

Biodiversity of Fish Families on Palm Beach County Reefs from 2003 to 2018

by

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Abstract

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For fifteen years the Palm Beach County Reef Research Team has been collecting data on the fishes seen at various reefs in Palm Beach County. The aim of this study was to determine the overall health of these reefs by comparing associated fish stocks biodiversity at two reef sites in Palm Beach County from 2003 to 2018. To compare the fish biodiversity over time as well as between reefs sites, a non-metric multidimensional scaling (NMDS) analyses was used. To evaluate general changes, a t-test was used to compare the total abundance of fish between 2003 and 2018. The results of the NMDS show that the reefs' fish assemblages do not significantly differ over time. Then, using the years as replicates, the t-test showed a few families differed on an individual basis. The results of this study show that the two selected reefs maintain similar fish stocks.

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Introduction

Biotic mixing is the concept that species are expanding into new habitats where they were not present previously (McKinney and Lockwood 2001). The key point of this concept is that the expansion of a species into a new habitat or the expansion of a locally widespread species can lead to the local or total extinction of endemic species, and therefore the loss of biodiversity on a reef (McKinney 1998). This idea is called biotic homogenization. This process is often due to anthropogenic impacts and the resulting ecosystem becoming increasingly similar to other ecosystems comparatively (Richardson *et al.* 2018).

The association of corals with other organisms, especially dinoflagellates, is what allows them to be so successful in the oligotrophic environments that are coral reefs (Muscatine and Porter 1977). However, many reefs in the Caribbean are becoming more heavily dominated by algae and sponges (Pawlik *et al.* 2013, McManus and Polsenburg 2004) . A good indicator of coral reef's health is fish biodiversity because their enormous variety reflects wide ranges of environmental conditions (Moyle and Leidy 1992). Moreover, fish predate on benthic organisms such as coral and sponges. Thus the reefs experience a top-down effect which means that the predation on sponges and algae is the primary way that the sponge and algae community is controlled (Pawlik *et al.* 2013). As overfishing takes place in an area of the reef, fish assemblages are impacted which in turn impacts the predation of the sponges and algae on the reefs (Pawlik *et al.* 2013). Coral reefs are one of the world's most biologically diverse habitats and as corals are threatened by climate change and bleaching, the possible resulting deaths of corals has further effects on abundance and

diversity of fishes on reefs (Hoegh-Guldberg *et al.* 2007, Pratchett *et al.* 2011). These effects may not be as drastic on the more sponge-dominated reefs that are more common in the Caribbean, but there is still an impact to the reefs (Hoegh-Guldberg *et al.* 2007). With the decline in corals in the Caribbean, the biodiversity of fishes had already been reduced to leading to the importance of tracking the changes on the current reefs (Pratchett *et al.* 2011, Jones *et al.* 2004). The reduction of fish biodiversity can lead to a phenomenon called biotic homogenization, which is a reduction of biodiversity in the environment at different locations as species assemblages tend towards sameness (Richardson *et al.* 2018, Walther *et al.* 2002). A healthy habitat is reliant upon the redundancy of ecological roles provided by the organisms living there, so it can be said that biodiversity is a decent indicator of a habitat's overall health (Pratchett *et al.* 2011). As overfishing on reefs occurs to the sponge eating fishes, the faster-growing sponges are the ones that will begin to dominate (Pawlik *et al.* 2013). Those sponges that lack a secondary metabolite will out-compete the other sponges on this "new" reef with fewer predators. The secondary metabolites are an energy-expensive defense strategy against predators. On a reef where the sponge eating predators have been mostly eliminated, the sponges without these metabolites will invest more energy into growing faster. This can impact the three-dimensional structure of the reef depending on the species that are being impacted as well as the associated fishes with the reef. Other than the obvious part where there is a decrease in spongivore fishes, some species live in different portions of the structure. Moreover, while it may not be the case for these sponges and fishes, some species develop exclusive life histories tied to another species. For example, the famous clownfish and sea anemone or the shrimp in the

glass sponge. These types of symbiotic or closely tied life histories may not be present in the coastal seas near Florida, but these habitat changes are occurring globally with impacts that are still being measured. Nearly 1.5 million people live here in Palm Beach County, which exerts considerable pressure on the natural resources in the area.

For fifteen years the Palm Beach County Reef Research Team has been collecting data on the fishes seen at various reefs in Palm Beach County; however, no analysis has been done on this data. This makes it difficult to determine the overall health of these reefs and their associated fish stocks. The objective of this honors thesis was to evaluate the differences on fish biodiversity from 2003 to 2018 between two coral reef sites in Palm Beach County. Data was analyzed using statistical analysis and employing a biodiversity index to compare the reefs' state over time as well as compare both reefs.

Specific Objectives and Hypotheses

Objective 1: To compare fish biodiversity between reefs using the data for each year as replicates using a NMDS, a PERMANOVA, and a SIMPER.

H_0 = There is no difference in fish biodiversity between the two reef sites.

H_a = This a statistically significant difference in fish biodiversity between the two reef sites.

Objective 2: To compare fish abundance (per family) between reef sites using a t-test.

H_0 = There is no change in fish abundance between the two reef sites.

H_a = There is a statistically significant difference in fish abundance between the two reef sites.

Methods

Area of Study

Visual surveys of fishes were done from 2003-2018 at two reef sites in Palm Beach County: Larsen's Valley and Delray Ledge. Delray Ledge is high profile— five to nine feet of relief— natural reef with several undercuts and overhangs is located approximately one mile from shore, with depths ranging from 57 to 66 feet. Larsen's Valley is a medium-profile— two to four feet of relief— natural reef, with a maximum depth of 77 feet, and has a double set of low-relief ledges. Both reefs consist of sponges, algal turfs, gorgonians, anemones, and corals. Corals are not very common on either of these two reefs as they are formed primarily of sponges and algae like many Caribbean reefs. The two reefs are approximately 22.5 miles away from each other.

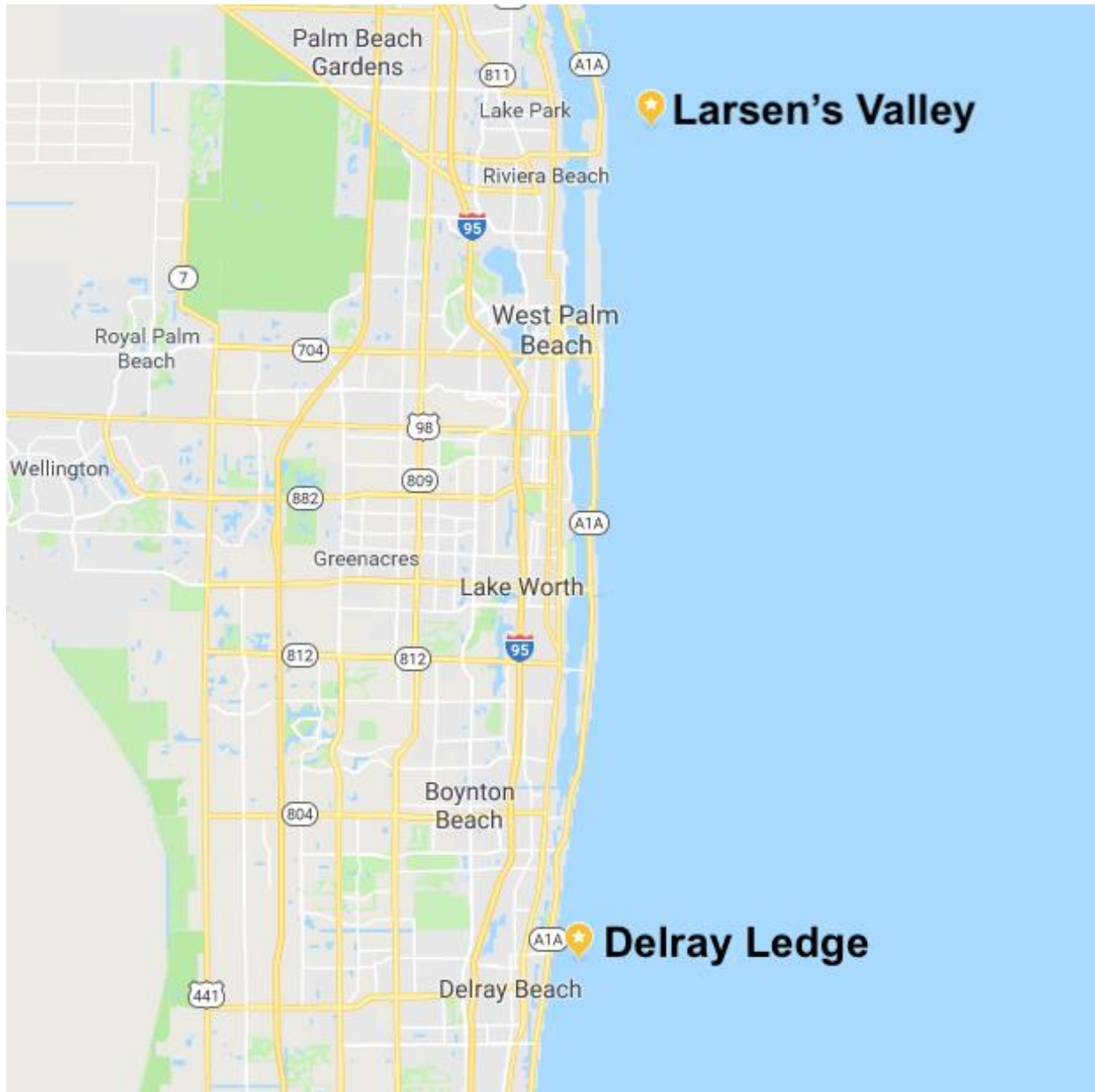


Figure 1: The figure above shows a map of the where the two reefs are located in relation to the coast of Palm Beach County.

Survey Methods

The general method of surveying fishes used a technique employing an altered version of the Stationary Visual Census Technique (Bohnsack and Bannerot 1986).

Divers that conducted the surveys created an imaginary, fifteen-meter cylinder at the

designated spots for the survey. At these predetermined locations, divers would count fishes, making sure to note the species and size of the fishes as well. Fishes were classified from one to size by size as follows: 1 being 0 to 1.99 cm; 2 being 2 to 5.99 cm; 3 being 6 to 10.99 cm; 4 being 11 to 20.99 cm; 5 being 21 to 30 cm; 6 being 30+ cm. The fish data sheets were reviewed by the Fish Leader; if there were questions, data was reviewed and discussed with the diver before turning the sheets over to the Grant Coordinator. This data was then proofed and entered into an Excel spreadsheet so that it could be organized into an appropriate format for data analysis.

Statistical Analyses

When reorganizing recorded surveys into a format compatible with the data analysis software, the fish species were pulled by family in form of number of fish per family at each reef site per year (See appendix). Fish families with only one fish were excluded from the counts as they are viewed as “rare” outliers. Univariate t-test analyses were performed in Excel. While multivariate analyses were performed in R Studio (Rstudio Team 2019) with the Vegan package.

To test the null hypothesis that there is no change in fish biodiversity between the two reef sites and evaluate what fish families could be driven differences, a non-metric multidimensional scaling (NMDS), ANOSIM, PERMANOVA, and SIMPER were performed. The use of nonmetric multidimensional scaling was employed for the inherent benefits that it brings to analysis. The NMDS used was based on the Bray-Curtis similarity measure and is an ordination-based technique (Holland 2008). The biplots were generated to look at differences between Larsen’s Valley and Delray

Ledge. The total abundance data of each site was created using the successive years as replicates to make the relative abundances. For the biplots, ellipses that were generated from the standard error of the weighted average of the relative abundances were superimposed to conceptualize the dispersion of fish families on each respective reef. There are five general steps to constructing an NMDS plot. First, the original positions of communities in multidimensional space must be defined. Second, the number of dimensions that the data is being reduced to must be specified. Usually, the data is reduced to two-dimensions like the plot in figure 2. Third, an initial configuration of the samples in two-dimensions needs to be created. Fourth, the distances in this initial configuration compared against the observed measured distances from the original version. Finally, the stress, or the disagreement between two-dimensional configuration and predicted values from the regression, is determined. The NMDS stress plot along with the non-metric fit and the linear fit values is a Shepard diagram which compares how far apart before and after data points are transformed– it looks at the goodness-of-fit– as a scatter plot.

An analysis of similarities (ANOSIM) was used to test statistically whether there was a significant difference between the two reef sites in the vegan package in Rstudio (Clark 1993). Similarly, a permutational analysis of variance (PERMANOVA) was conducted to test the multivariate response of fish family's relative abundance on each reef. When the PERMANOVAs were significant ($p < 0.05$), a similarity percentage analysis (SIMPER) was conducted to evaluate which family could be driven by differences. The PERMANOVA is useful for this analysis since it provides a numerical measure of the significance of the dispersion of data to which it is applied. This is useful

since a nonmetric multidimensional scaling only allows for the visualization of data with no real numerical measure of differentiation. PERMANOVAs are a form of non-parametric multivariate statistical test that are used to test the null hypothesis (Anderson 2001). The test looks at the dispersion of data and provides a p-value to be used in the determination of significance.

To test the hypothesis that abundance of fish families was the same at the two reef sites, one-tailed t-tests were performed for each fish family looking for statistical significance between locations. For the t-tests conducted, the null hypothesis was that there is no difference in total fish abundance for that specific family. The alternate hypothesis was that, between the two sites, there is a statistical difference in fish abundance for the specific fish family. The t-tests were calculated using each successive year as a replicate, as surveys did not include multiple replicates per year. With these calculations, the changing state of each reef can be looked at using each year as a replicate. Doing this allows the examiner to view the reef with fewer variables and another possible view of the reefs can be interpreted and then compared to the results of the multivariate analysis. Box-whisker plots were created using the minimum, quartile one, the median, quartile three, and the maximum in Excel.

Results

Reef site Comparisons – Multivariate Analysis

The results from the NMDS (Figure 2) shows a good amount of similarity at the two selected reef locations: Delray Ledge and Larsen's Valley. It is important to note that the numbers on the axes of the graph represent a computer-generated best-fit of

the data in a three-dimensional space. This means that the numbers are not representative and that another form of analysis will yield the numerical results— not this graphical representation. The stress of the plot of the data was recorded to be 0.09948011. Since this is less than 0.1, the plot of the nonmetric multidimensional scaling is viewed as being “great.” This stress value means that the plot can be looked at with confidence that it is a good fit when compared to the original. Less than 0.05 is considered to be the best but it is uncommon to have such a low measure of stress with the amount of data that was being changed into two-dimensions.

The graph of the stress plot (Figure 3) essentially shows a positive result for the NMDS. That means that since the regression shows a constant and stable upwards trend, the NMDS was completed accurately and reliably. This is another measure of the goodness of the fit for the NMDS. If the two-dimensional configuration perfectly preserved the original rank orders, then a plot of one against the other would be monotonically increasing. The extent to which the points on the 2-D configuration differs determines the degree of stress. The stress plot is a visual representation of this.

The PERMANOVA performed is the actual measure of how dissimilar the two reef sites are over time. The p-values for the PERMANOVA were calculated comparing the families and the site, the families and the year, and then the families and the site were compared to the families and the year. The p-values were 0.127, 0.151, and 0.264 respectively. Since these p-values are greater than 0.05, the null hypothesis is accepted. This means that, from a visual inspection there seems to be no significant difference, and from an analytical view, the spreads and centroids are not significantly different either. When looking at the results of the SIMPER that was conducted after the

PERMANOVA, the fish family that contributed most to any type of difference between the sites was Pomacentridae according to the calculated ratios.

The R value of the ANOSIM was not reliable (<0.5), as depicted in figure 5, thus these results were not taken into consideration to test the hypothesis. Instead the PERMANOVA was used.

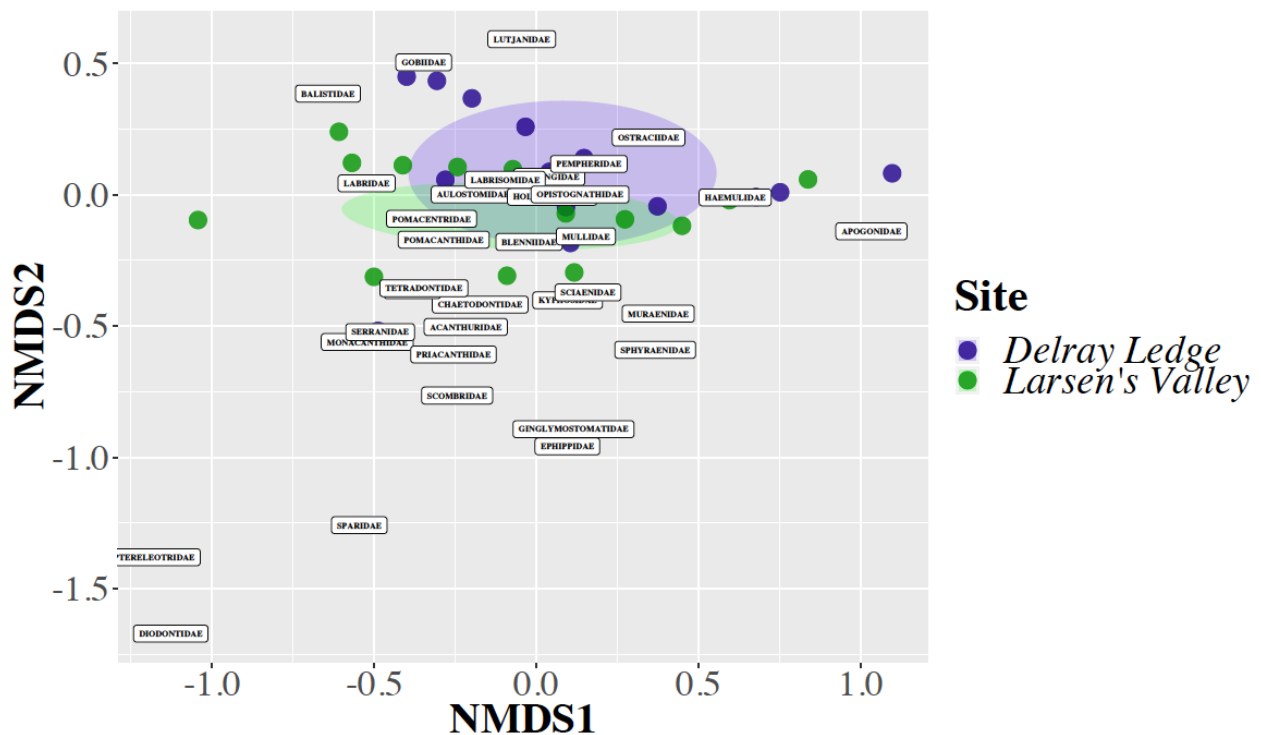


Figure 2: The plot of the nonmetric multivariate analysis. On this plot, ellipses representing the two sites are created to visually represent the homogeneity of fish families at the two sites through the years.

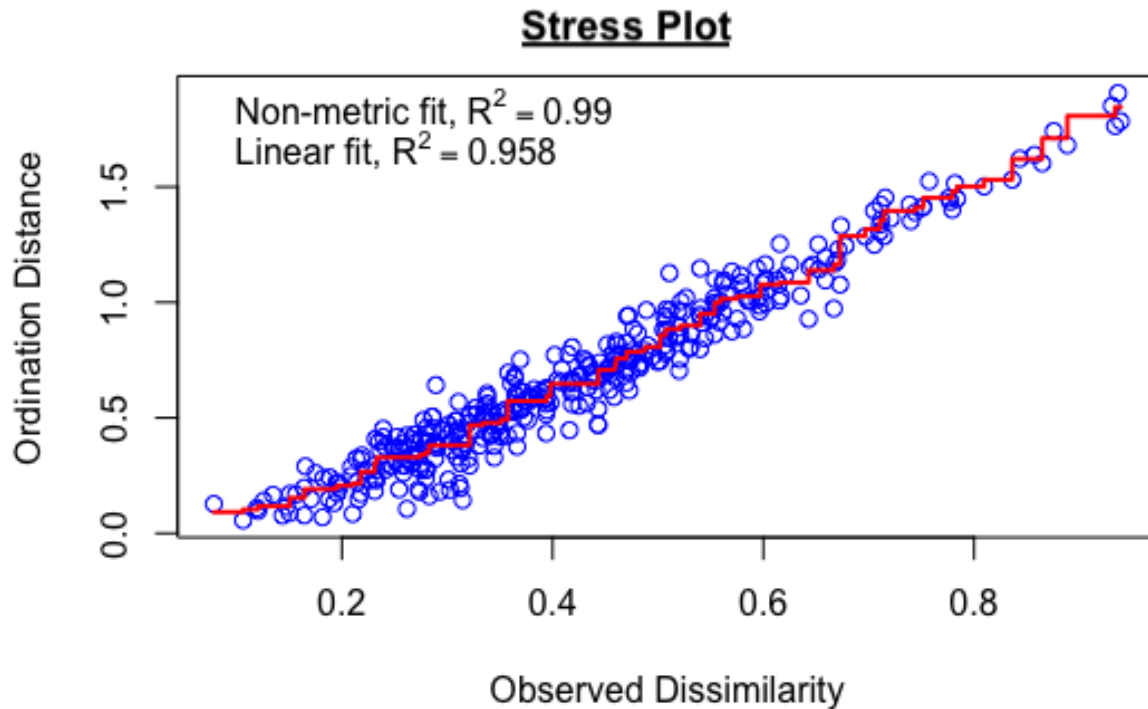


Figure 3: Stress plot that was created after running the NMDS. This graph is a scatter plot of the distances between points from the NMDS.

Permutation: free

Number of permutations: 999

Terms added sequentially (first to last)

	Df	SumsOfSqs	MeanSqs	F.Model	R2	Pr(>F)
fishfam\$Site	1	0.19502	0.195019	1.9670	0.06807	0.127
fishfam\$Year	1	0.16297	0.162967	1.6437	0.05688	0.151
fishfam\$Site:fishfam\$Year	1	0.12749	0.127490	1.2859	0.04450	0.264
Residuals	24	2.37949	0.099146		0.83055	
Total	27	2.86497			1.00000	

Figure 4: Results of the permutational multivariate analysis of variance, or PERMANOVA, that was performed.

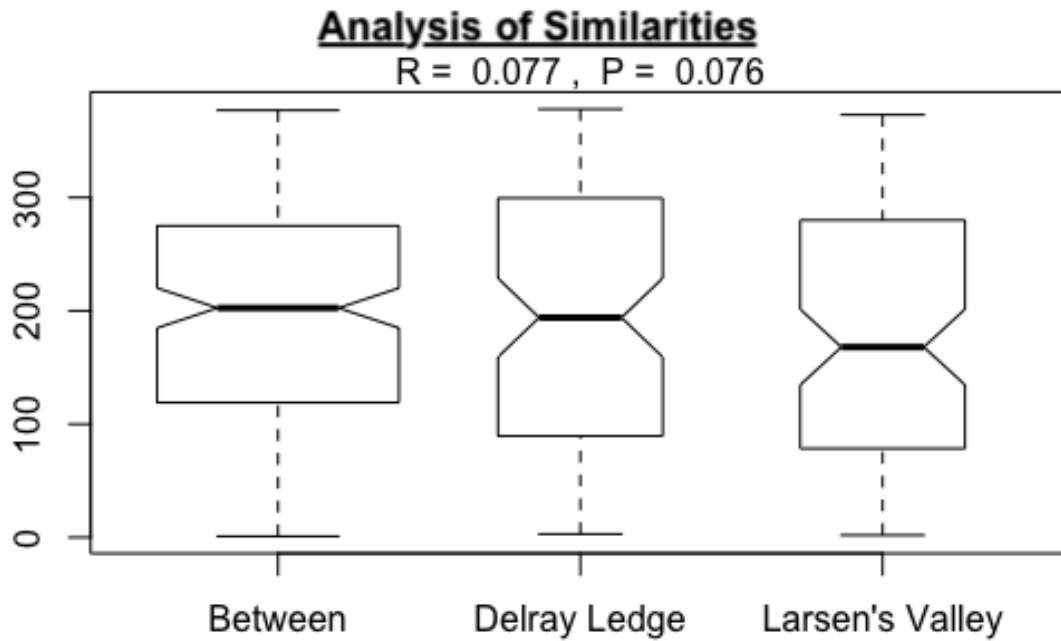


Figure 5: This plot shows the analysis of similarities or the “ANOSIM.”

Fish families Comparison Between Sites – Univariate statistics

Looking at the total abundances of both reef sites over fifteen years, the interquartile range appears quite different (Figure 6), while the minimum values are the same. From figure 6, it can also be noted that the maximum numbers of fish counted appear closely related, as well. Figure 7 shows the spread of the calculated t-tests for the fish families. This box-whisker plot shows the spread of the results of the t-tests for each family when the sites were compared using the years as replicates.

Abundance at Larsen's Valley and Delray Ledge

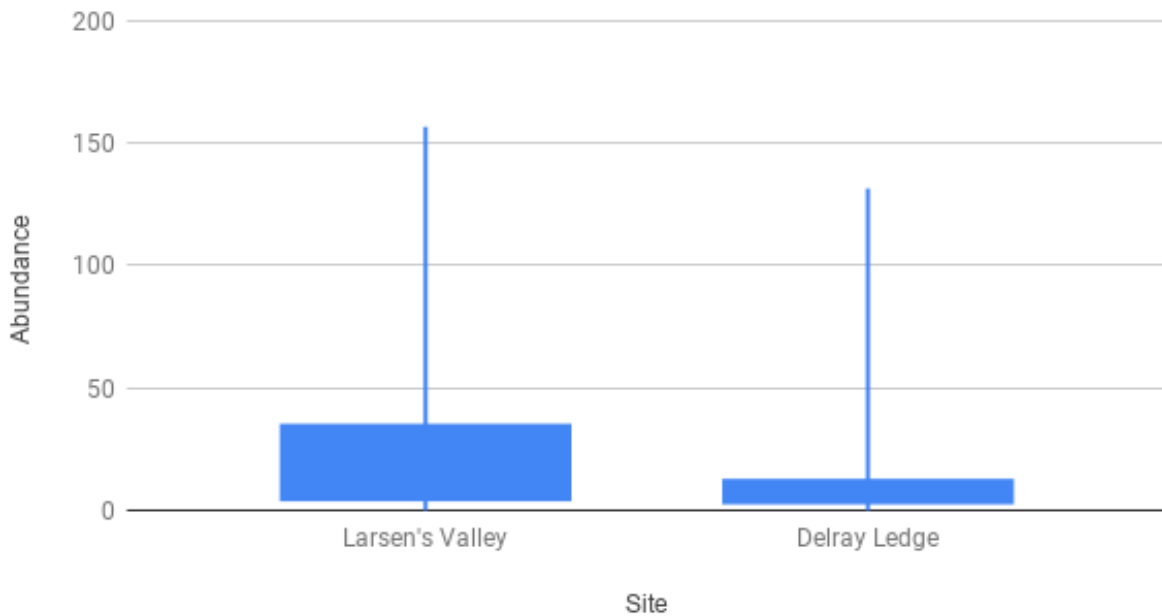


Figure 6: This figure above shows the total abundance of the fishes at each site respectively.

The t-test showed significant differences in fish abundance between Delray Ledge and Larsen's Valley for nine families: Acanthuridae, Aulostomidae, Holocentridae, Labrisomidae, Lutjanidae, Ostraciidae, Pempheridae, Scaridae, Serranidae. Table 1 shows the p-values that were calculated when the individual fish families were compared using the years as replicates. This data can show where there are dissimilarities for particular families but disregards the variable of time.

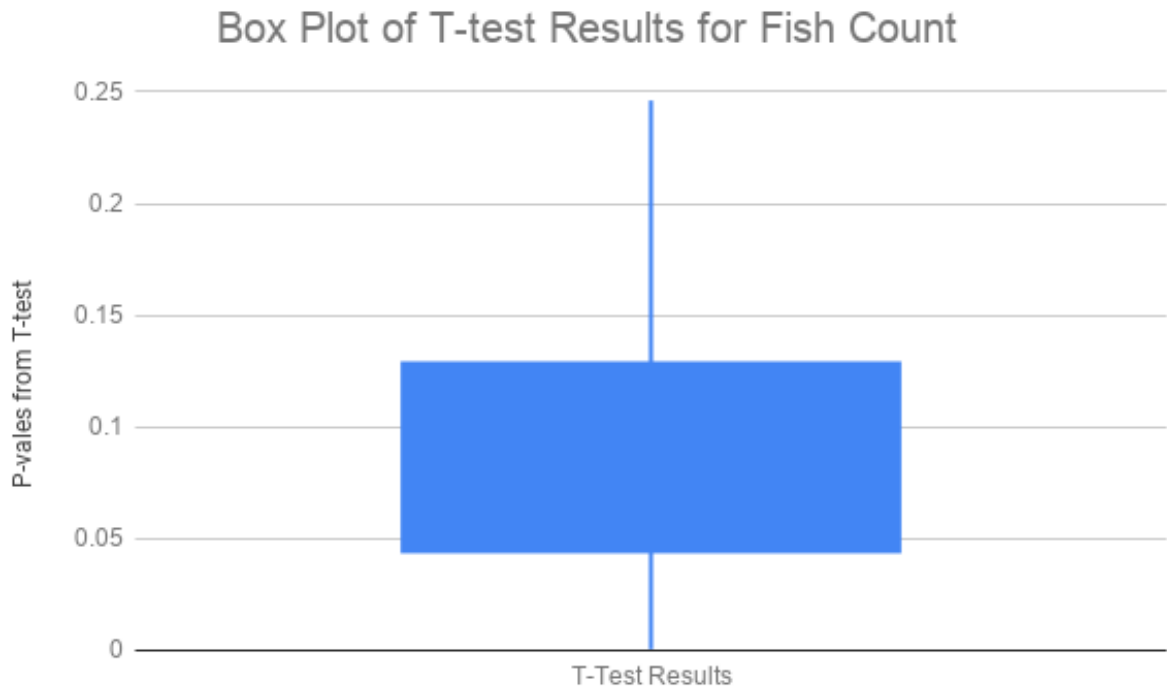


Figure 7: Figure six shows the spread of the calculated t-tests for the fish families.

Table 1: Results of the t-test comparing each fish family between reef sites. Statistically significant p-values ($p < 0.05$) are marked with an asterisk and indicate differences between reef sites for that specific family.

Table of T-tests	
Families	T-Test Results
ACANTHURIDAE	0.000758689*
AULOSTOMIDAE	0.002411759*
APOGONIDAE	0.167780639
BALISTIDAE	0.409080364
BLENNIIDAE	0.317988075
CARANGIDAE	0.33661102
CHAETODONTIDAE	0.14219375
DIODONTIDAE	0.157582164
EPHIPPIDAE	0.292
GINGLYMOSTOMATIDAE	0.329873216
GOBIIDAE	0.022417703
HAEMULIDAE	0.0985
HOLOCENTRIDAE	0.0192*
KYPHOSIDAE	0.074254803
LABRIDAE	0.266332291

LABRISOMIDAE	0.048060579*
LUTJANIDAE	0.036686631*
MONACANTHIDAE	0.095028063
MULLIDAE	0.124432358
MURAENIDAE	0.086553218
OPISTOGNATHIDAE	0.254342523
OSTRACIIDAE	0.00849589*
PEMPHERIDAE	0.043141457*
POMACANTHIDAE	0.074580536
POMACENTRIDAE	0.320603915
PRIACANTHIDAE	0.220851162
PTERELEOTRIDAE	0.132393392
SCARIDAE	0.01177484*
SCIAENIDAE	0.148010273
SCOMBRIDAE	0.094690603
SERRANIDAE	0.000531739*
SPARIDAE	0.221840846
SPHYRAENIDAE	0.5
TETRADONTIDAE	0.16427761

Discussion

Overall, this study showed that fish biodiversity tend to be the same between Larsen's Valley and Delray Ledge reef sites at Palm Beach County, Florida. Only a couple of fish families tend to be different in terms of abundance and do not contribute enough to overall fish biodiversity.

When these results are thought about, it becomes more difficult to tell what they mean in a biological context. Geographically, these reefs are quite close to each other, on the order of less than 30 miles. Considering this, concluding that biotic homogenization is occurring is hard to say. These reefs are quite similar in nature. Both of the depths for the reefs range from about 50 feet to 70 feet. Both of the reefs are primarily sponge reefs. Both of the reefs are a mile off shore. Given these facts, it is not possible to rule out the chance that there is migration occurring between these reefs and all the other reefs in an area. This occurrence is quite likely given the presence of the Gulf Stream and the Florida Current offshore. Moreover, a lack of significant latitudinal distances furthers the argument for the similarity of the two reef sites. Given the likelihood of the ecological connectivity between the two sites, they may receive fish spawn from the same source in the Gulf of Mexico or the Florida Keys.

Additionally, it is hard to say if there are any endemic species found exclusively at one of the sites that was measured. Since they were so similar, it is likely that any endemic species could live at both sites. This study, however, was not taking into account endemism. To do so would mean to conduct these analyses using the species, rather than the families. While there may be an endemic family, there were 36,979 fishes in this study. To find a fish family that only had one species present that was also

endemic is unlikely, especially since there were very few such fish families even present in the data set that was originally received from Florida Fish and Wildlife Conservation Commission. Furthermore, on the topic of endemic species, the removal of fishes with a single count of one (the “cleaning up” of data) may have removed endemic species. In removing fishes that had a singular count of “1” over fifteen years may have unintentionally removed an endemic species from this study, even though it was an outlier.

From the overall results there were significant differences between Delray Ledge and Larsen’s Valley for nine families: Acanthuridae, Aulostomidae, Holocentridae, Labrisomidae, Lutjanidae, Ostraciidae, Pempheridae, Scaridae, Serranidae. There may be a variety of reasons for these specific fish families to have significantly different counts. Depending on the family, some fish are more cryptic and prefer a reef with more places to hide, with more three-dimensional structures, with more holes and ledges in which to hide. Some fish are active more at night than the day, so these fish counts may not be representative of the reef for these fish families since they were conducted during the day.

Of the nine families that show statistically significant total abundances, three fish families are completely absent for the other site: Aulostomidae, Labrisomidae, Pempheridae. Aulostomidae and Pempheridae were present at Larsen’s Valley reef but not at Delray Ledge reef while Labrisomidae were present at Delray Ledge reef and not at Larsen’s Valley reef.

Aulostomidae, trumpet fish, feed on primarily small invertebrates and fishes (Oceana 2019). These fish are known to often conceal themselves by floating among

gorgonian corals as well as swim alongside larger fishes (Vincent & Bell 2015). The benthic community at Larsen's Valley may more conducive to the feeding behaviors of trumpet fishes. It is also possible that these fish were participating in the second behavior mentioned and following a larger fish around. If the latter is true, then it could further explain why none were seen at the other site and so few seen— 46— at Larsen's Valley. Further observations and better notes of the fishes when they are observed are needed to dissect which is the case for this fish family.

Pempheridae, sweepers, gather in protected or sheltered areas in the daytime like caves. It is unclear why there are none at Larsen's Valley since this location is more protected with two ledges on either side. More observations on the fishes behavior need to be completed. It is also good to make note the observer may have simply not noticed them while counting fish due to some other distraction or simply overlooking or misidentifying them.

Labrisomidae, blennies, range from tropical to cold water environments and live in rocky pools, reefs, and kelp beds (The Editors of Encyclopaedia Britannica 2016). These fish can live in shallow waters but some species can live in depths up to 450 meters (The Editors of Encyclopaedia Britannica 2016). Due to the variety of species in this family, any meaningful dissection of why these fish were only at Larsen's Valley is hard to make. This is only exacerbated by the fact that there were only five blennies counted over fifteen years. It is possible that these fish can be rare to see at the sites in this study.

The differences found between the total abundances for the other families by the t-test that was conducted could be due to random error or chance, human error in

counting or recording, or, more likely, difference in behaviors of the fish such as feeding behaviors like being nocturnal or diurnal, or being ambush or hunting predators. It should also be noted that the foods available for the fishes may vary slightly between each site, even though the sites are quite similar. These slight differences may be enough to cause differences in the fish that live there.

Furthermore, the data for this study, while extensive, is somewhat lacking. For each site, there are no replicates. One fish count was conducted at each site per year. If the years are used as replicates, then there are plenty, but in order to observe fish biodiversity changes over time, more than one measurement (replicate) per year, and during the same season are needed. To build on this thought of possible shortcomings in the data, it is important to remember the possibility of human error. This could have occurred anywhere in the study from the fish counting, the fish identification, the input of data into a spreadsheet, or the analysis as well. The largest possible source of discrepancies of this study, though, is likely to come from the seasonality of some fishes. Some of the years that the fish counts were conducted, they were done in the early spring and late winter. Other counts were done in late summer and throughout fall. If this study were to be repeated or built upon, looking at how the fish families are potentially different or not by season would improve the overall comprehension of the data.

The one takeaway from this data, however, is the analyses conducted show a strong similarity in species assemblages. This can mean that as human impacts continue to occur and environmental impacts such as catastrophic weather continue to occur, the reefs can become susceptible and vulnerable from a functional view as

niches are lost or become filled by only one species (Kushlan 1976, McKinney 1998, McKinney Lockwood 2001).

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Appendix

The raw data from Larsen's Valley for the years 2003 to 2009 is shown in the table below.

Family/Year	2003	2004	2005	2006	2007	2008	2009
ACANTHURIDAE	36	10	24	29	48	38	12
AULOSTOMIDAE	0	0	0	0	0	0	0
APOGONIDAE	0	0	0	0	0	0	0
BALISTIDAE	0	0	0	0	0	0	3
BLENNIIDAE	1	0	0	0	1	0	0
CARANGIDAE	26	0	0	8	5	0	0
CARCHARHINIDAE	0	0	0	0	0	0	0
CHAETODONTIDAE	5	3	11	11	13	14	8
DASYATIDAE	0	0	0	0	0	0	0
DIODONTIDAE	0	0	0	0	1	0	0
ECHENEIDAE	0	0	0	1	0	0	0
EPHIPPIDAE	0	0	0	0	0	0	0
GINGLYMOSTOMATIDAE	0	0	0	0	0	0	0
GOBIIDAE	75	5	5	53	4	36	21
HAEMULIDAE	704	328	255	180	553	121	36
HEMIRAMPHIDAE	0	0	0	0	0	0	0
HOLOCENTRIDAE	3	10	1	1	13	1	1
KYPHOSIDAE	1	3	0	8	8	0	0
LABRIDAE	213	85	35	429	376	216	321
LABRISOMIDAE	2	0	0	0	0	0	0
LUTJANIDAE	6	0	4	4	19	0	32
MALACANTHIDAE	0	0	0	1	0	0	0
MONACANTHIDAE	1	0	0	0	2	1	0
MULLIDAE	9	4	5	18	12	6	4
MURAENIDAE	1	2	1	0	0	0	0
OPHICHTHIDAE	0	0	1	0	0	0	0
OPISTOGNATHIDAE	0	0	3	5	0	2	2

OSTRACIIDAE	1	2	1	0	1	0	0
PEMPHERIDAE	0	0	0	0	0	0	0
POMACANTHIDAE	10	2	4	19	7	15	8
POMACENTRIDAE	323	225	22	180	151	274	235
PTERELEOTRIDAE	0	0	0	0	0	0	3
PTERELEOTRIDAE	0	0	0	0	0	0	0
SCARIDAE	68	5	6	7	18	1	28
SCIAENIDAE	7	28	0	1	5	1	0
SCORPAENIDAE	0	0	0	0	0	0	1
SERRANIDAE	5	3	0	4	10	10	6
SPARIDAE	0	1	2	0	0	0	0
SPHYRAENIDAE	1	1	0	0	0	0	0
SYNODONTIDAE	0	0	0	0	0	0	0
TETRADONTIDAE	9	2	1	8	6	18	4
TRIPTERYGIIDAE	0	0	0	0	0	0	0
UROTRYGONIDAE	0	0	0	0	0	0	0

The raw data for Larsen's Valley for years 2010 to 2018 is shown in the table below.

Family/Year	2010	2012	2013	2015	2016	2017	2018
ACANTHURIDAE	14	26	32	2	19	33	27
AULOSTOMIDAE	0	0	0	0	0	0	0
APOGONIDAE	0	0	4	0	0	0	0
BALISTIDAE	0	0	0	0	0	0	0
BLENNIIDAE	0	1	0	0	0	0	0
CARANGIDAE	4	4	0	0	0	6	0
CARCHARHINIDAE	0	0	0	0	0	1	0
CHAETODONTIDAE	8	10	8	2	4	21	9
DASYATIDAE	0	0	0	0	0	0	0
DIODONTIDAE	0	0	0	0	0	0	0
ECHENEIDAE	0	0	0	0	0	0	0
EPHIPPIDAE	0	0	0	0	0	5	0
GINGLYMOSTOMATIDAE	0	0	0	0	0	1	0

GObIIDAE	49	323	14	2	8	0	3
HAEMULIDAE	105	116	1113	76	3	156	1752
HEMIRAMPHIDAE	0	0	0	0	0	0	0
HOLOCENTRIDAE	4	1	1	1	5	2	0
KYPHOSIDAE	0	0	2	0	0	6	0
LABRIDAE	271	546	195	76	366	67	99
LABRISOMIDAE	0	2	1	0	0	0	0
LUTJANIDAE	14	40	1	0	0	0	111
MALACANTHIDAE	0	0	0	0	0	0	0
MONACANTHIDAE	0	0	0	0	2	1	0
MULLIDAE	0	8	14	0	0	27	27
MURAENIDAE	1	0	1	0	0	2	0
OPHICHTHIDAE	0	0	0	0	0	0	0
OPISTOGNATHIDAE	0	4	0	0	0	0	0
OSTRACIIDAE	0	1	1	0	0	0	1
PEMPHERIDAE	0	0	0	0	0	0	0
POMACANTHIDAE	5	10	10	1	14	21	7
POMACENTRIDAE	151	452	159	39	94	82	97
PTERELEOTRIDAE	0	0	0	0	0	1	0
PTERELEOTRIDAE	0	0	0	0	0	0	0
SCARIDAE	10	12	6	0	22	16	7
SCIAENIDAE	2	6	0	0	0	0	0
SCORPAENIDAE	0	0	0	0	0	2	0
SERRANIDAE	4	16	3	0	2	4	4
SPARIDAE	0	0	0	0	0	2	0
SPHYRAENIDAE	0	0	0	0	0	0	0
SYNODONTIDAE	0	0	0	0	0	0	0
TETRADONTIDAE	3	9	12	0	4	6	2
TRIPTERYGIIDAE	0	0	0	0	0	0	0
UROTRYGONIDAE	0	0	0	0	0	0	0

The raw data from Delray Ledge for the years 2003 to 2009 is shown in the table below.

Families/Years	2003	2004	2005	2006	2007	2008	2009
ACANTHURIDAE	13	4	24	17	13	25	6
AULOSTOMIDAE	1	2	0	0	1	10	11
APOGONIDAE	0	0	0	0	0	0	0
BALISTIDAE	0	0	0	1	0	0	0
BLENNIIDAE	0	0	0	0	0	6	0
CARANGIDAE	0	1	9	17	1	6	2
CARCHARHINIDAE	0	0	0	0	0	0	0
CHAETODONTIDAE	8	9	20	7	6	20	11
DASYATIDAE	1	0	0	0	0	0	0
DIODONTIDAE	2	0	0	0	0	0	0
ECHENEIDAE	0	0	0	0	0	0	0
EPHIPPIDAE	0	0	0	0	0	2	0
GINGLYMOSTOMATIDAE	0	0	0	0	0	2	0
GOBIIDAE	0	12	50	20	73	256	151
HAEMULIDAE	2	104	623	2138	5347	1761	261
HEMIRAMPHIDAE	0	0	0	0	0	0	0
HOLOCENTRIDAE	0	8	8	12	3	37	3
KYPHOSIDAE	0	0	5	0	1	2	1
LABRIDAE	33	38	64	55	125	515	182
LABRISOMIDAE	0	0	0	0	0	0	0
LUTJANIDAE	0	1	27	254	19	24	64
MALACANTHIDAE	0	0	0	0	0	0	0
MONACANTHIDAE	1	0	3	0	0	1	2
MULLIDAE	2	11	5	5	4	168	61
MURAENIDAE	0	0	0	2	0	0	0
OPHICHTHIDAE	0	0	0	0	0	0	0
OPISTOGNATHIDAE	0	0	0	0	0	0	0
OSTRACIIDAE	0	0	1	6	1	7	5
PEMPHERIDAE	0	12	0	0	48	30	0
POMACANTHIDAE	0	0	5	8	4	10	13
POMACENTRIDAE	20	26	104	27	67	1273	148
PRIACANTHIDAE	1	4	0	0	0	1	0

PTERELEOTRIDAE	1	0	0	0	0	0	0
SCARIDAE	22	15	12	11	24	80	42
SCIAENIDAE	0	0	1	2	0	2	0
SCOMBRIDAE	0	0	0	0	0	0	0
SERRANIDAE	12	5	18	7	13	16	13
SPARIDAE	3	0	0	0	0	0	2
SPHYRAENIDAE	0	0	0	0	0	2	0
SYNODONTIDAE	0	0	0	0	0	0	1
TETRADONTIDAE	4	2	10	1	5	41	8
TRIPTERYGIIDAE	0	0	0	0	0	0	1
UROTRYGONIDAE	0	1	0	0	0	0	0

The raw data from Delray Ledge for the years 2010 to 2018 is shown in the table below.

Families/Years	2010	2012	2013	2015	2016	2017	2018
ACANTHURIDAE	7	12	10	2	0	8	11
AULOSTOMIDAE	2	2	3	0	7	5	2
APOGONIDAE	0	0	0	0	0	0	
BALISTIDAE	0	0	0	0	0	0	3
BLENNIIDAE	0	0	0	0	0	0	0
CARANGIDAE	0	1	12	5	2	10	1
CARCHARHINIDAE	0	0	0	0	0	0	0
CHAETODONTIDAE	17	16	14	6	7	12	4
DASYATIDAE	0	0	0	0	0	0	0
DIODONTIDAE	0	2	0	0	0	0	0
ECHENEIDAE	0	0	0	0	0	0	0
EPHIPPIDAE	0	0	0	0	0	0	0
GINGLYMOSTOMATIDAE	0	0	0	0	0	0	0
GOBIIDAE	33	205	547	120	261	0	282
HAEMULIDAE	558	608	425	108	484	327	286
HEMIRAMPHIDAE	0	0	0	0	0	0	0
HOLOCENTRIDAE	7	8	9	5	20	7	2
KYPHOSIDAE	0	0	0	0	0	0	0

LABRIDAE	196	674	1101	222	391	334	169
LABRISOMIDAE	0	0	0	0	0	0	0
LUTJANIDAE	26	9	516	45	24	225	70
MALACANTHIDAE	0	0	0	0	0	0	0
MONACANTHIDAE	1	1	0	0	2	1	1
MULLIDAE	84	0	3	4	3	3	2
MURAENIDAE	0	0	0	0	0	1	0
OPHICHTHIDAE	0	0	0	0	0	0	0
OPISTOGNATHIDAE	30	0	7	0	0	0	0
OSTRACIIDAE	4	2	2	1	0	2	1
PEMPHERIDAE	3	100	2	3	0	0	0
POMACANTHIDAE	10	11	9	1	2	14	3
POMACENTRIDAE	139	146	590	45	228	146	155
PRIACANTHIDAE	0	0	0	0	1	1	0
PTERELEOTRIDAE	0	0	6	0	0	0	0
SCARIDAE	74	36	40	21	18	49	16
SCIAENIDAE	2	6	1	0	2	3	0
SCOMBRIDAE	0	0	0	0	0	0	0
SERRANIDAE	7	10	14	6	7	18	10
SPARIDAE	3	1	0	0	0	0	0
SPHYRAENIDAE	0	0	0	0	0	0	0
SYNODONTIDAE	0	0	0	0	0	0	0
TETRADONTIDAE	6	3	21	0	20	1	8
TRIPTERYGIIDAE	0	0	0	0	0	0	0
UROTRYGONIDAE	0	0	0	0	0	0	0