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A Biting Review of Shark Attacks Off Florida's Coast, 1960-2016

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ABSTRACT

The authors examine the monthly total and average number of unprovoked shark attacks off Florida's Atlantic and Gulf coasts between 1960 and 2016, with special emphasis on the last twenty-seven years, divided into three nine-year intervals. Two-way connected-line plots, bar graphs and a series of two-sample t-tests reveal that monthly averages were highest in April (1999 – 2007) and September (1999 – 2007 and 2008 – 2016). Topographic maps created for each nine-year period show the lowest densities (shark attacks per square mile) from 1990 to 1998 and the highest densities from 1999 to 2007, off the shore of the east-central part of the state, northeast of Orlando in Volusia County, home to Daytona Beach.

> *"Is it true that most people get attacked by sharks*
> *in three feet of water about ten feet from the beach?"*
> — *Ellen Brody*
> *(wife of police chief Martin Brody)*
> *in Jaws (1975)*

The iconic opening scene of Steven Spielberg's movie *Jaws* depicting the film's first shark attack victim shocked audiences, especially beachgoers. Although the fictional tale takes place off the coast of a New England tourist town, most shark attacks in the United States occur off the Florida coast. Despite their relative rarity, shark attacks (unprovoked or otherwise) can occur at any time of the year, even during winter months. In this paper, the authors examine the number of shark attacks by month between 1960 and 2016. The period since 1990 is divided into three nine-year periods for closer examination. For a given nine-year period, has the total number of shark attacks been greater in some months than in others? For a given month, has the average number of shark attacks been changing over time? And, since 1990, how has the intensity of shark attacks (per square mile) changed from one nine-year period to the next?

The Data

The location and date of all unprovoked shark attacks off the Florida coast between 1960 and 2016 were collected from [1]. Over the 57-year period, there were 750 total attacks: 15 in January, 19 in February, 51 in March, 82 in April, 64 in May, 70 in June, 85 in July, 97 in August, 127 in September, 82 in October, 46 in November, and 12 in December. The two busiest months are, not surprisingly, August and September, near the end of summer.

Methodology

We first present descriptive statistics of the differences in the total number of shark attacks by month in four time periods: 1960 – 1989 and three subsequent nine-year periods. We conduct a series of two-sample t-tests. For each month, we compare the average number of shark attacks between 1990 and 1998 to the corresponding averages in 1999 – 2007 and 2008 – 2016.

To get a better idea of not when but *where* the intensity of shark attacks has changed along Florida's coast since 1990, we create a point density map showing the frequency of attacks off Florida's coast in each of three nine-year intervals. Using the information on the latitude and longitude of each of the 571 reported shark attacks since 1990, we produce kernel density maps in ArcGIS for each nine-year period.[1] Color gradations help identify "hot" spots to show differences between areas of high occurrence from areas of low occurrence.
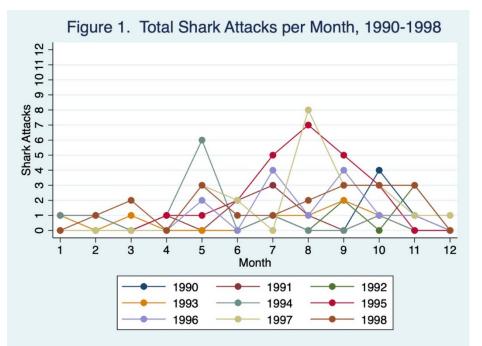
The Results

Table 1. Summary Statistics on Shark Attacks Off the Florida Coast, by Month, 1960 – 2016

	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
						1960 – 1989						
mean	.20	.27	.47	.47	.40	.63	.73	.67	.77	.73	.37	.13
st. dev.	.41	.64	.57	.90	.81	.81	.91	.96	1.36	1.11	.67	.35
min	0	0	0	0	0	0	0	0	0	0	0	0
max	1	3	2	3	3	2	3	3	5	4	3	1
						1990 – 1998						
mean	.33	.33	.33	.33	1.67	.78	1.89	2.22	2.11	1.89	1.11	.11
st. dev.	.50	.50	.71	.50	2.06	.97	1.69	3.07	1.83	1.36	1.17	.33
min	0	0	0	0	0	0	0	0	0	0	0	0
max	1	1	2	1	6	2	5	8	5	4	3	1

						1999 – 2007						
mean	.11	.44	1.78	4.11	1.67	2.67	3.56	3.56	4.22	2.67	1.44	.22
st. dev.	.33	.53	1.92	4.11	1.12	1.32	2.70	4.07	2.77	2.12	1.59	.44
min	0	0	0	0	0	0	0	0	0	0	0	0
max	1	1	4	12	3	4	8	12	9	6	5	1

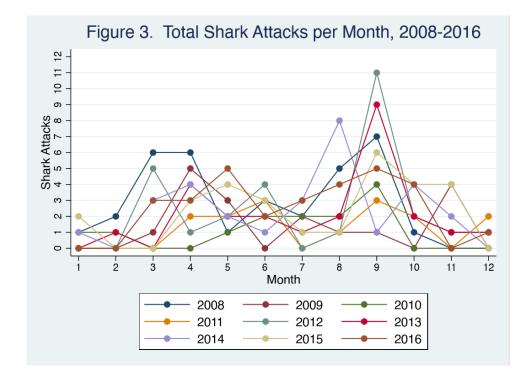|						2008 – 2016						
mean	.56	.44	2.00	3.11	2.44	2.22	1.56	2.78	5.22	2.11	1.33	.56
st. dev.	.73	.73	2.35	1.90	1.33	1.20	1.13	2.44	3.42	1.62	1.66	.73
min	0	0	0	0	1	0	0	1	1	0	0	0
max	2	2	6	6	5	4	3	8	11	4	4	2

Source: http://www.sharkattackdata.com/place/united_states_of_america/florida

Table 1 reports the summary statistics (mean, standard deviation, minimum, and maximum) for each month in the four different selected time periods: 1960 – 1989, 1990 – 1998, 1999 – 2007, and 2008 – 2016. In almost all cases, monthly averages in the last three nine-year periods exceeded their monthly counterparts between 1960 and 1989. Monthly averages did not exceed 1.0 for any month between 1960 and 1989, but did thereafter: for six months between 1990 and 1998 and for all but three months (December, January, and February) every year since 1999. The highest monthly average was September in the most recent nine-year period (2008 – 2016); the next four busiest months (April, July, August, and September) belong to the 1999 – 2007 period.

Figure 1. Total Shark Attacks per Month, 1990-1998

Figure 2. Total Shark Attacks per Month, 1999-2007

Monthly variations in the total number of shark attacks year-by-year since 1990 are illustrated in three different two-way connected-line plots, one for each nine-year period. For the period 1990 to 1998, shark attacks spike in August (1995 and 1997) [see Figure 1]. For the period 1999 to 2007, there are spikes in April (2001 and 2003), July (2000 and 2006), August (2001 and 2007), and September (2003 and 2007) [see Figure 2]. And, for the period 2008 to 2016, spikes are evident in August (2014) and September (2008, 2012, 2013) [see Figure 3].

Figure 3. Total Shark Attacks per Month, 2008-2016

Figure 4. Average Number of Shark Attacks per Month, 1990-1998, 1999-2007, 2008-2016
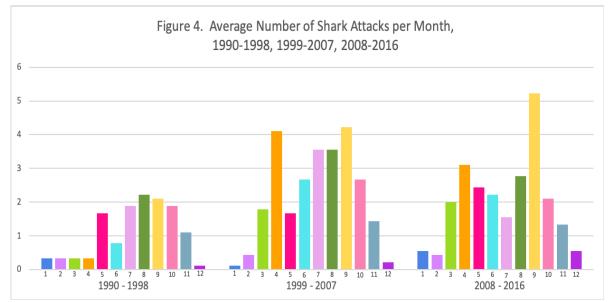
Figure 4 shows the average number of shark attacks per month for each of the last three nine-year periods. The monthly averages are easily seen to be higher in the last two nine-year periods than in the first. And, the spikes previously noted are here conspicuous in April (1999 – 2007) and September (1997 – 2007 and 2008 – 2016).

Table 2. Summary of Two-Sample *t*-Tests, by Month, 1990 – 2016

Month	Group 1	Group 2	Averages Group 1	Group 2	*p*-value on difference[a]
January	1990-1998	1999-2007	0.333	0.111	.284
	1990-1998	2008-2016	0.333	0.556	.461
	1999-2007	2008-2016	0.111	0.556	.115
February	1990-1998	1999-2007	0.333	0.444	.653
	1990-1998	2008-2016	0.333	0.444	.710
	1999-2007	2008-2016	0.444	0.444	1.000
March	1990-1998	1999-2007	0.333	1.778	*.050*
	1990-1998	2008-2016	0.333	2.000	*.058*
	1999-2007	2008-2016	1.778	2.000	.829
April	1990-1998	1999-2007	0.333	4.111	**.015**
	1990-1998	2008-2016	0.333	3.111	**.001**
	1999-2007	2008-2016	4.111	3.111	.517
May	1990-1998	1999-2007	1.667	1.667	1.000
	1990-1998	2008-2016	1.667	2.444	.356
	1999-2007	2008-2016	1.667	2.444	.199
June	1990-1998	1999-2007	0.778	2.667	**.003**
	1990-1998	2008-2016	0.778	2.222	**.013**
	1999-2007	2008-2016	2.667	2.222	.467
July	1990-1998	1999-2007	1.889	3.556	.136
	1990-1998	2008-2016	1.889	1.556	.630
	1999-2007	2008-2016	3.556	1.556	*.057*
August	1990-1998	1999-2007	2.222	3.556	.444
	1990-1998	2008-2016	2.222	2.778	.677
	1999-2007	2008-2016	3.556	2.778	.629

September	1990-1998	1999-2007	2.111	4.222	*.075*
	1990-1998	2008-2016	2.111	5.222	**.029**
	1999-2007	2008-2016	4.222	5.222	.505
October	1990-1998	1999-2007	1.889	2.667	.369
	1990-1998	2008-2016	1.889	2.111	.757
	1999-2007	2008-2016	2.667	2.111	.541
November	1990-1998	1999-2007	1.111	1.444	.619
	1990-1998	2008-2016	1.111	1.333	.747
	1999-2007	2008-2016	1.444	1.333	.886
December	1990-1998	1999-2007	0.111	0.222	.555
	1990-1998	2008-2016	0.111	0.556	.115
	1999-2007	2008-2016	0.222	0.556	.257

Source: http://www.sharkattackdata.com/place/united_states_of_america/florida

[a]p-values in boldface (italics) are significant at better than the .05 (.10) level.

Table 2 reports the results of a series of two-sample t-tests. Each test compares the monthly average in one nine-year period to the same monthly average in each of the two other nine-year periods. For example, the average number of shark attacks in April 1999 – 2007 and April 2008 – 2016 were both discernibly different from the April average in 1990 – 1998 (p = .015 and p = .001, respectively). Other notable differences include: (i) significantly higher averages in June 1999 – 2007 and June 2008 – 2016 than in June 1990 – 1998 (p = .003 and p = .013, respectively) and (ii) significantly higher averages in September 2008 – 2016 than in September 1990 – 1998 (p = .029).
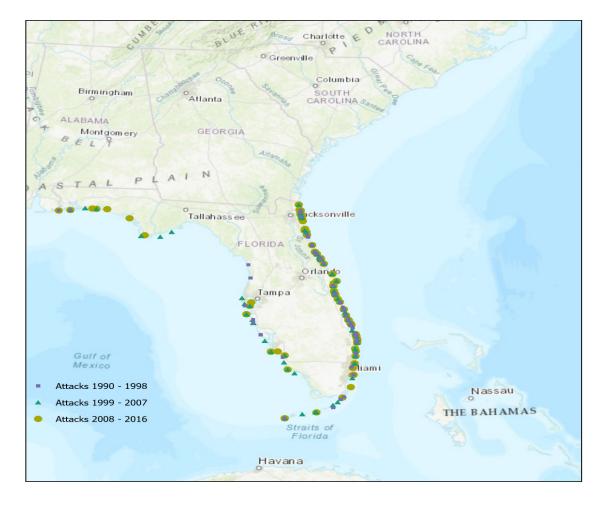
Figure 5. Topographic Map of Shark Attacks Along Florida's Coast, 1990 – 1998, 1999 – 2007, and 2008 – 2016

Figure 5 depicts all shark attacks off Florida's coast in a topographic map between 1990 and 2016, divided into three nine-year periods [2]. Numerous attacks off Florida's east coast, especially between 1999 and 2007, are evident from this map. Although there are relatively few shark attacks off Florida's Panhandle, most appear to have occurred off Florida's Emerald and Forgotten Coasts since 1999. On Florida's west coast, there have been practically no shark attacks offshore since 1999 along the Big Bend Coast on the Gulf of Mexico (that stretches from Wakulla County, south of Tallahassee, down to Pasco County, north of Tampa).
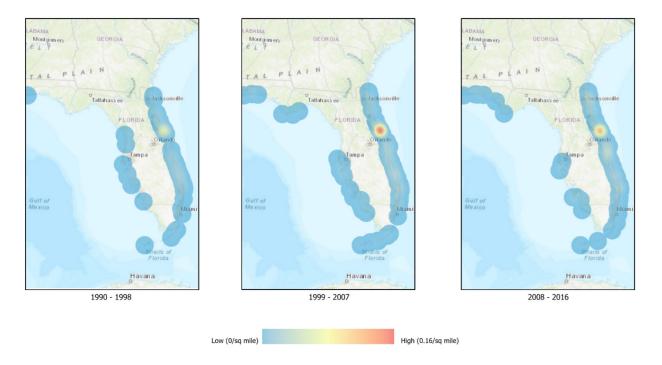
Figure 6. Kernel Density Map of Shark Attacks, 1990 - 1998, 1999 – 2007, and 2008 – 2016

The three kernel density maps in Figure 6 underscore the higher level of activity (shark attacks per square mile) between 1999 – 2007 and 2008 – 2016 relative to the period between 1990 and 1998 [3]. The highest level of activity in the period 1999 – 2007 is off the shores of Volusia County, situated about 50 miles northeast of Orlando.

Concluding Remarks

Shark attacks off the coast of Florida have been well-documented. Using data on the number of monthly attacks since 1960, we find relative calm between 1960 and 1989. When the period since 1990 is divided into three nine-year intervals, monthly averages are highest in April and September between 1999 and 2007 as well as between 2008 and 2016. The intensity of shark attacks has during the last eighteen years, 1999 – 2016, been highest in the east central part of Florida, off the coast of Volusia County, home to Daytona Beach, good for college students on spring break, and arguably even better for sharks.

Acknowledgment

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References

1.   The location and date of all shark attacks between 1960 and 2016 were retrieved from:
       http://www.sharkattackdata.com/place/united_states_of_america/florida .

2.   Esri. "Topographic" Scale: 1:5,000,000. "World Topographic Map." June 18, 2020.
       http://geography.middlebury.edu/data/Shark_Attacks/ (June 18, 2020).

3.   Esri. "Topographic" Scale: 1:10,500,000. "World Topographic Map." June 18, 2020.
       http://geography.middlebury.edu/data/Shark_Attacks/ (June 18, 2020).

Footnote

1.   Of the 575 observations between 1990 and 2016, the latitude and longitude of three shark
       attacks were unknown. We dropped one additional observation as its latitude and
       longitude placed it off the coast of Alabama.