A FINAL REPORT TO THE MOBILE BAY NATIONAL ESTUARY PROGRAM

An Analysis of the Long Term Fisheries Assessment and Monitoring Program Data Set Collected by the Marine Resources Division of the Alabama Department of Conservation and Natural Resources

BY

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Contract No: CIAP AL-15-01

2006

Acknowledgements

The authors wish to acknowledge the cooperation of the Marine Resources Division (MRD) of the Alabama Department of Conservation and Natural Resources in making this data available for examination. This examination was carried out using data collected by members of the Marine Resources Division over the past twenty plus years The importance of our state's living marine resources to both quality of life and the economic well-being of our coastal area are well established. Continued examination of the status of these local resources may also provide an important bellwether toward assessing the health of such living resource populations in a regional or northern Gulf of Mexico context. Accordingly, we look forward to the opportunity of working with the Marine Resources Division in assessing future data sets or in providing any information that may help in designing future sampling strategies or other tools to answer questions left unanswered in this first look. We also wish to acknowledge the support of the Mobile Bay National Estuary Program (MBNEP) in identifying the need for, and obtaining funds for this project using Coastal Impact Assistance Program (CIAP) grants administered by the National Oceanic and Atmospheric Administration and Alabama Department of Conservation and Natural Resources State Lands Division.

Introduction

Among the priority recommendations of the Preliminary Characterization of Living Resources is the determination of the status and trends of as many estuarine species as possible using existing data sets. The Mobile Bay National Estuary Program (MBNEP) area has been sampled on a reasonably regular basis for many years (Fisheries Assessment and Monitoring Program (FAMP)) by the Marine Resources Division (MRD). While the MRD routinely used this information for their own purposes, the entire data set has never been evaluated for the status and trends of individual species, human impacts on fish populations or the value of fish populations as an indicator of ecosystem health. Several action items found in the CCMP proposed by the Living Resources Workgroup hinge on documentation of status and trends of living estuarine resources and identification of indicators of ecological change. Objectives relating to restoration of habitat and management of these living resources require detailed knowledge of the abundance and distribution of estuarine fishes and invertebrates.

Objectives of this study

The objectives of this MBNEP-funded study were to: 1) evaluate species with adequate spatial and temporal coverage of the data set for status and trends analysis; 2) analyze long term trends in the abundance of targeted species and suggest probable causes of change, 3) summarize status of commercial or recreationally important finfish or shellfish species collected by FAMP based on analysis of the data set (we considered these species to be potential indicators of ecosystem change), and 4) identify species requiring additional management and make specific recommendations necessary to increase their abundance, including public outreach, habitat manipulation, protection etc.

Statistical Analyses of the FAMP Data Set

To statistically evaluate the extent which the composition and abundances of finfishes and commercially important shellfishes changed over the duration of these collections, we used both the non-parametric multivariate Analysis of Similarity (ANOSIM) and Analysis of Variance (ANOVA) techniques. In the former case, we used the similarity percentage breakdown procedure (SIMPER) to assess the extent to which the relative abundances of these organisms (those comprising the top 85% of the most common individuals recorded) have changed over time. More detailed descriptions of the ANOSIM and SIMPER procedures can be found in the multivariate statistical package PRIMER-E. Multidimensional Scaling Diagrams are presented to illustrate differences in community composition when they existed.

Variance in spatially replicated sampling within the MBNEP area prevented refined spatial analysis. As a result, analyses of collections of fin and shell fish communities made by FAMP were conducted on a study area wide basis.

Results of nonparametric multivariate analyses of temporal changes within the geographic confines of the Mobile Bay National Estuary Program

Analysis of Beam Plankton Trawl Collections

Beam plankton trawl samples were collected annually from 1980 until 2003. An average of 9 stations were sampled monthly each year, and ranged from a high of 17 stations/month being sampled in 1982, to a low of just 6/month in 2003. Collections made over 23 years, resulted in a dataset that included 154 species. A total of 471,430 individuals were collected during the 23 year sampling effort.

A 1-way analysis of similarity (conducted on 4th root transformed data) showed that the composition and relative abundances of finfish and larger epifaunal invertebrates in collections made with the Beam Plankton Trawl changed significantly over time (Global R = 0.145, p = 0.001). Visual inspection of these changes, as viewed using a Multidimensional Scaling (MDS) plot (Figure 1) showed that the composition of organisms in these collections changed little throughout most of the 1980's (specifically 1981-1985, 1987). Collection composition changed throughout the early 1990's (specifically 1990, 1992-1995), then returned to its original state towards the end of the current evaluation (2002, 2003). Inspection of the composition of fishes in these collections showed that the numerically most abundant species of fishes in the beam trawls collected during the 1980's were spot (*Leiostomus xanthurus*), bay anchovies (*Anchoa mitchilli*), gulf menhaden (*Brevoortia patronus*), and to a lesser extent, naked goby (*Gobiosoma bosci*). Collections made with beam trawls in early-mid 1990's were also dominated by spot and anchovies. Assessments of change in the numerical importance (in terms of their contributions to the overall pool of organisms) of the dominant species in these collections were conducted using the SIMPER procedure. This analysis was focused on those species which contributed to the top 85% of all animals collected.

When samples were combined over the duration of the FAMP collections, 14 species (Table 1) were found to contribute over 85% of fin and shell fishes collected.

Over time, we found no evidence of dramatic changes in the relative abundances of these 14 species. Of these, 6 were found to consistently abundant in the collections. In order of decreasing abundance, they were the spot, gulf menhaden, bay anchovy, goby, brown shrimp (*Penaeus aztecus*), and blue crabs (*Callinectes sapidus*).

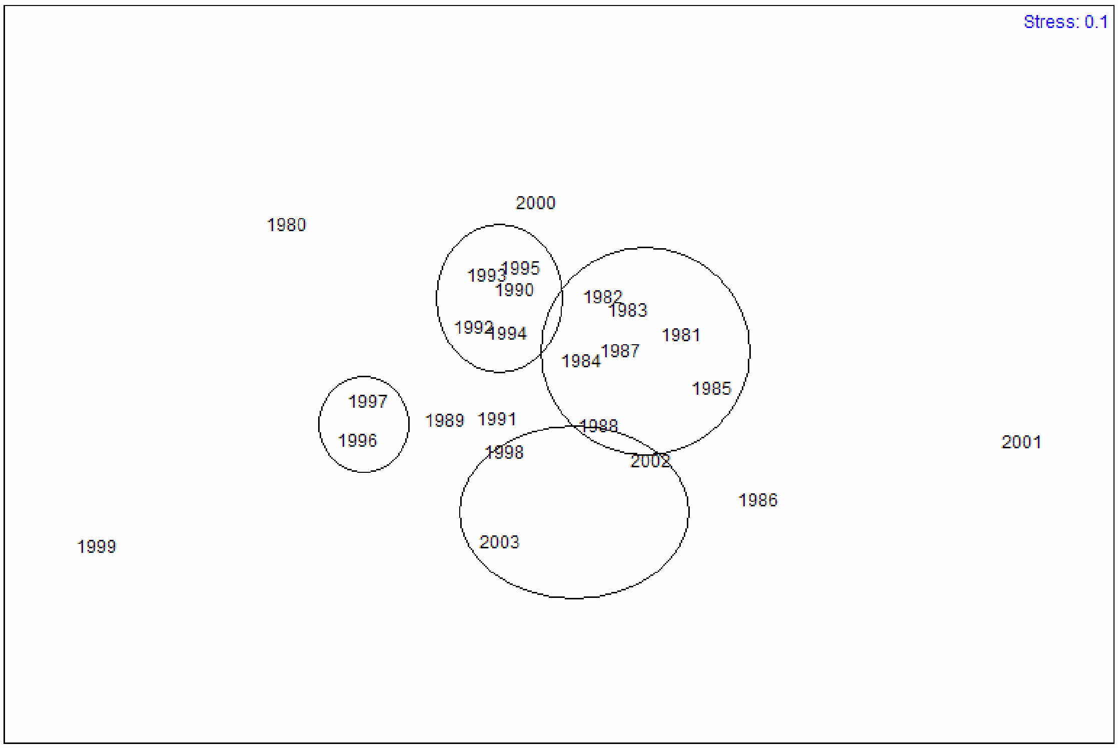

Figure 1: This multidimensional scaling (MDS) plot pictorially describes annual changes in the composition of finfishes and shellfishes in collected using Beam Plankton Trawl (BPL) from 1980-2003. Years included within circles indicate years in which the composition of species collected in the BPL were similar.

Results of analysis of Seine collections

Seines collections were made in 1971 and 1972, and again annually from 1980 through 2003. On average the number of locations sampled was low annually (4.8 stations/year). The numbers of collections made each year was found to vary, ranging from a high of 12 stations being sampled in 1981, and 1982, to a low of two stations being sampled in 1991-1996 and 1998-1999. Analyses of these collections revealed that 173 species were collected using seines. Of these, 153 species were used in the analyses following deletions of recorded collections of infaunal and smaller epifaunal invertebrates. A total of 397,818 individuals were collected with seines during the 26 years of collection.

As with the beam trawls, results of 1-way ANOSIM (conducted 4th root transformed data) showed that the collections of fish and larger epifaunal invertebrates varied significantly among years (Global R = 0.211, p = 0.001). Visual inspection of the MDS plots of these collections did not however reveal discernable temporal trends (Figure 2). Analyses of the numerically most abundant species collected with seines, using SIMPER, showed that only 19 of the 153 species recorded were consistently numerically important (i.e., accounting for the top 85% of all individuals collected). As with the beam plankton trawls, there no observable reductions or increases in the collections of any of these 19 species during the study period. Of these, only 5 were abundant throughout the study period. Ranked in terms of decreasing abundance, they were the gulf menhaden, bay anchovies, striped mullet (*Mugil cephalus*), spot and silversides (*Menidia berylina*).

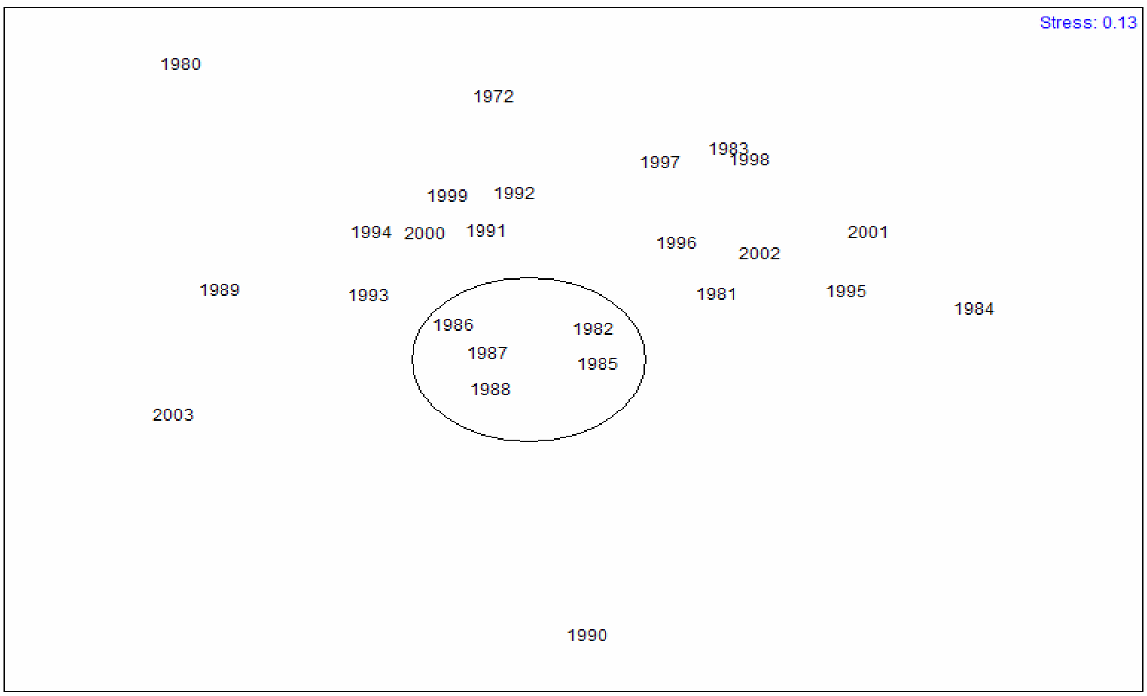

Figure 2: MDS plot of changes in the composition of fin and shellfishes in collections made with a Seine during the study period.

Results of the analysis of Otter Trawl Collections

The dataset containing the results of the collections made using an otter trawl was by far the most extensive of the three data sets, in terms of years sampled and number of trawls taken. Trawls were taken in 1938 and 1947, 1968-1972, and then again from 1980-2003 for a total of 31 years. Only one station was sampled in 1938 and 1947. As a result data collected in 1938 and 1947 were removed from subsequent analysis. On average, 8.3 stations were sampled annually over the course of the remaining 29 years. Over this period of time sampling intensity varied greatly, ranging from samples being collected at 11 stations in 2002, to just 3 stations in 1970. A total of 189 species and 2,357,045 individuals were included in this analysis.

As with the finding of the analyses of the beam plankton trawls and seines, the results of a 1-way analysis of similarity conducted on the otter trawl data set, following transformation (4th root transformation of all counts), showed that the composition of organisms collected with the otter trawl varied significantly among years (Global R = 0.326, p = 0.001). Visual inspection of these collections plotted over time (MDS plots) do not reveal sustained discernable temporal shifts in the numbers or composition of species collected in trawls, just year to year shifts in the relative abundances of animals in the collections (Figure 3).

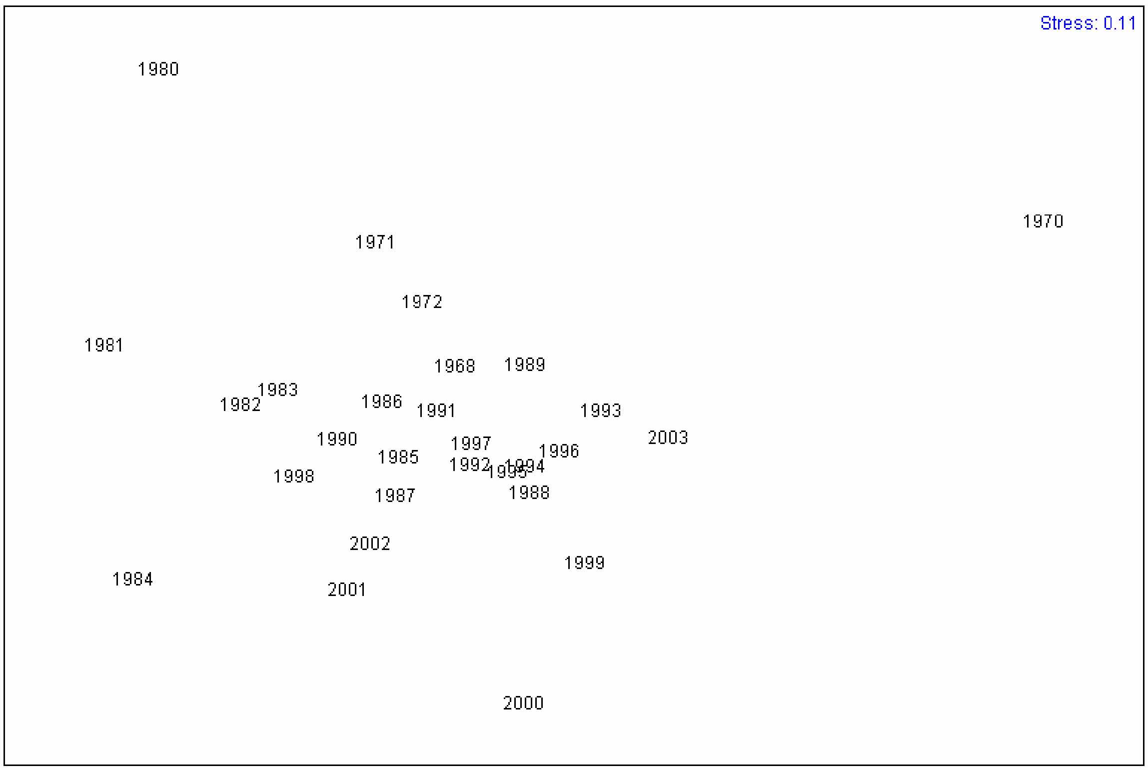

Figure 3: MDS plot of changes in the composition of fin and shellfishes in collections made using an otter trawl during the study period

Subsequent SIMPER analyses revealed that only 27 species (Table 1), of the 189 collected, were ever present in the trawls in any abundance. Of these only 5 were collected consistently in large numbers throughout the duration of this study. Ranked in decreasing order of abundance the five species were the bay anchovy, spot, gulf menhaden, atlantic croaker and brown shrimp. Although there were year to year fluctuations in brown shrimp collections, *P. aztecus,* were seen to decrease in abundance from 1971 through 2003 in this comparison (see discussion below).

Analysis of potential indicator species

Since most species of commercial and recreational interest were collected in low numbers relative to the other species using the three sampling techniques described above, changes in their populations were hard to track over time. As a result, we conducted a second assessment which focused solely on changes in individual populations of these species over time. Because, these species were not present in any abundance in the beam plankton trawls or the seines, we focused this analysis on the trawl collections. Species selected for this analysis included the blue crab, brown shrimp, fringed flounder, gulf flounder, oscellated flounder, red drum, red snapper, southern flounder, spotted seatrout and stripped mullet. Study area wide assessments of long term population changes were made based on the means of all collections made each year. Sample year was considered to be the treatment in each comparison.

Results of analysis of temporal patterns of recreation and commercially important populations

Blue Crabs

Blue crabs were found to be widespread in collections made throughout the study area and they were present in collections made during each year of sampling. Variance in blue crab collections was great. This resulted in our inability to satisfy the assumption of homogeneity of variance for Analysis of Variance (ANOVA), regardless of count transformation. To reduce this variance, ANOVA was conducted on log transformed (x+1) records of blue crab collections within the data set. The results of this comparison showed that blue crab collections varied significantly among years ($F = 2.74$, $df = 1, 22$, $p = 0.000$). A subsequent plot of the blue crab collections over time (Figure 4) identified two years of very high blue crab abundance in the trawls (1984, 1989). It is of note that collections of blue crabs in trawl collections were consistently low recently (2001-2003). This happened once previously, in 1982, but this decline was followed by a large increase in 1983. As such this recent 3 year downturn in this collection should be of concern and requires follow up to determine if the population has rebounded to previously documented levels of abundance.

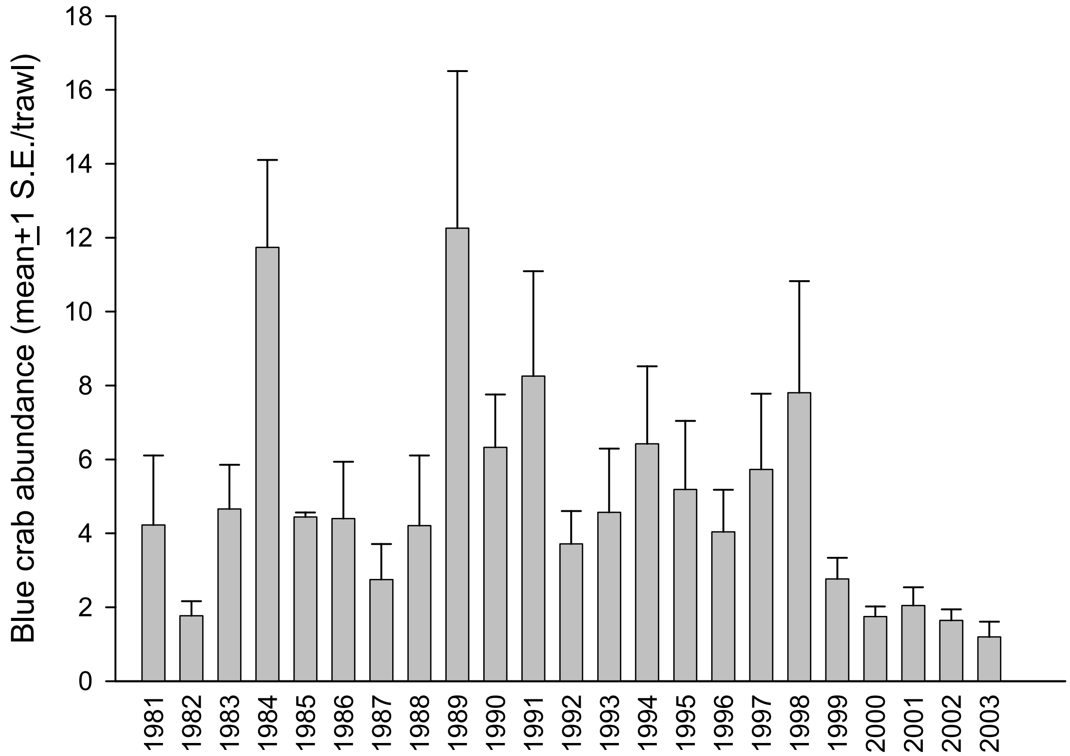

Figure 4. Long term collections of blue crabs made by MRD personnel in the MBNEP Study Area

Brown Shrimp

Brown shrimp were also collected in trawls at all locations except the northeastern most reaches of the study area. As a result, collections made in this area were excluded from the long term analysis as we sought to reduce problems associated with violations of homogeneity of variance. Results of an ANOVA conducted on log (x+1) transformed (homogeneity of variance $p = 0.794$) collections of brown shrimp made using the otter trawl showed that brown shrimp collections also varied significantly among years ($F = 2.04$, df =1, 22, $p = 0.006$). A plot of the brown shrimp collections made over time (Figure 5) shows that brown shrimp abundance in trawls oscillated greatly over the study period with years of low collections followed by years of abundant brown shrimp collections. As with the blue crab analysis, there have been consistently smaller collections of brown shrimp in the last four years of this study (1999-2003). This 4 year downturn in collection should be of concern and require additional follow up to determine if the population has rebounded to previously documented levels of abundance.

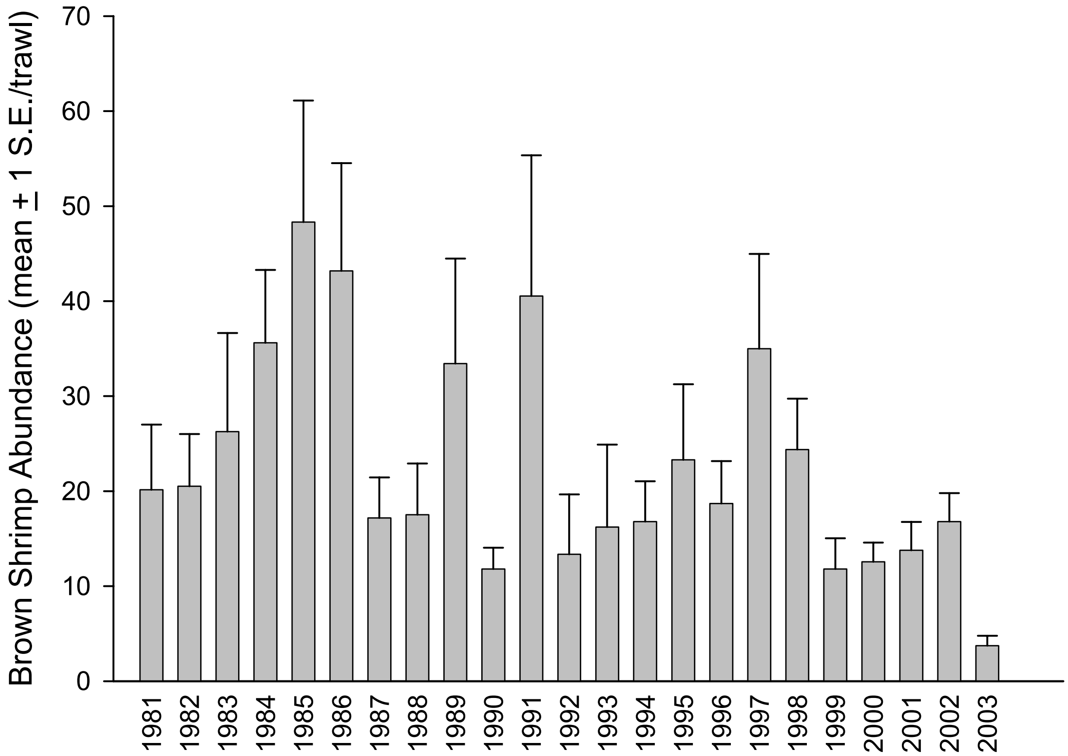

Figure 5. Long term collections of brown shrimp made by MRD personnel in the MBNEP Study Area.

Spotted Sea trout

Preliminary examinations of spotted sea trout collections indicated that these fishes were infrequently collected in the northeastern areas of Mobile Bay, southwestern stretches of Mobile Bay, and the Gulf of Mexico. As a result, trawl collections made at these locations were excluded from subsequent analyses. The assumption of homogeneity of variance for 1-way ANOVA was not satisfied following log (x+1) transformation despite these deletions. The results of the ANOVA conducted on the transformed collections failed to detect significant increases or decreases in spotted sea trout density over the course of this study ($F = 1.44$, $df = 1, 22$, $p = 0.150$; Figure 6).

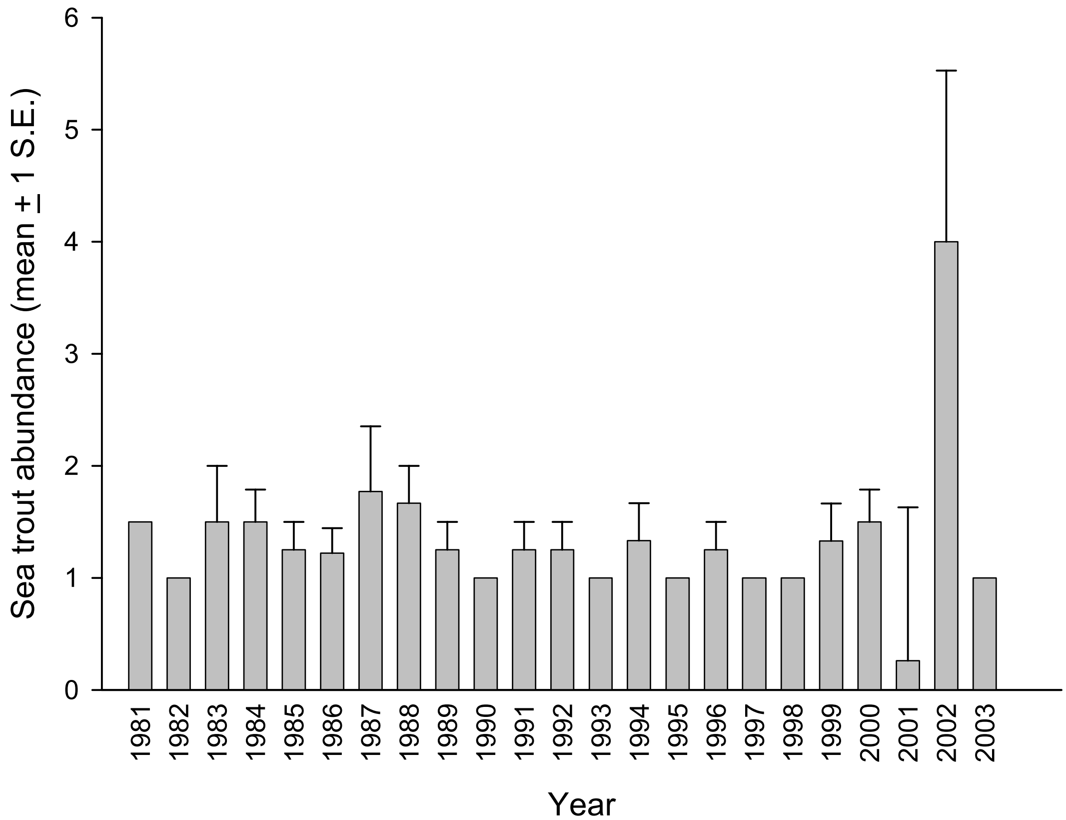

Figure 6. Long term collections of spotted sea trout made by MRD personnel in the MBNEP Study Area.

Red Drum

Sustained collections of red drum were limited to southeastern areas of the study site, Little Lagoon, Mississippi Sound, and Gulf of Mexico. As a result the analyses of red drum trends were limited to these regions. Although we were unable to satisfy the assumption of homogeneity of variance in a 1-way ANOVA under any transformation, ANOVA conducted on log (x+1) transformed collections of Red Drum made at the previously described locations did not detect significant changes in red drum collections over the duration of this study ($F = 0.73$, $df = 1, 22$, $p = 0.794$). It is of note, however, that trawl collections of red drum were consistently smaller (Figure 7) and caution should be used in interpreting temporal trends of red fish abundance using these data.

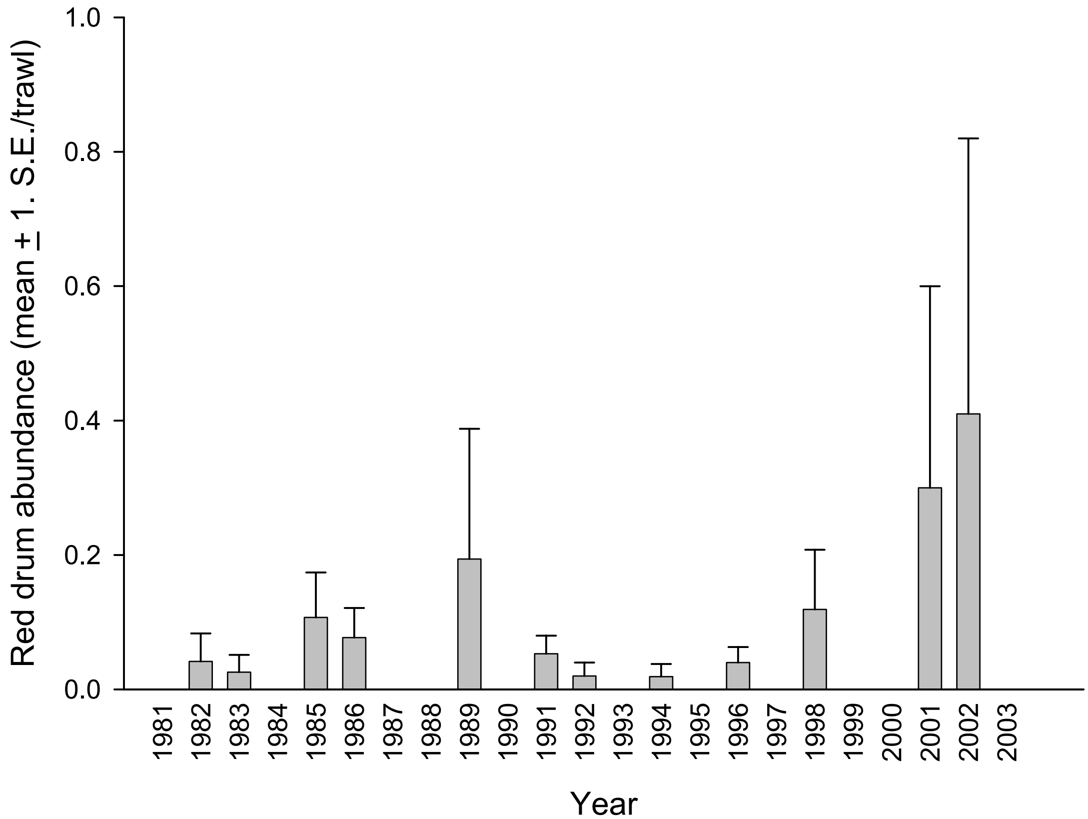

Figure 7. Long term collections of red drum made by MRD personnel in the MBNEP Study Area.

Striped Mullet

The distribution of stripped mullet in the trawl collections was also quite heterogeneous geographically. Consistent annual collections of striped mullet were made at the middle and lower reaches of the eastern shore, Little Lagoon, Perdido Bay, and the northwestern segment of Mobile Bay. Regardless of transformations of these collections, we could not satisfy the assumption of homogeneity of variance. Results from ANOVA conducted on these collections failed to detect either significant increases or decreases in trawl collections over the course of this study ($F = 0.946$, $df = 1, 22$, $p = 0.538$). This interpretation should be viewed with caution as trawling collected low numbers of mullet in most years and may not be the best sampling gear for such evaluations (Figure 8).

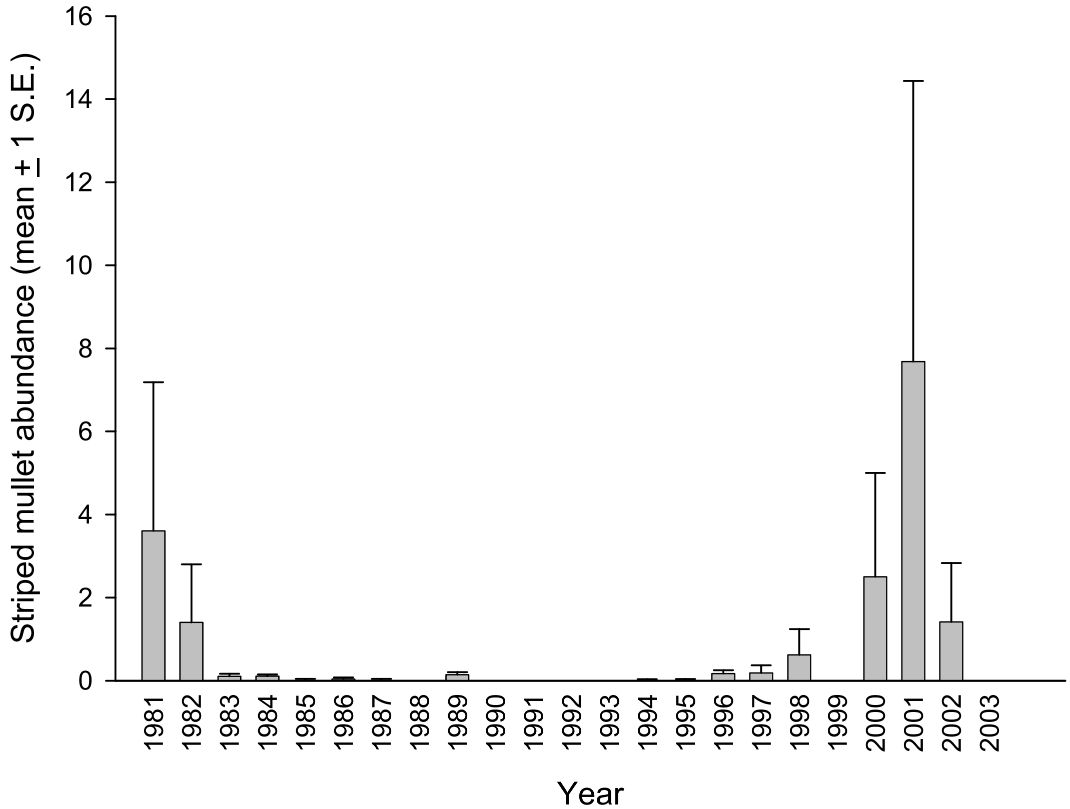

Figure 8. Long term collections of striped mullet made by MRD personnel in the MBNEP Study Area.

The flounders

Five species of flounders were collected frequently enough to provide analysis on. Of these, only the fringed flounder and the southern flounder were collected frequently enough to provide quantitative evaluation.

Fringed Flounder

Fringed flounder were wide spread and the most abundant of the flounders found in this data set. Fringed Flounders were present in every geographic subdivision considered in this study area, with the exception of the northeastern reaches of Mobile Bay. Log (x+1) transformation of trawl collections of this species of flounders satisfied the assumption of homogeneity of variance (p=0.182) for ANOVA. ANOVA conducted on these transformed collections detected marginally significant changes in fringe flounder density with time ($F = 1.51$, $df = 1, 22$, $p = 0.076$). Collections of fringed flounder over the duration of this study show that the abundance of this species can oscillate from year to year. No clear patterns of increased or decreased abundance between 1980 and 2003 were apparent in these data (Figure 9).

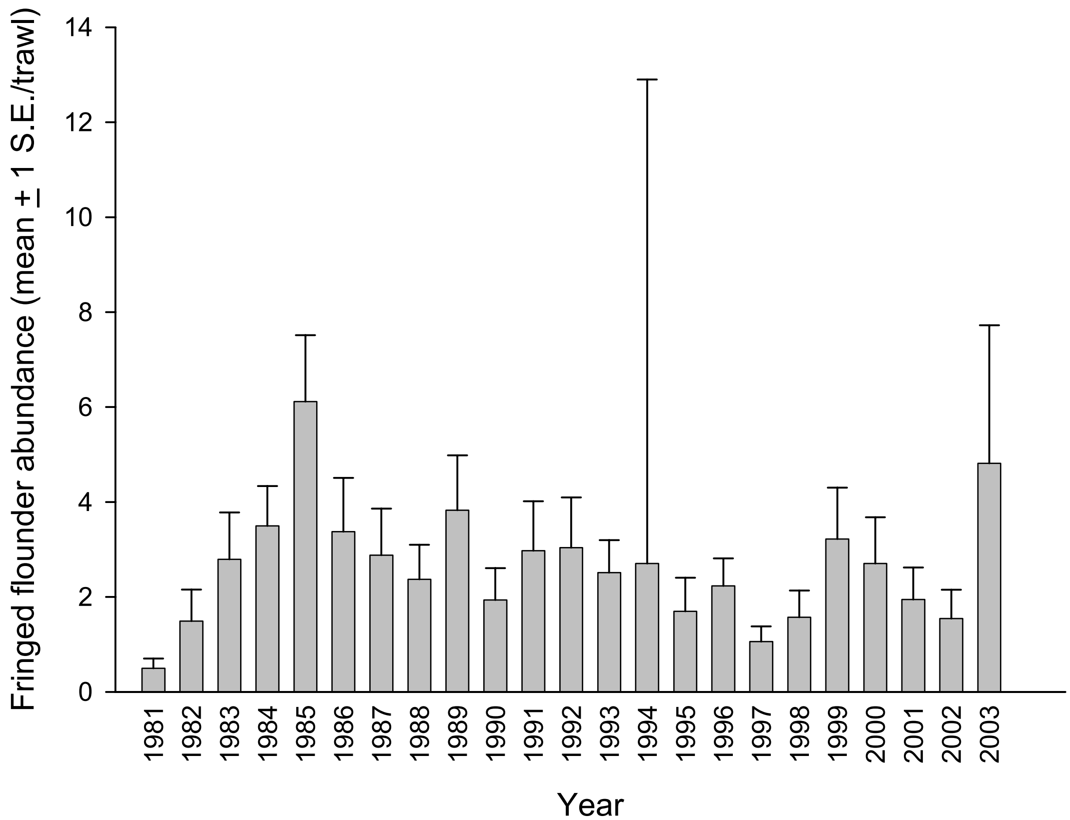

Figure 9. Long term collections of Fringed Flounders made by MRD personnel in the MBNEP Study Area.

Southern Flounder

Southern flounder were collected in all of the major geographic subdivisions of this study, except the northeastern Mobile Bay and Gulf of Mexico. A plot of the collections of southern flounder over time indicates that the abundance of this species oscillates substantially over time with years of low collections followed by years of very high catches (Figure 10). As a result, annual estimates of variance are great among years again, and we were unable to satisfy the assumption of homogeneity of variance using transformation. We did, however, find that collections of these flounders did vary significantly from year to year ($F = 1.87$, $df = 1, 22$, $p = 0.016$).

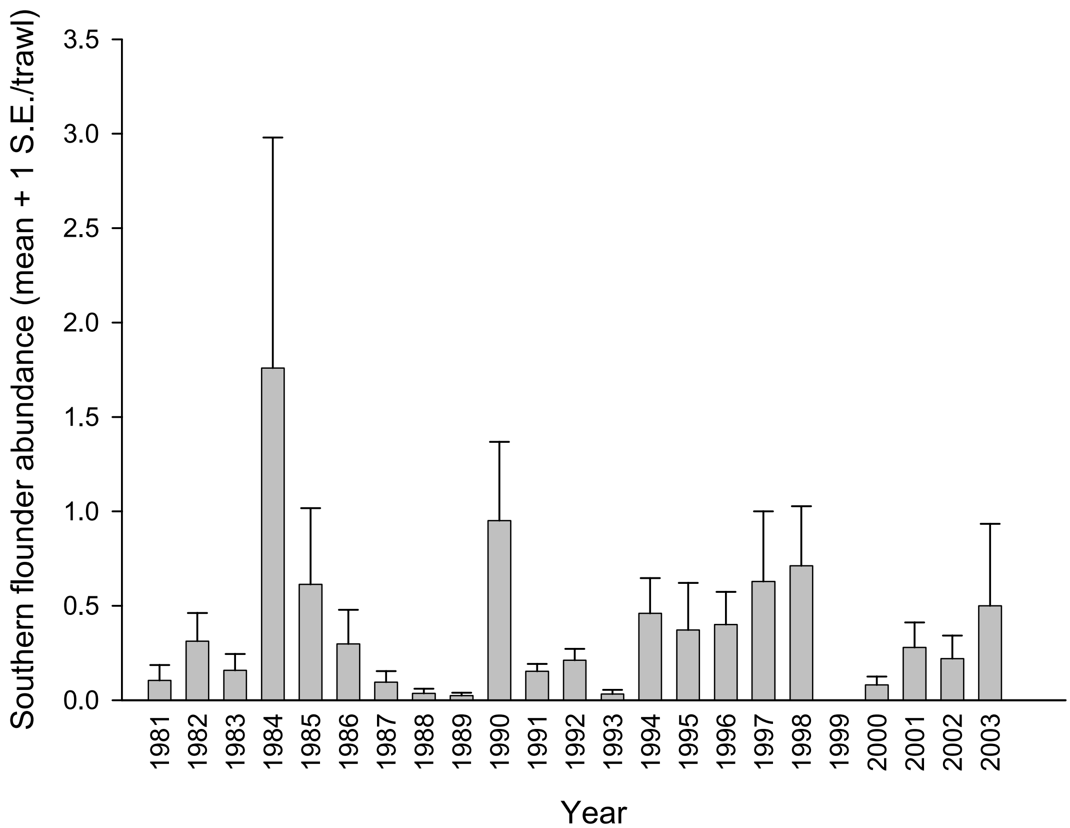

Figure 10. Long term collections of Southern Flounder made by MRD personnel in the MBNEP Study Area.

Gulf Flounder

Collections of Gulf flounder were limited to Little Lagoon and Perdido Bay. In addition few or no gulf flounders were collected from 1981 to 1987. Relatively speaking much greater densities of Gulf Flounder were collected in 1980 and again in 1989. The great variance in numbers of Gulf Flounder collected annually during the course of this study prevented us from satisfying the homogeneity of variance assumption, regardless of transformation, for ANOVA and so the analysis should be interpreted with caution. ANOVA conducted on collections of Gulf Flounder suggest that their densities may vary greatly from year to year ($F = 2.87$, $df = 1, 23$, $p=0.022$). It is of note that the densities of gulf flounder are very low compared to those of the previous commercially valuable species already discussed.

Oscellated Flounder

Collections of oscellated flounders were very infrequent and when collected their abundances were very low. Oscellated flounders were collected, at one time or another, along the entire eastern side of Mobile Bay, and from approximately Dog River northward to the Mobile Bay Causeway. The low numbers of these fishes present in MRD collections prevents any conclusion as to changes in their abundance over time.

Summary of Results and Recommendations

Overall the community of fishes recorded within the FAMP data set was numerically dominated by unexploited species which were found to be widespread throughout the study period. These fishes played a key role in determining the outcome of the temporal comparisons of community structure as a whole within the MBNEP study area. Results from these analyses show that the composition and relative abundances of the community of fishes and epifaunal invertebrates collected in the BPL samples by the FAMP base changed for a short period of time in the 1980's. This change was not permanent as community structure returned to its originally documented state in the 1990's. MDS plots from the seine and trawl samples showed the stability of these communities. Having said that, populations of commercially exploited species may require additional collection and analyses as both blue crab and brown shrimp collections have been much lower in recent times. Since the most recent data in this study was from 2003, it is recommended that data from 2004-2006 be examined to determine if the lower collections of blue crab and brown shrimp are anomalous or indicate a persistent trend.

Differences between the goals and questions of concern of the MBNEP and MRD addressed by the FAMP prevented us from conducting the anticipated spatially explicit assessments of change within the major hydrographic settings of the study area. Large ranges of variance observed in annual estimates of the abundance of organisms add uncertainty and can result in an inability to detect significant changes in the abundances of organisms over time. Accordingly, use of the indicator species assessments alone for definitive determination of the relative abundance of organisms should be considered with this caveat in mind.

With the exception of the more recent collections of brown shrimp and blue crabs, analyses of the FAMP data set did not detect significant shifts in the composition of fin and shellfishes within the MBNEP area. As such it is a useful beginning for further investigation. Since the Gulf of Mexico Estuarine Inventory (GMEI) and the Fisheries Assessment Monitoring Program (FAMP) data from Alabama have not previously been subjected to this particular level of statistical rigor, we have learned a great deal in this examination concerning the nature of questions such data sets may be reasonably expected to assist in answering. Equally important, is the fact that we now have the opportunity to examine overall sampling design in the context of these questions regarding population trends to ensure that it reflects the most recent and locally appropriate techniques and methodologies available.

The analysis of historic data can be challenging given the questions that inevitably arise concerning collection methods, terminology, taxonomy and coding requirements extant at the time of collection. Accordingly, the MBNEP supports a recommendation that the MRD obtain additional resident capability to conduct continuous analysis of this and other fishery data. The services of a full-time fishery statistician on the MRD staff would provide such a capability. The increase in funding necessary to support this is small in comparison to the value of the resource under study and its importance to our region.

Table 1. Numerically most abundant species found in collections made by MRD personnel using beam plankton trawls, otter trawls and seines. Check marks indicate which species were present in an abundance in each sampling gear.

		Gear type		
Scientific Name	**Common Name**	**Beam plankton trawl**	**Otter trawl**	**Seine**
Anchoa hepsetus	striped anchovy	√	√	√
Anchoa lyolepis	dusky anchovy		√	
Anchoa mitchilli	bay anchovy	√	√	√
Anchoa nasuta	longnose anchovy		√	
Arius felis	hardhead catfish		√	√
Bairdiella chrysoura	silver perch	√		√
Brevoortia patronus	gulf menhaden	√	√	√
Callinectes sapidus	blue crab	√	√	√
Callinectes similis	lesser blue crab		√	
Chloroscombrus chrysurus	atlantic bumper		√	
Citharichthys spilopterus	bay whiff		√	
Cynoscion arenarius	sand seatrout		√	
Etropus crossotus	fringed flounder		√	
Eucinostomus argenteus	spotfin mojarra	√		√
Fundulus grandis	gulf killifish			√
Gambusia affinis	mosquito fish			√
Gobionellus boleosoma	darter goby	√		
Gobiosoma bosci	naked goby	√		√
Harengula jaguana	scaled herring			√
Lagodon rhomboides	pinfish	√	√	√
Leiostomus xanthurus	spot	√	√	√
Loliguncula brevis	atlantic brief squid		√	
Membras martinica	rough silverside			√
Menidia berylina	silversides	√		√
Micropogonias undulatus	atlantic croaker	√	√	√
Mugil cephalus	striped mullet	√		√
Mugil curema	white mullet			√
Penaeus aztecus	brown shrimp	√	√	√

Penaeus duorarum	pink shrimp	√	√	√
Penaeus setiferus	white shrimp	√	√	√
Peprilus burti	butterfish		√	
Sphoerodies parvus	least puffer		√	
Stellifer lanceolatus	american stardrum		√	
Symphurus plagiusa	blackcheek tongue fish		√	
Synodus poeyi	lizardfish		√	
Trichiurus lepturus	atlantic cutlassfish		√	
Trachypenaeus constrictus	roughneck shrimp		√	
Trachypenaeus similis	roughback shrimp		√	