid.
21 Ibid.
22 Ibid.
23 Ibid.
24 Ibid.
supplying the tumor in an effort to block or reduce the blood flow.\textsuperscript{25} One negative to this idea is that hypertumors cause necrosis of the tissues they affect.\textsuperscript{26} If this method were used, it would need to be carefully conducted to cause minimal damage to the healthy tissues surrounding the tumor. Another strategy involves significantly more research into hypertumors than currently exists. If the mutant hypertumor sequences that lead to its effects on tumor vascular structures can be identified, the next step would be isolating them in a lab setting. This could be individualized to the patient by extracting some cancerous tissue and splicing it with the beneficial hypertumor genes. Treating the tumor with this modified tissue could encourage the growth of a hypertumor, which would minimize further growth of the cancerous tissue, as discussed previously. Using tissue from the patient or a source of stem cells would decrease the risk of rejection.\textsuperscript{27} Despite the potential benefits of hypertumor treatments, there are numerous drawbacks to consider with this method. First, significantly more research would need to be done on hypertumors to identify important factors and the specific gene mutations that are beneficial. Investigating tumor growth factors could play an important role in finding beneficial mutations, but, as of now, no specific genes have been identified that directly correspond to hypertumor formation.\textsuperscript{28} This further expounds the importance of continued research. This procedure would also come with significant risks, as if it fails it could encourage the growth of the tumor past the threshold rather than inhibit it. However, if a hypertumor could successfully be grown and implanted into an active tumor, the added time could be worth the potential risks.


In summary, there are a number of applications that Greenland shark research could have for treating and preventing cancer in humans. Grasping an understanding of the structure of their specific TP53 gene would shed light on beneficial mutations that could be applied to gene therapy methods could help diminish the formation of cancer in humans. Researching greenland shark tumor formation and the possibility of the role of hypertumors in inhibiting tumor growth could also have positive effects on human longevity.

**Cardiovascular Disease**

Cardiovascular disease and heart related ailments are the leading cause of death worldwide.\(^29\) Of the deaths caused by cardiovascular disease, four out of five are related to either heart attacks or strokes.\(^30\) High blood pressure is strongly correlated with both heart attacks and strokes, as is an elevated resting heart rate.\(^31\) \(^32\) \(^33\) Even if the patient does not die, they will often be left with lifelong impacts on their physical and mental health, so preventative measures are of the utmost importance.\(^34\) Heart disease displays a strong correlation with aging. The risks of heart disease increase drastically every year a person lives past the age of 65.\(^35\) This expounds the importance of researching long lived animals to discover what contributes to their failure to


\(^{30}\) Ibid.


develop heart disease. Given this information, it makes sense to turn to the longest living vertebrate, the Greenland shark, for answers. Understanding how to lengthen the functional lifespan of a vertebrate heart is an important step in improving the longevity of the organ.

Resting heart rate is used as an important diagnostic factor in determining cardiovascular health. Higher resting heart rate is associated with higher incidence of cardiovascular illness. Greenland sharks demonstrate a low resting heart rate, which is coupled with incredibly high stroke volume. Mirroring this in humans could help decrease risks of cardiovascular illness. Minimizing resting heart rate for humans could happen in a number of ways. Firstly, exercise is linked to a lower resting heart rate, as it trains the heart to pump more efficiently. Aerobic exercise, such as distance swimming, is an effective method of increasing stroke volume and lowering resting heart rate due to the effects it has on the parasympathetic nervous system. Greenland sharks swim approximately 74 kilometers per day at a low intensity, which could contribute to the fortitude of their cardiac cells. Finding ways to build aerobic exercise into one’s daily routine could be an effective preventative measure for cardiovascular illness.

There are risks to the heart rate decreasing too much. Most notably is the development of bradycardia, which is classified as having a resting heart rate below 60 beats per minute. This can cause insufficient blood flow and oxygen supply to the body, leading to dizziness, chest pain, and electrolyte imbalances.\textsuperscript{42} Exercising 30-45 minutes per day and eating a heart healthy diet are shown to contribute to maintaining the ideal heart rate while minimizing risks of bradycardia.\textsuperscript{43}

Managing blood pressure is another area of cardiac health that could increase overall cardiac longevity. Although Greenland shark blood pressure has never been officially recorded, it has been extrapolated from measuring elastin and collagen concentration in the walls of the ventral aorta and testing it at various pressures.\textsuperscript{44} From these tests, it was determined that Greenland shark blood pressure averages between 2.3-2.8 kPa, which is equivalent to 17.3-21 mmHg.\textsuperscript{45} This sets Greenland sharks apart even from close relatives such as the Epaulette shark and Shovelnose rays, which average a dorsal blood pressure between 2.6 and 4.8 kPa, which equates to 19.5-36 mmHg.\textsuperscript{46} The low blood pressure estimated in Greenland sharks could be a contributing factor to their longevity, as high blood pressure is related to reduced life expectancy.


\textsuperscript{45} Ibid.

and more years spent living with cardiovascular disease. More research needs to be conducted to fully validate this claim, but this evidence lends itself to the conclusion that Greenland shark blood pressure contributes to their extensive life span.

Safely lowering human blood pressure would be an effective way to prevent cardiovascular disease. Low blood pressure decreases the amount of wear and tear on the walls of the cardiovascular system, increasing the lifespan of these vessels. Approximately 30 minutes of moderate physical activity per day has been shown to lower blood pressure. Paying attention to these factors would go a long way in reducing rates of cardiovascular disease in the general population. Human blood pressure does need to stay elevated above that of most ocean dwelling animals, as terrestrial animals need to work harder against gravity to move their blood. Ideally, human blood pressure should be less than 120/80 mmHg. If blood pressure drops down to 90/60 mmHg, this is known as hypotension, which can also cause damage to the cardiovascular system. Monitoring blood pressure during a program designed to decrease it is an important step to mitigate risks of decreasing blood pressure too much.

Understanding the factors that contribute to Greenland shark cardiovascular longevity will contribute to broader understanding of extending human cardiovascular longevity and

49 Ibid.
51 “High Blood Pressure Symptoms and Causes.” Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, May 18, 2021. https://www.cdc.gov/bloodpressure/about.htm#:~:text=%2F80%20mmHg.%E2%80%9D-,What%20are%20normal%20blood%20pressure%20numbers%3F,less%20than%20120%2F80%20mmHg.&amp;text=No%20matter%20you're%20age%2C%20you,pressure%20in%20a%20healthy%20range.
preventing cardiovascular disease. Increasing daily exercise can help reduce resting heart rate and blood pressure, both of which are used as measures of cardiovascular well being. Increased understanding of the unique factors of the Greenland shark cardiovascular system will translate into more effective prevention of human cardiovascular disease. As it stands, the most critical step now is to develop methods of researching Greenland shark heart tissue.

**Metabolic Function**

Metabolism is closely related to every other aspect of health. Metabolism is defined as the sum of the catabolic and anabolic reactions that break down nutrients into fuel for the organism. The process of metabolism involves the management and regulation of thousands of enzymes. This system must be carefully balanced and maintained at all times in order to keep the organism in homeostasis. Aging has a considerable impact on metabolism. There is a near linear relationship between age and decreasing basal metabolic rate. In contrast, Greenland sharks have an extremely low metabolic rate at all ages. Greenland sharks average a resting routine metabolic rate of 20.86 mgO_{2}h^{-1}kg^{-0.04}. This contradicts the expected metabolic cold adaptation seen in many other animals, leading to questions regarding the evolutionary benefit of maintaining such a low metabolism. Current evidence suggests that this may be an adaptation to allow Greenland sharks to last longer in between feeding periods as a result of inconsistent

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55 Ibid.

56 Ibid.
food availability.\textsuperscript{57} Regardless of why their metabolism is so slow, the rate itself may be a contributing factor to why these sharks live for so long. It is thought that there is an inverse relationship between metabolic rate and lifespan.\textsuperscript{58} The lengthy lifespan of Greenland sharks, combined with their known low metabolic rate, lends itself to the idea that researching the benefits of reduced metabolic rate could have positive impacts on human lifespan.

Greenland shark muscle tissue has a very low metabolic capacity paired with a low contraction rate. The abundance of slow twitch muscle correlates with Greenland sharks’ lower metabolic rate, as slow twitch muscle is used more in instances when energy needs to be used slowly and fairly evenly—such as swimming at a very slow rate all day.\textsuperscript{59} The low contraction rate likely prevents Greenland sharks from using all of their available energy sources at once, a reasonable adaptation in a nutrient poor environment. It should be noted that a low contraction rate does correlate with diminished capacity to engage in sustained aerobic or anaerobic contraction.\textsuperscript{60} In humans, slow twitch muscle fibers are present in high percentages in individuals that engage in endurance exercise, such as marathon runners and distance cyclers.\textsuperscript{61} Much like Greenland sharks, these individuals must hold a sustained pace, sometimes for hours, with minimal deviation. There is an inverse relationship between metabolic rate and muscle torque complexity, indicating that a low metabolic rate increases adaptability to changes in task

\textsuperscript{57} Ibid.
demands.\textsuperscript{62} Essentially, the low metabolic rate in Greenland shark muscle tissue could help them respond quickly to changes in their environment, extending the lifespan of their energy stores.

Metabolic rate is also closely related to cancer formation.\textsuperscript{63} Greenland sharks’ low metabolism could be a contributing factor in their mysterious lack of cancer development. Cancer cells require significantly more glucose to promote their rapid division.\textsuperscript{64} Cancers rewire the metabolic flow in an organism in order to channel as many resources as possible to themselves to fuel their exponential growth.\textsuperscript{65} Higher metabolism creates a greater supply of energy and nutrients, which can then be used to fuel tumor growth. Greenland sharks’ extremely low basal metabolic rate could make it difficult for cancers to fuel their own growth, decreasing the chances of tumor formation and further contributing to their centuries long survival.

Decreasing basal metabolic rate in humans is another method of potentially extending lifespan. Lower metabolic rates have been shown to promote slow twitch muscle formation, which is useful for decreasing the rate of fuel consumption. Decreased metabolic rate is also linked to lower risks of cancer formation. Slow metabolism is linked to weight gain and difficulty losing weight, so it is important to maintain a healthy balance if attempting to lower metabolic rate.\textsuperscript{66} There are ways to slightly manipulate metabolism, but drastic changes are


\textsuperscript{63} “Cell Metabolism and Cancer.” Cell Metabolism and Cancer | Center for Cancer Research. Accessed March 9, 2023

\textsuperscript{64} Ibid.


unlikely. That said, high intensity interval training and increased muscle mass are related to increased basal metabolic rate.\textsuperscript{67} Caloric intake also has an effect on metabolic rate, with high caloric intake being associated with higher basal metabolic rate and low caloric intake relating to lower basal metabolic rate.\textsuperscript{68} Greenland sharks are opportunistic eaters, meaning they consume heavy, energy dense meals whenever possible to counteract the nutrient poor environment of the deep Arctic.\textsuperscript{69} This dietary pattern would likely not translate well to humans for long term metabolic reduction. Though Greenland shark metabolism could contribute to their longevity, decreasing human metabolism might not be the best strategy in humans, as it can lead to obesity, causing a host of other issues.

**Further Study**

Clearly, developing a broader understanding of the factors contributing to Greenland shark longevity is important in attempting to extend human longevity. Whole organism studies are especially complicated in this case, as Greenland sharks dwell in the depths of the Arctic Ocean, sometimes as far down as 2,200 meters.\textsuperscript{70} Additionally, Greenland sharks average 13 kilometers of distance per day, making recapture difficult even with tracking.\textsuperscript{71} The number of logistical limitations impairs the possibility of extensive research on Greenland sharks. Fortunately, some potential solutions exist for this problem.

\textsuperscript{67} Ibid.  
\textsuperscript{70} Campana, S. E., Joyce, W., Fowler, M., and Showell, M. (2015b). Discards, hooking, and post-release mortality of porbeagle (Lamna nasus), shortfin mako (Isurus oxyrinchus), and blue shark (Prionace glauca) in the Canadian pelagic longline fishery. ICES J. Mar. Sci. 73, 520–528. doi: 10.1093/icesjms/fsv234  
\textsuperscript{71} Ibid.
Given the complicated nature of whole organism studies, whole genome sequencing for Greenland sharks offers potential insight into unique aspects that may contribute to their long lives. Nearly 100 Greenland sharks have had their genome sequenced, which will help identify areas of interest for further research.\textsuperscript{72} The majority of these samples have been acquisitioned via tissue studies on individual sharks through a catch and release program.\textsuperscript{73} Establishing a whole genome sequence for the Greenland shark could shed light on the limitations of vertebrate lifespan and genetic contributors to this factor. It would also aid in identifying important genes, such as the presence of TP53 genes and useful mutations that could be applied to human biology.

One of the major limitations to tissue studies is the lack of information they provide on whole organism physiology. Conducting experiments on tissue samples is often complicated as they do not remain viable outside of the organism for extended periods of time. Studying Greenland sharks in captivity presents a host of issues. Firstly, adult Greenland sharks can grow up to 7 meters and weigh up to 1,025 kilograms.\textsuperscript{74} Their size alone would be prohibitive in building a suitable tank for them at the surface. The difference in pressure would also potentially negatively impact Greenland sharks. They swim at depths ranging from surface level to 2,200 meters below sea level, a difference that would be difficult to replicate in a laboratory setting.\textsuperscript{75} Technology, such as the AbyssBox, is currently being developed to aid in bringing deep water dwelling organisms to the surface.\textsuperscript{76} Creating a healthy environment for a captive Greenland


\textsuperscript{73} Ibid.


\textsuperscript{75} Ibid.

shark would require a tank with dimensions in the kilometers. The water temperature would have to be between -1.8 °C and 4 °C to mimic that of the Arctic Ocean.\textsuperscript{77} It would be incredibly difficult and cost prohibitive to attempt to recreate the Greenland shark’s natural habitat in a lab setting, and would be a poor substitute even with unlimited resources.

Seaside sanctuaries might be a viable alternative to laboratory studies, allowing a more accurate recreation of the Greenland shark environment. A seaside sanctuary essentially bars a small inlet or bay off from the rest of the ocean, keeping the large animals contained. The goal of seaside sanctuaries is to maximize the autonomy of the animals and mimic their natural environment as closely as possible.\textsuperscript{78} This is currently being implemented in Nova Scotia as a strategy for rehabilitating former captive or injured Orcas.\textsuperscript{79} Creating a seaside sanctuary for researching Greenland sharks is comparatively easier than establishing a laboratory setting for them. Once the structure itself had been constructed, a couple specimens would need to be relocated to be inside the pen. There, they could be studied for a few months to a year before being released. The release would minimize long term stress on the sharks and also free up space in the sanctuary to bring in new specimens.

Open ocean studies offer another chance to observe Greenland sharks with minimal risk of experimental factors altering their behavior. Baited cameras have been used to observe qualitative data about Greenland sharks, such as swimming speed, approximate size, and


\textsuperscript{79} Ibid.
mannerisms. Ultrasonic telemetry has provided useful insight into swimming and diving behavior, temperature preferences, and potential feeding behaviors. Tagging efforts could also offer another strategy of measuring population and travel patterns in Greenland sharks.

More research needs to be conducted to better understand the physiology of Greenland sharks, including their more secretive practices, such as mating, birthing, and feeding. Designing a method of tagging and tracking female Greenland sharks may shed insight on their mating habits, which, as of now, remain unknown. Greenland shark mating and birthing has never been observed, leaving many questions unanswered about the gestation period, mating habits, and whether Greenland sharks are viviparous, oviparous, or ovoviviparous. Only one pregnant Greenland shark has ever been observed, and its pregnancy indicated that Greenland shark embryos may be aplacental viviparous or ovoviviparous. Tagging and tracking future female Greenland sharks could provide important information that could aid researchers in understanding their reproductive patterns and in conservation efforts.

**Conservation Efforts**

Conducting further research on Greenland sharks is critical to understanding how their biology contributes to their lifespan. In order to use this information to further research into

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human longevity, preservation of this species is crucial, especially given that living specimens are necessary for deepening the understanding of Greenland shark physiology. Greenland sharks are currently classified as near-threatened. They were hunted extensively due to their valuable liver oil, but many Greenland shark fisheries have shut down as demand for liver oil has decreased. Now, the biggest threat to Greenland sharks is commercial fishing. As deep sea trawling increases in popularity, Greenland sharks are turning up more often in bycatch. Around 3,500 Greenland sharks are captured as bycatch yearly. This has had a devastating impact on Greenland shark populations. Greenland sharks do not reach sexual maturity until approximately 150 years old, which makes it hard for their population to recover from overhunting or increases in accidental deaths. Deep sea trawling adversely affects most areas of the deep sea biome, from shark populations, to coral formations, to populations of fish that are actually intended to be caught. Gillnets used for trawling that are lost at sea can kill ocean animals for years. Developing new fish hooks and trawling nets is an important step in reducing bycatch incidents. While this technology is in development, spreading awareness of the negative impacts of bycatch and the importance of sustainable fishing practices are critical.

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85 Ibid.
91 Ibid.
Protecting the Greenland shark so this wonderful species is around for years to come is not only important for scientific reasons, but also for cultural reasons. Greenland shark meat - or Hákarl- is considered a delicacy in Iceland. Due to the high concentration of uric acid and trimethylamine oxide in the meat, it must undergo a special fermentation process to be safe for human consumption. Many of the sharks that become Hákarl were first captured as bycatch, and one Greenland shark can provide up to 10,000 servings of Hákarl. As Hákarl is mainly eaten ceremonially during the yearly Þorri festival, it can be concluded that the supply of Greenland sharks from bycatch far exceeds the demand for Hákarl. Outside of this yearly festival, the main market for Hákarl consumption is tourists, but even that is minimal.

It is important to pursue conservation efforts for Greenland sharks if further research is to be conducted on them. Reducing the rate of Greenland sharks turning up as bycatch is central to this cause, as bycatch and overfishing is the leading cause of Greenland shark death. This can be accomplished through further development of sustainable fishing practices and increased education about the importance of sustainable fishing. While minimizing the death rate of Greenland sharks is important, the cultural history of Iceland must be respected. There must be a careful balance between killing enough Greenland sharks to continue Icelandic traditions and simply creating needless deaths.

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Conclusion

Developing a greater understanding of the factors that contribute to Greenland shark longevity could have extraordinary implications for increasing human lifespan and longevity. Understanding what causes them not to develop and die from cancer would help make great strides in human cancer research. This knowledge could be used to develop new treatments in severe cases or even preventative treatment for especially cancer prone patients. The Greenland shark cardiovascular system could serve as a model for reducing rates of human cardiovascular disease by expanding the current understanding of the impacts of blood pressure and stroke volume on human physiology. Finally, understanding the implications behind Greenland sharks’ extremely low basal metabolic rate could also contribute to a greater understanding of how metabolism affects the aging process in humans.

Currently, significantly more research needs to be conducted on these amazing animals if their full physiology is to be understood. Assembling a full genome sequence will help identify areas of interest for further research. Conducting open ocean studies will help establish an understanding of their physiology as a whole.

The necessity of this research expounds the importance of protecting Greenland sharks. Without an abundance of live samples, all hope for understanding the intricacies of these animals will be lost. Reducing bycatch while still respecting the cultural significance of Greenland sharks will hopefully aid in changing their protective status from near-threatened to least concerned, ensuring their survival for generations to come.
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Greenland Shark Lifespan

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