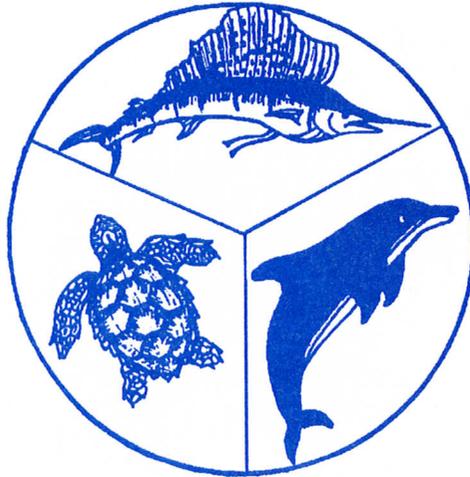


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# MARINE FORENSICS PROGRAM: DEVELOPMENT OF A BIOCHEMICAL METHOD TO DISTINGUISH WILD FROM CULTURED FISH: FINAL REPORT

September 1992



**U.S. DEPARTMENT OF COMMERCE**  
National Oceanic and Atmospheric Administration  
National Marine Fisheries Service  
Southeast Fisheries Science Center  
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# MARINE FORENSICS PROGRAM: DEVELOPMENT OF A BIOCHEMICAL METHOD TO DISTINGUISH WILD FROM CULTURED FISH: FINAL REPORT

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September 1992

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## CONTENTS

	<u>Page</u>
Executive Summary .....	i
Introduction .....	1
Materials and Methods .....	4
Results and Discussion .....	9
Conclusions .....	34
Recommendations .....	36
Literature Cited .....	38

### Appendices

- A. Development and application of forensic techniques for use in management of South Carolina's fishery resources. A Progress Report.
- B. An enforcement report for New Jersey Fish, Game and Wildlife (NJFG&W) Marine Fisheries Law Enforcement.
- C. Fatty acid compositional tables for cultured and wild fish.

## LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Collection card for the wild striped bass and wild hybrid striped bass . . . . .	5
2. Wild fish collection sites in South Carolina . . . . .	6
3. Indicator fatty acids of wild striped bass/hybrid striped bass and cultured hybrid striped bass . . . . .	13
4. Average values of selected fatty acids of commercial trout diets and of cultured reciprocal hybrid striped bass fed these diets at the Waddell Mariculture Center - 1988-1990 . . . . .	14
5. Average values of selected fatty acids in wild fish collected from Lake Hartwell during year one of the study . . . . .	17
6. Average values of selected fatty acids in wild fish collected from Lake Hartwell during year two of the study . . . . .	18
7. Average values of selected fatty acids in wild fish collected from Lake Thurmond (Clark's Hill) during year one of the study . . . . .	19
8. Average values of selected fatty acids in wild fish collected from Lake Thurmond (Clark's Hill) during year two of the study . . . . .	20
9. Average values of selected fatty acids in wild fish collected from Lake Murray during year one of the study . . . . .	22
10. Average values of selected fatty acids in wild fish collected from Lake Murray during year two of the study . . . . .	23
11. Average values of selected fatty acids in wild fish collected from Lake Wateree during year one of the study . . . . .	24

12.	Average values of selected fatty acids in wild fish collected from Lake Wateree during year two of the study .....	25
13.	Average values of selected fatty acids in wild fish collected from the Santee Cooper River System (Lakes Moultrie and Marion) during year one of the study .....	26
14.	Average values of selected fatty acids in wild fish collected from the Santee Cooper River System (Lakes Moultrie and Marion) during year two of the study .....	27

## LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Weight percent fatty acid composition of ten samples of homogenized tissue from a single fish collected from the Santee-Cooper River System, January 1990 . . . . .	11
2. Weight percent fatty acid composition of ten samples of homogenized tissue from a single fish collected from Lake Murray, January 1990 . . . . .	11
3. Weight percent fatty acid composition of five individual fish collected from Lake Murray, January 1990 and of the composite sample of these fish . . . . .	12
4. Weight percent fatty acid composition of five individual fish collected from Lake Thurmond, November 1989 and of the composite sample of these fish . . . . .	12
5. Ranges and average values of weights (in grams) of cultured and wild fish collected during the study . . . . .	16
6. Weight percent fatty acid composition of three fish diets and of reciprocal hybrid striped bass fed these diets . . . . .	29
7. Weight percent fatty acid composition of a commercial trout diet and fish fed this diet . . . . .	30
8. Weight percent fatty acid composition of commercially raised hybrid striped bass and their diets . . . . .	31
9. Mean weight percent fatty acid composition of striped bass collected from the Mattaponi (MR) and Chowan Rivers (CR) in Virginia . . . . .	33
10. Classification of single fish into catch location by Linear Discriminant Analysis . . . . .	35
11. Classification of 5-fish composites into catch location by Linear Discriminant Analysis . . . . .	35

12.	Classification of single fish into catch location without linoleic acid values by Linear Discriminant Analysis .....	35
13.	Classification of 5-fish composites into catch location without linoleic acid values by Linear Discriminant Analysis .....	35

## Executive Summary

This study reports the results of a two year cooperative research effort between the National Marine Fisheries Service (NMFS), Charleston Laboratory's Marine Forensics Program, and the South Carolina Wildlife and Marine Resources Department (SCWMRD), to develop a biochemical method to distinguish wild fish from those that were "farm-reared" (cultured) using the edible portion of the fish as the test material. This research effort was initiated because of concern by SCWMRD that a successful hybrid striped bass aquaculture industry might result in an increase in the illegal sale of wild striped bass and its hybrids from SC waters.

States from Massachusetts through Texas have developed legal provisions to allow the commercial culture of these fish even though some states list striped bass and its hybrids as "game" fish. In these states, including SC, these "game" fish support substantial recreational fishing activities.

Traditionally, enforcement officials have relied on paper trails to monitor sales and movement of cultured fish. Recently the Atlantic States Marine Fisheries Commission (ASMFC) proposed a 12 digit tag requirement for each individual fish or fillet because no biochemical method was available to distinguish wild from cultured fish. The results of our two year cooperative effort have demonstrated that wild striped bass and its hybrids can be positively discriminated from cultured fish using differences in their fatty acid profiles, particularly linoleic acid concentrations. Linoleic acid is especially high in cultured fish, since soybean meal is often used as a major ingredient in fish feeds, and soybean oil contains approximately 54% linoleic acid. Similarly, linoleic acid is the major fatty acid of other vegetable materials (e.g. cottonseed, corn, wheat, barley, rice) commonly used in the manufacture of commercial fish feeds. Based on the results of our analyses, the ASMFC amended their recommendation to eliminate the tagging of whole or gutted individual cultured hybrid striped bass.

In order to determine the extent of seasonal and geographical differences, wild striped bass and its hybrids were collected four times a year, over a two year period, from Hartwell, Thurmond, Murray, and Wateree reservoirs and the Santee Cooper River System (Moultrie and Marion). Samples of wild striped bass were also obtained from the Chowan and Mattaponi Rivers in Virginia. In addition, samples of cultured hybrid striped bass and their commercial diet were collected from the Waddell Mariculture Center (WMC) and from two commercial aquaculture farms operating in SC.

Fatty acids from 633 wild fish and 68 cultured fish were analyzed during the two year study. Linoleic acid concentrations (weight percent) averaged  $3.3 \pm 0.37$  for wild fish and  $11.7 \pm 0.73$  for cultured fish. Differences in linolenic acid, arachidonic acid, docosapentaenoic acid, and docosahexaenoic acid were also recorded and used as

supportive information to help distinguish wild from cultured fish. Differences in the concentrations of these fatty acids were also used to identify the geographic origin of wild fish. In addition to visual interpretation of the data, Linear Discriminant Analysis was used to classify fish into wild or cultured categories and lake or region of origin. Classification into wild and cultured categories was 100% accurate. Classification into the correct SC lake or region of origin ranged from 61-100% accuracy, averaging  $85.0\% \pm 13.0$ .

Appended to this document is a report entitled "Development and Application of Forensic Techniques for Use in Management of South Carolina's Fishery Resources: A Progress Report". In this study, a SC law enforcement official supplied the NMFS Charleston Laboratory with seven unidentified skinless fillets. Our laboratory was 100% accurate in distinguishing wild from cultured fish using fatty acid differences, and whether they were hybrid striped bass or striped bass using isoelectric focusing (IEF) (Appendix A).

Using the techniques described in this report, the NMFS laboratory also analyzed suspect wild bass tissue for the New Jersey Fish, Game and Wildlife (NJFG&W) Marine Fisheries Law Enforcement (Appendix B). In the NJ enforcement case, 15 skin-on fillets were sent to our laboratory for species identification and for determining if the fillets were wild or cultured fish. All 15 fillets were successfully identified as wild fish by fatty acid analyses and as striped bass by IEF. This information was used as evidence in court, and as a result the defendants pleaded guilty.

Sufficient information is included in this report to conclude that wild striped bass and its hybrids can be successfully distinguished with 100% accuracy from cultured hybrid striped bass, using differences in their fatty acid profiles. Over the next few years, this database should be expanded to include possible changes in diet formulations and to include wild and cultured fish from other regions of the country. This database, when combined with solid law enforcement efforts, will help to protect and conserve our natural resources.

## INTRODUCTION

The demand for high quality seafood is expected to increase over the next several years. The National Fisheries Institute (NFI) has set a seafood consumption goal of 20 pounds per capita by the year 2000 (Anonymous, 1990a). This is a 20% increase over the 1989 consumption level of 15.9 pounds (Anonymous, 1990b). Increased seafood consumption, however, will occur at levels exceeding that which can be supplied by commercial harvest of wild fisheries (Anonymous, 1988).

The U.S. is the world's second largest seafood importer. In 1987, imports were valued at \$8.5 billion (Martin, 1988). From 1960-1986, U.S. seafood imports expanded at an annual rate of \$278 million (Parker, 1988). As the upward trend for seafood demand continues, the U.S. must develop alternative seafood supplies in the 1990's or suffer further trade imbalances in fishery products. Domestic landings are not expected to increase, and any additional seafood products will have to be produced through domestic aquaculture operations to meet future demand and reduce our dependence on imported seafoods. Our ocean resources are limited and estimates are that farm-raised species will contribute 25% of the world's seafood supply by the year 2000 (Rhodes, 1987).

In the U.S., channel catfish (*Ictalurus punctatus*) and rainbow trout (*Salmo gairdneri*) are the most commonly cultured food finfish. They are defined as agricultural crops in some states (e.g., catfish in Mississippi, trout in Idaho, and all cultured animals in Missouri), and as such are not regulated by state conservation and natural resource agencies (Parker, 1988). Currently, considerable interest has also been shown in the commercial culture of hybrid striped bass, a cross between striped bass (*Morone saxatilis*) and white bass (*Morone chrysops*) (Olst and Carlberg, 1990). However, striped bass and its hybrids are considered "game" fish in several states (Parker, 1988). In SC, as well as other locations, these "game" fish support considerable recreational activity. Therefore, most states have implemented legal provisions for the culture and sale of these fish (Sharpe and Moore, 1987; Parker and Miller, 1988).

South Carolina law enforcement officials are concerned that commercial culture of hybrid striped bass will lead to an increase in the illegal capture of wild striped bass and its hybrids for sale in commercial markets (Lareau, 1987). Currently, law enforcement agencies rely on paper trails to determine source and movement of cultured fish. In 1987, law enforcement personnel proposed a resolution to establish a 12 digit alpha-numeric tagging system for individual fish and/or fillet (Parker, 1988). Cost estimates to implement this tagging system ranged from 5-15¢ per tag. Recently, partly due to our research, this restriction has been relaxed. The recommendations still require individual tags for skinless fillets, but for whole or gutted hybrid striped bass, a single tag on the outside of the box is acceptable. However, all commercially grown striped bass must still be individually tagged.

In June 1988, the SC General Assembly passed a Resolution allowing the commercial culture and sale of hybrid striped bass. As a result, in November 1988, the National Marine Fisheries Service (NMFS) Charleston Laboratory's Forensics

Program, and the SCWMRD signed a cooperative agreement to develop forensic techniques in areas of mutual interest. In particular, one primary objective was to develop a biochemical method to distinguish wild from cultured fish using the edible portion of the fish. To accomplish these objectives, the possibility of using differences in fatty acid composition of tissue lipids to differentiate wild fish from cultured fish was examined (Jahncke et al., 1988a, Jahncke and Seaborn, 1989; Jahncke et al., 1989, 1991).

The term "lipid" generally refers to a wide variety of natural products which are readily soluble in organic solvents. More specifically, the term is often restricted to fatty acids and their naturally occurring derivatives and to compounds closely related biosynthetically. The major lipid classes found in wild and cultured fish are cholesterol (a simple lipid), triacylglycerols (TG), phospholipids (PL), and occasionally wax esters. The latter three classes are complex lipids in which component fatty acids form part of the molecular structure. Phospholipids are generally considered to be structural or functional lipids and are incorporated to a large extent into cell membranes. Most of the remaining fat, usually TG, occurs as depot, or storage fat. The fatty acids found in the depot fats generally reflect the diet of the animal and serve as an energy source or a reserve from which fatty acids may be selected for incorporation into the PL.

The common fatty acids found in these fish contain even numbers of carbon atoms (12-24) in straight chains and may be fully saturated or contain one to six double bonds. The fatty acid "shorthand" used in this report has been suggested by the IUPAC-IUB Commission on Biochemical Nomenclature (1977) as a replacement for the " $\omega$ " (omega) system. This shorthand notation specifies the number of carbon atoms and the number of double bonds, followed by the position of the terminal double bond relative to the hydrocarbon end of the molecule, designated as "n-x". For example, the shorthand notation for linoleic acid (18:2n-6) denotes a fatty acid that contains 18 carbon atoms with two double bonds and is a member of the n-6 family of fatty acids.

Fatty acids have been used by researchers to distinguish cod (*Gadus morhua*) eggs from haddock (*Melanogrammus aeglefinus*) eggs (Knutson et al., 1985). Joseph et al. (1985) suggested using fatty acid analysis to determine the presence of marine turtle oil in cosmetic products. Seaborn (unpublished) recently used fatty acid composition to determine the species of marine turtle eggs. This information, provided to NMFS and USF&W enforcement agencies, was instrumental in the successful prosecution of several cases related to the illegal taking of loggerhead (*Caretta caretta*) and green sea turtle (*Chelonia mydas*) eggs.

Fatty acids in the depot lipids of wild fish will reflect the fatty acids found in the food chain (Linko et al., 1985). Phytoplankton are regarded as the primary source of the n-3 fatty acids that are prominent in the lipids of wild fish. (Ackman et al., 1964, Ackman, 1982). In contrast, cultured fish are typically fed a commercially formulated diet based primarily on soybean or other vegetable sources, and thus

cultured fish usually have lower n-3/n-6 ratios, reflecting the higher concentrations of linoleic acid (18:2n-6) in the commercial diet (Chanmugam et al., 1986; Jahncke et al., 1988a, 1988b; Jahncke and Seaborn, 1989; Jahncke et al., 1991).

Fatty acid composition of fish can vary by season, sex, species, location, diet, physiological condition, and other factors (Stansby, 1981). To determine the extent of these variations, and to develop sufficient baseline data for enforcement purposes, SCWMRD fishery biologists collected wild striped bass and its hybrids from November 1988 to July 1990. During this time, samples were collected quarterly in Nov., Jan., April and July. Collection sites were based on fish abundance and environmental diversity. Specimens were collected from five SC lakes and two rivers in Virginia. Cultured hybrid striped bass and diet samples were collected from the Waddell Mariculture Center (WMC) and from two SC commercial aquaculture operations. During this two-year study, 989 wild fish were collected. Fatty acid compositions were determined for 633 of these fish and 68 cultured fish.

In order to test the reliability of our method, a SCWMRD enforcement officer brought seven unidentified skinless fillets to the NMFS Charleston Laboratory for analysis during the course of the study. Our laboratory was charged with identifying the samples as to origin (wild or cultured fish) using fatty acid analyses, and as to whether they were striped bass or hybrid striped bass using isoelectric focusing (IEF) of proteins (Jahncke and Seaborn, 1989), (Appendix A).

In addition to the above study, our laboratory also analyzed 15 suspect striped bass skin-on fillets to determine species and origin (wild or cultured fish) for the NJ Fish Game and Wildlife Marine Fisheries Law Enforcement (NJFG&W), using a combination of IEF and fatty acid analysis. The results were used as chemical evidence in court (Appendix B).

This report summarizes the results of the two year cooperative research effort between SCWMRD and NMFS Charleston Laboratory's Marine Forensics Program. This database, when combined with solid law enforcement efforts, will help to better protect and conserve wild fishery resources.

## MATERIALS AND METHODS

### Sample Collection

#### Wild Striped Bass and Hybrid Striped Bass from SC (reference fish)

Wild fish (both striped bass and hybrid striped bass) were collected by SCWMRD fishery biologists and provided to NMFS, Charleston Laboratory, for fatty acid analysis. These biologists also recorded information on species, size, sex, sexual maturity and collection site (Figure 1). The objective was to collect approximately 50-60 fish per site (Lakes Hartwell, Thurmond, Murray, Wateree, and the Santee Cooper River System) per seasonal collection period (Nov., Jan., April and July). Actual numbers of fish collected depended upon season and availability and ranged from a minimum of three fish (April, 1990 - Lake Moultrie) to a maximum of 63 fish (Jan., 1989 - Lake Murray). A total of 967 wild SC fish were collected over the course of the two year study. Fishery biologists were not available for collections from Lake Murray in July, 1990 and Lake Wateree in Jan., 1990.

The general collection protocol was:

1. Fish were collected from: 1) Santee Cooper River System (Lakes Moultrie and Marion), 2) Lake Wateree, 3) Lake Murray, 4) Lake Thurmond (Clark's Hill) and 5) Lake Hartwell (Figure 2).
2. Samples were collected in November 1988 and 1989, January, April and July, 1989 and 1990. All sites were sampled over a maximum period of 30 days.
3. Fish sizes included the range of "marketable" sizes (approximately 400-3500g).
4. Fish were iced at the time of collection and then frozen as soon as possible. Small fish were frozen whole. Large fish were sub-sampled (200g minimum of flesh, skinless preferred) instead of freezing the whole fish.

#### Cultured Hybrid Striped Bass from the Waddell Mariculture Center (WMC) (reference fish)

Cultured hybrid striped bass and commercial diet samples were collected from the WMC. Fatty acid analyses were conducted to: (1) develop baseline information on the fatty acids of WMC-cultured hybrid striped bass, (2) determine the effects of feeding different commercial diets on tissue composition, and (3) determine the effect of fish type on tissue composition. The three experimental groups consisted of the following:

**Group (1):** Cultured reciprocal hybrid striped bass, (female white bass x male striped bass), from SCWMRD Waddell Mariculture Center, Bluffton, SC, were pond-raised using commercial techniques. These fish were hatched in captivity and fed a commercial trout diet (38-481) (Zeigler Bros. Inc., Gardner, PA) for about 20 months. The fish were collected in February 1988, January and March 1989, and April and May 1990.

**Group (2):** Cultured reciprocal hybrid striped bass from SCWMRD Waddell Mariculture Center were pond-raised using commercial techniques, and fed a standard commercial trout diet (38-481) for 18 months. The fish were then placed in nine

Collector's Name \_\_\_\_\_ Date \_\_\_\_\_  
Collection Site (describe in detail) \_\_\_\_\_  
\_\_\_\_\_  
Method of Collection \_\_\_\_\_  
Species (Striped Bass or Hybrid) \_\_\_\_\_  
Total Length: Inches \_\_\_\_\_ or MM \_\_\_\_\_  
Weight: Lbs \_\_\_\_\_ or Kg \_\_\_\_\_  
Sex \_\_\_\_\_ Mature \_\_\_\_\_ Immature \_\_\_\_\_  
add comments to back of card

Figure 1. Collection card for the wild striped bass and wild hybrid striped bass.

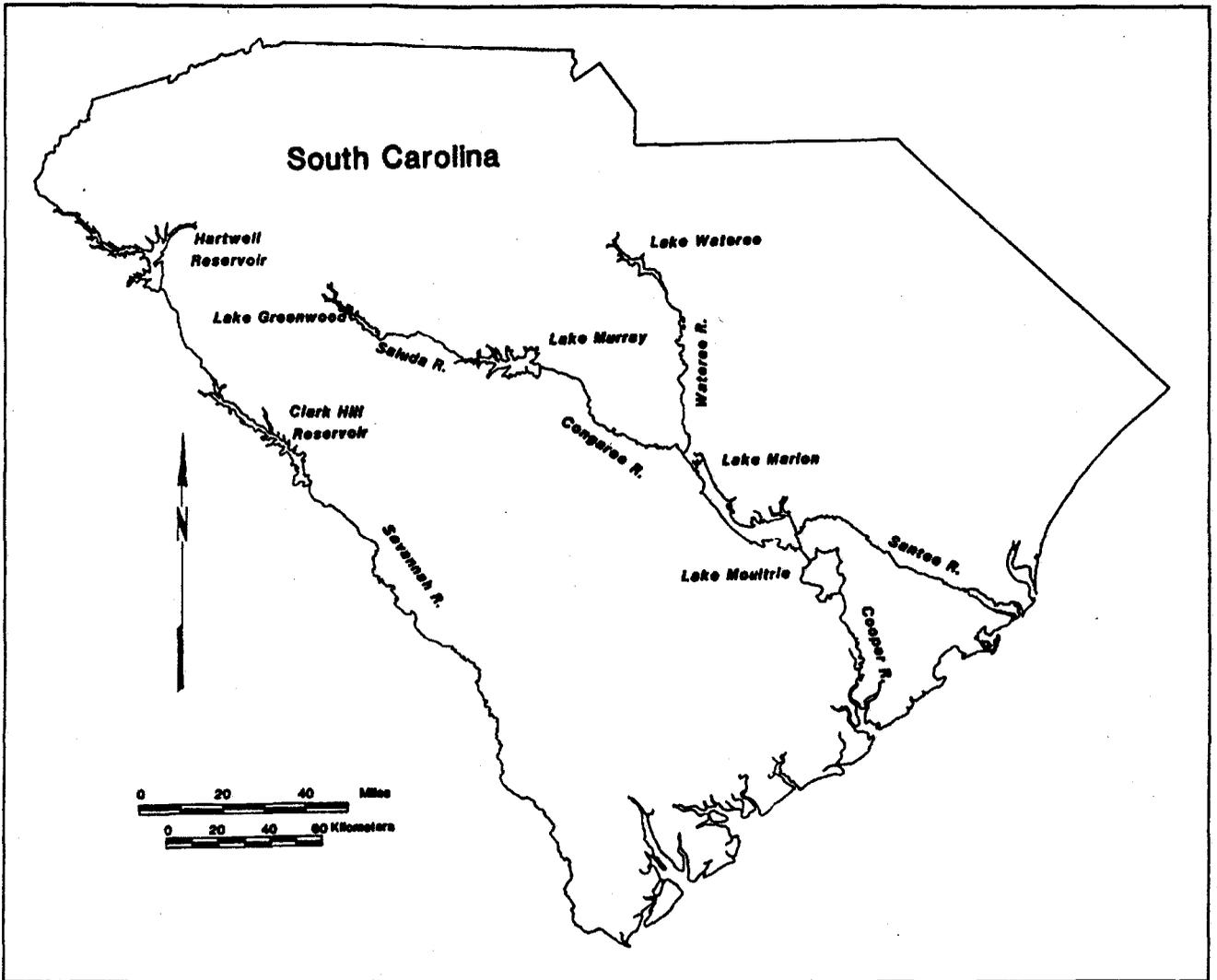


Figure 2. Wild fish collection sites in South Carolina

cylindrical tanks (three replicates per diet) for 8 months and fed: (1) a tilapia diet (Zeigler Bros. Inc., Gardner, PA), (2) an experimental trout diet containing 40% fish meal (38-480) (Zeigler Bros. Inc., Gardner, PA), or (3) continued on the standard commercial trout diet (38-481). Three fish were randomly selected from each of the three replicate tanks in each treatment for fatty acid analysis at the end of the study. All fish were of commercial size at the end of the study.

**Group (3):** Cultured original hybrid striped bass (female striped bass and a male white bass cross), a backcross (original cross hybrid female x striped bass male), and striped bass were pond-raised for 18 months and fed a commercial trout diet (38-481). These fish were then placed in nine cylindrical tanks for 258 days (three tank replications per fish group) and continued on the same diet. Three fish were randomly selected per tank for fatty acid analysis. All fish were of commercial size at the end of the study.

#### Cultured Hybrid Striped Bass from SC Commercial Operations (reference fish)

Two SC commercial hybrid striped bass aquaculture operations supplied fish and samples of the commercial diets fed to the fish for analysis. The fish were collected by SCWMRD biologists and delivered to the NMFS Charleston Laboratory. The fish were small, averaging 230mm (TL) and 240g. Only lengths and weights were recorded. The cooperating commercial producers were Taylor Aquaculture and Edisto Aquaculture Farms.

#### Wild Striped Bass from Virginia (reference fish)

The VA Department of Game and Inland Fisheries collected wild striped bass averaging 457mm (TL) and 906g, from the Chowan River in March, 1990 and from the Mattaponi River in Nov., 1989 and March, 1990.

### **Sample Preparation**

#### Wild Striped Bass and Hybrid Striped Bass from SC (reference fish)

The reference fish were separated by collection period, location, species, size, sex and sexual maturity. Frozen skinless fillets were prepared with belly flap, nape and tail section removed. Partially frozen fillets from single fish were homogenized in a commercial food processor and 100 g samples of the homogenized tissue were retained for analysis. Both individual and 5-fish composite samples were prepared. For the 5-fish composite, 20g from each of five individual fish homogenates were combined and formed into a single 100g composite sample.

#### Cultured Hybrid Striped Bass from Waddell Mariculture Center (WMC) (reference fish)

**Group (1):** Fish samples collected from the WMC in February 1988, January and March 1989, and April and May 1990 were prepared as above.

**Groups (2 and 3):** Composite samples, consisting of 33.3 g from each of three individual fish homogenates were prepared, in triplicate, for fish fed each of the diets.

### Cultured Hybrid Striped Bass from SC Commercial Operations (reference fish)

Five fish from Taylor Aquaculture Farms and 10 fish from Edisto Aquaculture Farms were prepared as individual samples.

### Wild Striped Bass from VA. (reference fish)

Twenty-two individual fish samples were prepared as above.

## **Sample Storage**

All of the samples were homogenized using a food processor, formed into thin sheets, and placed in moisture and oxygen barrier bags. They were then stored at -30°C until analyzed approximately one to six months later.

## **Fatty Acid Analysis**

Prior to analysis, each 100g sample was re-ground, while still frozen, using a commercial food processor to ensure homogeneity. Lipids were extracted from duplicate 5 g portions of each individual or composite sample with chloroform-methanol (Folch et al., 1957). Fatty acid methyl esters (FAME) were prepared as described by Metcalfe et al. (1966). Briefly, methanolic sodium hydroxide (1.5 ml - 0.5N) was added to approximately 25 mg of lipid contained in a screw-capped culture tube and the mixture heated at 105°C for 5 min. After cooling the sample to room temperature, 2 ml of boron trifluoride/methanol (12%) was added, and the mixture was heated for an additional 20 min. The esters were extracted into 1 ml of iso-octane, dried over anhydrous sodium sulfate, and transferred to a 2 ml crimp-cap vial.

Samples were analyzed by gas chromatography (GC) using a Hewlett-Packard 5890 gas chromatograph equipped with flame ionization detector and electronic integrator. Separation was achieved on a 30m x 0.25mm DB225 fused-silica capillary column (J&W Scientific). The initial oven temperature of 170°C was increased at a rate of 1°C/min to 220°C. Helium gas was the carrier at a rate of 1.5 ml/min. Nitrogen was the auxiliary gas. Injections were in the split mode with a split ratio of 1:60. Mass spectra of FAME from representative samples of wild and cultured fish were obtained using a Hewlett-Packard 5890A GC with a 5970 Series mass selective detector. GC parameters were as described above. Spectra were recorded at an ionization energy of 70 eV.

Esters were tentatively identified by comparison of their relative retention times from GC analyses with those of known primary and secondary standards. Double bond positions for methylene-interrupted polyenoic esters were assigned based upon knowledge of the elution order of positional isomers and by comparison of ion intensities at  $m/e=108$ , 150, and 192 in their mass spectra as described by Fellenberg et al. (1987).

Empirical correction factors (Craske and Bannon, 1988) were used to convert area percent to weight percent of fatty acids. The GC output was interfaced with a

personal computer for transfer of chromatographic data for processing and storage. Lotus Symphony Spreadsheet software was used to create data files.

### **Evaluation of Sampling Protocol**

An experiment was carried out to determine if lipids extracted from a 5 g sample of tissue would accurately represent the fatty acid composition of the fish. Ten five-gram samples from the 100 g homogenized tissue of each of two fish were extracted, transesterified, and analyzed by GC as described in the previous section.

A second experiment was carried out to evaluate the procedure for preparation of the five fish composite samples. Homogenized tissue from 5 individual fish and the composite samples prepared from these fish were extracted, transesterified and analyzed as described in the previous section.

### **Statistical Analysis**

Symphony data files were converted into a SAS data set, using a Proc. DIF procedure. An analysis of variance was performed using the General Linear Model (GLM) procedure (SAS Institute, Inc., 1985). Tukey's Standard Range (HSD) test was used to further evaluate the data whenever the F test was found to be significant.

Six fatty acids, linoleic (18:2n-6), linolenic (18:3n-3), arachidonic (20:4n-6), eicosapentaenoic (20:5n-3, EPA) docosapentaenoic (22:5n-6), and docosohexaenoic acids (22:6n-3, DHA), were also selected as quantitative variables to classify fish into wild and cultured categories and to lake or region of origin using Linear Discriminant Analysis with pooled variance (SAS Institute Inc., 1985). Percentages of these fatty acids for 75% of the individual SC wild fish and individual WMC cultured fish samples, randomly selected, were used to develop a model. The remaining 25% of the SC wild fish and WMC cultured fish, 100% of the 5-fish composite SC samples, and 100% of wild individual VA fish samples were used to test the accuracy of the model.

## **RESULTS AND DISCUSSION**

An important consideration for this study was the total volume of solvents required for lipid extraction of very large numbers of fish. Solvent waste from these extractions are considered hazardous waste and require expensive disposal. The Folch method used for these extractions requires specific solvent/tissue ratios to achieve complete lipid extraction. Therefore, overall solvent volumes could be reduced only by using small tissue samples for each extraction and by reducing the total number of samples.

Data used to evaluate sample size and variability due to sample preparation are given in Tables 1 and 2. These data show that there are essentially no differences in compositions of the ten replicates. Based on these data, a five gram sample size was considered ample and was used for all samples included in this study. Five-fish composite samples were prepared when five or more fish of the same sex, size and type (striped or hybrid striped) were collected during one sampling period. Data used to evaluate composite preparation are listed in Tables 3 and 4. Mean values of fatty acids from the five individual fish were compared to those of the composite. There were no statistically significant differences, indicating that each fish was equally represented in the composite. Therefore, to reduce the total number of samples, composite samples were used.

These data indicate that either individual fish or composites can be used. However, composite fish must be carefully selected. The fish must be of the same species, sex, of similar size, and collected from the same site during the same season. If these protocols are not followed, considerable variation in fatty acid composition between individual fish and the composite may result.

Of the 60 component fatty acids found in wild striped bass, wild hybrid striped bass, and cultured hybrid striped bass, 41 were selected to describe the composition of these fish. These fatty acids comprised >96% of the total fatty acids. Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity were not included. Mean values for the 41 fatty acids were calculated for each fish type for each collection period. These data for composite samples and individual fish are listed in Tables C.1-C.39 in Appendix C. Based on comparison of these compositions, six fatty acids were selected for classification of cultured and wild fish. These fatty acids were 18:2n-6, 18:3n-3, 20:4n-6, 20:5n-3, 22:5n-6 and 22:6n-3. The ranges and average values of these fatty acids for cultured and wild fish are compared in Figure 3. In addition to being important factors for distinguishing wild from cultured fish, these six fatty acids also have nutritional implications regarding n-3 and n-6 ratios and concentrations. The data presented in Figure 4 show that dietary 18:2n-6 readily accumulated in the tissue lipids of the cultured fish. The low levels of 20:4n-6 and 22:5n-6 reflect the low levels of these fatty acids found in the diets. Since the fatty acid composition of the diets of wild fish was not examined, it is not known whether the comparatively high levels of 20:4n-6 and 22:5n-6 found in wild fish were from conversion of 18:2n-6 or were obtained preformed in the diet (Figure 3). Low concentrations of 18:3n-3 were observed in cultured fish and their commercial diets, while wild fish contained higher concentrations.

Linoleic acid was the primary fatty acid used in this study for distinguishing wild from cultured fish. Much higher concentrations of 18:2n-6 were found in cultured fish than in wild fish ( $P < 0.05$ ). The soybean meal component of the diet was responsible for these high concentrations. Although 18:2n-6 is present in natural foods, it is especially high in commercial fish feeds, since soybean meal is often used as a major ingredient. Soybean oil contains approximately 64% 18:2n-6 (Haard, 1976). Similarly, cottonseed, corn, wheat, and sunflower meals are often used in the

Table 1. Weight percent fatty acid composition of ten samples of homogenized tissue from a single fish collected from the Santee-Cooper System January 1990.

FATTY ACID	1	2	3	4	5	6	7	8	9	10	mean	SD	CV %
14:0	4.4	4.4	4.6	4.4	4.5	4.5	4.4	4.5	4.5	4.4	4.5	0.07	1.57
16:0	17.2	17.2	17.1	17.2	17.2	17.2	17.2	17.2	17.1	17.1	17.2	0.05	0.28
18:0	3.2	3.3	3.2	3.3	3.2	3.3	3.3	3.2	3.3	3.3	3.3	0.05	1.58
18:1n-9	11.6	11.7	11.9	11.7	11.8	11.8	11.7	11.8	11.8	11.7	11.8	0.08	0.72
18:2n-6	3.6	3.6	3.7	3.6	3.7	3.6	3.6	3.7	3.7	3.6	3.6	0.05	1.37
18:3n-3	5.3	5.3	5.5	5.3	5.5	5.3	5.3	5.3	5.3	5.3	5.3	0.08	1.58
20:4n-6	3.5	3.5	3.2	3.4	3.4	3.4	3.5	3.4	3.4	3.4	3.4	0.09	2.57
20:5n-3	5.5	5.4	5.3	5.4	5.4	5.4	5.5	5.4	5.4	5.4	5.4	0.06	1.05
22:5n-6	2.4	2.4	2.3	2.4	2.3	2.4	2.4	2.3	2.3	2.4	2.4	0.05	2.19
22:6n-3	8.2	8.1	7.4	8.1	7.8	8.0	8.1	7.8	7.9	8.0	7.9	0.23	2.92

Table 2. Weight percent fatty acid composition of ten samples of homogenized tissue from a single fish collected from Lake Murray January 1990.

FATTY ACID	1	2	3	4	5	6	7	8	9	10	mean	SD	CV %
14:0	4.1	4.1	4.0	4.0	4.0	4.0	4.1	4.0	4.0	4.0	4.0	0.05	1.20
16:0	17.4	17.3	17.5	17.3	17.3	17.4	17.5	17.3	17.2	17.4	17.4	0.10	0.56
18:0	3.6	3.6	3.6	3.6	3.6	3.6	3.5	3.6	3.6	3.6	3.6	0.03	0.88
18:1n-9	14.2	14.4	14.2	14.1	14.1	14.2	14.4	14.0	14.3	14.1	14.2	0.13	0.94
18:2n-6	3.8	3.8	3.8	3.8	3.8	3.8	3.9	3.8	3.8	3.8	3.8	0.03	0.83
18:3n-3	6.1	6.2	6.1	6.1	6.1	6.1	6.2	6.1	6.2	6.1	6.1	0.05	0.79
20:4n-6	4.5	4.3	4.5	4.5	4.5	4.5	4.4	4.5	4.4	4.5	4.5	0.07	1.57
20:5n-3	5.4	5.4	5.4	5.4	5.4	5.4	5.3	5.4	5.4	5.4	5.4	0.03	0.59
22:5n-6	3.0	2.9	2.9	3.0	3.0	3.0	2.9	3.0	2.9	3.0	3.0	0.05	1.74
22:6n-3	10.7	10.3	10.6	10.7	10.8	10.7	10.3	10.9	10.5	10.7	10.6	0.20	1.87

Table 3. Weight percent fatty acid composition of five individual fish collected from Lake Murray January 1990 and of the composite sample of these fish.

FATTY ACID	1	2	3	4	5	mean	SD	composite
14:0	4.3	4.0	3.8	4.7	4.4	4.2	0.4	4.3
16:0	18.4	17.5	18.5	17.6	17.4	17.9	0.5	17.4
18:0	3.7	3.6	4.0	3.5	3.7	3.7	0.2	3.6
18:1n-9	14.3	13.8	16.0	13.8	13.1	14.2	1.1	14.0
18:2n-6	3.9	3.9	3.6	4.4	3.9	3.9	0.3	4.0
18:3n-3	5.5	6.0	4.7	6.1	6.6	5.8	0.7	5.9
20:4n-6	4.1	4.6	4.2	4.2	3.9	4.2	0.3	4.2
20:5n-3	5.0	5.1	4.5	4.8	5.1	4.9	0.3	5.0
22:5n-6	2.9	2.9	3.0	3.0	2.9	2.9	0.1	3.0
22:6n-3	10.4	10.9	10.8	9.5	9.6	10.2	0.7	10.4

Table 4. Weight percent fatty acid composition of five individual fish collected from Lake Thurmond November 1989 and of the composite sample of these fish.

FATTY ACID	1	2	3	4	5	mean	SD	composite
14:0	2.6	2.5	2.5	2.6	2.6	2.6	0.1	2.6
16:0	19.8	19.0	18.8	18.6	19.4	19.1	0.5	19.3
18:0	4.3	4.9	4.3	4.4	4.8	4.5	0.3	4.4
18:1n-9	19.1	15.0	16.8	18.4	14.7	16.8	2.0	17.3
18:2n-6	2.8	2.8	2.9	3.1	2.6	2.8	0.2	2.8
18:3n-3	3.1	2.9	3.0	3.1	2.6	2.9	0.2	3.0
20:4n-6	5.1	6.4	5.9	5.3	6.5	5.8	0.6	5.7
20:5n-3	4.1	4.0	4.2	3.9	4.6	4.2	0.3	4.2
22:5n-6	3.7	4.5	4.1	3.9	4.4	4.1	0.3	4.1
22:6n-3	13.5	16.4	15.7	14.1	17.3	15.4	1.6	15.2

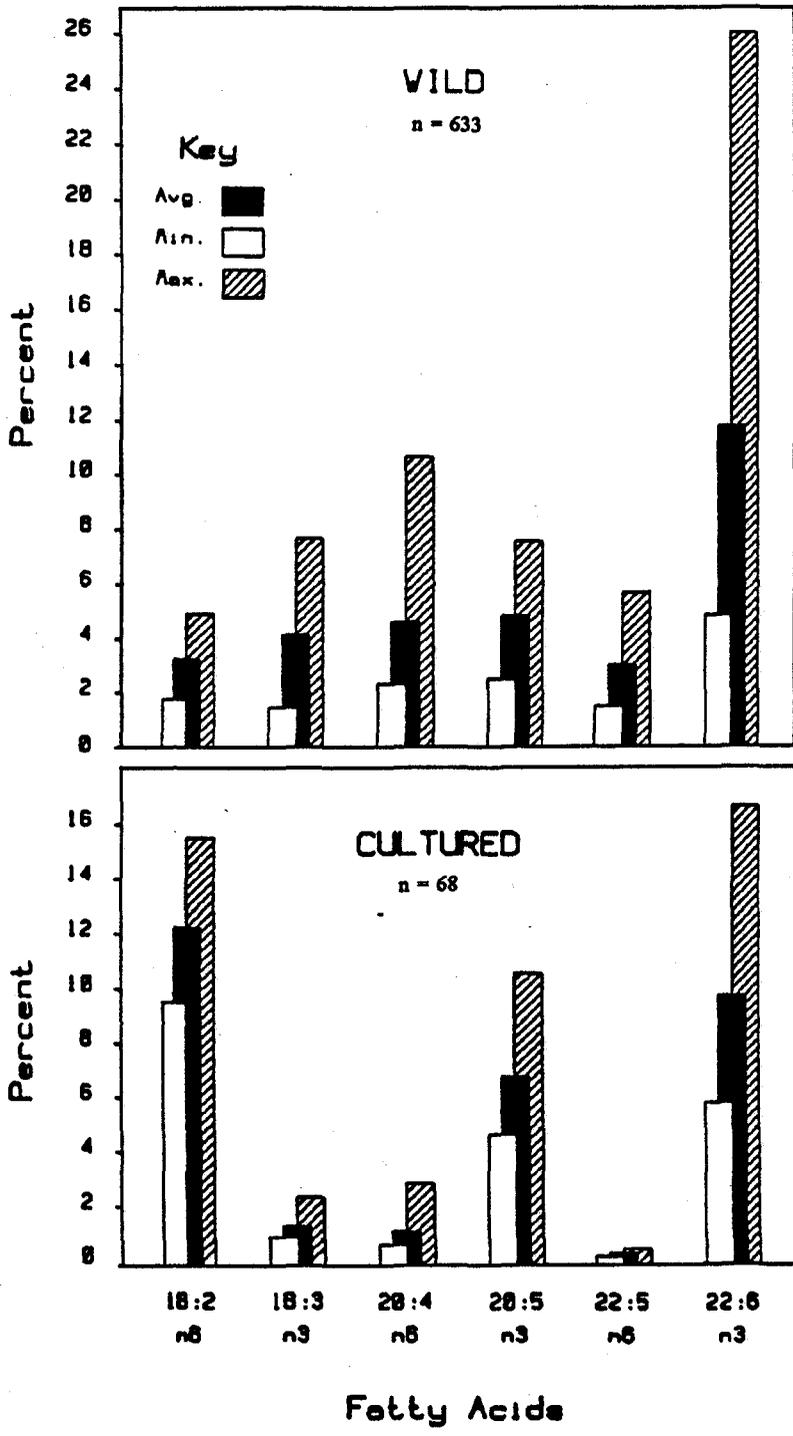
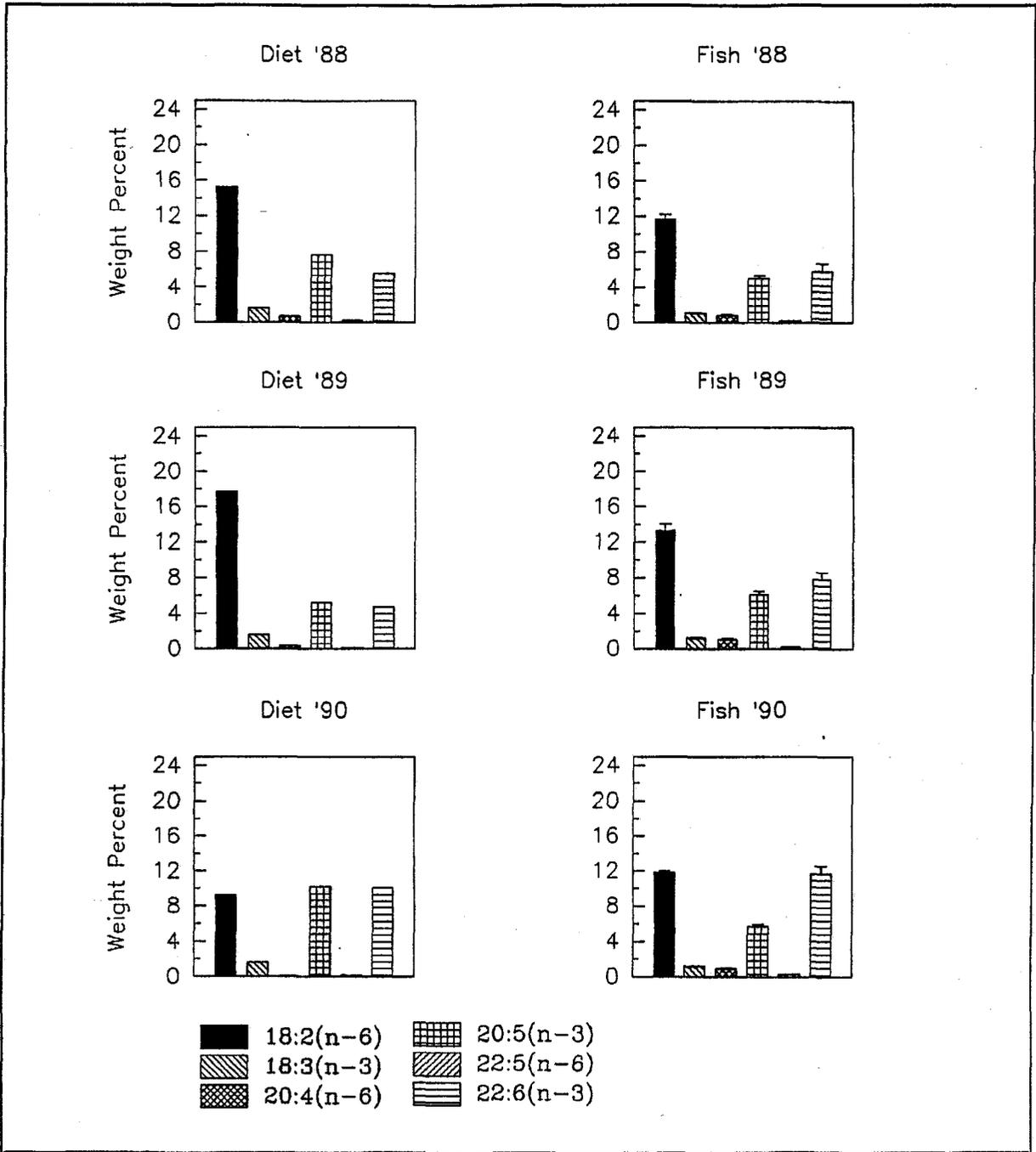


Figure 3. Indicator fatty acids of wild striped bass/hybrid striped bass and cultured hybrid striped bass.



**Figure 4.** Average values of selected fatty acids of commercial trout diets and of cultured reciprocal hybrid striped bass fed these diets at the Waddell Mariculture Center - 1988-1990.

production of commercial rations and linoleic acid comprises about 45-57% of the fatty acids found in the seed oils of these plants (Haard, 1976).

Moderately high concentrations of EPA and DHA were also present in the commercial diet and the tissue of fish fed this diet. These concentrations were due to the presence of approximately 8% fish meal in the commercial diet. Docosahexaenoic levels were useful in identifying wild fish as to site of origin and seemed to reflect differences in fish sizes and possibly water temperatures (not confirmed). In this study, fatty acid concentrations in fish varied by collection site and season. These differences appeared to be due mainly to intrinsic factors (i.e. fish size), although extrinsic factors (i.e. seasonal effects) could not be ruled out. Differences in fatty acid concentrations due to fish size may also have accounted for some of the misclassification of fish as to collection site. This possibility will be evaluated in the future.

Minor differences in fatty acid concentrations were found between wild fish types, but the differences had no effect on the success of this method for distinguishing wild from cultured fish. Fish type, sex, and sexual maturity have been shown to affect fatty acid compositions and therefore have important nutritional and physiological implications (Stansby, 1981), but for the purpose of this study they were not considered critical factors.

#### Wild Striped Bass and Wild Hybrid Striped Bass From SC 1988-1990

**Lake Hartwell and Lake Thurmond (Clark's Hill)** : Lakes Hartwell and Thurmond are deep cool oligotrophic reservoirs located in the NW corner of the state. These two reservoirs are connected and share similar physical and biological characteristics. Thus, fish migrate between these two reservoirs (S. Lamprecht, personal communication). Fish collected from these two reservoirs were on average smaller than fish from other sites (Table 5). The average percentages for DHA during the two year study were 13.7% for Lake Hartwell and 14.6% for Lake Thurmond (Figs. 5-8). These were the highest average DHA concentrations measured in wild fish ( $P < 0.05$ ). A probable explanation is that smaller fish generally have less total fat and a higher proportion of white muscle to red muscle tissue. White muscle tissue lipids are present mostly as phospholipids in the membranes, and DHA is a major component of the phospholipids (Kinsella, 1991).

Hartwell and Thurmond were the deepest and coolest of all the reservoirs studied. The cooler water temperatures of these reservoirs may have contributed to the slower growth rate of these fish compared with other reservoirs. In addition, temperature has also been shown to have a direct effect on fatty acid concentrations. There is a general trend toward higher percentages of long chain polyunsaturated fatty acids at lower water temperatures. The greater degree of unsaturation may allow for increased flexibility of cellular membranes at lower temperatures (Halver, 1980).

Table 5. Ranges and average values of weights (in grams) of cultured and wild fish collected during the study.

collection date:	11/88	1/89	4/89	7/89	11/89	1/90	4/90	7/90
<b>Lake Murray</b>								
# of fish	63	52	44	3	50	33	51	*
min wt.	443	682	698	361	347	472	155	
max wt.	4020	2749	5534	1301	4310	2820	2660	
avg wt.	1127	1289	1493	674	1858	1572	1471	
SD	661	417	849	443	573	608	624	
<b>Lake Thurmond</b>								
# of fish	31	43	33	30	31	25	14	25
min wt.	588	578	323	436	136	522	232	227
max wt.	2440	4900	3324	2372	1422	1708	1203	2539
avg wt.	1183	1255	930	1052	567	1041	698	549
SD	697	691	524	563	288	326	417	484
<b>Lake Wateree</b>								
# of fish	19	5	5	22	7	*	6	6
min wt.	1941	2665	3265	390	949		978	1064
max wt.	4748	5216	6520	4172	5169		5690	5275
avg wt.	3144	4179	4950	2251	2942		3439	2349
SD	856	1140	1357	1199	1636		1723	1622
<b>Santee-Cooper System</b>								
# of fish	35	22	62	10	24	26	3	19
min wt.	356	428	908	1481	1925	179	**	**
max wt.	3461	4243	8172	3722	5662	5930		
avg wt.	1672	1927	1809	2690	3127	1523		
SD	834	1018	1197	537	1077	1278		
<b>Lake Hartwell</b>								
# of fish	32	30	31	8	23	11	20	12
min wt.	398	838	312	605	165	256	197	408
max wt.	1886	2285	2180	2165	2180	3773	510	835
avg wt.	998	1424	969	1324	875	1443	385	640
SD	337	469	548	545	400	1080	83	111
<b>Waddell Mariculture Center</b>								
collection date:	2/88	2/89	3/89		4/90		4/90	
# of fish	**	6	10		5		10	
min wt.		686	696		331		590	
max wt.		903	965		488		967	
avg wt.		828	836		395		793	
SD		69	77		56		119	

\* no fish were collected

\*\* no weight data were collected

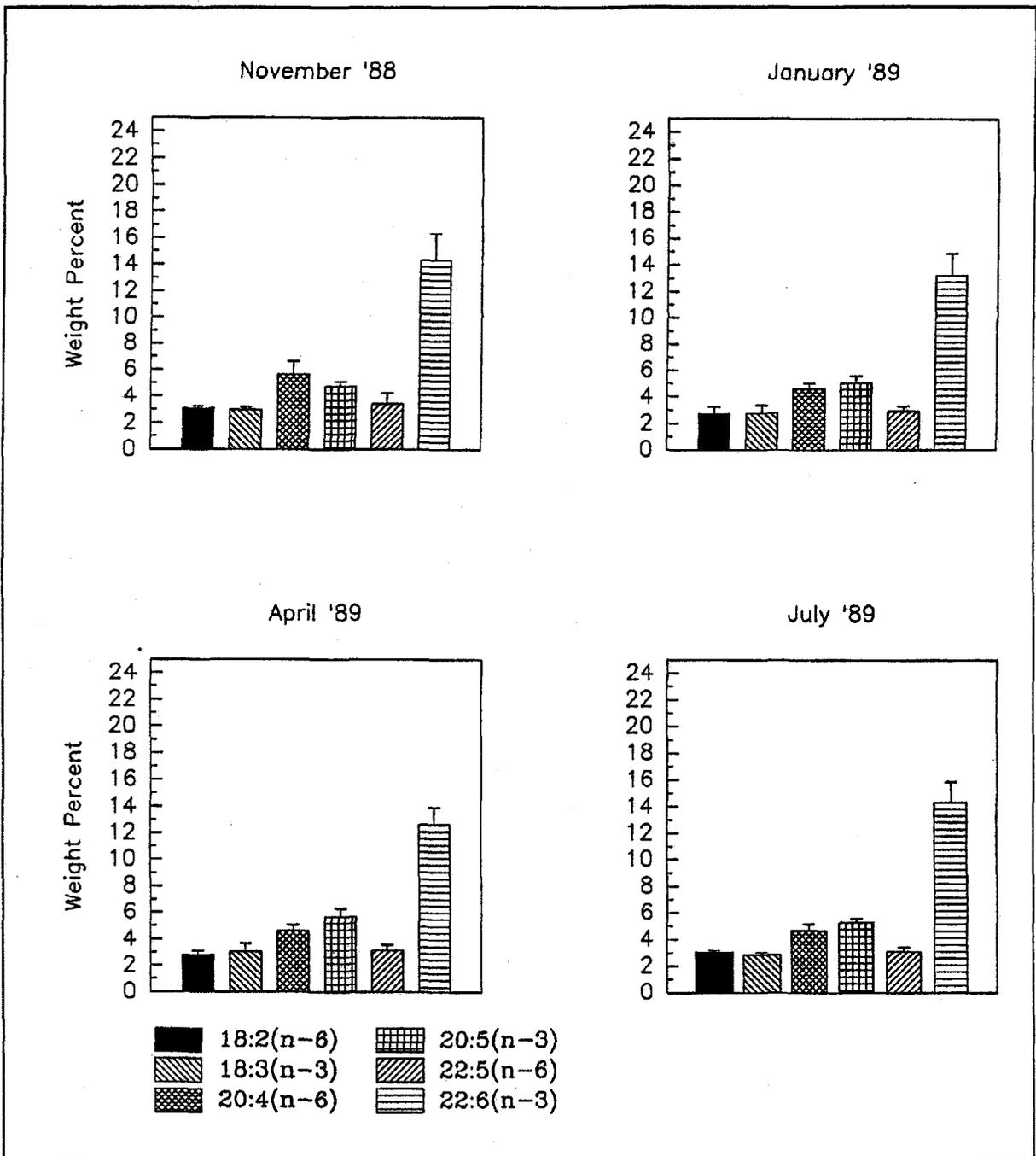


Figure 5. Average values of selected fatty acids in wild fish collected from Lake Hartwell during year one of the study.

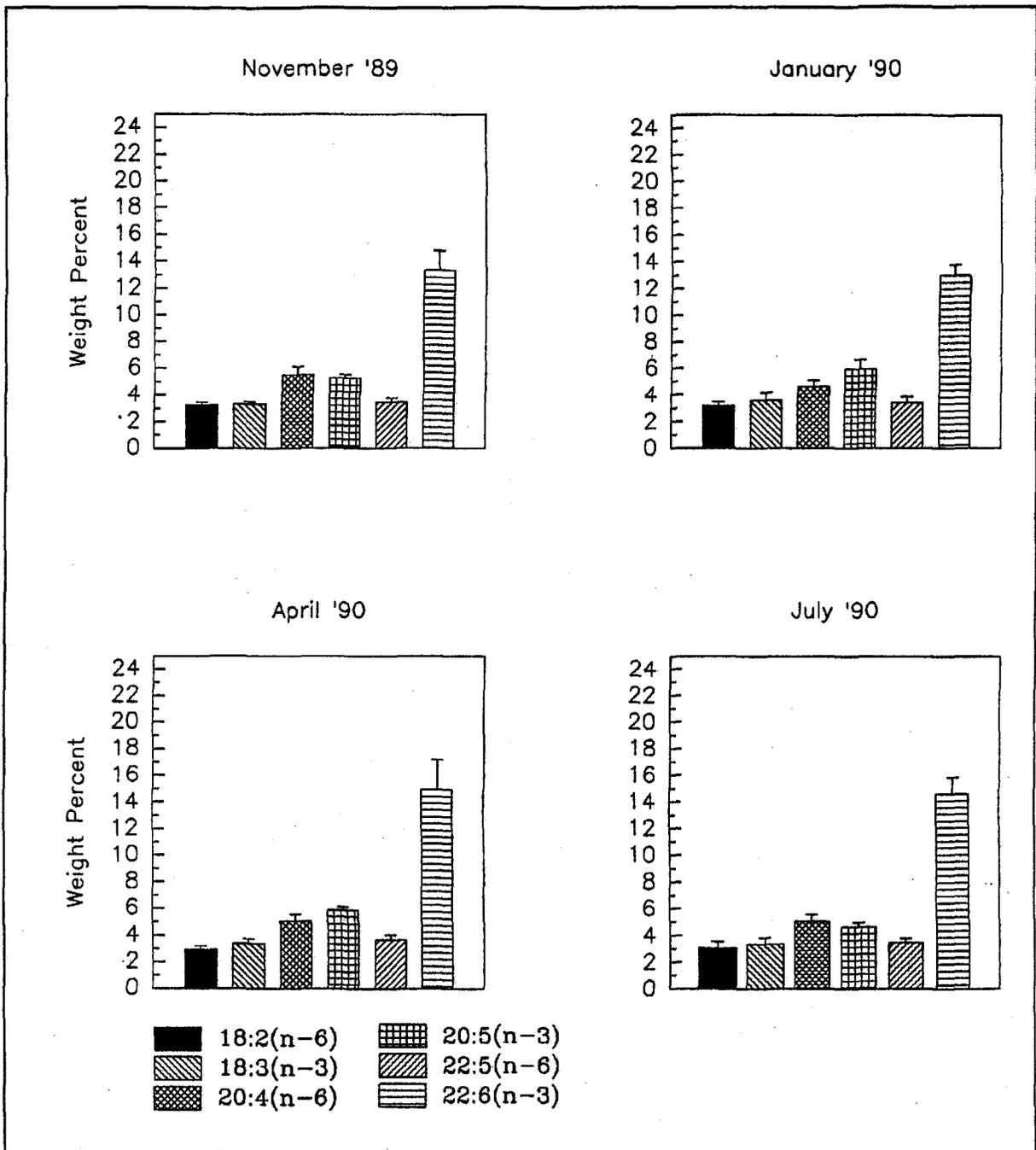


Figure 6. Average values of selected fatty acids in wild fish collected from Lake Hartwell during year two of the study.

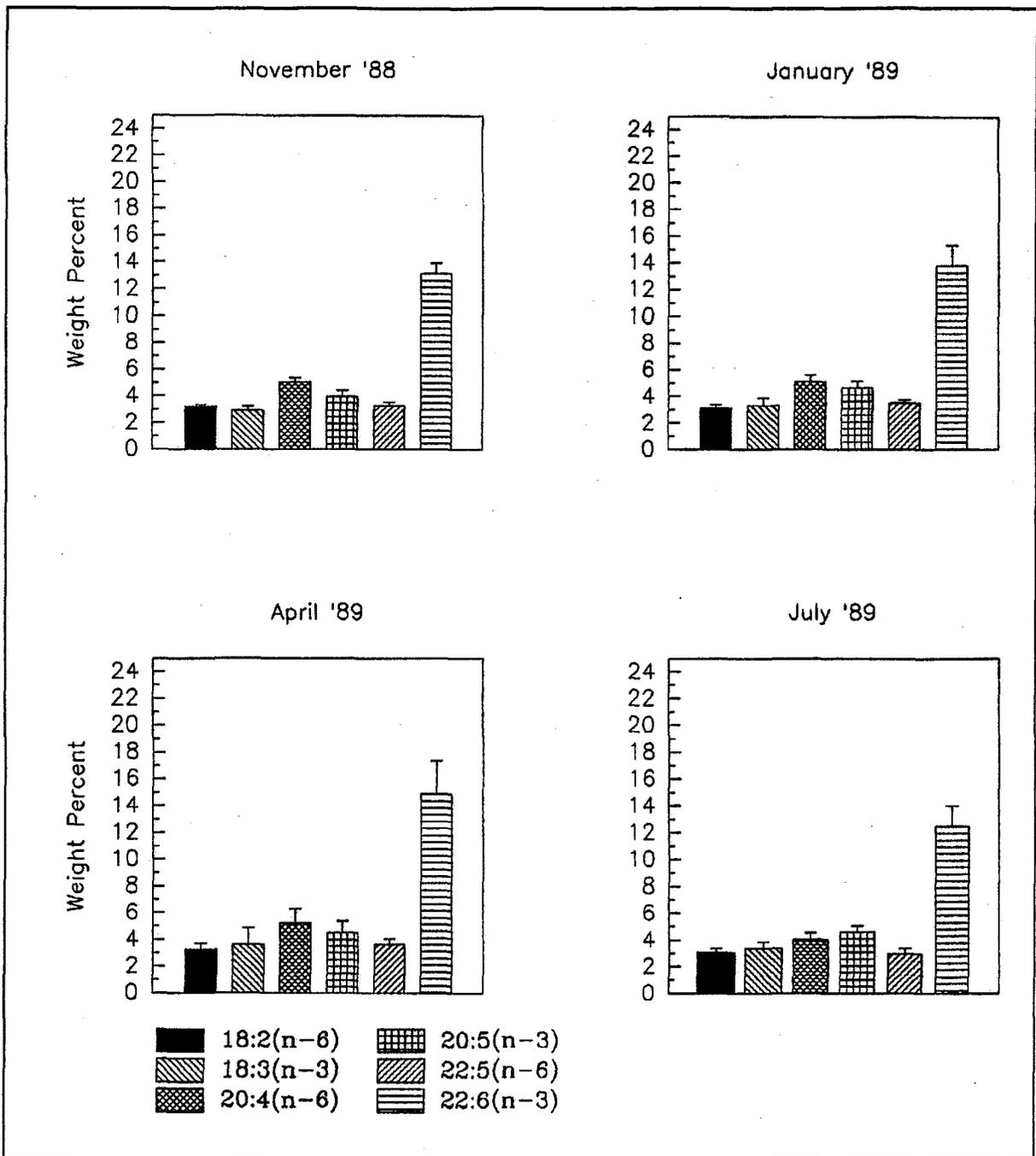


Figure 7. Average values of selected fatty acids in wild fish collected from Lake Thurmond (Clark's Hill) during year one of the study.

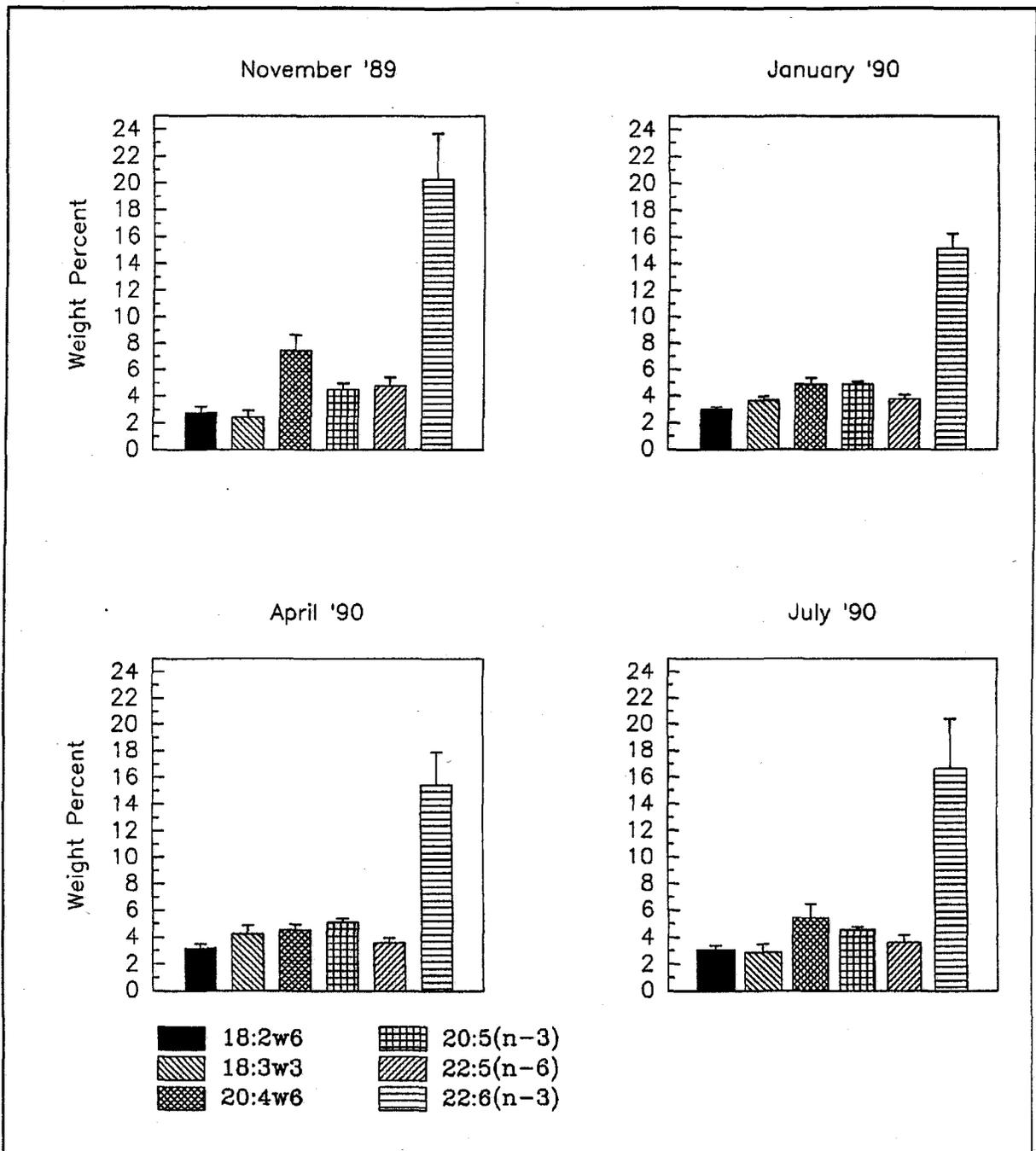


Figure 8. Average values of selected fatty acids in wild fish collected from Lake Thurmond (Clark's Hill) during year two of the study.

**Lake Murray:** Some sections of Lake Murray receive both direct and indirect wastewater discharges from treatment facilities, and thus are very fertile (McIlwaine, 1990). In fact, Lake Murray has been described as having three distinct zones: (1) eutrophic headwaters; (2) mesoeutrophic mid-lake waters; and (3) mesotrophic lower lake waters (McIlwaine, 1990). This may help to explain why fish from Murray (Figures 9-10) contained higher concentrations of 18:3n-3 than fish collected from Lakes Hartwell, Thurmond, Moultrie and Marion ( $P < 0.05$ ), but not Wateree ( $P > 0.05$ ). Algae have been shown to be a good source of 18:3n-3 (Ackman et al., 1964; Ackman, 1982). These higher 18:3n-3 concentrations may be due (not confirmed) to food chain transfer from smaller fish feeding on the algae to bass feeding on smaller fish.

Lake Murray fish also had a higher average percentage of DHA (10.9%) than fish from Wateree (7.2%) and Moultrie (8.0%), but had lower DHA concentrations than fish from Hartwell and Thurmond ( $P < 0.05$ ). This may be attributed to the fact that fish collected from Murray were larger than those from Hartwell and Thurmond but were smaller than fish collected from Wateree, Moultrie and Marion. Lake Murray also is more fertile, more shallow and warmer than Hartwell and Thurmond (S. Lamprecht, personal communication), but deeper and cooler than Wateree and Moultrie. (M. White, personal communication).

**Lake Wateree:** Wateree is also a very productive reservoir and has the largest standing crop of fish and algae biomass in all the reservoirs studied. This productivity may be related to the fact that it receives high phosphate run-off from Charlotte, NC (Val Nash, personal communication). Fish collected from Lake Wateree had higher concentrations of 18:3n-3 than fish from Lakes Hartwell, Thurmond, Moultrie and Marion ( $P < 0.05$ ) and lower concentrations of DHA than fish from Lakes Murray, Hartwell and Thurmond ( $P < 0.05$ ) but not Marion and Moultrie ( $P > 0.05$ ) (Figures 11-12). The lower DHA concentrations may be attributed in part to the large size of these fish.

**Santee Cooper River System:** Lakes Moultrie and Marion are part of the Santee Cooper River drainage system. They are shallow, low alkalinity mesoeutrophic reservoirs which are intermediate in fertility to Wateree and Murray (S. Lamprecht, personal communication). The 18:3n-3 levels in these fish were lower than in fish from Wateree and Murray ( $P < 0.05$ ), but higher than in fish from Hartwell and Thurmond ( $P < 0.05$ ). The DHA concentrations in these fish were lower than in fish from Hartwell, Thurmond and Murray ( $P < 0.05$ ). With the exception of sampling period 7 (April, 1990), the concentrations of the six fatty acids remained relatively constant between seasons and years (Figures 13-14). The higher concentration of DHA in fish collected during sampling period 7 may be due to the fact that it represents analyses from only three small fish. These results illustrate the importance of analyzing sufficient numbers of fish to establish representative levels of DHA for each reservoir.

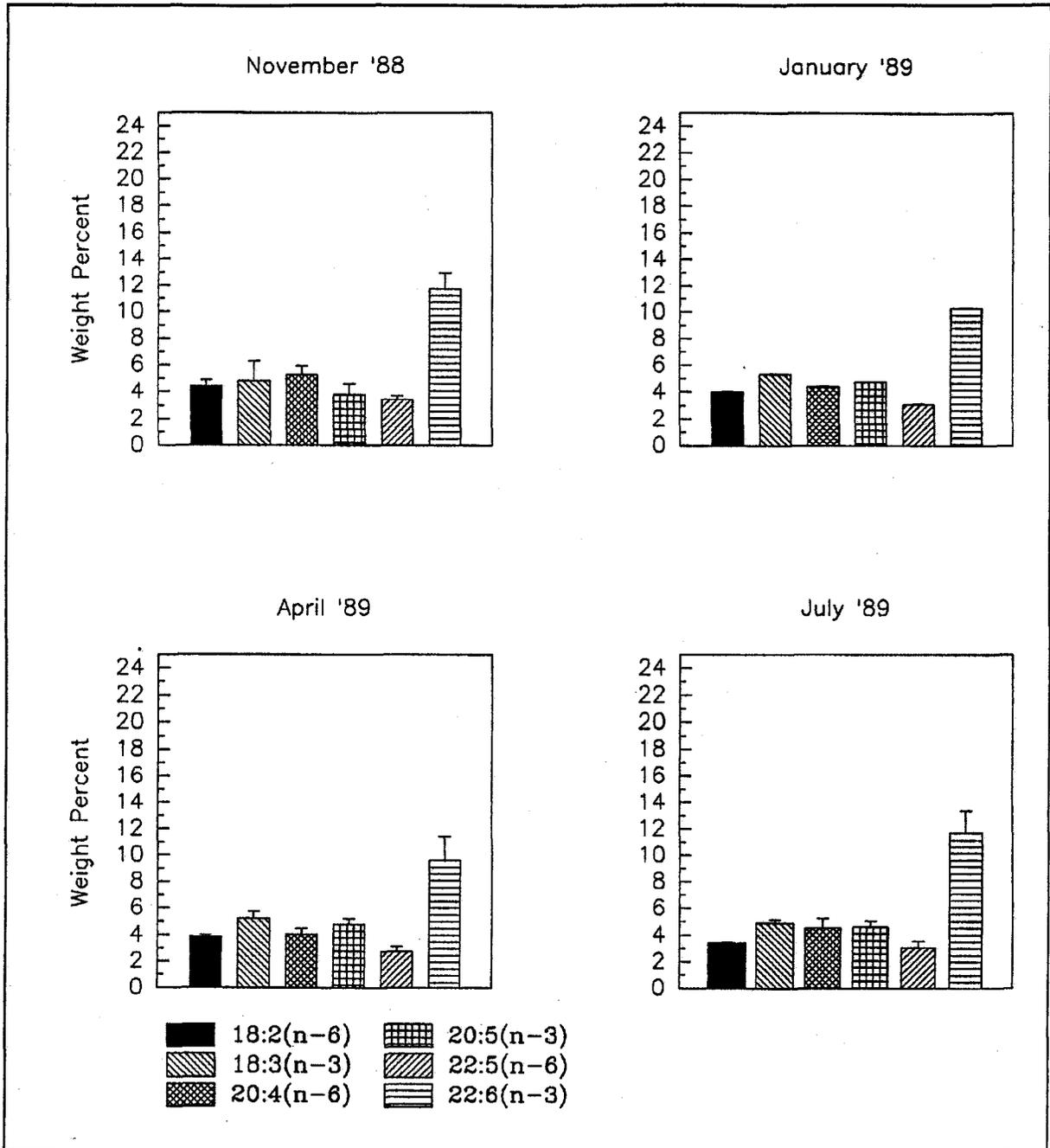


Figure 9. Average values of selected fatty acids in wild fish collected from Lake Murray during year one of the study.

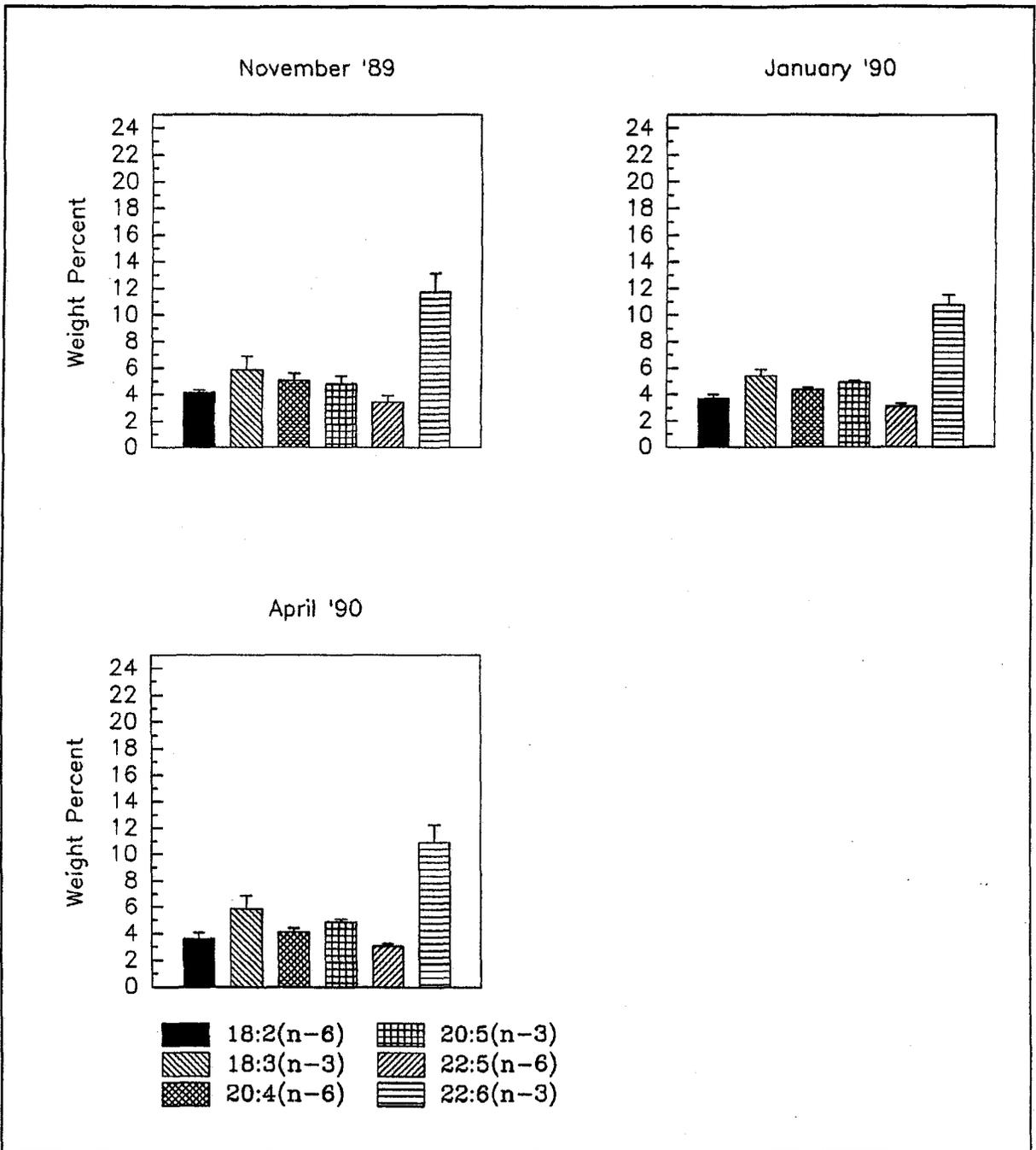


Figure 10. Average values of selected fatty acids in wild fish collected from Lake Murray during year two of the study.

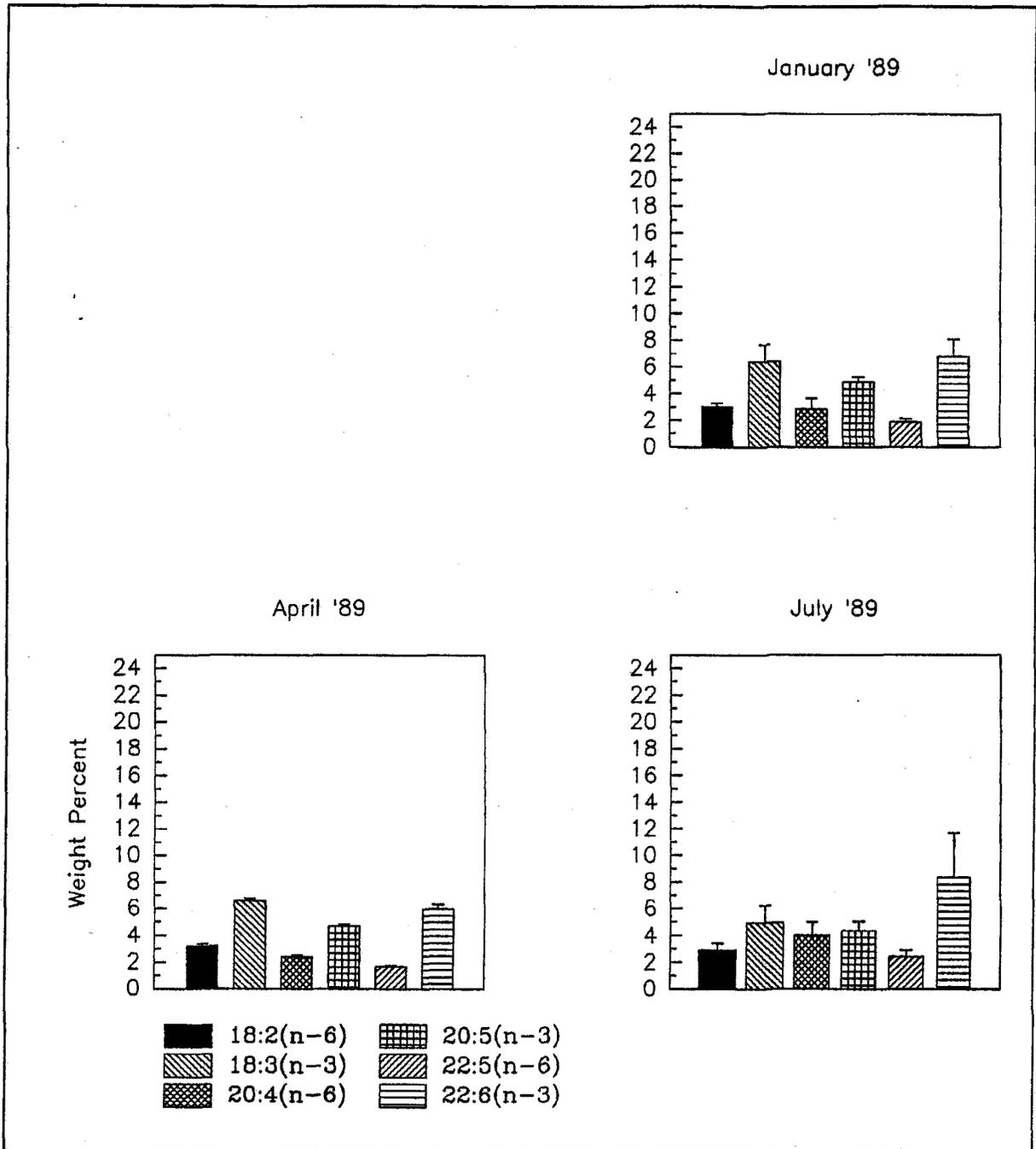


Figure 11. Average values of selected fatty acids in wild fish collected from Lake Waterec during year one of the study.

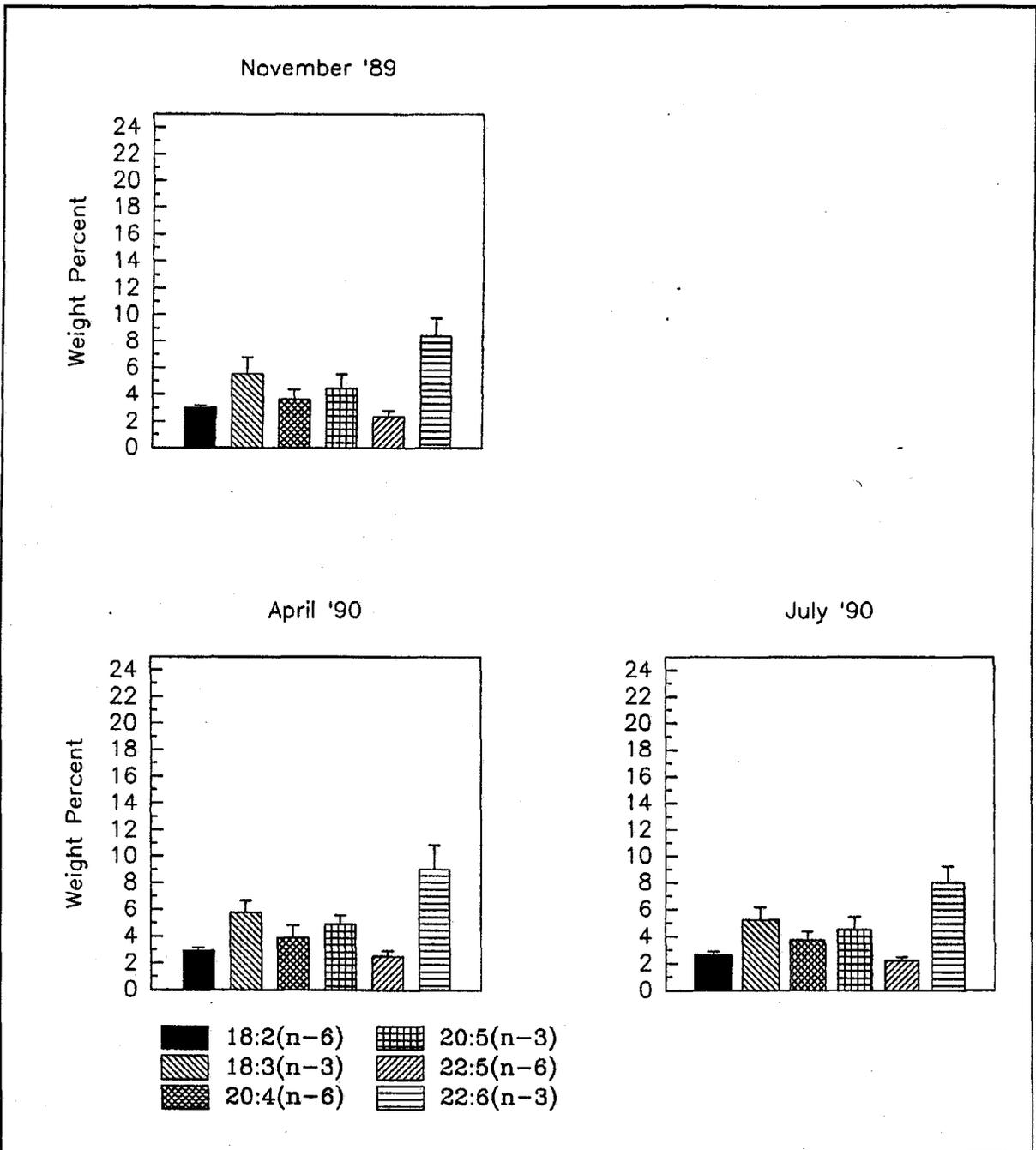
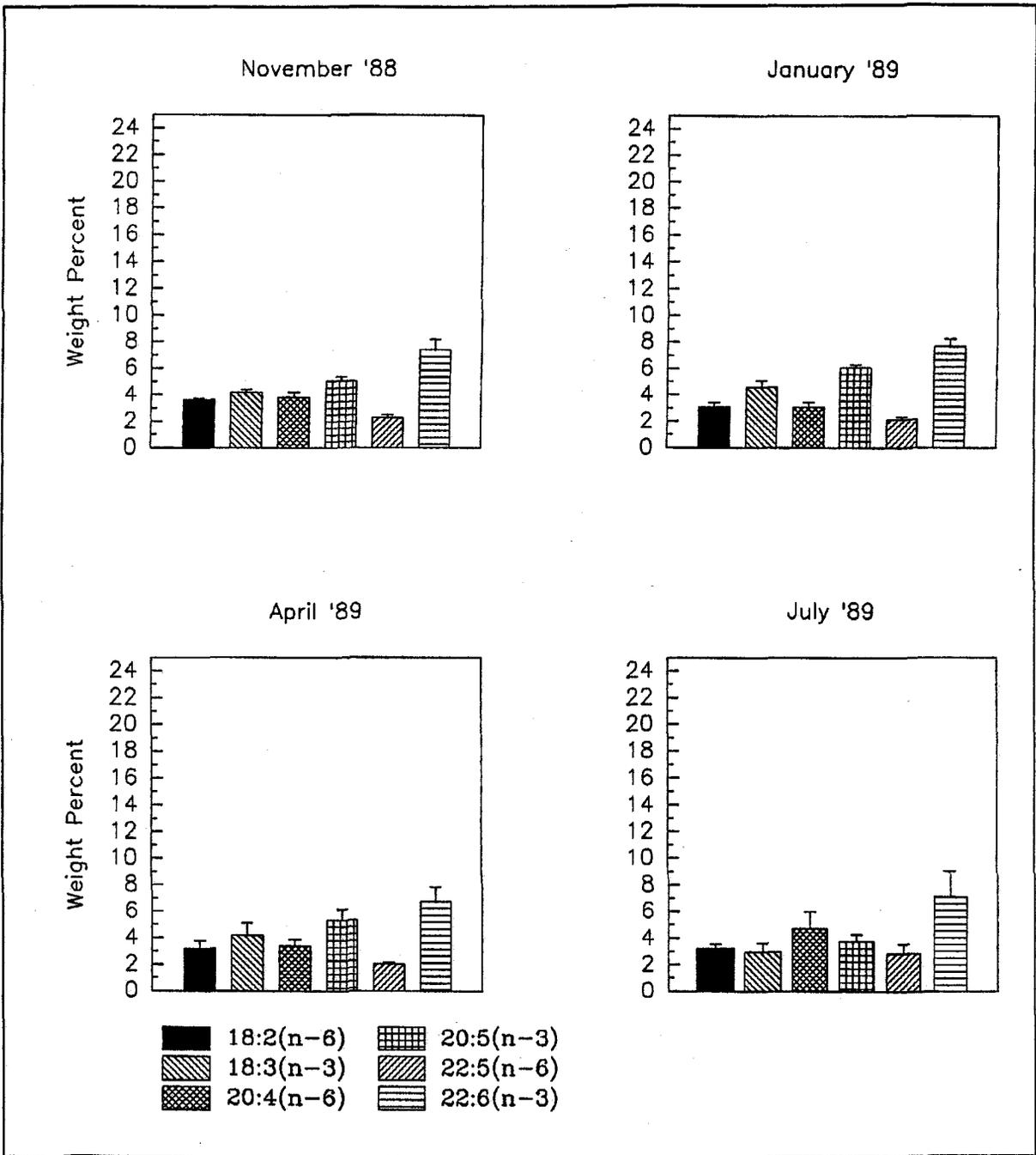


Figure 12. Average values of selected fatty acids in wild fish collected from Lake Waterec during year two of the study.



**Figure 13.** Average values of selected fatty acids in wild fish collected from the Santee Cooper River System (Lakes Moultrie and Marion) during year one of the study.

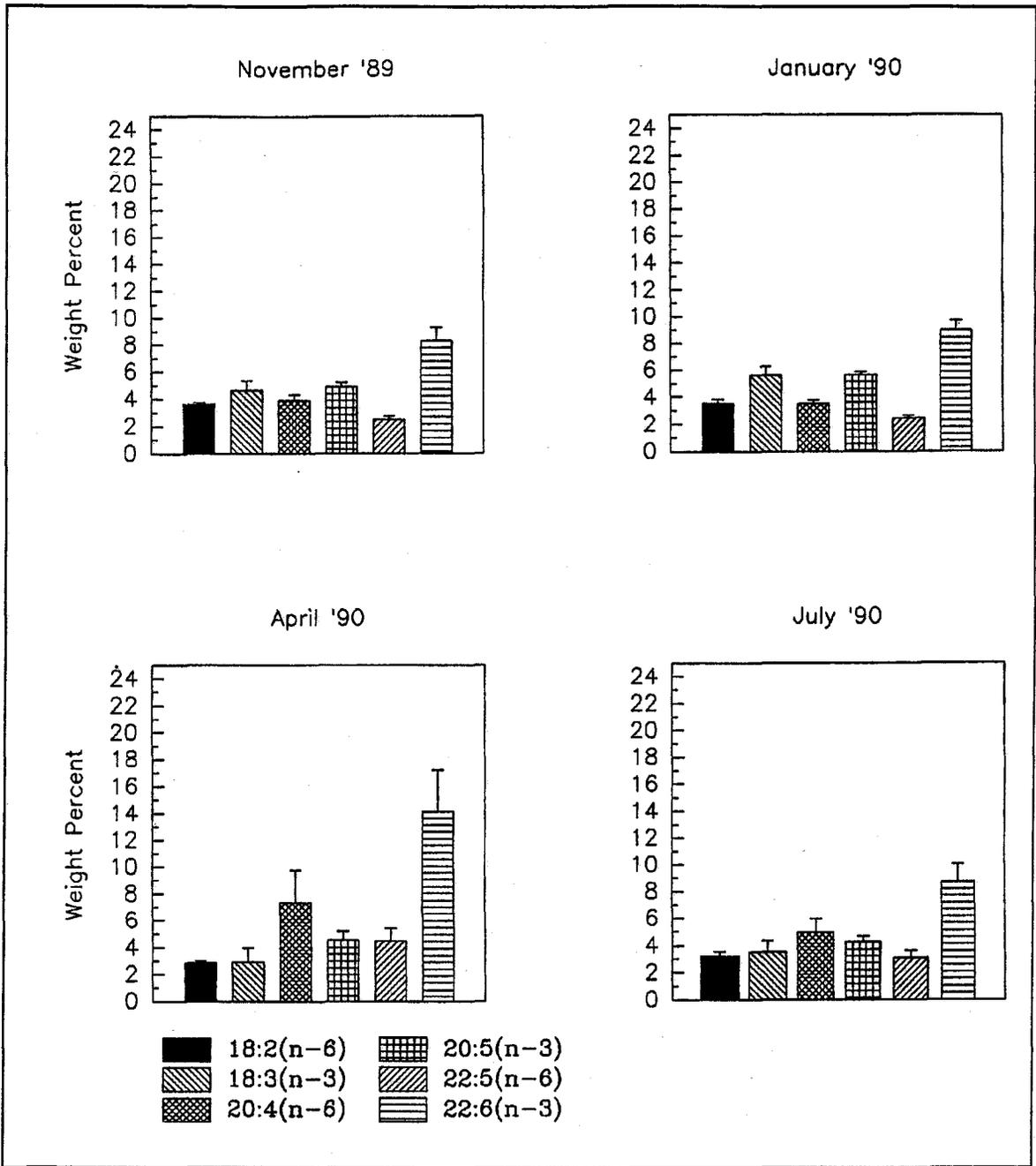


Figure 14. Average values of selected fatty acids in wild fish collected from the Santee Cooper River System (Lakes Moultrie and Marion) during year two of the study.

## Cultured Fish from the WMC

**Group (1):** These fish were collected and analyzed over a two year period. The analyses indicate that fatty acid composition of the fish reflected those of the diet. Note the high concentration of 18:2n-6 in both the diet and the fish (Figure 4). These high concentrations of 18:2n-6 were due to the soybean component of the diet. Thus 18:2n-6 concentrations were used in this study as the primary indicator fatty acid for distinguishing wild from cultured fish.

With the exception of DHA, the fatty acid concentrations for the six selected fatty acids were fairly consistent over all of the sampling periods. The percentages of DHA in these fish ranged from a low of 5.8% in 1988 and continually increased to 12.0% in 1990, correlating with increasing levels in the diets from 4.7% to 10.1% during the same time period. Commercial trout diets are formulated on a least cost basis. This means that substitutions may be made in favor of a less expensive ingredient that will provide an equivalent nutritional value. Thus, diet composition and hence fatty acid profiles vary from batch to batch and year to year.

Researchers have recently focused on developing commercial diets containing higher levels of menhaden oil in order to enhance the concentration of n-3 fatty acids in cultured hybrid striped bass. Results of one such study indicated that although relative amounts of 18:2n-6 were reduced, the typical fatty acid pattern for cultured hybrid striped bass was retained (P. Fair, personal communication). There is no evidence to suggest that the ability to distinguish wild from cultured fish is compromised by additions of substantial amounts of a marine oil to the diet.

**Group (2):** Hybrids fed the tilapia diet contained the highest concentrations of 18:2n-6 (Table 6). This diet also contained very high levels of soybean meal. Fish fed the standard commercial trout diet had the next highest concentration of 18:2n-6. Similarly, hybrids fed the experimental 40% fish meal diet contained the lowest concentrations of 18:2n-6 (6%). This was due to the higher proportion of fish meal and lower percentage of soybean meal in this diet. A diet containing 40% fish meal, in all likelihood, would not be used in commercial aquaculture operations because of its high cost. However, even if it were used in a commercial operation, cultured fish could still be distinguished from wild fish based on lower concentrations of 18:3n-3, 20:4n-6 and 22:5n-6. Despite the fact that the level of 18:2n-6 was considerably lower in fish fed this experimental diet than that found in other cultured fish, it was still above the percentage range found for wild fish (Figure 3).

**Group (3).** The fatty acid compositions of the three fish types fed identical commercial trout diets (38-481) were very similar (Table 7). This seems reasonable since these fish are hybrids of each other.

## Cultured Hybrid Striped Bass and Diet Samples Collected from SC Aquaculture Operations

The fatty acids in these fish generally reflected those in the diet (Table 8). Docosahexaenoic acid concentrations in these fish were higher than in fish collected

Table 6. Weight percent fatty acid composition of three fish diets and of reciprocal hybrid striped bass fed these diets.

FATTY ACID	Experimental Diet			Tilapia Diet			Trout Diet		
	Diet	Fish		Diet	Fish		Diet	Fish	
		Mean (n=3)	SD		Mean (n=3)	SD		Mean (n=3)	SD
14:0	5.0	3.4	0.27	1.4	2.7	0.05	5.8	3.7	0.11
15:0	0.4	0.3	0.00	0.2	0.2	0.00	0.4	0.3	0.00
16:0	19.0	19.5	0.14	17.3	18.6	0.09	18.5	19.0	0.41
17:0	0.6	0.3	0.00	0.3	0.3	0.00	0.5	0.3	0.00
18:0	8.1	4.2	0.05	4.2	3.8	0.12	5.0	3.5	0.12
20:0	0.2	0.1	0.00	0.3	0.1	0.00	0.3	0.1	0.00
TOTAL SATS.	33.4	28.2	0.00	23.9	25.7	0.00	30.8	27.0	0.00
14:1	<0.1	0.1	0.09	<0.1	0.2	0.12	<0.1	0.1	0.09
16:1n-9	0.2	0.5	0.05	0.2	0.6	0.00	0.2	0.5	0.05
16:1n-7	<0.1	6.4	0.05	1.7	5.2	0.09	6.2	7.0	0.05
16:1n-5	0.3	0.2	0.00	<0.1	0.1	0.00	0.1	0.1	0.00
17:1	0.8	0.6	0.00	<0.1	0.4	0.00	0.8	0.6	0.00
18:1n-9	19.4	31.0	0.00	21.2	29.3	0.00	16.2	29.0	0.00
18:1n-7	2.0	2.6	0.05	1.6	2.1	0.05	2.5	2.6	0.14
18:1n-5	0.1	1.1	0.08	0.1	1.0	0.00	0.2	0.7	0.40
20:1n-11+13	0.5	0.7	0.05	<0.1	0.2	0.00	0.1	0.2	0.08
20:1n-9	4.5	4.0	0.16	0.5	2.1	0.08	0.8	2.6	0.09
20:1n-7	0.1	0.1	0.00	<0.1	0.1	0.00	0.1	0.1	0.00
20:1n-5/NMID?	0.1	0.0	0.05	<0.1	0.1	0.00	0.2	<0.1	-
22:1n-11+13	7.2	2.7	0.21	<0.1	0.7	0.21	0.2	0.8	0.12
22:1n-9	0.3	0.4	0.05	0.1	0.2	0.00	0.1	0.2	0.00
24:1	<0.1	0.3	0.00	<0.1	0.1	0.00	0.3	0.2	0.00
TOTAL MONOENES	39.8	47.5	1.28	25.6	42.4	0.25	28.0	44.3	0.38
16:2n-4	0.4	0.2	0.00	0.1	0.2	0.00	0.7	0.3	0.00
18:2n-9	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-
18:2n-6	5.1	6.1	0.37	40.1	18.7	0.37	15.3	10.9	0.12
18:2n-4/3n-6	0.1	0.2	0.00	<0.1	0.5	0.00	0.3	0.4	0.00
20:2n-6	0.1	0.4	0.05	0.1	1.0	0.00	0.1	0.6	0.12
TOTAL DIENES	5.7	7.0	0.42	40.3	20.4	0.37	16.4	12.2	0.22
16:3n-4	0.5	0.2	0.05	0.2	0.2	0.05	1.0	0.4	0.05
16:3n-3	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-
18:3n-4	0.1	0.1	0.00	0.1	0.1	0.00	2.0	0.1	0.00
18:3n-3	0.9	0.8	0.00	2.9	1.6	0.00	1.6	1.1	0.00
18:4n-3	1.2	0.7	0.00	0.3	0.5	0.00	1.2	0.8	0.00
20:3n-6	0.3	0.1	0.00	<0.1	0.2	0.00	0.1	0.1	0.00
20:4n-6	0.4	0.5	0.09	0.2	0.5	0.05	0.7	0.5	0.00
20:3n-3	0.1	0.1	0.00	<0.1	0.0	0.00	0.1	<0.1	-
20:4n-3	0.4	0.3	0.00	0.1	0.2	0.00	0.6	0.4	0.00
20:5n-3	5.1	3.4	0.34	1.9	1.3	1.18	7.6	4.6	0.16
21:5n-3	0.1	0.2	0.05	<0.1	0.1	0.00	0.4	0.2	0.00
22:4n-6	0.1	0.1	0.00	<0.1	<0.1	-	0.1	0.1	0.00
22:5n-6	<0.1	0.1	0.00	<0.1	0.1	0.00	0.2	0.2	0.00
22:5n-3	0.7	0.7	0.08	0.3	0.6	0.05	1.4	1.0	0.05
22:6n-3	6.5	4.2	0.47	2.5	3.0	0.28	5.5	4.2	0.33
TOTAL PUFA	22.1	19.2	1.93	48.8	28.9	1.27	38.9	26.4	0.88

Table 7. Weight percent fatty acid composition of a commercial trout diet and fish fed this diet.

FATTY ACID	Diet	Fish 1*		Fish 2**		Fish 3***	
		Mean (n=3)	SD	Mean (n=3)	SD	Mean (n=3)	SD
14:0	5.8	4.5	0.05	4.0	0.05	4.3	0.08
15:0	0.4	0.3	0.00	0.2	0.00	0.3	0.00
16:0	18.5	18.0	0.22	18.4	0.64	18.0	0.40
17:0	0.5	0.3	0.00	0.0	0.00	0.3	0.00
18:0	5.3	3.2	0.05	3.4	0.08	3.2	0.14
20:0	0.3	0.1	0.00	0.1	0.00	0.1	0.00
TOTAL SATS.	30.8	26.4	0.00	26.1	0.00	26.3	0.00
14:1	0.0	0.1	0.14	0.1	0.09	<0.1	-
16:1n-9	0.2	0.5	0.00	0.5	0.00	0.4	0.05
16:1n-7	6.2	7.5	0.24	7.2	0.12	7.5	0.25
16:1n-5	0.1	0.1	0.00	0.1	0.00	0.1	0.00
17:1	0.8	0.6	0.00	0.6	0.00	0.6	0.00
18:1n-9	16.2	26.1	0.00	25.0	0.00	26.5	0.00
18:1n-7	2.5	2.6	0.05	2.5	0.00	2.6	0.09
18:1n-5	0.2	0.1	0.00	0.6	0.05	0.3	0.24
20:1n-11+13	0.1	0.1	0.05	<0.1	-	0.1	0.00
20:1n-9	0.8	2.0	0.08	1.9	0.05	2.2	0.09
20:1n-7	0.1	0.1	0.00	0.1	0.00	0.1	0.00
20:1n-5/NMID?	0.2	<0.1	-	<0.1	-	<0.1	-
22:1n-11+13	0.2	0.1	0.05	<0.1	-	<0.1	-
22:1n-9	0.1	0.2	0.05	0.1	0.00	0.2	0.00
24:1	0.3	0.2	0.00	0.1	0.00	0.2	0.00
TOTAL MONOENES	27.0	40.3	1.11	38.9	0.90	40.8	0.75
16:2n-4	0.7	0.5	0.00	0.5	0.00	0.5	0.00
18:2n-9	<0.1	<0.1	-	<0.1	-	<0.1	-
18:2n-6	15.3	11.8	0.31	11.7	0.29	12.2	0.14
18:2n-4/3n-6	0.3	0.4	0.00	0.4	0.00	0.4	0.00
20:2n-6	0.1	0.8	0.09	0.8	0.05	0.8	0.05
TOTAL DIENES	16.5	13.4	0.40	13.5	0.33	13.9	0.17
16:3n-4	1.0	0.7	0.05	0.6	0.00	0.7	0.05
16:3n-3	<0.1	<0.1	-	<0.1	-	<0.1	-
18:3n-4	2.0	0.2	0.00	0.2	0.00	0.2	0.00
18:3n-3	1.6	1.2	0.00	1.2	0.00	1.3	0.00
18:4n-3	1.2	0.8	0.00	0.8	0.00	0.8	0.00
20:3n-6	0.1	0.2	0.00	0.2	0.00	0.2	0.00
20:4n-6	0.7	0.7	0.00	0.8	0.00	0.7	0.00
20:3n-3	0.1	<0.1	-	<0.1	-	<0.1	-
20:4n-3	0.6	0.5	0.00	0.4	0.00	0.5	0.00
20:5n-3	7.6	5.9	0.24	6.4	0.34	5.8	0.21
21:5n-3	0.4	0.2	0.14	0.2	0.09	0.3	0.00
22:4n-6	0.1	0.1	0.00	0.1	0.00	0.1	0.00
22:5n-6	0.2	0.2	0.00	0.2	0.00	0.2	0.00
22:5n-3	1.4	1.4	0.00	1.5	0.00	1.3	0.00
22:6n-3	5.5	5.0	0.45	6.0	0.36	4.6	0.31
TOTAL PUFA	41.5	30.4	1.41	32.0	1.10	30.5	0.51

\* original hybrid striped bass

\*\* backcross

\*\*\* striped bass

Table 8. Weight percent fatty acid composition of commercially raised hybrid striped bass and their diets.

FATTY ACID	Farm X Fish		Diet	Farm Y Fish		Diet
	Mean (n=9)	SD		Mean (n=5)	SD	
14:0	2.6	0.28	4.9	3.3	0.05	6.0
15:0	0.3	0.03	0.4	0.2	0.00	0.5
16:0	18.1	0.38	19.8	20.0	0.26	21.8
17:0	0.4	0.05	0.6	0.2	0.01	0.5
18:0	3.9	0.44	3.8	3.9	0.19	4.2
20:0	0.1	0.03	0.3	<0.1	-	0.3
TOTAL SATS.	26.1	0.30	30.4	27.8	0.41	33.7
14:1	0.2	0.02	0.1	0.2	0.01	0.1
16:1n-9	0.4	0.05	0.2	0.6	0.03	0.3
16:1n-7	5.1	0.37	6.0	7.8	0.29	7.5
16:1n-5	0.2	0.04	0.2	<0.1	-	<0.1
17:1	0.4	0.06	0.9	0.2	0.04	1.1
18:1n-9	15.6	1.43	14.3	26.7	1.33	14.9
18:1n-7	2.6	0.14	2.3	2.5	0.08	2.4
18:1n-5	0.4	0.04	0.2	0.8	0.07	0.3
20:1n-11+13	0.2	0.08	<0.1	<0.1	-	<0.1
20:1n-9	1.8	0.18	1.0	2.2	0.16	0.6
20:1n-7	<0.1	-	0.1	<0.1	-	0.2
20:1n-5/NMID?	<0.1	-	0.1	0.1	0.07	<0.1
22:1n-11+13	<0.1	-	<0.1	<0.1	-	<0.1
22:1n-9	<0.1	-	<0.1	<0.1	-	<0.1
24:1	0.2	0.04	0.3	<0.1	-	<0.1
TOTAL MONOENES	27.6	1.87	26.0	41.5	1.69	27.9
16:2n-4	0.3	0.04	0.7	0.4	0.01	0.9
18:2n-9	<0.1	-	<0.1	<0.1	-	<0.1
18:2n-6	12.6	0.71	17.3	10.0	0.52	12.4
18:2n-4/3n-6	0.4	0.01	0.4	0.4	0.03	0.5
20:2n-6	0.9	0.06	0.1	0.7	0.03	0.1
TOTAL DIENES	14.2	0.77	18.6	11.6	0.52	14.1
16:3n-4	0.4	0.04	0.9	0.5	0.02	1.4
16:3n-3	<0.1	-	<0.1	<0.1	-	<0.1
18:3n-4	0.1	0.03	0.2	0.2	0.04	0.2
18:3n-3	1.8	0.21	2.1	0.9	0.04	1.4
18:4n-3	1.0	0.09	1.9	0.7	0.03	1.7
20:3n-6	0.1	0.03	0.1	0.2	0.01	0.2
20:4n-6	1.6	0.51	0.5	1.1	0.09	1.1
20:3n-3	<0.1	-	<0.1	<0.1	-	<0.1
20:4n-3	0.6	0.05	0.8	0.4	0.02	0.6
20:5n-3	8.6	0.82	8.1	6.2	0.42	8.9
21:5n-3	0.2	0.05	0.4	0.1	0.11	<0.1
22:4n-6	<0.1	-	<0.1	<0.1	-	<0.1
22:5n-6	0.3	0.03	0.2	0.3	0.02	0.4
22:5n-3	1.6	0.07	1.3	1.3	0.07	1.9
22:6n-3	13.5	1.20	7.4	6.6	0.66	5.4
TOTAL PUFA	44.3	1.67	42.5	30.1	1.39	37.3

from the Waddell Mariculture Center. A notable difference in the fish from Farm X, as compared to other cultured fish, was the percentage of 18:1n-9 found in these fish. The level of this fatty acid was below that found for any cultured fish and fell within the range of values found in wild fish. The differences found in fatty acids of these fish may be due to a combination of the smaller size of these fish and to the different types of commercial diets fed these fish (e.g., Taylor Aquaculture fed a combination of Biosponge and Purina Trout Chow). Additionally, each commercial site was sampled only once during the study.

#### Wild Striped Bass from Virginia

Fatty acids were analyzed from wild striped bass collected in Virginia from the Mattaponi River in Nov., 1989 and March, 1990, and from the Chowan River in March, 1990 (Table 9). Despite the fact that some of the VA fish had substantially lower percentages of 18:3n-3 and 22:5n-6 than wild fish from the SC lakes, the low percentages of 18:2n-6 (1.1 - 2.2 %) clearly distinguished them as wild fish.

#### SC Law Enforcement "Test Case"

To test the reliability of using fatty acids to distinguish wild from cultured fish, seven Test Case samples were brought to the Charleston Laboratory by a SCWMRD law enforcement official for analysis. A comparison of results with the known origin of these samples indicated that the method was 100% accurate in distinguishing wild from cultured fish (Appendix A) (Jahncke et al., 1991). One sample also had fatty acid characteristics of both a wild and cultured fish. It was also hypothesized that this was a cultured fish being fed a commercial diet, but at some point had eaten natural food. We based this assumption on the high concentrations of not only 18:2n-6, but also 18:3n-3, and 20:4n-6 (Jahncke and Seaborn 1991). The enforcement agent confirmed our suspicions, and indicated that this cultured fish had fed on natural foods in a pond before being transferred into a raceway and fed a commercial diet.

The successful analyses of the "Test Case" samples resulted in SC agreeing to relax the individual tagging requirements for cultured fish. In its place, SC law enforcement officials agreed to use specific labels on open containers shipped to market. The recommendations still require individual tags for skinless fillets, but for whole or gutted hybrid striped bass, a single tag on the outside of the box is acceptable.

#### NJ Enforcement Case

Results of analysis for samples supplied by NJ Marine Wildlife enforcement officials (15 fillets, suspected to be wild bass) indicated that all 15 fillets came from wild fish. Using isoelectric focusing techniques (IEF), it was demonstrated that all 15 fillets were striped bass (Enforcement Report, Appendix B). The report was accepted as evidence in court, and the NJ enforcement official informed us that our analyses were essential to the successful prosecution of their case.

TABLE 9. Weight percent fatty acid composition of striped bass collected from the Mattaponi (MR) and the Chowan (CR) Rivers in Virginia.

FATTY ACID	MR 11/89		CH 11/89		MR 3/90	
	Mean (n=8)	SD	Mean (n=3)	SD	Mean (n=11)	SD
14:0	2.0	0.80	3.3	0.34	3.5	0.86
15:0	0.9	0.39	0.6	0.05	0.6	0.06
16:0	18.4	0.97	19.4	0.33	17.7	0.86
17:0	0.7	0.16	0.9	0.08	0.6	0.05
18:0	5.7	0.65	4.2	0.47	3.8	0.26
20:0	0.1	0.07	0.2	0.01	0.2	0.02
TOTAL SATS.	27.8	1.24	28.7	0.33	26.3	1.04
14:1	0.1	0.04	0.1	0.02	0.1	0.03
16:1n-9	0.3	0.11	0.3	0.03	0.3	0.03
16:1n-7	5.6	1.27	8.1	1.24	8.0	1.12
16:1n-5	0.3	0.08	0.5	0.04	0.2	0.04
17:1	0.3	0.26	0.5	0.08	0.3	0.17
18:1n-9	10.0	2.46	11.8	0.27	12.8	2.36
18:1n-7	2.9	0.27	3.7	0.33	3.6	0.22
18:1n-5	0.2	0.06	0.2	0.03	0.2	0.03
20:1n-11+13	0.2	0.26	0.2	0.01	0.4	0.15
20:1n-9	1.2	0.85	1.5	0.07	1.8	0.29
20:1n-7	0.2	0.23	0.2	0.01	0.5	0.19
20:1n-5/NMID?	0.0	0.00	0.0	0.00	0.0	0.08
22:1n-11+13	0.1	0.37	0.0	0.00	0.0	0.07
22:1n-9	0.0	0.11	0.0	0.00	0.2	0.04
24:1	0.3	0.09	0.2	0.02	0.3	0.05
TOTAL MONOENES	21.9	4.31	27.4	1.92	29.0	2.10
16:2n-4	0.7	0.38	0.5	0.06	1.1	0.48
18:2n-9	0.0	0.00	0.0	0.00	0.0	0.00
18:2n-6	2.0	1.13	2.2	0.17	1.1	0.19
18:2n-4/3n-6	0.5	0.13	0.5	0.05	0.5	0.18
20:2n-6	0.3	0.10	0.4	0.03	0.3	0.05
TOTAL DIENES	3.7	1.29	3.8	0.32	3.3	0.88
16:3n-4	0.9	0.48	0.5	0.01	1.7	0.56
18:3n-4	0.0	0.00	0.0	0.00	0.0	0.00
18:3n-3	1.2	0.87	4.1	0.47	1.0	0.23
18:4n-3	0.7	0.43	1.0	0.07	2.0	0.60
20:3n-6	0.3	0.21	0.4	0.03	0.1	0.07
20:4n-6	5.5	2.92	4.6	0.72	1.9	0.35
20:3n-3	0.1	0.13	0.4	0.05	0.1	0.04
20:4n-3	0.6	0.23	1.1	0.12	1.0	0.24
20:5n-3	6.8	1.95	5.5	0.44	9.2	1.20
21:5n-3	0.2	0.19	0.2	0.01	0.5	0.12
22:4n-6	0.5	0.20	0.6	0.06	0.3	0.07
22:5n-6	1.5	0.49	3.1	0.52	0.8	0.19
22:5n-3	2.8	0.17	2.1	0.11	2.7	0.29
22:6n-3	20.4	3.17	12.8	1.63	16.8	3.66
TOTAL PUFA	45.8	2.76	40.6	2.07	42.1	1.69

### Linear Discriminate Analysis

Linear Discriminant Analysis is a weighted combination of predictor variables used to classify objects into one of several variable groups. Either individual fish or composite samples can be used to successfully classify fish into wild and cultured groups and collection sites. Composite samples reduce time and labor requirements when there are large numbers of samples to analyze. Composites also "smooth-out" individual fatty acid variations between single fish.

Linear Discriminant Analysis was conducted using 18:2n-6, 18:3n-3, 20:4n-6, 20:5n-3, 22:5n-6, and 22:6n-3 concentrations from individual fish and from 5-fish composite samples. The results show that for both individual and composite samples, cultured fish could be distinguished from wild fish with 100% accuracy (Tables 10-11).

A rather unexpected result of this study was the ability to classify wild fish as to geographic origin with a high degree of accuracy. The greatest degree of misclassification of wild fish as to site of origin was between Lakes Hartwell and Thurmond. This is not surprising since these lakes have similar biological characteristics, and fish populations migrate between the two reservoirs. Fish collected from the other three reservoirs were correctly classified as to site of origin 77-100% of the time. Identification of SC aquaculture sites was achieved with a high degree of precision (Table 10). Wild fish collected from VA were also distinguished from SC cultured fish with 100% accuracy (data not shown).

An evaluation was also made to determine if removing 18:2n-6 values from the Linear Discriminant Analysis procedure would affect the accuracy of the method. The results show that even without 18:2n-6 values, the Linear Discriminant Analysis procedure was able to distinguish wild from cultured fish with 100% accuracy. This was true for both individual fish and for composite samples (Tables 12-13).

## CONCLUSIONS

Enforcement officials now have a new tool for protection and conservation of our natural resources. The developed data base using fatty acid profiles will now allow enforcement officials to identify cultured fish with 100% accuracy. Results also indicate that classification of wild fish to sites of origin was 100% accurate for cultured fish and 77-100% accurate for wild fish collected from Murray, Moultrie and Wateree. More overlap occurred between Hartwell and Thurmond (Clark's Hill), but these reservoirs and their fish populations have similar biological and physical characteristics.

Collection site and fish size had the greatest overall effect on individual fatty acid concentrations. Seasonal effects were difficult to evaluate due to lack of sufficient environmental data.

Table 10. Classification of single fish into catch location by Linear Discriminant Analysis.								
catch location	catch location probability (%)							
	Thurmond	Hartwell	Murray	Santee-Cooper	Wateree	Waddell	Farm X	Farm Y
Thurmond	83.7	16.3	0.0	0.0	0.0	0.0	0.0	0.0
Hartwell	14.6	75.6	0.0	9.8	0.0	0.0	0.0	0.0
Murray	4.0	0.0	92.0	4.0	0.0	0.0	0.0	0.0
Santee-Cooper	0.0	0.0	16.3	77.4	6.5	0.0	0.0	0.0
Wateree	0.0	0.0	0.0	4.4	95.7	0.0	0.0	0.0
Waddell	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Farm X	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Farm Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Table 11. Classification of 5-fish composites into catch location by Linear Discriminant Analysis.								
catch location	catch location probability (%)							
	Thurmond	Hartwell	Murray	Santee-Cooper	Wateree	Waddell	Farm X	Farm Y
Thurmond	72.7	22.7	0.0	4.6	0.0	0.0	0.0	0.0
Hartwell	27.8	61.1	0.0	11.1	0.0	0.0	0.0	0.0
Murray	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Santee-Cooper	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Wateree	0.0	0.0	0.0	8.3	91.7	0.0	0.0	0.0

Table 12. Classification of single fish into catch location without linoleic acid values by Linear Discriminant Analysis.								
catch location	catch location probability (%)							
	Thurmond	Hartwell	Murray	Santee-Cooper	Wateree	Waddell	Farm X	Farm Y
Thurmond	83.7	16.3	0.0	0.0	0.0	0.0	0.0	0.0
Hartwell	14.6	75.6	0.0	9.8	0.0	0.0	0.0	0.0
Murray	4.0	0.0	72.0	4.0	20.0	0.0	0.0	0.0
Santee-Cooper	0.0	3.2	6.5	71.0	19.4	0.0	0.0	0.0
Wateree	0.0	0.0	4.4	4.4	91.3	0.0	0.0	0.0
Waddell	0.0	0.0	0.0	0.0	0.0	81.8	0.0	18.2
Farm X	0.0	0.0	0.0	0.0	0.0	33.3	66.7	0.0
Farm Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Table 13. Classification of 5-fish composites into catch location without linoleic acid values by Linear Discriminant Analysis.								
catch location	catch location probability (%)							
	Thurmond	Hartwell	Murray	Santee-Cooper	Wateree	Waddell	Farm X	Farm Y
Thurmond	72.7	22.7	0.0	4.6	0.0	0.0	0.0	0.0
Hartwell	27.8	61.1	0.0	11.1	0.0	0.0	0.0	0.0
Murray	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Santee-Cooper	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Wateree	0.0	0.0	0.0	8.3	91.7	0.0	0.0	0.0

## RECOMMENDATIONS

The objective of this study was to develop a biochemical method to distinguish wild (illegally caught) from cultured (farmed) fish using the edible portion of the fish. This has been accomplished.

### Law Enforcement Considerations

Two essential requirements for use of this method for enforcement purposes are: (1) equipment and expertise for sample analyses, data interpretation and "expert witness" testimony in a court of law; (2) sufficient information on fatty acid compositions of wild and cultured fish to establish a database for locations under consideration. NMFS Charleston Laboratory has the facility and staff to meet the first requirement. The data collected during this study establishes a sufficient database for SC. Technology transfer can be provided to assist other states in establishing this technique. Alternatively, data for fatty acid compositions of wild and cultured fish in other states could be added to the existing database for SC. Out-of-state "suspect" samples could then be sent to the NMFS Charleston Laboratory for analysis (as was done in the NJ enforcement case).

The analytical methods used in this study are based on those routinely used by lipid chemists. Sample collection procedures are simple. Approximately 50g of fresh or frozen tissue is needed for fatty acid analysis. Samples are stored in "zip-lock" bags and placed on ice in insulated coolers for transfer. Upon arrival at the laboratory, the lipids are extracted from the fish tissue. Fatty acid methyl esters are prepared from the extracted lipid and analyzed by gas chromatography. With prior notification, results can usually be provided within 48 hrs after sample receipt.

Although the entire fatty acid profile of an unknown fish sample is examined by an experienced lipid chemist before reporting analytical results, the dramatic differences in concentrations of the 6 major polyunsaturated fatty acids (PUFA) between wild and cultured fish (Figure 3) are readily distinguishable by persons untrained in lipid chemistry (e.g., law enforcement agents, attorneys, judges and jurors). The additional use of Linear Discriminant Analysis will provide statistical verification of the data.

The detailed information in this report will allow enforcement officials to develop appropriate regulations for the hybrid striped bass industry. The use of "paper trails" in conjunction with this fatty acid data base is recommended to ensure compliance with the law. Information on sample collection and analytical procedures is available upon request. A detailed protocol for sample collection and analysis will be included in the Charleston Laboratory Marine Forensics Manual to be published in the near future.

## ACKNOWLEDGMENTS

### South Carolina Wildlife and Marine Resources Department

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### NMFS Charleston Laboratory

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**APPENDIX A**

## PROGRESS REPORT

Development & Application of Forensic Techniques  
for Use in Management of South Carolina's Fishery Resources

Prepared by: Michael Jahncke, Ph.D. and Gloria Seaborn (Research Chemist)  
National Marine Fisheries Service  
Charleston Laboratory  
P.O. Box 12607  
Charleston, SC 29412-0607

Submitted to: Dr. James A. Timmerman, Jr.  
SCWMRD  
P.O. Box 167  
Columbia, SC 29202

Date: June 13, 1989

## INTRODUCTION/BACKGROUND

As part of NMFS Charleston Laboratory's Forensic Program, a cooperative agreement was established with the South Carolina Wildlife and Marine Resources Department (SCWMRD) with the goal to develop forensic techniques in areas of mutual interest. In particular, one objective was to develop a biochemical method to distinguish wild (poached) from cultured (farmed) fish, and to identify whether the fillets came from striped bass or hybrid striped bass. A second objective was that the method should utilize the edible portion of the fillet. It was agreed that such techniques would be highly useful to the SCWMRD Law Enforcement Division in its role of protecting the state fishery resources as well as in overseeing commercial aquaculture operations. Our approach has been two-fold: (1) to use fatty acid composition differences to differentiate wild fish (both striped bass and hybrid striped bass) from cultured hybrid striped bass; and (2) to identify striped bass and hybrid striped bass species by isoelectric focusing techniques (IEF).

In order to develop baseline reference data, SCWMRD Fisheries Biologists have been involved in the study by collecting wild striped bass and wild hybrid striped bass from various major state waters. To date, approximately 500 fish have been collected. These striped bass and hybrid striped bass were gill netted in November 1988, January 1989, and April 1989 from Lake Moultrie/Lake Marion, Lake Wateree, Lake Murray and Lake Thurmond (Clarks Hill)/Lake Hartwell. The next collection date is scheduled for July 1989, and the 2 year cooperative study will be completed in July, 1990.

At the time of collection, all fish were verified as to species (striped bass or hybrid striped bass). Data consisting of total length (mm), weight (g),

sex and sexual maturity (mature or immature) were also collected. Inclusion of this information is important as it will allow us to examine differences in fatty acids due to differences in species, season, size, sex, sexual maturity, site of capture, etc.

In addition to wild fish, Dr. Ted Smith (SCWMRD) has supplied cultured hybrid striped bass and diet samples for fatty acid analyses to establish the baseline/reference data for cultured fish. We have conducted approximately three years of research on the fatty acid profiles of these cultured hybrid striped bass. In addition to this information, members of the American Fisheries Society Striped Bass Technical Committee have recently agreed to send samples of wild striped bass and hybrid striped bass from their states. Also, several commercial growers have agreed to provide cultured fish and diet samples for fatty acid analyses. Thus, at completion of this cooperative study excellent information should be available for use in forensic activities throughout the U.S.

On April 21, 1989, an agreement was made with Lt. Sharpe, SCWMRD Law Enforcement Division, to test the reliability of our methods for distinguishing wild from cultured fish and for identifying striped bass and hybrid striped bass species. Lt. Sharpe brought to our laboratory seven (7) unknown fish samples for analysis. The objectives of the study were to: (1) identify the samples as to whether they came from wild or cultured fish using fatty acid composition differences, and (2) to identify striped bass and hybrid striped bass species by muscle protein isoelectric focusing. Accuracy of results of this study were to be used by SCWMRD in decisions related to product identification for cultured hybrid bass.

## MATERIALS AND METHODS

### Sample Receipt

On Monday, April 24, 1989, Lt. Chip Sharpe delivered seven groups of unidentified skinless fillets labeled A, B, C, 1, 2, 3 and 4 to the Charleston Laboratory. The fresh samples were immediately iced and placed in a cold room (+3°C).

### Sample Preparation

The size and weight of the seven unknown samples varied. Unknown C was the smallest sample consisting of two fillets weighing a total of 13 g. Unknown 4 was the largest sample consisting of several fillets weighing a total of 450 g. The five remaining samples (A, B, 1, 2, and 3) each contained two fillets (approximately 110 g in total weight). For each unknown, one fillet was used for fatty acid analysis and the other fillet was used for isoelectric focusing.

### Fatty Acid Analysis

The skinless fillets, with belly flaps removed, were rinsed with tap water before preparation. One fillet from each sample was homogenized in a commercial food processor which was thoroughly cleaned between samples. Lipids were extracted from duplicate 5 g portions of each homogenized sample using a chloroform-methanol extraction method (Folch et al., 1957).

Fatty acid methyl esters (FAME) were prepared by saponification of the extracted lipids followed by esterification (Metcalf and Schmitz 1961, Metcalfe et al. 1966). The esters were analyzed by gas-liquid chromatography (GLC) utilizing a Hewlett Packard (H-P) 5890 GLC, equipped with flame ionization detector and electronic integrator. Separation of the fatty acid methyl esters

was achieved on a 30 m x 0.25 mm ID DB225 (J&W Scientific) column. Helium was the carrier gas at a flow rate of 1.5 ml/min. Nitrogen was used as the make-up gas. Analytical runs were temperature programmed from 170° to 225°C @ 1°/min. Injections were in the split mode with a split ratio of 50:1.

Fatty acids were identified by comparison of their equivalent chain length values, calculated from isothermal runs, with those of primary and secondary standards (Jamieson 1970) and by GC/MS of the methyl esters.

### Isoelectric Focusing (IEF)

For each unknown sample a single intact fillet was frozen and held at 0°C until thawed for analysis by IEF. Approximately 0.4 g of white muscle tissue was excised from each fillet and homogenized in 1 ml of distilled deionized water. After 20 minutes of centrifugation at 18,000 rpm (0-5°C), the supernatant was removed for analysis by isoelectric focusing.

Commercially prepared LKB PAG plates (pH 3.5-9.5) were used for IEF. The gels were run on a flatbed LKB Ultraphor basic unit which was cooled to 10°C. The electrode solution consisted of 1 M H<sub>3</sub>PO<sub>4</sub> at the anode and 1 M NaOH at the cathode. Prior to sample application, the gel was prefocused for 30 min until the voltage reached 0.50 kv. Samples were applied using filter paper wicks that had been dipped in the sample supernatant. Each sample wick holds 10 µl supernatant. The wicks were placed directly on the gel surface. The sample wicks were removed when the voltage reached 1.0 kv, and the gel was focused to a final voltage of 1.5 kv.

Immediately following the run, the gel was fixed for 30 min. in 20% trichloroacetic acid and then washed for 5 min. in destaining solution. The gel was stained with 0.05% Coomassie blue R-250, destained and air dried.

## Collection of Reference Standards

The salmon (Salmo salar) (STD Salmon) and catfish (Ictalurus punctatus) (STD Catfish) reference standards were purchased from Harris Teeter Supermarket. The hybrid striped bass (STD Hybrid), striped bass (STD SB), red breast sunfish (Lepomis auritus) (STD RBSF) and bluegill (Lepomis macrochirus) (STD BG) reference standards were provided by Dr. Ted Smith, SCWMRD.



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**National Oceanic and Atmospheric Administration**  
NATIONAL MARINE FISHERIES SERVICE

Southeast Fisheries Center  
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**SPECIES IDENTIFICATION REPORT**

**A. SAMPLE INFORMATION**

**Identification:** CHAS REF # 16-39

**Location of collection or confiscation:** Site information was not provided but the unknown fish tissue samples were collected by Lt. Chip Sharpe, SCWMRD Law Enforcement Division

**Date transferred to NMFS, Charleston, S.C.:** 5/24/89

**Transferred by:** Lt. Chip Sharpe, SC Law Enforcement Division, SC Wildlife and Marine Resources Department, P.O. Box 167, Columbia, SC 29202

**Received by:** Michael Jahncke, NMFS, Charleston Laboratory, Charleston, SC 29412

**Comments:** Seven groups of skinless fillets labeled A, B, C, 1, 2, 3 and 4 were brought to the Charleston Laboratory by Lt. Chip Sharpe. The samples were unfrozen and in good condition upon receipt.

**B. SPECIES DOCUMENTATION**

**Species Identification:** Striped bass (Sample B) and hybrid striped bass (Samples C and 4)

**Method Used:** Polyacrylamide gel isoelectric focusing\*

**Standard species used for identification:** Striped bass, hybrid striped bass, red breast sunfish and bluegill sunfish.

**Date of report:** 5/28/89

**Documented by:** \_\_\_\_\_

Michael Jahncke, Ph.D.  
Program Manager  
Marine Animal Forensics

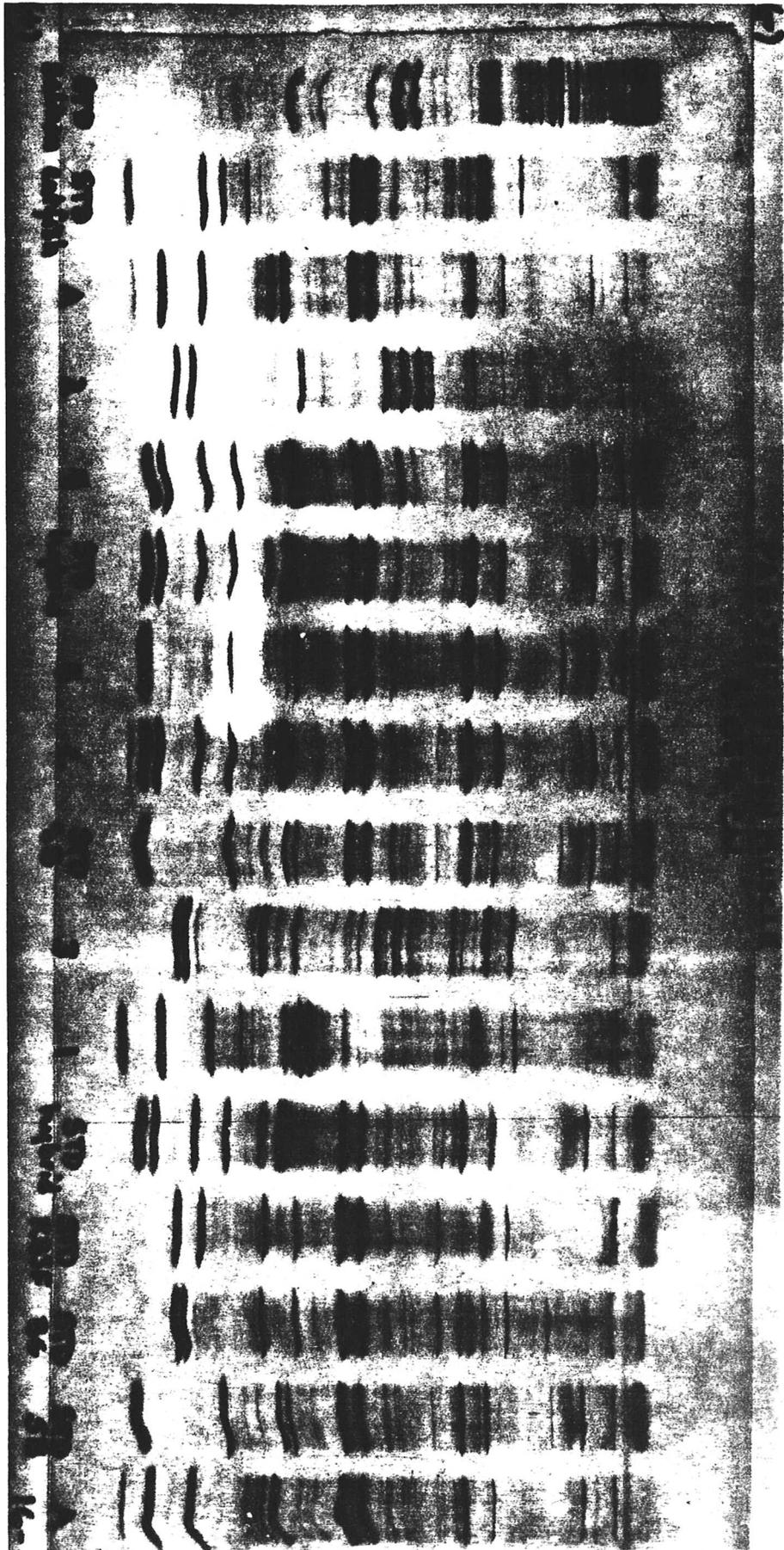
**Comments:** All unknowns were given Charleston reference number 16-39 and were compared with known and verified standards of striped bass, hybrid striped bass, red breast sunfish and bluegill. The identifications were made by PAG-IEF\* analysis using a general protein stain (coomassie blue). Our analysis identified 1 striped bass (Unknown Sample B) and 2 hybrid striped bass (Unknown Samples C and 4). The species of the other 4 unknown samples (A, 1, 2 and 3) could have been identified if we had been provided with authentic reference standards.



## Species Identification Key to Polyacrylamide Gel #16-44

Sample  
Position  
on Gel  
L - R

<u>L - R</u>	<u>Fish Samples</u>	<u>Sample Description</u>
1	STD Salmon	- Purchased from Harris Teeter - Atlantic salmon ( <u>Salmo salar</u> )
2	STD Catfish	- Purchased from Harris Teeter - Channel catfish ( <u>Ictalurus punctatus</u> )
3	A	- Unknown Sample A
4	2	- Unknown Sample 2
5	4	- Unknown Sample 4
6	STD Hybrid	- Hybrid Striped Bass Standard
7	B	- Unknown Sample B
8	C	- Unknown Sample C
9	STD SB	- Striped Bass Standard ( <u>Morone saxatilis</u> )
10	3	- Unknown Sample 3
11	1	- Unknown Sample 1
12	STD Hybrid	- Hybrid Striped Bass Standard
13	STD RBSF	- Red Breast Sunfish Standard ( <u>Lepomis auritus</u> )
14	STD BG	- Bluegill Sunfish Standard ( <u>Lepomis macrochirus</u> )
15	STD SB	- Striped Bass Standard
16	A	- Unknown Sample A





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NATIONAL MARINE FISHERIES SERVICE

Southeast Fisheries Center  
Charleston Laboratory  
P. O. Box 12607  
Charleston, SC 29412-0607

**WILD/CULTURED IDENTIFICATION REPORT**

**A. SAMPLE INFORMATION**

**Identification:** CHAS REF # 16-39

**Location of collection or confiscation:** Site information was not provided but the unknown fish tissue samples were collected by Lt. Chip Sharpe, Law Enforcement Division

**Date transferred to NMFS, Charleston, S.C.:** 5/24/89

**Transferred by:** Lt. Chip Sharpe, Law Enforcement Division, SC Wildlife and Marine Resources Department, P.O. Box 167, Columbia, SC 29202

**Received by:** Michael Jahncke, NMFS, Charleston Laboratory, Charleston, SC 29412

**Comments:** Seven groups of skinless fillets labeled A, B, C, 1, 2, 3 and 4 were brought to the Charleston Laboratory by Lt. Chip Sharpe. The samples were unfrozen and in good condition upon receipt.

**B. SPECIES DOCUMENTATION**

**Wild/Cultured Identification:** Cultured Fish: (Sample C); Wild Fish (Samples A, B, 1, 2, 3 and 4)

**Method Used:** Gas-liquid chromatography/mass spectroscopy

**Standard species used for identification:** Wild striped bass, wild hybrid striped bass, cultured hybrid striped bass

**Date of report:** 5/28/89

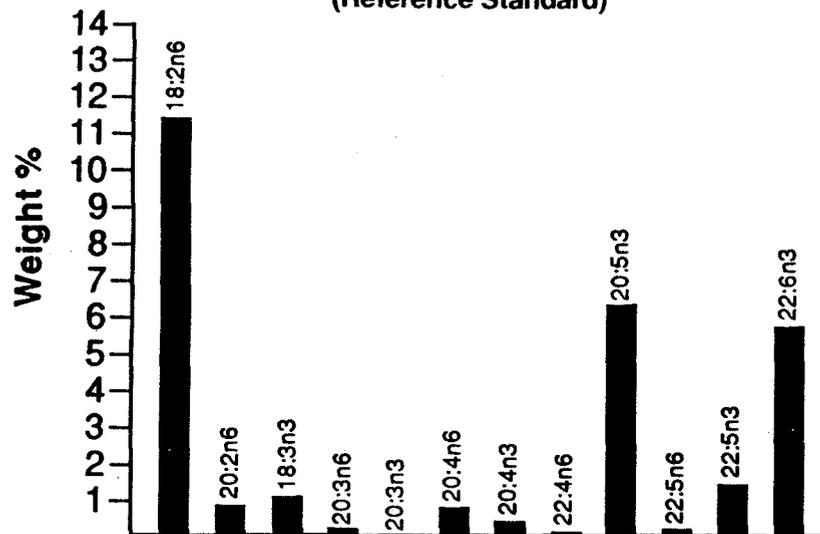
**Documented by:** \_\_\_\_\_

Gloria Seaborn  
Research Chemist

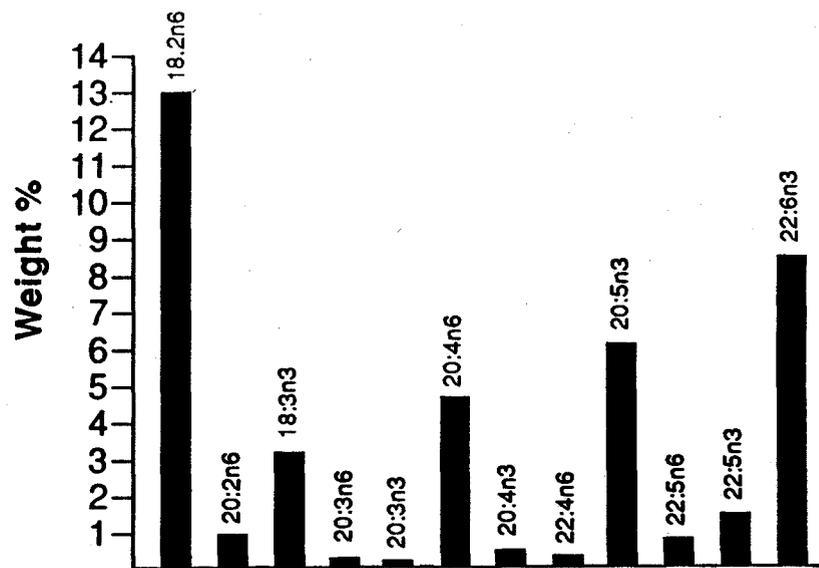
**Comments:** The fatty acid profiles of the unknown samples labeled A, B, C, 1, 2, 3 and 4 were given Charleston Reference number 16-39 and were compared with known and verified fatty acid profiles from approximately 500 wild striped bass, wild hybrid striped bass and cultured hybrid striped bass. An example of some of the differences in the fatty acid profiles between cultured and wild fish is provided (Figure 1). Note the higher concentration of 18:2n6 (linoleic acid) and the lower concentration of 22:5n6 in the cultured fish compared with the wild fish.



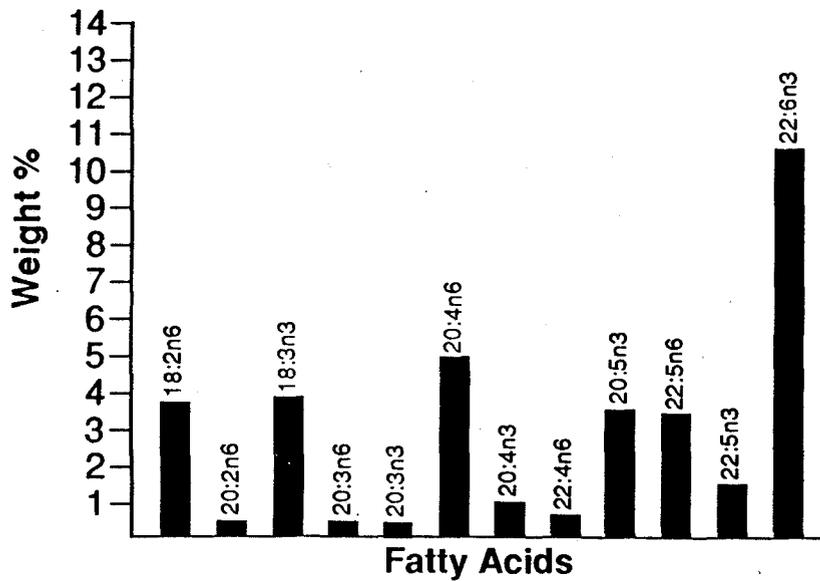
**Selected Fatty Acids in a Cultured Hybrid Striped Bass Fed a Commercial Trout Diet (Reference Standard)**



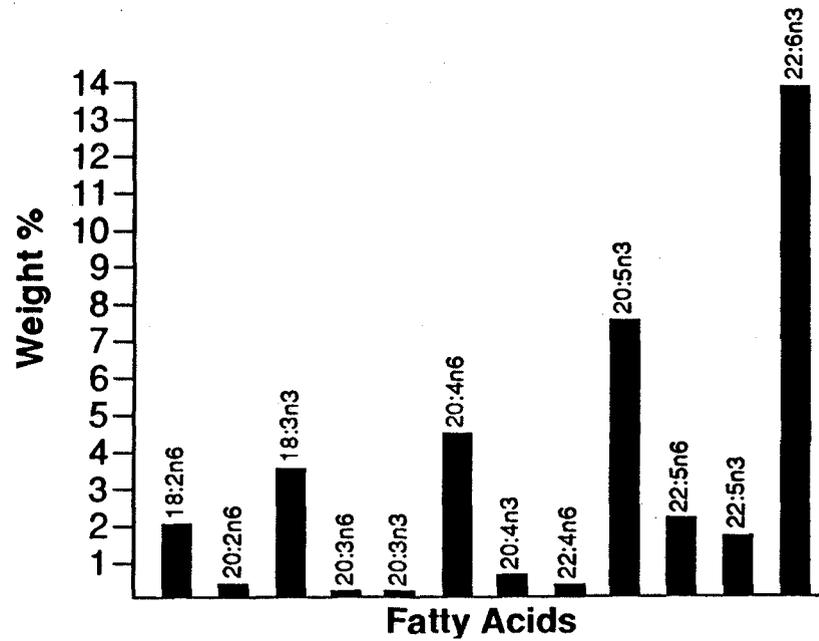
**Selected Fatty Acids in Unknown Sample C (Identified as a Cultured Hybrid Striped Bass)**



**Selected Fatty Acids in an Immature Male Striped Bass Collected From Clark Hill (Nov. '88) (Reference Standard)**



**Selected Fatty Acids in Unknown Sample B (Identified as a Wild Striped Bass)**



## DISCUSSION

### Wild/Cultured Differentiation

The fatty acid composition of fish will reflect the fatty acids found in their diet. Based on differences in fatty acid compositions, particularly the linoleic acid (18:2n6) concentration, a successful identification was made for the fillets that came from a cultured (farmed) fish (Sample C) as well as those that came from wild fishes (Samples A, B, 1, 2, 3, and 4).

Figure 1 shows the concentrations of several long chain polyunsaturated fatty acids found in a cultured hybrid striped bass reference standard, in a wild striped bass reference standard, in Sample C and in Sample B. Note the difference in the linoleic acid (18:2n6) concentrations. The linoleic acid concentration is several times higher in the cultured hybrid striped bass standard (11%) and in Sample C (13%) than in the wild striped bass standard (3%) or in Sample B (3%). Samples A, 1, 2, 3 and 4 were also found to have low concentrations of linoleic acid (1.2 - 4.9%) (Table 1). Our research shows that cultured hybrid striped bass contain higher concentrations of linoleic acid than do wild striped bass or wild hybrid striped bass. This difference, due to the high concentrations of linoleic acid found in manufactured fish feeds, can be used as a tool to distinguish cultured hybrid striped bass from wild striped bass and wild hybrid striped bass.

Although found in natural foods, linoleic acid is especially high in commercial fish feeds since soybean meal is often used as a major ingredient in fish feeds and soybean oil contains approximately 64% linoleic acid. Such high concentrations are not found in a wild fish's natural diet.

Our current research indicates that in addition to linoleic acid,

differences in the concentrations of several other long chain polyunsaturated fatty acids such as; linolenic acid (18:3n3), arachidonic acid (20:4n6), docosapentaenoic acid (22:5n6) and docosahexaenoic acid (22:6n3) can also be used to help distinguish wild from cultured fish.

### Striped Bass/Hybrid Striped Bass Identification

Isoelectric focusing (IEF) is a powerful technique for use in the identification of fish species (Lundstrom 1981). Harvey and Fries (1987) used isoelectric focusing to identify four Morone species and their congeneric hybrids. It is a relatively simple technique in which a protein solution (soluble muscle protein in this case) is placed on a gel on which a pH gradient has been established. The proteins are separated based upon their inherent net charges by passage of direct electric current through the gel. The proteins move in the gel until they reach the area of the pH gradient in the gel which is equivalent to their own isoelectric point. Isoelectric focusing results in specific protein banding patterns for each species.

By comparing the protein banding patterns of unknown samples (A, B, C, 1, 2, 3 and 4) with standard reference samples (STD - hybrid striped bass, STD - Striped Bass), a correct identification was made for the fillets that came from a hybrid striped bass (Unknown Samples C and 4) and those that came from a striped bass (Unknown Sample B) (Gel 16-44).

The species of the other unknown samples (A, 1, 2 and 3) could easily have been identified with the provision of authentic reference standards. Currently, the marine forensics program at the Charleston Laboratory is in the process of establishing an extensive reference collection consisting of striped bass, hybrid striped bass and endangered and protected marine and freshwater finfish

and reptiles. These samples will be available as standards in future isoelectric focusing work.

### CONCLUSIONS

Results of the forensic analyses are summarized in the following table:

<u>SAMPLES</u>	<u>NMFS ID</u>	<u>ID PROVIDED by Chip Sharpe</u>	<u>DIAGNOSTIC RESULTS</u>
A	Wild-NOT Striped or Hybrid Striped Bass	Wild-White Bass	Correct
B	Wild-Striped Bass	Wild-Striped Bass	Correct
C	Cultured-Hybrid Striped Bass	Cultured-Hybrid Striped Bass	Correct
1	Wild-NOT Striped or Hybrid Striped Bass	Wild-Catfish	Correct
2	Wild-NOT Striped or Hybrid Striped Bass	Wild-Crappie	Correct
3	Wild-NOT Striped or Hybrid Striped Bass	Wild-Largemouth Bass	Correct
4	Wild-Hybrid Striped Bass	Wild-Hybrid Striped Bass	Correct

As can be seen, the identification of striped bass and hybrid striped bass from the unknown samples was 100% accurate, as was the discrimination of wild from cultured fish. These findings document the potential use of these biochemical tools for use in protection and management of fishery resources.

Table 1. Selected Fatty Acids of Unknown Samples A, 1, 2, 3 and 4.  
Data are expressed as weight percent of total fatty acids.

Fatty Acids	Unknown Sample A	Unknown Sample 1	Unknown Sample 2	Unknown Sample 3	Unknown Sample 4
18:2n6 <sup>a</sup>	4.9	1.2	2.6	2.8	3.2
20:2n6	0.8	0.3	0.2	0.3	0.6
18:3n3	4.0	0.7	0.7	1.7	3.1
20:3n6	0.5	0.3	0.2	0.7	0.3
20:3n3	0.3	0.1	0.1	0.2	0.3
20:4n6	5.9	7.1	17.0	12.9	6.3
20:4n3	0.9	0.5	0.5	0.5	0.9
22:4n6	0.7	0.5	1.0	1.7	0.6
20:5n3	3.7	9.8	5.1	4.6	4.7
22:5n6	4.5	1.3	2.0	6.3	4.2
22:5n3	2.6	3.3	4.4	3.1	1.8
22:6n3	12.4	17.6	21.5	17.6	17.2

<sup>a</sup> linoleic acid

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**APPENDIX B**



UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL MARINE FISHERIES SERVICE  
Southeast Fisheries Center  
Charleston Laboratory  
P. O. Box 12607  
Charleston, SC 29412-0607

June 19, 1990

Karl P. Yunghans  
NJFG&W Marine Fisheries Law Enforcement  
Route 9 - Milepost 51  
Port Republic, NJ 08241

Dear Mr. Yunghans:

Analyses have been completed on the species identification request for the suspect striped bass samples, seized property #9176. The samples were assigned Charleston Reference #18-7 upon receipt. Each individual fillet was analyzed to determine the species and whether it came from a wild or cultured fish.

Species identification was done by an isoelectric focusing method using a general protein stain (coomassie blue). The samples were compared with known standards of striped bass and hybrid striped bass. The results indicated that all 15 fillet samples, seized property #9176, were striped bass. (See attached photographs.)

Fatty acid analyses were conducted to determine if the fillet samples came from wild or cultured fish. Fatty acid profiles for the 15 samples were obtained by gas-liquid chromatography. Mass spectroscopy was used to verify identifications of the individual fatty acids. The profiles of the unknown samples were compared with known and verified fatty acid profiles from approximately 500 wild striped bass, wild hybrid striped bass, and cultured hybrid striped bass from South Carolina and with profiles of wild striped bass taken from the Hudson River near Cornwall, NY. Based on the overall fatty acid profiles and specifically on the levels of 18:2w6 (linoleic acid), all of the samples submitted were identified as wild fish.

Linoleic acid is especially high in cultured fish since soybean meal is often used as a major ingredient in fish feeds and soybean oil contains approximately 54% linoleic acid. (See Figures 1 and 2).

Enclosed is a photocopy of the chain of custody tag. The original will be sent to you along with the seized samples.



Please feel free to call if you have any further questions regarding the report.

Sincerely,

Michael L. Jahncke  
Program Manager,  
Marine Forensics

Enclosures



THE MATERIAL TO WHICH THIS TAG IS AFFIXED IS IN THE CUSTODY OF THE UNITED STATES GOVERNMENT AND MUST NOT BE TAMPERED WITH UNDER PENALTY OF LAW.

DATE	CHAIN OF CUSTODY	PURPOSE
4/20/90	SIGNATURE AND TITLE <i>Karl Gumbert - C. O. III</i>	<i>Search incident</i>
5/8/90	SIGNATURE AND TITLE <i>Michael L. ... Maine Forensics</i>	<i>analysis</i>
	SIGNATURE AND TITLE	

I HEREBY ACKNOWLEDGE the return to me of the article(s) listed on the reverse side of this tag in as good condition as when seized by officer.

SIGNATURE	DATE
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UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL MARINE FISHERIES SERVICE

Southeast Fisheries Center  
Charleston Laboratory  
P. O. Box 12607  
Charleston, SC 29412-0607

May 30, 1990

SPECIES IDENTIFICATION REPORT

A. SAMPLE INFORMATION

Identification: Seized Property #9176  
(assigned Charleston Reference #18-7)

Location of collection or confiscation:  
Seized from the Charlesworth Hotel, NJ

Date transferred to NMFS, Charleston, SC: Monday, May 7,  
1990 via Federal Express Airbill #845571963.

Transferred by: Karl P. Yunghans - C.O. III, NJFG&W Marine  
Fisheries Law Enforcement, Route 9-Milepost 51, Port  
Republic, New Jersey 08241 (609)441-3474

Received by: Michael L. Jahncke, PhD, NMFS, 217 Fort Johnson  
Road, Charleston, SC 29412 (803)762-1200 at approximately  
9:45 am on 5/8/90.

Comments: One small cooler contained 15 individually wrapped  
fillets (skin attached). Seizure tag and chain of custody  
were enclosed. The samples were still frozen and in  
excellent condition upon receipt. Samples were placed in a  
locked freezer at -80°C until analyzed.

B. SPECIES DOCUMENTATION

Species Identification: Seized property #9176 was identified  
as striped bass (Morone saxatilis).

Method Used: Polyacrylamide gel isoelectric focusing

Standard species used for identification: Striped bass  
(Morone saxatilis) and Hybrid striped bass (Morone chrysops x  
Morone saxatilis cross)

Date of report: May 25, 1990

Documented by:

Michael Jahncke  
Michael Jahncke, Ph.D.  
Program Manager  
Marine Animal Forensics









UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL MARINE FISHERIES SERVICE

WILD/CULTURED IDENTIFICATION REPORT

A. SAMPLE INFORMATION

Identification: Seized property #9176, Charleston Case Reference #18-7.

Location of collection of confiscation: The Charlesworth Hotel, NJ

Date transferred to NMFS, Charleston, S.C: Monday, May 7, 1990 via Federal Express, airbill #845571963

Transferred by: Karl Yunghans, NJFG&W - Marine Fish./Law Enforcement, Route 9 - Milepost 51, Port Republic, NJ 08241, (609) 441-3474

Received by: Michael Jahncke, NMFS, Charleston Laboratory, Charleston, SC 29412

Comments: One small cooler contained 15 individually wrapped fillets (skin attached). Seizure tag and Chain-of-Custody were enclosed. The samples were still frozen and in excellent condition upon receipt. Samples were placed in a locked freezer at -80°C until analyzed. Fillets were assigned numbers 1-15 at the time of analysis.

B. SPECIES DOCUMENTATION

Wild/Cultured Identification: All samples (15) were identified as wild fish

Methods used: Gas-liquid chromatography, Mass spectroscopy

Standard species used for identification: Wild striped bass, wild hybrid striped bass, cultured hybrid striped bass

Date of Report: 06/11/90

Documented by :

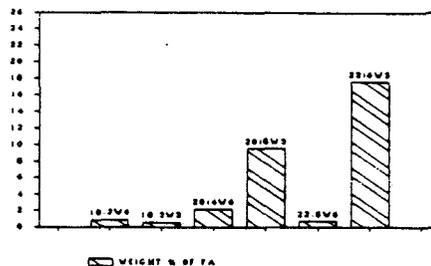
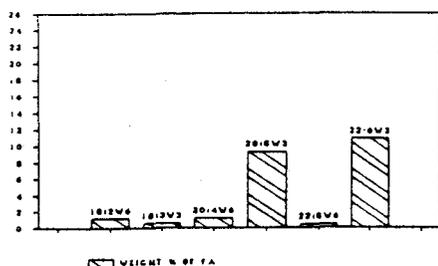
  
Gloria T. Seaborn  
Chemist

Comments: The fatty acid profiles of the unknown samples were compared with known and verified fatty acid profiles from approximately 500 wild striped bass, wild hybrid striped bass, and cultured hybrid striped bass from South Carolina as well as those of wild striped bass taken from the Hudson River near Cornwall, NY. Graphic illustration of some differences in the fatty acid profiles between cultured and wild fish is given in Figure 1. The most significant difference is seen in the levels of 18:2w6 (linoleic acid). Graphs of samples 1-15 are presented in Figure 2.

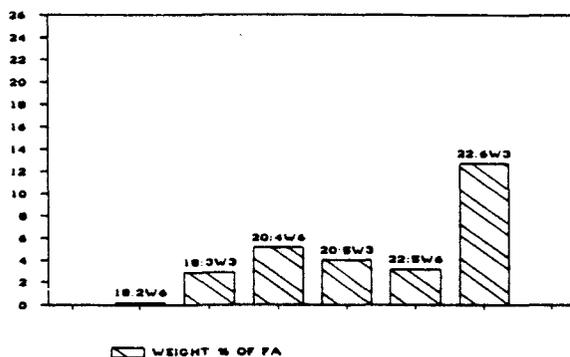


**FIGURE 1. Selected Fatty Acids Used to Distinguish Wild and Cultured Bass**

**Typical Fatty acids of Wild Striped Bass Collected from the Hudson River near Cornwall, NY  
(Reference Standard)**



**Typical Fatty Acids of Wild Striped Bass Collected from Clarks Hill, SC  
(Reference Standard)**



**Typical Fatty Acids of Cultured Hybrid Striped Bass from Waddell Center, SC  
(Reference Standard)**

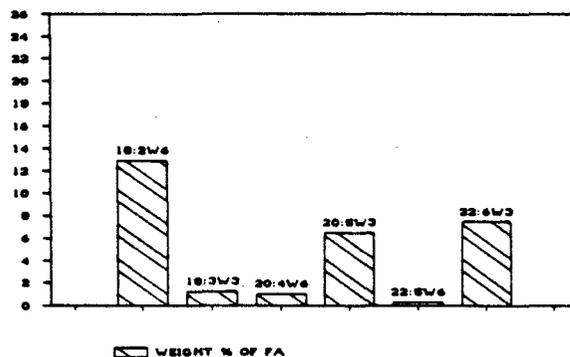


FIGURE 2. Selected Fatty Acids in Unknown Samples 1-15

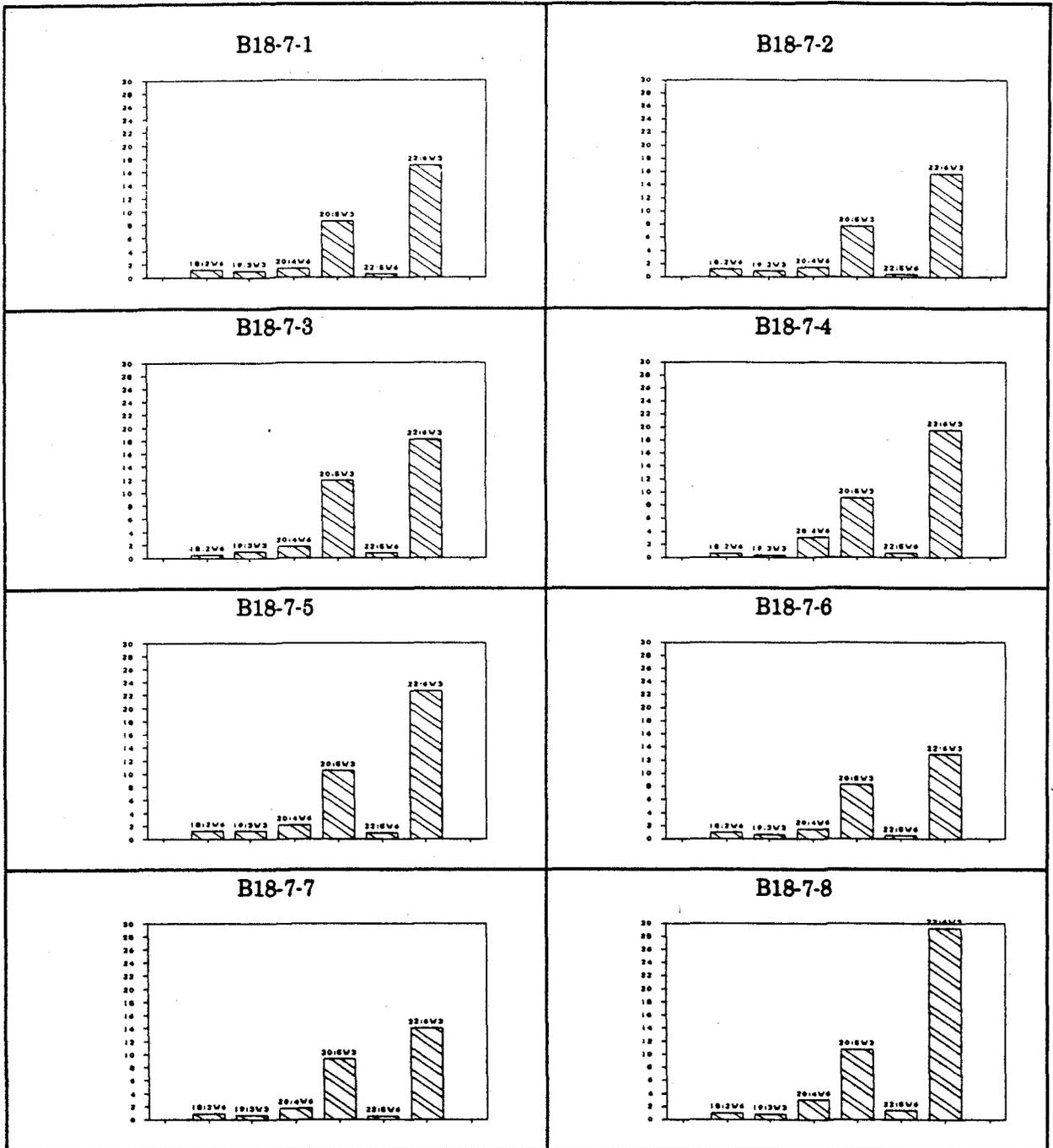
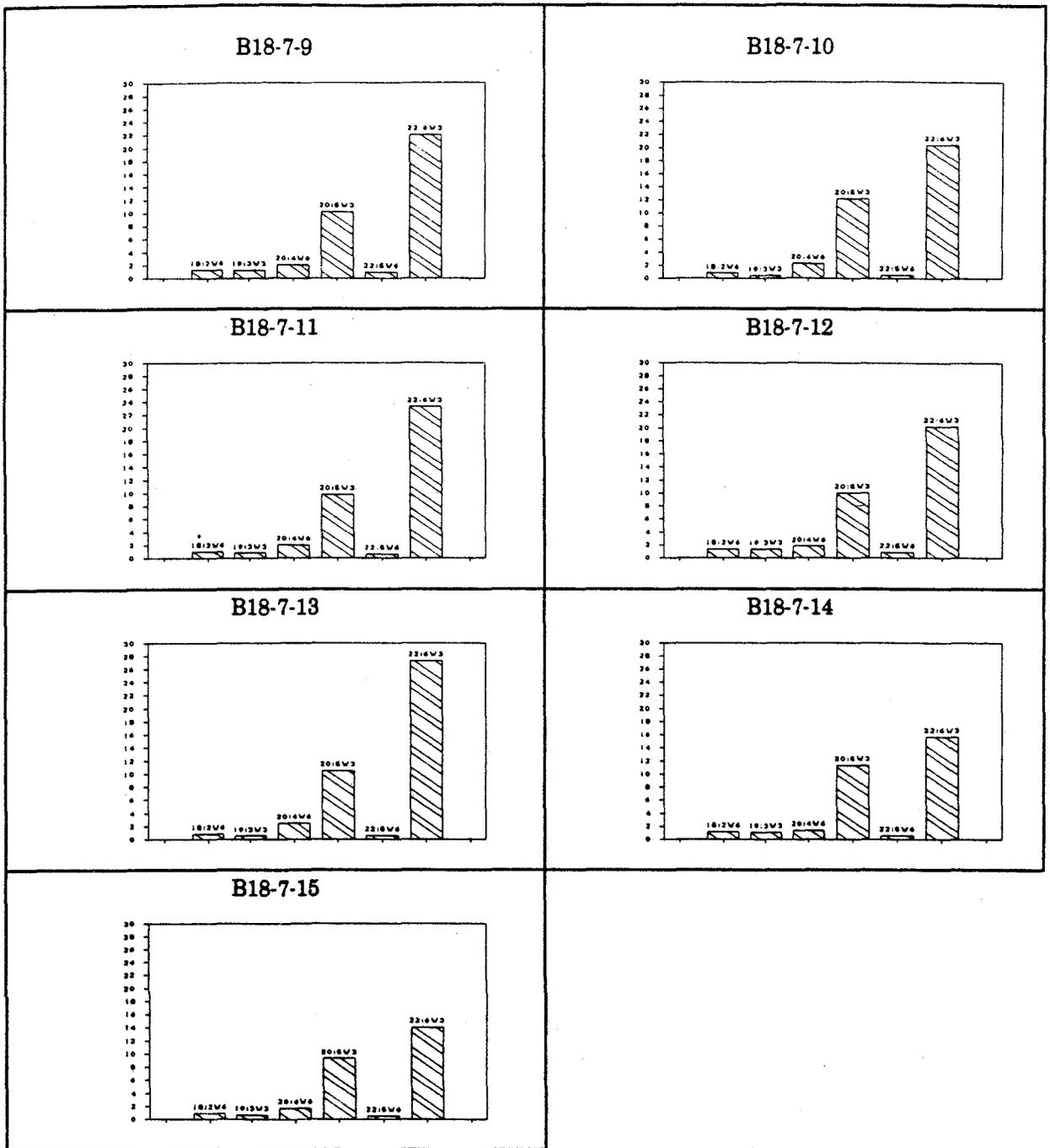


FIGURE 2. (cont.)



APPENDIX C

TABLE C.1. Weight percent fatty acid composition of fish collected from Lake Hartwell November, 1988. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=3)	+ - SD	Mean (n=4)	+ - SD	Mean	+ - SD	Mean (n=1)	+ - SD
14:0	3.4	0.07	3.4	0.21			3.5	
15:0	0.7	0.02	0.6	0.06			0.7	
16:0	17.3	0.34	17.4	0.23			18.0	
17:0	0.7	0.02	0.7	0.11			0.8	
18:0	3.3	0.16	3.5	0.90			3.6	
20:0	0.2	0.01	0.2	0.03			0.2	
TOTAL SATS.	25.5	0.43	25.8	1.30			26.7	
14:1	0.1	0.04	0.1	0.08			0.1	
16:1n-9	0.7	0.01	0.7	0.12			0.7	
16:1n-7	6.9	0.02	6.5	0.76			6.4	
16:1n-5	0.3	0.09	0.3	0.08			<0.1	
17:1	0.8	0.01	0.6	0.34			0.8	
18:1n-9	16.8	0.90	17.2	4.09			16.0	
18:1n-7	3.5	0.03	3.4	0.30			3.4	
18:1n-5	<0.1	-	<0.1	-			<0.1	
20:1n-11+13	0.1	0.02	0.1	0.05			0.1	
20:1n-9	1.5	0.04	1.3	0.30			1.4	
20:1n-7	0.1	0.02	0.1	0.04			0.1	
20:1n-5/NMID?	<0.1	-	<0.1	-			<0.1	
22:1n-11+13	<0.1	-	<0.1	-			0.1	
22:1n-9	0.1	0.05	0.1	0.02			<0.1	
24:1	0.3	0.01	0.3	0.03			0.3	
TOTAL MONOENES	31.1	0.84	30.5	5.20			29.2	
16:2n-4	0.2	0.00	0.2	0.03			0.2	
18:2n-9	0.2	0.02	0.2	0.08			0.2	
18:2n-6	2.9	0.08	3.0	0.07			3.2	
18:2n-4/3n-6	0.4	0.01	0.4	0.04			0.4	
20:2n-6	0.4	0.00	0.4	0.03			0.4	
TOTAL DIENES	4.2	0.11	4.2	0.09			4.4	
16:3n-4	0.4	0.01	0.4	0.02			0.4	
16:3n-3	0.1	0.05	<0.1	-			0.1	
18:3n-4	<0.1	-	<0.1	-			<0.1	
18:3n-3	2.8	0.17	2.8	0.15			3.1	
18:4n-3	1.4	0.12	1.4	0.12			1.5	
20:3n-6	0.3	0.01	0.3	0.04			0.3	
20:4n-6	5.1	0.29	5.3	0.82			5.7	
20:3n-3	0.2	0.01	0.2	0.02			0.2	
20:4n-3	0.9	0.03	1.0	0.07			1.0	
20:5n-3	4.5	0.07	4.5	0.31			4.9	
21:5n-3	0.1	0.08	<0.1	-			<0.1	
22:4n-6	0.6	0.02	0.6	0.04			0.6	
22:5n-6	3.2	0.16	3.2	0.62			3.2	
22:5n-3	1.7	0.01	1.6	0.05			1.5	
22:6n-3	14.5	0.74	13.9	1.75			13.1	
TOTAL PUFA	40.0	2.86	39.5	5.05			39.9	

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.2. Weight percent fatty acid composition of fish collected from Lake Hartwell January, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=1)	+ - SD (n=8)	Mean (n=1)	+ - SD	Mean	+ - SD	Mean (n=10)	+ - SD
14:0	3.7		3.6	0.10			4.0	0.52
15:0	0.6		0.6	0.02			0.6	0.09
16:0	15.8		15.2	0.33			17.5	1.20
17:0	0.7		0.6	0.04			0.7	0.08
18:0	2.9		2.5	0.21			3.4	0.20
20:0	0.1		0.1	0.00			0.2	0.01
TOTAL SATS.	23.8		22.7	0.55			26.4	0.96
14:1	0.1		0.2	0.05			0.1	0.03
16:1n-9	0.6		0.7	0.05			0.5	0.04
16:1n-7	7.1		8.1	0.58			8.7	1.44
16:1n-5	0.4		0.4	0.00			0.3	0.03
17:1	0.8		0.9	0.05			0.7	0.10
18:1n-9	17.9		19.0	1.70			15.9	2.98
18:1n-7	3.8		3.8	0.06			3.5	0.21
18:1n-5	0.2		0.1	0.09			0.1	0.04
20:1n-11+13	<0.1		0.1	0.02			<0.1	-
20:1n-9	1.6		1.6	0.13			2.0	0.42
20:1n-7	<0.1		0.1	0.01			0.1	0.03
20:1n-5/NMID?	<0.1		<0.1	-			<0.1	-
22:1n-11+13	<0.1		<0.1	-			<0.1	-
22:1n-9	<0.1		0.1	-			0.1	0.02
24:1	0.2		0.2	0.01			0.3	0.05
TOTAL MONOENES	32.8		35.3	1.19			32.4	3.75
16:2n-4	0.2		0.3	0.09			0.4	0.19
18:2n-9	<0.1		0.1	0.11			0.0	0.04
18:2n-6	3.2		3.4	0.15			2.5	0.40
18:2n-4/3n-6	0.4		0.4	0.01			0.4	0.09
20:2n-6	0.5		0.5	0.02			0.4	0.04
TOTAL DIENES	4.3		4.6	0.11			3.7	0.77
16:3n-4	0.5		0.4	0.06			0.4	0.12
16:3n-3	<0.1		<0.1	-			<0.1	-
18:3n-4	<0.1		<0.1	-			<0.1	-
18:3n-3	2.9		3.3	0.28			2.6	0.64
18:4n-3	1.6		1.6	0.04			1.8	0.49
20:3n-6	0.3		0.3	0.02			0.3	0.04
20:4n-6	4.9		4.7	0.15			4.5	0.44
20:3n-3	0.2		0.2	0.02			0.1	0.03
20:4n-3	1.0		1.1	0.04			0.9	0.15
20:5n-3	4.8		4.8	0.20			5.2	0.70
21:5n-3	0.2		0.2	0.02			0.2	0.07
22:4n-6	0.6		0.6	0.02			0.5	0.04
22:5n-6	3.1		2.7	0.13			3.0	0.27
22:5n-3	1.7		1.9	0.19			1.4	0.11
22:6n-3	14.4		12.5	0.31			13.1	1.89
TOTAL PUFA	40.5		39.1	1.01			37.7	3.01

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.3. Weight percent fatty acid composition of fish collected from Lake Hartwell April, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=3)	+ - SD	Mean (n=3)	+ - SD	Mean (n=1)	+ - SD	Mean (n=2)	+ - SD
14:0	3.9	0.35	4.3	0.30	4.3		3.6	0.29
15:0	0.7	0.05	0.7	0.05	0.6		0.5	0.04
16:0	16.2	0.24	16.2	0.44	16.7		17.2	0.42
17:0	0.8	0.09	0.8	0.06	0.8		0.6	0.00
18:0	3.2	0.36	3.4	0.29	3.0		3.4	0.27
20:0	<0.1	-	<0.1	-	0.0		<0.1	-
TOTAL SATS.	24.9	0.70	25.6	0.26	25.7		25.6	0.19
14:1	0.2	0.02	0.2	0.01	0.2		0.2	0.02
16:1n-9	0.6	0.17	0.5	0.09	0.4		0.5	0.06
16:1n-7	8.9	0.69	9.9	0.97	10.6		9.9	0.98
16:1n-5	0.3	0.02	0.3	0.02	0.3		0.3	0.01
17:1	0.8	0.06	0.8	0.06	0.7		0.7	0.02
18:1n-9	14.0	2.54	12.0	0.79	16.3		18.1	2.76
18:1n-7	4.0	0.03	4.0	0.22	3.9		4.2	0.20
18:1n-5	0.2	0.01	0.2	0.02	0.2		0.2	0.01
20:1n-11+13	<0.1	-	0.1	0.02	0.0		<0.1	-
20:1n-9	1.6	0.18	1.4	0.14	2.1		2.5	0.33
20:1n-7	<0.1	-	0.1	0.02	0.0		<0.1	-
20:1n-5/NMID?	<0.1	-	<0.1	-	0.0		<0.1	-
22:1n-11+13	<0.1	-	0.1	0.05	0.0		<0.1	-
22:1n-9	<0.1	-	<0.1	-	0.1		0.1	0.08
24:1	0.3	0.00	0.2	0.01	0.3		0.3	0.03
TOTAL MONOENES	30.2	2.19	29.6	1.55	34.5		36.3	2.08
16:2n-4	0.4	0.11	0.6	0.07	0.6		0.4	0.17
18:2n-9	<0.1	-	<0.1	-	0.0		<0.1	-
18:2n-6	3.0	0.16	3.1	0.11	2.9		2.3	0.02
18:2n-4/3n-6	0.5	0.06	0.5	0.06	0.5		0.4	0.07
20:2n-6	0.5	0.01	0.5	0.01	0.4		0.4	0.01
TOTAL DIENES	4.5	0.34	4.8	0.28	4.5		3.7	0.29
16:3n-4	0.4	0.05	0.5	0.03	0.5		0.5	0.10
16:3n-3	0.1	0.02	0.1	0.02	0.2		0.1	0.01
18:3n-4	<0.1	-	<0.1	-	0.0		<0.1	-
18:3n-3	3.3	0.41	3.5	0.38	3.4		2.3	0.02
18:4n-3	1.9	0.32	2.0	0.26	2.1		1.5	0.12
20:3n-6	0.3	0.03	0.4	0.03	0.3		0.2	0.02
20:4n-6	4.8	0.07	4.9	0.34	4.0		4.2	0.12
20:3n-3	0.2	0.03	0.2	0.02	0.2		0.1	0.01
20:4n-3	1.0	0.11	1.1	0.12	1.0		0.7	0.01
20:5n-3	5.6	0.62	6.0	0.29	5.7		5.2	0.66
21:5n-3	0.3	0.06	0.2	0.08	0.3		0.2	0.03
22:4n-6	0.5	0.05	0.5	0.03	0.4		0.5	0.02
22:5n-6	3.3	0.16	3.4	0.29	2.6		2.7	0.20
22:5n-3	1.7	0.05	1.7	0.03	1.5		1.4	0.06
22:6n-3	13.7	0.81	12.7	1.67	10.4		12.5	0.25
TOTAL PUFA	42.7	1.45	42.3	1.28	37.9		36.5	1.84

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.4. Weight percent fatty acid composition of fish collected from Lake Hartwell July, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)	Hybrid (I)	Striped (C)	Striped (I)	
		Mean (n=8)	+ - SD		
14:0		3.9	0.20		
15:0		0.6	0.03		
16:0		17.0	0.88		
17:0		0.7	0.06		
18:0		3.4	0.60		
20:0		0.2	0.04		
TOTAL SATS.		25.9	1.38		
14:1		0.2	0.03		
16:1n-9		0.6	0.05		
16:1n-7		6.7	0.58		
16:1n-5		0.4	0.03		
17:1		0.7	0.08		
18:1n-9		16.7	1.82		
18:1n-7		3.5	0.23		
18:1n-5		0.2	0.03		
20:1n-11+13		<0.1	-		
20:1n-9		1.5	0.25		
20:1n-7		<0.1	-		
20:1n-5/NMID?		<0.1	-		
22:1n-11+13		<0.1	-		
22:1n-9		<0.1	-		
24:1		0.3	0.04		
TOTAL MONOENES		30.9	2.76		
16:2n-4		0.2	0.04		
18:2n-9		<0.1	-		
18:2n-6		3.1	0.12		
18:2n-4/3n-6		0.4	0.02		
20:2n-6		0.5	0.03		
TOTAL DIENES		4.2	0.17		
16:3n-4		0.4	0.02		
16:3n-3		0.1	0.01		
18:3n-4		<0.1	-		
18:3n-3		2.8	0.17		
18:4n-3		1.7	0.14		
20:3n-6		0.3	0.02		
20:4n-6		4.7	0.49		
20:3n-3		0.2	0.02		
20:4n-3		1.0	0.07		
20:5n-3		5.3	0.27		
21:5n-3		0.2	0.04		
22:4n-6		0.5	0.03		
22:5n-6		3.1	0.33		
22:5n-3		1.7	0.06		
22:6n-3		14.3	1.51		
TOTAL PUFA		40.4	2.08		

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.5. Weight percent fatty acid composition of fish collected from Lake Hartwell November, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=3)	+/- SD	Mean (n=6)	+/- SD	Mean	+/- SD	Mean (n=2)	+/- SD
14:0	4.3	0.08	4.1	0.19			4.4	0.30
15:0	0.7	0.02	0.7	0.02			0.7	0.00
16:0	18.3	0.14	18.1	0.80			17.6	0.03
17:0	0.9	0.04	0.8	0.06			0.9	0.01
18:0	3.5	0.25	3.5	0.63			4.3	0.25
20:0	0.2	0.00	0.2	0.03			0.2	0.00
TOTAL SATS.	27.9	0.40	27.5	1.34			28.2	0.21
14:1	0.2	0.01	0.2	0.04			0.2	0.00
16:1n-9	0.6	0.02	0.7	0.11			0.5	0.01
16:1n-7	6.6	0.18	6.8	1.17			6.4	0.60
16:1n-5	0.3	0.08	0.4	0.08			0.4	0.01
17:1	0.8	0.02	0.8	0.07			0.7	0.02
18:1n-9	15.6	0.60	14.6	2.05			13.2	0.31
18:1n-7	3.3	0.07	3.3	0.26			2.9	0.01
18:1n-5	0.1	0.04	0.1	0.05			0.1	0.02
20:1n-11+13	<0.1	-	<0.1	-			0.1	0.06
20:1n-9	1.1	0.05	1.1	0.16			1.0	0.13
20:1n-7	<0.1	-	<0.1	-			<0.1	-
20:1n-5/NMID?	<0.1	-	<0.1	-			<0.1	-
22:1n-11+13	<0.1	-	<0.1	-			<0.1	-
22:1n-9	<0.1	-	<0.1	-			<0.1	-
24:1	0.3	0.01	0.3	0.06			0.2	0.06
TOTAL MONOENES	29.2	0.84	28.3	3.64			25.8	1.27
16:2n-4	0.2	0.01	0.2	0.07			0.3	0.05
18:2n-9	<0.1	-	<0.1	-			<0.1	-
18:2n-6	3.2	0.01	3.2	0.20			3.2	0.26
18:2n-4/3n-6	0.4	0.01	0.4	0.03			0.5	0.06
20:2n-6	0.4	0.00	0.4	0.03			0.4	0.03
TOTAL DIENES	4.4	0.03	4.4	0.31			4.4	0.27
16:3n-4	0.3	0.01	0.3	0.03			0.4	0.03
16:3n-3	0.1	0.01	0.1	0.03			0.1	0.01
18:3n-4	<0.1	-	<0.1	-			<0.1	-
18:3n-3	3.5	0.05	3.3	0.17			3.3	0.11
18:4n-3	1.7	0.07	1.6	0.12			2.0	0.26
20:3n-6	0.3	0.01	0.3	0.02			0.4	0.05
20:4n-6	5.2	0.19	5.6	0.74			6.0	0.42
20:3n-3	0.2	0.01	0.2	0.05			0.1	0.04
20:4n-3	1.1	0.01	1.0	0.04			1.1	0.06
20:5n-3	5.1	0.12	5.2	0.25			5.5	0.22
21:5n-3	0.1	0.08	0.1	0.09			<0.1	-
22:4n-6	0.6	0.02	0.6	0.03			0.6	0.05
22:5n-6	3.3	0.16	3.5	0.44			3.6	0.21
22:5n-3	1.6	0.00	1.6	0.14			1.5	0.14
22:6n-3	12.5	0.41	13.6	1.83			14.2	1.19
TOTAL PUFA	40.0	0.51	41.3	2.58			43.1	1.65

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.6. Weight percent fatty acid composition of fish collected from Lake Hartwell  
January, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD (n=10)	Mean	+ - SD	Mean	+ - SD (n=1)	Mean	+ - SD
14:0			4.2	0.22			4.4	
15:0			0.7	0.08			0.6	
16:0			16.5	0.54			16.3	
17:0			0.8	0.11			0.7	
18:0			3.3	0.34			3.0	
20:0			0.1	0.04			0.2	
TOTAL SATS.			25.7	0.47			25.3	
14:1			0.2	0.03			0.2	
16:1n-9			0.5	0.17			0.6	
16:1n-7			8.5	0.81			7.2	
16:1n-5			0.3	0.05			0.4	
17:1			0.7	0.07			0.7	
18:1n-9			13.5	2.82			17.6	
18:1n-7			3.6	0.16			3.4	
18:1n-5			0.2	0.03			0.2	
20:1n-11+13			<0.1	-			<0.1	
20:1n-9			1.3	0.14			2.0	
20:1n-7			<0.1	-			<0.1	
20:1n-5/NMID?			<0.1	-			<0.1	
22:1n-11+13			<0.1	-			<0.1	
22:1n-9			<0.1	-			<0.1	
24:1			0.2	0.09			0.4	
TOTAL MONOENES			29.2	2.78			32.7	
16:2n-4			0.4	0.10			0.3	
18:2n-9			<0.1	-			<0.1	
18:2n-6			3.2	0.31			3.0	
18:2n-4/3n-6			0.5	0.08			0.4	
20:2n-6			0.5	0.05			0.4	
TOTAL DIENES			4.7	0.51			4.3	
16:3n-4			0.4	0.05			0.4	
16:3n-3			0.1	0.04			0.1	
18:3n-4			<0.1	-			<0.1	
18:3n-3			3.6	0.58			3.3	
18:4n-3			2.0	0.25			2.2	
20:3n-6			0.3	0.07			0.2	
20:4n-6			4.7	0.38			4.0	
20:3n-3			0.2	0.04			0.2	
20:4n-3			1.1	0.11			1.1	
20:5n-3			6.0	0.70			5.9	
21:5n-3			0.3	0.04			0.3	
22:4n-6			0.5	0.04			0.5	
22:5n-6			3.5	0.40			2.8	
22:5n-3			1.8	0.18			1.6	
22:6n-3			13.0	0.77			12.8	
TOTAL PUFA			42.5	2.61			39.7	

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.7. Weight percent fatty acid composition of fish collected from Lake Hartwell April, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean (n=10)	+/- SD	Mean	+/- SD	Mean	+/- SD
14:0			3.9	0.37				
15:0			0.7	0.11				
16:0			16.4	0.35				
17:0			0.8	0.05				
18:0			3.8	0.32				
20:0			0.1	0.06				
TOTAL SATS.			25.7	0.36				
14:1			0.2	0.02				
16:1n-9			0.5	0.04				
16:1n-7			8.7	0.76				
16:1n-5			0.2	0.10				
17:1			0.7	0.09				
18:1n-9			12.1	1.43				
18:1n-7			3.8	0.12				
18:1n-5			0.1	0.06				
20:1n-11+13			<0.1	-				
20:1n-9			1.5	0.13				
20:1n-7			<0.1	-				
20:1n-5/NMID?			<0.1	-				
22:1n-11+13			<0.1	-				
22:1n-9			<0.1	-				
24:1			0.2	0.13				
TOTAL MONOENES			28.2	2.40				
16:2n-4			0.4	0.04				
18:2n-9			<0.1	-				
18:2n-6			2.9	0.28				
18:2n-4/3n-6			0.5	0.03				
20:2n-6			0.5	0.04				
TOTAL DIENES			4.5	0.35				
16:3n-4			0.4	0.04				
16:3n-3			0.1	0.05				
18:3n-4			<0.1	-				
18:3n-3			3.4	0.34				
18:4n-3			1.9	0.19				
20:3n-6			0.3	0.07				
20:4n-6			5.0	0.49				
20:3n-3			0.2	0.07				
20:4n-3			1.0	0.06				
20:5n-3			5.9	0.23				
21:5n-3			0.2	0.09				
22:4n-6			0.5	0.02				
22:5n-6			3.6	0.37				
22:5n-3			1.7	0.08				
22:6n-3			14.9	2.24				
TOTAL PUFA			43.7	2.34				

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.8. Weight percent fatty acid composition of fish collected from Lake Hartwell July, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean (n=12)	+ - SD	Mean	+ - SD	Mean	+ - SD
14:0			3.5	0.17				
15:0			0.7	0.06				
16:0			17.5	0.35				
17:0			0.9	0.09				
18:0			3.9	0.48				
20:0			0.2	0.18				
TOTAL SATS.			26.8	0.80				
14:1			0.2	0.02				
16:1n-9			0.5	0.05				
16:1n-7			6.9	0.53				
16:1n-5			0.2	0.13				
17:1			0.7	0.07				
18:1n-9			14.6	0.83				
18:1n-7			3.2	0.16				
18:1n-5			0.2	0.03				
20:1n-11+13			<0.1	-				
20:1n-9			1.3	0.12				
20:1n-7			<0.1	-				
20:1n-5/NMID?			<0.1	-				
22:1n-11+13			<0.1	-				
22:1n-9			<0.1	-				
24:1			0.1	0.08				
TOTAL MONOENES			28.0	1.61				
16:2n-4			0.3	0.02				
18:2n-9			<0.1	-				
18:2n-6			3.1	0.26				
18:2n-4/3n-6			0.4	0.03				
20:2n-6			0.5	0.04				
TOTAL DIENES			4.4	0.27				
16:3n-4			0.4	0.02				
16:3n-3			0.1	0.03				
18:3n-4			<0.1	-				
18:3n-3			3.4	0.48				
18:4n-3			1.6	0.16				
20:3n-6			0.3	0.03				
20:4n-6			5.1	0.42				
20:3n-3			0.3	0.04				
20:4n-3			1.0	0.06				
20:5n-3			4.7	0.20				
21:5n-3			0.1	0.08				
22:4n-6			0.6	0.04				
22:5n-6			3.5	0.26				
22:5n-3			1.8	0.13				
22:6n-3			14.7	0.98				
TOTAL PUFA			42.0	1.52				

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.9. Weight percent fatty acid composition of fish collected from Lake Thurmond November, 1988. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=2)	+/- SD	Mean (n=7)	+/- SD	Mean (n=1)	+/- SD	Mean	+/- SD
14:0	2.8	0.10	3.0	0.23	3.4			
15:0	0.6	0.03	0.6	0.04	0.7			
16:0	17.3	0.58	17.6	0.96	18.4			
17:0	0.8	0.03	0.7	0.09	0.9			
18:0	3.7	0.18	3.5	0.45	4.1			
20:0	0.2	0.01	0.2	0.03	0.2			
TOTAL SATS.	25.4	0.99	25.6	1.51	27.8			
14:1	0.2	0.00	0.2	0.07	0.2			
16:1n-9	0.7	0.01	0.8	0.13	0.7			
16:1n-7	5.7	0.07	6.2	0.54	5.9			
16:1n-5	0.3	0.01	0.3	0.03	0.4			
17:1	0.8	0.03	0.8	0.06	0.8			
18:1n-9	18.3	1.23	18.9	2.24	17.0			
18:1n-7	3.5	0.08	3.6	0.17	3.2			
18:1n-5	<0.1	-	<0.1	-	<0.1			
20:1n-11+13	0.1	0.00	0.1	0.06	0.1			
20:1n-9	1.8	0.24	1.7	0.24	1.5			
20:1n-7	0.1	0.02	0.1	0.05	<0.1			
20:1n-5/NMID?	<0.1	-	<0.1	-	<0.1			
22:1n-11+13	<0.1	-	<0.1	-	<0.1			
22:1n-9	0.1	0.01	0.1	0.01	0.1			
24:1	0.3	0.02	0.3	0.04	0.2			
TOTAL MONOENES	31.3	1.61	32.4	2.93	29.4			
16:2n-4	0.1	0.01	0.1	0.01	0.2			
18:2n-9	0.2	0.01	0.2	0.09	0.2			
18:2n-6	3.2	0.04	3.2	0.14	3.5			
18:2n-4/3n-6	0.3	0.00	0.3	0.01	0.3			
20:2n-6	0.5	0.03	0.5	0.05	0.5			
TOTAL DIENES	4.5	0.02	4.5	0.19	4.8			
16:3n-4	0.4	0.00	0.4	0.04	0.4			
16:3n-3	<0.1	-	<0.1	-	<0.1			
18:3n-4	<0.1	-	<0.1	-	<0.1			
18:3n-3	3.0	0.02	3.0	0.33	3.4			
18:4n-3	1.2	0.00	1.3	0.16	1.4			
20:3n-6	0.3	0.01	0.3	0.02	0.3			
20:4n-6	5.5	0.23	5.1	0.32	5.5			
20:3n-3	0.3	0.00	0.3	0.02	0.3			
20:4n-3	0.9	0.01	0.9	0.12	1.0			
20:5n-3	3.9	0.13	4.0	0.46	4.1			
21:5n-3	0.2	0.00	0.1	0.07	0.2			
22:4n-6	0.7	0.02	0.7	0.06	0.7			
22:5n-6	3.6	0.04	3.2	0.26	3.6			
22:5n-3	1.7	0.00	1.8	0.21	1.5			
22:6n-3	13.8	0.13	12.9	0.91	12.3			
TOTAL PUFA	40.6	0.48	38.6	2.78	40.1			

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.10. Weight percent fatty acid composition of fish collected from Lake Thurmond January, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=1)	+ - SD	Mean (n=7)	+ - SD	Mean (n=1)	+ - SD	Mean (n=8)	+ - SD
14:0	3.3		3.1	0.29	4.0		3.6	0.58
15:0	0.6		0.6	0.03	0.7		0.6	0.09
16:0	16.0		16.8	0.65	17.4		17.7	0.49
17:0	0.8		0.8	0.08	0.9		0.8	0.14
18:0	3.2		3.3	0.32	3.5		3.8	0.29
20:0	0.2		0.2	0.04	0.2		0.2	0.02
TOTAL SATS.	24.4		24.9	1.19	26.9		26.9	0.89
14:1	0.1		0.2	0.04	0.2		0.2	0.03
16:1n-9	0.7		0.7	0.06	0.5		0.5	0.06
16:1n-7	6.3		6.3	0.31	6.8		6.7	0.77
16:1n-5	0.3		0.3	0.01	0.3		0.3	0.02
17:1	1.0		0.7	0.31	0.9		0.6	0.25
18:1n-9	19.4		16.9	1.99	16.2		15.7	1.57
18:1n-7	3.8		3.7	0.16	3.2		3.3	0.23
18:1n-5	0.2		0.1	0.09	0.2		0.0	0.05
20:1n-11+13	0.1		0.1	0.05	0.1		0.1	0.04
20:1n-9	2.0		1.8	0.10	1.8		1.9	0.34
20:1n-7	0.1		0.1	0.03	0.1		0.1	0.01
20:1n-5/NMID?	<0.1		<0.1	-	<0.1		<0.1	-
22:1n-11+13	<0.1		<0.1	-	<0.1		<0.1	-
22:1n-9	0.1		0.1	0.04	0.2		0.1	0.02
24:1	0.3		0.3	0.02	0.2		0.3	0.06
TOTAL MONOENES	33.6		30.6	2.10	30.0		29.3	2.47
16:2n-4	<0.1		0.2	0.06	0.3		0.3	0.07
18:2n-9	0.0		0.1	0.09	0.0		0.1	0.06
18:2n-6	3.4		3.1	0.20	3.5		3.1	0.35
18:2n-4/3n-6	0.3		0.3	0.02	0.4		0.3	0.06
20:2n-6	0.6		0.5	0.04	0.5		0.5	0.02
TOTAL DIENES	4.7		4.5	0.25	5.0		4.5	0.47
16:3n-4	0.4		0.4	0.05	0.3		0.5	0.02
16:3n-3	<0.1		<0.1	-	<0.1		<0.1	-
18:3n-4	<0.1		<0.1	-	0.1		<0.1	-
18:3n-3	3.4		3.3	0.33	4.3		3.5	0.77
18:4n-3	1.5		1.5	0.34	2.3		1.9	0.59
20:3n-6	0.3		0.3	0.02	0.3		0.3	0.03
20:4n-6	4.7		5.2	0.36	4.4		5.0	0.59
20:3n-3	0.3		0.3	0.01	0.3		0.2	0.03
20:4n-3	1.0		1.0	0.07	1.1		1.0	0.17
20:5n-3	4.2		4.6	0.58	5.0		4.7	0.46
21:5n-3	0.2		0.2	0.04	0.3		0.2	0.08
22:4n-6	0.7		0.7	0.07	0.5		0.6	0.07
22:5n-6	3.4		3.5	0.13	3.3		3.5	0.26
22:5n-3	1.8		1.7	0.21	1.3		1.4	0.13
22:6n-3	12.1		14.2	1.27	11.2		13.4	1.64
TOTAL PUFA	39.6		42.0	1.53	40.2		41.3	1.64

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.11. Weight percent fatty acid composition of fish collected from Lake Thurmond April, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=3)	+ \- SD	Mean (n=6)	+ \- SD	Mean	+ \- SD	Mean (n=2)	+ \- SD
14:0	3.1	0.09	3.5	0.86			3.1	0.08
15:0	0.8	0.14	0.8	0.18			0.7	0.17
16:0	16.7	0.73	16.4	0.72			15.2	0.94
17:0	0.9	0.11	0.9	0.18			0.8	0.17
18:0	3.4	0.16	3.7	0.61			3.6	0.51
20:0	0.2	0.00	0.1	0.03			0.2	0.01
TOTAL SATS.	25.1	1.04	25.4	0.87			23.5	1.71
14:1	0.2	0.01	0.2	0.04			0.2	0.04
16:1n-9	0.7	0.03	0.6	0.13			0.7	0.10
16:1n-7	7.0	0.25	7.1	1.96			6.0	0.14
16:1n-5	0.3	0.04	0.3	0.02			0.4	0.00
17:1	0.9	0.05	0.8	0.12			0.8	0.04
18:1n-9	15.4	1.56	13.9	2.11			16.4	2.14
18:1n-7	3.9	0.03	3.7	0.33			3.6	0.10
18:1n-5	0.2	0.00	0.2	0.02			0.2	0.01
20:1n-11+13	<0.1	-	0.1	0.06			0.1	0.05
20:1n-9	1.9	0.21	1.7	0.27			2.0	0.14
20:1n-7	0.1	0.04	<0.1	-			<0.1	-
20:1n-5/NMID?	<0.1	-	<0.1	-			0.1	0.06
22:1n-11+13	<0.1	-	<0.1	-			<0.1	-
22:1n-9	0.1	0.06	0.1	0.06			0.1	0.04
24:1	0.3	0.02	0.2	0.05			0.3	0.02
TOTAL MONOENES	30.1	1.66	28.8	2.24			31.0	2.38
16:2n-4	0.2	0.03	0.3	0.16			0.2	0.05
18:2n-9	<0.1	-	<0.1	-			<0.1	-
18:2n-6	3.1	0.14	3.2	0.44			3.4	0.43
18:2n-4/3n-6	0.3	0.02	0.4	0.13			0.3	0.01
20:2n-6	0.6	0.02	0.6	0.05			0.6	0.01
TOTAL DIENES	4.3	0.10	4.6	0.70			4.6	0.33
16:3n-4	0.4	0.01	0.4	0.09			0.4	0.02
16:3n-3	0.2	0.03	0.2	0.08			0.2	0.04
18:3n-4	<0.1	-	<0.1	-			<0.1	-
18:3n-3	3.9	0.42	3.7	1.42			3.7	0.23
18:4n-3	1.5	0.08	1.7	0.73			1.3	0.07
20:3n-6	0.3	0.01	0.3	0.04			0.3	0.01
20:4n-6	5.1	0.07	5.4	1.17			5.4	0.26
20:3n-3	0.3	0.03	0.3	0.07			0.3	0.04
20:4n-3	0.9	0.01	0.9	0.26			0.9	0.09
20:5n-3	4.4	0.25	4.5	1.00			4.1	0.09
21:5n-3	0.1	0.04	0.2	0.13			0.2	0.03
22:4n-6	0.6	0.05	0.6	0.14			0.7	0.01
22:5n-6	3.5	0.13	3.7	0.44			3.6	0.08
22:5n-3	1.7	0.10	1.8	0.35			2.1	0.04
22:6n-3	14.5	0.28	14.8	2.79			15.0	0.36
TOTAL PUFA	42.4	0.57	43.2	1.61			42.7	0.55

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.12. Weight percent fatty acid composition of fish collected from Lake Thurmond July, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean (n=10)	+/- SD	Mean	+/- SD	Mean (n=4)	+/- SD
14:0			3.3	0.31			3.6	0.25
15:0			0.5	0.07			0.6	0.07
16:0			18.3	0.84			17.0	0.22
17:0			0.7	0.08			0.8	0.07
18:0			3.7	0.28			3.8	0.36
20:0			0.2	0.01			0.2	0.01
TOTAL SATS.			26.7	0.95			25.9	0.20
14:1			0.2	0.02			0.2	0.02
16:1n-9			0.6	0.09			0.5	0.03
16:1n-7			6.3	0.39			6.4	0.63
16:1n-5			0.3	0.03			0.3	0.03
17:1			0.7	0.05			0.7	0.10
18:1n-9			21.2	2.27			17.5	1.88
18:1n-7			3.3	0.16			3.2	0.17
18:1n-5			0.3	0.04			0.2	0.01
20:1n-11+13			<0.1	-			<0.1	-
20:1n-9			1.7	0.19			1.7	0.13
20:1n-7			<0.1	-			<0.1	-
20:1n-5/NMID?			<0.1	-			<0.1	-
22:1n-11+13			<0.1	-			<0.1	-
22:1n-9			<0.1	-			0.1	0.06
24:1			0.3	0.03			0.3	0.07
TOTAL MONOENES			35.0	2.47			31.3	1.89
16:2n-4			0.2	0.03			0.3	0.05
18:2n-9			<0.1	-			<0.1	-
18:2n-6			3.0	0.25			3.4	0.20
18:2n-4/3n-6			0.3	0.03			0.3	0.03
20:2n-6			0.5	0.05			0.5	0.03
TOTAL DIENES			4.0	0.38			4.5	0.31
16:3n-4			0.3	0.02			0.4	0.02
16:3n-3			0.1	0.03			0.1	0.03
18:3n-4			<0.1	-			<0.1	-
18:3n-3			3.2	0.36			3.8	0.38
18:4n-3			1.5	0.25			1.9	0.19
20:3n-6			0.2	0.03			0.2	0.02
20:4n-6			4.0	0.48			4.2	0.44
20:3n-3			0.3	0.02			0.2	0.03
20:4n-3			1.0	0.11			1.0	0.08
20:5n-3			4.4	0.37			5.1	0.34
21:5n-3			0.2	0.07			0.2	0.02
22:4n-6			0.5	0.04			0.4	0.03
22:5n-6			2.8	0.31			3.2	0.48
22:5n-3			1.6	0.07			1.5	0.15
22:6n-3			11.9	1.09			13.3	1.64
TOTAL PUFA			36.0	2.18			40.3	1.63

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.13. Weight percent fatty acid composition of fish collected from Lake Thurmond November, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean (n=4)	+ - SD	Mean (n=7)	+ - SD	Mean	+ - SD	Mean	+ - SD
14:0	2.5	0.26	2.1	0.53				
15:0	0.6	0.02	0.5	0.11				
16:0	19.0	0.57	18.0	1.02				
17:0	0.8	0.04	0.8	0.08				
18:0	4.5	0.63	5.3	0.92				
20:0	0.2	0.01	0.2	0.04				
TOTAL SATS.	27.7	0.70	26.9	1.50				
14:1	0.2	0.04	0.1	0.06				
16:1n-9	0.6	0.07	0.5	0.10				
16:1n-7	4.8	0.92	3.6	1.38				
16:1n-5	0.3	0.08	0.3	0.08				
17:1	0.7	0.09	0.6	0.14				
18:1n-9	16.2	2.76	13.3	3.50				
18:1n-7	3.1	0.21	3.0	0.42				
18:1n-5	0.1	0.05	0.1	0.09				
20:1n-11+13	<0.1	-	<0.1	-				
20:1n-9	1.2	0.14	1.2	0.34				
20:1n-7	<0.1	-	0.1	0.12				
20:1n-5/NMID?	<0.1	-	<0.1	-				
22:1n-11+13	<0.1	-	<0.1	-				
22:1n-9	<0.1	-	<0.1	-				
24:1	0.2	0.06	0.3	0.07				
TOTAL MONOENES	27.6	4.18	23.2	5.87				
16:2n-4	0.1	0.04	0.1	0.07				
18:2n-9	<0.1	-	<0.1	-				
18:2n-6	2.8	0.24	2.8	0.46				
18:2n-4/3n-6	0.2	0.03	0.2	0.10				
20:2n-6	0.4	0.03	0.5	0.08				
TOTAL DIENES	3.6	0.30	3.6	0.67				
16:3n-4	0.3	0.02	0.3	0.04				
16:3n-3	0.1	0.02	<0.1	-				
18:3n-4	<0.1	-	<0.1	-				
18:3n-3	2.9	0.35	2.4	0.51				
18:4n-3	1.0	0.12	0.8	0.23				
20:3n-6	0.3	0.01	0.3	0.11				
20:4n-6	5.9	0.87	7.2	1.29				
20:3n-3	0.2	0.01	0.2	0.02				
20:4n-3	0.8	0.04	0.7	0.14				
20:5n-3	4.2	0.20	4.4	0.46				
21:5n-3	0.0	0.06	0.0	0.03				
22:4n-6	0.7	0.03	0.7	0.09				
22:5n-6	4.2	0.51	4.7	0.66				
22:5n-3	1.7	0.02	1.7	0.21				
22:6n-3	16.0	2.64	19.7	3.66				
TOTAL PUFA	42.0	3.68	47.0	4.69				

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.14. Weight percent fatty acid composition of fish collected from Lake Thurmond January, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean (n=13)	+ - SD	Mean	+ - SD	Mean	+ - SD
14:0			3.0	0.16				
15:0			0.6	0.17				
16:0			17.2	0.93				
17:0			0.8	0.11				
18:0			3.6	0.36				
20:0			0.2	0.03				
TOTAL SATS.			25.4	1.53				
14:1			0.2	0.02				
16:1n-9			0.6	0.07				
16:1n-7			5.9	0.36				
16:1n-5			0.3	0.03				
17:1			0.8	0.06				
18:1n-9			16.5	2.68				
18:1n-7			3.4	0.17				
18:1n-5			0.2	0.02				
20:1n-11+13			<0.1	-				
20:1n-9			1.6	0.15				
20:1n-7			<0.1	-				
20:1n-5/NMID?			<0.1	-				
22:1n-11+13			<0.1	-				
22:1n-9			<0.1	-				
24:1			0.3	0.03				
TOTAL MONOENES			29.9	3.19				
16:2n-4			0.2	0.03				
18:2n-9			<0.1	-				
18:2n-6			3.0	0.15				
18:2n-4/3n-6			0.3	0.03				
20:2n-6			0.5	0.02				
TOTAL DIENES			4.1	0.21				
16:3n-4			0.3	0.02				
16:3n-3			0.1	0.02				
18:3n-4			<0.1	-				
18:3n-3			3.6	0.30				
18:4n-3			1.6	0.25				
20:3n-6			0.3	0.02				
20:4n-6			4.8	0.48				
20:3n-3			0.3	0.02				
20:4n-3			0.9	0.09				
20:5n-3			4.9	0.21				
21:5n-3			0.2	0.05				
22:4n-6			0.6	0.04				
22:5n-6			3.7	0.33				
22:5n-3			1.7	0.14				
22:6n-3			15.1	1.15				
TOTAL PUFA			42.2	1.90				

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.15. Weight percent fatty acid composition of fish collected from Lake Thurmond April, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean (n=10)	+ - SD	Mean	+ - SD	Mean (n=4)	+ - SD
14:0			3.1	0.29			3.8	0.44
15:0			0.6	0.11			0.8	0.05
16:0			16.9	0.60			16.2	0.44
17:0			0.7	0.23			0.9	0.05
18:0			3.8	0.39			3.7	0.40
20:0			0.1	0.06			0.2	0.01
TOTAL SATS.			25.3	0.83			25.5	0.41
14:1			0.2	0.03			0.2	0.03
16:1n-9			0.5	0.11			0.4	0.06
16:1n-7			5.8	0.42			5.9	0.93
16:1n-5			0.3	0.06			0.3	0.01
17:1			0.7	0.08			0.8	0.06
18:1n-9			15.2	1.29			15.0	1.69
18:1n-7			3.5	0.26			3.2	0.24
18:1n-5			0.2	0.05			0.2	0.01
20:1n-11+13			<0.1	-			<0.1	-
20:1n-9			1.8	0.18			1.7	0.09
20:1n-7			<0.1	-			<0.1	-
20:1n-5/NMID?			<0.1	-			<0.1	-
22:1n-11+13			<0.1	-			<0.1	-
22:1n-9			<0.1	-			<0.1	-
24:1			0.2	0.09			0.2	0.01
TOTAL MONOENES			28.6	1.91			28.3	3.10
16:2n-4			0.2	0.04			0.2	0.04
18:2n-9			<0.1	-			<0.1	-
18:2n-6			3.0	0.19			3.5	0.33
18:2n-4/3n-6			0.3	0.03			0.4	0.03
20:2n-6			0.5	0.05			0.6	0.01
TOTAL DIENES			4.2	0.26			4.8	0.42
16:3n-4			0.3	0.02			0.4	0.03
16:3n-3			0.1	0.04			0.2	0.01
18:3n-4			<0.1	-			<0.1	-
18:3n-3			4.0	0.56			4.9	0.41
18:4n-3			2.2	0.40			2.8	0.33
20:3n-6			0.2	0.02			0.3	0.01
20:4n-6			4.6	0.36			4.4	0.52
20:3n-3			0.3	0.06			0.3	0.02
20:4n-3			0.9	0.08			1.1	0.11
20:5n-3			5.1	0.31			5.0	0.18
21:5n-3			<0.1	-			<0.1	-
22:4n-6			0.5	0.08			0.5	0.02
22:5n-6			3.6	0.31			3.7	0.46
22:5n-3			1.6	0.23			1.4	0.04
22:6n-3			16.0	2.07			14.0	2.60
TOTAL PUFA			43.7	1.86			43.7	2.54

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.16. Weight percent fatty acid composition of fish collected from Lake Thurmond July, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean (n=9)	+/- SD	Mean	+/- SD	Mean (n=1)	+/- SD
14:0			3.0	0.41			3.1	
15:0			0.5	0.06			0.7	
16:0			18.1	0.66			17.5	
17:0			0.7	0.08			0.9	
18:0			4.6	1.17			4.7	
20:0			0.1	0.05			0.2	
TOTAL SATS.			27.1	1.20			27.0	
14:1			0.1	0.06			0.1	
16:1n-9			0.6	0.13			0.5	
16:1n-7			5.3	1.19			5.7	
16:1n-5			0.3	0.04			0.4	
17:1			<0.1	-			<0.1	
18:1n-9			15.1	4.43			15.2	
18:1n-7			3.1	0.35			3.1	
18:1n-5			0.2	0.10			0.2	
20:1n-11+13			<0.1	-			<0.1	
20:1n-9			1.3	0.37			1.4	
20:1n-7			<0.1	-			<0.1	
20:1n-5/NMID?			<0.1	-			<0.1	
22:1n-11+13			<0.1	-			<0.1	
22:1n-9			<0.1	-			<0.1	
24:1			0.3	0.04			0.2	
TOTAL MONOENES			26.5	6.44			27.0	
16:2n-4			0.1	0.03			0.2	
18:2n-9			<0.1	-			<0.1	
18:2n-6			3.0	0.34			3.0	
18:2n-4/3n-6			0.3	0.05			0.4	
20:2n-6			0.5	0.03			0.4	
TOTAL DIENES			4.1	0.41			4.3	
16:3n-4			0.3	0.03			0.3	
16:3n-3			0.1	0.04			0.1	
18:3n-4			<0.1	-			<0.1	
18:3n-3			2.8	0.58			3.6	
18:4n-3			1.6	0.30			2.0	
20:3n-6			0.3	0.04			0.3	
20:4n-6			5.4	1.07			5.4	
20:3n-3			0.2	0.07			0.2	
20:4n-3			0.9	0.14			1.0	
20:5n-3			4.5	0.17			4.7	
21:5n-3			0.1	0.09			0.2	
22:4n-6			0.5	0.05			0.5	
22:5n-6			3.6	0.57			3.6	
22:5n-3			1.6	0.11			1.4	
22:6n-3			16.8	3.89			14.7	
TOTAL PUFA			42.8	5.02			42.3	

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.17. Weight percent fatty acid composition of fish collected from Lake Murray November, 1988. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=8)	+ - SD	Mean (n=2)	+ - SD
14:0					3.9	0.35	3.4	0.61
15:0					0.9	0.10	0.9	0.21
16:0					17.0	0.36	17.4	0.29
17:0					1.3	0.19	1.2	0.30
18:0					3.8	0.18	4.1	0.41
20:0					0.2	0.01	0.2	0.02
TOTAL SATS.					27.2	0.76	27.4	0.49
14:1					0.2	0.01	0.2	0.02
16:1n-9					0.5	0.06	0.6	0.08
16:1n-7					6.2	0.39	6.0	0.10
16:1n-5					0.4	0.01	0.4	0.02
17:1					<0.1	-	<0.1	-
18:1n-9					12.8	1.59	13.2	1.43
18:1n-7					3.1	0.06	3.2	0.15
18:1n-5					0.2	0.01	0.2	0.01
20:1n-11+13					0.2	0.02	0.3	0.09
20:1n-9					1.2	0.25	1.1	0.20
20:1n-7					0.1	0.04	0.1	0.01
20:1n-5/NMID?					<0.1	-	<0.1	-
22:1n-11+13					<0.1	-	<0.1	-
22:1n-9					0.1	0.05	0.1	0.00
24:1					0.2	0.02	0.2	0.01
TOTAL MONOENES					25.1	2.22	25.6	2.18
16:2n-4					0.3	0.05	0.2	0.02
18:2n-9					<0.1	-	<0.1	-
18:2n-6					4.3	0.24	4.4	0.47
18:2n-4/3n-6					0.5	0.06	0.4	0.10
20:2n-6					0.6	0.02	0.6	0.02
TOTAL DIENES					5.9	0.38	5.9	0.58
16:3n-4					0.3	0.07	0.4	0.01
16:3n-3					0.2	0.05	0.2	0.05
18:3n-4					<0.1	-	<0.1	-
18:3n-3					5.9	0.81	4.8	1.50
18:4n-3					2.2	0.34	1.5	0.58
20:3n-6					<0.1	-	<0.1	-
20:4n-6					4.8	0.43	5.3	0.62
20:3n-3					<0.1	-	<0.1	-
20:4n-3					1.2	0.10	1.0	0.31
20:5n-3					5.0	0.39	3.8	0.82
21:5n-3					0.3	0.03	0.2	0.05
22:4n-6					0.6	0.04	0.7	0.13
22:5n-6					3.2	0.15	3.4	0.26
22:5n-3					1.8	0.06	2.3	0.45
22:6n-3					11.1	1.05	11.7	1.13
TOTAL PUFA					42.4	1.23	41.1	0.74

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.18. Weight percent fatty acid composition of fish collected from Lake Murray January, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean	+ - SD	Mean (n=1)	+ - SD
14:0							4.2	
15:0							0.8	
16:0							16.8	
17:0							1.0	
18:0							3.1	
20:0							0.2	
TOTAL SATS.							26.0	
14:1							0.2	
16:1n-9							0.5	
16:1n-7							7.4	
16:1n-5							0.4	
17:1							0.9	
18:1n-9							15.1	
18:1n-7							3.2	
18:1n-5							0.2	
20:1n-11+13							0.2	
20:1n-9							1.8	
20:1n-7							0.1	
20:1n-5/NMID?							<0.1	
22:1n-11+13							<0.1	
22:1n-9							0.1	
24:1							0.2	
TOTAL MONOENES							29.4	
16:2n-4							0.3	
18:2n-9							<0.1	
18:2n-6							4.0	
18:2n-4/3n-6							0.4	
20:2n-6							0.6	
TOTAL DIENES							5.6	
16:3n-4							0.4	
16:3n-3							<0.1	
18:3n-4							<0.1	
18:3n-3							5.3	
18:4n-3							2.3	
20:3n-6							0.4	
20:4n-6							4.4	
20:3n-3							0.3	
20:4n-3							1.2	
20:5n-3							4.7	
21:5n-3							0.2	
22:4n-6							0.5	
22:5n-6							3.1	
22:5n-3							1.6	
22:6n-3							10.3	
TOTAL PUFA							40.4	

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.19. Weight percent fatty acid composition of fish collected from Lake Murray April, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=5)	+ - SD	Mean (n=7)	+ - SD
14:0					4.1	0.09	4.1	0.28
15:0					0.8	0.02	0.8	0.05
16:0					16.6	0.26	16.8	0.31
17:0					1.0	0.03	1.0	0.06
18:0					3.5	0.05	3.4	0.27
20:0					0.2	0.00	0.2	0.01
TOTAL SATS.					26.3	0.24	26.5	0.43
14:1					0.2	0.01	0.2	0.01
16:1n-9					0.5	0.03	0.5	0.10
16:1n-7					6.9	0.28	7.5	0.75
16:1n-5					0.3	0.00	0.3	0.02
17:1					0.8	0.02	0.9	0.05
18:1n-9					15.2	0.49	16.3	0.67
18:1n-7					3.4	0.07	3.6	0.39
18:1n-5					0.2	0.00	0.2	0.03
20:1n-11+13					0.2	0.03	0.2	0.08
20:1n-9					1.8	0.10	1.9	0.15
20:1n-7					0.1	0.04	0.1	0.07
20:1n-5/NMID?					<0.1	-	<0.1	-
22:1n-11+13					<0.1	-	<0.1	-
22:1n-9					0.1	0.03	0.1	0.07
24:1					0.2	0.01	0.2	0.01
TOTAL MONOENES					30.0	0.93	31.9	2.02
16:2n-4					0.3	0.02	0.3	0.07
18:2n-9					<0.1	-	<0.1	-
18:2n-6					3.8	0.10	3.8	0.17
18:2n-4/3n-6					0.4	0.01	0.4	0.03
20:2n-6					0.6	0.03	0.5	0.04
TOTAL DIENES					5.3	0.14	5.3	0.28
16:3n-4					0.4	0.02	0.5	0.08
16:3n-3					0.2	0.01	0.2	0.03
18:3n-4					0.0	0.00	0.0	0.00
18:3n-3					5.4	0.22	5.2	0.55
18:4n-3					2.2	0.10	2.1	0.30
20:3n-6					0.4	0.01	0.4	0.01
20:4n-6					4.3	0.13	4.0	0.44
20:3n-3					0.4	0.02	0.3	0.02
20:4n-3					1.2	0.03	1.1	0.11
20:5n-3					5.0	0.26	4.8	0.38
21:5n-3					0.3	0.03	0.2	0.02
22:4n-6					0.5	0.02	0.5	0.04
22:5n-6					2.9	0.06	2.7	0.36
22:5n-3					1.7	0.04	1.6	0.14
22:6n-3					10.6	0.44	9.6	1.79
TOTAL PUFA					40.7	0.65	38.6	2.04

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.20. Weight percent fatty acid composition of fish collected from Lake Murray July, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean	+/- SD	Mean	+/- SD	Mean (n=3)	+/- SD
14:0							3.8	0.18
15:0							0.8	0.11
16:0							17.3	0.12
17:0							1.1	0.15
18:0							4.4	0.81
20:0							0.2	0.03
TOTAL SATS.							27.7	1.13
14:1							0.2	0.02
16:1n-9							0.5	0.03
16:1n-7							6.2	1.01
16:1n-5							0.3	0.06
17:1							0.8	0.00
18:1n-9							15.2	2.42
18:1n-7							3.2	0.21
18:1n-5							0.2	0.01
20:1n-11+13							0.2	0.04
20:1n-9							1.6	0.16
20:1n-7							0.1	0.03
20:1n-5/NMID?							<0.1	-
22:1n-11+13							<0.1	-
22:1n-9							<0.1	-
24:1							0.2	0.05
TOTAL MONOENES							28.7	3.87
16:2n-4							0.3	0.03
18:2n-9							<0.1	-
18:2n-6							3.4	0.07
18:2n-4/3n-6							0.4	0.01
20:2n-6							0.5	0.06
TOTAL DIENES							4.8	0.09
16:3n-4							0.5	0.05
16:3n-3							0.3	0.03
18:3n-4							<0.1	-
18:3n-3							4.9	0.25
18:4n-3							1.7	0.29
20:3n-6							0.4	0.06
20:4n-6							4.5	0.70
20:3n-3							0.4	0.02
20:4n-3							1.0	0.04
20:5n-3							4.6	0.42
21:5n-3							0.2	0.07
22:4n-6							0.5	0.11
22:5n-6							3.1	0.48
22:5n-3							1.9	0.20
22:6n-3							11.7	1.67
TOTAL PUFA							40.5	2.27

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.21. Weight percent fatty acid composition of fish collected from Lake Murray November, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean	+/- SD	Mean (n=4)	+/- SD	Mean (n=16)	+/- SD
14:0					4.2	0.14	4.1	0.31
15:0					0.8	0.02	0.8	0.07
16:0					16.8	0.29	16.9	0.61
17:0					1.0	0.21	1.1	0.13
18:0					3.7	0.17	3.9	0.43
20:0					0.2	0.01	0.2	0.02
TOTAL SATS.					26.7	0.44	27.0	0.69
14:1					0.2	0.01	0.2	0.04
16:1n-9					0.1	0.14	0.1	0.11
16:1n-7					5.8	1.31	6.0	0.76
16:1n-5					0.2	0.08	0.2	0.17
17:1					0.8	0.04	0.8	0.09
18:1n-9					14.0	0.66	12.7	1.92
18:1n-7					2.9	0.63	3.1	0.15
18:1n-5					0.2	0.01	0.2	0.02
20:1n-11+13					0.2	0.01	0.2	0.10
20:1n-9					1.4	0.09	1.2	0.34
20:1n-7					0.1	0.03	0.1	0.05
20:1n-5/NMID?					<0.1	-	<0.1	-
22:1n-11+13					<0.1	-	0.1	0.05
22:1n-9					<0.1	-	<0.1	-
24:1					0.2	0.04	0.2	0.04
TOTAL MONOENES					26.6	2.50	25.5	3.31
16:2n-4					0.3	0.02	0.3	0.03
18:2n-9					<0.1	-	<0.1	-
18:2n-6					4.1	0.11	4.1	0.20
18:2n-4/3n-6					0.5	0.01	0.4	0.05
20:2n-6					0.5	0.01	0.5	0.07
TOTAL DIENES					5.6	0.13	5.6	0.22
16:3n-4					0.4	0.03	0.4	0.03
16:3n-3					0.3	0.19	0.2	0.05
18:3n-4					<0.1	-	<0.1	-
18:3n-3					5.9	0.18	5.8	0.97
18:4n-3					2.3	0.19	2.3	0.45
20:3n-6					0.4	0.01	0.4	0.02
20:4n-6					4.6	0.15	5.0	0.51
20:3n-3					0.4	0.00	0.4	0.05
20:4n-3					1.3	0.04	1.2	0.14
20:5n-3					4.8	0.15	4.8	0.58
21:5n-3					0.2	0.05	0.2	0.05
22:4n-6					0.6	0.01	0.6	0.08
22:5n-6					3.0	0.12	3.4	0.51
22:5n-3					1.8	0.04	1.9	0.14
22:6n-3					10.7	0.60	11.8	1.37
TOTAL PUFA					42.3	1.10	44.0	2.86

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.22. Weight percent fatty acid composition of fish collected from Lake Murray January, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean	+/- SD	Mean (n=4)	+/- SD	Mean (n=7)	+/- SD
14:0					4.2	0.11	4.0	0.17
15:0					0.8	0.03	0.7	0.07
16:0					17.1	0.42	17.4	0.23
17:0					1.1	0.04	1.0	0.06
18:0					3.5	0.06	3.6	0.21
20:0					0.2	0.01	0.2	0.01
TOTAL SATS.					26.9	0.43	27.0	0.24
14:1					0.2	0.01	0.2	0.01
16:1n-9					0.5	0.03	0.5	0.04
16:1n-7					6.9	0.09	7.0	0.07
16:1n-5					0.3	0.07	0.3	0.07
17:1					0.8	0.01	0.5	0.38
18:1n-9					14.5	0.40	14.7	0.34
18:1n-7					3.2	0.06	3.2	0.10
18:1n-5					0.2	0.01	0.2	0.01
20:1n-11+13					0.2	0.01	0.2	0.02
20:1n-9					1.5	0.03	1.6	0.17
20:1n-7					0.1	0.02	<0.1	-
20:1n-5/NMID?					<0.1	-	<0.1	-
22:1n-11+13					0.1	0.06	<0.1	-
22:1n-9					<0.1	-	<0.1	-
24:1					0.2	0.01	0.1	0.09
TOTAL MONOENES					28.8	0.33	28.7	1.03
16:2n-4					0.3	0.00	0.3	0.01
18:2n-9					<0.1	-	<0.1	-
18:2n-6					3.9	0.09	3.7	0.25
18:2n-4/3n-6					0.4	0.01	0.4	0.04
20:2n-6					0.5	0.03	0.5	0.02
TOTAL DIENES					5.3	0.13	5.2	0.32
16:3n-4					0.4	0.01	0.4	0.03
16:3n-3					0.2	0.03	0.2	0.03
18:3n-4					<0.1	-	<0.1	-
18:3n-3					6.0	0.34	5.6	0.57
18:4n-3					2.5	0.14	2.3	0.17
20:3n-6					0.3	0.01	0.3	0.01
20:4n-6					4.2	0.05	4.4	0.14
20:3n-3					0.4	0.02	0.4	0.03
20:4n-3					1.3	0.02	1.2	0.06
20:5n-3					5.1	0.06	5.1	0.24
21:5n-3					0.1	0.13	0.2	0.09
22:4n-6					0.5	0.01	0.5	0.03
22:5n-6					2.9	0.05	3.1	0.20
22:5n-3					1.6	0.08	1.6	0.09
22:6n-3					10.4	0.33	10.8	0.78
TOTAL PUFA					41.2	0.50	41.1	0.68

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.23. Weight percent fatty acid composition of fish collected from Lake Murray April, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=4)	+ - SD	Mean (n=12)	+ - SD
14:0							3.9	0.34
15:0							0.7	0.09
16:0							16.8	0.83
17:0							1.0	0.12
18:0							3.5	0.20
20:0							0.2	0.03
TOTAL SATS.							26.2	0.57
14:1							0.2	0.02
16:1n-9							0.5	0.04
16:1n-7							7.1	0.39
16:1n-5							0.2	0.13
17:1							0.8	0.05
18:1n-9							15.7	0.95
18:1n-7							3.4	0.08
18:1n-5							0.2	0.03
20:1n-11+13							0.1	0.06
20:1n-9							1.8	0.28
20:1n-7							<0.1	-
20:1n-5/NMID?							<0.1	-
22:1n-11+13							<0.1	-
22:1n-9							<0.1	-
24:1							<0.1	-
TOTAL MONOENES							30.2	1.50
16:2n-4							0.3	0.02
18:2n-9							<0.1	-
18:2n-6							3.6	0.42
18:2n-4/3n-6							0.4	0.05
20:2n-6							0.5	0.04
TOTAL DIENES							4.9	0.54
16:3n-4							0.4	0.02
16:3n-3							0.2	0.06
18:3n-4							<0.1	-
18:3n-3							5.9	1.00
18:4n-3							2.4	0.41
20:3n-6							0.3	0.04
20:4n-6							4.1	0.27
20:3n-3							0.4	0.06
20:4n-3							1.1	0.13
20:5n-3							4.9	0.22
21:5n-3							0.1	0.12
22:4n-6							0.4	0.03
22:5n-6							3.0	0.23
22:5n-3							1.6	0.13
22:6n-3							10.9	1.34
TOTAL PUFA							40.7	1.55

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.24. Weight percent fatty acid composition of fish collected from Lake Waterec November, 1988. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=2)	+ - SD	Mean	+ - SD
14:0					4.8	0.19		
15:0					0.8	0.03		
16:0					16.3	0.20		
17:0					1.3	0.01		
18:0					2.9	0.12		
20:0					0.1	0.05		
TOTAL SATS.					26.3	0.17		
14:1					0.2	0.01		
16:1n-9					0.4	0.06		
16:1n-7					10.9	0.05		
16:1n-5					0.4	0.00		
17:1					0.8	0.10		
18:1n-9					13.5	0.05		
18:1n-7					4.2	0.02		
18:1n-5					0.2	0.01		
20:1n-11+13					0.1	0.07		
20:1n-9					1.5	0.08		
20:1n-7					0.1	0.06		
20:1n-5/NMID?					<0.1	-		
22:1n-11+13					<0.1	-		
22:1n-9					0.1	0.07		
24:1					0.1	0.00		
TOTAL MONOENES					31.8	0.24		
16:2n-4					0.8	0.01		
18:2n-9					<0.1	-		
18:2n-6					3.3	0.05		
18:2n-4/3n-6					0.7	0.01		
20:2n-6					0.4	0.01		
TOTAL DIENES					5.4	0.04		
16:3n-4					0.9	0.03		
16:3n-3					0.4	0.00		
18:3n-4					0.2	0.01		
18:3n-3					7.2	0.27		
18:4n-3					2.5	0.07		
20:3n-6					<0.1	-		
20:4n-6					2.6	0.05		
20:3n-3					<0.1	-		
20:4n-3					1.2	0.04		
20:5n-3					5.3	0.22		
21:5n-3					0.3	0.00		
22:4n-6					0.3	0.01		
22:5n-6					1.8	0.01		
22:5n-3					1.7	0.02		
22:6n-3					6.7	0.26		
TOTAL PUFA					31.3	0.75		

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.25. Weight percent fatty acid composition of fish collected from Lake Waterec  
January, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ \- SD	Mean	+ \- SD	Mean	+ \- SD	Mean (n=4)	+ \- SD
14:0							4.6	0.49
15:0							0.8	0.07
16:0							17.2	0.65
17:0							1.1	0.20
18:0							3.0	0.33
20:0							0.1	0.03
TOTAL SATS.							26.9	0.59
14:1							0.2	0.02
16:1n-9							0.5	0.10
16:1n-7							10.8	0.77
16:1n-5							0.4	0.02
17:1							0.9	0.00
18:1n-9							14.5	1.23
18:1n-7							4.3	0.10
18:1n-5							0.2	0.01
20:1n-11+13							0.1	0.03
20:1n-9							1.8	0.17
20:1n-7							0.2	0.02
20:1n-5/NMID?							<0.1	-
22:1n-11+13							<0.1	-
22:1n-9							0.1	0.00
24:1							0.2	0.04
TOTAL MONOENES							33.6	0.93
16:2n-4							0.8	0.12
18:2n-9							0.1	0.09
18:2n-6							3.0	0.23
18:2n-4/3n-6							0.6	0.06
20:2n-6							0.4	0.02
TOTAL DIENES							5.3	0.51
16:3n-4							0.8	0.07
16:3n-3							<0.1	-
18:3n-4							0.2	0.07
18:3n-3							6.4	1.24
18:4n-3							2.2	0.42
20:3n-6							0.4	0.01
20:4n-6							2.9	0.73
20:3n-3							0.3	0.03
20:4n-3							1.0	0.18
20:5n-3							4.9	0.36
21:5n-3							0.3	0.02
22:4n-6							0.3	0.07
22:5n-6							1.8	0.27
22:5n-3							1.7	0.28
22:6n-3							6.8	1.25
TOTAL PUFA							36.2	0.73

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.26. Weight percent fatty acid composition of fish collected from Lake Wateree April, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ \- SD	Mean	+ \- SD	Mean	+ \- SD	Mean (n=5)	+ \- SD
14:0							4.7	0.21
15:0							0.8	0.02
16:0							16.9	0.41
17:0+?							1.2	0.04
18:0							3.0	0.17
20:0							0.1	0.03
TOTAL SATS.							26.6	0.56
14:1							0.2	0.01
16:1n-9							0.5	0.04
16:1n-7							11.5	0.29
16:1n-5							0.4	0.02
17:1							0.9	0.10
18:1n-9							15.2	0.93
18:1n-7							4.6	0.14
18:1n-5							0.2	0.01
20:1n-11+13							0.2	0.05
20:1n-9							2.0	0.21
20:1n-7							0.2	0.04
20:1n-5/NMID?							<0.1	-
22:1n-11+13							<0.1	-
22:1n-9							<0.1	-
24:1							0.0	0.03
TOTAL MONOENES							35.0	1.02
16:2n-4							0.8	0.05
18:2n-9							0.2	0.01
18:2n-6							3.2	0.18
18:2n-4/3n-6							0.7	0.01
20:2n-6							0.4	0.02
TOTAL DIENES							5.4	0.25
16:3n-4							0.8	0.03
16:3n-3							0.4	0.02
18:3n-4							0.2	0.00
18:3n-3							6.6	0.16
18:4n-3							2.2	0.05
20:3n-6							0.4	0.02
20:4n-6							2.4	0.15
20:3n-3							0.3	0.01
20:4n-3							1.1	0.03
20:5n-3							4.7	0.16
21:5n-3							0.3	0.01
22:4n-6							0.3	0.02
22:5n-6							1.7	0.08
22:5n-3							1.6	0.08
22:6n-3							6.0	0.28
TOTAL PUFA							35.2	0.65

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.27. Weight percent fatty acid composition of fish collected from Lake Wateree  
 July, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=2)	+ - SD	Mean (n=8)	+ - SD
14:0					5.0	0.09	4.2	0.90
15:0					0.8	0.00	0.7	0.10
16:0					15.7	0.03	16.5	1.06
17:0					1.2	0.02	1.1	0.13
18:0					3.3	0.18	4.0	0.85
20:0					0.2	0.02	0.2	0.04
TOTAL SATS.					26.2	0.11	26.7	0.69
14:1					0.2	0.01	0.2	0.03
16:1n-9					0.5	0.03	0.5	0.03
16:1n-7					11.3	0.27	9.5	1.83
16:1n-5					0.4	0.00	0.4	0.03
17:1					1.0	0.01	0.8	0.11
18:1n-9					16.6	0.36	15.2	0.95
18:1n-7					4.7	0.05	4.2	0.42
18:1n-5					0.2	0.00	0.2	0.03
20:1n-11+13					0.3	0.04	0.2	0.09
20:1n-9					2.5	0.04	2.1	0.31
20:1n-7					0.2	0.08	0.2	0.07
20:1n-5/NMID?					<0.1	-	<0.1	-
22:1n-11+13					<0.1	-	<0.1	-
22:1n-9					0.2	0.00	0.1	0.12
24:1					0.2	0.06	0.2	0.06
TOTAL MONOENES					38.2	0.25	33.9	3.25
16:2n-4					0.7	0.04	0.6	0.14
18:2n-9					0.2	0.01	0.1	0.06
18:2n-6					3.3	0.03	2.9	0.51
18:2n-4/3n-6					0.6	0.02	0.6	0.10
20:2n-6					0.5	0.00	0.4	0.07
TOTAL DIENES					5.6	0.10	4.8	0.87
16:3n-4					0.8	0.03	0.7	0.09
16:3n-3					0.5	0.03	0.4	0.10
18:3n-4					0.2	0.02	0.2	0.05
18:3n-3					5.6	0.35	4.9	1.29
18:4n-3					1.7	0.11	1.5	0.43
20:3n-6					0.5	0.00	0.4	0.06
20:4n-6					3.0	0.17	4.0	0.99
20:3n-3					0.3	0.00	0.3	0.05
20:4n-3					1.0	0.05	0.9	0.18
20:5n-3					3.7	0.06	4.4	0.64
21:5n-3					0.3	0.02	0.2	0.10
22:4n-6					0.4	0.01	0.4	0.05
22:5n-6					1.9	0.04	2.4	0.51
22:5n-3					1.6	0.00	1.8	0.12
22:6n-3					4.9	0.07	8.3	3.33
TOTAL PUFA					31.7	0.46	35.5	2.83

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.28. Weight percent fatty acid composition of fish collected from Lake Wateree November, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean	+ - SD	Mean (n=7)	+ - SD
14:0							4.4	0.40
15:0							0.8	0.09
16:0							16.4	0.47
17:0							1.2	0.19
18:0							3.5	0.56
20:0							0.2	0.02
TOTAL SATS.							26.5	0.64
14:1							0.2	0.03
16:1n-9							0.5	0.09
16:1n-7							9.3	0.88
16:1n-5							0.1	0.17
17:1							0.9	0.11
18:1n-9							14.5	1.75
18:1n-7							4.1	0.26
18:1n-5							0.2	0.01
20:1n-11+13							0.2	0.05
20:1n-9							1.9	0.76
20:1n-7							0.2	0.04
20:1n-5/NMID?							<0.1	-
22:1n-11+13							0.1	0.10
22:1n-9							0.1	0.13
24:1							0.2	0.09
TOTAL MONOENES							32.6	3.06
16:2n-4							0.7	0.13
18:2n-9							0.2	0.03
18:2n-6							3.0	0.18
18:2n-4/3n-6							0.6	0.08
20:2n-6							0.4	0.06
TOTAL DIENES							5.1	0.37
16:3n-4							0.7	0.08
16:3n-3							0.4	0.04
18:3n-4							0.2	0.07
18:3n-3							5.5	1.19
18:4n-3							1.6	0.40
20:3n-6							0.4	0.03
20:4n-6							3.6	0.74
20:3n-3							0.3	0.04
20:4n-3							1.0	0.22
20:5n-3							4.4	1.06
21:5n-3							0.3	0.08
22:4n-6							0.4	0.08
22:5n-6							2.3	0.44
22:5n-3							2.1	0.19
22:6n-3							8.4	1.30
TOTAL PUFA							36.8	2.52

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.29. Weight percent fatty acid composition of fish collected from Lake Wateree April, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean	+ - SD	Mean (n=6)	+ - SD
14:0							4.3	0.57
15:0							0.7	0.08
16:0							16.5	0.56
17:0							1.1	0.13
18:0							3.4	0.42
20:0							0.1	0.06
TOTAL SATS.							26.2	0.92
14:1							0.2	0.04
16:1n-9							0.5	0.06
16:1n-7							9.3	1.01
16:1n-5							<0.1	-
17:1							0.9	0.06
18:1n-9							14.3	1.13
18:1n-7							4.2	0.25
18:1n-5							0.2	0.01
20:1n-11+13							0.2	0.08
20:1n-9							1.8	0.34
20:1n-7							0.1	0.05
20:1n-5/NMID?							<0.1	-
22:1n-11+13							<0.1	-
22:1n-9							0.1	0.09
24:1							0.1	0.08
TOTAL MONOENES							31.9	2.54
16:2n-4							0.7	0.10
18:2n-9							0.2	0.02
18:2n-6							2.9	0.20
18:2n-4/3n-6							0.5	0.05
20:2n-6							0.4	0.05
TOTAL DIENES							4.9	0.34
16:3n-4							0.7	0.07
16:3n-3							0.4	0.06
18:3n-4							0.2	0.04
18:3n-3							5.8	0.87
18:4n-3							1.7	0.28
20:3n-6							0.4	0.03
20:4n-6							3.9	0.92
20:3n-3							0.3	0.02
20:4n-3							1.0	0.14
20:5n-3							4.9	0.68
21:5n-3							0.2	0.10
22:4n-6							0.4	0.04
22:5n-6							2.5	0.37
22:5n-3							2.0	0.16
22:6n-3							9.0	1.82
TOTAL PUFA							38.1	2.96

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.30. Weight percent fatty acid composition of fish collected from Lake Wateree July, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ \- SD	Mean	+ \- SD	Mean	+ \- SD	Mean (n=6)	+ \- SD
14:0							4.2	0.31
15:0							0.7	0.04
16:0							17.0	0.64
17:0							1.1	0.10
18:0							3.6	0.52
20:0							0.2	0.02
TOTAL SATS.							26.8	1.00
14:1							0.2	0.01
16:1n-9							0.5	0.07
16:1n-7							9.3	0.69
16:1n-5							0.1	0.1
17:1							0.8	0.09
18:1n-9							16.5	0.76
18:1n-7							4.0	0.18
18:1n-5							0.2	0.02
20:1n-11+13							0.2	0.08
20:1n-9							2.0	0.47
20:1n-7							0.2	0.07
20:1n-5/NMID?							<0.1	-
22:1n-11+13							0.1	0.1
22:1n-9							<0.1	-
24:1							0.1	0.14
TOTAL MONOENES							34.4	1.95
16:2n-4							0.6	0.10
18:2n-9							0.1	0.06
18:2n-6							2.7	0.22
18:2n-4/3n-6							0.5	0.05
20:2n-6							0.4	0.05
TOTAL DIENES							4.5	0.38
16:3n-4							0.6	0.06
16:3n-3							0.4	0.04
18:3n-4							0.2	0.09
18:3n-3							5.2	0.98
18:4n-3							1.5	0.28
20:3n-6							0.4	0.04
20:4n-6							3.8	0.66
20:3n-3							0.3	0.05
20:4n-3							0.9	0.19
20:5n-3							4.5	0.93
21:5n-3							0.2	0.10
22:4n-6							0.4	0.09
22:5n-6							2.2	0.31
22:5n-3							1.8	0.10
22:6n-3							8.0	1.16
TOTAL PUFA							34.9	2.48

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.31. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System November, 1988. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean	+/- SD	Mean (n=3)	+/- SD	Mean (n=7)	+/- SD
14:0					4.7	0.16	4.6	0.19
15:0					0.8	0.03	0.7	0.04
16:0					17.4	0.09	17.2	0.48
17:0					0.9	0.09	0.9	0.07
18:0					3.2	0.07	3.3	0.23
20:0					0.1	0.00	0.2	0.01
TOTAL SATS.					27.3	0.25	27.0	0.37
14:1					0.2	0.00	0.1	0.06
16:1n-9					0.4	0.00	0.4	0.02
16:1n-7					14.3	0.56	13.7	1.01
16:1n-5					0.4	0.01	0.4	0.01
17:1					0.7	0.08	0.8	0.05
18:1n-9					12.0	0.51	12.2	0.89
18:1n-7					4.4	0.07	4.4	0.10
18:1n-5					<0.1	-	<0.1	-
20:1n-11+13					0.1	0.01	0.1	0.04
20:1n-9					0.9	0.08	1.1	0.39
20:1n-7					0.1	0.01	0.2	0.02
20:1n-5/NMID?					0.1	0.01	0.1	0.05
22:1n-11+13					<0.1	-	<0.1	-
22:1n-9					0.1	0.00	0.1	0.04
24:1					0.2	0.01	0.2	0.03
TOTAL MONOENES					33.4	0.14	33.2	1.30
16:2n-4					0.9	0.04	0.9	0.06
18:2n-9					0.2	0.01	0.2	0.01
18:2n-6					3.5	0.13	3.6	0.14
18:2n-4/3n-6					0.8	0.02	0.8	0.07
20:2n-6					0.4	0.02	0.4	0.07
TOTAL DIENES					6.1	0.12	6.3	0.20
16:3n-4					0.7	0.07	0.6	0.05
16:3n-3					<0.1	-	<0.1	-
18:3n-4					0.2	0.01	0.2	0.01
18:3n-3					4.4	0.33	4.1	0.24
18:4n-3					1.4	0.13	1.3	0.06
20:3n-6					0.5	0.02	0.5	0.02
20:4n-6					3.5	0.36	3.8	0.38
20:3n-3					0.3	0.01	0.3	0.03
20:4n-3					1.2	0.03	1.1	0.09
20:5n-3					5.2	0.09	5.0	0.32
21:5n-3					0.1	0.09	0.0	0.09
22:4n-6					0.5	0.05	0.5	0.05
22:5n-6					2.2	0.11	2.3	0.22
22:5n-3					2.0	0.07	2.0	0.07
22:6n-3					7.3	0.33	7.4	0.78
TOTAL PUFA					36.2	0.47	36.4	1.59

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.32. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System January, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ \- SD	Mean	+ \- SD	Mean (n=1)	+ \- SD	Mean (n=7)	+ \- SD
14:0					4.5		4.5	0.13
15:0					0.8		0.7	0.04
16:0					17.1		17.2	0.19
17:0					1.0		0.9	0.11
18:0					3.1		3.1	0.12
20:0					0.1		0.1	0.01
TOTAL SATS.					26.6		26.6	0.35
14:1					0.2		0.2	0.01
16:1n-9					0.4		0.4	0.02
16:1n-7					13.4		14.2	0.62
16:1n-5					0.4		0.4	0.03
17:1					0.8		0.8	0.07
18:1n-9					12.1		12.3	0.92
18:1n-7					4.4		4.4	0.13
18:1n-5					0.2		0.2	0.02
20:1n-11+13					0.1		0.1	0.02
20:1n-9					1.2		1.1	0.07
20:1n-7					0.1		0.1	0.01
20:1n-5/NMID?					0.1		0.1	0.03
22:1n-11+13					<0.1		<0.1	-
22:1n-9					0.1		0.1	0.02
24:1					0.2		0.1	0.01
TOTAL MONOENES					32.8		33.7	1.60
16:2n-4					0.9		0.9	0.02
18:2n-9					0.1		0.1	0.02
18:2n-6					3.1		3.2	0.32
18:2n-4/3n-6					0.7		0.7	0.06
20:2n-6					0.4		0.4	0.03
TOTAL DIENES					5.6		5.6	0.40
16:3n-4					0.8		0.8	0.06
16:3n-3					<0.1		<0.1	-
18:3n-4					0.2		0.2	0.02
18:3n-3					4.7		4.6	0.44
18:4n-3					1.8		1.7	0.16
20:3n-6					0.4		0.4	0.03
20:4n-6					3.3		3.1	0.34
20:3n-3					0.3		0.3	0.03
20:4n-3					1.1		1.1	0.09
20:5n-3					6.3		6.0	0.20
21:5n-3					0.3		0.3	0.02
22:4n-6					0.4		0.4	0.04
22:5n-6					2.1		2.1	0.18
22:5n-3					1.8		1.8	0.08
22:6n-3					7.6		7.6	0.48
TOTAL PUFA					37.5		36.9	1.22

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.33. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System April, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+/- SD	Mean	+/- SD	Mean (n=3)	+/- SD	Mean (n=6)	+/- SD
14:0					4.7	0.17	4.9	0.18
15:0					0.8	0.02	0.8	0.04
16:0					16.8	0.33	16.7	0.35
17:0					0.9	0.05	0.9	0.11
18:0					3.3	0.25	3.2	0.12
20:0					0.1	0.07	0.1	0.03
TOTAL SATS.					26.7	0.52	26.7	0.16
14:1					0.2	0.01	0.2	0.01
16:1n-9					0.4	0.03	0.5	0.04
16:1n-7					14.1	0.85	14.3	0.53
16:1n-5					0.4	0.02	0.4	0.02
17:1					0.8	0.04	0.8	0.03
18:1n-9					13.8	0.79	13.6	0.31
18:1n-7					4.8	0.11	4.9	0.09
18:1n-5					0.2	0.03	0.1	0.02
20:1n-11+13					0.1	0.09	0.2	0.03
20:1n-9					1.5	0.24	1.4	0.17
20:1n-7					0.1	0.07	0.2	0.02
20:1n-5/NMID?					<0.1	-	<0.1	-
22:1n-11+13					<0.1	-	<0.1	-
22:1n-9					<0.1	-	<0.1	-
24:1					<0.1	-	<0.1	-
TOTAL MONOENES					35.8	1.54	35.9	0.73
16:2n-4					1.0	0.08	1.0	0.04
18:2n-9					<0.1	-	<0.1	-
18:2n-6					3.1	0.17	3.4	0.30
18:2n-4/3n-6					0.7	0.04	0.7	0.07
20:2n-6					0.4	0.03	0.4	0.01
TOTAL DIENES					5.3	0.22	5.7	0.33
16:3n-4					0.8	0.20	0.8	0.12
16:3n-3					0.3	0.02	0.3	0.02
18:3n-4					0.2	0.06	0.2	0.02
18:3n-3					4.3	0.15	4.6	0.24
18:4n-3					1.5	0.11	1.5	0.16
20:3n-6					0.4	0.03	0.4	0.02
20:4n-6					3.2	0.38	3.2	0.32
20:3n-3					0.3	0.02	0.3	0.01
20:4n-3					1.0	0.05	1.0	0.05
20:5n-3					5.2	0.31	5.0	0.19
21:5n-3					0.2	0.07	0.2	0.03
22:4n-6					0.4	0.02	0.4	0.04
22:5n-6					2.1	0.21	2.1	0.05
22:5n-3					1.8	0.07	1.8	0.02
22:6n-3					7.0	1.02	6.4	0.44
TOTAL PUFA					35.0	1.39	34.7	0.78

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.34. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System July, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=3)	+ - SD	Mean (n=10)	+ - SD
14:0							4.8	0.49
15:0							0.7	0.06
16:0							16.0	0.43
17:0							0.8	0.12
18:0							4.3	0.78
20:0							0.2	0.03
TOTAL SATS.							26.9	0.46
14:1							0.2	0.03
16:1n-9							0.5	0.05
16:1n-7							11.9	1.98
16:1n-5							0.4	0.04
17:1							0.7	0.12
18:1n-9							14.7	1.49
18:1n-7							4.5	0.35
18:1n-5							0.2	0.03
20:1n-11+13							0.3	0.06
20:1n-9							2.1	0.34
20:1n-7							0.2	0.02
20:1n-5/NMID?							0.1	0.07
22:1n-11+13							0.1	0.17
22:1n-9							0.2	0.08
24:1							0.3	0.06
TOTAL MONOENES							36.4	3.64
16:2n-4							0.7	0.12
18:2n-9							0.1	0.05
18:2n-6							3.3	0.29
18:2n-4/3n-6							0.6	0.08
20:2n-6							0.5	0.05
TOTAL DIENES							5.3	0.52
16:3n-4							0.6	0.07
16:3n-3							0.3	0.07
18:3n-4							0.1	0.06
18:3n-3							3.1	0.98
18:4n-3							0.9	0.35
20:3n-6							0.5	0.05
20:4n-6							4.7	1.22
20:3n-3							0.2	0.04
20:4n-3							0.8	0.13
20:5n-3							3.6	0.25
21:5n-3							0.1	0.08
22:4n-6							0.5	0.09
22:5n-6							2.8	0.72
22:5n-3							2.0	0.21
22:6n-3							7.0	1.93
TOTAL PUFA							32.8	2.70

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.35. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System November, 1989. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=1)	+ - SD	Mean (n=15)	+ - SD
14:0					4.6		4.5	0.21
15:0					0.9		0.8	0.05
16:0					17.1		16.6	0.49
17:0					1.1		1.0	0.13
18:0					3.2		3.4	0.40
20:0					0.2		0.2	0.02
TOTAL SATS.					27.1		26.5	0.58
14:1					0.2		0.2	0.03
16:1n-9					0.2		0.4	0.09
16:1n-7					12.0		12.7	0.98
16:1n-5					0.4		0.3	0.19
17:1					0.8		0.8	0.06
18:1n-9					11.8		12.3	0.76
18:1n-7					4.2		4.4	0.14
18:1n-5					0.2		0.2	0.02
20:1n-11+13					0.2		0.2	0.04
20:1n-9					0.9		1.2	0.23
20:1n-7					0.2		0.2	0.03
20:1n-5/NMID?					<0.1		<0.1	-
22:1n-11+13					0.1		<0.1	-
22:1n-9					<0.1		<0.1	-
24:1					0.1		0.2	0.05
TOTAL MONOENES					31.5		33.2	1.82
16:2n-4					0.7		0.7	0.07
18:2n-9					0.1		0.1	0.02
18:2n-6					3.7		3.6	0.15
18:2n-4/3n-6					0.7		0.6	0.05
20:2n-6					0.4		0.5	0.04
TOTAL DIENES					5.9		5.8	0.24
16:3n-4					0.5		0.6	0.07
16:3n-3					0.3		0.3	0.04
18:3n-4					0.2		0.2	0.01
18:3n-3					5.7		4.6	0.71
18:4n-3					1.7		1.3	0.26
20:3n-6					0.5		0.5	0.02
20:4n-6					3.7		3.9	0.42
20:3n-3					0.4		0.3	0.04
20:4n-3					1.2		1.1	0.08
20:5n-3					4.9		4.9	0.31
21:5n-3					0.3		0.2	0.04
22:4n-6					0.5		0.5	0.06
22:5n-6					2.4		2.5	0.23
22:5n-3					1.9		2.1	0.16
22:6n-3					8.3		8.3	0.91
TOTAL PUFA					38.3		37.0	1.35

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.36. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System January, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=1)	+ - SD	Mean (n=10)	+ - SD
14:0					4.1		4.1	0.28
15:0					0.8		0.8	0.05
16:0					17.5		17.1	0.33
17:0					0.9		1.0	0.04
18:0					3.1		3.2	0.27
20:0					0.1		0.2	0.01
TOTAL SATS.					26.6		26.4	0.42
14:1					0.2		0.2	0.02
16:1n-9					0.5		0.4	0.06
16:1n-7					12.5		11.7	1.09
16:1n-5					<0.1		0.1	0.16
17:1					0.9		0.8	0.27
18:1n-9					11.4		12.1	0.98
18:1n-7					4.0		4.2	0.13
18:1n-5					0.2		0.2	0.01
20:1n-11+13					0.2		0.2	0.01
20:1n-9					1.1		1.3	0.20
20:1n-7					0.1		0.1	0.03
20:1n-5/NMID?					<0.1		<0.1	-
22:1n-11+13					<0.1		<0.1	-
22:1n-9					<0.1		<0.1	-
24:1					0.1		0.1	0.05
TOTAL MONOENES					31.5		31.5	1.64
16:2n-4					0.6		0.6	0.08
18:2n-9					0.1		0.1	0.04
18:2n-6					3.6		3.5	0.28
18:2n-4/3n-6					0.6		0.6	0.04
20:2n-6					0.4		0.4	0.03
TOTAL DIENES					5.6		5.5	0.30
16:3n-4					0.5		0.6	0.04
16:3n-3					0.3		0.3	0.04
18:3n-4					0.1		0.1	0.05
18:3n-3					5.2		5.6	0.62
18:4n-3					1.6		1.7	0.17
20:3n-6					0.4		0.4	0.02
20:4n-6					3.6		3.5	0.25
20:3n-3					0.3		0.4	0.03
20:4n-3					1.2		1.2	0.08
20:5n-3					5.6		5.6	0.24
21:5n-3					<0.1		0.2	0.09
22:4n-6					0.4		0.4	0.05
22:5n-6					2.4		2.4	0.21
22:5n-3					1.8		1.9	0.16
22:6n-3					9.3		8.9	0.77
TOTAL PUFA					38.4		38.8	1.49

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.37. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System April, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=1)	+ - SD	Mean (n=3)	+ - SD
14:0							3.3	0.66
15:0							0.7	0.08
16:0							16.7	0.15
17:0							0.9	0.14
18:0							5.2	0.76
20:0							0.2	0.07
TOTAL SATS.							27.0	0.20
14:1							0.1	0.05
16:1n-9							0.5	0.02
16:1n-7							6.9	1.58
16:1n-5							<0.1	-
17:1							0.5	0.17
18:1n-9							11.1	2.74
18:1n-7							3.8	0.23
18:1n-5							0.1	0.08
20:1n-11+13							0.2	0.07
20:1n-9							1.8	0.50
20:1n-7							0.1	0.10
20:1n-5/NMID?							<0.1	-
22:1n-11+13							<0.1	-
22:1n-9							0.1	0.10
24:1							0.3	0.05
TOTAL MONOENES							25.5	5.53
16:2n-4							0.3	0.10
18:2n-9							<0.1	-
18:2n-6							2.9	0.10
18:2n-4/3n-6							0.4	0.06
20:2n-6							0.5	0.02
TOTAL DIENES							4.2	0.31
16:3n-4							0.4	0.11
16:3n-3							0.2	0.10
18:3n-4							<0.1	-
18:3n-3							2.9	1.00
18:4n-3							0.9	0.37
20:3n-6							0.4	0.04
20:4n-6							7.3	2.39
20:3n-3							0.2	0.09
20:4n-3							0.7	0.14
20:5n-3							4.5	0.66
21:5n-3							<0.1	-
22:4n-6							0.5	0.07
22:5n-6							4.4	0.94
22:5n-3							2.1	0.23
22:6n-3							14.1	2.94
TOTAL PUFA							42.9	5.12

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.38. Weight percent fatty acid composition of fish collected from the Santee-Cooper River System July, 1990. (C = five fish composite, I = single fish)

FATTY ACID*	Hybrid (C)		Hybrid (I)		Striped (C)		Striped (I)	
	Mean	+ - SD	Mean	+ - SD	Mean (n=1)	+ - SD	Mean (n=10)	+ - SD
14:0							4.1	0.23
15:0							0.7	0.03
16:0							16.3	0.68
17:0							0.8	0.06
18:0							4.0	0.70
20:0							0.2	0.06
TOTAL SATS.							26.2	1.26
14:1							0.2	0.02
16:1n-9							0.5	0.04
16:1n-7							11.3	2.21
16:1n-5							0.2	0.13
17:1							0.8	0.10
18:1n-9							14.3	0.95
18:1n-7							4.2	0.44
18:1n-5							0.2	0.07
20:1n-11+13							0.2	0.09
20:1n-9							1.7	0.30
20:1n-7							0.2	0.07
20:1n-5/NMID?							<0.1	-
22:1n-11+13							0.1	0.05
22:1n-9							<0.1	-
24:1							0.2	0.14
TOTAL MONOENES							34.0	3.64
16:2n-4							0.6	0.16
18:2n-9							<0.1	-
18:2n-6							3.3	0.31
18:2n-4/3n-6							0.5	0.08
20:2n-6							0.5	0.03
TOTAL DIENES							5.0	0.52
16:3n-4							0.5	0.07
16:3n-3							0.3	0.05
18:3n-4							0.1	0.07
18:3n-3							3.6	0.68
18:4n-3							1.1	0.26
20:3n-6							0.5	0.06
20:4n-6							4.8	0.69
20:3n-3							0.3	0.05
20:4n-3							0.9	0.14
20:5n-3							4.4	0.45
21:5n-3							0.1	0.09
22:4n-6							0.5	0.05
22:5n-6							3.0	0.53
22:5n-3							2.0	0.13
22:6n-3							9.2	2.37
TOTAL PUFA							36.3	2.66

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.39. Weight percent fatty acid composition of fish collected from Waddell Mariculture Center 1988-1990

FATTY ACID	88 diet	fish 2/88		89 diet	fish 1/89		fish 3/89	
		Mean (n=5)	+/- SD		Mean (n=6)	+/- SD	Mean (n=10)	+/- SD
14:0	5.8	3.4	0.10	4.3	3.6	0.14	3.5	0.12
15:0	0.4	0.2	0.01	0.3	0.3	0.01	0.3	0.02
16:0	18.5	18.4	0.54	15.0	16.9	0.42	16.7	0.33
17:0	0.5	0.3	0.00	0.0	0.3	0.01	0.3	0.02
18:0	5.0	3.3	0.12	2.4	2.8	0.18	3.1	0.15
20:0	0.3	<0.1	-	0.3	0.1	0.01	0.1	0.06
TOTAL SATS.	30.8	25.9	0.43	22.5	24.2	0.43	24.1	0.77
14:1	<0.1	0.2	0.01	<0.1	0.1	0.00	0.2	0.01
16:1n-9	0.2	0.6	0.07	0.2	0.5	0.04	0.4	0.19
16:1n-7	6.2	6.5	0.26	4.8	6.2	0.86	6.4	0.23
16:1n-5	0.1	0.1	0.01	0.2	0.1	0.00	0.1	0.05
17:1	0.8	0.5	0.03	<0.1	<0.1	-	<0.1	-
18:1n-9	16.2	29.2	1.29	12.1	21.7	2.31	24.5	1.01
18:1n-7	2.5	2.9	0.10	1.7	2.6	0.13	2.7	0.06
18:1n-5	0.2	0.9	0.12	0.2	0.1	0.19	0.6	0.06
20:1n-11+13	0.1	0.1	0.07	0.6	0.3	0.21	0.3	0.03
20:1n-9	0.8	2.4	0.24	7.9	3.0	0.54	2.4	0.13
20:1n-7	0.1	<0.1	-	0.3	0.1	0.03	<0.1	-
20:1n-5/NMID?	0.2	0.1	0.06	0.1	0.1	0.03	0.1	0.07
22:1n-11+13	0.2	0.1	0.08	11.8	1.7	0.85	0.7	0.27
22:1n-9	0.1	<0.1	-	0.9	0.2	0.06	0.1	0.09
24:1	0.3	<0.1	-	<0.1	0.2	0.04	0.1	0.09
TOTAL MONOENES	28.0	43.6	1.77	41.1	37.1	2.00	38.9	0.97
16:2n-4	0.7	0.3	0.01	0.5	0.4	0.03	0.4	0.02
18:2n-9	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	-
18:2n-6	15.3	11.7	0.51	17.7	13.5	0.73	13.0	0.68
18:2n-4/3n-6	0.3	0.4	0.03	0.2	0.4	0.02	0.4	0.02
20:2n-6	0.1	0.9	0.05	0.1	0.9	0.04	0.9	0.07
TOTAL DIENES	16.4	13.4	0.49	18.7	15.9	0.46	14.8	0.70
16:3n-4	1.0	0.4	0.02	0.4	0.4	0.03	0.4	0.02
16:3n-3	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	-
18:3n-4	2.0	0.2	0.01	0.1	0.2	0.02	0.2	0.03
18:3n-3	1.6	1.1	0.04	1.6	1.3	0.08	1.2	0.06
18:4n-3	1.2	0.6	0.04	1.2	0.7	0.04	0.6	0.03
20:3n-6	0.1	0.2	0.01	0.1	0.2	0.00	0.1	0.08
20:4n-6	0.7	0.8	0.10	0.4	1.0	0.10	1.2	0.09
20:3n-3	0.1	<0.1	-	0.1	<0.1	-	<0.1	-
20:4n-3	0.6	0.4	0.02	0.3	0.5	0.02	0.5	0.02
20:5n-3	7.6	5.0	0.29	5.2	6.2	0.36	6.1	0.25
21:5n-3	0.4	0.2	0.02	0.2	0.3	0.02	0.1	0.08
22:4n-6	0.1	<0.1	-	0.0	0.1	0.01	0.1	0.07
22:5n-6	0.2	0.2	0.03	0.1	0.3	0.02	0.3	0.02
22:5n-3	1.4	1.4	0.12	0.8	1.7	0.10	1.9	0.06
22:6n-3	5.5	5.8	0.93	4.7	7.5	0.99	8.0	0.36
TOTAL PUFA	38.9	29.7	1.70	34.8	37.0	1.85	35.8	0.73

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.

TABLE C.39. (continued)

FATTY ACID	90 diet	fish 4/90		fish 5/90	
		Mean (n=5)	+/- SD	Mean (n=10)	+/- SD
14:0	5.3	3.1	0.13	3.0	0.08
15:0	0.5	0.3	0.01	0.3	0.01
16:0	19.0	18.4	0.53	18.4	0.41
17:0	0.6	0.3	0.01	0.3	0.01
18:0	4.0	3.4	0.14	3.2	0.20
20:0	0.3	0.1	0.01	0.1	0.03
<b>TOTAL SATS.</b>	<b>30.1</b>	<b>25.6</b>	<b>0.58</b>	<b>25.3</b>	<b>0.36</b>
14:1	<0.1	0.2	0.01	0.2	0.02
16:1n-9	<0.1	<0.1	-	0.4	0.14
16:1n-7	6.2	6.0	0.13	6.0	0.26
16:1n-5	0.0	<0.1	-	<0.1	-
17:1	1.0	0.4	0.03	0.4	0.08
18:1n-9	13.9	23.7	0.29	21.8	0.86
18:1n-7	2.8	2.5	0.10	2.6	0.05
18:1n-5	0.3	0.6	0.02	0.5	0.04
20:1n-11+13	<0.1	0.2	0.01	0.2	0.02
20:1n-9	1.4	2.2	0.08	1.9	0.13
20:1n-7	0.2	<0.1	-	<0.1	-
20:1n-5/20:1n-7	0.2	0.1	0.05	0.1	0.04
22:1n-11+13	0.5	0.5	0.03	0.4	0.07
22:1n-9	0.2	0.2	0.01	0.1	0.07
24:1	0.4	0.2	0.01	0.2	0.01
<b>TOTAL MONOENES</b>	<b>27.8</b>	<b>37.3</b>	<b>0.30</b>	<b>35.2</b>	<b>1.15</b>
16:2n-4	0.8	0.3	0.02	0.4	0.01
18:2n-9	<0.1	<0.1	-	<0.1	-
18:2n-6	9.3	11.7	0.29	11.8	0.20
18:2n-4/3n-6	0.4	0.3	0.07	0.4	0.02
20:2n-6	0.2	0.8	0.05	0.9	0.07
<b>TOTAL DIENES</b>	<b>10.9</b>	<b>13.2</b>	<b>0.38</b>	<b>13.6</b>	<b>0.25</b>
16:3n-4	1.1	0.4	0.02	0.4	0.02
16:3n-3	<0.1	<0.1	-	<0.1	-
18:3n-4	0.2	0.1	0.01	0.1	0.01
18:3n-3	1.6	1.1	0.05	1.2	0.03
18:4n-3	2.4	0.9	0.05	0.9	0.04
20:3n-6	<0.1	0.1	0.01	0.1	0.00
20:4n-6	0.6	0.8	0.04	1.0	0.08
20:3n-3	0.1	<0.1	-	<0.1	-
20:4n-3	1.0	0.6	0.03	0.6	0.02
20:5n-3	10.2	5.4	0.13	5.8	0.24
21:5n-3	<0.1	0.2	0.02	0.3	0.06
22:4n-6	<0.1	<0.1	-	<0.1	-
22:5n-6	0.2	0.3	0.02	0.3	0.02
22:5n-3	1.7	1.5	0.05	1.6	0.06
22:6n-3	10.1	11.0	0.63	12.0	0.69
<b>TOTAL PUFA</b>	<b>40.1</b>	<b>35.8</b>	<b>0.54</b>	<b>37.8</b>	<b>1.10</b>

\* Branched-chain fatty acids (iso-, anteiso-, and isoprenoid acids) and minor components of questionable identity are not included.