(Over)Analysis of Imminent Sharknados

Jesus Rodriguez

Table of contents

Preface

You are a data scientist for a mid-sized business, in a small group of 3-4 data scientists. You've been tasked with creating a report evaluating a scenario for your business. Your colleagues will also be evaluating the same scenario, and your reports will be used in aggregate to determine a consensus (or lack thereof) on the company's action. The reports will also be used to inform downsizing that is rumored to be coming - you want to ensure your report is better than your peers so that you aren't as easy to cut.

You may talk to your peers who are assigned the same scenario, but you do not want to collaborate too closely, lest you both become targets of the rumored layoffs.

I've scaffolded this report for you to make this process easier - as we talk about different sections of a report in class and read about how to create similar sections, you will practice by writing the equivalent section of your report.

The basic steps for this task are as follows:

- Identify the research question from the business question

What is the frequency of tornadoes that form in shark infested waters on the coastline happen to move inwards, and how common is it that these same tornadoes also have the strength to lift sharks from those waters?

- Identify data set(s) which are (1) publicly available (you don't have a budget to pay for private data) and (2) relevant to your task
  - (HW Week 6) Document your data sets in `draft-data-doc.qmd`
- Conduct a statistical analysis to support your answer to your research and business questions
  - Write a methods section for your business report corresponding to your statistical analysis
  - (HW Week 9) Draft of results section of business report with relevant graphics/visual aids in `draft-results.qmd`

- Write your report
  - (HW Week 10) Draft of Intro/Conclusion sections in `draft-intro-conclusions.qmd`
  - (HW Week 11) Draft of Executive summary section in `draft-exec-summary.qmd`
- Revise your report
  - (HW Week 12 – not turned in) Revise your report
  - (HW Week 13) - Rough draft of report due. Create one or more qmd files for your report (you can overwrite or delete intro.qmd and summary.qmd), include the names of each file (in order) in `_quarto.yml`. You should use references (edit references.bib and use pandoc citations). Make sure your report compiles and looks reasonable in both html and pdf.
  - Develop a presentation to go along with your report (Week 13). Create slides for your report using quarto.
- Peer revise reports
  - Peer revise reports
  - (HW Week 14) - Make edits to your report from comments received from peer review
- Final report & presentation due

1 Execectuive Summary

1.1 Purpose

The Sharknado film series takes the idea of tornadoes picking up marine life to a dramatic extreme. While there has not been a documented case of a tornado hurling sharks onto land, we explored whether such an event is even scientifically plausible. We examined whether powerful tornadoes could form over or near coastal shark-infested waters enough for them to become sharknados.

1.2 Evalutation

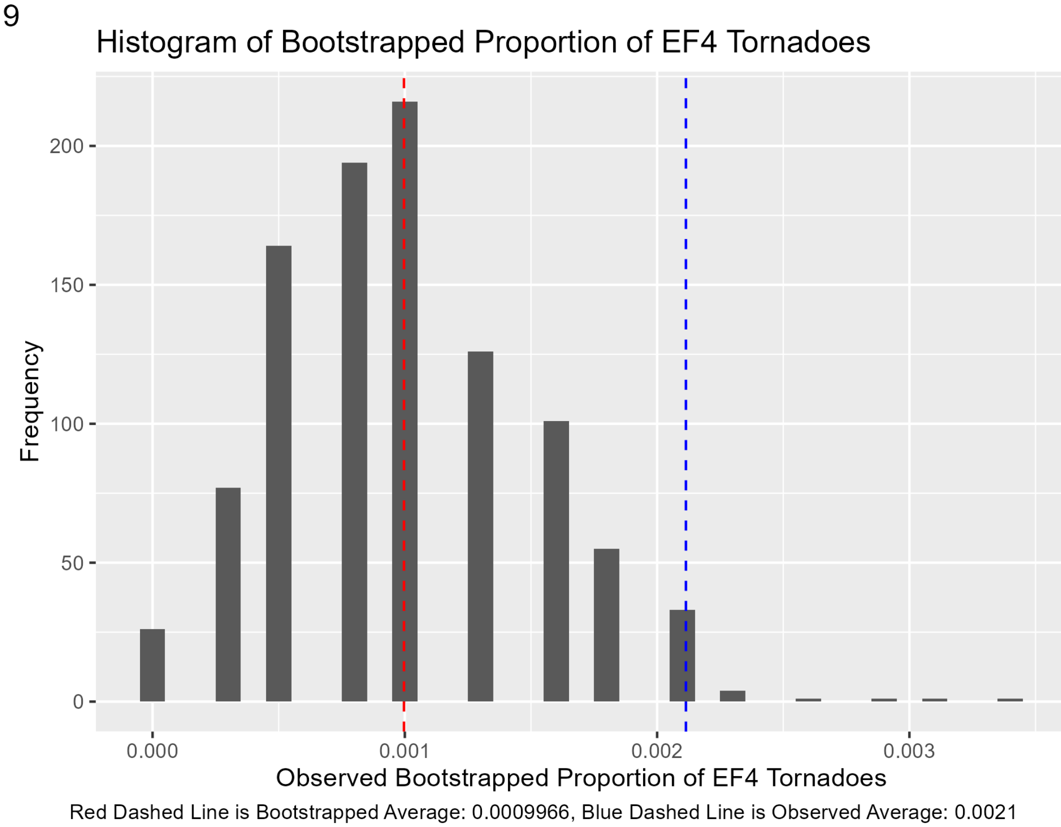
To assess the likelihood of a tornado capturing sharks within its vortex and terrorizing the public, we analyzed tornado data from 2020 to 2025 and shark data near U.S. coastlines, particularly around the Gulf of Mexico. We defined two key measurable conditions that are required for a Sharknado to occur: (1) a tornado must be strong enough to lift a shark and (2) it must form over or near shark-inhabited waters.

Tornadoes, waterspouts, sharks, and shark incidents were plotted on a map and the coasts of the United States were highlighted to better illustrate them.

1.3 Findings

Our findings indicate that waterspouts, tornadoes that form over water, are generally weaker than their land-based counterparts and are unlikely to lift large animals such as sharks. Tornadoes on the other hand, only two types of tornadoes have the potential to lift sharks from the water, these are EF4 and EF5 tornadoes. These tornadoes typically do not form directly over shark-infested waters or in close proximity to coasts of the Unites States. Even under theoretically perfect conditions, a proportion of 1000 bootstrapped samples based on the tornado data collected from 2020-2024 from NOAA, we get an observed bootstrap average of 0.0006 which is significantly smaller than our observed proportion of EF4 tornadoes: 0.0021.

Figure 9



1.4 Reccomendations

The Sharknado scenario remains a thrilling fictional concept, luckily, the probability of such an event occurring any time soon in real life is extremely low. People can be rest assured. There is no immenent threat of tornadoes hurling sharks from skies.

2 Introduction

2.1 A Real Life Sharknado?

There is a growing concern over the possibility of a real life *Sharknado*, a tornado that forms over water, gathers sharks in its powerful vortex, and then travels onto land, carrying the sharks with it. These sharknados wreak havoc all throughout the United States in locations like Los Angeles, New York City, and even Washington D.C. all the way down to Orlando, Florida raining sharks down from the sky. There have been circumstances where tornadoes have picked up animals such as fish and frogs, if one's imagination is not limited, one could see it be possible for tornadoes to carry sharks. Although this concept originates science fiction movie series, it raises serious questions on how thin the line between fiction and reality might be when it comes to such a catastrophic event.

2.2 Tornadoes and Sharks

To help figure out how a *sharknado* would be possible, the strengths and conditions of tornadoes must be analyzed to see how they could carry these apex marine predators.

2.2.1 How Strong can a Tornado Be?

The Enhanced Fujita Scale (EF Scale), which is used to assign a tornado a rating based on estimated wind speeds. The scores and their estimated wind speeds go as follows:

2.2.1.1 Enhanced Fujita (EF) Scale and Wind Speeds

Table 2.1: Enhanced Fujita (EF) scale and corresponding wind speeds

EF_Rating	Wind_Speed_Range
EF0 (Weakest)	65 - 85 mph
EF1	86 - 110 mph
EF2	111 - 135 mph
EF3	136 - 165 mph

EF_Rating	Wind_Speed_Range
EF4	166 - 200 mph
EF5 (Strongest)	Over 200 mph

Minor damage such as broken tree branches and roof shingles being blown away can be expected from EF0 tornadoes. While on the other end of the spectrum, EF5 tornadoes can promise wind speeds that can decimate well built homes and infrastructure. These tornadoes can carry objects like cars with no trouble. An EF2 tornado is where we finally see enough force for winds to pick up a small car around 2000lbs, but not enough force for it to be thrown wildly. In the center, an EF3 tornado can remove the roofs off buildings on uproot small trees. An EF4 tornado is where we finally begin to see heavy objects such as trucks, cars, and semis be thrown around considerable distances ("Tornadoes | National Oceanic and Atmospheric Administration" (n.d.)).

An EF5 tornado will for sure have the potential to be a *sharknado,* and another contender is the EF4 tornado and maybe, if the conditions are just right, an EF3 tornado might be able to, however, this is being very generous. Our *sharknado* would realistically have to be a category EF5 or EF4 tornado in order to cause terror similar to the film.

2.2.2 Tornado or Waterspout?

This *sharknado* would need to have a tornado that forms over shark infested waters. A tornado that forms over water is usually classified as a waterspout. Waterspouts are not classified as tornadoes, so they are not given a score on the EF scale. If a waterspout moves on shore however, The National Weather Service classifies it as a tornado and issues a tornado warning for the area.

Waterspouts are generally broken into two categories: fair weather waterspouts and tornadic waterspouts. Fair weather waterspouts to put it simply are a less dangerous event that form during relatively calm weather and are not associated with thunderstorms. The phenonema of interest are tornadic waterspouts. These have the same characteristics of a land tornado, they are often accompanied by high winds, severe thunderstorms, large hail (US Department of Commerce (n.d.)). It is essentially a tornado that forms over water, but it can also form by a tornado moving from land to water. If a *sharknado* would occur this is how it would form!

2.2.3 Sharks in Waters in the United Sates

Sharks are found in coastal waters along the East Coast, Gulf of Mexico, and the Caribbeans. These waters are where a *sharknado* would have to form.

Sharks vary greatly in size and weight. Some common sharks and their average adult weights include (Fisheries (n.d.)) :

Table 2.2: Shark species and typical weight ranges

Species	Weight_Range_lbs
Atlantic Sharpnose	15 - 25
Atlantic Blacktip	66 - 200
Tiger	850 - 1400
Hammerhead	500 - 1000
Sandtiger	200 - 350
The Great White	1500 - 2400

The sharks that were commonly seen inside the *sharknado* were the tiger shark, the hammerhead shark, and of course, the great white shark.

2.3 Can a Sharknado Actually Occur?

Is it possible to predict if a *sharknado* can happen in real life using exisiting data about sharks and tornadoes from years past?

To answer this burning question, a scrutinizing look at meteorological and marine data must be done.

3 Methods

3.1 Load Neccessary Libraries

Throughout the statistical , many R packages were used. There were three packages used to read in data, these being the readr and readxl packages which were used to read in common data formats such as .csv and .xlsx, while the sf package was used primarily for spatial data such as .shp and .kml files. The sf package was used to perform some data wrangling on spatial data as well. Other packages for data wrangling, cleaning, and manipulation were the dplyr, tidyverse, and stringr. The ggplot2 package was used to help make well designed charts and maps with accompanying titles, captions, and tags. With the use of ggplot(), the maps and mapdata packages were loaded in order to create maps of the United States, the West Coast, the Gulf of Mexico and East Coast, as well as Hawaii. Lastly, the knitr and patchwork packages were utilized to create better looking tables and charts in the quarto document.

3.2 Shark Data

Four shark datasets were used in this business report. Three come from trusted government agencies and report a survey of sharks tagged in the Gulf of Mexico, Florida, and Hawaii. The fourth one differs from the rest, being that it is data recorded on shark incidents in California.

3.2.1 Cleaning Shark Data

Not much data wrangling was needed to prepare for shark distribution plotting. However, in California's shark incident dataset, empty longitude and latitude were removed.

These are the following sharks included in each dataset.

Table 3.1: Names and Estimated Weights of Sharks in California Dataset

Scientific Name	Common Name	Max Weight (lbs)
PRIONACE_GLAUCA	Blue	400
SPHYRNA_MOKARRAN	Hammerhead	992

Scientific Name	Common Name	Max Weight (lbs)
ORCINUS_ORCA	Killer Whale	8800
TRIAKIS_SEMIFASCIATA	Leopard	70
LAMNA_DITROPIS	Salmon	992
NOTORYNCHUS_CEPEDIANUS	Sevengill	1100
ALOPIAS_VULPINUS	Thresher	1102
UNKNOWN	Unknown	NA
CARCHARODON_CARCHARIAS	White	5000

Table 3.2: Names and Estimated Weights of Sharks in Gulf of Mexico and Altantic Dataset

Scientific Name	Common Name	Max Weight (lbs)
ALOPIAS_VULPINUS	Common Thresher	1102.3
CARCHARHINUS_ACRONOTUS	Blacknose	39.7
CARCHARHINUS_ALTIMUS	Bignose	370.4
CARCHARHINUS_BREVIPINNA	Spinner	198.4
CARCHARHINUS_FALCIFORMIS	Silky	762.8
CARCHARHINUS_ISODON	Finetooth	30.0
CARCHARHINUS_LEUCAS	Bull	507.1
CARCHARHINUS_LIMBATUS	Blacktip	269.0
CARCHARHINUS_OBSCURUS	Dusky	762.8
CARCHARHINUS_PEREZII	Caribbean Reef	154.3
CARCHARHINUS_PLUMBEUS	Sandbar	257.9
CARCHARHINUS_POROSUS	Smalltail	19.8
CARCHARHINUS_SIGNATUS	Night	39.7
CENTROPHORUS_GRANULOSUS	Gulper	24.3
CENTROPHORUS_UYATO	Little Gulper	6.6
CIRRHIGALEUS_ASPER	Roughskin Spurdog	33.1
GALEOCERDO_CUVIER	Tiger	1984.2
GINGLYMOSTOMA_CIRRATUM	Nurse	242.5
HEPTRANCHIAS_PERLO	Sharpnose Sevengill	44.1
HEXANCHUS_GRISEUS	Bluntnose Sixgill	2425.1
HEXANCHUS_NAKAMURAI	Bigeye Sixgill	352.7
MUSTELUS_CANIS	Dusky Smooth-hound	26.5
MUSTELUS_NORRISI	Narrowfin Smooth-hound	15.4
MUSTELUS_SINUSMEXICANUS	Gulf Smooth-hound	22.0
NEGAPRION_BREVIROSTRIS	Lemon	403.4
RHIZOPRIONODON_TERRAENOVAE	Atlantic Sharpnose	9.9
SCYLIORHINUS_RETIFER	Chain Catshark	3.3
SPHYRNA_LEWINI	Scalloped Hammerhead	334.1
SPHYRNA_MOKARRAN	Great Hammerhead	992.1

Scientific Name	Common Name	Max Weight (lbs)
SPHYRNA_TIBURO	Bonnethead	22.0
SQUALUS_ACANTHIAS	Spiny Dogfish	19.8
SQUALUS_CUBENSIS	Cuban Dogfish	15.4
SQUALUS_MITSUKURII	Shortspine Spurdog	17.6
SQUATINA_DUMERIL	Atlantic Angel Shark	77.2

Table 3.3: Names and Estimated Weights of Sharks in Hawaii Shark Dataset

Scientic Name	Common Name	Max Weight (lbs)
GALEOCERDO_CUVIER	Tiger	1984.2

3.3 Tornado Data

Five datasets from the past 5 years as of 2025, each containing information for a different year, were analyzed in this report. All datasets were taken from the same source, National Oceanic and Atmospheric Association (NOAA).

The reasoning behind only including data from the past five years is climate change and recent weather activity. Modern tornado data is more valuable to be analyzed in this report due to modern weather trends. So, even with NOAA offering data recorded starting from the year 1950, only current data was implemented to be analyzed.

3.3.1 Cleaning Tornado Data

The storm events included in this dataset ranged from avalanches to thunderstorms. Due to interest only being in the events: Tornadoes and Waterspouts, all other unneccessary events were filtered out and removed from the data. These two events were then categorized in their own dataset.

In the waterspout dataset, the latter, less powerful fair weather waterspouts were removed in order to evaluate tornadic waterspouts. For this to be done, in the data's 'Event Narrative' columns, where they include a brief summary on the event, only cases where the string *"tornad"* were selected, as this string would keep observations that discussed waterspouts that either: Were tornadic waterspouts or transformed into tornadoes.

For the filtered tornado dataset, observations where the EF Score of a tornado was "EFU" meaning unknown were removed in order to keep tornadoes with a properly rated EF Scale.

In both filtereed datasets, rows wth 'NA' values in thier beginning and ending latitude and longitude values were excluded.

3.4 Coastal Data

Coastal data for the United States was taken from the United States Geological Survey (USGS). This data set included data plotting the borders of U.S. coasts as well as U.S. territories, the latter was rejected for this report.

3.4.1 Preparing Coastal Data for Plotting Maps

In order to overlay what parts our coastal data define the coasts in the United States, a plot consisting of both coordinate and spatial data was made.

The way to plot the coasts differed due to the data being spatial. The sf package was used to highlight (what the dataset considered) the coasts with a red outline. The coordinates were changed to make maps of the following regions: United States, The Southeast and Gulf of Mexico, The West Coast, and Hawaii.

This processed gave us the maps to be plotting shark and tornadoes with.

3.5 Comparing Waterspouts to Tornadoes

Tornadoes and waterspouts are classified as two different events. Both fit one of the requirements for a sharknado: The event must form over *or* near shark-inhabited waters. However, there is no simple, concrete way to measure the power scale of waterspouts. Therefore, an oversimplified way to check how much damage they are capable of is to look at the average cost of property each event has caused in our sample.

The following data wrangling was needed in order to get a clean chart comparing the averages. The data's property damage column was formatted as 100K or 1M, meaning $100,000 and $1,000,000. To combat this, rows with the letters K or M in the "DAMAGE_PROPERTY" column were multiplied by 1000 and 10000000. This prepared the property damage to be averaged out and listed in a chart using ggplot() from the ggplot2 packge.

3.6 Plotting Waterspouts

When plotting waterspouts, only the tornadic waterspouts were considered, as these are more related to tornadoes and cause a much bigger disruption than fair weather waterspouts. In ggplot(), geom_segment() was used to plot the beginning and end points of waterspouts, to see if they'd move inland. Although some do, most do not move a noticeable distance away from there beginning coordinates, and if they do, they do not make landfall.

3.7 Plotting Tornadoes

When plotting tornadoes, it is a very similar process to plotting waterspouts. In this situation, we only want tornadoes as our EVENT_TYPE. In the beginning, using geom_segment() was considered when plotting tornadoes, however, this caused the map to become more bloated than it already is, so it has been commented out in the code.

3.8 Bootstrap Sampling Assuming Perfect Conditions

Theoretically, assume the two most powerful tornadoes, EF4 and EF5, will become sharknados, given that they are coastal tornadoes, in other words: they form inside in the coastal data's spatial perimeter.

3.8.1 Joining Spatial Coastal Data and Regular Lat-Long Tornado Data

In this report, a 'coastal tornado' is defined as a tornado that falls inside the coordinates of the multipolygon coastal spatial data plotted. Some implications such as tornado points that fall on the borders will arise from this however.

The tornadoes coordinate data points were joined with the coastal spatial data polygons. The tornado points were transformed into spatial data via st_transform() from the 'sf' package. Then with the st_join() from the same package, we can finally filter all the points inside the coastal regions like we want. Here, the observed proportion of EF4 and EF5 tornadoes on the coasts was also found and it will be shown in the results.

3.8.2 Bootstrap Histogram

A histogram is made to show the distribution of the bootstrapped proportions, with a red dashed line showing the mean of these samples. Assuming an alpha level of 0.05. A long run proportion greater than 0.05 will be needed to state that, *assuming perfect conditions*, a sharknado will form.

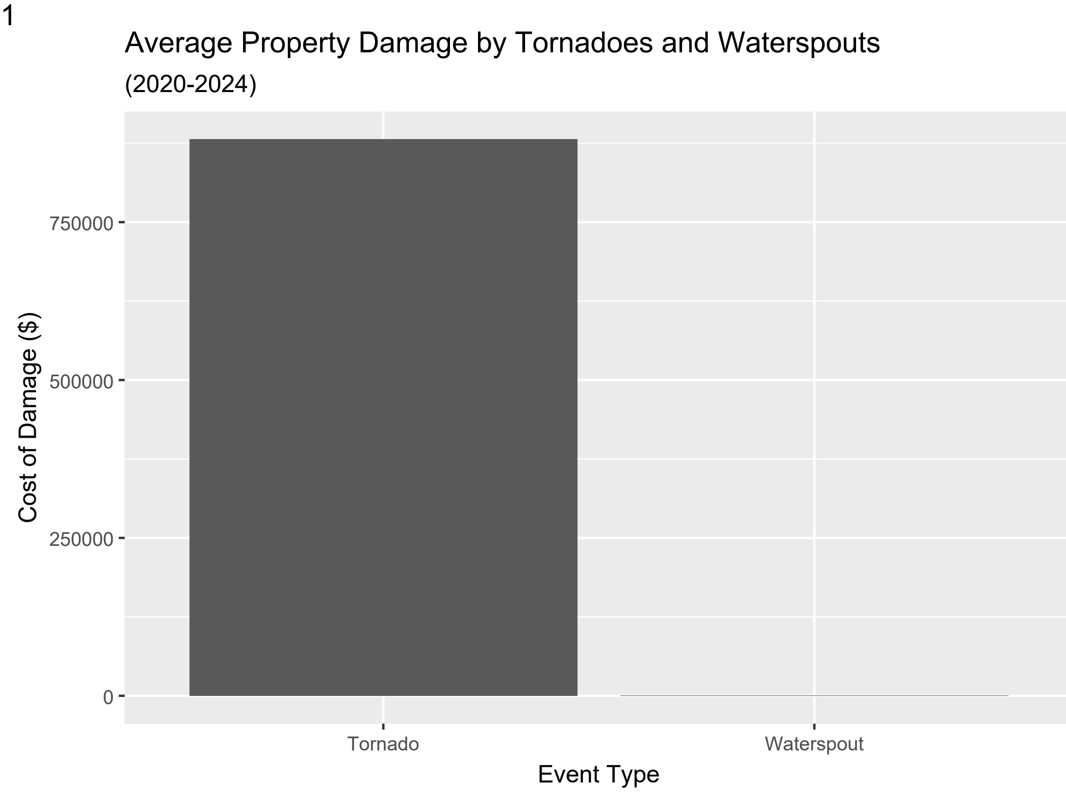
4 Results

4.1 Tornadoes that form over water (also known as "Waterspouts") in shark-infested waters, *that also* move inwards towards land, do not have the potential to carry sharks over towards mainland cities to cause a disruption similar to the movie 'Sharknado'

When plotting the data for sharks and waterspouts, it is apparent that waterspouts are not a common occurrence (at least in the past five years). These waterspouts have not caused any major damage to property or crops, and no deaths or injuries have been recorded, they either do not possess the strength to do so and many of these waterspouts do not last longer than an hour. The most action that has happened has been an incident where a waterspout damaged two vehicles and a power line, causing $5000 in damages. But when compared to tornadoes, this is very minuscule (See Figure 1). This clearly shows that tornadoes that form on water lack the power necessary to lift sharks.

In a perfect world, the better way to compare power is to compare levels on the Tor EF Scale. The scale that ranks how strong a tornado is from EF1 to EF5. However, waterspouts are not considered tornadoes and they do not have a power scale similar to tornadoes.

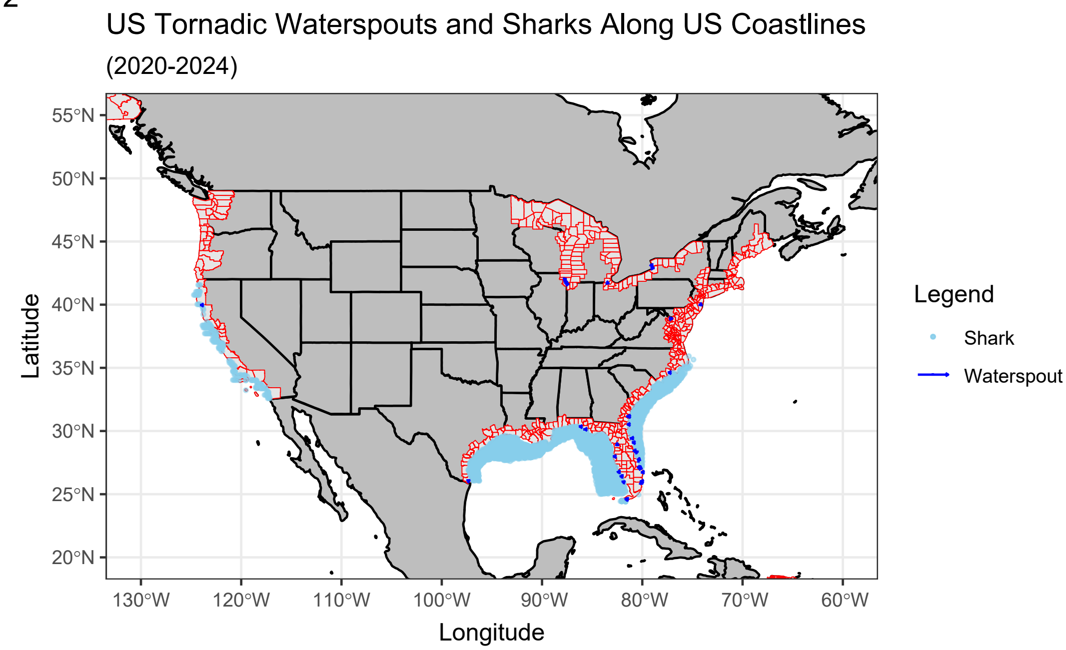
Figure 1



Waterspouts are very weak when compared to tornadoes. Their average in property damage is a $7.96.

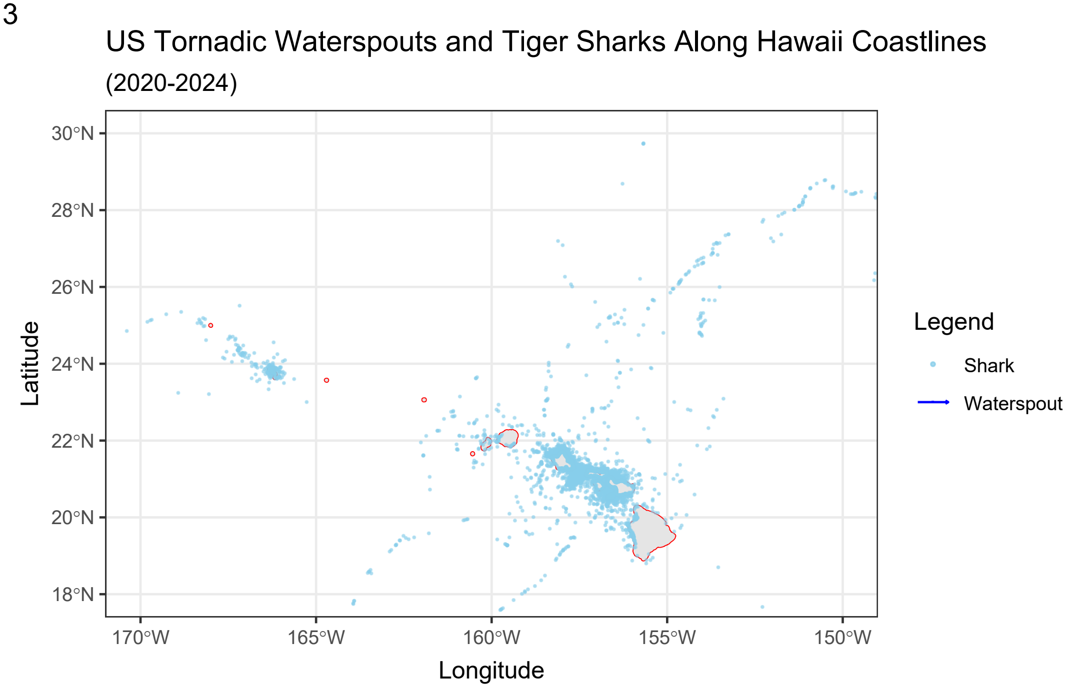
Considering that tornadic waterspouts are not capable to cause much destruction, plotting them is still valuable to see just how common they are in the United States. Two maps (Figures 2 and 3) are given to see their distribution among the sharks around the coasts of the US and Hawaii. It is important to remember that these maps showcase only the more capable **tornadic** waterspouts. These kinds of waterspouts are the most common in Florida, while the rest of the United States lacks these specific types of events. Given they are relatively weak, rest can be assured that no sharknados can be possible from a waterspout.

Figure 2



Very little waterspouts are actually tornadic. Florida seems to have the most activity.

Figure 3



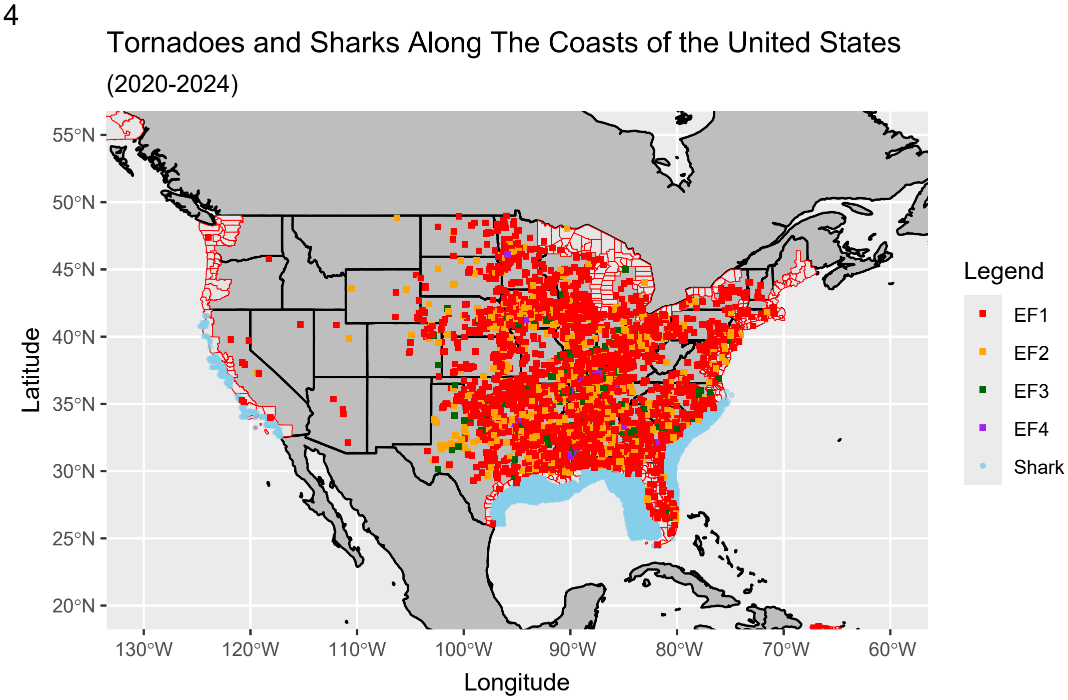
Although many sharks surround Hawaii, no tornadic waterspouts have formed at all.

4.2 Tornadoes that are strong enough to carry the weight of sharks do not typically form near the coasts.

Visualization of the distribution of tornadoes shows that tornadoes with enough strength to pull sharks from the depths of the water form near enough to the coastlines to cause "shark-terror." In the United States, EF1 and EF2 tornadoes are very common and form throughout the Midwest and Southeast the most. EF3 tornadoes appear throughout the Midwest and Southwest as well, although they are less common. These three types of tornadoes all seem to be the most common that occur on the coasts of the United States as well. EF4 and EF5 tornadoes on the other hand, are not that common (see Figure 4). In our data, there is no data recorded for an EF5 tornado, making them the least common among them all. Our analysis did not have any tornadoes appear in Hawaii (see Figure 5).

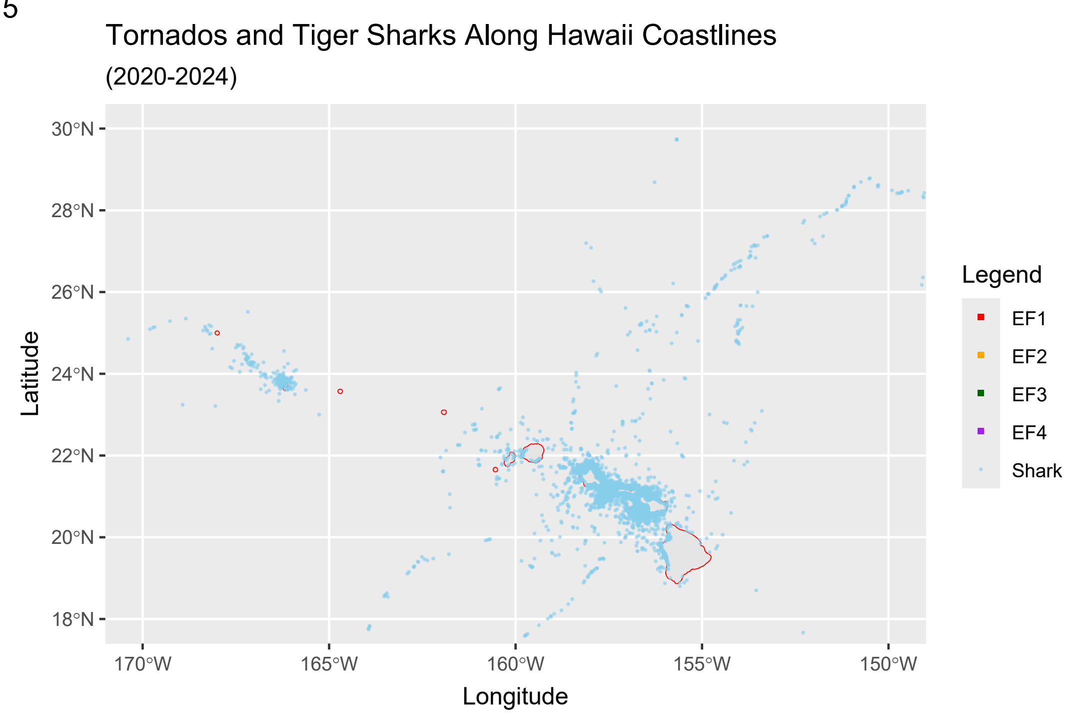
Tornadoes with less potential are more common throughout the United States. There seems to be an inverse relationship with EF Scale and Count of Tornadoes.

Figure 4



The weaker a tornado, the more common it is.

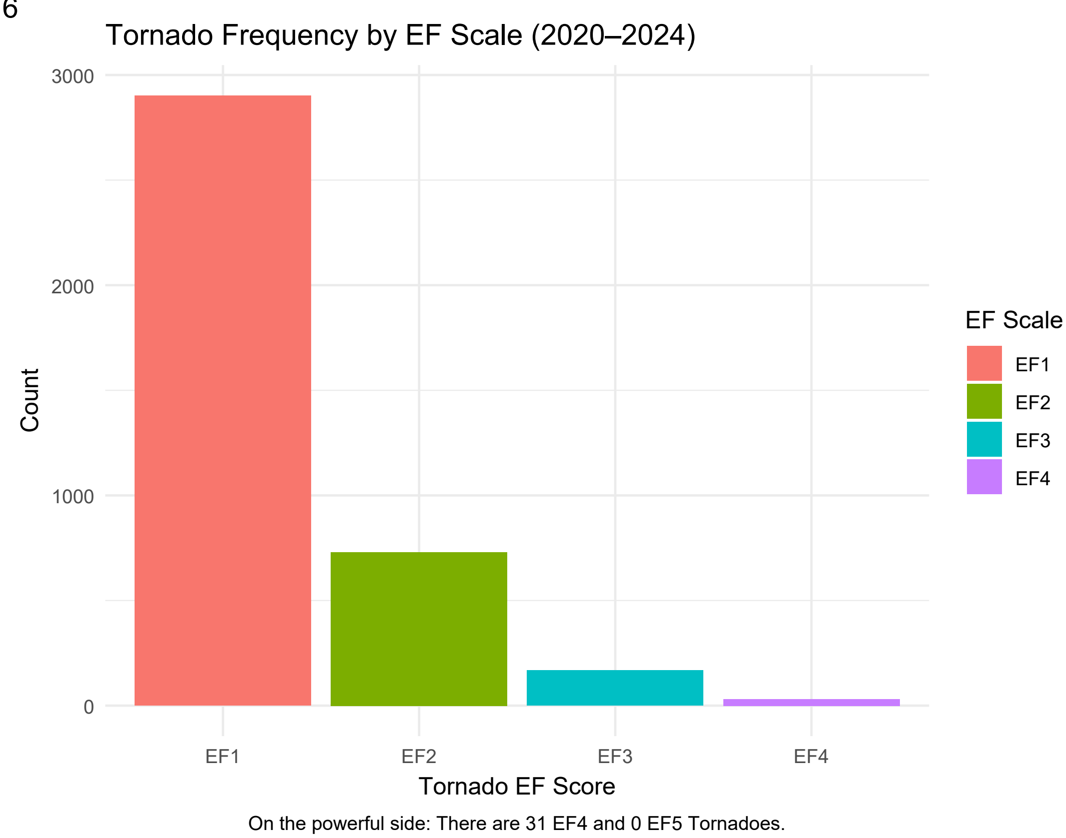
Figure 5



A tornado seems to be very uncommon around this shark-surrounded state.

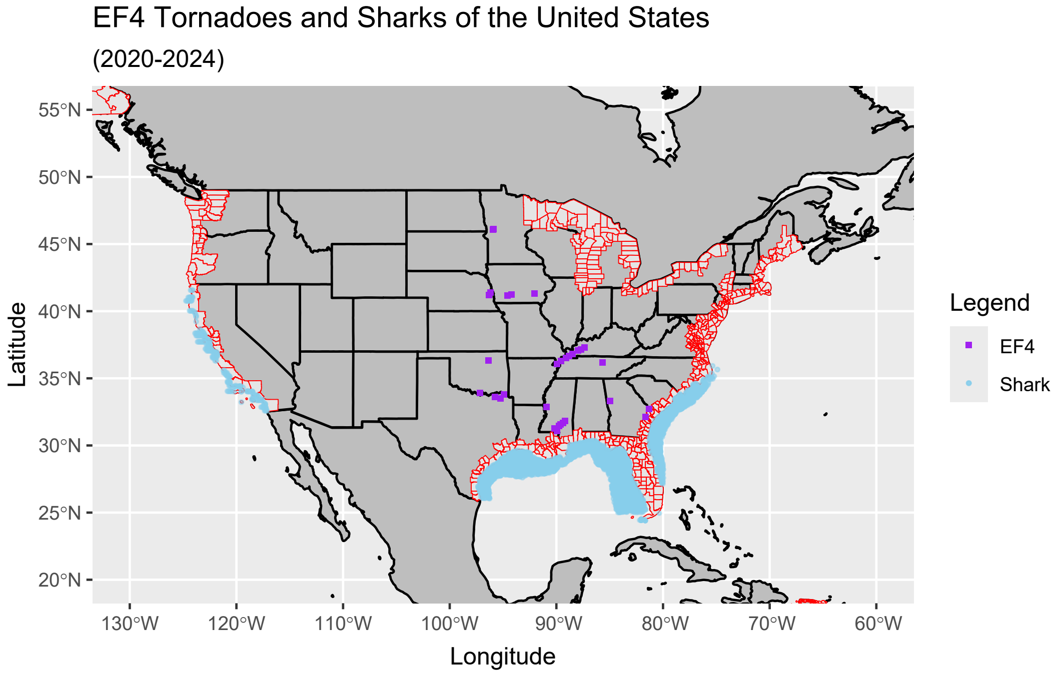
To better illustrate the EF Scale and Tornado Count Relationship (see Figure 6). Further analysis from this point on will disregard tornadoes with an EF Scale lower than or equal to 3, as these don't have the potential to even toss cars carelessly.

Figure 6



Only considering tornadoes with an EF Score greater than 3, a clearer view at the distribution of EF4 and EF5 tornadoes show that most do not tend to form near the coastlines. There are a few exceptions, yet these still are not close enough to the ocean waters to haul sharks from their habitat (See Figure 7).

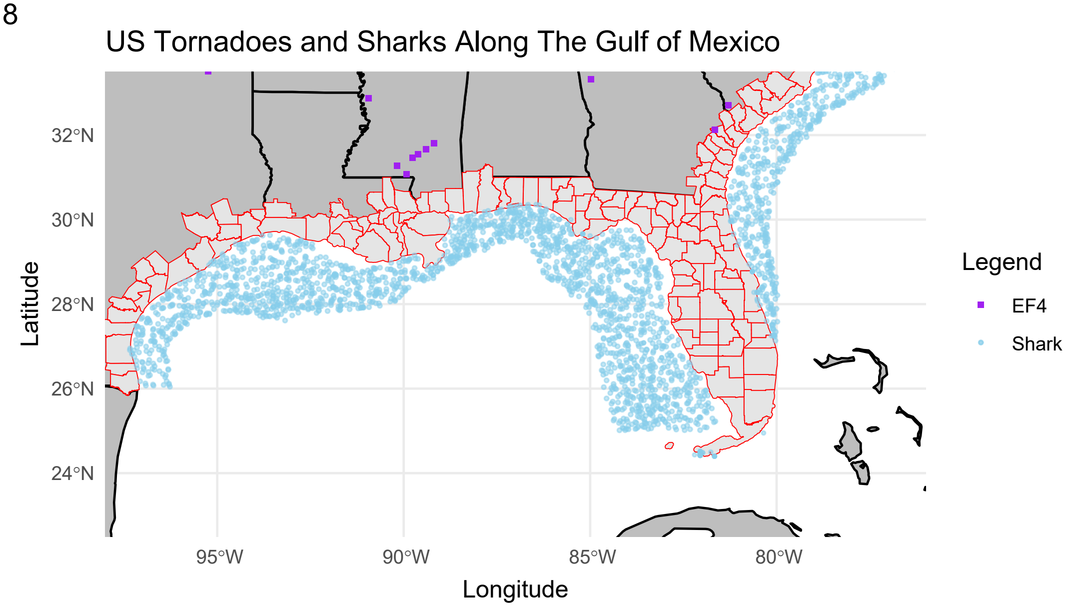
Figure 7



Only the Southeast Coast seems to have any occurrences of these tornadoes.

It seems if a sharknado were to form, it would occur in the Southeast Coast, near Alabama and the Gulf of Mexico. Yet, these tornadoes are still not near enough to the ocean and any population of sharks. See Figure 8 for a closer inspection.

Figure 8



There is a small amount of EF4 tornadoes and 0 EF5 tornadoes that are close to the coasts.

These illustrations show that effective tornadoes are typically going to form on the coasts. In fact, the proportion of these tornadoes greater than EF3 that formed on the coastal data plotted is 0.0021142. This is from 2 tornadoes from the 473 total tornadoes that fall inside the coastline. From the entire dataset, the probabilty a tornado is greater than EF3 is 31/3831 or 0.0080919. This is just from our one sample of analysis.

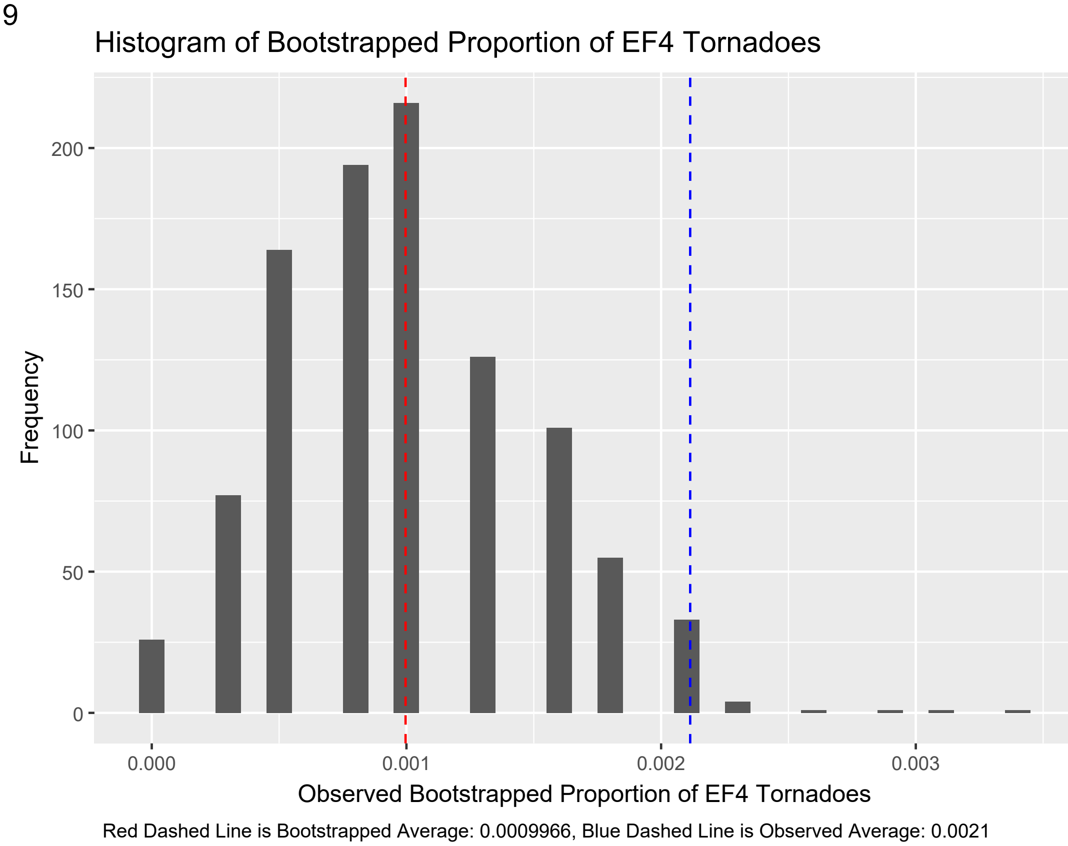
4.3 Assuming perfect conditions, it is still unlikely that capable tornadoes can form close enough to the coasts to become a sharknado.

Given these drastic, theoretical assumptions:

- All EF4 or higher tornadoes that form within the data's coastal perimeters will become sharknados

Using bootstrap sampling with replacement, our analysis suggests that there is a non-negligible long-run probability of dominant tornadoes forming near the coasts. Based on our data, there is not enough coastal tornadoes occur to plausibly support the hypothetical threat of a "sharknado." An observed bootstrapped proportion of EF4 tornadoes becoming sharknados is found to be 0.081 (See Figure 9).

Figure 9



Assuming the bootstrapped proportions follow an approximately normal distribution, the probability that there are averages greater than the observed average of 0.0021142, a p-value of 0.0141668 is found. This provides us enough evidence to deny any imminent threat of sharknados.

5 Conclusions

5.1 Tornadic Waterspouts Powerful Enough to Carry Sharks are not Very Realistic

Key findings suggest that a sharknado is not likely to occur. Waterspouts do tend to form in shark infested waters, but these are not powerful enough to lift sharks that can weight up to 2400 lbs and relocate them to land. From the more powerful of the two types of waterspouts, tornadic waterspouts' power are limited and never seem to make landfall.

5.2 There is a Little Amount of Tornadoes with a High Enough EF Score that form near the coasts

Tornadoes that do form near the coasts typically have an EF rating of EF2 or lower, with the occasional EF3. An EF2 tornado *has* the power to lift a car and move it from where it was, but when trying to find the possibility of lifting sharks throughout a city, a stronger EF4 tornado is very well needed to pull the sharks from the depths of the water. Although there are some EF3 tornadoes present in Florida, and EF3 tornadoes could pick up a car and throw them a considerable distance, these are not capable of producing a storm where sharks, like the Great Whites and Hammerheads in the films, are thrown violently. There is an EF4 tornado located in Georgia, however this tornado is not close enough to the ocean coasts that it would be able to make contact with the sharks present there.

5.2.1 Assuming Perfect Conditions, it is Still Unlikely that Capable Tornadoes can Form Close Enough to the Coasts to become Sharknados

Under the drastic assumption that all EF4 or higher tornadoes that form within the data's coastal perimeters will become sharknados, a long run average of `r mean_boot` is calculated. This means given perfect conditions and EF Scales being randomized with replacement, sharknados will form 0.10% of the time. We do not have enough evidence to state that sharknados are a probable threat in the near future, based on our tornado data from 2020-2025.

5.3 Real World Interpretation

People of the United States that live on the coasts can be clear of mind that a sharknado will not be one of their worries when it comes to weather events such as hurricanes and tropical storms.

5.4 Limitations in Data and Knowledge

5.4.1 No Free Shark Survey Dataset (From a Trusted Source) that Has Observations on the West Coast or Northeast of America

Although our data showed that tornadic waterspouts and tornadoes that form near the coasts of America do not form too often and are not that powerful, there was not much comparison when plotting those events against sharks surveyed or spotted outside of the Southeast or Hawaii. Data for California was found, however that was not survey or tracking data, rather it was shark incident data. This leads to more sharks being plotted in places that have more people, preventing an evenly distribution of shark points on the map. Due to this limitation, our interpretation can only be justified that people on the coasts of the Southeast region of America near the Gulf of Mexico, Hawaii, and California.

5.4.2 Bootstrapping

Our probability observed from our bootstrapped sample of 0.0010, truly only tells us that if the EF scales of the tornadoes in our dataset were randomized, this is the long run proportion of EF4 and EF5 tornadoes that will form near the coasts. However, the way the coastal data is set up, these tornadoes can be technically in the coastal region plotted, but be too far away from the coastline to be able to cause havoc with sharks.

Still regarding this, perfect conditions are assumed, and given there is no way based on the datasets collected to measure the probability of sharks being near the surface, this bootstrapped probability is only theoretical but it could be truly higher or lower.

5.4.3 Hurricanes?

In this report, only tornadoes were considered. This can be a bit problematic when looking at a place like the Southeast. It could be argued, that a hurricane of great strength could be enough to lift the numerous sharks surrounding Hawaii, but in as stated previous, we are not interested in *Shark-icanes*.

5.4.4 Comparing Tornadoes and Waterspouts

Waterspouts do not have any classification of power similar to tornadoes. In order to compare the differences in power between the two, the observed damage to property was looked at. A problem with this is that waterspouts will most likely be less damaging as they are not near much property at all when forming. This caused the averages to be compared instead, but there is still some limitations on how far the implication of just how strong waterspouts can be. It is clear though, that the greatest waterspouts, were still not able to match the power of tornadoes with a score of EF2 or higher.

5.5 Future Directions and Revisions

If a budget allows, using private data may be able to help know just how close these coastal tornadoes and tornadic waterspouts are to the shark population of America. It would also be very beneficial to collect a dataset from a source that record the depth of the shark, that way, the average depth of a shark by species can be found to better predict what sharks will be near the surface on a random given day.

References

Fisheries, NOAA. n.d. "Species Directory | NOAA Fisheries." https://www.fisheries.noaa.gov/species-directory.

"Tornadoes | National Oceanic and Atmospheric Administration." n.d. https://www.noaa.gov/education/resource-collections/weather-atmosphere/tornadoes.

US Department of Commerce, NOAA. n.d. "About Waterspouts." https://www.weather.gov/mfl/waterspouts.

A Data Documentation

This document summarizes several shark, tornado, and coastal datasets used to investigate spatial relationships between tornado-prone regions, shark distributions, and coastal areas. It describes the origin, purpose, structure, and limitations of each dataset.

A.1 Shark Data

Four shark datasets were used in this business report. Three come from trusted government agencies and report a survey of sharks tagged in the Gulf of Mexico, Florida, and Hawaii. The fourth one differs from the rest, being that it is data recorded on shark incidents in California.

A.1.1 Blacktip Shark Biological Data (2008–2010)

Source: NOAA InPort

Collected by: Southeast Fisheries Science Center (SEFSC), National Oceanic and Atmospheric Administration (NOAA)

Purpose: To study the foraging ecology of juvenile blacktip sharks in Florida and assess resource overlap

Coverage: Crooked Island Sound and Gulf of Mexico side of St. Vincent Island, Florida

Period: 2008–2010

Data Format: .csv file with separate columns for Day, Month, and Year

Structure: Biological and diet information of sharks, recorded through gillnets and longlines

Data Quality:

- Government source (NOAA); some missing values
- No listed license or use restrictions

A.1.2 NMFS Bottom Longline Survey Data (2010–2024)

Source: Data.gov

Collected by: SEFSC, NOAA

Purpose: To provide standardized, fisheries-independent data on sharks, snappers, and groupers

Coverage: U.S. Southeast and Gulf of Mexico

Period: 2010–2024

Data Format: Excel .xlsx file

Structure: Scientific names, measurements, weights, life history traits

Collection Method: Bottom longline surveys (day and night); sharks tagged or sampled

Formatting:

- Station Date: YYYY,MM,DD HH:MM:SS
- Species Name: Scientific name

Data Quality:

- Government source (NOAA)
- No license listed

A.1.3 Hawaii Tiger Shark Tracking Data (2016–Present)

Source: Pacific Islands Ocean Observing System (PACIOOS)

Collected by: PACIOOS

Purpose: To monitor the movement of tiger sharks using satellite tags

Coverage: Hawaii coastal waters

Period: 2016–Present

Data Format: KML (spatial) file

Structure:

- One species: Tiger sharks
- Spatial metadata embedded in geometry (KML) Data

Quality:

- Educational/research data
- Spatial column parsing may require additional formatting
- No license or usage policy listed

A.1.4 California Shark Incident Database (1950–2022)

Source: data.ca.gov

Collected by: California Department of Fish and Wildlife

Purpose: To document shark incidents along California coasts

Coverage: California coastal waters

Period: 1950–2022

Data Format: Excel .xlsx file

Structure & Key Fields:

- Date: YYYY-MM-DD
- Time: Decimal hours (e.g., 13.5 hrs)
- Shark Species: Common names (e.g., Blue, Blue* indicates uncertain ID)
- Details: Human activity, injury, depth, location, and source Data Quality:
- Public dataset with no usage restrictions
- Some incidents have unknown species recorded

A.2 Tornado Data

Five datasets from the past 5 years, each containing information for a different year, were analyzed in this report. All datasets were taken from the same source.

A.2.1 NOAA Sotrm Events Data (2020-2025)

Source: NOAA Storm Events Database

Collected by: National Centers for Environmental Information (NCEI), NOAA

Purpose: To track tornado-related damage and conditions in the U.S.

Coverage: United States (all states)

Period: 2020–2025 (annual datasets)

Data Format: .csv files

Structure & Fields:

- Date: YEARMONTH (e.g., 202403)
- Location: Latitude, Longitude
- Magnitude: Tornado category (EF scale)

Data Quality:

- Official government dataset; some missing values
- No formal licensing stated

A.3 Coastal Data

Only one dataset for coastal data was utilized in this report.

A.3.1 U.S. Coastal Zone Management Counties (2009)

Source: USGS Open File Report 2013-1284

Collected by: U.S. Geological Survey (USGS)

Purpose: To define official CZMP counties for coastal analysis

Coverage: 492 counties across the U.S. and territories

Period: Based on 2009 coastal conditions

Data Format: .shp shapefile with spatial geometry column

Structure:

- Multiple associated shapefile components (.shp, .shx, .dbf, etc.)
- Includes polygons with latitude/longitude of each coastal county

Data Quality:

- Government dataset
- No specific liscense given