

Appendix

Supplemental Materials for: Assessing the Resistance and Resilience of Recreationally Important Fish Species to Extreme Events in Coastal Texas

Time series analysis plots

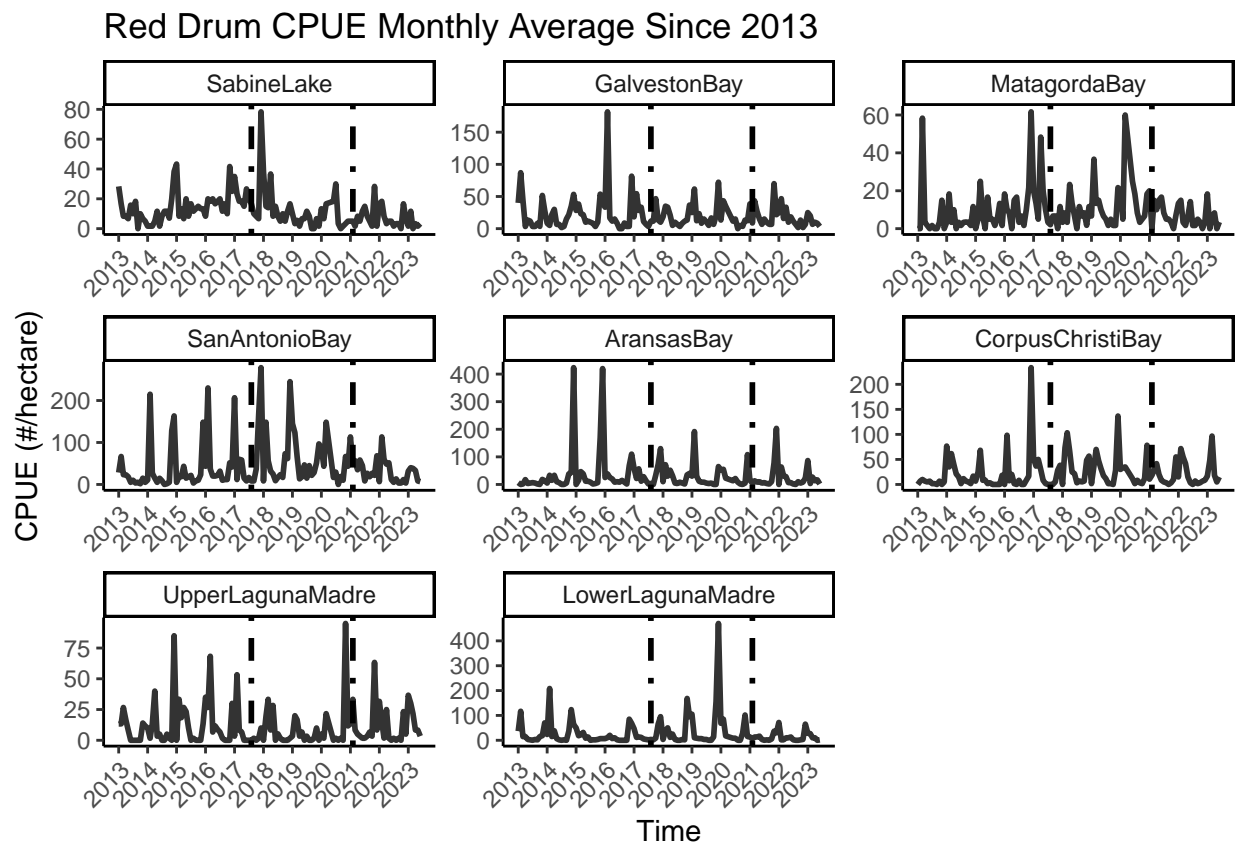


Figure S1: Red Drum monthly averaged CPUE over the last ten years parsed out by bay system. Dotted lines signifying two extreme events, Hurricane Harvey and the 2021 Texas Freeze, left to right.

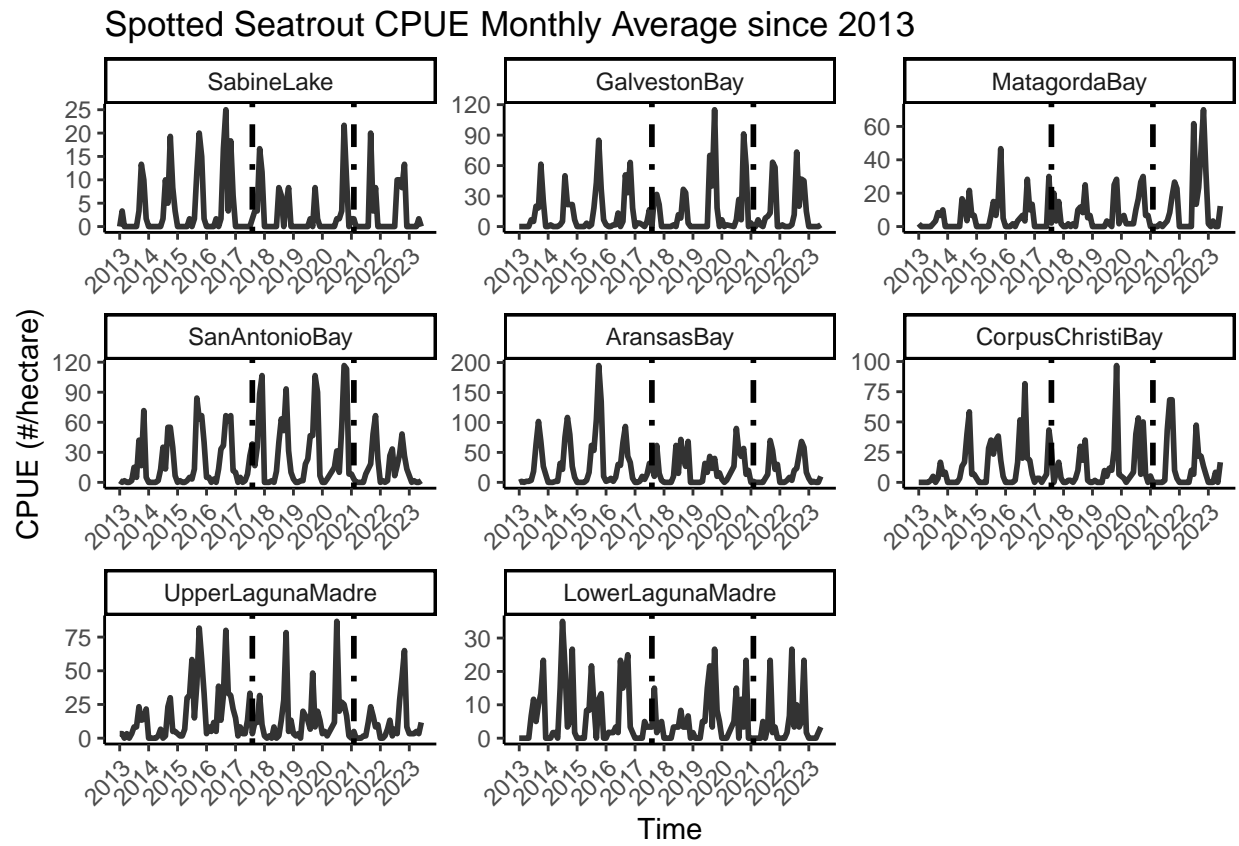


Figure S2: Spotted Seatrout monthly averaged CPUE over the last ten years parsed out by bay system. Dotted lines signifying two extreme events, Hurricane Harvey and the 2021 Texas Freeze, left to right.

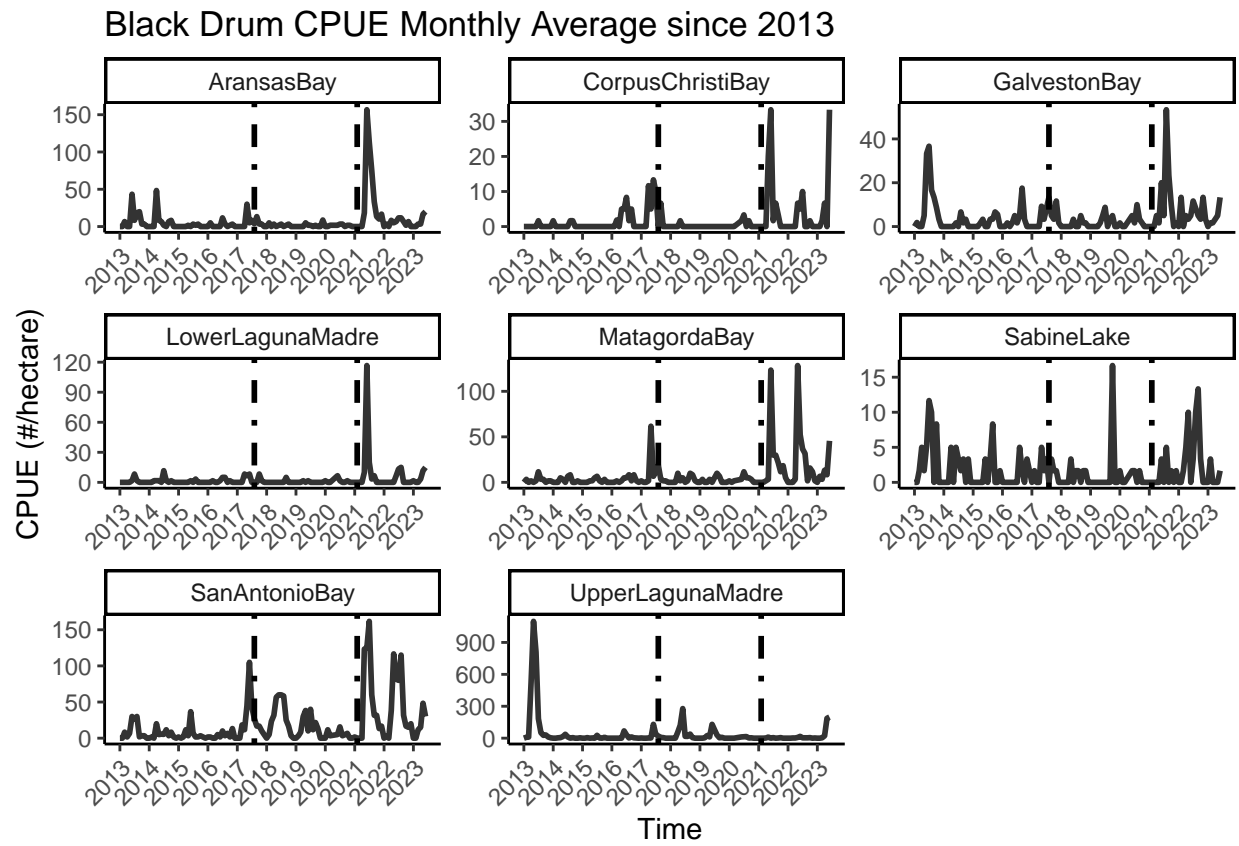


Figure S3: Black Drum monthly averaged CPUE over the last ten years parsed out by bay system. Dotted lines signifying two extreme events, Hurricane Harvey and the 2021 Texas Freeze, left to right.

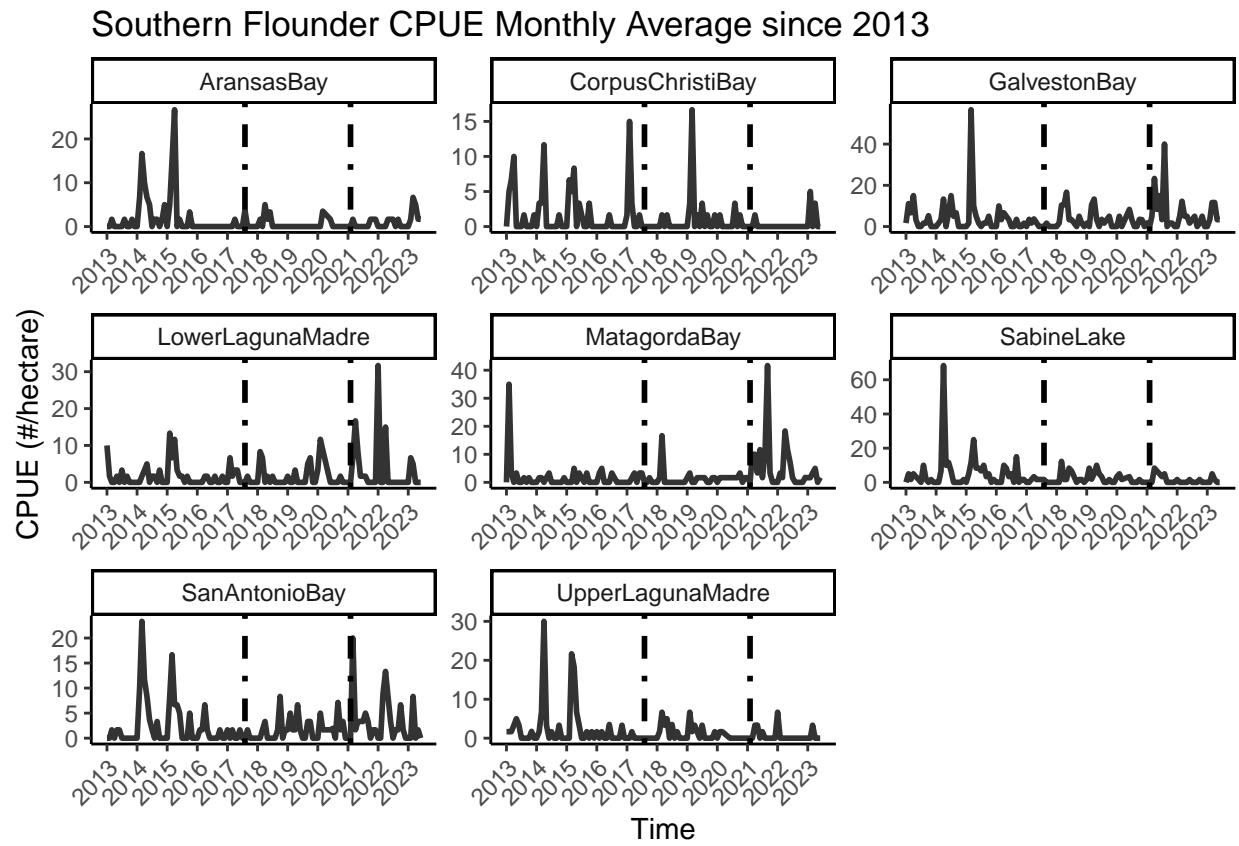


Figure S4: Southern Flounder monthly averaged CPUE over the last ten years parsed out by bay system. Dotted lines signifying two extreme events, Hurricane Harvey and the 2021 Texas Freeze, left to right.

Recruitment Windows

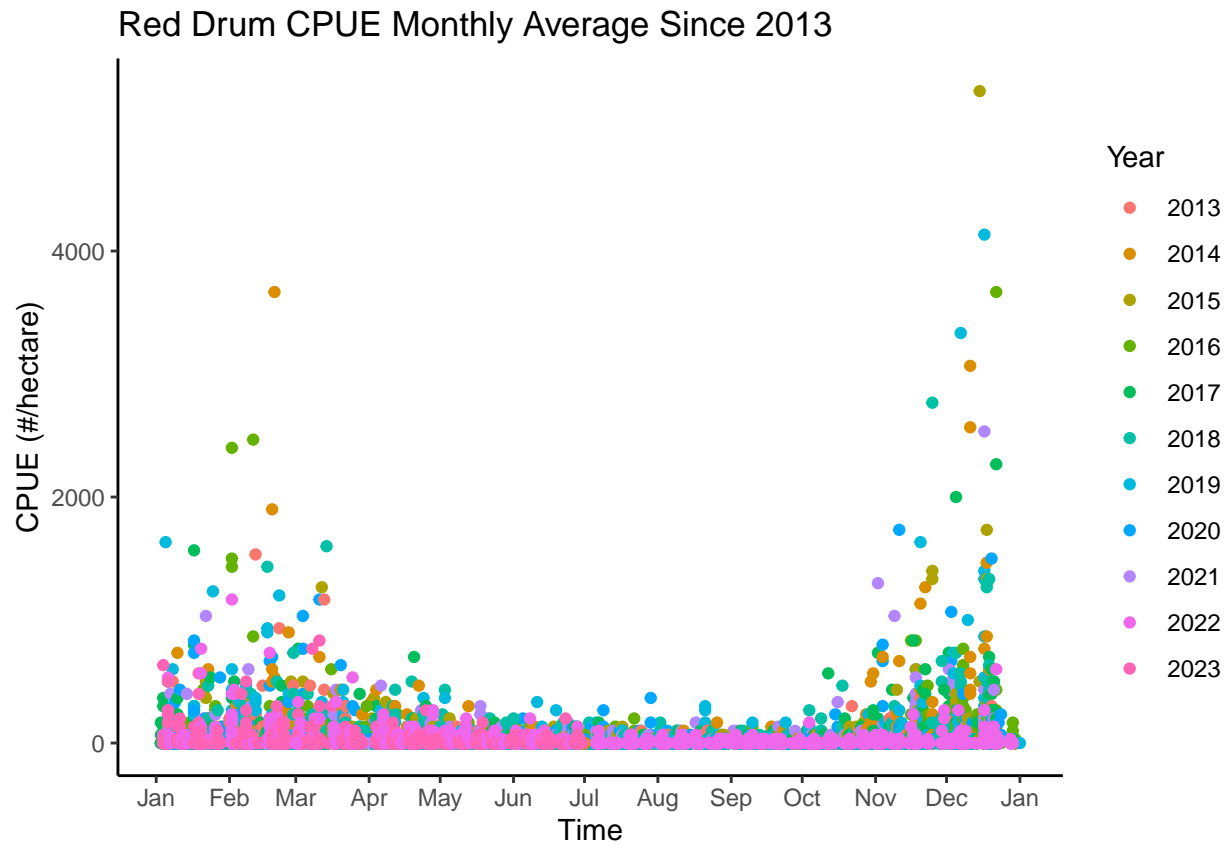


Figure S5: Red Drum CPUE monthly average raw data points plots over julian day establishing the recruitment window for Red Drum.

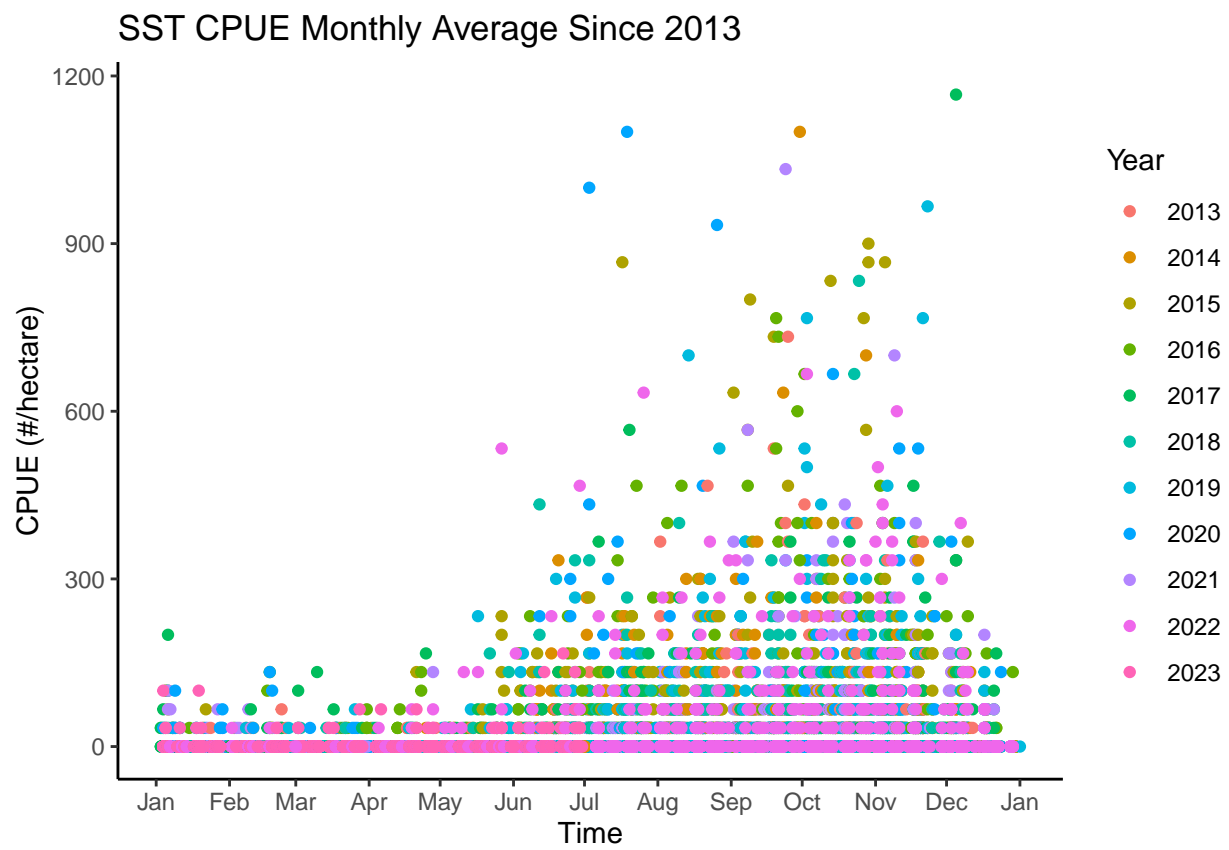


Figure S6: Spotted Seatrout CPUE monthly average raw data points plots over julian day establishing the recruitment window for Spotted Seatrout.

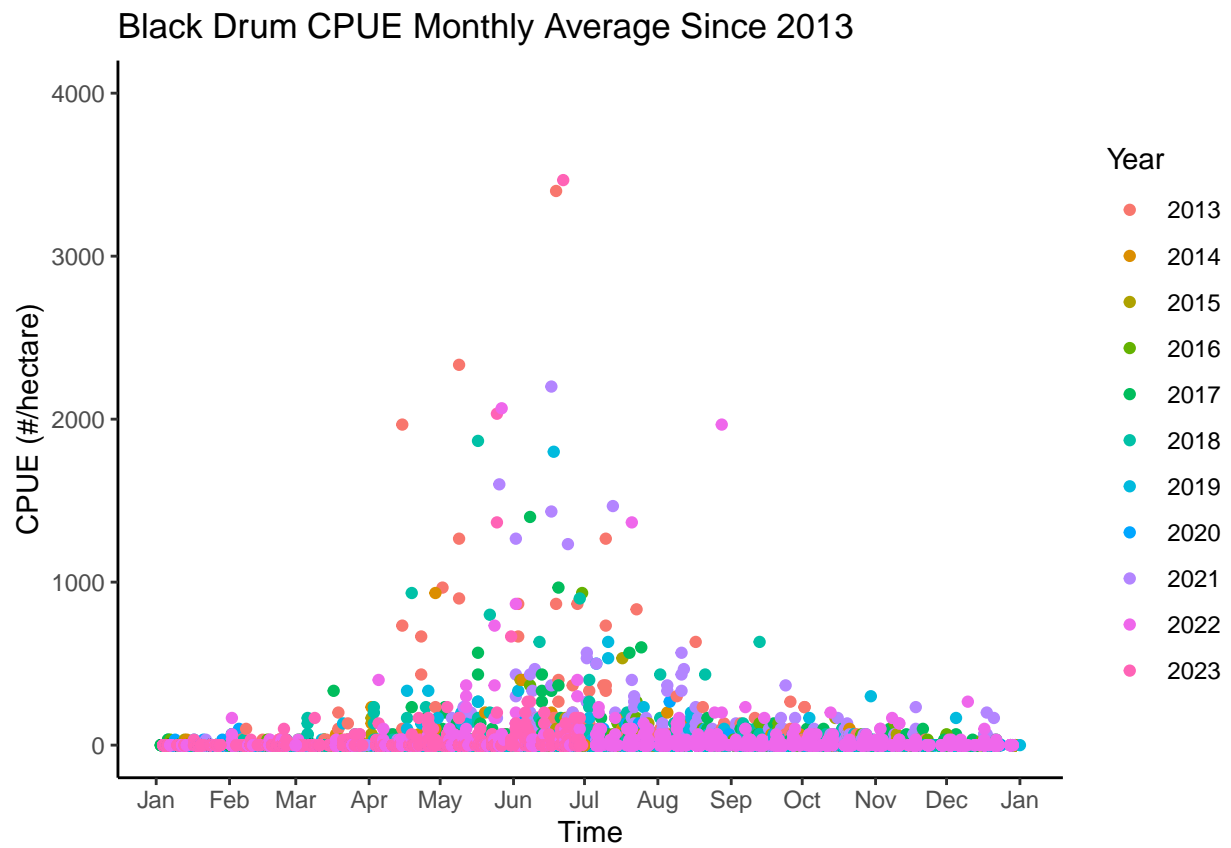


Figure S7: Black Drum CPUE monthly average raw data points plots over julian day establishing the recruitment window for Black Drum.

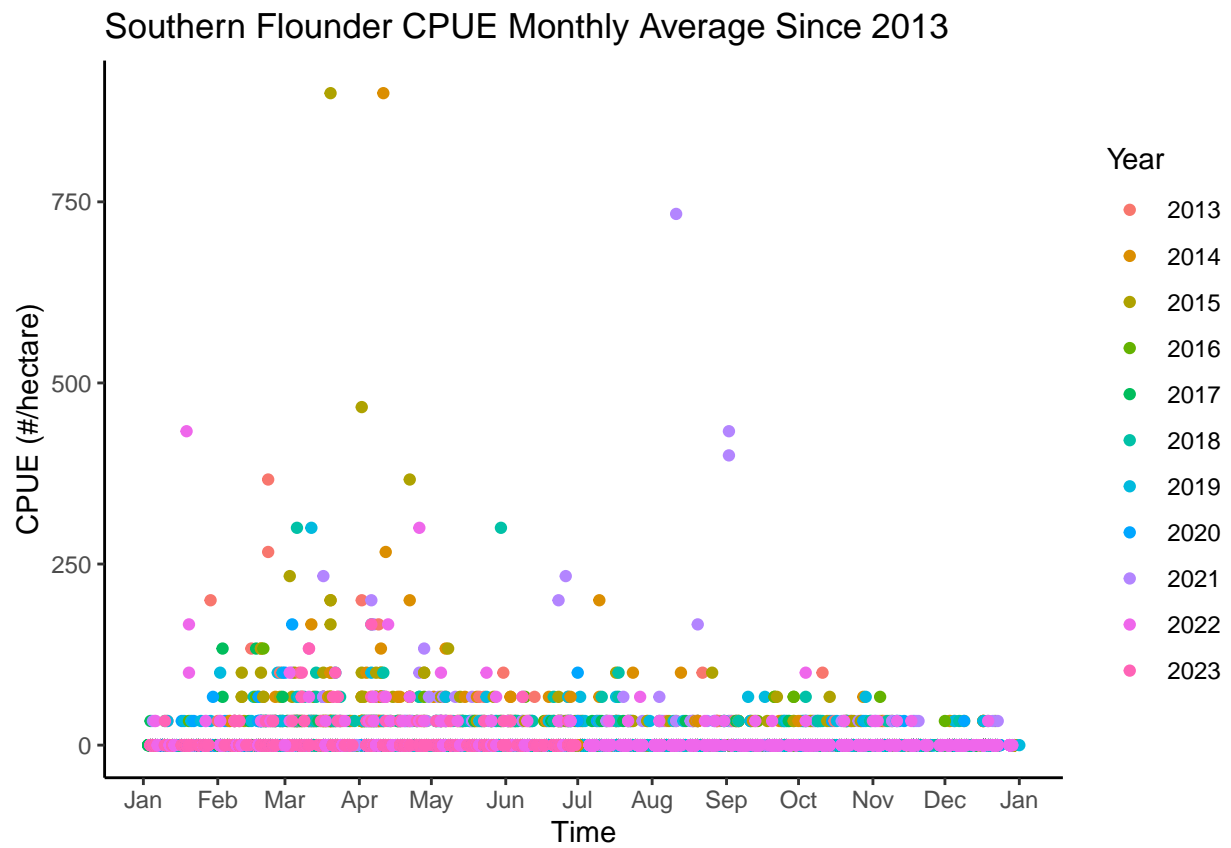


Figure S8: Southern Flounder CPUE monthly average raw data points plots over julian day establishing the recruitment window for Southern Flounder.

Hurricane Harvey Percent Change Tables

Table S1: Red Drum percent changes after Hurricane Harvey

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Red Drum	18.46	25.79	7.595	39.68	-58.86
GalvestonBay	Red Drum	27.26	22.58	24.109	-17.15	-11.54
MatagordaBay	Red Drum	12.57	8.75	12.998	-30.36	3.443
SanAntonioBay	Red Drum	35.42	93.75	93.333	164.7	163.5
AransasBay	Red Drum	34.80	53.96	43.542	55.04	25.11
CorpusChristiBay	Red Drum	28.69	43.31	37.317	50.99	30.09
UpperLagunaMadre	Red Drum	21.65	12.58	6.458	-41.9	-70.17
LowerLagunaMadre	Red Drum	35.50	37.08	50.208	4.448	41.42

Table S2: Spotted Seatrout percent changes after Hurricane Harvey

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Spotted Seatrout	5.926	4.048	1.667	-31.7	-71.88
GalvestonBay	Spotted Seatrout	22.470	13.333	35.523	-40.66	58.09
MatagordaBay	Spotted Seatrout	10.218	9.592	8.571	-6.121	-16.11
SanAntonioBay	Spotted Seatrout	29.361	44.197	48.333	50.53	64.62
AransasBay	Spotted Seatrout	60.999	40.476	25.899	-33.64	-57.54
CorpusChristiBay	Spotted Seatrout	21.365	13.909	24.088	-34.9	12.74
UpperLagunaMadre	Spotted Seatrout	26.590	20.144	18.095	-24.24	-31.95
LowerLagunaMadre	Spotted Seatrout	11.350	4.048	12.143	-64.34	6.99

Table S3: Black Drum percent changes after Hurricane Harvey

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Black Drum	4.402	1.1905	2.3810	-72.96	-45.92
GalvestonBay	Black Drum	8.214	1.4388	3.3573	-82.48	-59.13
MatagordaBay	Black Drum	4.608	5.2381	3.5714	13.66	-22.5
SanAntonioBay	Black Drum	9.971	43.4568	23.5714	335.8	136.4
AransasBay	Black Drum	5.906	1.9048	1.4286	-67.75	-75.81
CorpusChristiBay	Black Drum	2.269	0.2398	0.0000	-89.43	-100
UpperLagunaMadre	Black Drum	96.679	76.9784	41.1905	-20.38	-57.39
LowerLagunaMadre	Black Drum	1.073	0.7143	0.4762	-33.43	-55.62

Table S4: Southern Flounder percent changes after Hurricane Harvey

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Southern Flounder	7.673	5.0420	5.6497	-34.29	-26.37
GalvestonBay	Southern Flounder	8.842	7.5362	5.0847	-14.77	-42.5
MatagordaBay	Southern Flounder	4.762	3.0556	1.3889	-35.83	-70.83
SanAntonioBay	Southern Flounder	3.818	0.8696	2.7778	-77.23	-27.25
AransasBay	Southern Flounder	3.122	1.9444	0.0000	-37.71	-100
CorpusChristiBay	Southern Flounder	2.846	0.5556	4.3103	-80.48	51.46
UpperLagunaMadre	Southern Flounder	3.005	3.3898	2.7778	12.81	-7.562
LowerLagunaMadre	Southern Flounder	2.613	3.0556	0.5556	16.92	-78.74

Texas 2021 Freeze Percent Change Tables

Table S5: Red Drum percent changes after freeze event

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Red Drum	16.40	10.417	5.208	-36.46	-68.23
GalvestonBay	Red Drum	26.37	28.721	11.458	8.911	-56.55
MatagordaBay	Red Drum	11.68	6.289	5.063	-46.13	-56.63
SanAntonioBay	Red Drum	49.00	49.476	21.250	0.9738	-56.63
AransasBay	Red Drum	39.48	54.060	22.917	36.92	-41.96
CorpusChristiBay	Red Drum	29.86	33.333	25.417	11.64	-14.88
UpperLagunaMadre	Red Drum	17.07	18.868	16.667	10.51	-2.384
LowerLagunaMadre	Red Drum	34.67	20.833	18.125	-39.91	-47.72

Table S6: Spotted Seatrout percent changes after freeze event

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Spotted Seatrout	5.675	4.524	5.952	-20.28	4.892
GalvestonBay	Spotted Seatrout	23.084	21.905	30.476	-5.11	32.02
MatagordaBay	Spotted Seatrout	10.279	11.511	36.869	11.99	258.7
SanAntonioBay	Spotted Seatrout	37.269	25.476	24.762	-31.64	-33.56
AransasBay	Spotted Seatrout	56.129	27.857	33.809	-50.37	-39.76
CorpusChristiBay	Spotted Seatrout	19.396	27.857	17.986	43.63	-7.27
UpperLagunaMadre	Spotted Seatrout	23.861	10.476	22.619	-56.09	-5.204
LowerLagunaMadre	Spotted Seatrout	10.595	5.238	10.476	-50.56	-1.124

Table S7: Black Drum percent changes after freeze event

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Black Drum	2.718	1.429	6.429	-47.44	136.5
GalvestonBay	Black Drum	5.631	16.905	5.952	200.2	5.699
MatagordaBay	Black Drum	5.580	31.667	38.095	467.6	582.8
SanAntonioBay	Black Drum	17.831	76.191	68.571	327.3	284.6
AransasBay	Black Drum	5.499	58.571	7.381	965.1	34.22
CorpusChristiBay	Black Drum	1.886	9.286	3.357	392.4	78.02
UpperLagunaMadre	Black Drum	88.841	3.333	5.714	-96.25	-93.57
LowerLagunaMadre	Black Drum	1.524	22.381	5.000	1369	228.1

Table S8: Southern Flounder percent changes after freeze event

MAJOR_AREA_CODE	SPECIES	10 yrs	1st year	2nd year	first_perChange	second_perChange
SabineLake	Southern Flounder	7.386	4.2424	0.3236	-42.56	-95.62
GalvestonBay	Southern Flounder	7.911	10.5769	5.3872	33.7	-31.9
MatagordaBay	Southern Flounder	2.339	7.1197	7.9208	204.4	238.6
SanAntonioBay	Southern Flounder	3.440	6.0897	6.6007	77.05	91.9
AransasBay	Southern Flounder	2.673	0.3333	0.9709	-87.53	-63.68
CorpusChristiBay	Southern Flounder	2.597	0.3175	0.0000	-87.77	-100
UpperLagunaMadre	Southern Flounder	3.175	1.6181	0.0000	-49.03	-100
LowerLagunaMadre	Southern Flounder	2.446	6.4815	2.7273	164.9	11.48

The following analysis is organized as follows

A Generalized Mixed Model with a Negative Binomial Distribution for each species (4) in each storm (2)
Hurricane Harvey

- Red Drum Model = model.1
- Spotted Seatrout Model = model.2
- Black Drum Model = model.3
- Southern Flounder Model = model.4

2021 Freeze Storm

- Red Drum Model = model.5
- Spotted Seatrout Model = model.6
- Black Drum Model = model.7
- Southern Flounder Model = model.8

Hurricane Harvey Models

Red Drum

Model: Red_drum ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S9: Statistical results from a generalized linear mixed model analyzing how total Red Drum counts is influenced by month, year of study and storm classification type during Hurricane Harvey with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-0.7157	0.1694	-4.2254	2.39e-05	***
fixed	sin	0.6459	0.0394	16.3816	2.59e-60	***
fixed	cos	0.6417	0.0348	18.4620	4.17e-76	***
fixed	YEAR_OF_STUDY	-0.0260	0.0100	-2.6006	0.00931	**
fixed	classificationpost storm	0.2772	0.0560	4.9460	7.58e-07	***
fixed	classificationstorm	0.0477	0.3091	0.1543	0.877	

Year of study is significant (p-value = 0.009) with each additional year within the 10 year period, it is associated with a 2.6% decline in Red Drum counts. Classification post storm (p-value = <0.001) conditions are associated with a 32.2% increase in Red Drum counts. Classification storm (p-value = 0.877) is not significant, storm conditions do not significantly affect Red Drum counts. So Red Drum counts during the month of Hurricane Harvey are not significantly different to non-storm conditions.

Spotted Seatrout

Model: Spotted_seatrout ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S10: Statistical results from a generalized linear mixed model analyzing how total Spotted Seatrout counts is influenced by month, year of study and storm classification type during Hurricane Harvey with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-1.6653	0.2707	-6.1528	7.61e-10	***
fixed	sin	-1.9536	0.0559	-34.9630	8.22e-268	***
fixed	cos	0.0852	0.0433	1.9658	0.0493	*
fixed	YEAR_OF_STUDY	-0.0107	0.0138	-0.7755	0.438	
fixed	classificationpost storm	-0.2356	0.0727	-3.2380	0.0012	**
fixed	classificationstorm	-1.3537	0.2995	-4.5200	6.19e-06	***

Year of study shows no significant trend (p-value = 0.428) over time year to year in spotted seatrout counts. Classification post-storm are associated with a 21% decline in Spotted Seatrout counts (p-value = 0.0012) while storm designations are associated with a 74.1% decline in Spotted Seatrout counts (p-value <0.001).

Black Drum

Model: Black_drum ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S11: Statistical results from a generalized linear mixed model analyzing how total Black Drum counts is influenced by month, year of study and storm classification type during Hurricane Harvey with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-3.4544	0.3468	-9.9608	2.26e-23	***
fixed	sin	-0.6800	0.0629	-10.8130	2.99e-27	***
fixed	cos	-1.5187	0.0636	-23.8900	3.89e-126	***
fixed	YEAR_OF_STUDY	0.1728	0.0165	10.4966	8.95e-26	***
fixed	classificationpost storm	-0.0497	0.0981	-0.5068	0.612	
fixed	classificationstorm	-0.1507	0.3689	-0.4086	0.683	

Year of study is significant (p-value <0.001) where there is a 18.53% increase year to year over the 10 year period of Black Drum counts. Both classifications post storm and storm are not significant and therefore do not have an effect on Black Drum counts compared to non-storm.

Southern Flounder

Model: Southern_flounder ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S12: Statistical results from a generalized linear mixed model analyzing how total Southern Flounder counts is influenced by month, year of study and storm classification type during Hurricane Harvey with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-2.6091	0.1928	-13.533	9.98e-42	***
fixed	sin	0.7368	0.0702	10.502	8.48e-26	***
fixed	cos	-0.5136	0.0718	-7.157	8.25e-13	***
fixed	YEAR_OF_STUDY	-0.0543	0.0162	-3.353	0.000799	***
fixed	classificationpost storm	-0.3144	0.1079	-2.913	0.00358	**
fixed	classificationstorm	-1.1112	0.7894	-1.408	0.159	

Year of study is significant (p-value 0.0008), indicating a small but significant 4.9% decrease in Southern Flounder counts over the 10 year period. Classification post storm is significant (p-value 0.0036), suggests that in post storm designations, Southern Flounder count is decreasing by 26.7%. Classification storm: though it does show a 67% decrease in Southern Flounder counts in the storm period, it is a non-significant effect.

2021 Freeze

Red Drum

Model: Red_drum ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S13: Statistical results from a generalized linear mixed model analyzing how total Red Drum counts is influenced by month, year of study and storm classification type during the 2021 Freeze with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-0.5870	0.1694	-3.466	0.000528	***
fixed	sin	0.6724	0.0356	18.880	1.66e-79	***
fixed	cos	0.7643	0.0322	23.706	3.12e-124	***
fixed	YEAR_OF_STUDY	-0.0224	0.0121	-1.859	0.0631	
fixed	classificationpost storm	-0.1749	0.0782	-2.235	0.0254	*
fixed	classificationstorm	-0.9990	0.2528	-3.952	7.74e-05	***

Year of study (p-value = 0.063) is not significant effect on Red Drum counts. Classification post storm (p-value = 0.025) conditions are associated with a 16.1% decrease in Red Drum counts. Classification storm (p-value = <0.0001) designations are associated with a statistically significant 63.2% decrease of Red Drum counts.

Spotted Seatrout

Model: Spotted_seatrout ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S14: Statistical results from a generalized linear mixed model analyzing how total Spotted Seatrout counts is influenced by month, year of study and storm classification type during the 2021 Freeze with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-1.7059	0.2410	-7.0800	1.44e-12	***
fixed	sin	-1.8620	0.0472	-39.4390	0	***
fixed	cos	0.1475	0.0365	4.0408	5.33e-05	***
fixed	YEAR_OF_STUDY	-0.0058	0.0139	-0.4175	0.676	
fixed	classificationpost storm	-0.0557	0.0918	-0.6076	0.543	
fixed	classificationstorm	-0.0348	0.4481	-0.0776	0.938	

Year of study is not significant, suggesting no clear long-term trend of spotted seatrout count over the years in the study period. Classifications post storm and storm were found to be non-significant. post storm would be a 5.4% decrease and storm conditions a 3.4% but non-significant decreases.

Black Drum

Model: Black_drum ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S15: Statistical results from a generalized linear mixed model analyzing how total Black Drum counts is influenced by month, year of study and storm classification type during the 2021 Freeze with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-3.2238	0.3226	-9.994	1.63e-23	***
fixed	sin	-0.6147	0.0574	-10.706	9.52e-27	***
fixed	cos	-1.4754	0.0587	-25.142	1.71e-139	***
fixed	YEAR_OF_STUDY	0.1064	0.0185	5.761	8.34e-09	***
fixed	classificationpost storm	0.5941	0.1151	5.164	2.42e-07	***

Year of study was found to be a significant effect (p value = <0.0001) on Black Drum counts. Suggests an 11.17% increase of Black Drum counts over the course of the study period. Classification post storm has a significant effect (p value = <0.0001), during post storm classifications, Black Drum counts have 81.18% increase compared to non storm. No classification of storm as the catches were 0 for this month and year.

Southern Flounder

Model: Southern_flounder ~ sin + cos + YEAR_OF_STUDY + classification + (1 | MAJOR_AREA_CODE)

Table S16: Statistical results from a generalized linear mixed model analyzing how total Southern Flounder counts is influenced by month, year of study and storm classification type during the 2021 Freeze with major bay region as a random effect in a ten year period (2014-2023).

Variable Type	Covariate	Estimate	Std.Error	z value	p-value	Significance
fixed	(Intercept)	-2.4720	0.1788	-13.829	1.69e-43	***
fixed	sin	0.7953	0.0601	13.242	5.03e-40	***
fixed	cos	-0.5239	0.0655	-8.003	1.21e-15	***
fixed	YEAR_OF_STUDY	-0.1516	0.0210	-7.208	5.66e-13	***
fixed	classificationpost storm	1.0234	0.1412	7.250	4.16e-13	***

Year of study is significant (p value = <0.001), meaning there was a 14.1% decrease/decline in southern flounder counts during the study period. Classification post storm is significant (p value = <0.0001), meaning there was a 178.1% increase. in southern flounder counts compared to non-storm. There is no storm classification as catch was 0 for this fish during the storm month.