Ciguatera Fish Poisoning in Florida

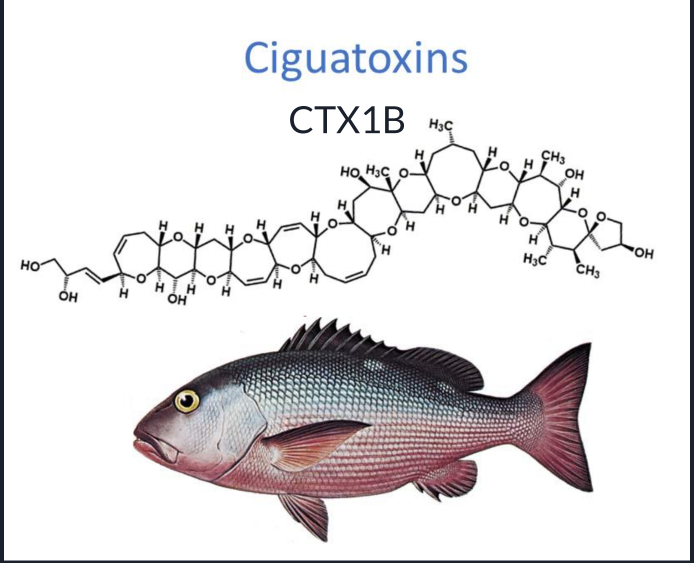
Motti Goldberger and Christopher Ryzowicz
University of Maryland New College of Florida

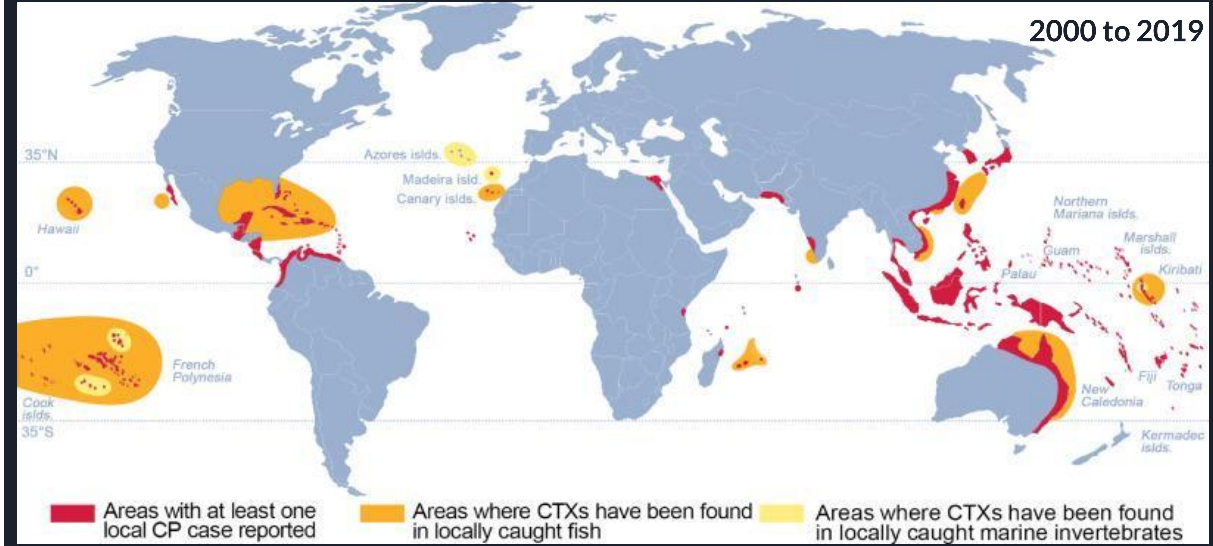
Order of Topics

1. Overview of Ciguatera Fish Poisoning (CFP)
2. Hypotheses
3. Variables/data collection
4. Modeling Strategy
5. Results/Analysis
6. Conclusion

Ciguatoxin Overview

- Foodborne illness caused by coral reef fish exposed to ciguatoxin



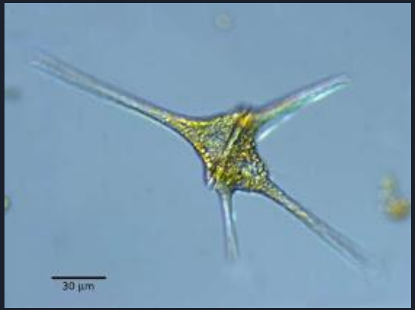


(Chinain et al. 2020)

Transfer of Ciguatoxin

- Ciguatoxin (CTXs) bioaccumulates up the food chain (Barrett, 2014)

Dinoflagellates → Herbivorous Fish → Carnivorous fish → Human



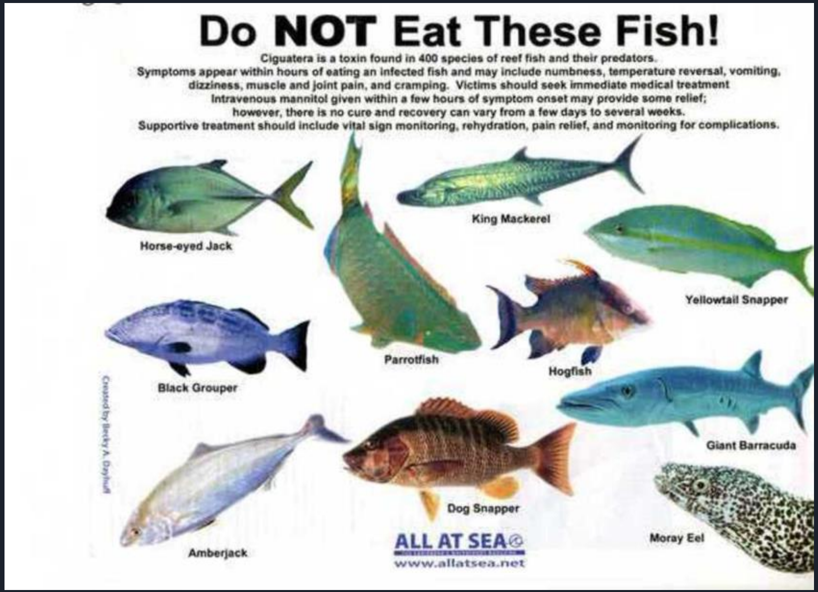
Significance for Studying CFP

- Ciguatera cases have steadily been increasing in Florida
  - Climate factors: Tropical Storms, SST, Heat stress?

- Economic factors
  - Reduction in fish sales/loss of jobs
  - Reduced tourism and recreational fishing
  - Medical costs

Symptoms/Treatments

- Approximately 50,000-500,000 cases annually worldwide (Fleming et al. 1998)
- Symptoms: nausea, itching, vomiting, fatigue, paralysis, and tachycardia
- Treatment: IV Mannitol, emetics, or self-healing (Human Immune System)

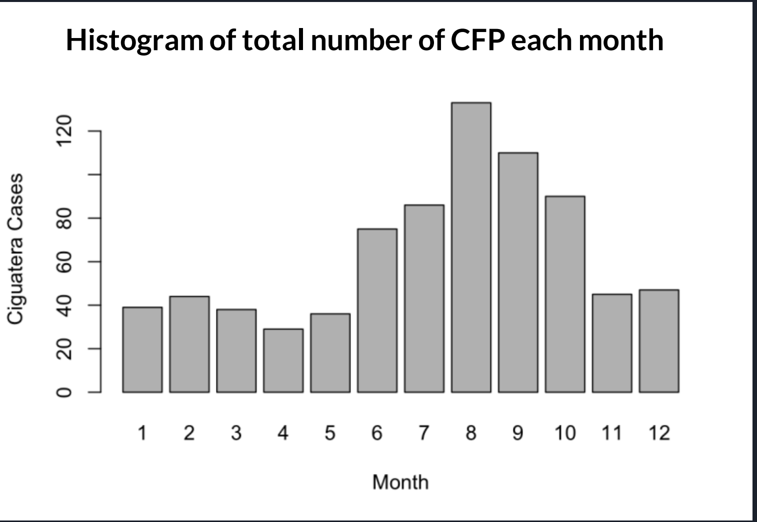


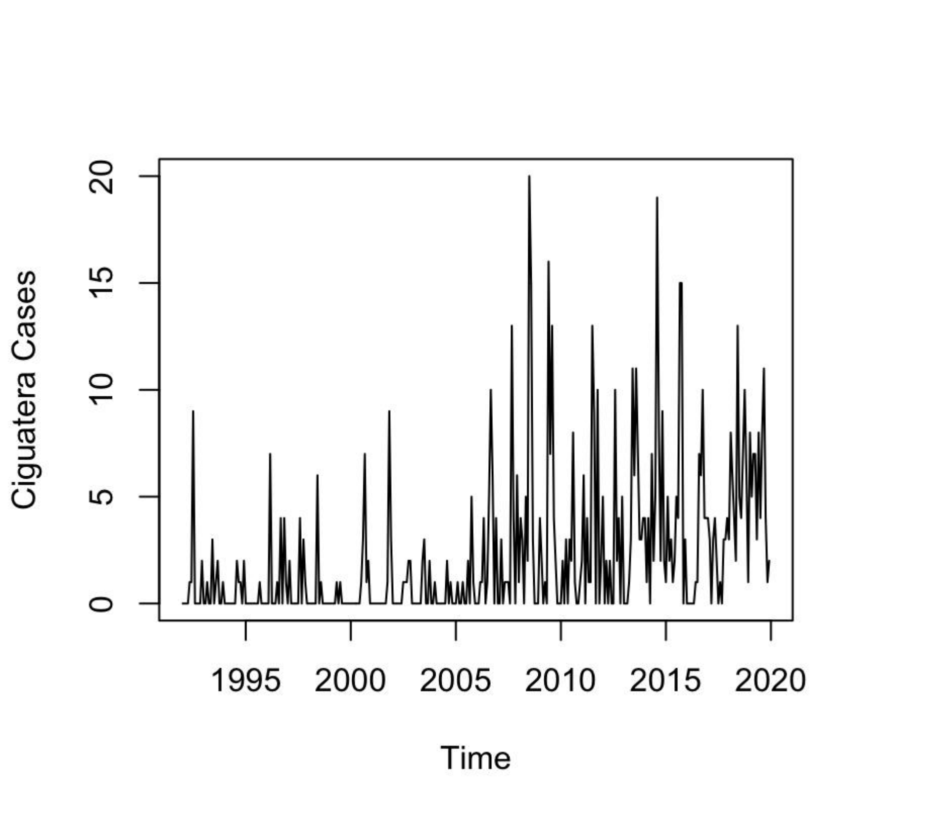
Hypotheses

- **Sea surface temperature** in southern Florida has a positive relationship with CFP cases in Florida
- **Fish landings** in Florida have a positive relationship with CFP cases in Florida
- **Heat stress** in southern Florida has a positive relationship with CFP cases in Florida
- **Tropical storm intensity** in southern Florida has a positive relationship with CFP cases in Florida

Ciguatera Fish Poisoning (CFP) Data

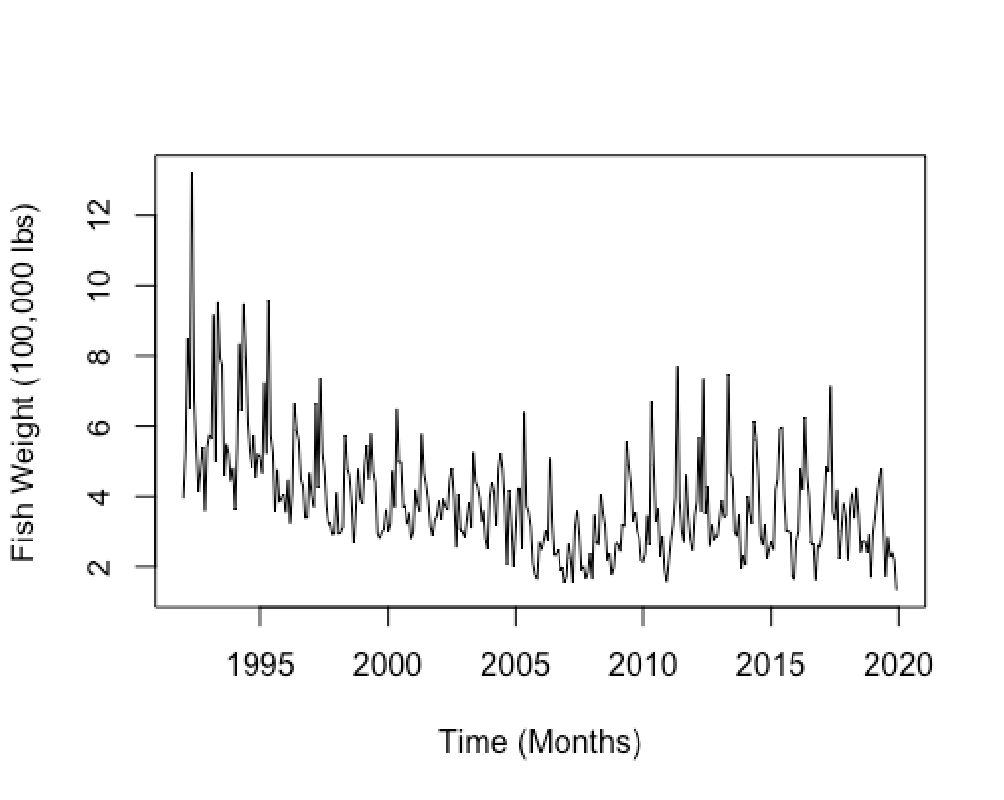
- Collected from Florida Department of Health Disease Reports
- Monthly CFP calls in Florida from 1992-2019
- Over 150 months that reported zero cases
- Our response variable





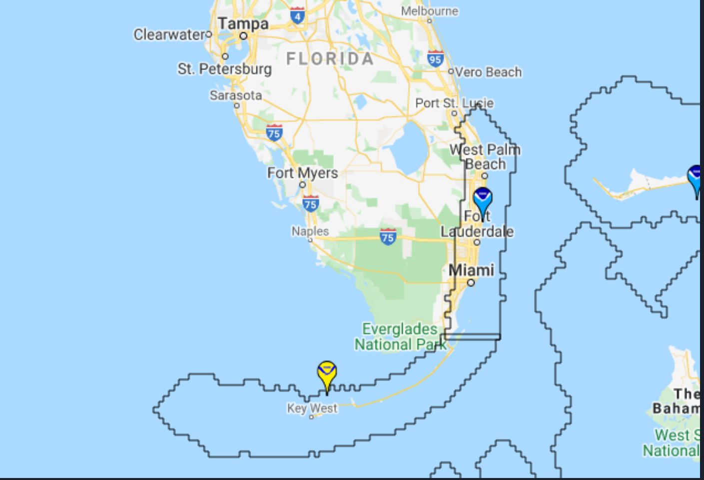
Commercial Fish Landings

- From Florida Fish and Wildlife Conservation Commission landings summaries
- Monthly weights in pounds of 8 species connected to the ciguatoxin
- Summed 8 fish weights each month

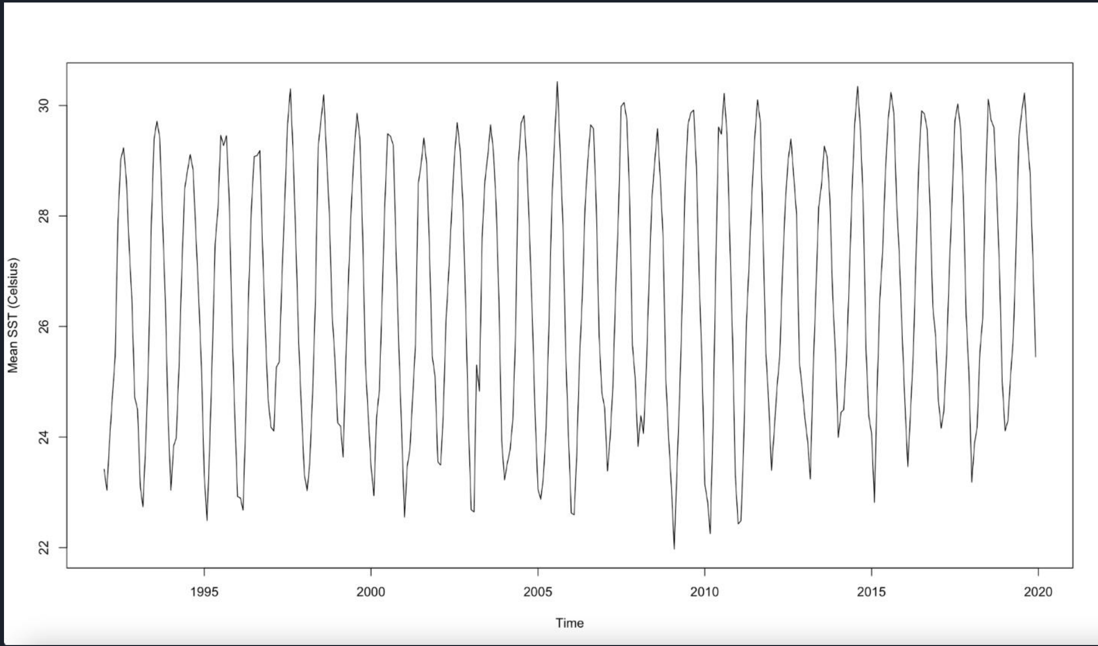


Mean Sea Surface Temperature (SST)

- Collected from 2 virtual stations in the Florida Keys by the NOAA Coral Reef Watch
- Averaged values for every month, then averaged the 2 stations



Mean SST (°C)

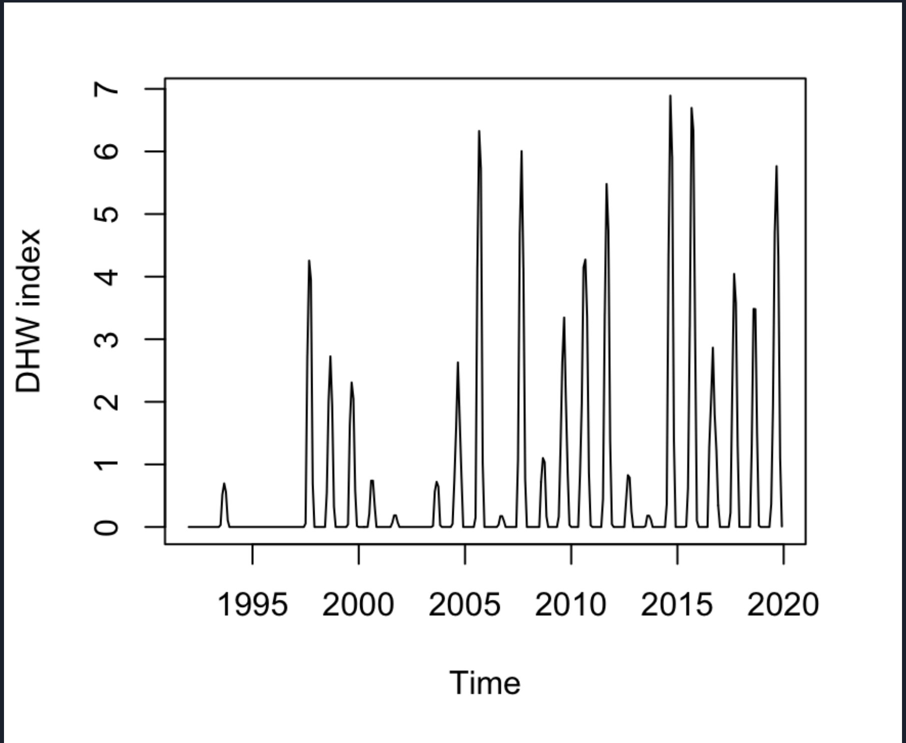


Time

Degree Heating Week (DHW) Index

- Also from NOAA Coral Reef Watch virtual stations
- Measure of accumulated heat stress for coral reefs
- Calculated based on previous 12 weeks HotSpot values

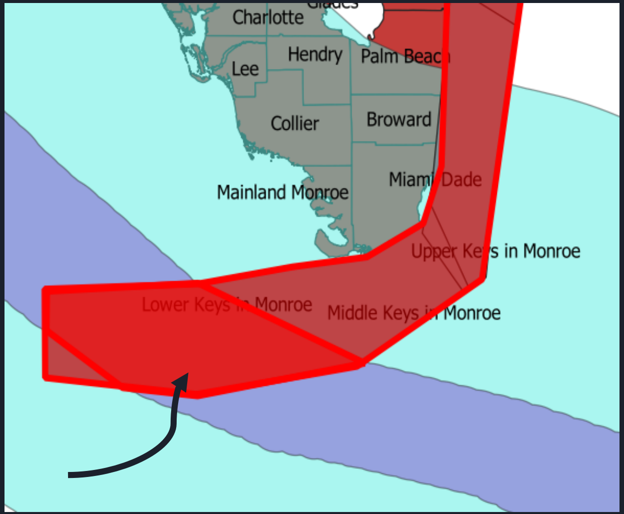
$$DHW_i = \sum_{j=i-83}^{i} \left(\frac{HS_j}{7}\right), \textbf{where}\ HS_j \geq 1$$

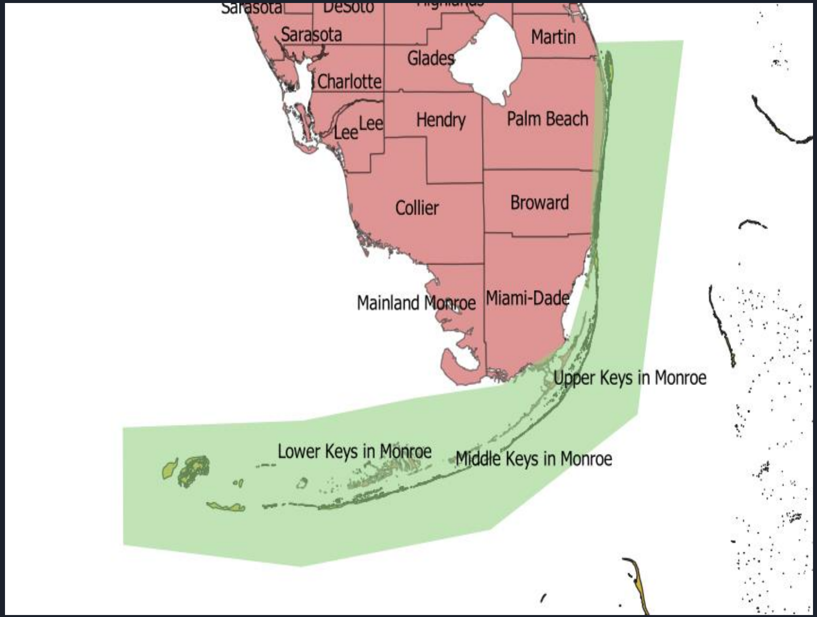


Impact Area and Wind Swaths

Wind Speed (WS) Classification:

0 if WS ∈ [0,34] knots
1 if WS ∈ (34,50] knots
2 if WS ∈ (50,64] knots
3 if WS ∈ (64,∞) knots

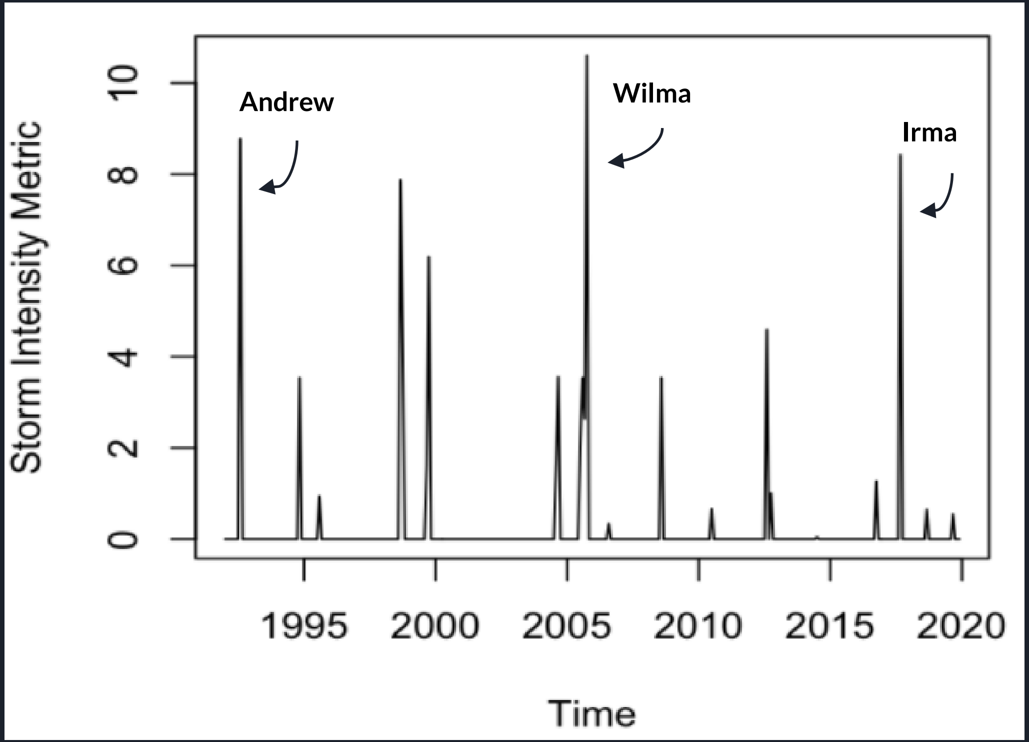




Tropical Storm Intensity Metric

- Collected wind swath from National Hurricane Center (NHC) of 24 tropical storms that hit our buffer area
- Based off a linear combination of wind swath area and wind intensity category

$$Storm\ Intensity = \sum_{i=0}^{3} (i \cdot Intersection\ Area_i)$$



Modeling CFP

- Predictor Variables
  - Storm Intensity
  - DHW Index
  - MeanSST
  - Fish Landings

- Models
  - Multi-Linear
    - Residuals are non-normal
    - Heteroscedasticity exists
  - Poisson
    - Mean CFP per month = 2.217
    - Variance CFP per month = 11.96
  - Negative Binomial
  - Zero Inflated Negative Binomial
    - Zero Inflated Model
    - Count Model based on Zero Inflated Model
- Lag
  - Is there a lag between the variables and their effect on CFP?

Best Negative Binomial Model

AIC = 1235.8

Sum of Residuals = 718.91

Predictors	Coefficients	P-Values
MeanSST	0.53	< .001
Storm Intensity	-0.78	.0095
Fish Weight	-0.56	< .001
Storm Intensity*Fish Weight	-0.63	.021

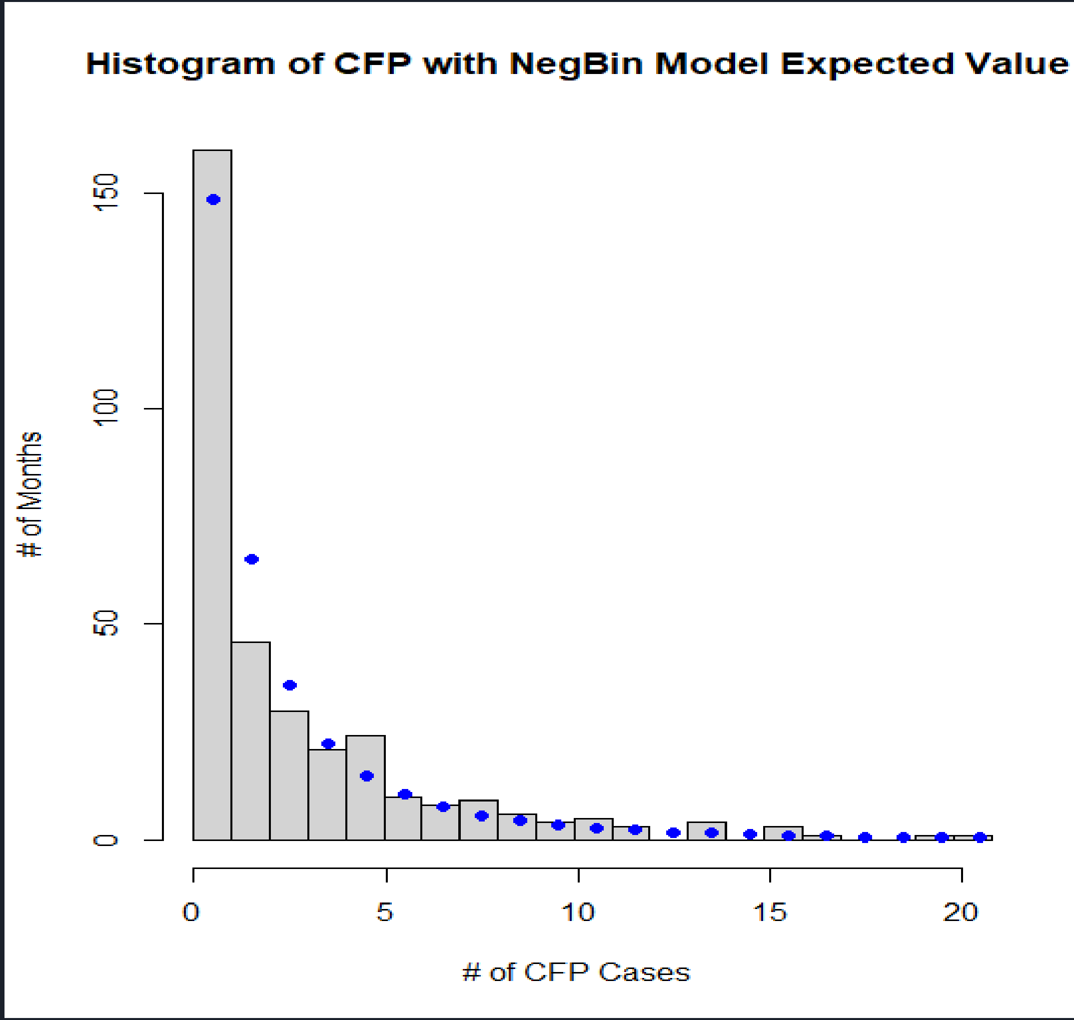
* Denotes interaction between variables

Best Negative Binomial Model with MonthNum

AIC = 1184.435

Sum of Residuals = 643.520

Predictors	Coefficients	P-Values
MonthNum	0.657	<.001
MeanSST	0.50	< .001
Storm Intensity	-0.63	.0349
Fish Weight	-0.27	.0143
Storm Intensity*Fish Weight	-0.54	.0420



Histogram of CFP with NegBin Model Expected Value
# of Months
0
50
100
150
0
5
10
15
20
# of CFP Cases

Best Zero Inflated Negative Binomial Model

AIC = 1223.526
Sum of Residuals = 704.43

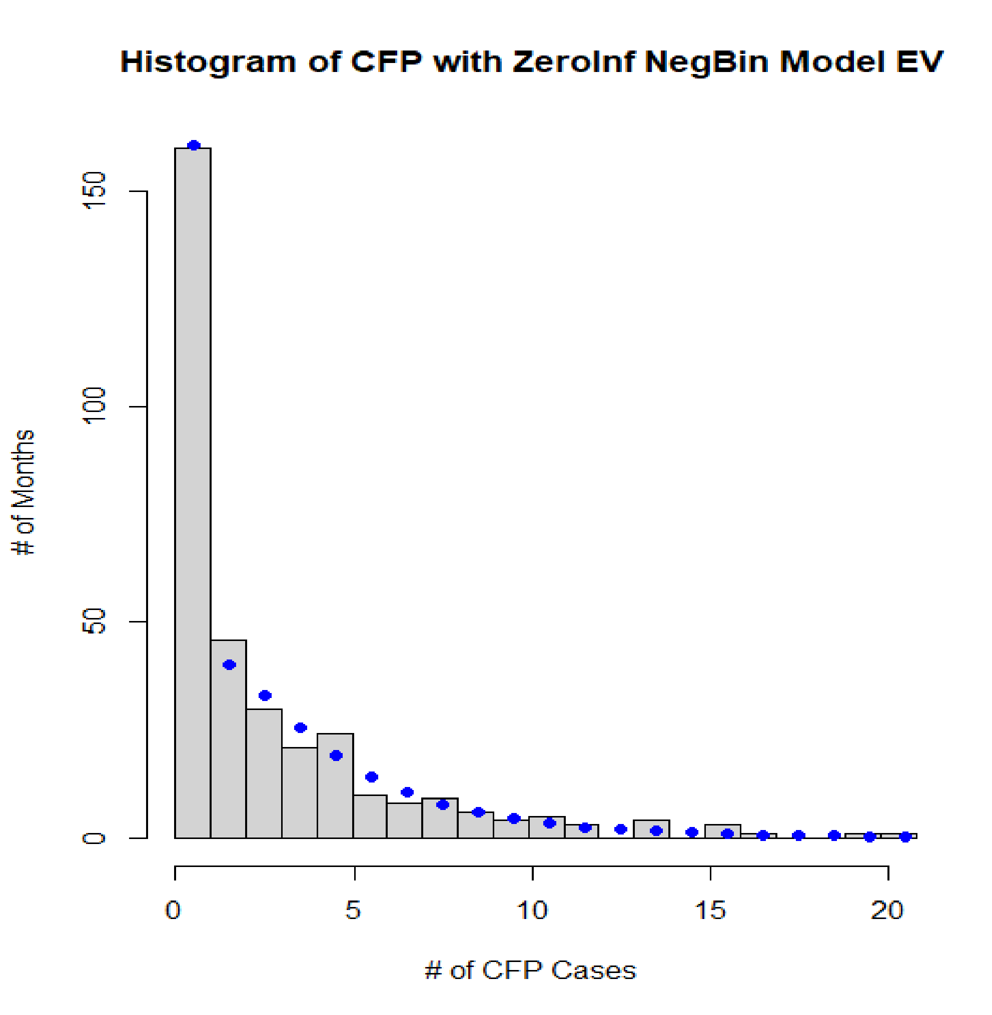
	Predictors	Coefficient	P-Value
Count Model			
	Fish Landings	-0.610	< .001
	MeanSST	0.310	< .001
	Storm Intensity	-0.937	.003
	DHW*Storm Intensity	-0.180	0.014
	Storm Intensity*Fish Weight	-1.16	.002
Zero Inflated Model			
	MeanSST	-0.71	.0015

Best Zero Inflated Negative Binomial Model with MonthNum

AIC: 1163.066

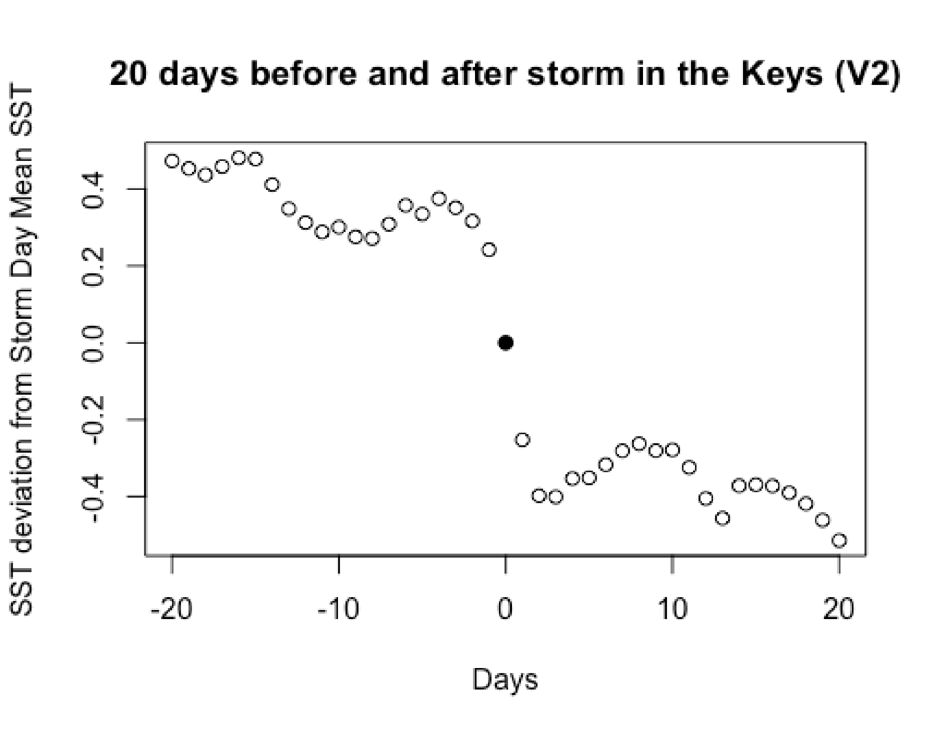
Sum of Residuals = 616.297

	Predictors	Coefficient	P-Value
Count Model			
	MonthNum	0.348	<.001
	MeanSST	0.295	< .001
	Storm Intensity	-0.36	< .001
	Fish Weight	-0.803	.0141
	Storm Intensity*DHW Index	-0.165	.0121
	Storm Intensity*Fish Weight	-1.05	.004
Zero Inflated Model			
	MonthNum	-1.003	<.001
	MeanSST	-0.638	<.001

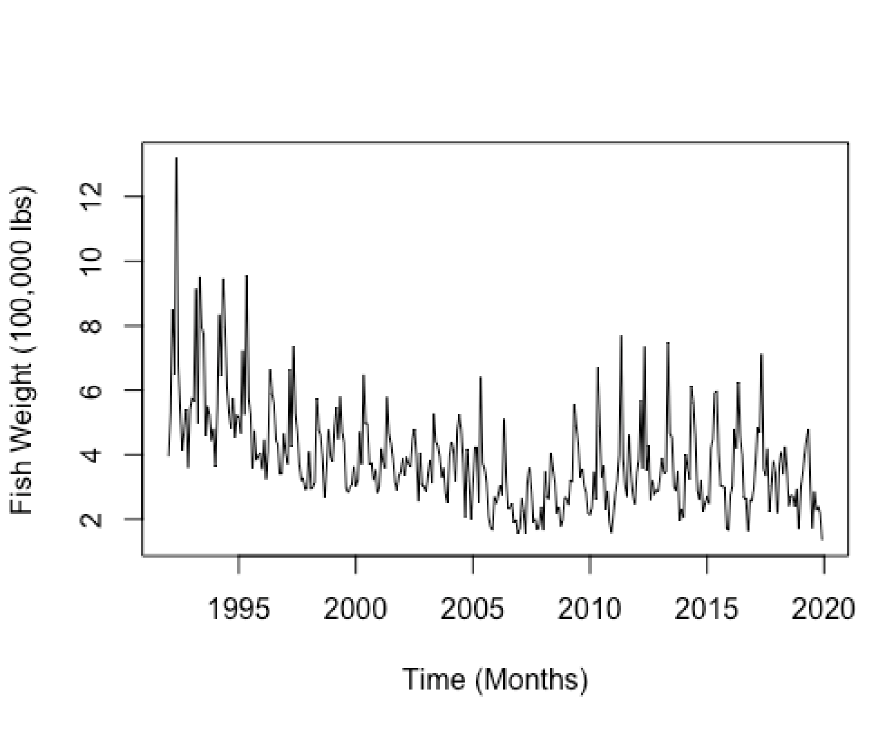

Histogram of CFP with ZeroInf NegBin Model EV
# of Months
0
50
100
150
0
5
10
15
20
# of CFP Cases

Analysis of Variable Coefficients

- Storm Intensity has a negative coefficient



- Fish Landings has a negative Coefficient



Conclusions

- MeanSST has a strong positive relationship with CFP
- Storm Intensity has a negative relationship with CFP
- Our ZINB is the best model we found and can predict a PMF of the # of CFP in a given month
- Confounding factors that are not in our model could contribute to the increase in CFP cases since 1992

Research Team

Faculty Advisors -

- Professor Michael Splitt - College of Aeronautics
- Dr. Nezamoddini-Kachouie - Dept. of Mathematical Sciences
- Dr. Van Woesik - Dept. of Engineering and Marine Science

Graduate Assistant -

- Dan Breininger - Dept. of Mathematical Sciences

References

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Questions?