Food habits and food webs of high Hg content commercially and recreationally harvested fishes in the Gulf of Mexico

Final Report for WQ-003

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by

James Simons, Jorrit Poelen, Reed Hewitt, Tiffany Miller and Brooke Gonzalez

Center for Coastal Studies
Texas A&M University-Corpus Christi
6300 Ocean Drive
Corpus Christi, TX 78412

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1.0 Introduction

This report provides a summary of our activities since our last report and a synthesis of the activities for the entire period of the project in assessing food habits data and creation of food web models for fishes that have high Hg content and that are consumed at relatively high rates by humans. During the last phase of the project we have compiled the mercury (Hg) concentration data for the spotted seatrout, edited the data entry spreadsheets for king mackerel, completed the food web construction, constructed a GoMexSI webpage and video, and re-written the data dictionary to reflect the edited data entry spreadsheets.

2.0 Goals of the Project

The goals of this research are: 1) to compile dietary data for identified commercially and recreationally important pelagic and demersal fishes from the estuaries, continental shelf and deep sea of the Gulf of Mexico that are suitable for the model development being carried out by Pollman and Harris, 2) to construct food web models for the identified fish species so that likely pathways of Hg movement through the food web can be ascertained, 3) compile data on Hg concentrations in organisms in Gulf of Mexico food webs, and 4) provide a platform for storage and retrieval of the trophic data.

3.0 Background

The primary route of exposure of humans to monomethylmercury (MMHg) is through the consumption of estuarine and marine fish (Sunderland et al 2011). Many of these fishes (eg. mackerel, tunas) are higher order carnivores at or near the top of the food web, their high concentrations of mercury (Hg) being the end result of the bio-magnification process. Thus it is important to understand the food habits and the food web in which these species reside. Only with knowledge of the organisms in the intermediate steps of the food web and the concentrations of Hg in these various organisms (*e.g*. Blanton and Blanton 1972, Palmer and Presley 1996) can we trace the pathways of the greatest sources of Hg to these predators. By understanding the beginning of the chain of transfer we can learn how the Hg is getting into the food web, and thus institute measures to reduce the Hg at its source.

A "screening" model of Hg dynamics in the Gulf of Mexico is being developed to examine the relationships between Hg inputs from atmospheric, terrestrial, riverine and sediment sources and the cycling of MMHg through Gulf food webs and its incorporation into commercially and recreationally important fish species (Pollman et al. 2010, Harris et al. 2010). Thus knowledge of the feeding habits of these fishes (and their prey, and their prey's prey, *etc.*) is critically important to the development of this model. As conducting diet studies on these fishes is too time consuming and cost prohibitive for the modeling effort, extraction of this information from literature sources is the most viable method to obtain this much needed data.

4.0 Data for food web construction

We compiled data on both seafood (fishes and macro-invertebrates) consumption rates by humans, and mercury (Hg) concentrations in seafood in the Gulf of Mexico. We found only two references that provided detailed data on the consumption of seafood in the Gulf, one from Louisiana (Lincoln et al. 2011) and the other from Florida (Degner et al. 1994). In Florida, tuna, shrimp, and grouper were found to have the highest consumption rates, while in Louisiana, it was tuna, spotted seatrout, and blue crab. A total of nine studies (Hall et al. 1978, Ache et al. 2000, Adams et al. 2003, Cunningham et al. 2003, Lowery and Garrett III 2005, Reisinger 2006, Bank et al. 2007, Senn et al. 2010, Stunz and Robillard 2011) on mercury concentrations in seafood of the Gulf were examined and the data compiled for further analysis. The reference studies spanned from 1978 to 2011. The highest mean and median Hg concentrations were found in blue marlin and three species of sharks (great white shark, reef shark, and lemon shark).

Considering both consumption rates and Hg concentrations in the seafood tissue, we highlighted ten of the species for further analysis. In addition to consumption rates and Hg concentrations, we also wanted to consider the primary habitats of the species, as we desired to include species from an estuarine, offshore pelagic and/or benthic habitat. A list of the ten species along with environmental and habitat data (abstracted from FishBase: www.fishbase.org/) for each of those ten species was compiled. This list was sent to members of the Hg Subcommittee of the GOMA WQ PIT for comments and suggestions before making a proposal and decision on the priority species to begin collection and digitization of trophic data, and construction of food webs.

The king mackerel (*Scomeromorus cavalla*) and spotted seatrout (*Cynoscion nebulosus*) were selected as the first and second priority species, respectively, for data compilation and food web construction. King mackerel was selected because it typically has fairly high Hg concentrations, is caught mainly in offshore, pelagic waters, although it can be caught from jetties and piers along the coast, and it is both a commercial and recreationally caught species. The spotted seatrout was selected because it is a very popular recreationally caught species and it spends all of its life cycle in the estuaries. Both species are found nearly throughout the Gulf of Mexico.

We collected diet data from the references that are in-hand from the Gulf trophic bibliography (Simons et al. unpublished manuscript). In addition, we have plotted the location of the study site for each of the 15 references for king mackerel diet. The spatial location and density of data will be determining factors in the number and location of food webs that will be constructed. Currently we have 1,454 predator-prey interactions recorded in the Excel spreadsheet from 27 references (see Appendix A).

A list of all prey items for king mackerel was compiled prior to beginning data entry to get a sense for which prey items occurred most frequently, and in the greatest number and biomass (or volume) in the diets of king mackerel. From this list we selected four species of prey fish (out of over 50) that were most important in the diet of king mackerel. Some diet data for these four species (*Chloroscombrus chrysurus* – Atlantic bumper, *Decapterus punctatus* – Round scad, *Opisthonema oglinum* – Atlantic thread herring, and *Sardinella aurita* – Spanish sardine) has been compiled now that all of the king mackerel diet data is entered. Based examination of the food webs, there are several other high priority species for which we need to compile diet data.

We identified a total of 83 references that contain trophic data on the spotted seatrout, with 73 of them being unique (*i.e.* that is by removal of references that are based on the same data set). Some of these data have been entered through another project currently underway that is funded by NOAA's SEFSC, Miami, Florida. Trophic data from 18 references for the spotted seatrout have been entered into spreadsheets under the auspices of the NOAA project (see Appendix B).

5.0 Spatial food webs for king mackerel

Trophic data for king mackerel food web construction was extracted from 13 references. These data included one reference that reported only on the diets of larval/post-larval and juvenile king mackerel, while the remainder of the references reported only on adults. The study locations of the references were located throughout the Gulf, although all but one of the study areas were located in US waters. Based on a plot of all the references for adult diet data, six different areas were located for food web construction. Although sampling for the larval/post-larval and juveniles came from three and two different locations respectively, the diet data from all locations was aggregated into the two life history stages, so no spatial differentiation of these webs is possible.

The food webs were constructed with a few differences than is typically seen. Food items were grouped taxonomically, and where absent, higher level taxa were added for taxonomic clarity. In addition, rectangles were used for the added taxa, while ovals were used for taxa that had been consumed by the king mackerel. Another feature is the shading of the consumed prey according to perceived place in the water column, with those perceived have more of a pelagic habit are shaded light red, those of a demersal habit are shaded blue, and those that appear throughout much of the water column are shaded green. These devices were used in an attempt to aid in the understanding of the food web and recognize taxonomic groups, or those that inhabit different realms. Within each prey symbol, the percent volume (%V) and percent frequency of occurrence (%FO) is also given.

LARVAL/POST-LARVAL FOOD WEBS:

The larval/post-larval specimens of king mackerel were collected in coastal waters around the Florida Keys, east of the Mississippi River delta, and off of Galveston. The data collected for these webs is rather sparse, as there were only 12 food categories reported. The resulting food web indicates that the most frequently occurring item in the stomachs of larval/post larval king mackerel were unidentified fishes, Actinopterygii, (46.7%), while jacks, family Carangidae, (23/3%) and drums, family Sciaenidae, (21.1%) were the most frequently occurring identifiable food items. In addition, anchovies, family Engraulidae, (8.9%) and herrings, family Clupeiidae, (6.7%) were minor parts of the diet (see Figure 1).

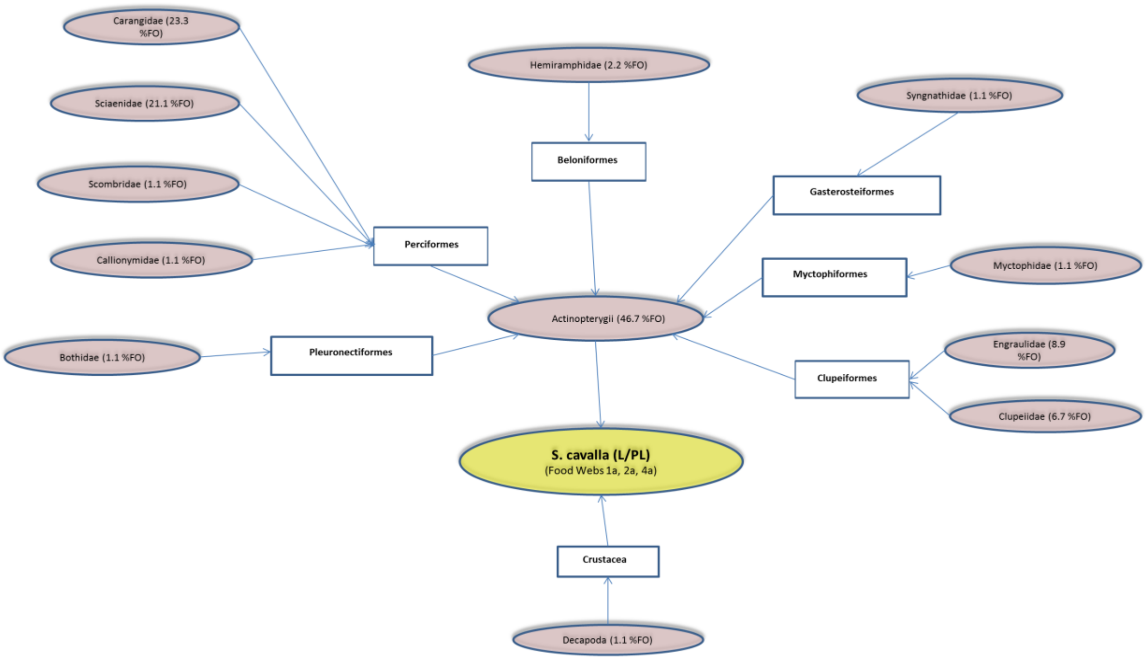

Figure 1. Food web diagram for the larval/post-larval king mackerel in the Gulf of Mexico.

JUVENILE FOOD WEBS:

The juvenile specimens of king mackerel were collected in coastal waters off of Mississippi, off of south Texas, and off of Veracruz. The data collected for these webs is very sparse, as there were only five food categories. The resulting food web indicates that the most frequently occurring item in the stomachs of the larval/post larval king mackerel were *Anchoa* sp. (56.3%), while unidentified fishes (26.6%) was a frequently food item. In addition, Engraulidae (9.3%) and squid, order Teuthida, (5.4%) were minor parts of the diet (see Figure 2).

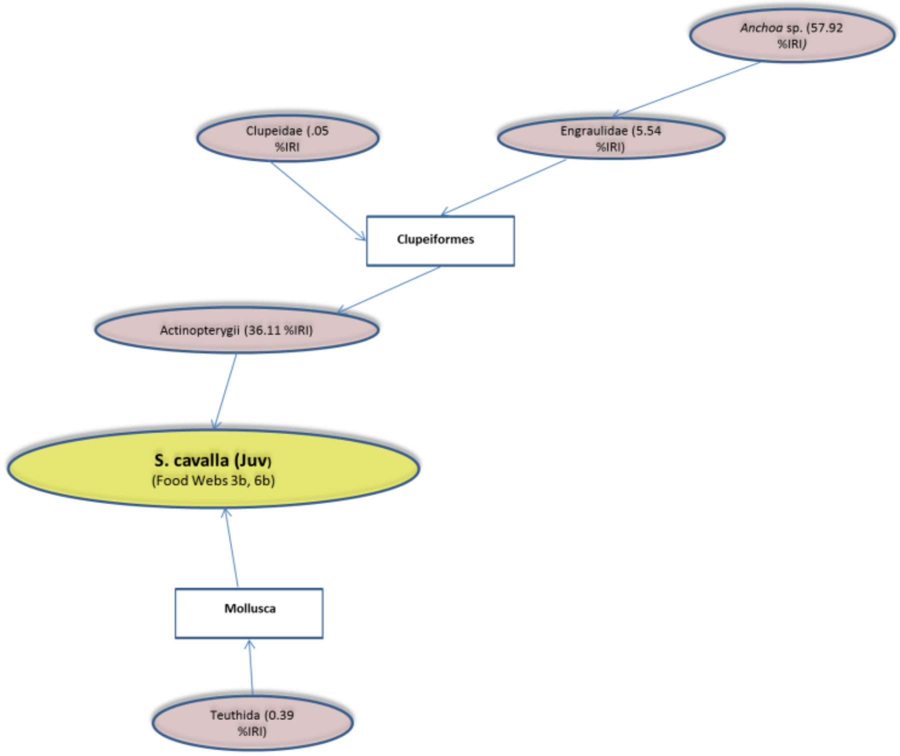

Figure 2. Food web diagram for the larval/post-larval king mackerel in the Gulf of Mexico.

ADULT FOOD WEBS:

Food webs for adult specimens of king mackerel were constructed for six locations around the Gulf: Web 1-the coastal waters around the Florida Keys, Web 2-coastal waters and continental shelf off the west coast of Florida from Tampa to Charlotte Harbor, Web 3-the northern Gulf coastal waters and continental shelf from the Mississippi River delta to Cape San Blas, Web 4-coastal and continental shelf off of Louisiana west of the Mississippi River delta, Web 5- coastal and continental shelf off Texas from Galveston to Port Isabel, and Web 6-coastal waters and continental shelf off of Veracruz (see Figure 3).

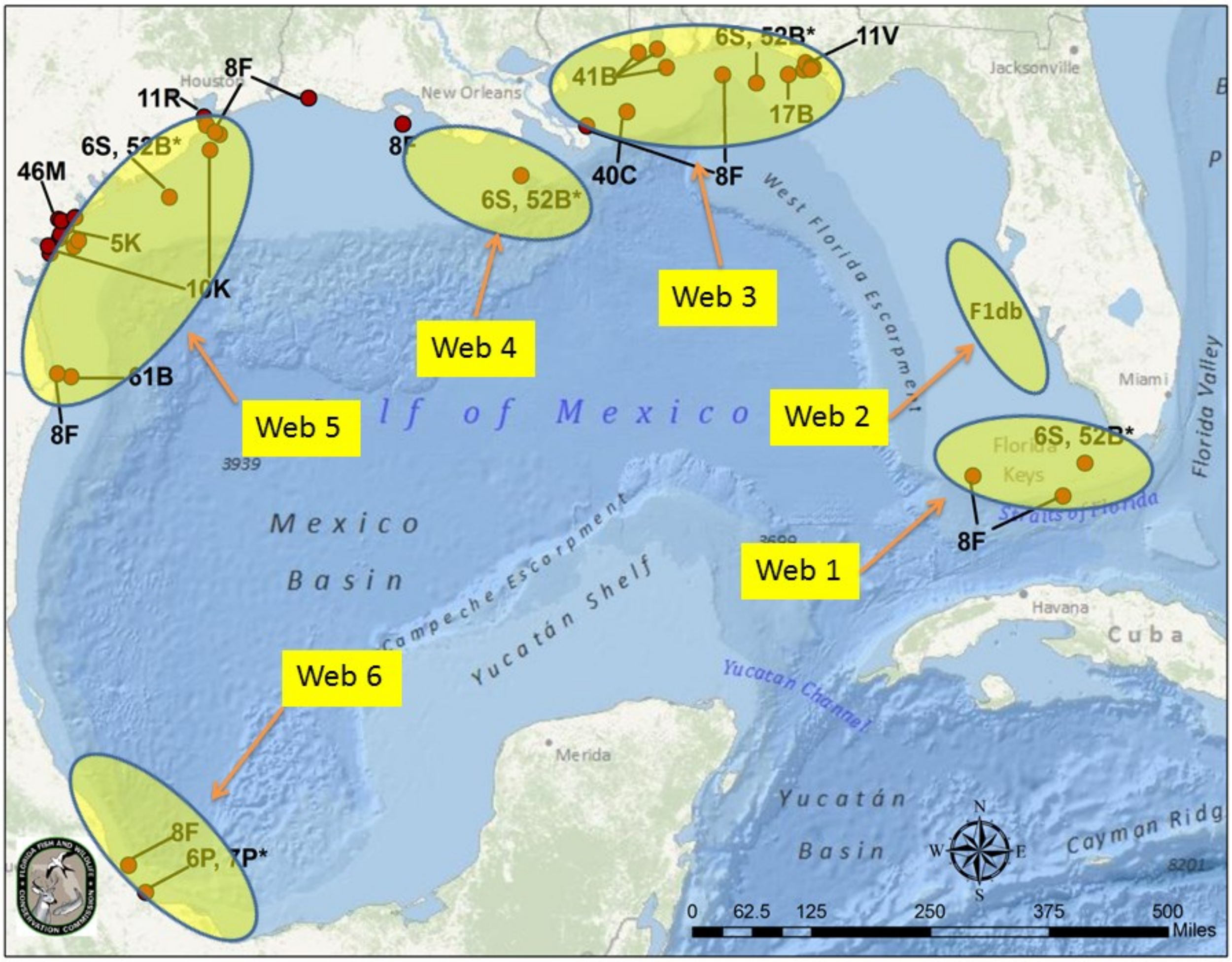

Figure 3. Map showing the location of the six food webs for the adult king mackerel in the Gulf of Mexico.

Web 1: Data for this food web came from a single reference which examined a total of 1,472 king mackerel stomachs. There were a total of 28 taxa, although a couple of higher taxa may be represented by the species identified in that family (Figure 4). The most dominant by percent volume were the halfbeak, *Hemiramphus brasiliensis* (20.1%) and the flying fish family, Exocetidae (14 %V). Other food items of minor importance were the red snapper, *Lutjanus campechanus* (4.7 %V), the white shrimp, *Penaeus duorarum* (3.6 %V), and the penaeid shrimp genus, *Penaeus* sp. (3.5 %V). The same food items were also the most frequently occurring items in the diet of king mackerel adults in this area.

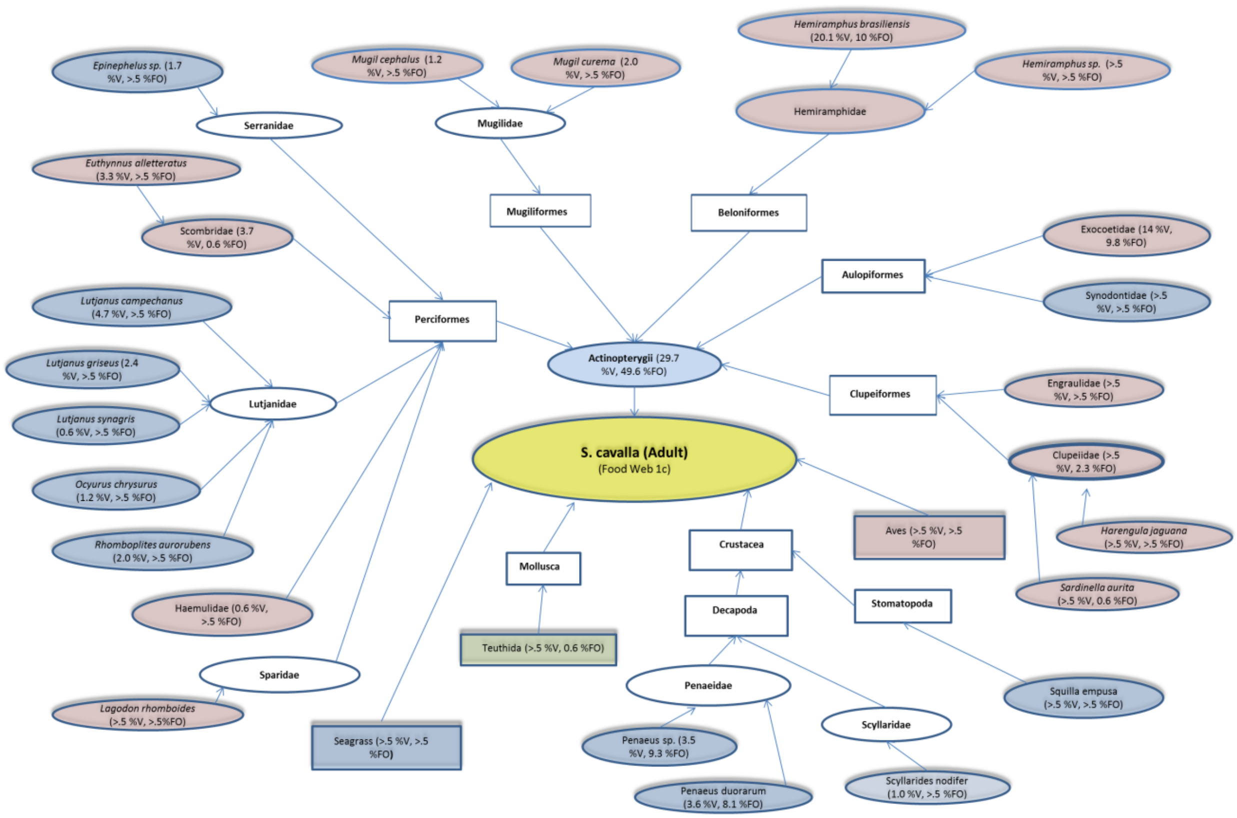

Figure 4. Food web diagram for Web 1 from the coastal waters of the Florida Keys.

Web 2: Data for this food web came from a single source, the Florida Wildlife Research Institute diet data base, which examined a total of 181 king mackerel stomachs. There were a total of 15 taxa, although a couple of higher taxa may be represented by the species identified in that family (Figure 5). The most dominant by percent volume were unidentifiable fishes, Actinopterygii (56 %V), with the emerald parrotfish, *Nicolsina usta usta,* (14.2 %V), the round scad, *Decapterus puncatatus* (9.8 %V), the mackerel family, Scombridae (8.1 %V), and the mojarra genus, *Eucinostomus* spp. (7.3 %V). The Actinopterygii were also the most frequently occurring item (24.6 %FO) in the diet of king mackerel adults in this area, with *Anchoa* spp (5.8 %FO), Engraulidae (4.3 %FO), and squids, Decabrachia, (4.3 %FO) the next most frequently occurring items.

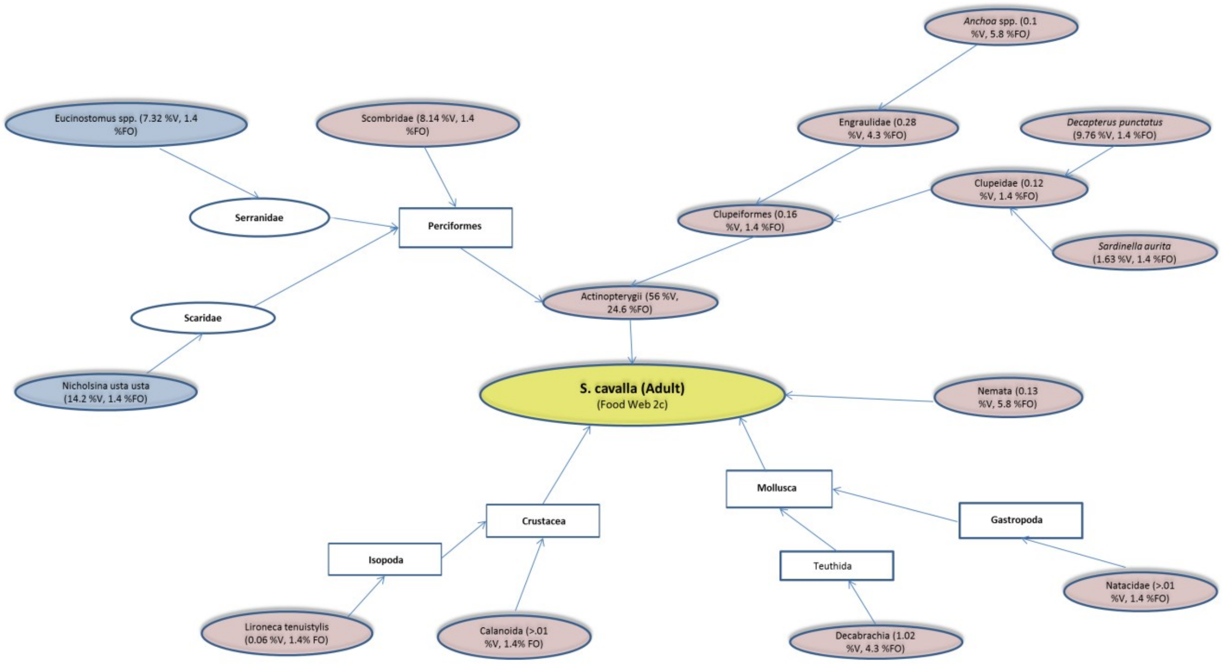

Figure 5. Food web diagram for Web 2 from the coastal waters of the western Florida shelf from Tampa to Charlotte Harbor.

Web 3: Data for this food web came from four sources, which examined a total of 3,786 king mackerel stomachs. There were a total of 57 taxa, although a couple of higher taxa may be represented by the species identified in that family (Figure 6). The most dominant by percent volume were the round scad, *Decapterus puncatatus* (29.9 %V), and unidentifiable fishes, Actinopterygii (26.7 %V). Other food items of importance included the flying fish family, Exocetidae (14.4 %V), the penaeid shrimp family, Penaeidae (11 %V), the Spanish sardine, Sardinella aurita (9.6 %V), the squid, Teuthida (6.7 %V), and the jack family, Carangidae (5.8 %V). The Actinopterygii were also the most frequently occurring item (50.9 %FO) in the diet of king mackerel adults in this area, with Teuthida (36.2 %FO), Carangidae (33.2 %FO), and *Decapterus punctatus* (25.6 %FO) also frequently occurring items. In addition, Exocetidae (10.3 %FO), *Sardinella aurita* (9.6 %FO), *Penaeus* sp. (9.3 %FO), and Penaeidae (9.3 %FO) were also of moderate importance by frequency of occurrence.

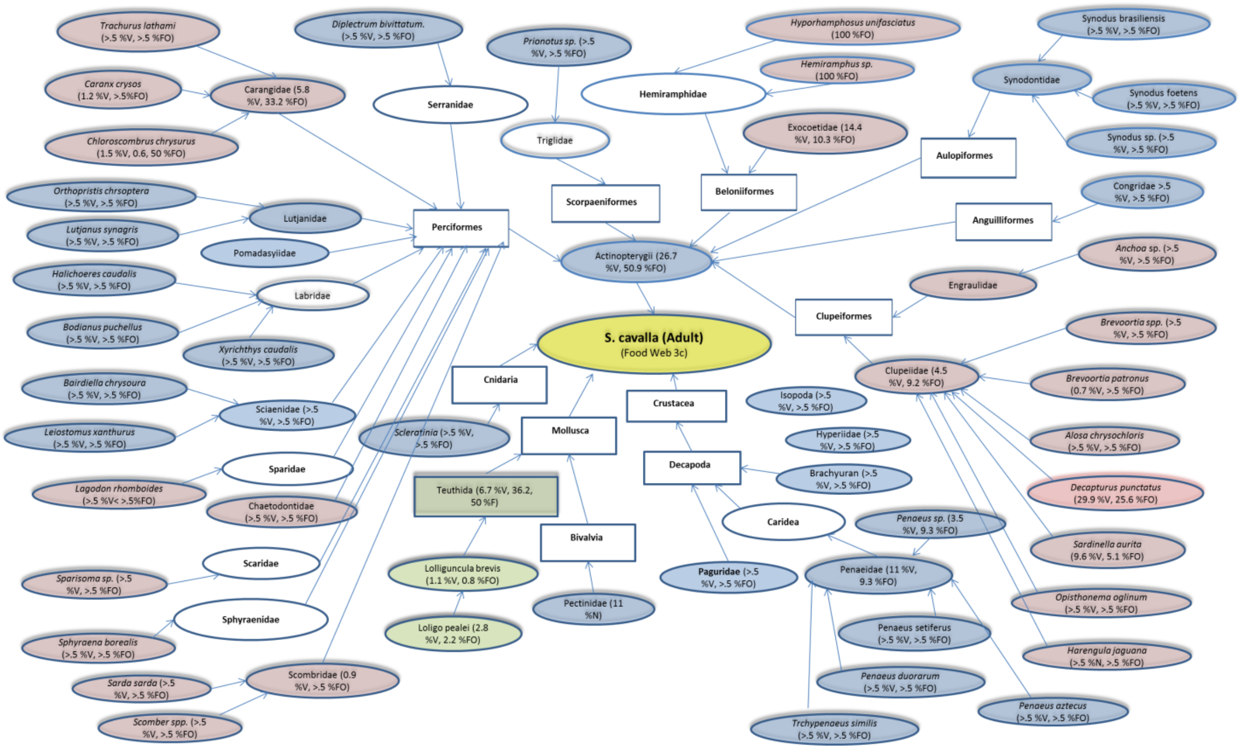

Figure 6. Food web diagram for Web 3 from the coastal waters of the northern Gulf from west of the Mississippi River to Cape San Blas.

Web 4: Data for this food web came from one source, which examined a total of 1,007 king mackerel stomachs. There were a total of 50 taxa, although a couple of higher taxa may be represented by the species identified in that family (Figure 7). The most dominant by percent volume were the sand seatrout, *Cynoscion arenarius* (18.2 %V), the Atlantic croaker, *Micorpogonias undulatus* (12.4 %V), *Cynoscion* sp. (11.4 %V), the Gulf menhaden, *Brevoortia patronus,* (9.5 %V), and Actinopterygii (9.2 %V). Other food items of importance included the Atlantic thread herring, *Opisthonema oglinum* (7.8 %V), the herring family, Clupeiidae (6.2 %V), and the blue runner, *Caranx crysos* (5 %V). The Actinopterygii (41.2 %FO) and Clupeiidae (32.7 %FO) were the most frequently occurring items for the king mackerel in this area. In addition, *Cynoscion* sp (9.3 %FO), Opisthonema oglinum (6.8 %FO), *Cynoscion arenarius* (6.1 %FO), the ribbon fish, *Trichiurus lepturus* (6.1 %FO), and *Micropogonias undulatus* (5.9 %FO) were also of moderate importance by frequency of occurrence.

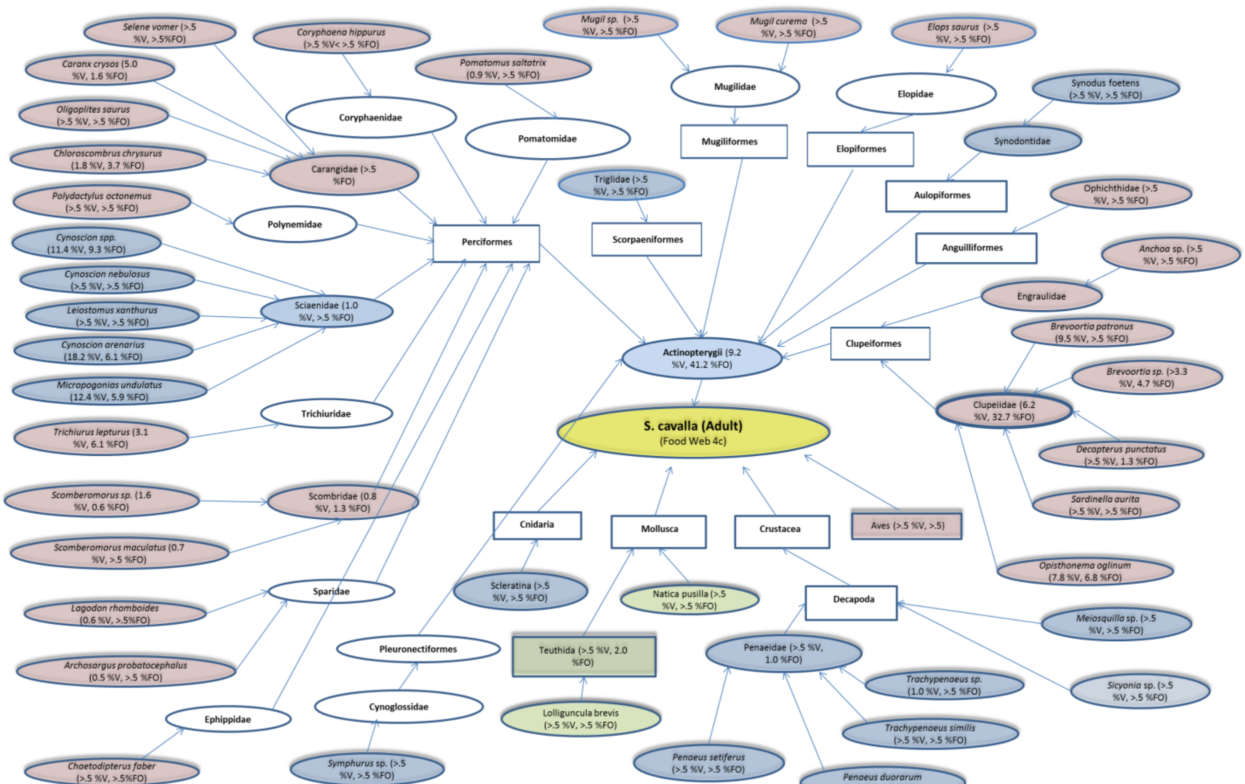

Figure 7. Food web diagram for Web 4 from the coastal waters of Louisiana just west of the Mississippi River delta.

Web 5: Data for this food web came from six sources, which examined a total of 2,014 king mackerel stomachs. There were a total of 81 taxa, although a couple of higher taxa may be represented by the species identified in that family (Figure 8). The most dominant food items by percent volume, by far, were Actinopterygii (34.2 %V), and *Trichiurus lepturus* (24.9 %V). Other food items of minor importance included the Atlantic bumper, Chloroscombrus chrysurus (6.9 %V), *Sardinella aurita* (3.9 %V), and *Decapterus punctatus* (3.8 %V). The Actinopterygii (59.6 %FO) were by far the most frequently occurring item in the king mackerel in this area. Other moderately frequent items included *Trichiurus lepturus* (20.5 %FO), Teuthoidea (15.1 %FO), Penaeidae (11.5 %FO), and Carangidae (9.1 %FO).

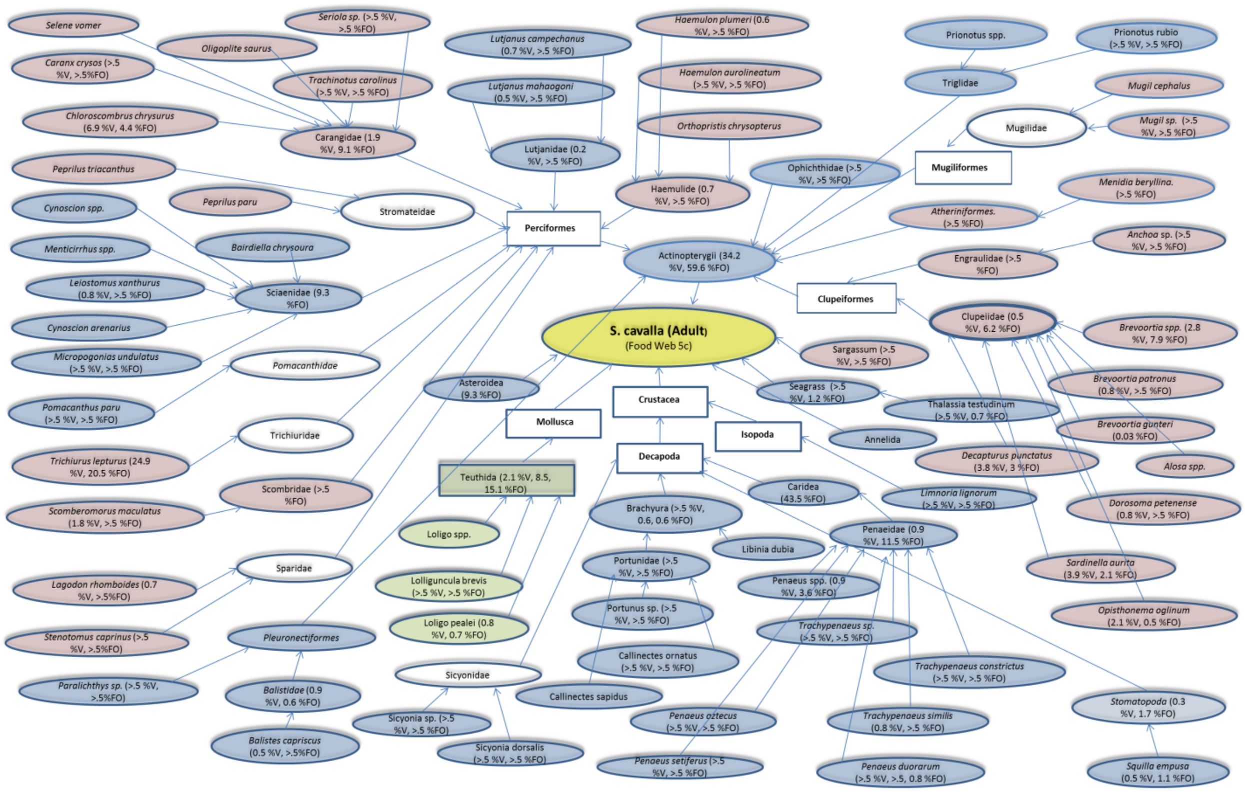

Figure 8. Food web diagram for Web 5 from the coastal waters and continental shelf of Texas from Galveston to Port Isabel.

Web 6: Data for this food web came from one source, which examined a total of 19 king mackerel stomachs. There were only 5 taxa of food items identified (Figure 9). The most dominant food items by percent volume was the striped anchovy, *Anchoa hepsetus* (81.3 %V), with the dwarf sand perch, *Diplectrum bivittatum* (7.4 %V) and the dwarf goatfish, *Upeneus parvus,* (5.5 %V) of minor importance. *Anchoa hepsetus* (78.9 %FO) was also, by far, the most frequently occurring item in the diet. Other moderately frequent items included the striped codlet, *Bregmaceros cantori* (19 %FO), and *Diplectrum bivittatum* (7.1 %FO).

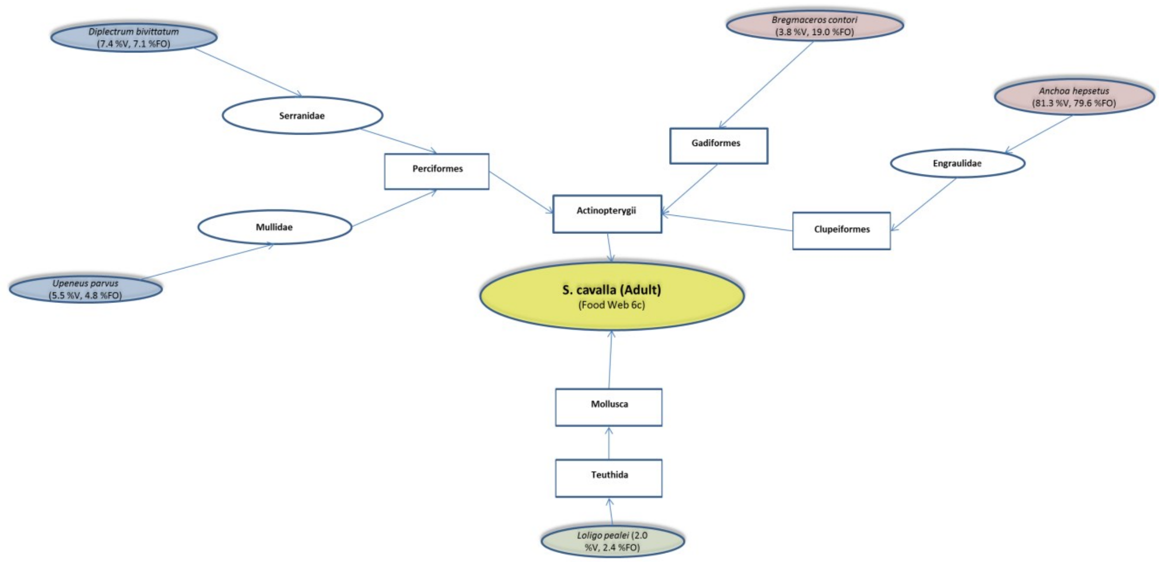

Figure 9. Food web diagram for Web 1 from the coastal waters and continental shelf off of Veracruz.

COMPARISON OF WEBS:

We will now compare the six adult food webs by looking at percent volume of food items grouped at the family level. Food items are grouped into major food categories (>20 %V), moderately important (<20 % and >10 %V), and minor food categories (<10 % and >3 %V) for at least one of the food webs for each category.

The major food items compared by percent volume varied among the six food webs (Figure 10). In Web 1, in the coastal waters around the Florida Keys, the dominant food were the halfbeaks, family Hemiramphidae at about 20 %V. Web 2, which was along the west Florida coast from Tampa to Charlotte Harbor, was dominated by food items that were unidentified fishes, Actinopterygii, at about 60 %V. The third web, located in coastal and continental shelf waters east of the Mississippi River delta to Cape San Blas, was dominated by Clupeidae at close to 50 %V. Web 4, which is west of the Mississippi River delta in Louisiana coastal and continental shelf waters, was dominated by drums, family Sciaenidae, at about 45 %V. The fifth web, located along the Texas coast from Galveston to Port Isabel, was dominated by the ribbon fish, family Trichiuruidae at 25 %V. Finally, Web 6, which was located in coastal and continental shelf waters off of Veracruz, was dominated by anchovies, family Engraulidae at about 80 %V. None of the webs had more than a single major food category.

Diet items of moderate importance for Web 1 included snappers and flying fishes, in the families Lutjanidae and Exocetidae (Figure 11). For the second web, the Scaridae at about 15 %V was of moderate importance in the diet. Web 3 had Exocetidae, Penaeidae and Teuthoidea were of moderate importance. Webs 4, 5 and 6 did not have any diet items at the family level that were of moderate importance.

Finally, diet items of minor importance included the mullets, family Mugilidae (3 %V) and the mackerels, family Scombridae (7 %V) for Web 1 (Figure 12). In Web 2, food items of minor importance occurred in the Scombridae (8 %V) and the sea basses, family Serranidae (8 %V). For webs 3, 4, and 5 the jacks, family Carangidae were of minor importance at 8, 4 and 8 %V respectively. Finally, the Serranidae, at about 8 %V, were of minor importance in Web 6.

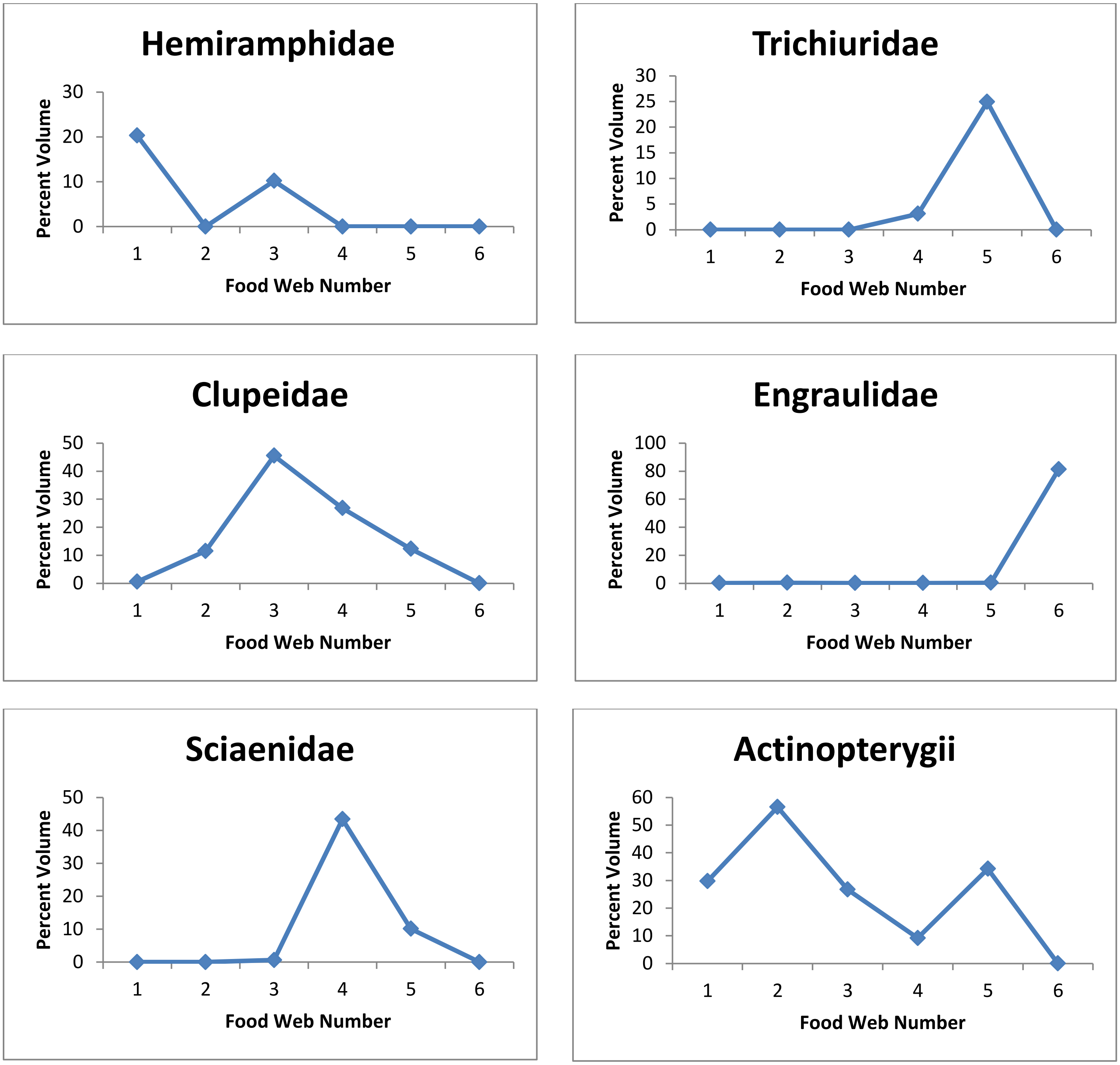

Figure 10. Plots showing the percent volume of families of major food categories for the six adult food webs for king mackerel in the Gulf of Mexico. Major food categories are those that were greater than 20 %V for at least one food web.

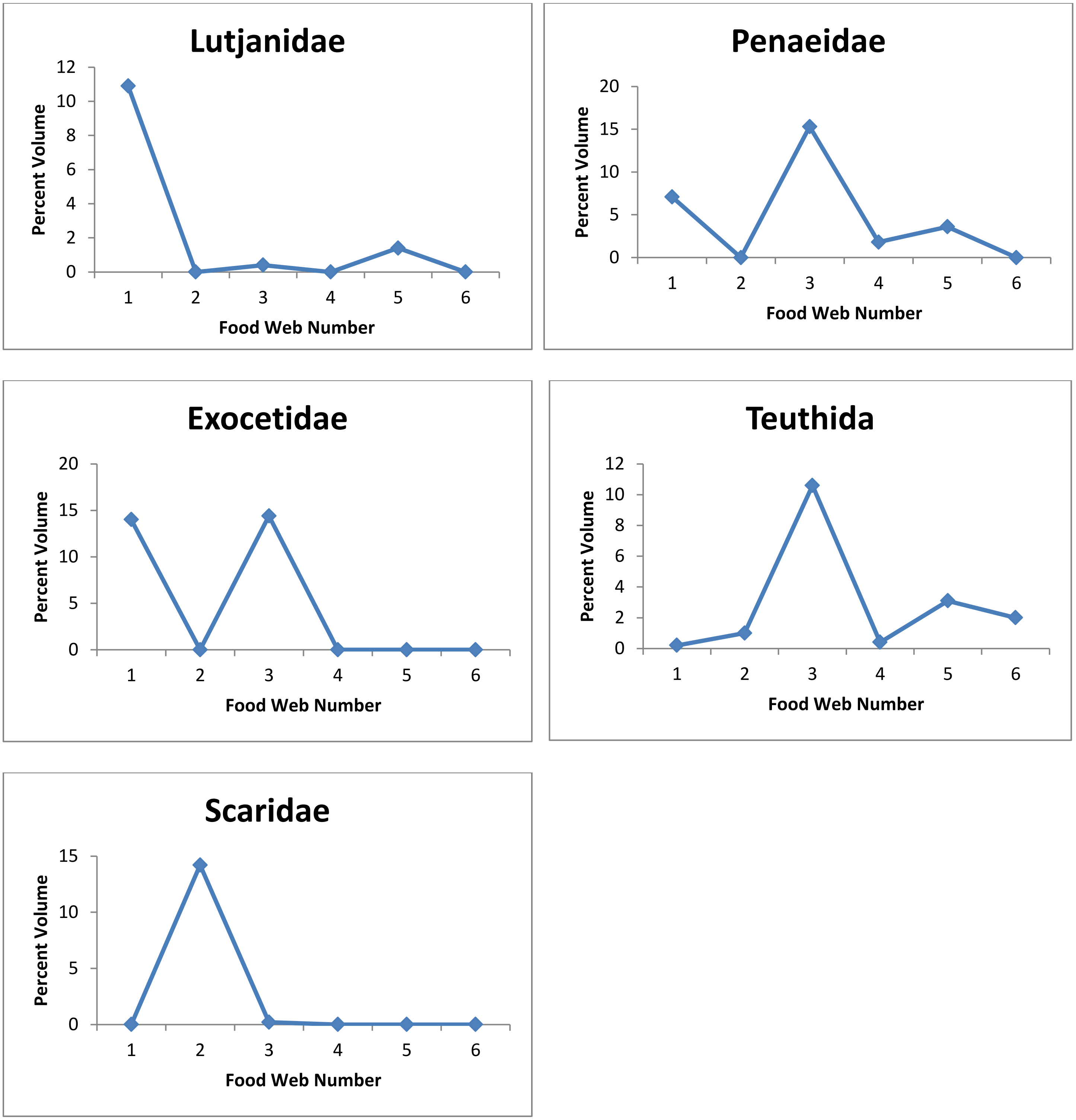

Figure 11. Plots showing the percent volume of families of moderately important food categories for the six adult food webs for king mackerel in the Gulf of Mexico. Moderately important food categories are those that were generally between 10 and 20 %V for at least one food web.

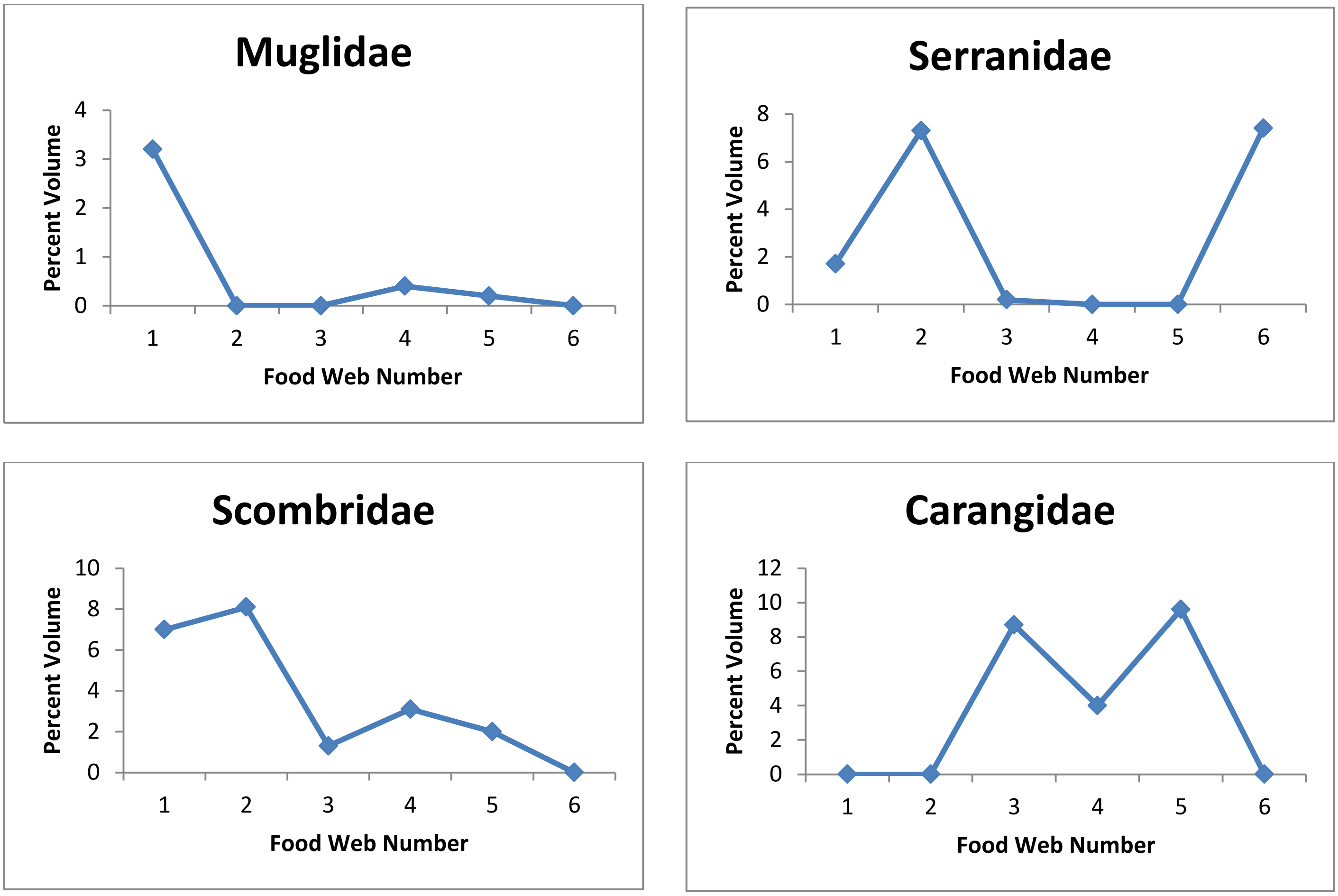

Figure 12. Plots showing the percent volume of families of minor food categories for the six adult food webs for king mackerel in the Gulf of Mexico. Minor food categories are those that were less than 10 %V for all food webs, and for at least one web greater than 3 %V.

6.0 Mercury data for Gulf of Mexico fishes

Data on both seafood (fishes and macro-invertebrates) consumption rates by humans, and mercury (Hg) concentrations in seafood in the Gulf of Mexico have been compiled. We found only two references that provided detailed data on the consumption of seafood in the Gulf, one from Louisiana (Lincoln et al. 2011) and the other from Florida (Degner et al 1994). In Florida, tuna, shrimp, and grouper were found to have the highest consumption rates, while in Louisiana, it was tuna, spotted seatrout, and blue crab. A total of nine studies (Hall et al. 1978, Ache et al 2000, Adams et al 2003, Cunningham et al 2003, Lowery and Garrett 2005, Reisinger 2006, Bank et al 2007, Senn et al 2010, Stunz and Robillard 2011) on mercury concentrations in seafood of the Gulf were examined and the data compiled for further analysis. The reference studies spanned from 1978 to 2011. The highest mean and median Hg concentrations were found in blue marlin and three species of sharks (great white shark, reef shark, and lemon shark).

We have compiled a total of 12 published data sets on mercury concentrations in tissues of king mackerel in the Gulf of Mexico. These data have been entered into an Excel spreadsheet, and also entered into ArcGIS for spatial display of the data. Data has also been collected for the spotted seatrout. In addition, mercury data for the following species has been assembled from EPA's national coastal assessment: brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*Litopenaeus duorarum*), white shrimp (*Litopenaeus setiferus*), blue catfish (*Ictalurus furcatus*), channel catfish ((*Ictalurus punctatus*), hard head catfish (*Ariopsis felis*), gafftopsail catfish (*Bagre marinus*), spot (*Leiostomus xanthurus)*, Atlantic croaker (*Micropogonias undulatus*) and sediment.

Following the data compilation of Hg concentrations in king mackerel (*Scomberomorus cavalla*) tissues, we prepared distribution maps (Figure 13). Data was obtained from a variety of sources (Hall et al. 1978, Ache et al. 2000, US Environmental Protection Agency 2003, Lowery and Garrett 2005, Reisinger 2006, Warner and Savitz 2006, Adams et al. 2007, Cai et al. 2007, Louisiana Department of Environmental Quality, n.d., Snyder and Patterson 2007, Thera and Rumbold 2009, Texas Department of Health Seafood Safety Division 2011) and compiled into an excel spreadsheet. Spatial attributes were given to the data based on the defined area in the sources. Some sources gave specific GPS coordinates, but with most we created a polygon of the area described or mapped in the text and calculated a centroid from that. The data was then added with the spatial attributes to ArcMap and classified for analysis with graduated symbols. The highest concentrations of Mercury appeared to occur close to the Mobile Bay area and the Mississippi delta and along the southern Florida coast from Tampa to the Keys.

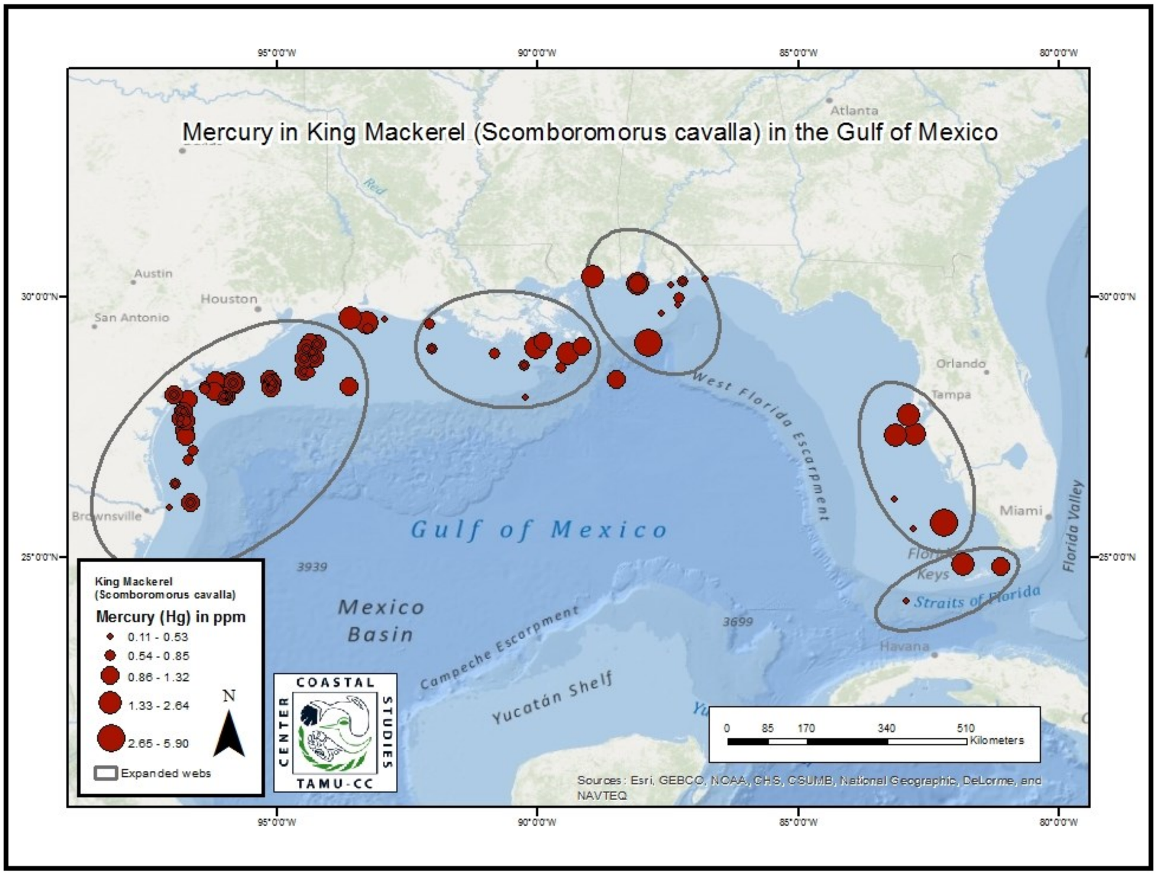

Figure 13. Map showing distribution of Hg concentrations in king mackerel in the Gulf of Mexico.

We grouped the plotted mercury concentrations for king mackerel into food web groupings and calculated the mean concentrations for those areas (Table 1). The web area that had the highest mean (1.404 ppm) was that for Web 2 on the west Florida shelf, while the lowest mean (0.673) ppm) was found in the area of Web 5 off the Texas coast.

Table 1. The mean, std deviation, std error and number of samples (n) for mercury concentrations in king mackerel collected in the areas of designated food webs.

Web	Mean (ppm)	n	Std. deviation	Std. Error
1	0.9520	3	0.6312	0.3645
2	1.4044	6	0.9761	0.3985
3	0.7784	19	0.8430	0.1934
4	0.8865	13	0.4519	0.1253
5	0.6725	214	0.2623	0.0179

Most recently we completed the compilation of Hg in spotted seatrout (*Cynoscion nebulosus*), and compiled distribution maps for this species as well (Figure 14). To determine the mercury concentration of the spotted sea trout in the Gulf of Mexico we accessed data from sources (Hall et al. 1978, Ache et al. 2000, Rider 2000, Strom, 2001, Adams et. al. 2003, Sager 2004, Evans and Crumley 2005, Lowery and Garrett 2005, Resinger 2006, Warner and Savitz 2006, Snyder and Ranga Rao 2008, Snyder and Karouna-Renier 2009, Adams et al. 2010, Katner et al. 2010, Senn et al. 2010, Gabriel 2011, Stunz and Robillard 2011). The data that was retrieved was put into an Excel spreadsheet. ArcGIS was used to load all these data and map all the data. Some sources did not have coordinates attached so polygons were constructed around these areas and the centroid of the system was calculated. Attribute tables were connected to each centroid. The parameters we looked for were: Mercury concentration (Hg ppm), maximum mercury concentration, minimum mercury concentration, number of samples, mean length of samples, mean weight of samples, author, species, latitude longitude, and area. Once every single point was calculated, all of the data was merged into one shape file and cleaned up to make one consolidated map to show the variations of mercury concentration all over the Gulf of Mexico, and visually represent the places where higher mercury concentration was found.

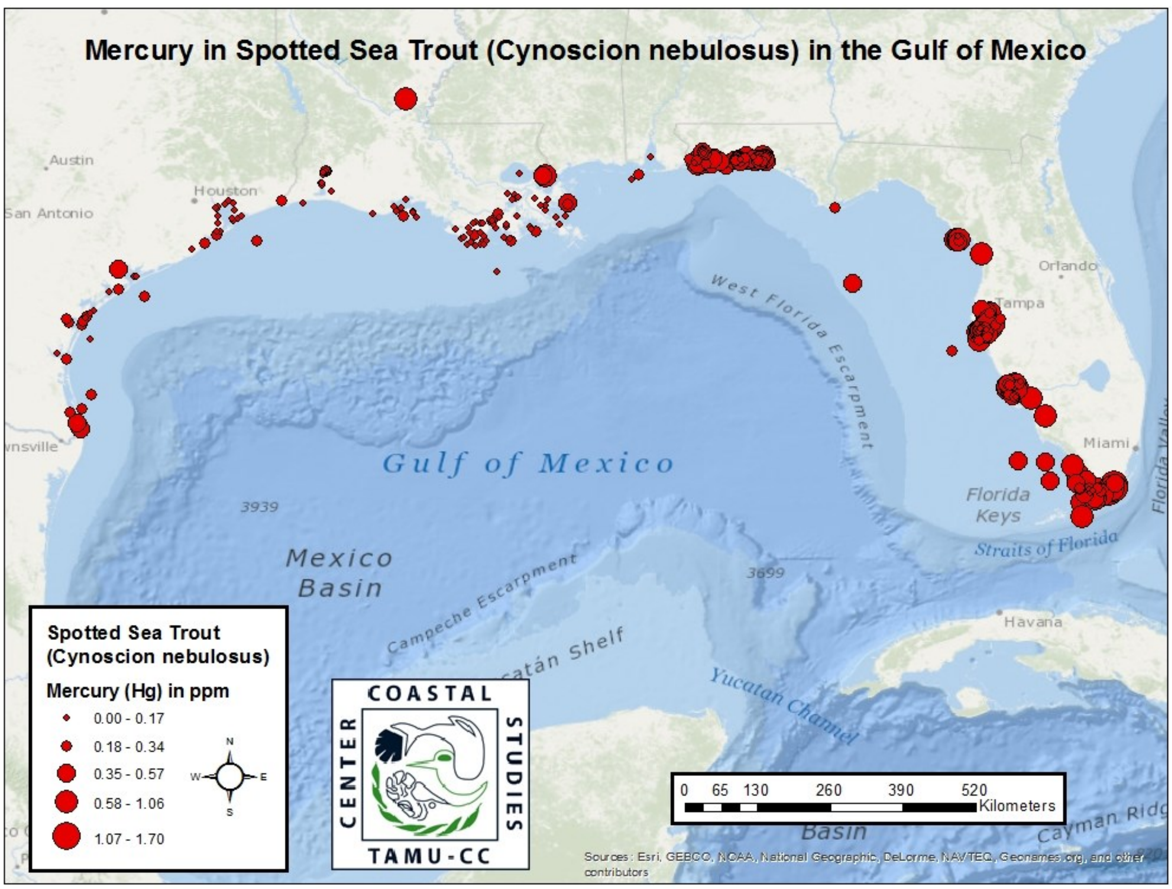

Figure 14. Map showing distribution of Hg concentrations in spotted seatrout in the Gulf of Mexico.

7.0 The species interaction database

To accommodate the normalization and integration of many heterogeneous digital trophic datasets, we developed computer programs to automate the process of parsing the raw source data files and matching scientific taxon names against external taxonomies such as provided by the Encyclopedia of Life (http://www.eol.org), Integrated Taxonomic Information System (http://www.itis.gov), World Register of Marine Species (Appeltrans et al. 2013) and GulfBase (Moretzohn et al. 2013). Scientific names that did not match against any of these taxonomies were manually corrected and digitally recorded. After the taxonomic mapping, the recorded spatial, temporal and specimen specific data (e.g. life stage, total length, stomach volume and contents) were captured in our trophic data model. This data was then used to populate the PostgreSQL / PostGIS database as well as Apache Lucene (McCandless et al. 2010), an optimized search index for fast (taxonomic) text searches, and neo4j (http://neo4j.org), a graph database optimized for complex network search and analysis.

PostgreSQL (The PostgreSQL Global Development Group 2011) was selected based on the recommendations of a number of experts (D. Vieglais, University of Kansas, M. Jones, NCEAS, M. Schildhauer, NCEAS, personal communication) as the software for the database, with PostGIS (The PostGIS Project Steering Committee 2011) as the geographical data handling extension. This combination is best suited to be able to handle the large amount of spatial data that will need to be stored and processed in applications using these data. A data dictionary that defines each of the columns of data in the six data entry spreadsheets can be found in Appendix C.

In addition to storing and indexing the GoMexSI trophic datasets, a web service was developed to facilitate integration with the GoMexSI public website. This web service provides access to functionality including, but not limited to: search for trophic interaction by predator/prey by scientific name, taxonomic rank, location, depth, and time. Also, a name lookup service was implemented to provide a list of suggestions for taxa based on partial or slightly incorrect (e.g. name with typos) scientific or common names.

For all of the software involved, automated tests have been written to a) document the expected behavior of the computer programs b) enabled automated regression testing to assure the quality of the software. All software written as part of this project is publicly available through github.com. For more information see http://github.com/jhpoelen/gomexsi and http://github.com/jhpoelen/eol-globi-data.

As the GoMexSI normalized and aggregated datasets are being used by enthusiasts and scientists alike, we hope to further expand our collection of datasets, enrich our data model and extend our web service capabilities to help answer questions to better understand the properties of Gulf of Mexico marine food webs.

8.0 GoMexSI website and video

WEBSITE:

To better serve the GoMexSI data to the public in an efficient manner, a website was developed. This task was accomplished by Reed Hewitt Media. The public-facing "front end" of the GoMexSI website is designed to welcome visitors with an attractive and uncluttered interface. The website is built on the WordPress content management system for easy maintenance and expansion over time. The website will be bilingual, allowing both English and Spanish versions of all pages and text, so that the GoMexSI database can be used more effectively by Spanish-speaking visitors.

At the heart of the GoMexSI website is the data query interface for species interactions. This portion of the website requires user registration, which is a simple and free process. Users can query data based on scientific or common names at any taxonomic level and they can limit their search to certain types of species interactions, such as predator-prey or parasite-host. Additionally, the users limit their search spatially by selecting a predefined geographic region or by drawing an arbitrary box on an interactive map. By providing a multitude of flexible search options, the GoMexSI data query interface allows users to pinpoint the data they need. The query results are rendered on the webpage in layout optimized for easy browsing. The intent is to allow users to quickly explore and preview the data. Researchers who need to do more rigorous analysis are able to download the raw data associated with their query.

Currently the GoMexSI website is up and running and content is being added. The data query interface allows simple searches for predators or prey of a given species. Development is on track to have the additional search options available by the end of March, 2013. The website can be viewed by going to the following url: http://gomexsi.tamucc.edu/.

VIDEO:

A video was produced by Reed Hewitt Media to introduce viewers to the GoMexSI project, giving them a quick overview of the purpose and capabilities of the database in less than three minutes. The video begins with a series of thought-provoking questions that would be difficult to answer without the GoMexSI database. The need for a resource that goes beyond cataloguing species and explores the interactions between species is then explained. The video also provides some inspiration to the viewers by showing examples of current projects that are already using the GoMexSI database. The video will be embedded on the home page of the GoMexSI website to give visitors a head start on their browsing experience. The video can be reviewed by going to the following url: http://reedhewitt.com/gomexsi/.

9.0 Mercury in Texas food webs

The Mercury Workgroup has identified the need to compile data on the concentration of mercury in not only the top predators and most highly consumed species of seafood in the Gulf, but there is also a need to collect and compile mercury data for the components of the food web for these species. As such, Dr. James Simons and Dr. Kim Withers (both at Center for Coastal Studies, TAMUCC) have obtained funding from the Texas Coastal Management Program (managed by the Texas General Land Office) to examine the concentration of mercury in the dominant elements of the food webs of spotted seatrout, red drum (*Sciaenops ocellatus*) and black drum (*Pogonias cromis*). In light of the importance of this study we were able to lend some support for this project so as to enable us to increase the number of samples that will be analyzed for mercury, an item that was unfortunately underfunded in the original proposal. Thus, we will be able to do an additional 29 methyl mercury analyses.

The sampling design will involve three bays along the Texas coast: Lavaca Bay (a secondary bay of the Matagorda Bay ecosystem), the upper portion of San Antonio Bay (northwest of where the ICWW transects the bay), and Nueces Bay (a secondary bay of the Corpus Christi Bay ecosystem) (see Figure 15). We will collect tissue and stomach samples in the spring and fall of 2013. Tissues for mercury and stable isotope analysis will be collected from the three aforementioned game fish. In addition, stomachs will be collected for gut content analysis to corroborate a preliminary diet table (Table 2) gleaned from the literature, and to provide samples of diet items for mercury and stable isotope analysis. Samples of dietary items will also be collected using trawls, bag seines, benthic grabs and cores, zooplankton nets, and phytoplankton nets. Analysis of stable isotopes will be conducted at Texas A&M University in College Station, and mercury analysis will be conducted at Florida State University in Tallhassee, Florida.

10.0 Summary

One of the primary pieces of information that the Mercury Workgroup of the GOMA WQ PIT is interested in is the bioaccumulation and movement of mercury through Gulf of Mexico estuarine and marine food webs. We began this project by assessing a compilation of mercury concentration data in Gulf seafood and human consumption patterns of Gulf seafood. Through this assessment, and recommendations of members of the Mercury Sub-committee, it was decided that king mackerel and spotted seatrout would be the target species for compilation of trophic data from a collection of references on trophic data in the Gulf, and the subsequent building of food webs for these species. In addition, data on mercury in these species and other food items of these species was to be compiled as well.

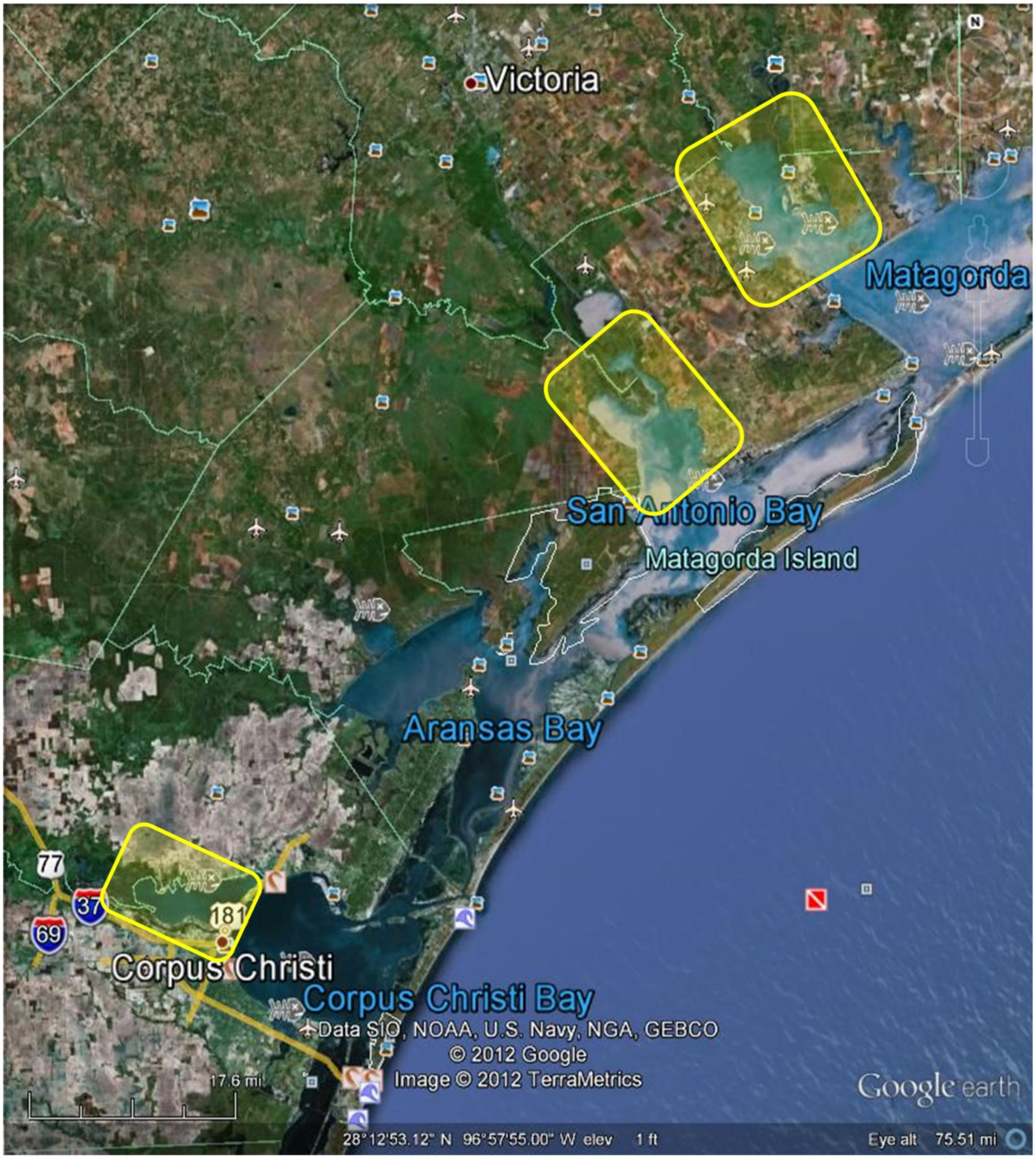

Figure 15. Map showing the location of the three Texas bays from which samples of game fish and their food items will be collected for mercury, stable isotope and gut content analysis.

Table 2. List of predators, tentative prey list, and the expected number of analyses per analyte that are expected to be conducted for each bay system for each season. Prey analyzed can be expected to change seasonally and will also depend on the results of gut content analysis and collecting efforts.

Predators	**Cynoscion nebulosus**	**3**	**3**	**8**	**24**	**3**
	Sciaenops ocellatus	3	3	8	24	3
	Pogonias cromis	3	3	8	24	3
					0	
Prey	Brevoortia patronus	3	3	8	24	2
	Anchoa mitchilli	3	3	8	24	2
	Mugil cephalus	3	3	8	24	2
	Micropogonias undulatus	3	3	8	24	2
	Leiostomus xanthurus	3	3	8	24	2
	Lagodon rhomboides	3	3	8	24	2
	Cyprinodon variegatus				0	
	Gobiidae				0	
	Polychaeta	3	3	8	24	2
	Mysida				0	
	Callinectes sapidus	3	3	8	24	2
	Dyspanopeus sayi				0	
	Palaemonetes sp.	3	3	8	24	2
	Farfantepenaeus aztecus	3	3	8	24	2
	Litopenaeus setiferus	3	3	8	24	2
	Bivalvia (Rangia, Crassostrea, Mytilus)	3	3	8	24	2
	Gastropoda				0	
	Tuethida				0	
	Zooplankton	3	3	8	24	2
	Phytoplankton	3	3	8	24	2
	Benthic algae				0	
	Detritus	3	3	8	24	2
	Sediment	3	3	8	24	2

In order to store, and serve these data it was also necessary to construct a database and companion website to house these data. The database, which is constructed using PostgreSQL software, and PostGIS software for handling of spatial data, will be accessible through a website created for that purpose. The website, named GoMexSI, stands for Gulf of Mexico Species Interactions, is now online at: www.gomexsi.tamucc.edu. There are still many things that need to be addressed to make the site fully functional, and much data still needs to be added to the database, which will be an ongoing effort into the foreseeable future.

The trophic data for king mackerel from all unique references has been compiled into Excel spreadsheets, edited and most corrections have been made. There are still some minor issues that need to be addressed, and some final format changes need to be made to the spreadsheet format before the data can be exported to csv files and uploaded to the database.

The trophic data for king mackerel has been assembled, synthesized and used to construct food webs that are spatially explicit around the Gulf of Mexico. Food webs were constructed for larval/post-larval and juvenile king mackerel, and six food webs were constructed for the adult king mackerel. These webs vary somewhat in level of detail, as those constructed for the west Florida shelf and the Veracruz areas did not have as highly resolved or as dense a data set as for the other four webs. As there is still the need to extract the diet data of many of the prey fishes of the king mackerel, much is left to be done.

Overall, a tremendous amount of progress has been made toward creating a trophic database for the Gulf of Mexico, assembling mercury data for the Gulf, and constructing food webs for impacted species. The stage has been set for continuing this work in conjunction with other efforts throughout the Gulf.

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12.0 List of Appendices

Appendix A. Excel spreadsheets with all of the current data that has been extracted and entered for king mackerel.

Appendix B. Excel spreadsheets with all of the current data that has been extracted and entered for spotted seatrout.

Appendix C. Excel spreadsheet with the current definitions for each of the column headers in the database.