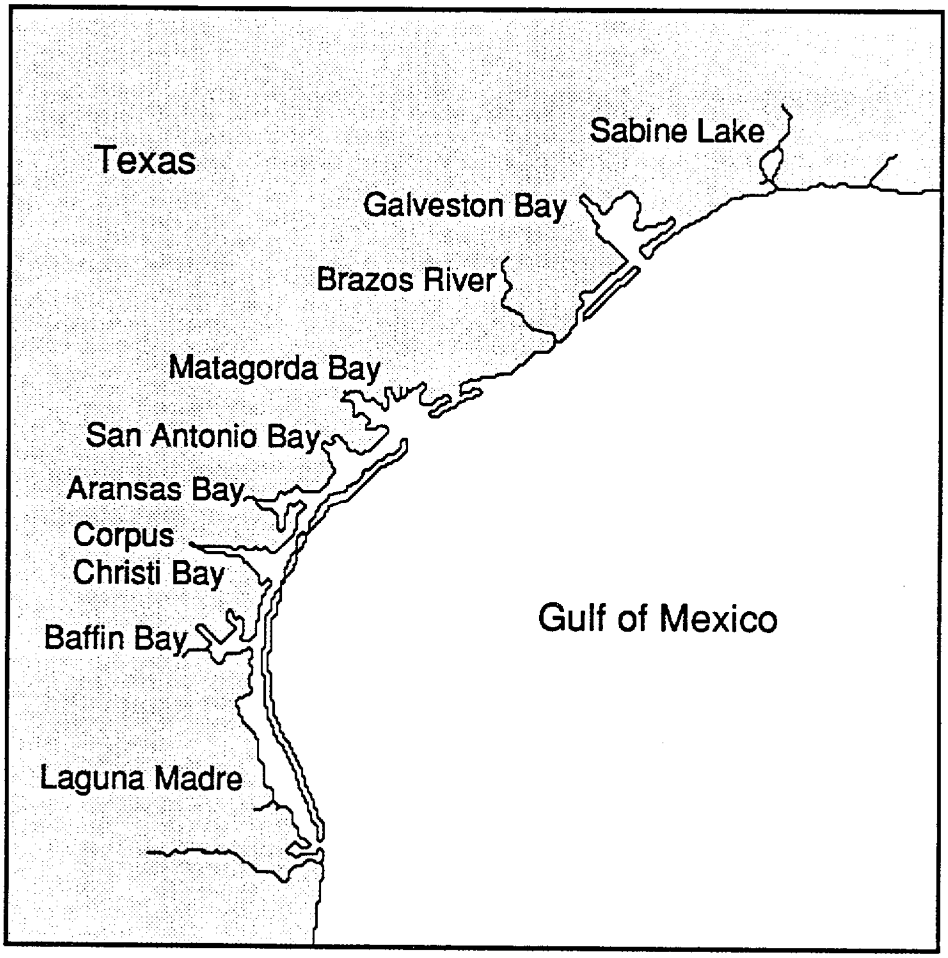
PB91-169987

NOAA's Estuarine Living Marine Resources Project

Distribution and Abundance of Fishes and Invertebrates in Texas Estuaries



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NOAA's Estuarine Living Marine Resources Project

In June 1985, the National Oceanic and Atmospheric Administration (NOAA) began a project to develop a comprehensive information base on the life history, relative abundance and distribution of fishes and invertebrates in estuaries throughout the Nation (Monaco 1986). This project, the Estuarine Living Marine Resources (ELMR) project, is conducted jointly by the Strategic Assessment Branch (SAB) of the Office of Oceanography & Marine Assessment and laboratories of the National Marine Fisheries Service (NMFS). Currently, the Pt. Adams (Hammond), OR; Galveston, TX; Beaufort, NC; and Oxford, MD laboratories are compiling information for the contiguous West Coast, Gulf of Mexico, Southeast, and Northeast regions.

To date, the project has compiled data for 115 species found in 73 estuaries. Four reports have been published: State of Washington (Monaco and Emmett 1988); State of Texas (Monaco et al. 1989); West Coast Volume I: Data Summaries (Monaco et al. 1990); and Eastern Gulf of Mexico (Williams et al. 1990). Also scheduled for publication in 1990 are the Central Gulf of Mexico (Mississippi Sound, MS through Calcasieu Lake, LA); the Southeast (Albemarle Sound, NC, through Biscayne Bay, FL) and the West Coast *Volume II: Life History Profiles.*

Three salinity zones as defined in Volume 1 of NOAA's *National Estuarine Inventory Data Atlas* (NOAA 1985) provided the spatial framework for organizing information on species distribution and abundance within each estuary. These salinity zones are tidal fresh (0.0 to 0.5 ppt), mixing (0.5 to 25.0 ppt), and seawater (25.0 and greater ppt). The primary data developed for each species for each salinity zone include spatial and temporal distribution and relative abundance by life stage, e. g., adult, spawning or mating, juvenile, larva, and egg. In addition, a detailed estuarine life history profile is developed for each species.

Additional information on this or other projects of the Strategic Assessment Branch is available from:

Strategic Assessment Branch
Office of Oceanography and Marine Assessment
National Oceanic and Atmospheric Administration
6001 Executive Blvd., Rm. 220
Rockville, Maryland 20852
(301) 443-0453

Reports available from NOAA's Estuarine Living Marine Resources project include:

Monaco, M. E., et al. 1989. Distribution and Abundance of Fishes and Invertebrates in Texas Estuaries. ELMR Rpt. No. 3. Strategic Assessment Branch, NOS/NOAA. Rockville, MD. 107 p.

Monaco, M. E., et al. 1990. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries, Volume I: Data Summaries. ELMR Rpt. No. 4. Strategic Assessment Branch, NOS/NOAA. Rockville, MD. 240 p.

Bulger, A. J., et al. 1990. A Proposed Estuarine Classification: Analysis of Species Salinity Ranges. ELMR Rpt. No. 5. Strategic Assessment Branch, NOS/NOAA. Rockville, MD. 28 p.

Williams, C. D., et al. 1990. Distribution and Abundance of Fishes and Invertebrates in Eastern Gulf of Mexico Estuaries. ELMR Rpt. No. 6. Strategic Assessment Branch, NOS/NOAA. Rockville, MD. 105 p.

BIBLIOGRAPHIC INFORMATION

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Abstract: The report presents information synthesized on the spatial and temporal distribution, relative abundance, and life history characteristics of 40 fish and invertebrate species in 9 estuaries along the Texas coast. Its purpose is to disseminate the results from the component of NOAA's Estuarine Living Marine Resources (ELMR) project. The presence, distribution, and relative abundance of each species' life history stage, and the time period it utilizes each estuary, are shown. The data and framework presented are illustrative of the nationwide ELMR project. As additional work continues on other estuaries throughout the Gulf of Mexico and more is learned about how specific species use estuaries, the data presented in the report may be refined further.

PB91-169987

Distribution and Abundance of Fishes and Invertebrates in Texas Estuaries

Project Team

Mark E. Monaco and David M. Nelson
Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
Rockville, MD 20852

Thomas E. Czapla and Mark E. Pattillo
Galveston Laboratory
Fishery Ecology Division
Southeast Fisheries Center
National Marine Fisheries Service
Galveston, TX 77551

ELMR Report Number 3

September 1989

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Introduction

This report presents information synthesized on the spatial and temporal distribution, relative abundance, and life history characteristics of 40 fish and invertebrate species in 9 estuaries along the Texas coast. Its purpose is to disseminate the results from this component of NOAA's *Estuarine Living Marine Resources* (ELMR) project (inside front cover). The presence, distribution, and relative abundance of each species' life history stage, and the time period it utilizes each estuary, are shown. The data and framework presented are illustrative of the nationwide ELMR project. As additional work continues on other estuaries throughout the Gulf of Mexico and more is learned about how specific species use estuaries, the data presented in this report may be refined further.

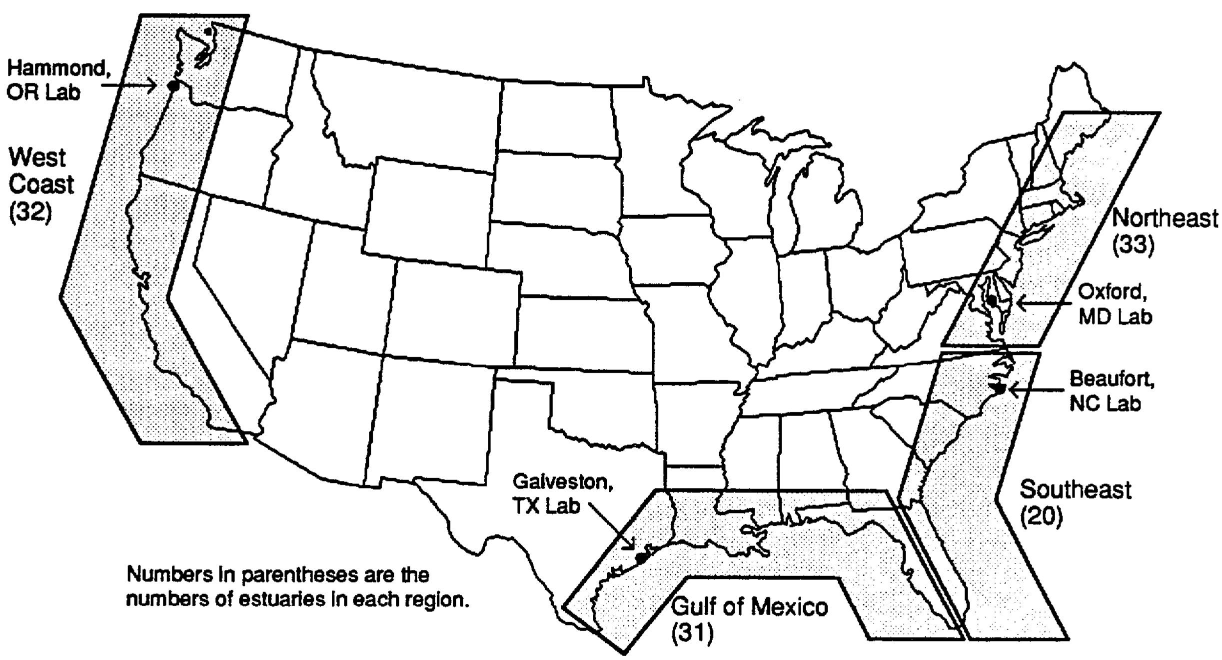
The objective of ELMR is to develop an inventory on the distribution of selected fishes and invertebrates within the Nation's estuaries. The relative abundance of each species' life stage and monthly occurrence were recorded by estuary for the three salinity regimes (seawater zone, mixing zone, and tidal fresh zone) identified in NOAA's National Estuarine Inventory - Volume I (NOAA 1985). When completed, the entire data base will contain information for approximately 150 estuarine species found in over 115 of the Nation's estuaries. The Nationwide data base is divided into four study regions (Figure 1).

Why Conduct ELMR?

Estuaries are among our most productive natural systems (Mann 1982, Odum and Heald 1975). The physical, chemical, and biological composition of estuaries are critically important to sustaining many living resources (Healy 1982, Gunter 1967, Weinstein 1979). These important nursery areas provide food, refuge from predation, and various habitats for many aquatic species (Joseph 1973). Many of these organisms are important commercial and recreational fishes and invertebrates, such as sciaenids, crabs and shrimp. In spite of the well documented importance of these areas to fish and invertebrate populations, very little comprehensive and consistent information exists on large numbers of species found in or among groups of estuaries. Much of the distribution and abundance information for these estuarine dependent species exists primarily for the offshore life history stage or the scale does not adequately address estuarine distributions (Darnell et al. 1983, NOAA 1988).

Only a few comprehensive sampling programs (e.g. State of Texas; Hammerschmidt and McEachron 1986, McEachron and Green 1984) collect organisms with identical methods across groups of estuaries within a region. Thus, much of the data cannot be compared among estuaries due to the variability in sampling strategies. In addition, existing programs do not focus on the importance of groups of estuaries

Figure 1. ELMR study regions and regional research labs.



for regional management of fishery resources. The comprehensive data that do exist are for a relatively few important commercial and recreational species.

Since life stages of many species use both estuarine and marine habitats, it is necessary to combine information on distribution, temporal utilization, and life history strategies to understand the relationships and linkages of estuaries to nearshore/offshore areas. To date, a national, comprehensive, and consistent data base does not exist on the time, space, and function of each life stage for many species found in estuarine and marine habitats. Consequently, a need exists to develop a framework to integrate the available fragments of information on marine and estuarine species and their associated habitats into a useful, comprehensive, and consistent structure.

The ELMR project has been designed to address the needs and to provide NOAA a uniform nationwide data base on selected estuarine species. Results will complement other NOAA efforts to formulate a national estuarine assessment capability (NOAA 1985) and coastal oceanic fishery sampling programs (e.g. Sherman 1985). Compiling this information will also provide a status of our knowledge of species in estuaries through the identification of information gaps and an assessment of existing data content and quality.

Data Collection and Organization

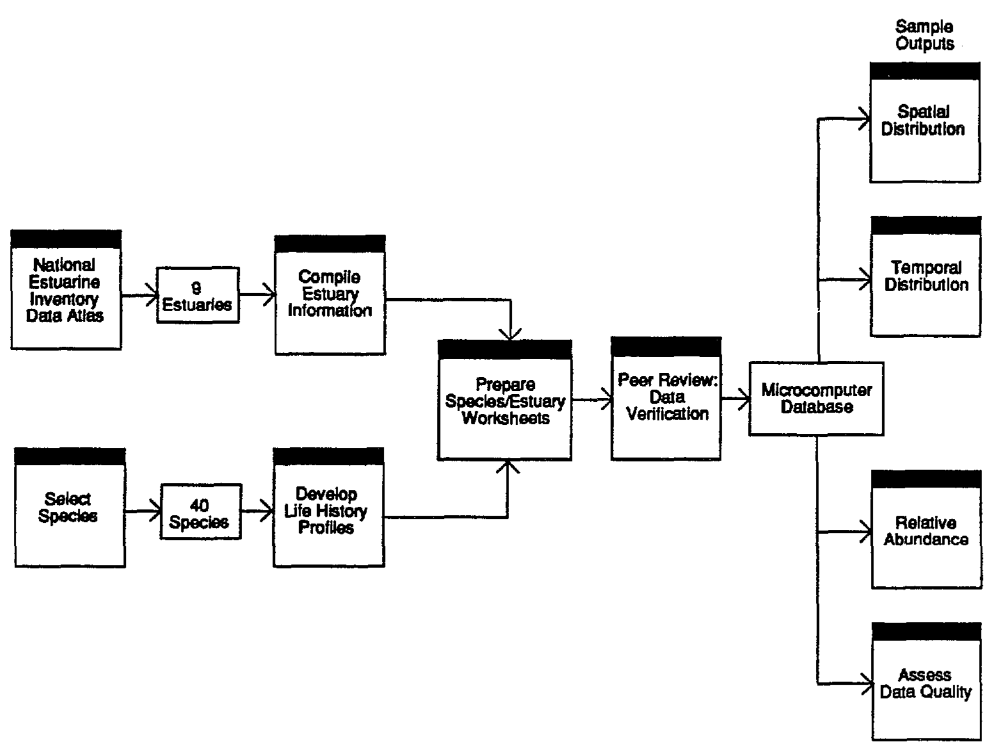
Figure 2 summarizes the major steps taken to collect and organize information on the distribution and abundance of fishes and invertebrates in Texas estuaries. The initial steps were selection of the estuaries and species to be studied.

Selection of Estuaries. Estuaries in Texas were selected based on NOAA's National Estuarine Inventory (NEI) Data Atlas - Volume 1 (Appendix 2) (NOAA 1985). Of the 38 Gulf of Mexico estuaries included in the NEI, nine of these are located along the Texas coast (Figure 3):

1. Sabine Lake
2. Galveston Bay
3. Brazos River
4. Matagorda Bay
5. San Antonio Bay
6. Aransas Bay
7. Corpus Christi Bay
8. Laguna Madre
9. Baffin Bay

Data on species spatial and temporal distributions were developed and organized based on the tidal fresh (0.0 to 0.5 ppt), mixing (0.5 to 25.0 ppt), and seawater (25.0 and greater ppt) zones delineated for each estuary in the NEI. A representative map and

Figure 2. Major steps taken to complete the ELMR Texas study.



data table (Galveston Bay) from the NEI Data Atlas (NOAA 1985) is shown in Appendix 3.

Compiling consistent species data nationwide for a region limits the amount of information that may be compiled for each species and estuary combination. Also, it would be time and cost prohibitive to map each species by life stage for each estuary (Monaco 1986). This framework enables a consistent compilation and organization of available information on the distribution of fishes and invertebrates in estuaries.

Although necessary for this study, the NEI Data Atlas (NOAA 1985) does not contain sufficient information on some physical parameters that affect species distributions. Additional information was compiled on geological history, bottom type, water temperature, tidal and freshwater circulation, and water quality to help understand the reported distribution of organisms. These additional data helped filter out seasonal anomalies and reports of unusual species distributions. Therefore, the information developed represents a species normal spatial and temporal distributions.

Figure 3. Texas estuaries.

Selection of Species. Species were selected based on four general criteria. However, species were ultimately selected based on data availability. Consequently, many of the species selected are either commercially or recreationally important. However, species of ecological value, or indicators of environmental stress were also chosen when possible. A species list (Table 1) was developed and peer reviewed to ensure that the most "important" species were chosen. The four criteria were defined as:

1) Commercial value - determined by review of catch data and value statistics from NMFS, e.g., Gulf menhaden (*Brevoortia patronus*) and Shrimp (*Penaeus* spp.).

2) Recreational value - defined as a species that recreational fishermen specifically try to catch that may or may not be of commercial importance. Recreational species were determined by consulting regional experts and NMFS reports, e.g., Spotted seatrout (*Cynoscion nebulosus*) and Red drum (*Sciaenops ocellatus*).

3) Indicator species of environmental stress - identified from the literature, discussions with fisheries experts, and from monitoring programs such as NOAA's National Status and Trends Program (NOAA 1984). These species were mollusks or bottom fishes that consume benthic invertebrates or have a strong association with bottom sediments. Their physiological disorders, morphological abnormalities, and bioaccumulation of contaminants, such as heavy metals, indicate episodes of environmental pollution and/or stress, e.g., Gulf flounder (*Paralichthys albigutta*) and American oyster (*Crassostrea virginica*).

4) Ecological value - based on several attributes, including trophic level, relative abundance, and evidence of its importance as a key predator or prey species, e.g., Bay anchovy (*Anchoa mitchilli*). Regional allowances for endangered species were also taken into consideration, e.g., Alabama shad (*Alosa alabamae*).

Species Profiles. A profile or life history description was developed for each species to provide an overview of how the species utilizes estuaries. The profiles contain more information than is depicted in the data summaries of this report and were essential to understanding and interpreting the distribution of each species. Although many species profiles previously have been published, most lack specifics on estuarine life history data deemed necessary for this study. Therefore, the profiles developed emphasize estuarine ecology, *in situ* species salinity and temperature ranges, and life history information for estuarine dependent life stages. Representative species profiles and data sheets for Bay anchovy (*Anchoa mitchilli*), Red drum (*Sciaenops ocellatus*), and Brown shrimp (*Penaeus aztecus*) are included in Appendix 4.

Table 1. ELMR species list for Texas

Scientific name	Common name
Argopecten irradians	Bay scallop
Crassostrea virginica	American oyster
Rangia cuneata	Common rangia
Mercenaria species	Hard clam
Lolliguncula brevis	Bay squid
Penaeus aztecus	Brown shrimp
Penaeus duorarum	Pink shrimp
Penaeus setiferus	White shrimp
Palaemonetes pugio	Grass shrimp
Menippe adina	Gulf stone crab
Callinectes sapidus	Blue crab
Carcharhinus leucas	Bull shark
Megalops atlanticus	Tarpon
Alosa alabamae	Alabama shad
Brevoortia patronus	Gulf menhaden
Dorosoma cepedianum	Gizzard shad
Anchoa mitchilli	Bay anchovy
Arius felis	Hardhead catfish
Cyprinodon variegatus	Sheepshead minnow
Fundulus grandis	Gulf killifish
Menidia species	Atlantic silversides
Centropomus undecimalis	Snook
Pomatomus saltatrix	Bluefish
Caranx hippos	Crevalle jack
Trachinotus carolinus	Florida pompano
Lutjanus griseus	Gray snapper
Archosargus probatocephalus	Sheepshead
Lagodon rhomboides	Pinfish
Bairdiella chrysoura	Silver perch
Cynoscion arenarius	Sand seatrout
Cynoscion nebulosus	Spotted seatrout
Leiostomus xanthurus	Spot
Micropogonias undulatus	Atlantic croaker
Pogonias cromis	Black drum
Sciaenops ocellatus	Red drum
Mugil cephalus	Striped mullet
Gobiosoma robustum	Code goby
Scomberomorus maculatus	Spanish mackerel
Paralichthys albigutta	Gulf flounder
Paralichthys lethostigma	Southern flounder

Data Sheets. A species data sheet was developed to enable quick compilation and simple graphic presentation of the data. Figure 4 shows the data sheet for Bay anchovy in Galveston Bay. A draft data sheet was developed for each species for each estuary before additional experts were consulted. Data collected on each species include: 1) the salinity zone it occupies (seawater, mixing, or tidal fresh); 2) monthly distribution throughout those zones; and 3) life history stage(s) in a particular zone and their relative abundance level.

Adults were defined as reproductively mature individuals, juveniles as immature but otherwise similar to adults, and spawning was defined as the release of eggs and sperm (fertilization). A few exceptions existed, such as the livebearers and mating in crabs.

Three steps were taken to compile these data. First, the presence or absence of a species within an estuary was determined. Second, the species monthly distribution was determined and, if possible, the peak occurrence of each life stage was noted. Finally, the relative abundance of a species in an estuary was determined using the following categories as defined below:

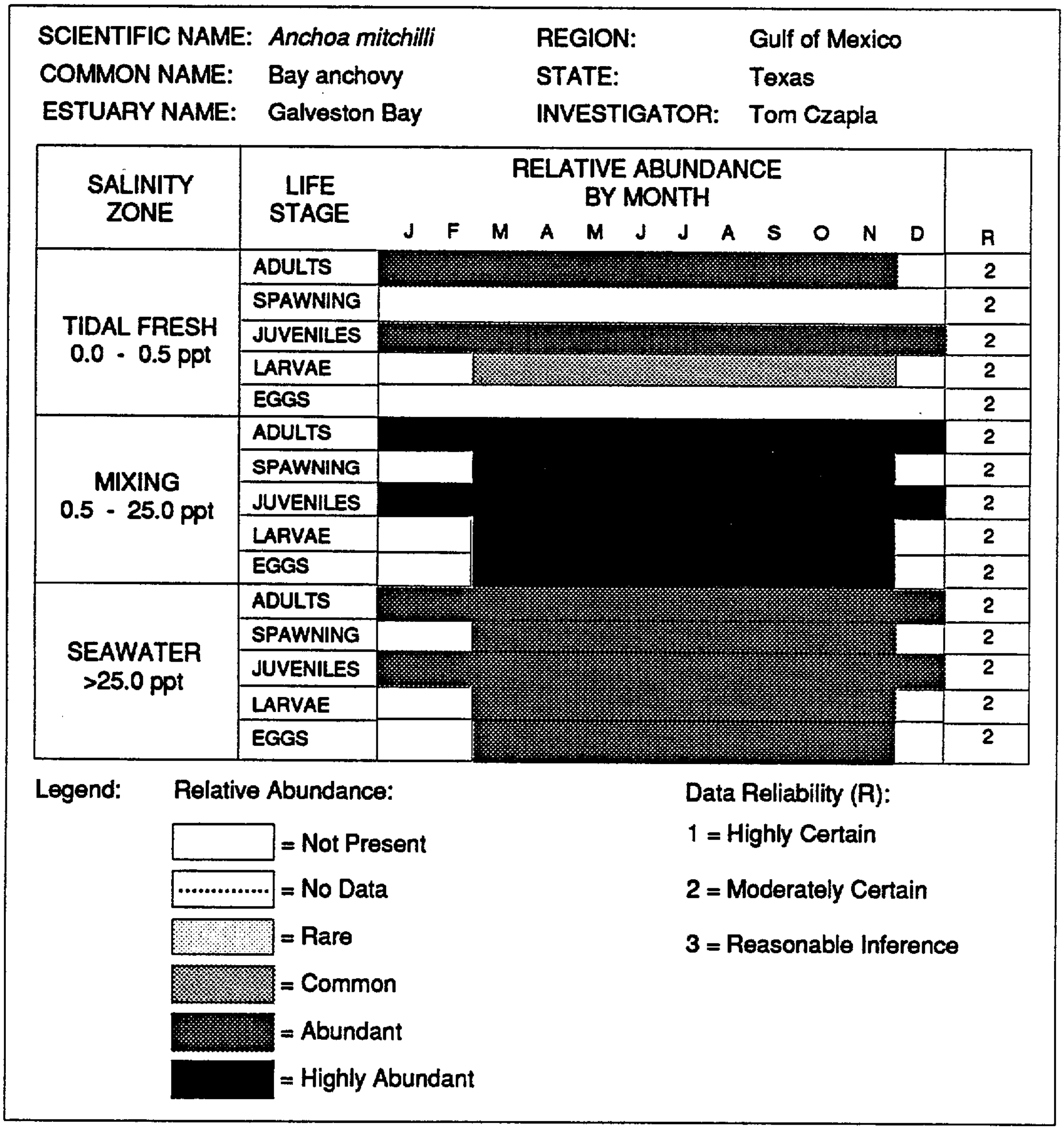
- *Not present*: species or life history stage not found, questionable data as to identification of species, and/or recent loss of habitat or environmental degradation suggests absence.
- *No information available*: no existing data available, and when after expert review it was determined that not even an educated guess would be appropriate.
- *Rare*: species is definitely present but not frequently encountered.
- *Common*: species is generally encountered but not in large numbers, does not imply an even distribution over a specific salinity zone.
- *Abundant*: species is often encountered in substantial numbers relative to other species.
- *Highly abundant*: species numerically dominates relative to other species.

For well-studied species such as shrimp, quantitative data were used to estimate abundance levels. However, for many species within any given estuary, reliable quantitative data were generally very limited. Therefore, regional and local experts were consulted to estimate relative abundance based on the above criteria. Reference or guide species with abundance levels corresponding to the above criteria were developed for each estuary in cooperation with local biologists. Other species were then placed into the appropriate category relative to the guide species. These data only represent species relative abundance levels within a specific estuary. Relative abundance levels across a suite of estuaries **could not** be determined.

Data Verification. Approximately one year was spent on data compilation and consultation with regional and local experts to develop, verify, and revise the 360 data sheets required for Texas estuaries (Figure 4). Initial interviews were arranged to explain the overall *Living Marine Resources Program* and to introduce the ELMR project. Each data sheet was carefully peer reviewed during these meetings or subsequently by mailing the draft data sheets to reviewers. These important consultations complemented the work and other published data sets aggregated by NOAA. Approximately 50 scientists and managers at 20 institutions or agencies were consulted. The names and affiliations of these experts are listed in Appendix 5, as well as in Appendix 6, which lists the primary data sources for each species by estuary. Local experts were particularly helpful in providing estuary/species specific information on distribution and abundance. They also provided additional references and contacts and identified additional species to be included in the ELMR data base.

The Texas Parks and Wildlife Department (TPWD) served as the primary source of data and reviewers of the data sheets because of their extensive estuarine fishery data base and knowledge. Each draft data sheet was reviewed and verified by several TPWD coastal biologists. In addition, experts were consulted at colleges and universities with estuarine research and academic programs.

Figure 4. Example of species/estuary data sheet: Bay anchovy in Galveston Bay.



Results of Study

Data Summaries. The information compiled for each species and estuary on the 360 data sheets has been synthesized into three data summaries. These summaries provide graphic presentations of the spatial and temporal distributions, and relative abundance by life stage, for each species and estuary (Tables 2 and 3). A ranking of the level of reliability associated with these data is provided (Table 4).

Spatial distribution and relative abundance. Table 2 summarizes the distribution and relative abundance by life stage for each species by salinity zone in each estuary. The highest level of abundance at any point in the year in each estuary is depicted. Although this report contains only a small portion of the nationwide data base, Table 2 begins to show the significance of estuaries, or at least their use by specific species and their life stages. In general, younger life stages occur at lower salinities, while adults often are found in the seawater zone.

Temporal distribution. Table 3 summarizes the temporal distribution of each species by month and life stage for each estuary. This information collapses over the three salinity zones and the highest level of abundance for a particular life stage by month is shown.

Although each species/lifestage is assigned one of five possible levels of relative abundance: not present; rare; common; abundant; or highly abundant, Tables 2 and 3 do not distinguish between the rare and not present levels. This has been done because management of estuarine fisheries often does not direct efforts towards rare species. To distinguish between "not present", "rare", and "no data", Table 5 presents information on the presence/absence of species/lifestages by salinity zone. If a lifestage of a species is rare, common, abundant, or highly abundant for at least one month of the year within an estuary, it is considered present. These data are important and are often used to explore linkages between habitats and species biogeography (Horn and Allen 1985). In addition, the Brazos River estuary has a number of species for which there are no data available. This is the only estuary in the Texas study where this occurs and these species are also reported as "not present" in Table 2 and 3. Approximately five percent of the entire Texas data base falls into the aggregated category "not present/ rare/no data".

Seasonal Abundance . To examine general seasonal abundances in species, the number of species ranked as abundant or highly abundant were counted for each lifestage in each month in the mixing zones of Sabine Lake, Galveston Bay, Brazos River, Matagorda Bay, San Antonio Bay, Aransas Bay, and Corpus Christi Bay. The numbers of species were averaged across estuaries, and the mean number of species present as larvae, juveniles, and adults were plotted versus month (Figure 5). Mixing zones only were considered because their intermediate salinities best typify the estuarine habitat and they are present in seven of the nine estuaries studied. Although this is not a statistical analysis of seasonal abundances, it does provide insights into how species are seasonally distributed in Texas estuaries. Results were:

1) The number of species for all life stages tends to be lower in winter, and higher in spring and summer.

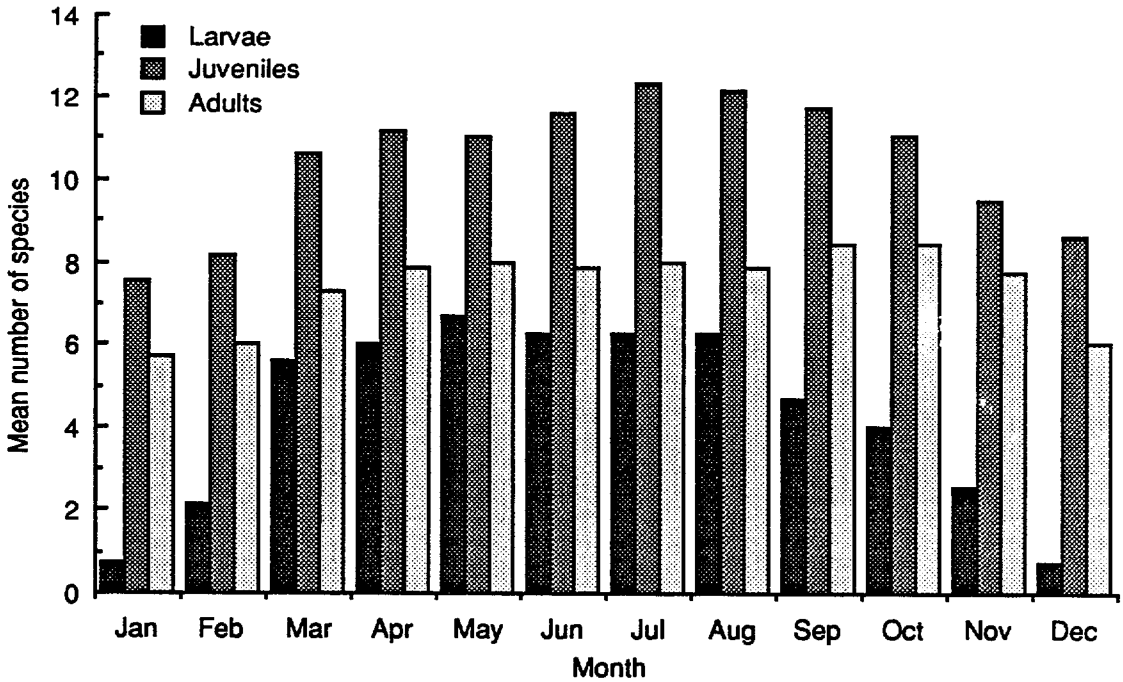
2) In each month, the number of species ranked as abundant or highly abundant in the mixing zone is highest for juveniles, moderate for adults, and lowest for larvae.

3) The number of larval species appears to peak in May, and the number of juvenile species appears to peak in July and August. This could be the result of maturation of larvae into juvenile size classes, or of immigration of juveniles into the mixing zone. The number of adult species is fairly stable from spring through fall, but is lower in the winter months.

4) The seasonal variation in the number of species is highest for larvae, moderate for juveniles, and lowest for adults.

Seasonal abundances for individual bays by larval, juvenile and adult lifestages are presented in Figure 6. Larval stages are lowest in the winter months (December to February), increasing during the spring (March to May), and summer (June to August), and finally declining in the fall (September to November). Juvenile and adult stages are abundant during the spring, summer and extending into the fall. The number of species present as juveniles and adults is high during the fall primarily due to many of these species having annual cycles, that is, juveniles are at or approaching maturity during fall and winter. In addition, adults that had earlier immigrated into the estuaries during spring/summer will experience cooler temperatures in late fall, which typically drives a majority of the adults out to warmer shelf waters, usually creating a "run" (e.g., the fall flounder run). The Brazos River system appears to have fewer species than other Texas estuaries for each lifestage. This may be primarily due to the lack of data for species in the Brazos. However, it may also be partially due to the comparatively atypical physical

Figure 5. Mean number of species ranked as abundant or highly abundant in the mixing zones of Texas estuaries.



and hydrographic characteristics of the Brazos estuary. The Brazos estuary is a river dominated system with relatively high flow and depth/width ratios, whereas most other Texas estuaries are relatively shallow, broad, tide/wind dominated systems.

Quantitative Abundance of Selected Species

Unlike most other coastal states, Texas, through its Texas Parks and Wildlife Department (TPWD), has been conducting a comprehensive fish monitoring program in coastal bays since 1977. The data presented in this section were synthesized from published TPWD reports. The monitoring program uses bag seine, otter trawl and gill net equipment to estimate abundances of fishes and invertebrates. This long-term monitoring program now makes it possible to meaningfully compare the relative abundance of selected species across Texas estuaries. The annual catch records can be monitored to witness or avoid the crashes of particular fisheries, and allow TPWD to modify existing regulations as necessary (McEachron and Green 1984). Details of the operation of this program, estuary boundaries as defined by TPWD, and sampling site locations are reported in McEachron and Green (1984).

The TPWD quantitative information supplements the relative abundance rankings of the ELMR species compiled in this report. Since TPWD generates a great deal of data from various sampling gear, only the bag seine data are being presented. Bag seines are routinely taken in the program twice a month giving more complete data (gill nets being set in the spring and fall; otter trawls once a month). Bag seine data typically include smaller fishes, juveniles and nektonic shellfish. The following discussion refers to data on annual mean number of fish per hectare by bay.

Fishes . Figure 7 shows that Galveston Bay is comparatively higher for annual mean catch for total number of fishes. Galveston Bay is in eastern Texas and receives a great deal of freshwater inflow. It is probably more representative of a "typical" estuary than the other Texas bays. Estuaries from San Antonio Bay to Mexico have only mixing and seawater zones or a seawater zone only; a tidal fresh zone is absent (NOAA 1985). While the mixing zone is the essential character of an estuary, the lack of either a tidal fresh or limited mixing zone may account for the comparatively lower abundance seen in these other bays.

In Figures 8, 9, and 10, the mean annual catch records by species have been grouped by orders of magnitude to illustrate three distinct levels of abundance by species and across estuaries. The "low abundance fishes", comprised mostly of the

Figure 6. Total number of species ranked abundant and highly abundant in the mixing zone by estuary.

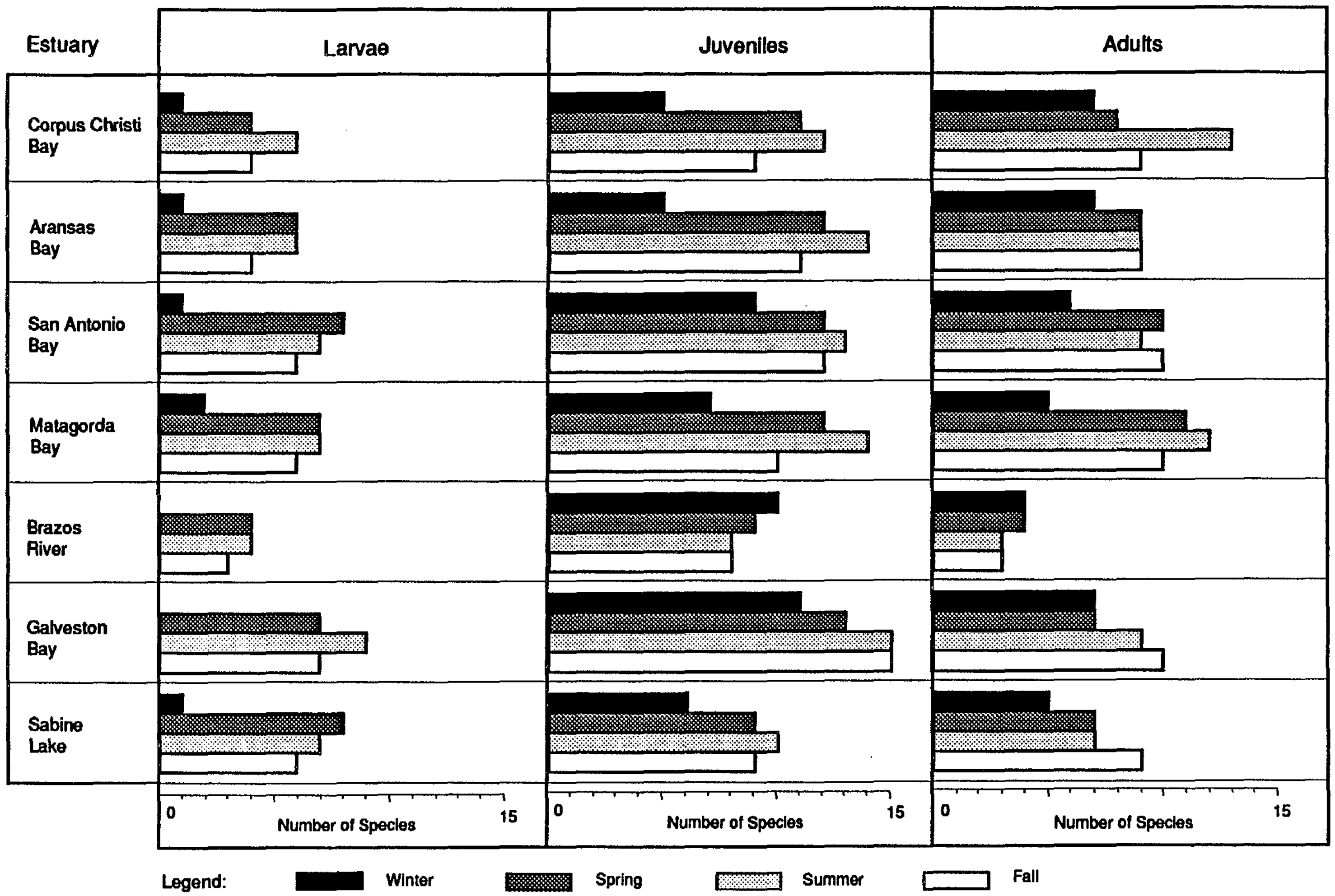


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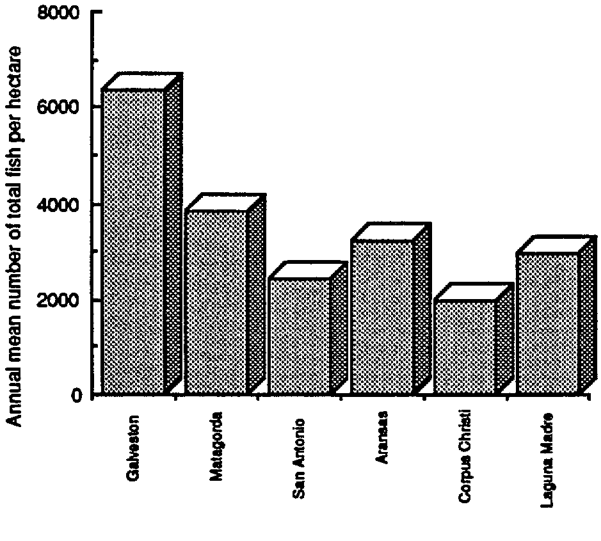
Figure 7. Annual mean number of fish per hectare by estuary.



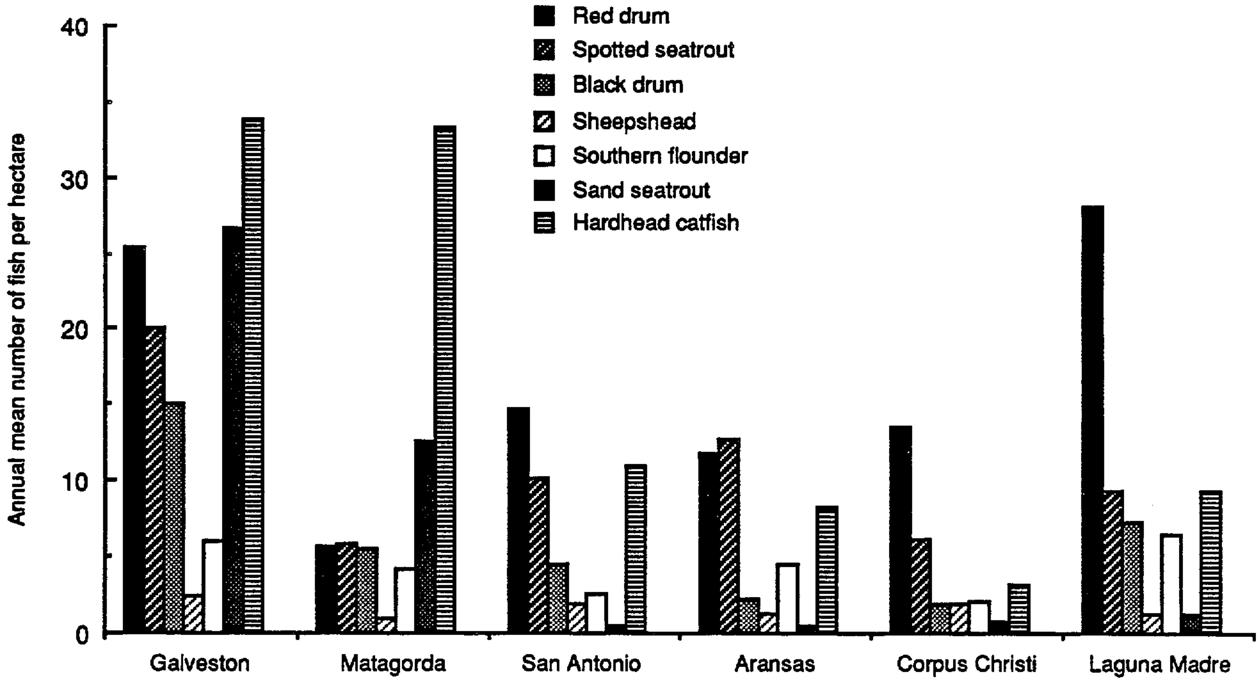
Source: Texas Parks and Wildlife Department

sciaenids and other major predatory fishes, range in annual mean number per hectare (ha) from 0-35 total fish (Figure 8). The "moderately abundant fishes", ranging in the hundreds per hectare, contain the smaller sciaenids, pinfish and mullet, all of which are forage fish inhabiting the estuaries as juveniles (Figure 9). The mean number of "highly abundant fishes", gulf menhaden and other primarily forage fishes, such as anchovy and killifishes, range in the thousands per hectare (Figure 10). Galveston Bay again has comparatively higher numbers for several species (spotted seatrout, black drum, sand seatrout, hardhead, Atlantic croaker, and gulf menhaden).

***Shrimp*.** The overall abundance data for the major penaeid species is shown in Figure 11. White shrimp are more abundant from Sabine Lake to Matagorda Bay and brown shrimp are relatively abundant throughout all the bays. Pink shrimp mostly occur in the estuaries of South Texas.

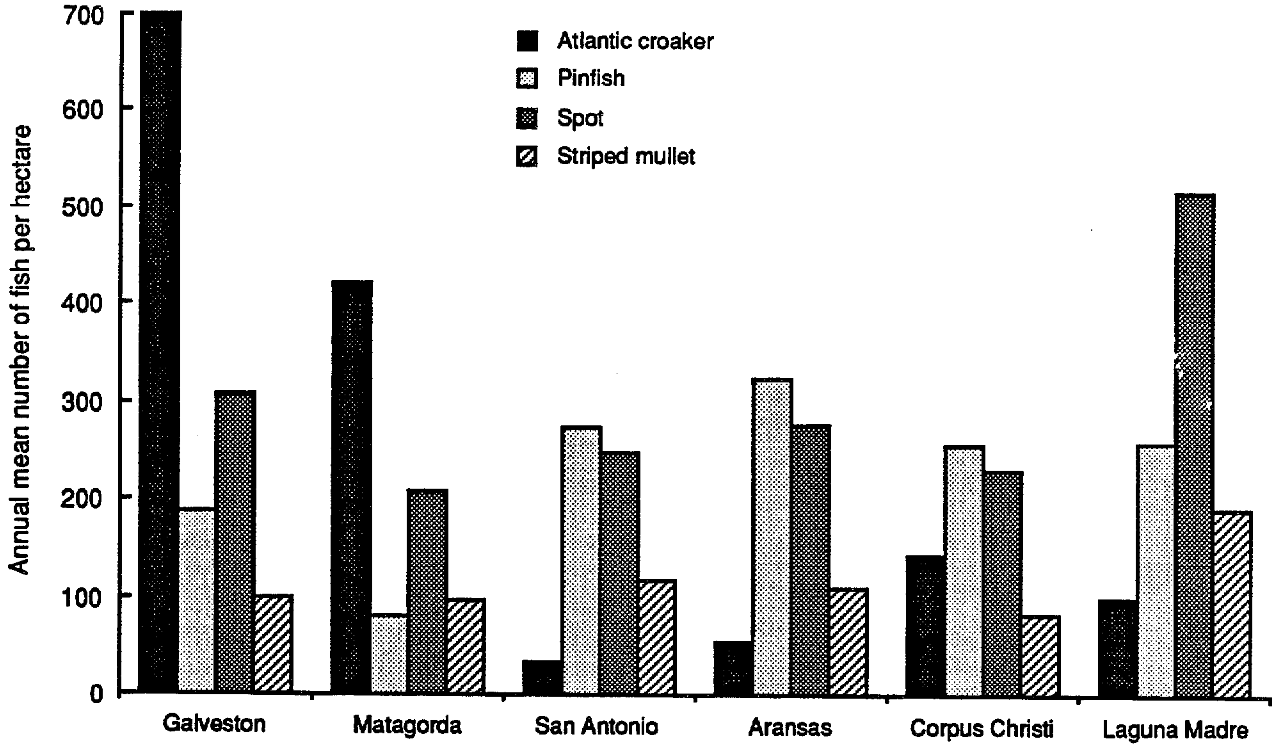
Salinity and Species Abundance. Estuaries along the Texas coast generally increase in salinity going south from Sabine Lake to Laguna Madre (Diener 1975). The effect of increasing salinity on relative abundance can be seen by changes in the numbers of certain species from estuary to estuary. Numbers of hardhead catfish, sand seatrout, Atlantic croaker, gulf menhaden and white shrimp are relatively high in Galveston and Matagorda Bays, but decline toward Laguna Madre. The importance of low salinity water to particular species, or estuarine dependence, can be seen by the production of commercially important species off Louisiana. As examples, the menhaden and shrimp fisheries are some of the most productive

Figure 8. Low abundance (<40/ha) fish by estuary.



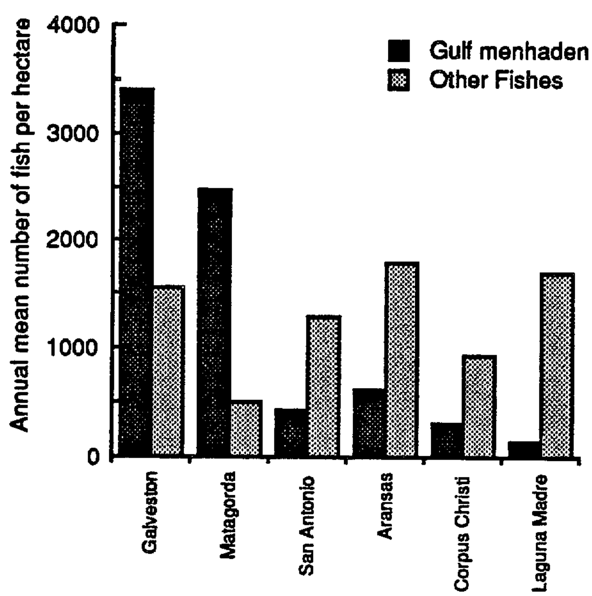
Source: Texas Parks and Wildlife Department

Figure 9. Moderately abundant (40-800/ha) fish by estuary



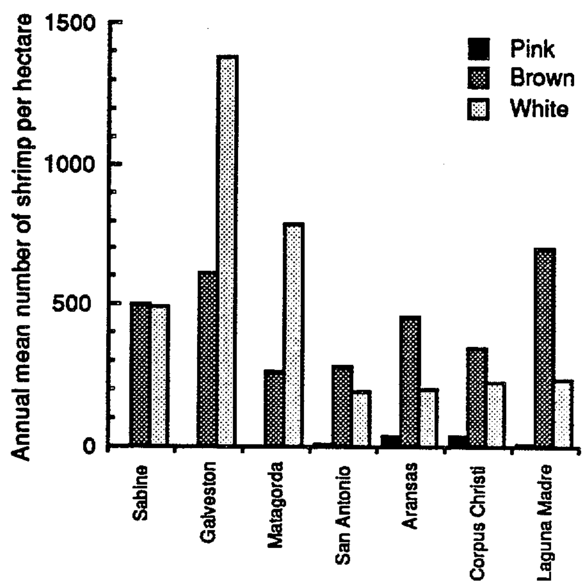
Source: Texas Parks and Wildlife Department

Figure 10. Highly abundant (>1000/ha) fish by estuary.



Source: Texas Parks and Wildlife Department

Figure 11. Abundance of shrimp by estuary.

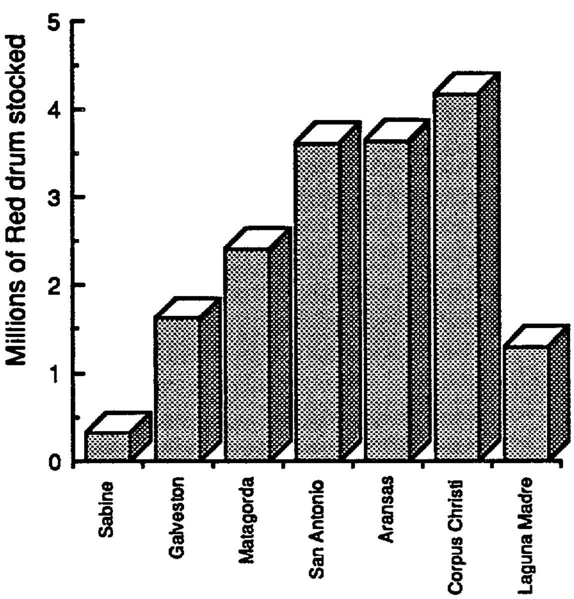


Source: Texas Parks and Wildlife Department fisheries in the United States (NMFS 1988). These species and many others, such as spot and Atlantic croaker, are very abundant in regions with low salinity waters. These waters, in conjunction with other abiotic and biotic parameters, such as bottom substrate, are important requirements of estuarine dependent organisms.

Stocking Programs. The Texas Parks and Wildlife Department releases eggs, fry and fingerlings of recreationally important fishes as an integral part of its fisheries management program to supplement the abundance of natural stocks. The program began in 1975 with red drum and striped bass. Since 1984, TPWD has released five different species of recreational importance: red drum, striped bass, spotted seatrout, black drum, and snook (Dailey 1988). The program varies in the number of releases between years and bays. Red drum have been released in all bays. Since 1983 spotted seatrout and striped bass have had limited releases in Matagorda and Galveston Bays. Black drum have only been released in Aransas Bay and snook only in Matagorda Bay.

Red drum. Red drum is regularly stocked in great abundance relative to other species (Figure 12). Since the beginning of the program in 1975, an annual average of over 10 million eggs, fry or fingerlings have been released (the number of the eggs was less than 10 % of the total). These releases have occurred in all months except January and February, and in all bay systems except Baffin Bay. The bay systems of the coastal bend (Corpus Christi, Aransas, and San Antonio) usually receive more releases because of their close proximity to the hatcheries.

Figure 12. Mean annual numbers of Red drum stocked by estuary.



Source: Texas Parks and Wildlife Department

The effect of stocking on any of these bay systems is not well understood. One study demonstrated that fingerlings survive up to one and a half months after stocking in some systems (Dailey and McEachron 1986), while another study did not demonstrate any survival (Matlock 1988). Although survival rates of stocked fishes cannot be determined at this time, average annual releases of 1 to 4 million eggs, fry or fingerlings within a system could increase the abundance of red drum.

Striped bass. From 1975 to 1977, striped bass were principally stocked in Corpus Christi and San Antonio Bays. More recently (1983-1987), efforts have been in stocking Galveston Bay with an average of 2.6 million striped bass fry per year (Dailey 1988). Less than 0.2 % of the total has been stocked in Matagorda Bay.

Spotted seatrout. Releases of spotted seatrout fry and fingerlings have taken place almost entirely in Matagorda Bay, with less than 3% of the total being stocked in Galveston Bay. An annual average of over 334,000 spotted seatrout have been released in Matagorda Bay since 1983.

Black drum and Snook. The stocking programs for black drum and snook are not as extensive as those for the species mentioned above. In 1984, 31,000 black drum were released in San Antonio Bay, and 4,249 black drum were released in Matagorda Bay. In 1985, 333 snook were released in Aransas Bay.

Data Content and Quality

An important aspect of any study, especially one based on literature reviews and consultations, is to determine the quality of the data used. Depending on the questions to be addressed, data of varying quality may or may not be suitable to use. An explicit effort was undertaken to assess consistently the "overall" quality of the data developed so that the information can be used appropriately.

Estimates of the level of reliability associated with the distributional information organized by species, life stage, and estuary are presented in Table 4 of the *Data Summary Tables* section. The following criteria were used:

Highly certain: Considerable sampling data available. Distribution, behavior, and preferred habitats well documented within an estuary.

Moderately certain: Some sampling data available for an estuary. Distribution, preferred habitat, and behavior well documented in similar estuaries.

Reasonable inference: Little or no sampling data available. Information on behavior and preferred habitats documented in similar estuaries.

The quality and quantity of available data vary by species and by estuary. For example, a large amount of information is available on shrimp because they are highly valued both commercially and recreationally. The least amount of information available and poorest quality of data are for the spawning, egg, and larval life stages. Except for a few species (e.g. brown shrimp), very little data has been generated on particular habitat preferences and environmental tolerances. This is particularly true for the smaller forage and/or non-commercial fishes and invertebrates. Gear selectivity, inability to correctly identify larval stages and difficulty of sampling various habitats limits the development and reliability of this information. In addition, life history data are lacking on some of the commercially important sciaenid and pelagic species.

Data reliability was also based on the number of studies conducted on a species within an estuary and whether they represented a time-series data set or were designed to identify and quantify a species' particular life stage. For example, TPWD used different gear types to sample various habitats accurately (Hammerschmidt and McEachron 1986). These data are more reliable due to sampling of specific habitats with consistent and efficient gear. In the case of limited studies, information was occasionally inferred. Because this report is part of the larger Gulf of Mexico data base still under development, an opportunity exists to refine the data presented based on additional reviews.

Given that the amount and quality of available information varies by species, by life stage, between estuaries, and even within an estuary, considerable scientific judgment is required to derive or infer spatial and temporal distributions from existing data and available literature. Unfortunately, even the most informed judgment is far from perfect due to the complexity of estuarine systems. Consequently, information on the level of certainty associated with each data element must be presented when synthesizing multiple data sets (Table 4). In addition, Appendices 5 and 6 provide a complete summary of the personal communications and primary references to enable individuals to track and obtain additional information efficiently.

Variability in Space and Time. Species data have been organized according to the salinity zone boundaries developed for each estuary in the NEI data atlas-Volume 1 (NOAA 1985). However, division of an estuary on the basis of salinity is highly variable due to the many interacting factors that affect salinity, such as variations in freshwater inflow, wind, and tides. To compile information on species distribution according to these zones, it is assumed that if a particular salinity zone increases or decreases, the distribution of a mobile species in that zone will correspond to that shift. For example, if increased freshwater inflow shifts the tidal fresh zone further down the estuary, the distribution of a species confined to that zone increases to include the new area. If a species exhibits a wide range of salinity tolerance, a shift may or may not occur. This information was combined with additional habitat parameters, such as bottom type, to develop species distributional data. The final placement of species in a salinity zone was ultimately determined by where they have actually been observed or captured.

Temporal distributions are often dependent on annual climatic conditions and water currents. Monthly distributional patterns were derived based on the consistent presence of a life stage within a particular month. If a species is only present in an estuary in unusual years (e.g. drought), it is not portrayed as part of that species spatial or temporal distribution. However, if a species is normally found, even during a restricted time period, it is portrayed present for the specific month(s). Greater temporal resolution, such as on a biweekly rather than on a monthly basis, was not possible.

Abundance Data. Except for a relatively few important commercial or recreational species, little or no quantitative information is available to determine relative species abundance for a large number of organisms across estuaries. Therefore, an attempt was made to only determine the relative abundance of a species compared to other species within an individual estuary. For well studied species, e.g. juvenile sciaenids or juvenile penaeids, quantitative data were used to estimate abundance within an estuary. However, in most cases the final level of abundance assigned to a species was determined by asking regional and local experts for opinions based on their knowledge of individual species within an estuary. This effort complemented the quantitative studies, and greatly increased the reliability of the abundance information. It is important to note that the TPWD has a quantitative computerized data base on the distribution and abundance of several species found in Texas bays. The published information from this data base was a component used to develop the relative abundance information shown in this report. However, for the reasons discussed below, it was not possible to use this data base to determine species abundance levels across the nine Texas bays in the ELMR study. First, not all of the estuaries in the ELMR project are included in the TPWD data base. Second, the TPWD reports only summarize some of the commercially or recreationally important fishes and invertebrates (approximately 15) and classify the rest of the fishes, such as forage species, into a category designated as "other finfish". Finally, it was not feasible to query the TPWD system for 40 species and 9 estuaries, by 3 salinity zones, for over approximately 10 years due to the tremendous amount of time and effort necessary to do this. Therefore, the analyses of the TPWD data shown in this report are synthesized from their annual reports. These reports typically summarize the last year of data by month along with several previous years of data by year, allowing for some comparison between bays, but only on a yearly basis. This report only attempts relatively simple analyses of the TPWD data to generate a summary of several years by months to explore seasonal patterns. Based on the above facts, the relative abundance information shown in the data summaries of this report is the "best" that could be synthesized from the TPWD reports, other studies, and expert reviews.

Brazos River Estuary Data. A special section on the data for the Brazos River estuary is presented here due to the limited amount of biological information available for this system. The Brazos River is one of the longest and largest river basins in Texas, making it an important system with respect to river drainage and as an estuarine ecosystem influenced by salinity. It is physically and hydrologically different from other Texas estuaries. Biological data on species temporal and spatial distributions and relative abundance is very limited for the Brazos River Estuary. The literature contained only two accessible reports addressing species distributions: Johnson (1977), and Armstrong and Goldstein (1975). Therefore much of the Brazos River data in this report is primarily inferred from the tidal fresh and mixing zones data of Matagorda and Galveston Bays; its closest neighbors. However, not all data can be easily transposed since the Brazos is a river dominated system (Bernard et al. 1978), and lacks the tidal influences that affect the adjacent estuaries. Therefore, the reliability of the Brazos River Estuary information is low.

Complex Life Histories. Because of the complex life histories of some species, the following comments are provided to clarify and supplement the information presented in the data summary tables.

Invertebrates. Sessile invertebrates, such as clams and oysters, usually have a patchy rather than a general distribution. Therefore, the areal distribution of these organisms may be overestimated, but the salinity zones of colonization are identified. Specific areas may contain acceptable salinity regimes, but suitable bottom habitat for colonization may not exist. Specific habitat requirements and life history characteristics of a number of invertebrate species are provided below:

- *Bay scallop*: Usually associated with seagrass beds.
- *Rangia*: All life stages occur in salinities below 25 ppt.
- *Hard clam*: Most life stages occur in salinities above 20 ppt.
- *Bay squid*: The lower lethal salinity limit is 17.5 ppt, and bay squid actively avoid salinities that are lower than this. Therefore, the distribution of juveniles and adults will only be from the lower margin of the mixing zone to the sea water zone, and out to the nearshore shelf waters of the Gulf of Mexico.
- *Penaeid shrimp*: Postlarvae and juveniles are the critical life stages utilizing the estuaries. Adults normally move to nearshore spawning grounds, where spawning, egg development, and most of the larval development occur.
- *Grass shrimp*: Eggs and larvae are brooded.
- *Gulf Stone crab*: Usually found in salinities greater than 20 ppt. Males are typically located in nearshore waters, but migrate into the estuaries for mating.
- *Blue crab*: Mating usually takes place in the low salinities of the tidal fresh to the upper region of the mixing zone. After mating, females move to the seawater zone, while males often remain in the upper reaches of the estuary. The females brood the eggs, and larvae are released in the seawater zone. Megalopae are transported into the estuary for dispersion throughout the salinity zones. As they approach maturity, blue crabs seek lower salinities.

Fishes. Aggregating species by salinity zone uses a single fundamental habitat parameter. However, a combination of habitat characteristics, such as bottom type, water temperature, and bathymetry, would more accurately indicate species spatial and temporal distributions. Specific habitat requirements and life history characteristics of a number of fishes are presented here:

- *Bull shark*: Development of eggs and larvae are internal, and birth results in pups of juvenile size. Therefore, only juveniles and adults are found in the estuaries. Fishing gear usually limits the ability to take large sharks. Based on the sizes of sharks captured, it may be inferred that parturition is occurring within the estuaries.

- *Tarpon*: Spawning, egg and larval stages occur well off shore. Juveniles use the estuaries as a nursery ground, often seeking waters of low dissolved oxygen and low salinity.

- *Alabama shad*: Not found west of the Barataria Bay barrier islands in Louisiana.

- *Gulf menhaden*: Typically only the juveniles are found in the estuaries. Sub-adults move into the Gulf for maturation and spawning, and larvae move towards the bays.

- *Gizzard shad*: Large juveniles and adults are found in the estuaries, but adults must return to freshwater to spawn. In large rivers there is a migration or "spring run" up the river. Large juveniles that are washed into bays with floods can mature to adulthood, but their upstream migration may be impeded by waterway restrictions.

- *Hardhead catfish*: Eggs and larvae are brooded in the mouths of adult males, therefore their distribution is determined by the adult population.

- *Bluefish*: Juveniles and adults are the principal life stages found in estuaries. Adults may ascend rivers into brackish waters. Spawning, egg and larval development occur offshore.

- *Crevalle jack*: The juvenile stage is found in estuaries, but all other life stages are in offshore waters.

- *Florida pompano*: Typically found in nearshore surf and inlet waters, but juveniles and adults sometimes enter the bays. Spawning, eggs and larvae are distributed offshore.

- *Gray snapper*: Larvae and juveniles are typically associated with vegetation in estuaries, particularly seagrass beds and mangroves. Adults, spawning and eggs usually occur offshore.

- *Pinfish*: Juveniles are the predominant life stage within estuaries. Spawning, eggs and adults are usually offshore. Larvae are transported to inlets, but usually juvenile size has been attained before they enter the bays. Subadults and adults may remain in some bays before migrating out to spawning grounds.

- *Sheepshead*: Spawning occurs in nearshore and inlet waters. Larvae are transported towards the estuaries, but usually juvenile size is reached before they enter.

- *Sciaenids*: Almost all of the sciaenids move to nearshore or offshore waters for spawning, although some fish may spawn in passes. Larvae may be transported toward estuaries, but fish are usually of juvenile size by the time they enter. Juveniles develop in the nursery habitats of the bays, then migrate out as subadults. Since some of these species have rather long life spans, several years may be spent in the estuaries as juveniles. As temperatures drop in the winter, they move into deeper waters.

- *Striped mullet*: Adults, spawning, eggs and larvae are in offshore waters, although some spawning may occur around the passes. Estuarine habitat is primarily used by juveniles.

- *Code goby*: Usually associated with seagrasses and higher salinities.

- *Spanish mackerel*: Juveniles occur in estuaries, but all other life stages are pelagic and occur offshore.

- *Flounders*: Both Southern and Gulf flounders have similar habitat requirements. Spawning, eggs and larvae are distributed in nearshore waters. Juveniles migrate into the bays for growth and development. Gulf flounder appear to be more restricted in their ascent into fresher water, typically remaining in salinities greater than 20 ppt. Juveniles and adults migrate according to temperature, creating "fall runs" to the offshore waters.

Use of ELMR Data

Classifying and Comparing Estuaries. In spite of the qualitative nature of the distributional data precluding exact comparisons of species abundances among estuaries, much can be done using information on presence or absence and timing of life stages in a salinity zone. This information, combined with the identification of the time period each species utilizes the estuary, is the strength of the data base. Estuaries can be categorized in a preliminary way by their biological characteristics, and correlations of species distributions in and among estuaries may be identified. The relative importance of individual estuaries in a particular region can also be assessed for a specific group of species based on varied criterion of significance.

The species found in a given estuary are far more sensitive indicators of both mean and extreme conditions than any set of physical measurements. Estuaries can therefore be classified by the number of species present and by whether they are primarily marine, estuarine, or freshwater dominated. Species assemblages may correlate with any number of physical characteristics, such as bottom substrate, vegetation, and the areal and temporal characteristics of salinity zones. Species assemblage correlations can be done even with an incomplete species list as long as the list's biases are considered. The information on species presence or absence, area, or other attributes can be used to determine whether estuaries cluster or are spread out along a continuum.

Any shift in a species position in a list ranked by degree of abundance when comparing estuaries warrants further analysis. A comparison among estuaries using various correlates of that species' distribution can identify differing factors among those estuaries that might account for the species shift in relative abundance, thereby helping to define the major environmental variables controlling its distribution. In addition, ecological controls on a species can also be investigated. For example, a species may show differing salinity tolerances among estuaries, indicating that some other factor, such as presence of a competitor, predator, availability of specific food source, bottom type, or degree of pollution may be regulating its distribution.

Linkages To Marine Ecosystems. Many species use estuaries for specific parts of their life histories and spend the rest offshore. Most species fall into four general categories: 1) diadromous species using estuaries as migration corridors and, in some instances, nursery areas; 2) species that enter estuaries to utilize various habitats for spawning, such as specific salinity regimes; 3) other offshore species spawning near the mouths of estuaries so that tidal and wind driven currents can carry eggs and larvae into estuarine nursery areas; and 4) species entering estuaries as adults during certain times of year to feed on higher densities of prey. The importance of any estuary to primarily offshore species can be determined by the intensity of use of that estuary by those species, most of which fall into one or more of the four categories. Importance can be measured both by the number of offshore species present as well as their actual abundances in the estuary and offshore. These data may provide clues for further investigation of the adverse effects on an offshore population due to environmental degradation of a given estuary.

The presence or absence of members of a set of pre-selected species or species with specific life history strategies can be used to rank an estuaries' importance to these species on a regional basis. For example, if the species group is defined as anadromous species which are commercially important offshore, the strength of the offshore-estuarine linkage for each estuary can be established. This can be used to identify, on a regional basis, estuaries worthy of special attention or management. This kind of approach may facilitate the linking and importance of estuaries to geographically defined marine ecosystems. The data sets developed or under development in the *Living Marine Resources Program* will enable regional assessments with consistent species information for life stage and life history strategies from the head-of-tide in estuaries to the continental shelf. The integration of the biological and physical data will significantly improve our ability to identify and define the linkages and interchanges between estuarine and shelf habitats.

Concluding Comments

This study is the second completed component of an effort to develop a consistent and comprehensive data base on the life history, distribution, and relative abundance of selected fishes and invertebrates throughout estuaries of the USA. The information presented is a result of a program designed to "capture" the Nation's data, information, and expertise on species in estuaries. This work is one step in developing an information base and operational capability to bridge the gap between site specific estuarine problems and formulation of regional management strategies. Filling this gap(s) is now more important than ever before, as it becomes clear that the cumulative effects of small changes in many places may have much greater systematic effects throughout the Nation's estuaries and coastal oceans.

Compiling, transcribing, and unifying the endless fragments of information is a very difficult task, but necessary to effectively manage the Nation's estuarine resource base. Although the knowledge available to effectively preserve these areas and their resources continues to be limited, the ELMR data base will enable comparisons among species, groups of species, specific life stages and times of year within an estuary, or by geographic regions. In addition, knowledge gaps will be identified. When combined with other NOAA data sets, the ELMR data base will also be useful in developing and testing various hypotheses.

Developing this information for the Nation is an enormous undertaking. This report alone required consultations with over 25 experts and the use of over 400 references to develop the relatively simple data summaries for only nine estuaries. Consequently, the emphasis has been primarily on developing distributional information on individual species by estuary, paying particular attention to life stage, the time period a species utilizes an estuary, and its general habitat requirements. Knowledge of the detailed biogeography of many species across estuaries provides new opportunities to address a range of broader problems and a framework to identify resource use conflicts for further investigation.

Data Summary Tables

Table 2. Spatial distribution and relative abundance.

		Texas Estuaries																										
		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
Species/Life Stage		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Bay scallop	A																											
Argopecten irradians	S																											
	J																											
	L																											
	E																											
American oyster	A		○			◉						○			◉			○			○							
Crassostrea virginica	S		○			◉						○			◉			○			○							
	J		○			●						○			◉			○			○							
	L		○			◉						○			◉			○			○							
	E		○			◉						○			◉			○			○							
Common rangia	A		●		◉	○					○	○																
Rangia cuneata	S		●		◉	○					○	○																
	J		●		◉	○					○	○																
	L		●		◉	○					○	○																
	E		●			○					○	○																
Hard clam	A						○						○			○		○	○		○	○						
Mercenaria species	S						○						○			○		○	○		○	○						
	J						○						○			○		○	○		○	○						
	L						○						○			○		○	○		○	○						
	E						○						○			○		○	○		○	○						
Bay squid	A					○	○		○			○	◉		○	◉		○	○		○	○			○			○
Lolliguncula brevis	S					○	○					○	◉		○	◉		○	○		○	○			○			
	J					○	○		○			○	◉		○	◉		○	○		○	○			○			○
	L					○	○					○	◉		○	◉		○	○		○	○			○			
	E					○	○					○	◉		○	◉		○	○		○	○			○			
Brown shrimp	A											○	●		○	◉									○			
Penaeus aztecus	S																											
	J	○	◉		◉	●	◉		◉		○	●	○		●	○		●	◉		●	○			◉			●
	L		◉			○	●		◉		○	●	●		●	●		◉	◉		○	○						
	E																											

T M * T M S T M * T M S * M S * M S * M S * * S * * S
Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Relative Abundance

● Highly Abundant
◉ Abundant
○ Common
Blank Not Present, Rare, or No Data Available

Salinity Zone

T - Tidal Fresh
M - Mixing
S - Seawater
* - Salinity zone not present

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 2, continued. Spatial distribution and relative abundance.

Species/Life Stage		Texas Estuaries: Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Pink shrimp	A											O	O		O	O		O							O			
Penaeus duorarum	S																											
	J								O						O	O		O	O		O	O			◉			O
	L																											
	E																											
White shrimp	A	◉	●			O	O		O			◉	O		●	●		O	O		O	◉			O			
Penaeus setiferus	S																											
	J	●	●		●	●	◉	●	●		●	◉	O		●	O		◉	O		◉	◉			◉			
	L		●		O	◉	●	◉	◉		●	●	●		●	●			O									
	E																											
Grass shrimp	A	◉	●		O	●	◉		◉		●	●	●		◉	O		◉	◉		●	◉			●			●
Palaemonetes pugio	S	◉	●		O	●	◉		◉		●	●	●		◉	O		◉	◉		●	◉			●			●
	J	◉	●		O	●	◉		◉		●	●	●		◉	O		◉	◉		●	◉			●			●
	L	◉	●		O	●	◉		◉		●	●	●		◉	O		◉	◉		●	◉			●			●
	E	◉	●		O	●	◉		◉		●	●	●		◉	O		◉	◉		●	◉			●			●
Blue crab	A	●	●		◉	◉	◉		O		O	◉	O		●	O		◉	O		O	◉			◉			◉
Callinectes sapidus	M	◉	◉		O	O			O		O				O			O			O				O			
	J	◉	◉		◉	◉	◉		O		O	◉	O		●			◉	●		O	●			◉			◉
	L		◉			◉	◉		O		●	◉	O			●		O	O		O	◉			◉			O
	S					◉	◉		O				O			●			O			◉			◉			O
Gulf stone crab	A						O					O	O		O	O		O	O		O	O						O
Menippe adina	M						O						O			O			O			O						O
	J						O					O	O		O	O		O	O		O	O						O
	L						O						O			O			O			O						O
	S						O						O			O			O			O						O
Bull shark	A																											
Carcharhinus leucas	M																											
	J					O					O	O	O		O	O		O	O		O	O						

T M * T M S T M * T M S * M S * M S * M S * * S * * S
Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Relative Abundance

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O Common
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* - Salinity zone not present

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs
M - Mating

Table 2, continued. Spatial distribution and relative abundance.

		Texas Estuaries																										
		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
Species/Life Stage		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Tarpon	A												O			O												
Megalops	S																											
atlanticus	J												O			O												
	L																											
	E																											
Alabama shad	A																											
Alosa	S																											
alabamae	J																											
	L																											
	E																											
Gulf menhaden	A	O	O									◉	●		O	O					O	O			O			
Brevoortia	S																											
patronus	J	●	●		O	●	◉		◉		●	●	●		◉	O		◉	◉		◉	◉			◉			●
	L																		◉			O						
	E																											
Gizzard shad	A	O	O		O	O	O	O	O		◉	O			O						O							◉
Dorosoma	S																											
cepedianum	J										◉	O			O						O							◉
	L																											
	E																											
Bay anchovy	A	◉	◉		◉	●	◉		●		◉	●	O		●	O		●	O		●	O			●			●
Anchoa	S		O			●	◉		●		O	●	O		●	O		●	O		●	O			●			●
mitchilli	J	◉	◉		◉	●	◉		●		◉	◉	O		◉	O		●	O		●	O			●			●
	L	O	O		O	●	◉		●		◉	O	O		●	O		●	O		●	O			●			●
	E		O			●	◉		●		O	O	O		●	O		●	O		●	O			●			●
Hardhead catfish	A		O		O	◉	◉	O	O			◉	◉		◉	●		◉	O		◉	O			◉			●
Arius	S		O			◉	◉					◉	◉		◉	●		◉	O		◉	O			◉			●
felis	J		O			◉	◉	O				◉	◉		◉	●		◉	O		◉	O			●			●
	L		O			◉	◉					◉	◉		◉	●		◉	O		◉	O			◉			●
	E		O			◉	◉					◉	◉		◉	●		◉	O		◉	O			◉			●

T M * T M S T M * T M S * M S * M S * M S * * S * * S
Sabine Lake, Galveston Bay, Brazos River, Matagorda Bay, San Antonio Bay, Aransas Bay, Corpus Christi Bay, Laguna Madre, Baffin Bay
Texas Estuaries

Relative Abundance

● Highly Abundant
◉ Abundant
O Common
Blank Not Present, Rare, or No Data Available

Salinity Zone

T - Tidal Fresh
M - Mixing
S - Seawater
* - Salinity zone not present

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 2, continued. Spatial distribution and relative abundance.

Species/Life Stage		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Sheepshead minnow	A	◉	◉		O	◉	◉	◉	O		◉	◉	◉		◉	◉		◉	◉		◉	◉			●			◉
Cyprinodon	S	◉	◉		O	◉	◉	◉	O		◉	◉	◉		◉	◉		◉	◉		◉	◉			●			◉
variegatus	J	◉	◉		O	◉	◉	◉	O		◉	◉	◉		◉	◉		◉	◉		◉	◉			●			●
	L	◉	◉		O	◉	◉	◉	O		◉	◉	◉		◉	◉		◉	◉		◉	◉			●			◉
	E	◉	◉		O	◉	◉	◉	O		◉	◉	◉		◉	◉		◉	◉		◉	◉			●			◉
Gulf killifish	A	O	◉		O	◉	◉	◉	◉		◉	◉	◉		◉	◉		◉	O		O	O			◉			◉
Fundulus	S		◉			◉	◉		O			◉	◉		◉	◉		◉	O		O	O			◉			◉
grandis	J	O	◉		O	◉	◉	◉	◉		◉	◉	◉		◉	◉		◉	O		O	O			◉			◉
	L		◉			◉	◉		O			◉	◉		◉	◉		◉	O		O	O			◉			◉
	E		◉			◉	◉		O			◉	◉		◉	◉		◉	O		O	O			◉			◉
Atlantic silversides	A	O	◉		◉	◉	O	◉	◉		◉	◉			◉			◉	O		◉	O			●			●
Menidia	S	O	◉		◉	◉		◉	◉		◉	◉			◉			◉			◉	O			●			●
species	J	O	◉		◉	◉	O	◉	◉		◉	◉			◉			◉	O		◉	O			●			●
	L	O	◉		◉	◉		◉	◉		◉	◉			◉			◉			◉	O			●			●
	E	O	◉		◉	◉		◉	◉		◉	◉			◉			◉			◉	O			●			●
Snook	A																											
Centropomus	S																											
undecimalis	J																								O			
	L																											
	E																											
Bluefish	A																											
Pomatomus	S																											
saltatrix	J						O		O																			
	L																											
	E																											
Crevalle jack	A											O	O		O	O		O	O		O	O			O			O
Caranx	S																											
hippos	J					O	O		O			O	O		O	O		O	O		O	O			◉			O
	L																											
	E																											

Texas Estuaries

T M * T M S T M * T M S * M S * M S * M S * * S * * S
Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Relative Abundance

- ● Highly Abundant
- ◉ Abundant
- O Common
- Blank Not Present, Rare, or No Data Available

Salinity Zone

- T - Tidal Fresh
- M - Mixing
- S - Seawater
- * - Salinity zone not present

Life Stage

- A - Adults
- S - Spawning
- J - Juveniles
- L - Larvae
- E - Eggs

Table 2, continued. Spatial distribution and relative abundance.

Species/Life Stage		Texas Estuaries																										
		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Florida pompano *Trachinotus carolinus*	A															O									O			
	S																											
	J						O						O			O			O			O			◉			
	L																											
	E																											
Gray snapper *Lutjanus griseus*	A																											
	S																											
	J																								O			
	L																											
	E																											
Sheepshead *Archosargus probatocephalus*	A	O	O			O	O		O		O	◉	◉		◉	O		O	O		O	O			O			O
	S																	O	O		O	O						
	J	O	O		O	O	O		O		O	◉	O		O	O		O	O		O	O			◉			O
	L																	O	O		O	O						
	E																	O	O		O	O						
Pinfish *Lagodon rhomboides*	A										O	O	◉			O		◉	◉		◉	◉			◉			O
	S																											
	J	O	O		O	◉	◉		◉		O	◉	●		◉	◉		◉	◉		◉	◉			●			◉
	L																											
	E																											
Silver perch *Bairdiella chrysoura*	A	O	O			O	O		O		O	O	O		O			O	O		O	O			O			◉
	S					O	O		O			O	O		O			O	O		O	O			O			◉
	J					O	O		O			O	O		O			O	O		O	O			◉			◉
	L					O	O		O			O	O		O			O	O		O	O			O			◉
	E					O	O		O			O	O		O			O	O		O	O			O			◉
Sand seatrout *Cynoscion arenarius*	A					◉	◉					O	O					O	O		◉	◉						O
	S																		O			O						
	J					O	O		O		O	O	O		O	O		O	O		◉	O						O
	L																		O			O						
	E																		O			O						

Relative Abundance

- ● Highly Abundant
- ◉ Abundant
- O Common
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Salinity Zone

- T - Tidal Fresh
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- A - Adults
- S - Spawning
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Table 2, continued. Spatial distribution and relative abundance.

Species/Life Stage		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Spotted seatrout *Cynoscion nebulosus*	A					O	O		O			O	O		O	O		O	O		O	O			O			O
	S					O	O		O			O	O		O	O		O	O		O	O			O			O
	J	O	O			O	O		O			O	O		O	O		O	O		O	O			O			O
	L	O				O	O		O			O	O		O	O		O	O		O	O			O			O
	E					O	O		O			O	O		O	O		O	O		O	O			O			O
Spot *Leiostomus xanthurus*	A	◉	◉			O	O				O	O	O		O	O		◉	◉		◉	◉			◉			O
	S																											
	J	O	O		O	◉	O	O	◉		O	◉	O		◉	O		◉	◉		◉	◉			●			●
	L																											
	E																											
Atlantic croaker *Micropogonias undulatus*	A	◉	◉			O	O				◉	◉	◉		◉	◉		◉	O		◉	O			◉			◉
	S																											
	J	O	◉		◉	●	●	O	●		◉	●	◉		●	◉		◉	◉		◉	◉			◉			◉
	L																		◉		O	◉			◉			
	E																											
Black drum *Pogonias cromis*	A					O	O		O			O	O		O	O		O	O		O	O			O			◉
	S						O						O						O			O			O			◉
	J	O	O			O	O	O	O		O	O	O		O	O		O	O		O	O			O			◉
	L						O						O						O			O			O			◉
	E						O						O						O			O			O			◉
Red drum *Sciaenops ocellatus*	A					O	O						O															
	S												O															
	J	O	O		O	O	O		O		O	O	O		O	O		O	O		O	O			O			O
	L					O	O						O															
	E												O															
Striped mullet *Mugil cephalus*	A	O	O		O	O	O		O		O	◉	◉		O	O		O	O		O	O			O			◉
	S												◉												O			
	J	O	O		O	◉	◉		O		◉	◉	◉		◉	O		◉	◉		◉	◉			◉			◉
	L												◉												O			
	E												◉												O			

T M * T M S T M * T M S * M S * M S * M S * * S * * S
Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Texas Estuaries

Relative Abundance

- ● Highly Abundant
- ◉ Abundant
- O Common
- Blank Not Present, Rare, or No Data Available

Salinity Zone

- T - Tidal Fresh
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- S - Seawater
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Life Stage

- A - Adults
- S - Spawning
- J - Juveniles
- L - Larvae
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Table 2, continued. Spatial distribution and relative abundance.

		Texas Estuaries																										
		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
Species/Life Stage		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Code goby *Gobiosoma robustum*	A											O	O					O	O		O	O			◉			◉
	S											O	O					O	O		O	O			◉			◉
	J											O	O					O	O		O	O			◉			◉
	L											O	O					O	O		O	O			◉			◉
	E											O	O					O	O		O	O			◉			◉
Spanish mackerel *Scomberomorus maculatus*	A		O																									
	S																											
	J					O	O																					
	L																											
	E																											
Gulf flounder *Paralichthys albigutta*	A																											
	S																											
	J																											
	L																											
	E																											
Southern flounder *Paralichthys lethostigma*	A	●	●		O	◉	●		O		O	◉	O		O	◉		O	O		O	O			O			O
	S																											
	J	O	O		O	O	O		O		O	O	O		O	O		O	O		O	O			◉			O
	L																											
	E																											

T M * T M S T M * T M S * M S * M S * M S * * S * * S
Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Relative Abundance

● Highly Abundant
◉ Abundant
O Common
Blank Not Present, Rare, or No Data Available

Salinity Zone

T - Tidal Fresh
M - Mixing
S - Seawater
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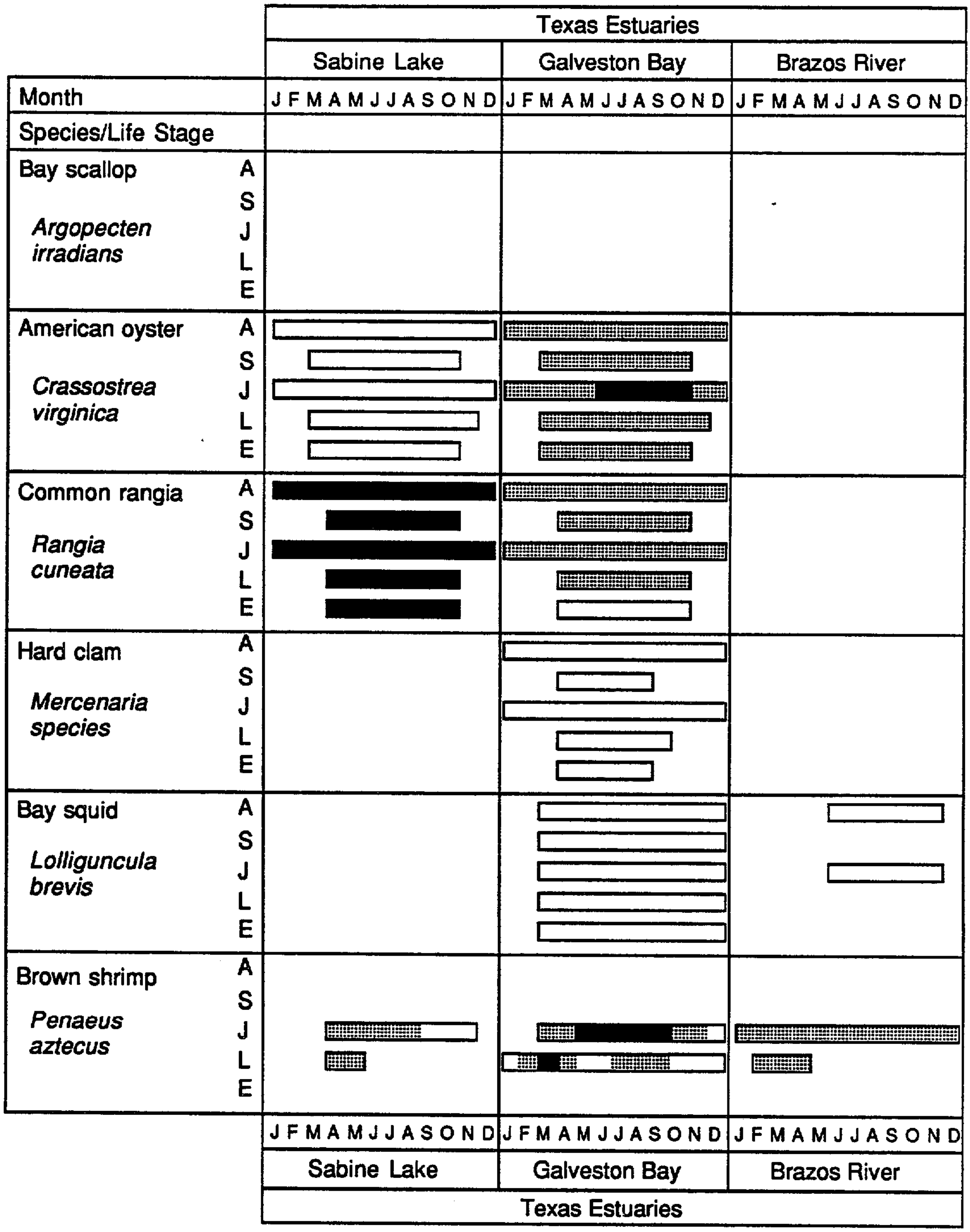
Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3. Data Summary Table: Temporal Distribution



Relative Abundance

Highly Abundant

Abundant

Common

Blank Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution

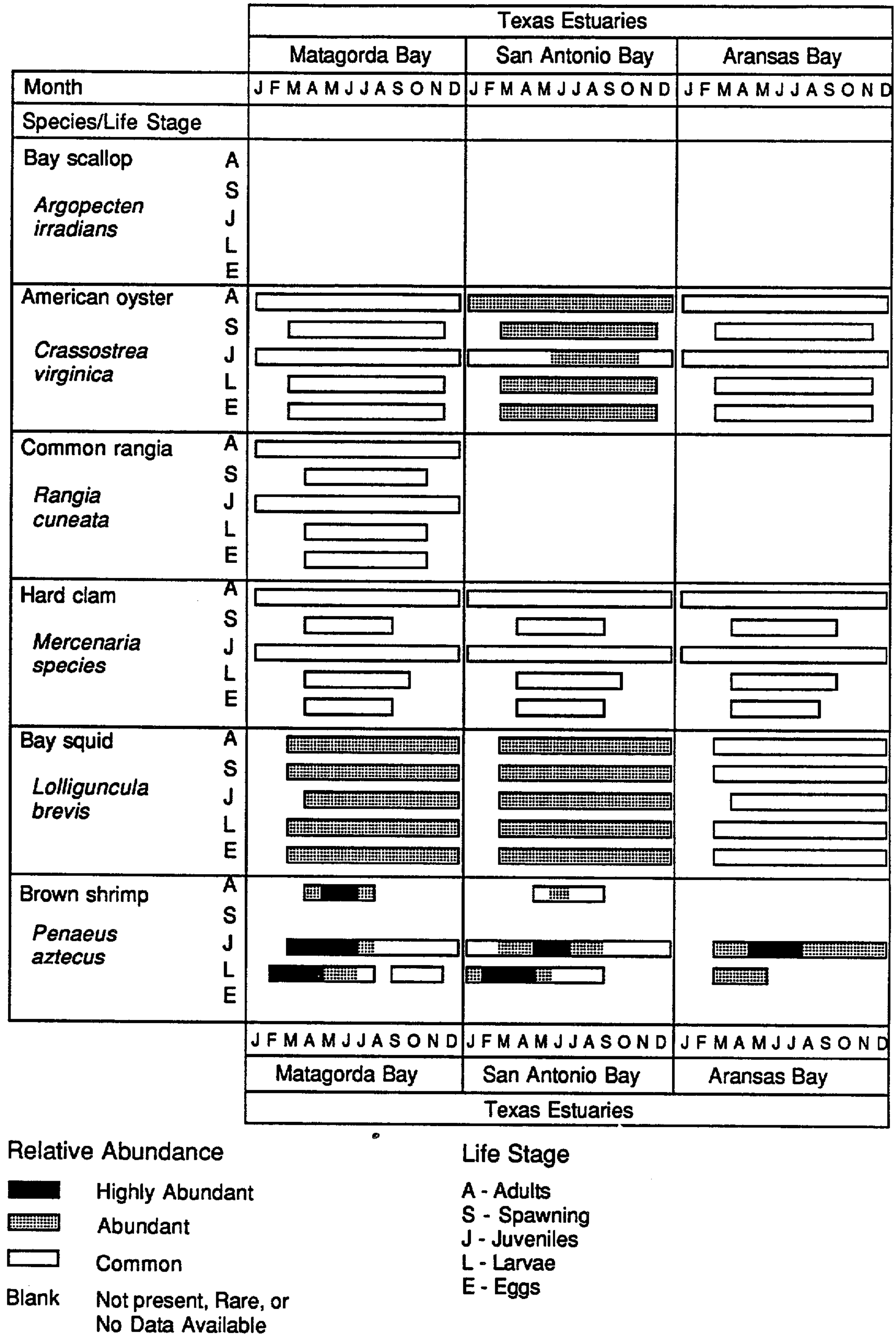
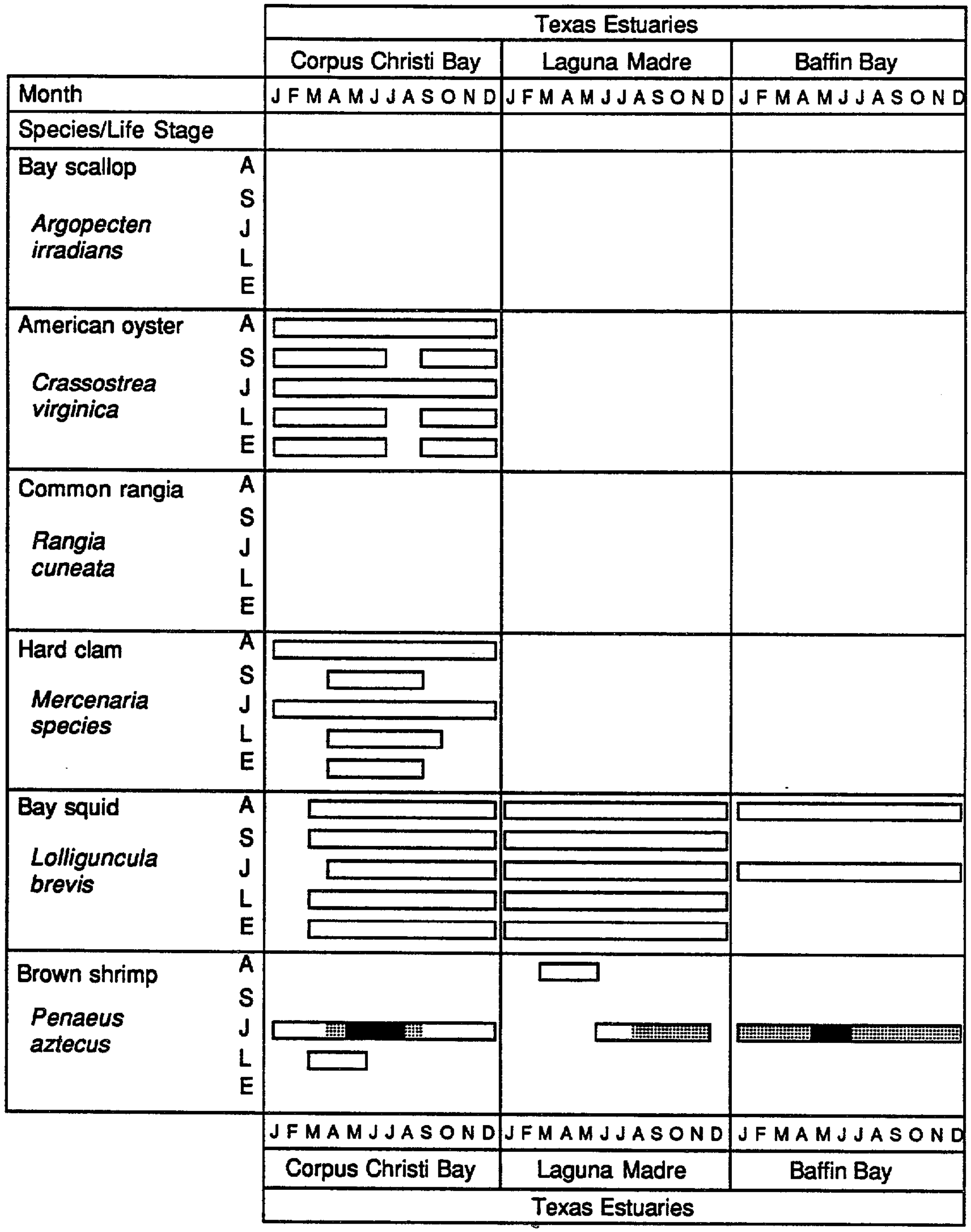


Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

Highly Abundant

Abundant

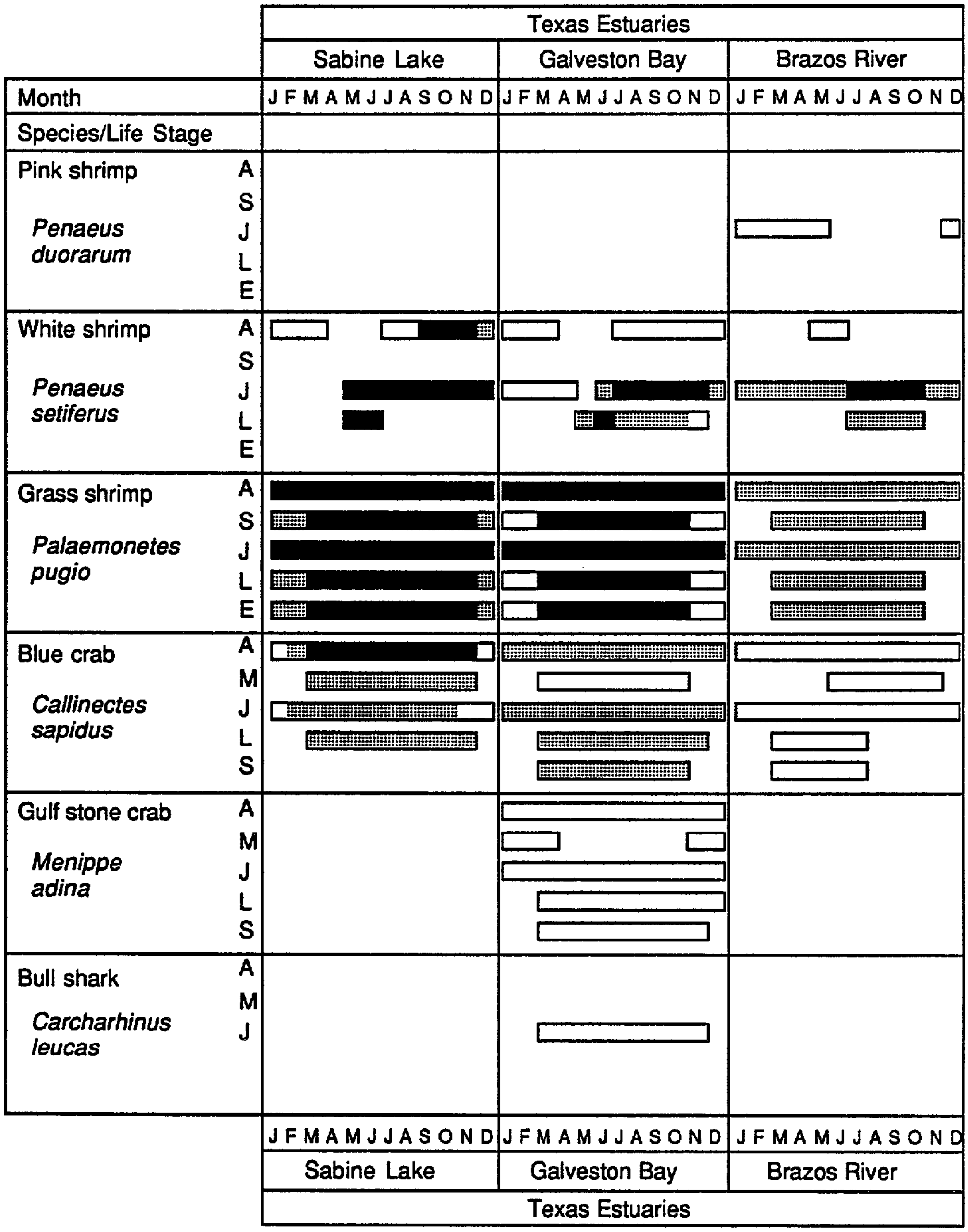
Common

Blank — Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3, continued. Temporal distribution.



Relative Abundance

- Highly Abundant
- Abundant
- Common
- Blank — Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs
M - Mating

Table 3, continued. Temporal distribution.

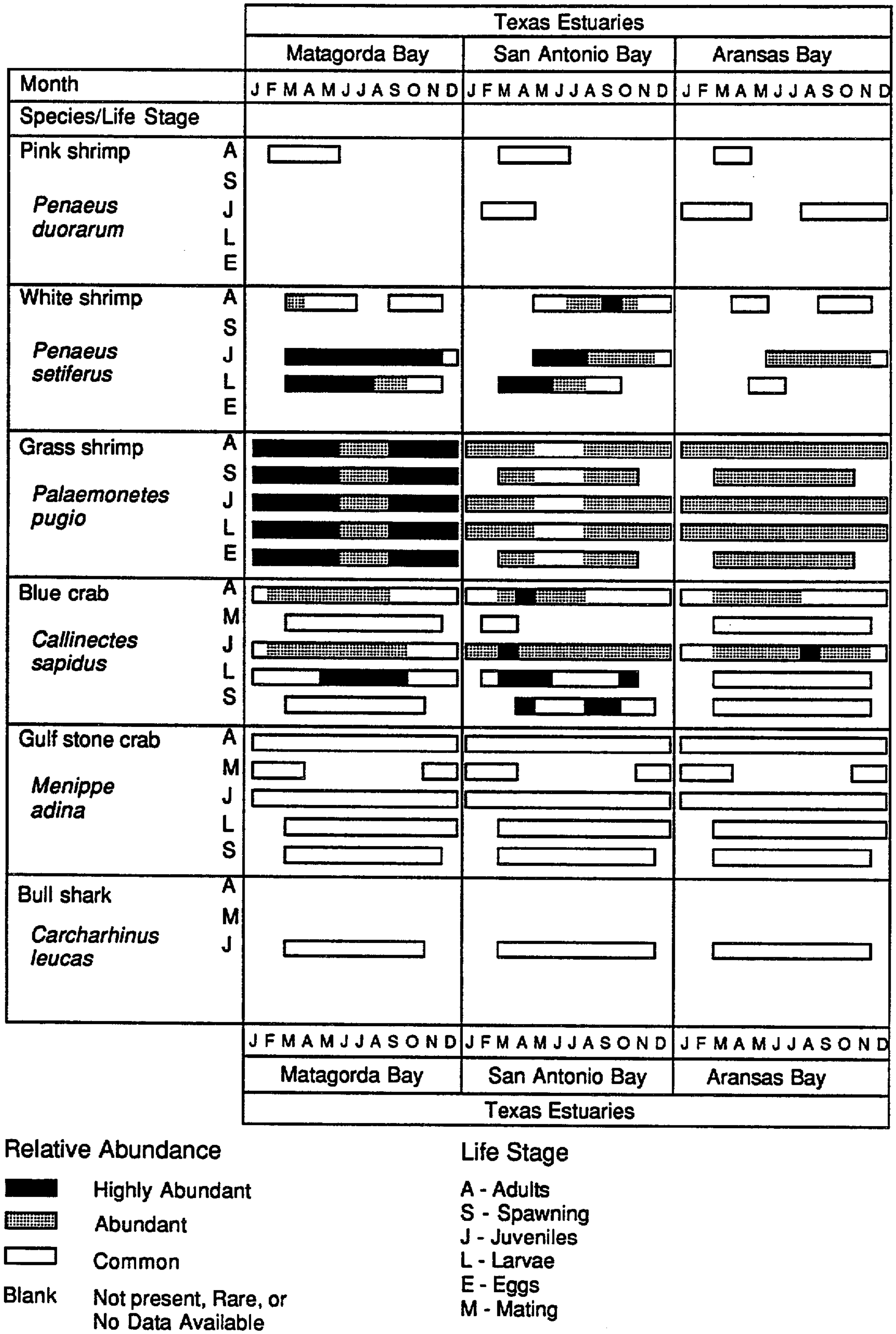
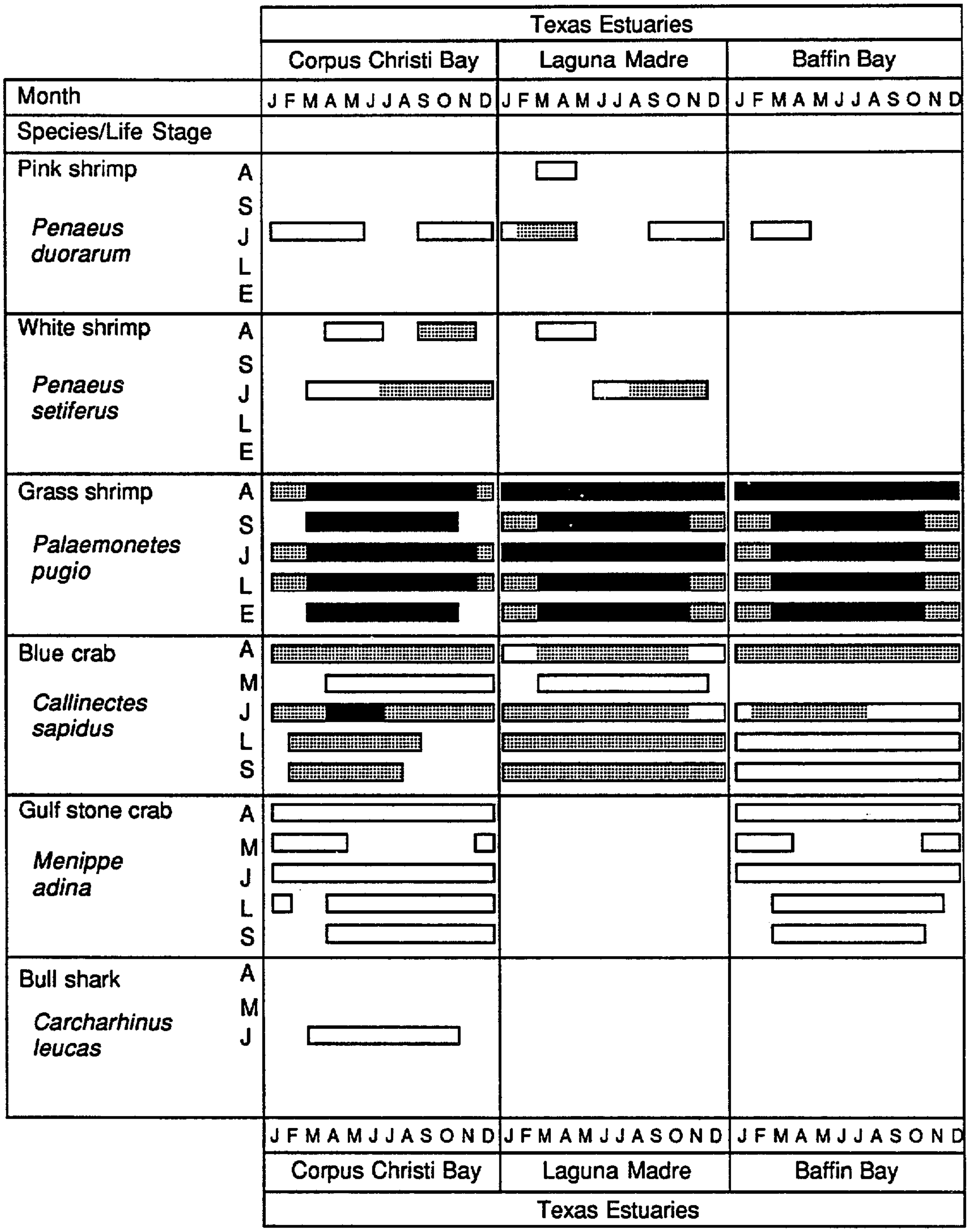


Table 3, continued. Temporal distribution.



Relative Abundance

Highly Abundant

Abundant

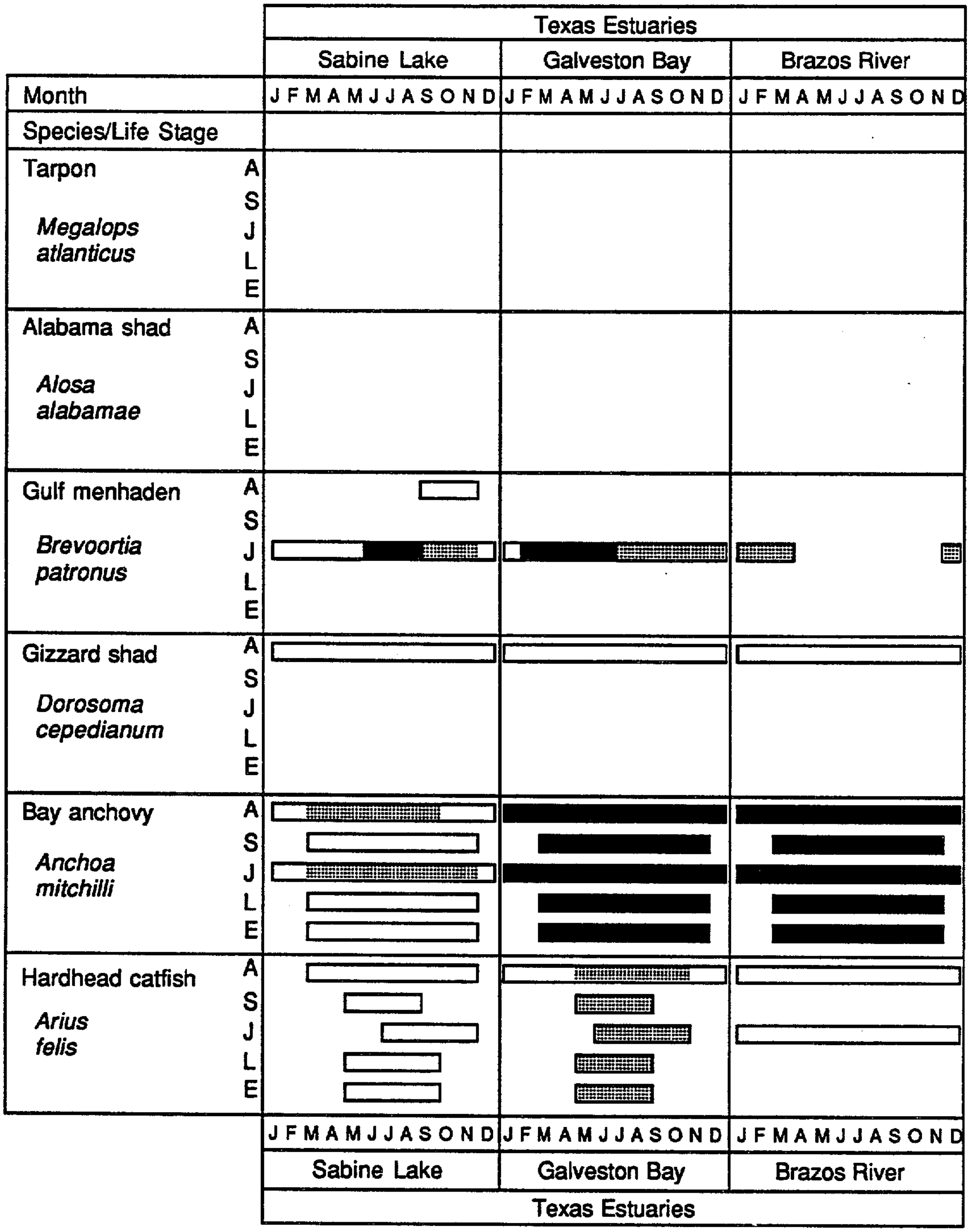
Common

Blank Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs
M - Mating

Table 3 (continued). Data Summary Table: Temporal Distribution



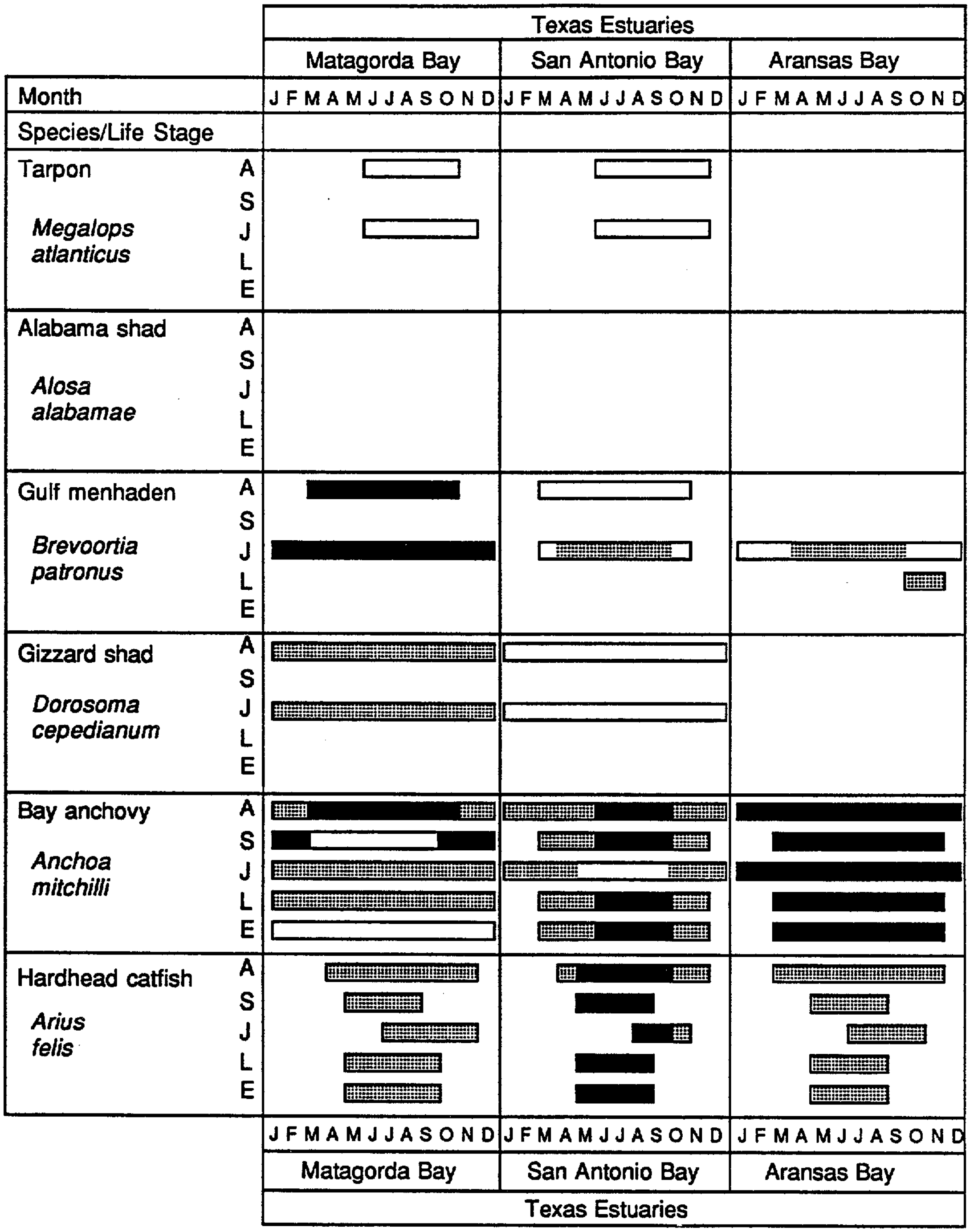
Relative Abundance

- Highly Abundant
- Abundant
- Common
- Blank: Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

- Highly Abundant
- Abundant
- Common
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Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
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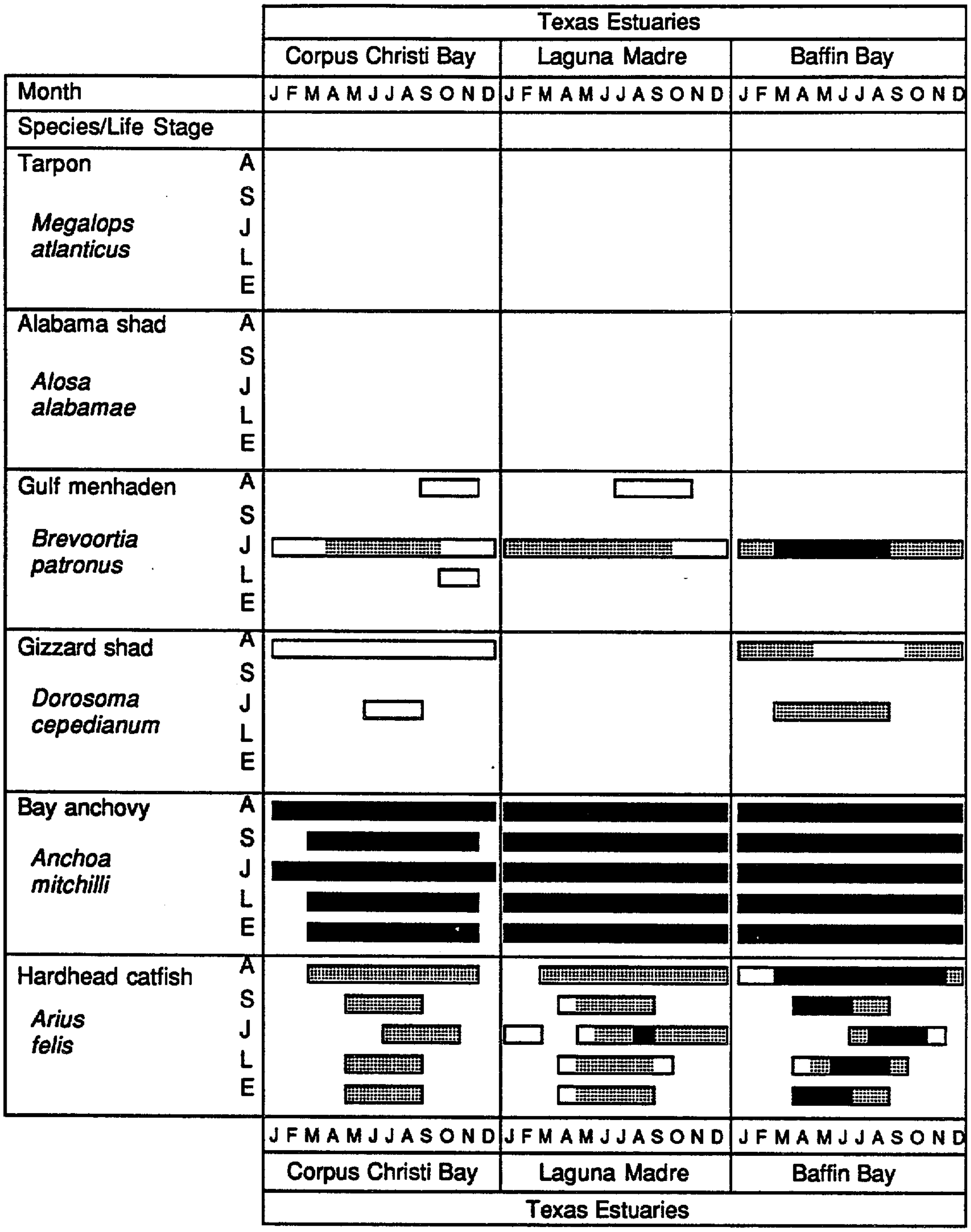
Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

Highly Abundant

Abundant

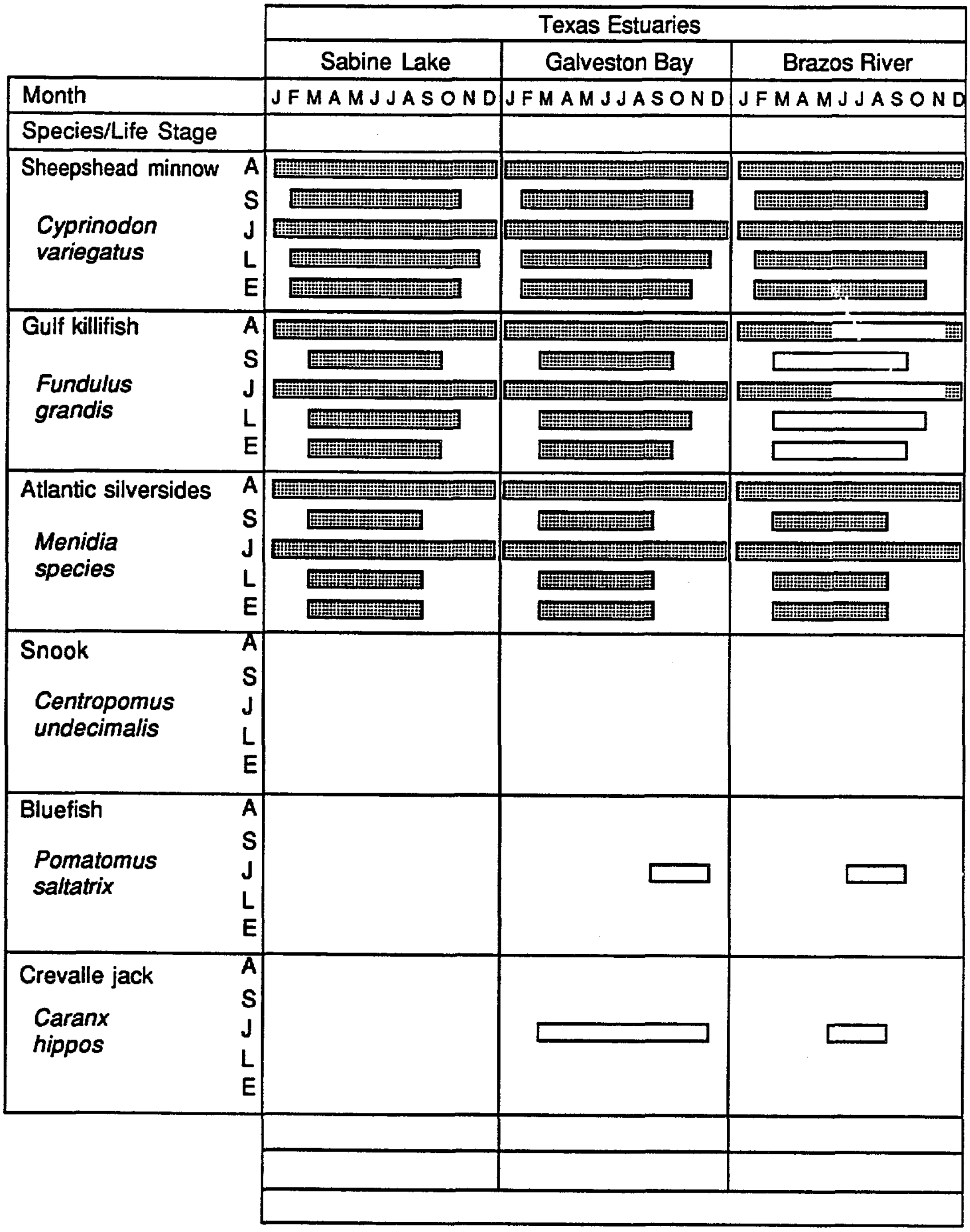
Common

Blank Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

- Highly Abundant
- Abundant
- Common
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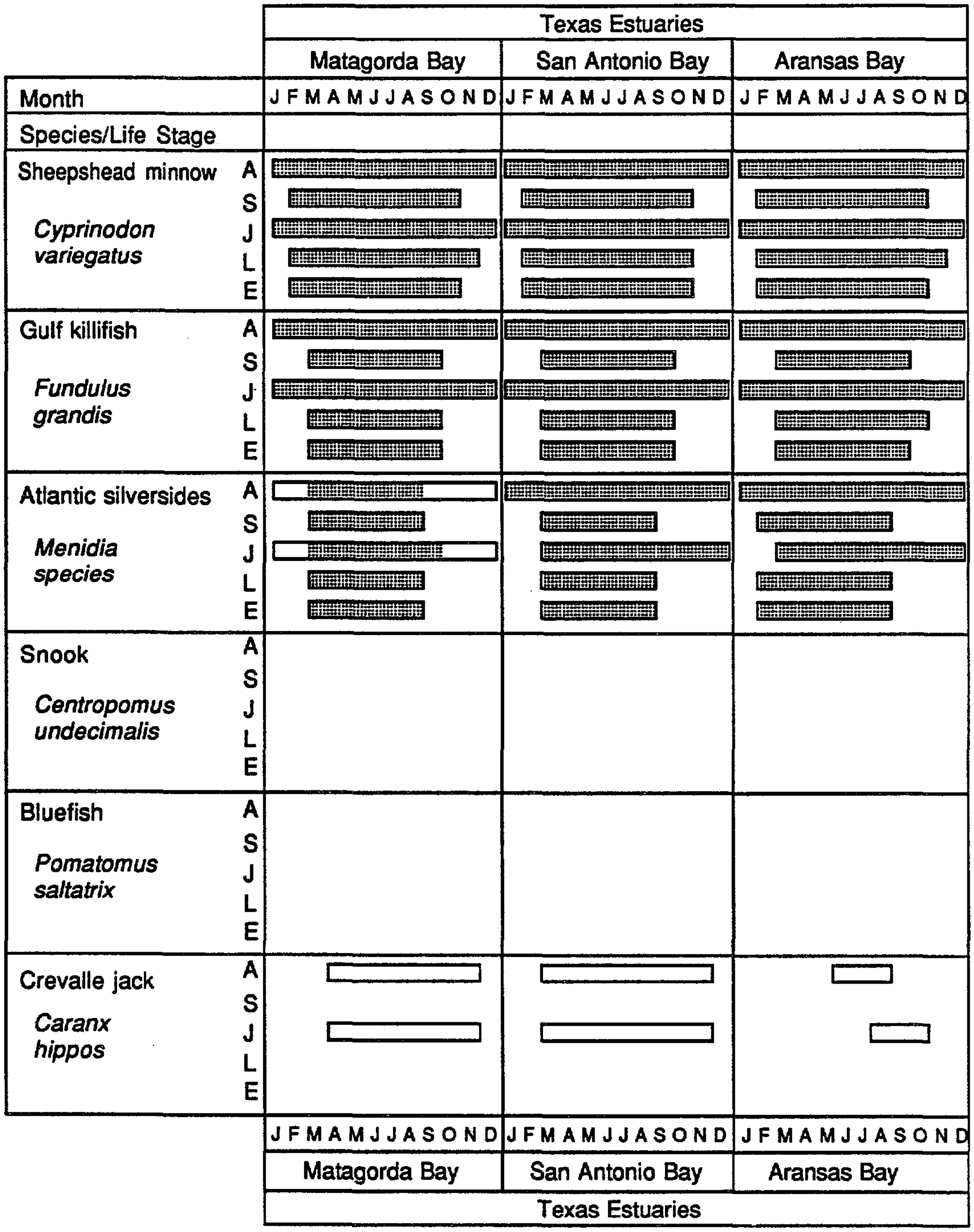
Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

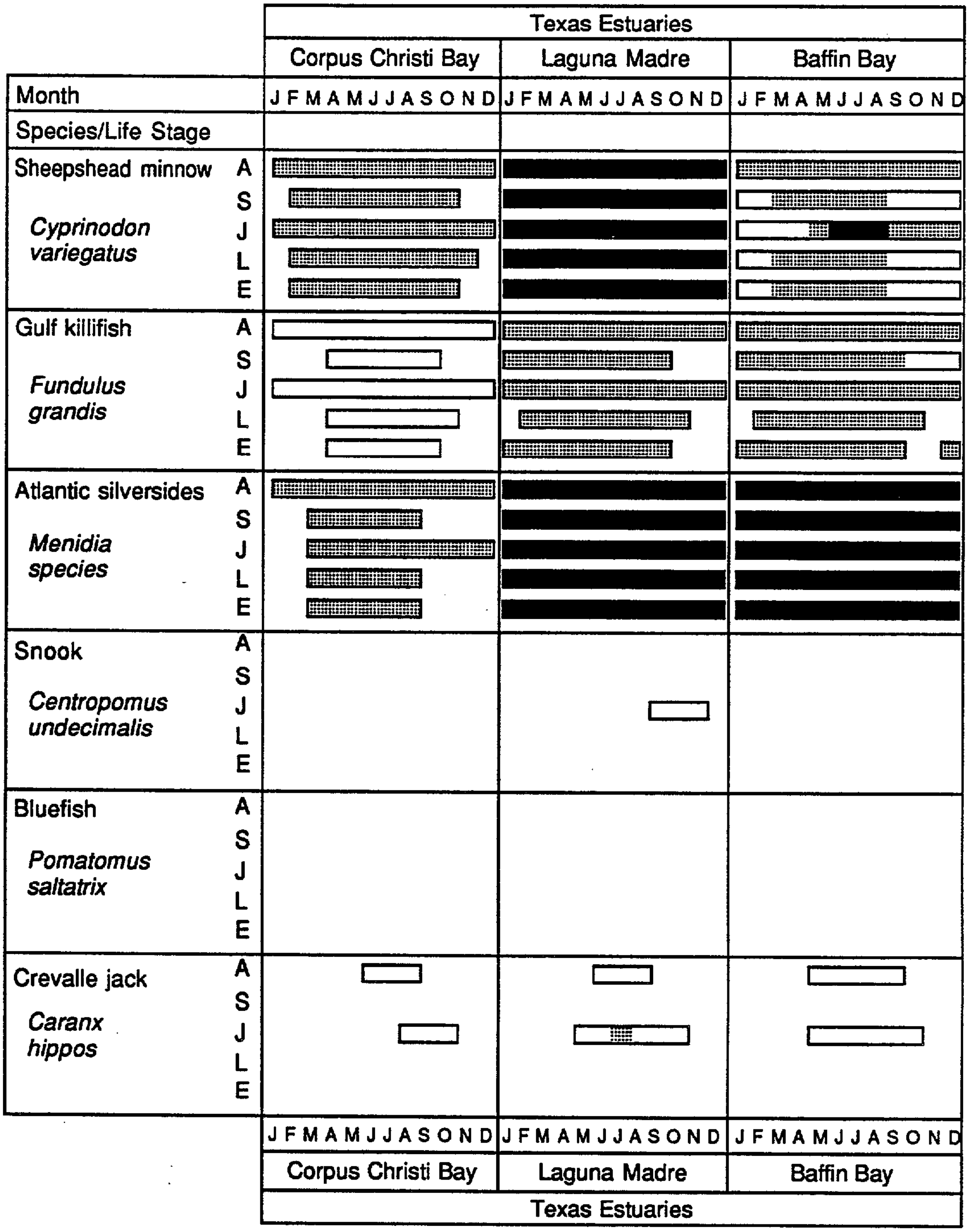
- Highly Abundant
- Abundant
- Common

Blank — Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

■	Highly Abundant
▦	Abundant
□	Common
Blank	Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
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E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution

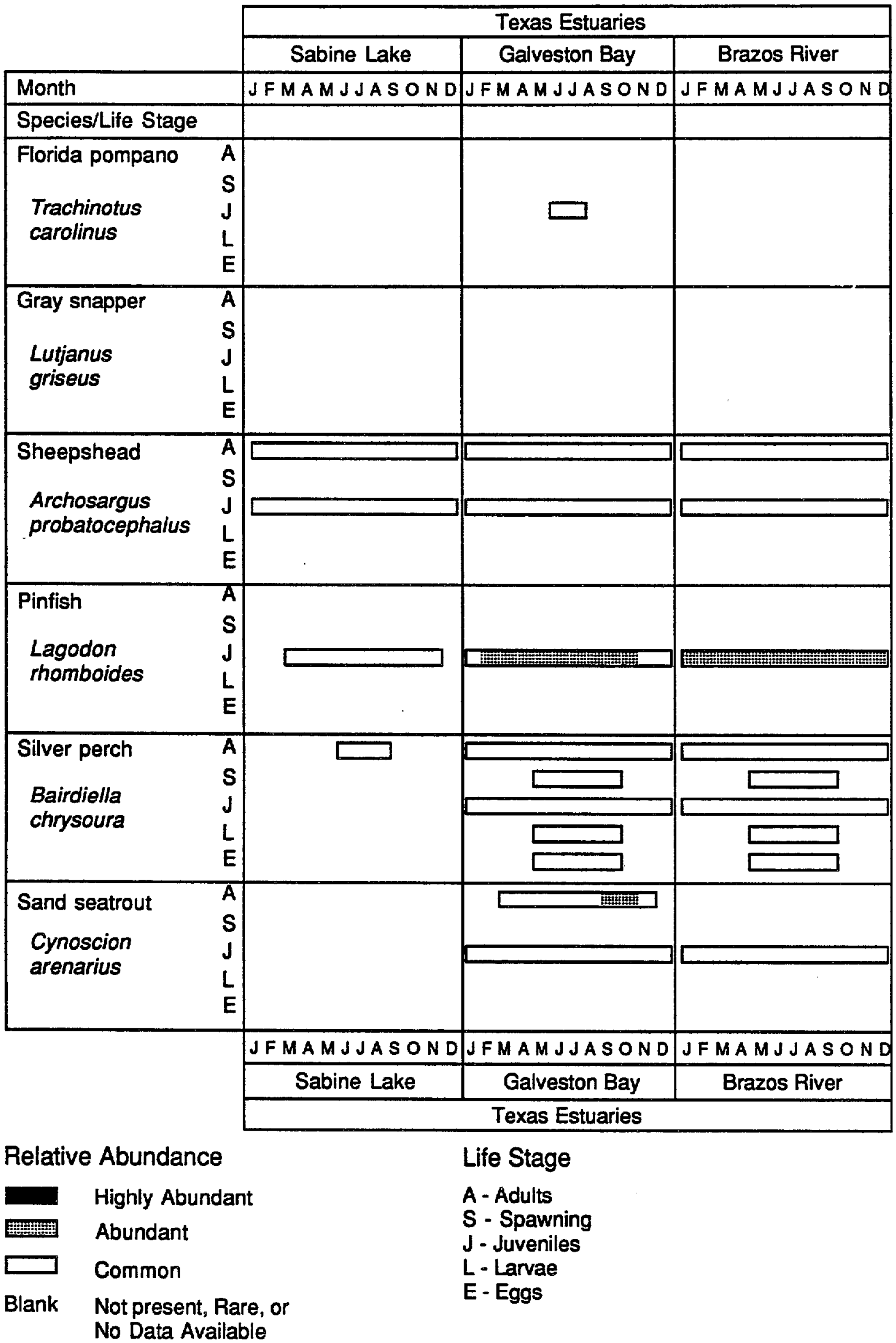
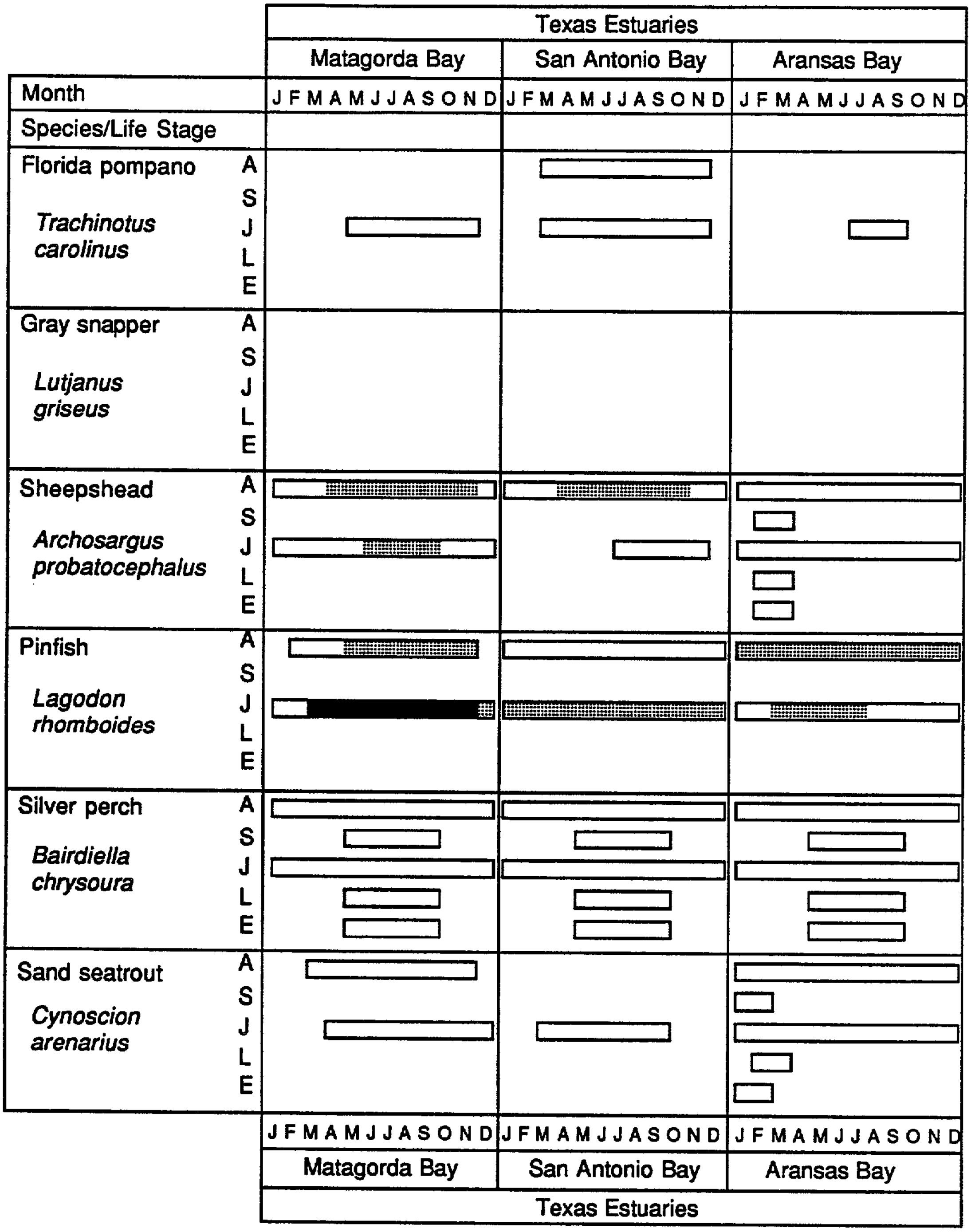


Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

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Life Stage

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J - Juveniles
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Table 3, continued. Temporal distribution.

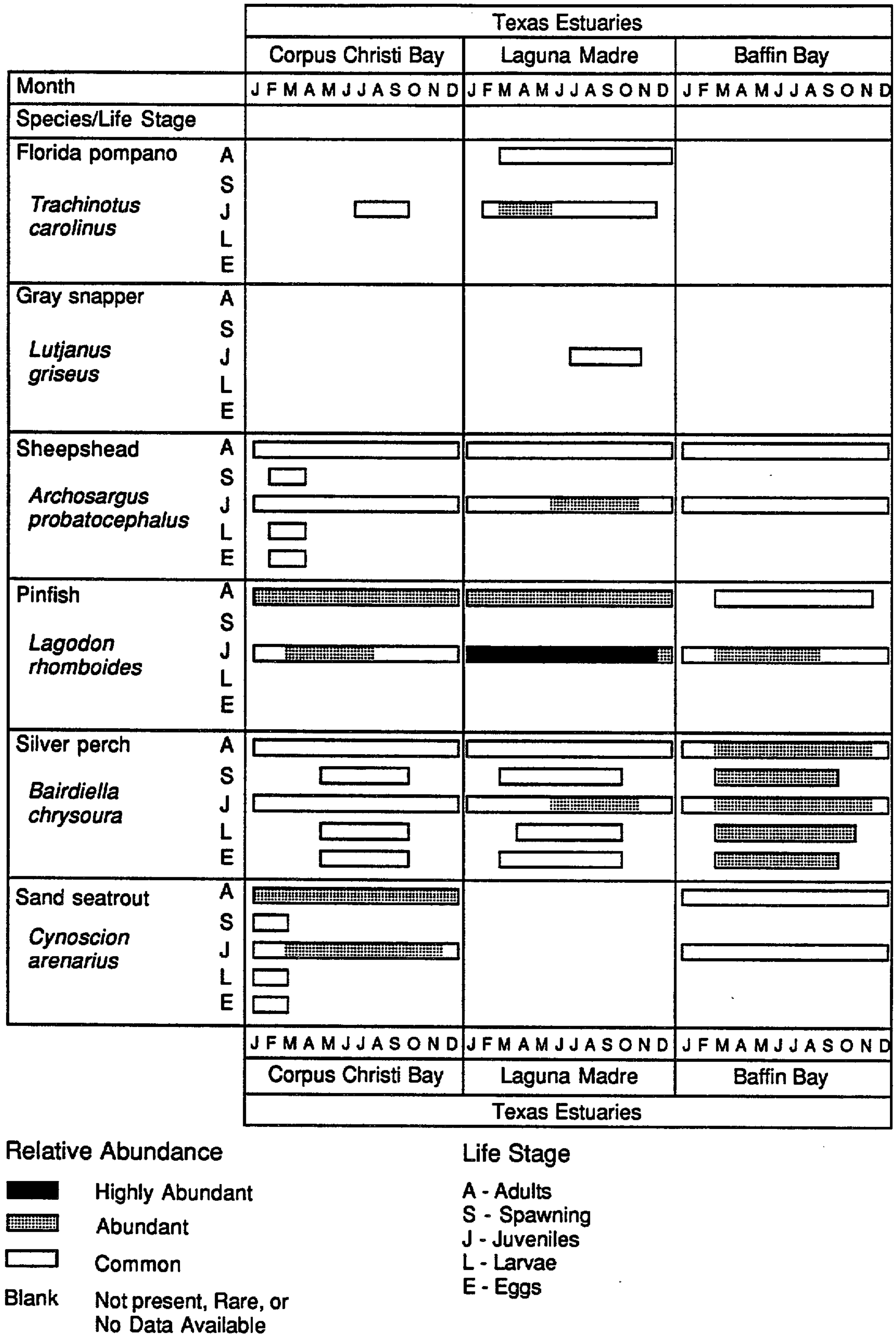
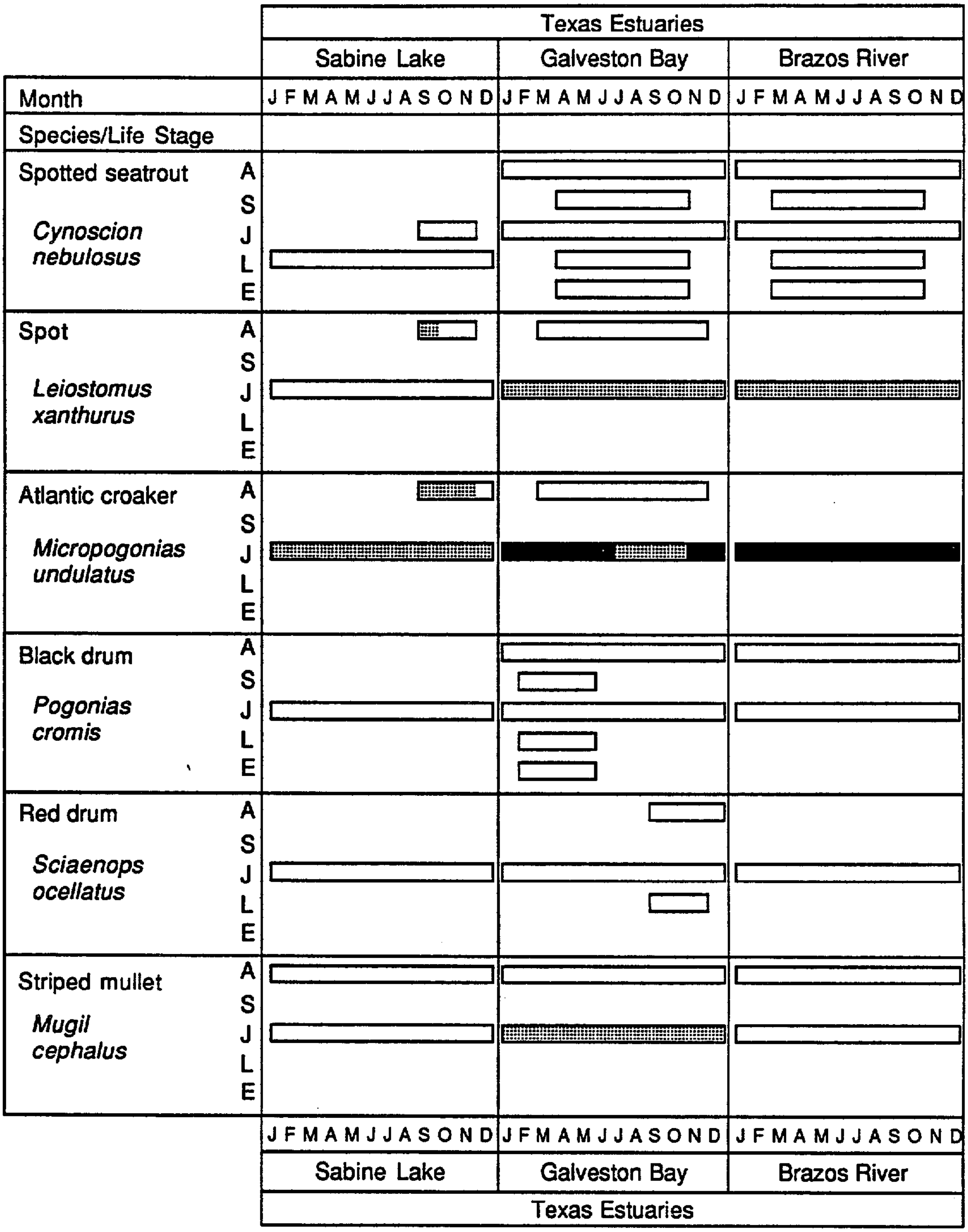


Table 3, continued. Temporal distribution.



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- ▒ Abundant
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Life Stage

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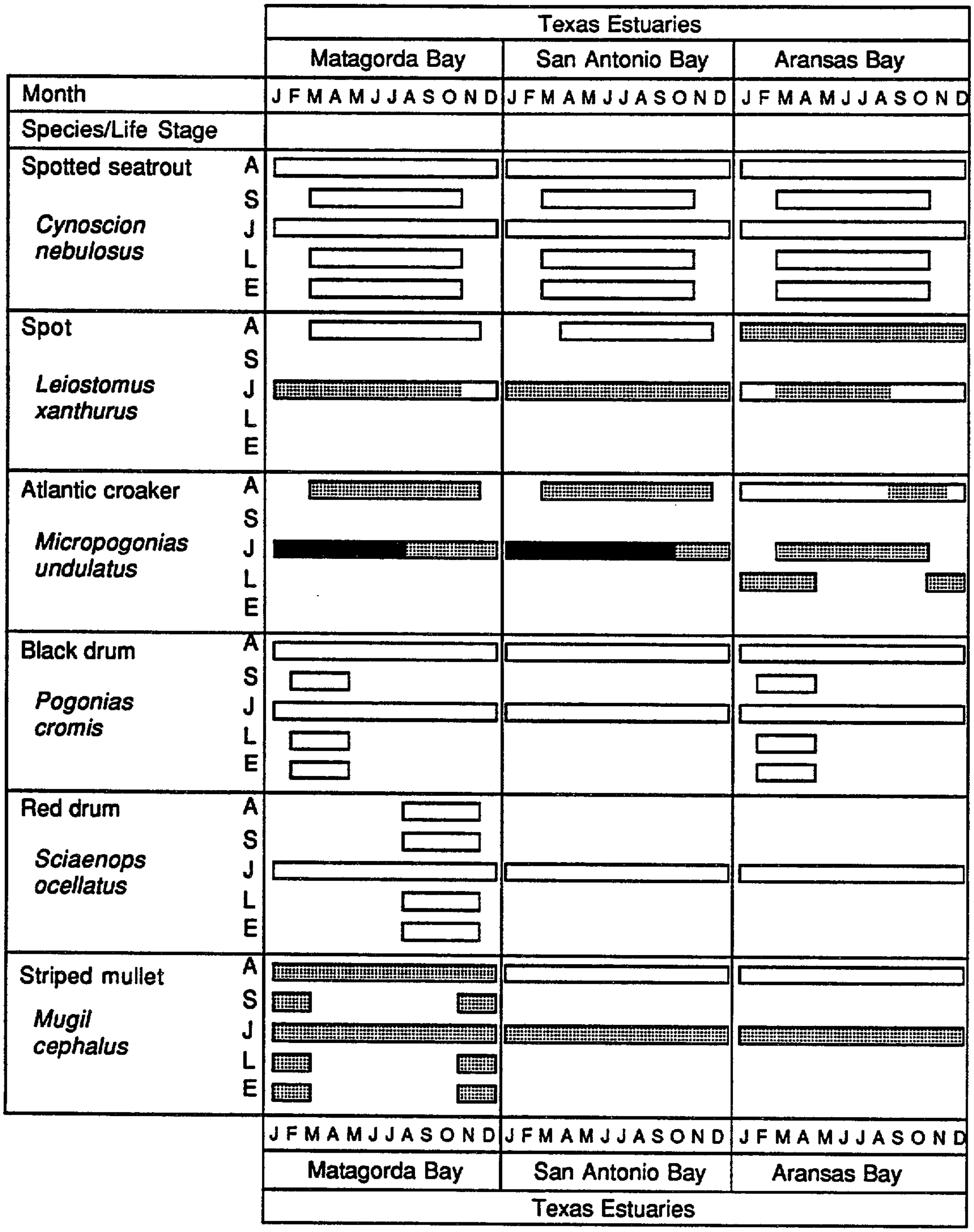
Table 3, continued. Temporal distribution.



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- Abundant
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Life Stage

A - Adults
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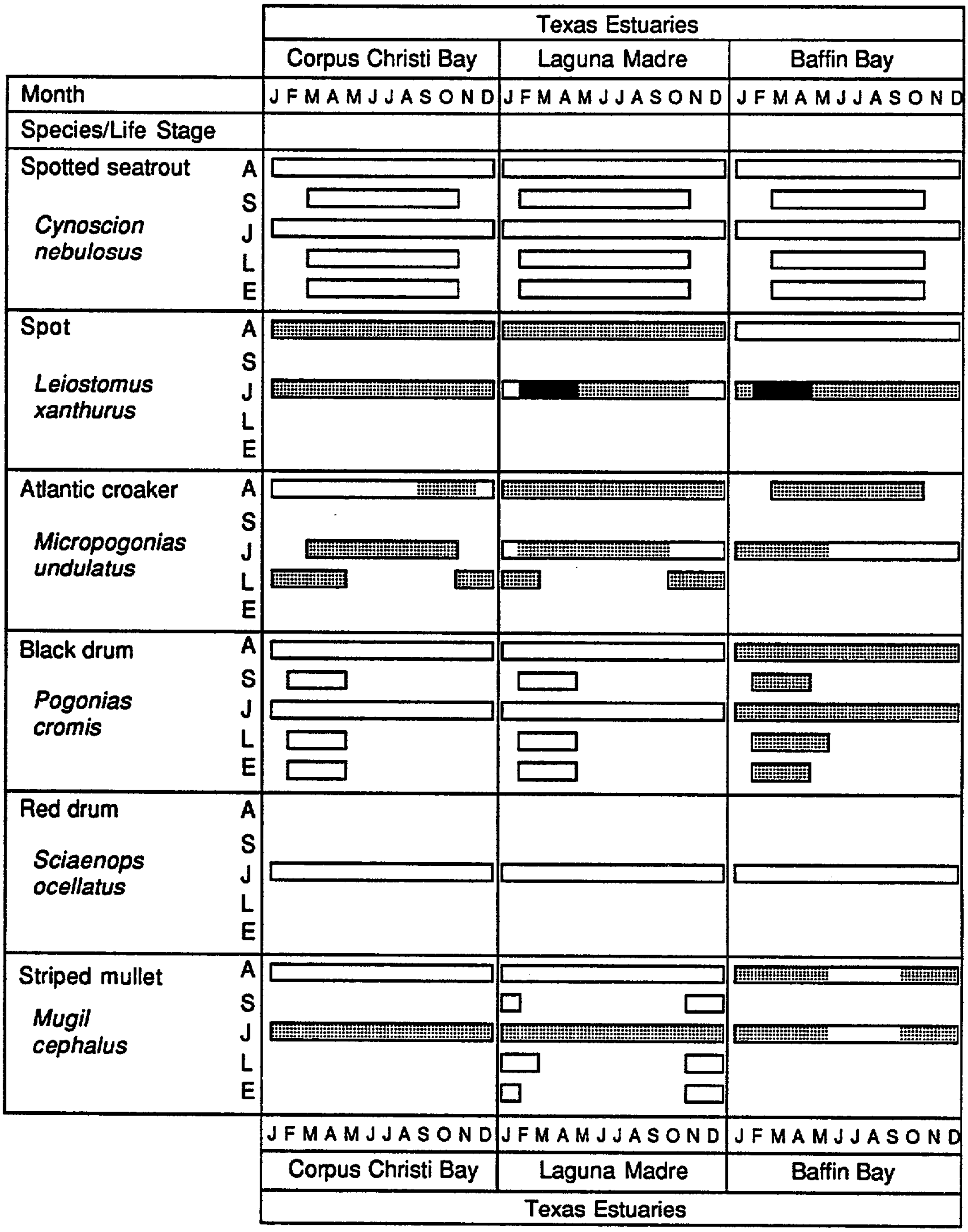
J - Juveniles
L - Larvae
E - Eggs

Table 3, continued. Temporal distribution.



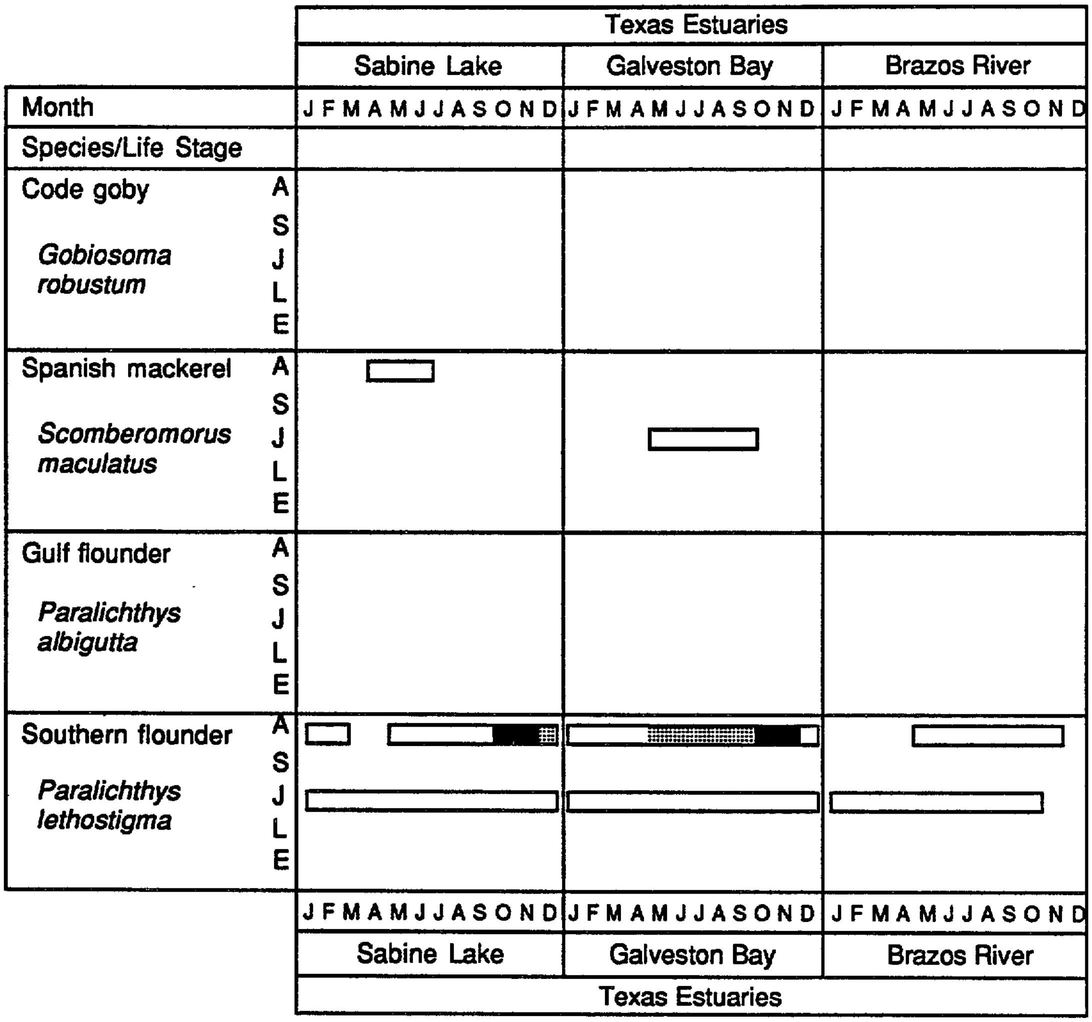
Relative Abundance

- Highly Abundant
- Abundant
- Common
- Blank — Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

Highly Abundant

Abundant

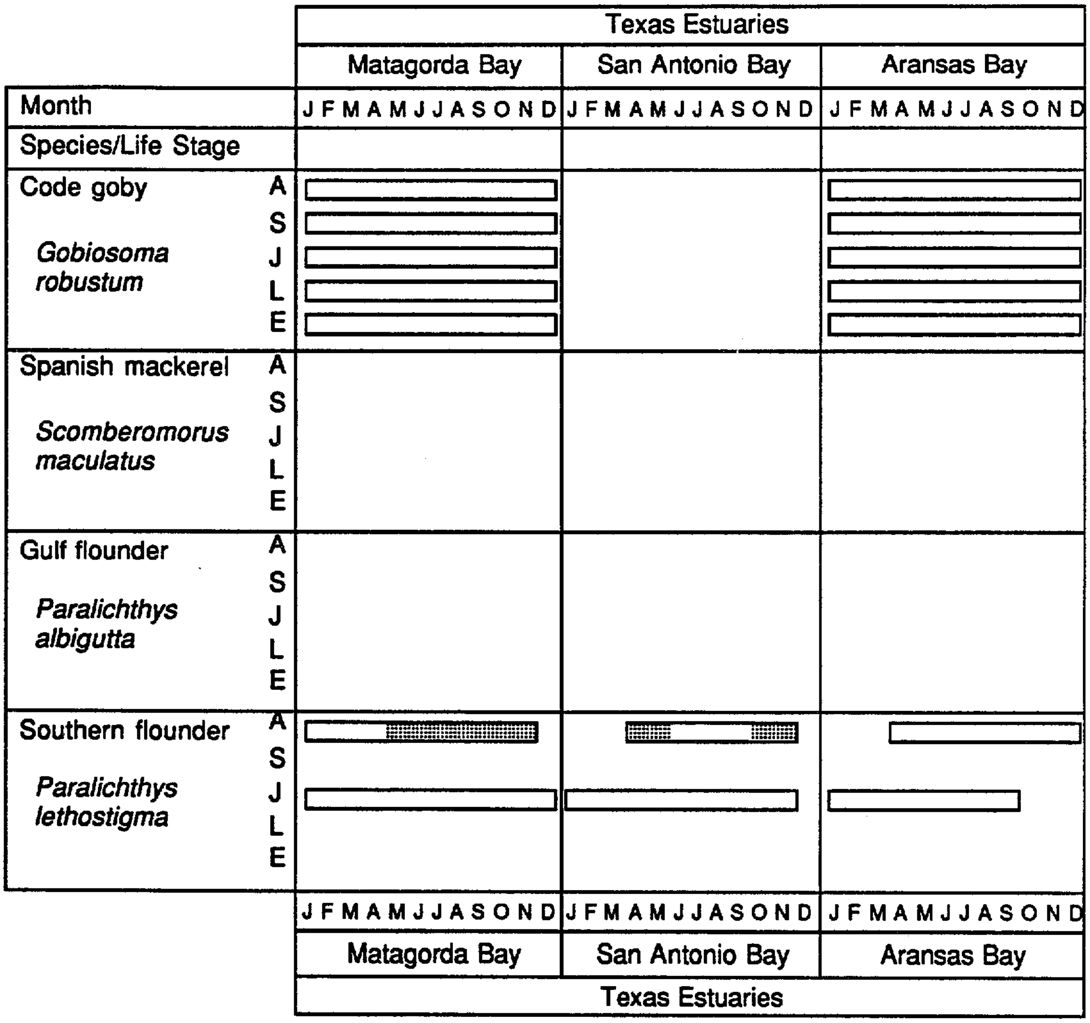
Common

Blank Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution



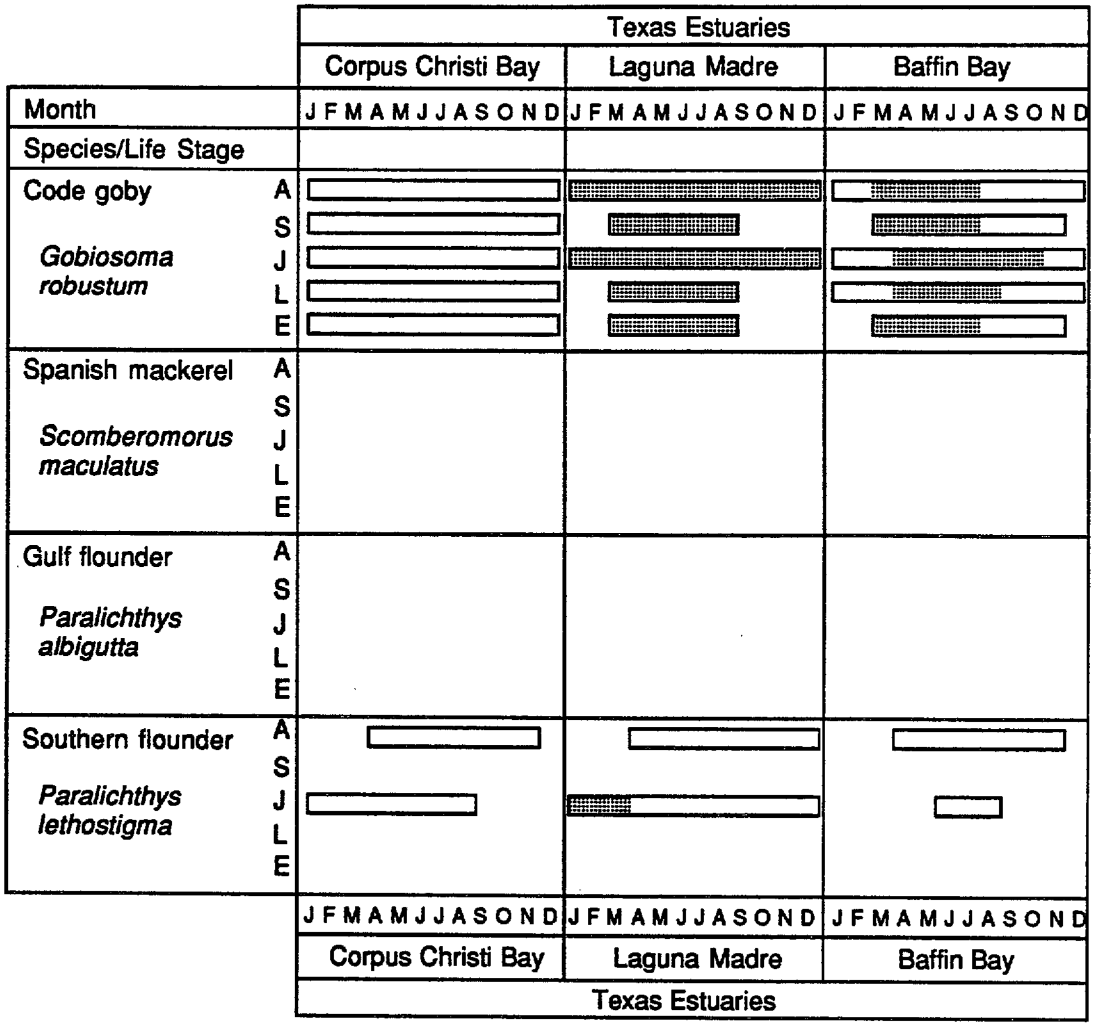
Relative Abundance

- Highly Abundant
- Abundant
- Common
- Blank — Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 3 (continued). Data Summary Table: Temporal Distribution



Relative Abundance

- Highly Abundant
- Abundant
- Common
- Blank: Not present, Rare, or No Data Available

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 4. Data Summary Table: Data Reliability

Species/Life Stage		Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
		Texas Estuaries								
Bay scallop	A	▣	▣	▣	□	□	□	□	▣	■
	S	▣	▣	▣	□	□	□	□	□	■
Argopecten irradians	J	▣	▣	▣	□	□	□	□	▣	■
	L	▣	▣	▣	□	□	□	□	□	■
	E	▣	▣	▣	□	□	□	□	□	■
American oyster	A	▣	▣	□	□	▣	▣	▣	▣	■
	S	□	□	□	□	□	□	□	□	■
Crassostrea virginica	J	▣	▣	□	□	▣	▣	▣	▣	■
	L	□	□	□	□	□	□	□	□	■
	E	□	□	□	□	□	□	□	□	■
Common rangia	A	▣	▣	□	▣	▣	▣	□	■	■
	S	□	□	□	□	□	□	□	■	■
Rangia cuneata	J	▣	▣	□	▣	▣	▣	□	■	■
	L	□	□	□	□	□	□	□	■	■
	E	□	□	□	□	□	□	□	■	■
Hard clam	A	▣	▣	□	▣	□	▣	▣	▣	■
	S	▣	□	□	□	□	□	□	▣	■
Mercenaria species	J	▣	▣	□	▣	□	▣	▣	▣	■
	L	▣	□	□	□	□	□	□	▣	■
	E	▣	□	□	□	□	□	□	▣	■
Bay squid	A	▣	▣	□	▣	□	▣	▣	▣	▣
	S	□	□	□	□	□	□	□	□	□
Lolliguncula brevis	J	▣	▣	□	▣	□	▣	▣	▣	▣
	L	□	□	□	□	□	□	□	□	□
	E	□	□	□	□	□	□	□	□	□
Brown shrimp	A	■	■	■	■	■	■	■	■	■
	S	■	■	■	■	■	■	■	■	■
Penaeus aztecus	J	■	■	□	■	■	■	■	■	■
	L	■	■	□	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■

Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Reliability

■ Highly Certain
▣ Moderately Certain
□ Reasonable Inference

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 4 (continued). Data Summary Table: Data Reliability

Species/Life Stage		Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
Pink shrimp	A	■	▣	■	▣	▣	▣	■	▣	▣
	S	■	■	■	■	■	■	■	■	□
Penaeus duorarum	J	■	▣	□	▣	▣	▣	▣	▣	▣
	L	■	■	■	▣	▣	▣	▣	■	□
	E	■	■	■	■	■	■	■	■	□
White shrimp	A	■	■	□	■	■	■	■	■	■
	S	■	■	■	■	■	■	■	■	■
Penaeus setiferus	J	■	■	□	■	■	■	■	■	■
	L	■	■	□	■	■	■	▣	■	■
	E	■	■	■	■	■	■	■	■	■
Grass shrimp	A	▣	▣	□	▣	▣	▣	▣	▣	■
	S	□	▣	□	▣	▣	▣	▣	▣	■
Palaemonetes pugio	J	▣	▣	□	▣	▣	▣	▣	▣	■
	L	□	▣	□	▣	▣	▣	▣	▣	■
	E	□	▣	□	▣	▣	▣	▣	▣	■
Blue crab	A	▣	■	□	▣	▣	▣	■	▣	■
	S	▣	■	□	▣	□	▣	▣	▣	□
Callinectes sapidus	J	▣	■	□	▣	▣	▣	■	▣	■
	L	▣	■	□	□	□	▣	▣	▣	□
	E	▣	■	□	□	□	▣	▣	▣	□
Gulf stone crab	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	□	▣	■	▣	□	▣	▣	▣	□
Menippe adina	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	□	▣	■	▣	▣	▣	▣	▣	□
	E	□	▣	■	▣	□	▣	▣	▣	□
Bull shark	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	▣	▣	□	▣	▣	▣	▣	▣	▣
Carcharhinus leucas	J	▣	▣	□	▣	▣	▣	▣	▣	□
	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
		Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
		Texas Estuaries								

Reliability

■ Highly Certain

▣ Moderately Certain

□ Reasonable Inference

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 4 (continued). Data Summary Table: Data Reliability

Species/Life Stage		Texas Estuaries: Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
Tarpon	A	□	▣	▣	▣	▣	▣	▣	▣	■
	S	□	▣	▣	▣	▣	▣	▣	□	■
Megalops	J	□	▣	□	▣	▣	▣	▣	▣	▣
atlanticus	L	□	▣	▣	▣	▣	▣	▣	□	■
	E	□	▣	▣	▣	▣	▣	▣	□	■
Alabama shad	A	■	■	□	■	■	■	■	■	■
	S	■	■	□	■	■	■	■	■	■
Alosa	J	■	■	□	■	■	■	■	■	■
alabamae	L	■	■	□	■	■	■	■	■	■
	E	■	■	□	■	■	■	■	■	■
Gulf menhaden	A	▣	▣	▣	▣	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
Brevoortia	J	▣	▣	□	▣	▣	■	▣	▣	■
patronus	L	▣	▣	▣	□	▣	▣	▣	▣	▣
	E	■	■	■	■	■	■	■	■	■
Gizzard shad	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
Dorosoma	J	□	▣	□	▣	▣	▣	▣	▣	▣
cepedianum	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
Bay anchovy	A	▣	▣	□	▣	▣	▣	■	▣	▣
	S	□	▣	□	□	□	▣	▣	▣	▣
Anchoa	J	▣	▣	□	▣	▣	▣	■	▣	▣
mitchilli	L	□	▣	□	□	□	▣	▣	▣	▣
	E	□	▣	□	□	□	▣	▣	▣	▣
Hardhead catfish	A	▣	▣	□	▣	▣	▣	▣	▣	■
	S	▣	▣	□	▣	▣	▣	▣	▣	▣
Arius	J	▣	▣	□	▣	▣	▣	▣	▣	▣
felis	L	▣	▣	□	▣	▣	▣	▣	▣	▣
	E	▣	▣	□	▣	▣	▣	▣	▣	▣

Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Reliability

■ Highly Certain
▣ Moderately Certain
□ Reasonable Inference

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 4 (continued). Data Summary Table: Data Reliability

Species/Life Stage		Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
		Texas Estuaries								
Sheepshead minnow *Cyprinodon variegatus*	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	□	□	□	□	□	□	□	□	□
	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	□	□	□	□	□	□	□	▣	□
	E	□	□	□	□	□	□	□	□	□
Gulf killifish *Fundulus grandis*	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	▣	▣	□	▣	▣	▣	▣	▣	□
	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	▣	▣	□	▣	▣	▣	▣	▣	□
	E	▣	▣	□	▣	▣	▣	▣	▣	□
Atlantic silversides *Menidia species*	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	□	□	□	□	□	□	□	□	□
	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	□	□	□	□	□	□	□	▣	□
	E	□	□	□	□	□	□	□	□	□
Snook *Centropomus undecimalis*	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	■	■	▣	■	▣	▣	■	■
	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	□	▣	▣	▣	▣	▣	▣
	E	■	■	■	▣	■	▣	▣	■	■
Bluefish *Pomatomus saltatrix*	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
Crevalle jack *Caranx hippos*	A	▣	▣	□	□	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
	J	▣	▣	□	□	▣	▣	▣	▣	▣
	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
		Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
		Texas Estuaries								

Reliability

- ■ Highly Certain
- ▣ Moderately Certain
- □ Reasonable Inference

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 4 (continued). Data Summary Table: Data Reliability

Species/Life Stage		Texas Estuaries: Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
Florida pompano	A	▣	▣	□	□	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
Trachinotus carolinus	J	▣	▣	□	□	▣	▣	▣	▣	▣
	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
Gray snapper	A	▣	▣	□	□	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
Lutjanus griseus	J	▣	▣	□	□	▣	▣	▣	▣	▣
	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
Sheepshead	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	▣	▣	▣	▣	▣	▣	▣	▣	▣
Archosargus probatocephalus	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	▣	▣	▣	▣	▣	▣	▣	▣	▣
	E	▣	▣	▣	▣	▣	▣	▣	▣	▣
Pinfish	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
Lagodon rhomboides	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
Silver perch	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	▣	▣	□	▣	▣	▣	▣	▣	▣
Bairdiella chrysoura	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	▣	▣	□	▣	▣	▣	▣	▣	▣
	E	▣	▣	□	▣	▣	▣	▣	▣	▣
Sand seatrout	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	□	□	□	□	□	□	□	□	□
Cynoscion arenarius	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	□	□	□	□	□	□	□	□	□
	E	□	□	□	□	□	□	□	□	□

Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Reliability

- ■ Highly Certain
- ▣ Moderately Certain
- □ Reasonable Inference

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 4 (continued). Data Summary Table: Data Reliability

Species/Life Stage		Texas Estuaries								
		Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
Speckled seatrout	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	□	▣	□	□	▣	▣	▣	▣	▣
Cynoscion nebulosus	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	▣	▣	□	□	▣	▣	▣	▣	▣
	E	□	▣	□	□	▣	▣	▣	▣	▣
Spot	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	▣	■	▣	▣	▣	▣	▣	▣
Leiostomus xanthurus	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	■	▣	▣	▣	▣	▣	▣
	E	■	▣	■	▣	▣	▣	▣	▣	▣
Atlantic croaker	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
Micropogonias undulatus	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	■	▣	▣	▣	▣	▣	▣
	E	■	■	■	■	■	■	■	■	■
Black drum	A	□	▣	□	▣	▣	▣	▣	▣	▣
	S	■	▣	■	▣	▣	▣	▣	▣	▣
Pogonias cromis	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	■	▣	▣	▣	▣	□	▣
	E	■	▣	■	▣	▣	▣	▣	□	▣
Red drum	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	□	■	□	□	□	□	□	■
Scianops ocellatus	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	■	▣	▣	▣	▣	▣	▣
	E	■	□	■	□	□	□	□	□	■
Striped mullet	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	▣	■	▣	▣	▣	▣	▣	▣
Mugil cephalus	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	■	▣	▣	▣	▣	▣	▣
	E	■	▣	■	▣	▣	▣	▣	▣	▣
		Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
		Texas Estuaries								

Reliability

- ■ Highly Certain
- ▣ Moderately Certain
- □ Reasonable Inference

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 4 (continued). Data Summary Table: Data Reliability

Species/Life Stage		Texas Estuaries: Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
Code goby	A	▣	▣	□	□	□	▣	▣	□	▣
	S	▣	▣	□	□	□	▣	▣	□	□
Gobiosoma robustum	J	▣	▣	□	□	□	▣	▣	▣	▣
	L	▣	▣	□	□	□	▣	▣	□	□
	E	▣	▣	□	□	□	▣	▣	□	□
Spanish mackerel	A	□	▣	□	□	▣	▣	▣	□	▣
	S	■	■	■	■	■	■	■	■	■
Scomberomorus maculatus	J	□	▣	□	□	▣	▣	▣	▣	▣
	L	■	■	■	■	■	■	■	■	■
	E	■	■	■	■	■	■	■	■	■
Gulf flounder	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	■	■	■	■	■	■	■	■
Paralichthys albigutta	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	■	■	▣	▣	▣	▣	▣
	E	■	■	■	■	■	■	■	■	■
Southern flounder	A	▣	▣	□	▣	▣	▣	▣	▣	▣
	S	■	▣	■	▣	▣	▣	▣	▣	▣
Paralichthys lethostigma	J	▣	▣	□	▣	▣	▣	▣	▣	▣
	L	■	▣	■	▣	▣	▣	▣	▣	▣
	E	■	▣	■	▣	▣	▣	▣	▣	▣

Sabine Lake | Galveston Bay | Brazos River | Matagorda Bay | San Antonio Bay | Aransas Bay | Corpus Christi Bay | Laguna Madre | Baffin Bay
Texas Estuaries

Reliability

■ Highly Certain
▣ Moderately Certain
□ Reasonable Inference

Life Stage

A - Adults
S - Spawning
J - Juveniles
L - Larvae
E - Eggs

Table 5. Presence/absence of 40 species in Texas estuaries.

Species		Estuary: Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Bay scallop,	A						√					√	√		√	√		√	√		√	√			√			
Argopecten	J						√					√	√		√	√		√	√		√	√			√			
irradians	L						√						√			√		√	√		√	√			√			
American oyster,	A	√	√		√	√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			
Crassostrea	J	√	√		√	√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			
virginica	L	√	√		√	√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			
Common rangia,	A	√	√		√	√		nd	nd		√	√			√			√			√							
Rangia	J	√	√		√	√		nd	nd		√	√			√			√			√							
cuneata	L	√	√		√	√		nd	nd		√	√			√			√			√							
Hard clam,	A					√	√		nd			√	√		√	√		√	√		√	√						
Mercenaria	J					√	√		nd			√	√		√	√		√	√		√	√						
species	L					√	√		nd			√	√		√	√		√	√		√	√						
Bay squid,	A		√			√	√		√			√	√		√	√		√	√		√	√			√			√
Lolliguncula	J		√			√	√		√			√	√		√	√		√	√		√	√			√			√
brevis	L					√	√		nd			√	√		√	√		√	√		√	√			√			
Brown shrimp,	A	√	√									√	√		√	√									√			
Penaeus	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
aztecus	L		√			√	√	nd	√		√	√	√		√	√		√	√		√	√			√			
Pink shrimp,	A					√	√					√	√		√	√		√							√			√
Penaeus	J					√	√	nd	√			√	√		√	√		√	√		√	√			√			√
duorarum	L																											
White shrimp,	A	√	√			√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Penaeus	J	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
setiferus	L		√		√	√	√	√	√		√	√	√		√	√			√						√			
Grass shrimp,	A	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Palaemonetes	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
pugio	L	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Gulf stone crab,	A		√			√	√		nd			√	√		√	√		√	√		√	√			√			√
Menippe	J		√			√	√		nd			√	√		√	√		√	√		√	√			√			√
adina	L						√						√			√			√			√			√			√
Blue crab,	A	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Callinectes	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
sapidus	L		√		√	√	√		√		√	√	√			√		√	√		√	√			√			√
Bull shark,	A						√																					
Carcharhinus	J	√	√		√	√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			√
leucas	L																											
Tarpon,	A					√	√						√		√	√		√	√		√	√			√			
Megalops	J		√			√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			√
atlanticus	L																		√			√						
Alabama shad,	A																											
Alosa	J																											
alabamae	L																											
Gulf menhaden,	A	√	√									√	√		√	√					√	√			√			√
Brevoortia	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
patronus	L																		√			√						√
Gizzard shad,	A	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
Dorosoma	J							nd	nd		√	√	√		√			√			√							√
cepedianum	L																											
Bay anchovy,	A	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Anchoa	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
mitchilli	L	√	√		√	√	√		√		√	√	√		√	√		√	√		√	√			√			√
Hardhead catfish,	A	√	√		√	√	√	√	√			√	√		√	√		√	√		√	√			√			√
Arius	J	√	√		√	√	√	√	nd			√	√		√	√		√	√		√	√			√			√
felis	L		√			√	√		nd			√	√		√	√		√	√		√	√			√			√
Sheepshead minnow,	A	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
Cyprinodon	J	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
variegatus	L	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
Gulf killifish,	A	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
Fundulus	J	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
grandis	L	√	√		√	√	√	√	√			√	√		√	√		√	√		√	√			√			√
Atlantic silversides,	A	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
Menidia	J	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
species	L	√	√		√	√		√	√		√	√			√			√	√		√	√			√			√
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		

Legend:

T = Tidal fresh zone
M = Mixing zone
S = Seawater zone
* = Salinity zone not present

A = Adults
J = Juveniles
L = Larvae

√ = Species/lifestage is present. Present = rare, common, abundant, or highly abundant
Blank = Species/lifestage is not present
nd = No data available

Table 5, continued. Presence/absence of 40 species in Texas estuaries.

Species		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
Snook,	A						√				√	√	√					√	√		√	√						
Centropomus	J						√				√	√	√					√	√		√	√			√			
undecimalis	L																		√			√						
Bluefish,	A															√		√	√		√	√						
Pomatomus	J		√		√	√	√	nd	√			√	√					√	√		√	√						
saltatrix	L																											
Crevalle jack,	A	√	√		√	√	√					√	√		√	√		√	√		√	√			√			√
Caranx	J		√			√	√		√			√	√		√	√		√	√		√	√			√			√
hippos	L																											
Florida pompano,	A															√		√	√		√	√			√			√
Trachinotus	J						√						√			√		√	√		√	√			√			√
carolinus	L																											
Gray snapper,	A												√					√	√		√	√			√			√
Lutjanus	J						√						√			√		√	√		√	√			√			√
griseus	L																											
Sheepshead,	A	√	√			√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Archosargus	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
probatocephalus	L																	√	√		√	√						√
Pinfish,	A										√	√	√		√	√		√	√		√	√			√			√
Lagodon	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
rhomboides	L																											
Silver perch,	A	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Bairdiella	J	√	√		√	√	√	nd	√			√	√		√	√		√	√		√	√			√			√
chrysoura	L					√	√		√			√	√		√	√		√	√		√	√			√			√
Sand seatrout,	A					√	√					√	√					√	√		√	√			√			√
Cynoscion	J		√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
arenarius	L																					√						
Spotted seatrout,	A	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Cynoscion	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
nebulosus	L	√	√			√	√		√			√	√		√	√		√	√		√	√			√			√
Spot,	A	√	√		√	√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			√
Leiostomus	J	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
xanthurus	L																											
Atlantic croaker,	A	√	√		√	√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			√
Micropogonias	J	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
undulatus	L																		√		√	√			√			
Black drum,	A		√			√	√		√			√	√		√	√		√	√		√	√			√			√
Pogonias	J	√	√		√	√	√	√	√		√	√	√		√	√		√	√		√	√			√			√
cromis	L						√						√						√			√			√			√
Red drum,	A	√	√		√	√	√	nd	nd		√	√	√		√	√		√	√		√	√			√			√
Sciaenops	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
ocellatus	L					√	√						√															
Striped mullet,	A	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Mugil	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
cephalus	L												√												√			
Code goby,	A						√		nd			√	√		√	√		√	√		√	√			√			√
Gobiosoma	J						√		nd			√	√		√	√		√	√		√	√			√			√
robustum	L						√		nd			√	√		√	√		√	√		√	√			√			√
Spanish mackerel,	A		√													√			√		√	√						
Scomberomorus	J		√			√	√		√			√	√			√		√	√		√	√			√			
maculatus	L																											
Gulf flounder,	A						√					√	√			√		√	√		√	√			√			
Paralichthys	J						√					√	√		√	√		√	√		√	√			√			√
albigutta	L																											
Southern flounder,	A	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
Paralichthys	J	√	√		√	√	√	nd	√		√	√	√		√	√		√	√		√	√			√			√
lethostigma	L																											
Number of species/	A	22	26		18	27	31	5	16		20	33	34		31	34		35	34		36	35			33			28
lifestages present	J	23	30		25	32	37	8	25		25	37	38		34	35		39	37		39	37			35			32
within each zone:	L	8	12		10	16	18	4	10		9	16	19		15	16		17	23		18	23			19			14
		T	M	*	T	M	S	T	M	*	T	M	S	*	M	S	*	M	S	*	M	S	*	*	S	*	*	S
		Sabine Lake			Galveston Bay			Brazos River			Matagorda Bay			San Antonio Bay			Aransas Bay			Corpus Christi Bay			Laguna Madre			Baffin Bay		

Legend:

T = Tidal fresh zone
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Blank = Species/lifestage is not present
nd = No data available

List of Appendices

Appendix 1. ELMR Gulf of Mexico Species List

Scientific Name	Common Name
Argopecten irradians	Bay scallop
Crassostrea virginica	American oyster
Rangia cuneata	Common rangia
Mercenaria species	Hard clam
Lolliguncula brevis	Bay squid
Penaeus aztecus	Brown shrimp
Penaeus duorarum	Pink shrimp
Penaeus setiferus	White shrimp
Palaemonetes pugio	Grass shrimp
Panulirus argus	Spiny lobster
Callinectes sapidus	Blue crab
Menippe adina	Gulf stone crab
Menippe mercenaria	Stone crab
Carcharhinus leucas	Bull shark
Megalops atlanticus	Tarpon
Alosa alabamae	Alabama shad
Brevoortia patronus	Gulf menhaden
Brevoortia smithi	Yellowfin menhaden
Dorosoma cepedianum	Gizzard shad
Anchoa mitchilli	Bay anchovy
Arius felis	Hardhead catfish
Cyprinodon variegatus	Sheepshead minnow
Fundulus grandis	Gulf killifish
Menidia species	Atlantic silversides
Centropomus undecimalis	Snook
Pomatomus saltatrix	Bluefish
Caranx crysos	Blue runner
Caranx hippos	Crevalle jack
Trachinotus carolinus	Florida pompano
Lutjanus griseus	Gray snapper
Archosargus probatocephalus	Sheepshead
Lagodon rhomboides	Pinfish
Bairdiella chrysoura	Silver perch
Cynoscion arenarius	Sand seatrout
Cynoscion nebulosus	Speckled seatrout
Leiostomus xanthurus	Spot
Micropogonias undulatus	Atlantic croaker
Pogonias cromis	Black drum
Sciaenops ocellatus	Red drum
Mugil cephalus	Striped mullet
Gobiosoma robustum	Code goby
Scomberomorus maculatus	Spanish mackerel
Paralichthys albigutta	Gulf flounder
Paralichthys lethostigma	Southern flounder

Appendix 2. ELMR Gulf of Mexico Estuaries

Estuary	State
Florida Bay	Florida
Ten Thousand Islands	Florida
Charlotte Harbor	Florida
Caloosahatchee River	Florida
Tampa Bay	Florida
Suwanee River	Florida
Apalachee Bay	Florida
Apalachicola Bay	Florida
St. Andrew Bay	Florida
Choctawhatchee Bay	Florida
Pensacola Bay	Florida
Perdido Bay	Florida
Mobile Bay	Alabama
Mississippi Sound	Alabama/Mississippi
Breton/Chandeleur Sounds	Louisiana
Lake Borgne	Louisiana
Lake Pontchartrain	Louisiana
Mississippi River	Louisiana
Barataria Bay	Louisiana
Terrebonne/Timbalier Bays	Louisiana
Atchafalaya and Vermilion Bays	Louisiana
Calcasieu Lake	Louisiana
Sabine Lake	Louisiana/Texas
Galveston Bay	Texas
Brazos River	Texas
Matagorda Bay	Texas
San Antonio Bay	Texas
Aransas Bay	Texas
Corpus Christi Bay	Texas
Laguna Madre	Texas
Baffin Bay	Texas

Appendix 3. National Estuarine Inventory map of Galveston Bay

Galveston Bay
TX

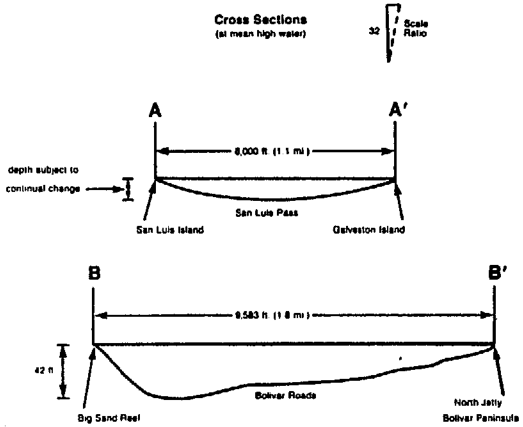
PHYSICAL AND HYDROLOGIC CHARACTERISTICS

PHYSICAL	
Surface Areas (mi²)	
Fluvial Drainage	20 035
Estuarine Drainage	4,265
Estuarine Zones	
Tidal Fresh	3
Mixing Zone	470
Seawater	51
Total	52
Dimensions	
Length (mi.)	45 0
Width (mi.) Average	12 1
Minimum	2 2
Maximum	27 2
Average Depth (ft.)	6 8
Average Depth to Width Ratio	$1\ 0 \times 10^{-4}$
Stratification Classification	
3-Month High Flow	VH
3-Month Low Flow	VH

FRESHWATER INFLOW		
Flow Rates (1000 cfs)		
Period of Record		1924-1984
Long Term Average Daily		15 2
Long Term Average Monthly	J 16 1	J 11 7
	F 19 2	A 9 0
	M 18 5	S 11 3
	A 18 1	O 10 8
	M 21 8	N 13 4
	J 20 5	D 15 3
7-Day, 10-Year Low Flow		0 4
50-Year Flood		133 0
100-Year Flood		142 0
Flow Ratios		
Average Annual		0 183
High Flow Period		0 247
Low Flow Period		0 125

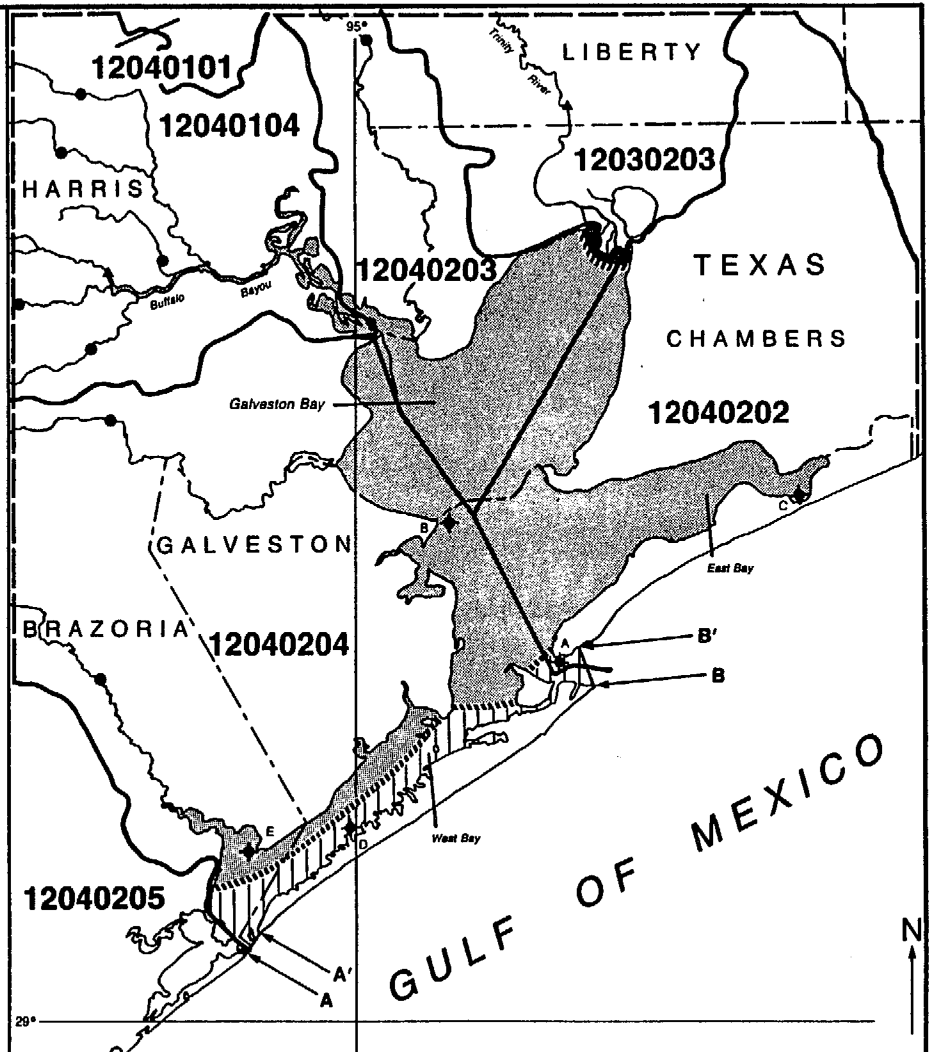
TIDAL DATA		
Prevailing Tide Diurnal		
Tidal Prism (cf)		$7\ 41 \times 10^{9}$
Phase Range of Tide (ft.)		
Map Key	Station	Range
A	3276	1 4
B	3280	0 6
C	3285	0 8
D	3287	0 8
E	3288	0 7

Abbreviations Vertically Homogeneous, VH, Moderately Stratified, MS, Highly Stratified HS

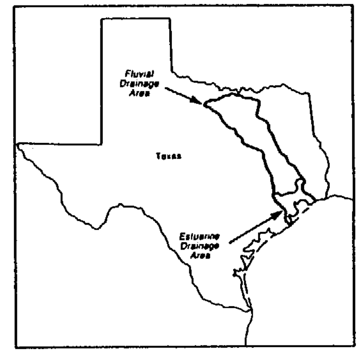


Notes:
Approximately 40% of Estuarine Drainage Area is shown on map Flows include freshwater input from precipitation.

References:
Carrillo and Buckner, 1985 Hofstetter, 1977, Hann, 1970 Texas Department of Water Resources, 1981. Texas Department of Water Resources, 1980 Qasim, et al., 1981 Parmer, et al , 1971 Ward, 1977. Ward, 1979. Massey, et al , 1983a U S Department of Commerce, 1983a.



Map Sources:
U S Geological Survey, State of Texas, Hydrologic Unit Map, 1974, scale 1 500,000. USGS Accounting Units of the National Water Data Network, 1979, scale 1 7,500,000 NOAA/NOS Nautical Charts No 11322, March, 1984, scale 1 40,000; No 11326, April, 1984, scale 1 25,000



- Tide Gage
- Flow Gage
- Head of Tide
- Estuarine Drainage Area (EDA)
- Tidal Fresh Zone
- Mixing Zone
- Seawater Zone
- Hydrologic Cataloging Unit Boundary
- County Boundary
- Salinity Zone Boundary - Low Variability
- Salinity Zone Boundary - Moderate Variability
- Salinity Zone Boundary - High Variability

Species profile: Bay anchovy (*Anchoa mitchilli*)

Common Name: Bay Anchovy
Scientific Name: *Anchoa mitchilli*

Other Common Names: Anchovy

Classification

Phylum:	Chordata
Class:	Osteichthyes
Order:	Clupeiformes
Family:	Engraulidae

Value

Commercial: Not currently harvested in United States due to their small size, but of some use as bait and for the preparation of anchovy paste (Christmas and Waller 1973; Daly 1970; Hildebrand 1943; Hildebrand 1963).

Recreational: Indirectly important to sport fishery by serving as a major forage species for many game fish (Hildebrand 1943; Christmas and Waller 1973).

Indicator of Environmental Stress: Studies supported by the Texas Water Quality Board show that the bay anchovy can be used to indicate poor water quality. This species can quickly adapt to pollution stress due to its small size and short food chain and can become the dominant species of the polluted area. Its dominance in a particular area for two of more consecutive seasons is indicative of deteriorating water quality (Bechtel and Copeland 1970).

Ecological: Bay anchovies probably constitute the greatest biomass of any fish in the estuarine waters of both the south Atlantic and the Gulf of Mexico (Christmas and Waller 1973; Perret *et al.* 1971; Perry 1979; Reid 1955). This large population provides a major staple in the diet of many birds and fish (Christmas and Waller 1973; Hildebrand 1943; Reid 1955). Piscine predators include *Sciaenops ocellatus, Cynoscion arenarius, C. nebulosus, Bairdiella chrysoura, Strongylura marina, Synodus foetens, Elops saurus, Ictalurus furcatus, Micropogon undulatus, Paralichthys lethostigma*, and *Caranx hippos* (Carr and Adams 1973; Darnell 1958; Darnell 1961; Gunter 1945; Reid 1955; Sheridan 1978). Distributions of predators indicate that the bay anchovy is an important prey species in the weedy shallows as well as surface and bottom waters (Darnell 1961).

Range

Overall: Occurs from Casco Bay, Maine to Vera Cruz, Rio Panuco, Tampico, Mexico (Daly 1970; Hoese and Moore 1977; Hildebrand 1943; Hildebrand 1963; Houde 1974). Taken only rarely in Yucatan, Gulf of Maine, and Florida Keys and never in the West Indies (Daly 1970; Hoese and Moore 1977; Hildebrand 1943). There are two distinct subspecies of the bay anchovy: *Anchoa mitchilli diaphana* which occurs in the study area and ranges from the Yucatan to South Carolina, and *Anchoa mitchilli mitchilli* which extends from North Carolina to Maine (Hildebrand 1943). It has also been shown by morphometric methods that virtually every section of the coast within the range of the bay anchovy has a distinct population (Hildebrand 1943; Hildebrand 1963).

Within Study Area: Occurs from Rio Grande to Mobile, Alabama, primarily in open bays (Hoese and Moore 1977; Springer and Woodburn 1960).

Life Mode

All stages are pelagic, occurring throughout the water column (Hoese 1965; Hoese and Moore 1977; Houde 1974; Kuntz 1913; Reid 1955; Ward and Armstrong 1980) as nektonic larvae, juveniles, and adults (Darnell 1958; Darnell 1961; Hildebrand 1943; Kuntz 1913; Reid 1955). Small schooling occurs in large numbers during the day in protected areas usually close to shore. Small schools have been observed while feeding at night when in the presence of predators (Arnold *et al.* 1960; Daly 1970; Hildebrand 1943; Hoese and Moore 1977; Ward and Armstrong 1980). Activity is primarily nocturnal and probably associated with feeding (Daly 1970; Zimmerman 1969).

Habitat

Type: Bay anchovy primarily a shallow estuarine and inshore coastal water species (Jones *et al.* 1978; Arnold *et al.* 1960; Swingle and Bland 1974; Springer and Woodburn 1960; Kilby 1955; Gunter 1945; Sheridan 1978; Sheridan 1983; Ward and Armstrong 1980). Studies show the bay anchovy is able to exploit a wide variety of habitats such as: in bays and bayous; off sandy beaches; in muddy coves; grassy areas along beaches; around mouths of rivers; and in both shallow and deeper waters offshore (Jones *et al.* 1978; Reid 1955; Sheridan 1978; Swingle and Bland 1974), but prefers bays and estuaries to shallow waters of the Gulf of Mexico (Christmas and Waller 1973; Gunter 1945; Kilby 1955; Springer and Woodburn 1960). Population density appears to be influenced by the mass of zooplankton present (Reid 1955) which probably accounts for their preference for bays and, when found in the Gulf, bay water masses (Hoese 1965). It is particularly common in primary and secondary bays, around shallow bay margins, islands, spoil banks, and sheltered coves, but scarce in tertiary bays (Kilby 1955; Simmons

1957; Swingle 1971; Ward and Armstrong 1980). Reported as occurring from fresh to hypersaline waters (Perret *et al.* 1971; Simmons 1957; Swingle and Bland 1974) and from depths of 0.5 to 20.0 m, appearing to prefer 2 to 3 m (Bechtel and Copeland 1970; Dokken *et al.* 1984; Dunham 1972; Franks 1970; Miller 1965; Perret *et al.* 1971; Reid 1954; Renfro 1960; Swingle 1971).

Substrate: Characteristic of unvegetated mud substrate (Cornelius 1984). Also occur over bottoms of clay, hard sand, silty clay, clayey silt, silt and sand, sandy mud, and muddy sand (Dunham 1972; Dokken *et al.* 1984; Franks 1970; Miller 1965; Reid 1954; Reid 1955; Swingle 1971; Tarver and Savoie 1976).

Physical/Chemical Characteristics:
Temperature-
Eggs- Spawning and egg development have been recorded from 22° to 32° C (Detwyler and Houde 1970; Houde 1974; Kuntz 1913). Preferred temperature range is 27.2° to 27.8° C (Ward and Armstrong 1980).

Larvae/juveniles/adults- Eurythermal, reported from waters ranging from 4.5° to 39.8° C (Chung and Strawn 1982; Dunham 1972; Franks 1970; Gunter 1945; Juneau 1975; Kilby 1955; Miller 1965; Perret *et al.* 1971; Reid 1954; Renfro 1960; Simmons 1957; Springer and Woodburn 1960; Swingle 1971; Swingle and Bland 1974; Tarver and Savoie 1976) with larvae preferring >11° C and adults preferring 8.1° to 32.2° C (Ward and Armstrong 1980). A possible upper lethal limit of 40° C was reported in one temperature study (Chung and Strawn 1982).

Salinity-
Eggs- Spawning and development has occurred at 30.9 to 37 ppt (Detwyler and Houde 1970; Hoese 1965; Houde 1974 and per. comm.1989).

Larvae/juveniles/adults- Euryhaline, collected from waters ranging from 0.0 to 80 ppt (Juneau 1975; Perret *et al.* 1971; Swingle 1971; Simmons 1957; Tarver and Savoie 1976; Cornelius 1984; Swingle and Bland 1974; Gunter 1945; Renfro 1960; Franks 1970; Dunham 1972). Salinity appears to have no relationship with distribution (Christmas and Waller 1973; Cornelius 1984; Hoese 1965; Krull 1976; Ward and Armstrong 1980), but recorded preferences include: 0.5 to 1+ ppt for larvae and 1 to 32 ppt for juveniles and adults in Matagorda Bay, TX (Ward and Armstrong 1980); 5 ppt and less in Copano and Aransas Bays, TX (Gunter 1945); 11 to 30 ppt for adults, and 11 to 20 ppt and 31 to 40 ppt for juveniles in Alazan Bay, TX (Cornelius 1984); less than 50 ppt in the upper Laguna Madre, TX (Simmons 1957); 20 to 29.9 ppt in Mobile and Baldwin counties, AL (Swingle 1971); 0.0 to 14.9 ppt in Lake Pontchartrain, LA (Tarver and Savoie 1976); and 2 to 4.9 ppt along the Mississippi coastline (Christmas and Waller 1973). Larvae tend to move into less saline waters near the freshwater interface, moving back to more saline waters as they mature (Gunter 1945; Swingle and Bland 1974; Hoese 1965).

Migrations and Movements
Moves into deeper waters during winter, and back inshore during summer (Hildebrand 1943; Hildebrand 1963; Christmas and Waller 1973; Swingle and Bland 1974). Larvae reported to migrate into lower salinity nursery areas while developing toward adulthood, and then migrate back to more saline areas (Hoese 1965; Swingle and Bland 1974).

Reproduction
Mode: Sexual, external fertilization.

Mating and Spawning: Spawning occurs in waters less than 20 m deep in bays and estuaries, and in the Gulf of Mexico where it is limited to the shallow inshore areas in bay water masses (Bechtel and Copeland 1970; Jones *et al.* 1978; Hoese 1965; Ward and Armstrong 1980). Eggs usually are released in the early evening, 6-9 pm, during warm water (>19° C) periods (Jones *et al.* 1978; Kuntz 1913; Hoese 1965; Ward and Armstrong 1980) with typical seasons in the study area being: February to March and to June in the Gulf near Port Aransas, TX and the latter part of March in Copano and Aransas Bays (Gunter 1945; Hoese 1965); summer months (June and July) in East Bay, TX; February to October in Galveston Bay, TX (Bechtel and Copeland 1970; and February through October along the Mississippi coastline (Christmas and Waller 1973). In addition, some year round spawning is reported throughout the study area (Dokken *et al.* 1984; Miller 1965; Perret *et al.* 1971; Swingle 1971; Ward and Armstrong 1980) that may be due to the area's usually short mild winters which involve warming trends during which shallow water temperatures approach and exceed 20° C (Dokken *et al.* 1984; Hoese 1965). Spawning has been observed occurring in higher salinity portions of estuaries with ranges of 30 to 37 ppt and <45 ppt being reported (Bechtel and Copeland 1970; Dokken *et al.*, 1984; Swingle and Bland 1974).

Reproductive Capacity: Preliminary data using fish from the Chesapeake Bay population indicate that during the peak spawning period virturally all females daily spawn a batch of eggs that can range from ca. 400-2000, with the actual directly related to the weight of the female. This can conceivably result in a female producing 30,000 to 50,000 eggs during the four month season in Chesapeake Bay (Houde per. comm., 1989).

Growth and Development

Egg: Slightly elongated; major axis 0.65 to 0.75 mm in length and is 0.1 to 0.8 mm longer than minor axis. Transparent with no oil globule; yolk composed of separate masses appearing as large cells (Kuntz 1913; Hildebrand 1943). Yolk volume of 0.15 mm^3 (Houde 1974). Eggs float at or near water surface until near hatching and then gradually sink (Kuntz 1913; Hildebrand 1943). Cleavage advances with great regularity and at a rapid rate (Kuntz 1913). Blastopore closes approximately ten hours after spawning with embryo slightly longer than 1/2 the greater circumference of the egg. Soon after blastopore closure, Kupffer's vesicle forms and embryo increases in length until it extends more than two thirds around the greater circumference of the yolk. Incubation is approximately 24 hours at 27.8° C (Kuntz 1913).

Larvae: 1.8-2.7 mm TL (total length) at hatching and weigh 0.0176 mg (Detwyler and Houde 1970; Houde 1978; Kuntz 1913; Ward and Armstrong 1980). Yolk sac comparatively large and greatly elongated tapering to a point posteriorly. Flattened slender body almost perfectly transparent with no evidence of pigmentation. Larvae are 2.6 to 2.8 mm TL after hatching. Yolk mass retains elongated form and segmented character decreasing in size until its absorbed 15 to 25 hours after hatching with post yolk sac larvae ranging from 2.7-16 mm (Kuntz 1913; Houde 1974; Ward and Armstrong 1980).

Juvenile: Limits of stage unknown, metamorphosis is essentially complete by 22.5 mm SL (standard length) (Jones *et al.* 1978; Ward and Armstrong 1980). Development of mouth and gut, pigmentation of eyes, and yolk exhaustion completed simultaneously at 36 hours after hatching at 26.2° C and 30.9 ppt (Detwyler and Houde 1970; Kuntz 1913; Hildebrand 1943). Size when feeding was initiated was 2.9 mm SL (Houde 1978). Growth rate of 0.70 mm/day reported after fourth day from hatch (Detwyler and Houde 1970) reaching a weight of 0.236 mg after 16 days (Houde 1978). Length of 18 mm TL attained during first month after hatch growing 10 mm/month over following 2 months (Christmas and Waller 1973).

Adult: Attain maturity at approximately 2.5 months (Jones *et al.* 1978; Hildebrand 1963) and at 34-40 mm TL (Gunter 1945; Ward and Armstrong 1980). Reported size range for adults in study area is 34-93 TL (Franks 1970; Dunham 1972; Gunter 1945; Perret *et al.* 1971; Renfro 1960; Tarver and Savoie 1976) with a recorded mean of 56.3 mm TL for males and 60.0 mm TL for females (Ward and Armstrong 1980). Two and possibly three size classes have been observed in wild fish populations but are virtually indistinguishable due to year round spawning (Cornelius 1984; Gunter 1945; Miller 1965; Perret *et al.* 1971).

Food and Feeding

Bay anchovies are primary consumers that feed predominantly on zooplankton in nocturnal currents (Bechtel and Copeland 1970; Daly 1970; Reid 1955). Young individuals are plankton strainers, consuming microzooplankton such as copepod nauplii and rotifers. When a body length of approximately 7 mm is reached, they feed on copepodites and copepods (Detwyler and Houde 1970; Darnell 1958). Some detritus is also consumed but phytoplankton is not, suggesting that food straining occurs near the bottom (Darnell 1958). As anchovies grow in size their diet becomes increasingly selective, shifting from copepods more and more to small shrimp, larval and juvenile fish, mysids, insect larvae, crab zoeae, clams, cladocerans, schizopods, gastropods, isopods, malacostracans, and supplemented by detritus from occasional bottom feeding (Arnold *et al.* 1960; Bechtel and Copeland 1970; Carr and Adams 1973; Detwyler and Houde 1970; Darnell 1958; Darnell 1961; Hildebrand 1943; Reid 1954; Reid 1955; Sheridan 1978; Weaver and Holloway 1974). Gut analysis of individuals 30-49 mm long showed the following diet proportions: 9% microinvertebrates; 58% zooplankton, and 33% organic detritus (Darnell 1961). Benthic animals and sand are most frequently encountered during the winter suggesting more intensive feeding in this area at this time (Darnell 1958).

Persons Consulted

Dr. Edward Houde, University of Maryland, Chesapeake Biological Laboratory, Solomons Maryland.

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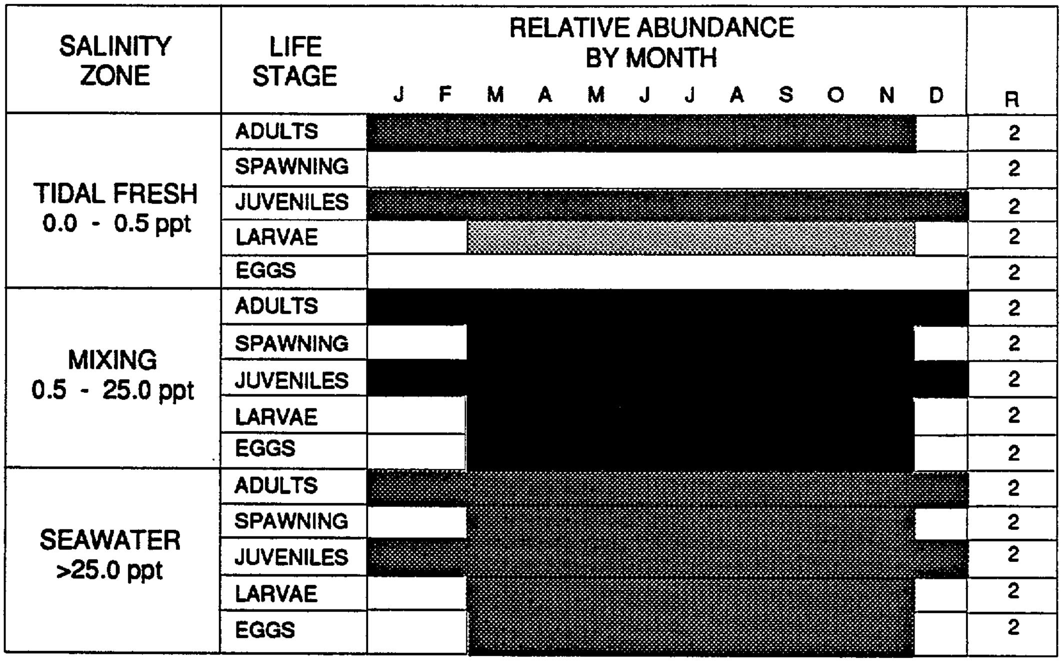
SCIENTIFIC NAME: *Anchoa mitchilli*
COMMON NAME: Bay anchovy
ESTUARY NAME: Galveston Bay
REGION: Gulf of Mexico
STATE: Texas
INVESTIGATOR: Tom Czapla



Legend: Relative Abundance:

= Not Present

= No Data

= Rare

= Common

= Abundant

= Highly Abundant

Data Reliability (R):

1 = Highly Certain

2 = Moderately Certain

3 = Reasonable Inference

Species profile: Brown shrimp (*Penaeus aztecus*)

Common Name: Brown shrimp
Scientific Name: *Penaeus aztecus*

Other Common Names: Brownies; Golden shrimp; Green lake shrimp; Native shrimp; Red or red tail shrimp (Motoh 1977).

Classification

Phylum:	Arthropoda
Class:	Crustacea
Order:	Decapoda
Family:	Penaeidae

Value

Commercial: The Gulf of Mexico shrimp fishery is the most valuable commercial fishery in the U.S. Total brown shrimp production for the area west of the Mississippi River Delta to the Texas-Mexico border was 67.7 million pounds (heads off) in 1985; slightly higher than the average yield of 67.1 million pounds from 1976-1984 (Klima *et al.* 1987). The season begins in May, peaks from June to July and gradually declines through April. Major fishing grounds are off the coasts of Texas and Louisiana. Federal regulations have annually closed the offshore fishery along the coast of Texas from around mid-May to mid-July, not more than 55 days, to allow shrimp to grow to larger sizes (Klima *et al.* 1982; 1987). The majority of the brown shrimp are harvested for human consumption, although a bait-shrimp fishery also exists (Klima *et al.* 1987).

Recreational: Approximately 8.8 and 5.2 million lbs (heads on) of total shrimp were taken by recreational shrimpers in 1979 and 1980, respectively, in Texas and Louisiana. In Louisiana, no license is required for otter trawls up to 16 ft. In Texas, licenses are required for recreational fishermen, in addition, a license is needed for trawls; catches are limited by location and season of fishing (Gulf of Mexico Fishery Management Council 1981).

Indicator of Environmental Stress: Miligan (1983) indicated dredge material was non-toxic to brown shrimp when exposed to dredge material free of significant concentrations of heavy metals, pesticides and waste metabolites. A second experiment demonstrated faster growth of shrimp in dredge material treated ponds. Confounding factors prevented direct interpretation of a third experiment in a dredge material containment site. Ward *et al.* (1981) determined a concentration of 1.2 mg/l selenium (96 h LC50) to be toxic to brown shrimp. Wofford *et al.* (1981) observed the bioaccumulation of phthalate esters (plasticizers) and demonstrated brown shrimp were better biodegraders of the ester than oysters.

Ecological: Brown shrimp are consumed by many finfish species and by large crustaceans. The loss of marsh habitat and reduction in freshwater inflow into the bays have come under recent scrutiny as major factors influencing shrimp production (Kutkuhn 1966; Minello and Zimmerman 1985; Zimmerman and Minello 1984).

Range

Overall: *Penaeus aztecus* is distributed from Martha's Vineyard, Massachusetts, around the tip of Florida and throughout the Gulf of Mexico to northwestern Yucatan. They are conspicuously absent along the western Florida coast from the Sanibel grounds to Apalachicola Bay. Their maximum density occurs along the coasts of Texas, Louisiana, and Mississippi (Williams 1984; NOAA 1985).

Within Study Area: In the northwest Gulf of Mexico, brown shrimp are distributed throughout bays, estuaries and coastal waters. In the estuaries, postlarvae and small juveniles are associated with shallow vegetated habitats and large juveniles/ subadults inhabit nonvegetated, deeper open water bottoms (Parker 1970; Zimmerman and Minello 1984).

Life Mode

Eggs are denser than seawater and are demersal (Kutkuhn 1966). Larval stages are planktonic, and their position in the water column is dependent on time of day, water temperature and water clarity (Temple and Fischer 1965; 1967; Kutkuhn *et al.* 1969). Fall-spawned postlarvae may burrow into the sediments to escape cooler temperatures and to overwinter (St. Amant *et al.* 1966; Aldrich *et al.* 1969). Postlarvae move into estuaries and transform into benthic juveniles (Cook and Lindner 1970). Adults generally inhabit offshore waters ranging from 14 to 110 meters (Renfro and Brusher 1982). Brown shrimp have an annual life cycle (Perez-Farfante 1969).

Habitat

Type: Eggs occur offshore and are demersal. Larvae occur offshore and begin to immigrate to estuaries as postlarvae around 8-14 mm TL (total length) (Cook and Lindner 1970). Juveniles and subadults prefer shallow marsh areas and estuarine bays. Adults occur in neritic Gulf waters (Perez-Farfante 1969; Williams 1984).

Substrate: Larvae and juveniles inhabit soft, muddy areas, especially in association with plant/water interfaces. Adults are associated with terrigenous silt and muddy sand substrate (Williams 1984; Hildebrand 1954).

Physical/Chemical Characteristics:

Temperature- Eggs will not hatch at temperatures below 24° C (Cook and Lindner 1970). Postlarvae have been collected from temperatures of 12.6° - 30.6° C. Aldrich *et al.* (1969) demonstrated postlarval burrowing in temperatures below 18° C. Extended exposure to temperatures below 20° C may be detrimental to population survival (Zein-Eldin and Renaud 1986). Brown shrimp greater than 75 mm tolerate temperatures between 4° and 36° C with a preferred range of 14.9° - 31.0° C (Ward *et al.* 1980).

Salinity- Brown shrimp are euryhaline to stenohaline depending on lifestage. Larvae tolerate salinities ranging from 24.1 - 36 ppt (Cook and Lindner 1970). Postlarvae have been collected from salinities of 0.1 - 69 ppt and have shown good growth at 2 - 40 ppt. Juvenile brown shrimp are distributed from 0 - 45 ppt, but prefer 10 - 20 ppt. Adults tolerate salinities of 0.8 - 45 ppt with an optimum range of 24 - 38.9 ppt. Salinity and temperature effects are more conspicuous at either extreme (Zein-Eldin and Renaud 1986).

Migrations and Movements

Brown shrimp and postlarvae move into estuaries from February to April with the incoming tides (Copeland and Truitt 1966; King 1971). In the northern Gulf of Mexico, estuarine recruitment may occur all year (Baxter and Renfro 1967). Emigration to offshore spawning grounds occurs from May through August, coinciding with full moons and ebb tides (Copeland 1965). Tagging studies in the northern Gulf indicate a west and southward movement of the adults with the prevailing currents (Cook and Lindner 1970). However more recent studies do not indicate any net movement in any direction (P. Sheridan, personal communication).

Reproduction

Mode: Sexual reproduction with external fertilization (Cook and Lindner 1970; Lassuy 1983).

Mating and Spawning: In waters off Texas, spawning occurs at depths greater than 14 m; year-round at depths of 64-110 m; and peaks of spawning in shallower water are during late spring and in the fall (Renfro and Brusher 1982). Brown shrimp may spawn more than once (Perez-Farfante 1969).

Reproductive Capacity: Renfro and Brusher (1982) found brown shrimp released an average of 246,000 viable eggs of which 15 % hatched.

Growth and Development

Embryos: Eggs are approximately 0.26 mm in diameter. Hatch occurs within 24 hours of release into the water column (Kutkuhn 1966).

Larval and Juvenile Development: Larvae transform through five naupliar stages with average TL's of 0.35, 0.39, 0.40, 0.44 and 0.50 mm respectively; three protozoeal stages with average TL's of 0.96, 1.71, and 2.59 mm; and three myses stages with average TL's of 3.3, 3.8 and 4.3 mm to become postlarvae at an average TL of 4.6 mm, in a period of 10-25 days (Cook and Murphy 1971). Postlarvae enter the estuaries and transform into juveniles around 25 mm TL. Juveniles in the estuary range from approximately 25 - 90 mm. The shrimp spend approximately three months on the nursery grounds and then move back offshore in sizes ranging from 80 - 100 mm TL (Cook and Lindner 1970; Copeland 1965; Parker 1970). Growth rates are temperature dependent. Larval growth rate estimates are: nauplii, 0.1 - 0.2 mm/day; protozoea 0.3 - 0.35 mm/day; myses 0.4 - 0.5 mm/day (Ward *et al.* 1980). Postlarval growth is maximum (greater than 0.5 mm/day) between 25° - 27° C. Juveniles have grown at 3.3 mm/day at temperatures above 25° C, but their growth decreases from 29° - 33° C (Zein-Eldin and Renaud 1986). Growth of offshore adults has not been studied in detail.

Food and Feeding

All life stages are omnivorous, and feeding begins with the first protozoeal stage (Cook and Murphy 1971). Larval stages feed on phytoplankton and zooplankton. Postlarvae feed on epiphytes, phytoplankton and detritus, but faster growth is attained on food of animal origin (Zein-Eldin and Renaud 1986). Juveniles and adults forage nocturnally on available food, including polychaetes, amphipods, chironomid larvae, but also detritus and algae. Juveniles are primarily encounter-feeders, whereas adults are selective omnivorous predators (Gulf of Mexico Fishery Management Council 1981; Zein-Eldin and Renaud 1986).

Persons Consulted

Sheridan, Peter F. DOC\NOAA\NMFS\SEFC - Galveston Laboratory, 4700 Ave U, Galveston, Texas 77550.

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SCIENTIFIC NAME:	Penaeus aztecus	REGION:	Gulf of Mexico
COMMON NAME:	Brown shrimp	STATE:	Texas
ESTUARY NAME:	Galveston Bay	INVESTIGATOR:	Tom Czapla

SALINITY ZONE	LIFE STAGE	J	F	M	A	M	J	J	A	S	O	N	D	R
TIDAL FRESH 0.0 - 0.5 ppt	ADULTS													1
	SPAWNING													1
	JUVENILES				Abundant	Abundant	Abundant	Abundant	Abundant	Common	Common	Common		1
	LARVAE													1
	EGGS													1
MIXING 0.5 - 25.0 ppt	ADULTS													1
	SPAWNING													1
	JUVENILES			Abundant	Abundant	Highly Abundant	Highly Abundant	Highly Abundant	Highly Abundant	Highly Abundant	Abundant	Abundant		1
	LARVAE	Rare	Common	Common	Common	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	1
	EGGS													1
SEAWATER >25.0 ppt	ADULTS													1
	SPAWNING													1
	JUVENILES				Common	Abundant	Abundant	Abundant	Abundant	Abundant	Common	Common	Common	1
	LARVAE	Common	Abundant	Highly Abundant	Abundant	Common	Common	Abundant	Abundant	Abundant	Common	Common	Common	1
	EGGS													1

Peaks: Juveniles peak May - June

Comments: Larvae are less than 25 mm TL (= "postlarvae")

Legend:

Relative Abundance:

- (blank) = Not Present
- (dotted) = No Data
- (light shading) = Rare
- (medium shading) = Common
- (dark shading) = Abundant
- (black) = Highly Abundant

Data Reliability (R):

1 = Highly Certain

2 = Moderately Certain

3 = Reasonable Inference

Species profile: Red drum (*Sciaenops ocellatus*)

Common Name: Red Drum
Scientific Name: *Sciaenops ocellatus*

Other Common Names - red fish, channel bass, drum, branded drum, spotted bass, spottail (Benson 1982; Bryan 1971; Daniels and Robinson 1986; Hoese and Moore 1977; Overstreet and Heard 1978; Pearson 1929; Welsh and Breder 1924; Yokel 1966). Smaller fish (<2.27 kg) are called rat reds or puppy drum while larger fish (>2.27 kg) are referred to as bull reds (Breuer 1957; Christmas and Waller 1973; Welsh and Breder 1924; Yokel 1966).

Classification
Phylum: Chordata
Class: Osteichthyes
Order: Perciformes
Family: Sciaenidae

Value
Commercial: Highly prized as a food fish throughout its range and is probably the most important sciaenid commercially. Although a commercial fishery exists on the Atlantic coast, the main industry is along the northern Gulf of Mexico in Texas, Louisiana, and Florida (Bass and Avault 1975; Benson 1982; Boothby and Avault 1971; Hoese and Moore 1977; Matlock et al. 1977; Perret et al. 1980; Vetter et al. 1983). Commercial harvest is by gill net, trammel net, and trotline (Adkins et al. 1979; Heffernan and Kemp 1980; Matlock 1980; Matlock et al. 1977). Fish in the Gulf of Mexico are also caught by hand lines, beach seines in the surf, and intertidally in Gulf shrimp trawls. Harvest occurs mainly during fall (October - December) and spring (March - June), usually in estuaries (Matlock 1980).

A decline in reported landings in recent years for Gulf coast states has been due to overfishing and habitat destruction (Swingle et al. 1984; Heffernan and Kemp 1982). These declines resulted in closure of the Texas commercial fishery in 1981, closure of the Alabama commercial fisheries, and severe restriction of the harvest in Louisiana, Mississippi, and Florida. Commercial landings for 1985 were: Alabama 1,292,368 kg; Mississippi 12,272 kg; and Louisiana 1,334,545 kg (NMFS 1986).

Recreational: Highly prized as both a game and food fish. Their fighting ability on light tackle and delectable taste has probably made this fish the most important recreational species of sciaenid. It is highly esteemed for the table in the south, but in the northern part of its range it is primarily a game fish caught by surf fishing (Adkins et al. 1979; Arnold et al. 1960; Bass and Avault 1975; Boothby and Avault 1971; Hoese and Moore 1977; Matlock 1980; Overstreet 1983; Perret et al. 1980; Welsh and Breder 1924). The most important recreational fisheries in the study area are in Texas and Louisiana. Alabama does not consider this species a popular sport fish, and in Mississippi, although popular, low fishing effort due to a low human population and few tourists results in relatively insignificant catches (Bass and Avault 1975; Christmas and Waller 1973; Matlock 1980; Overstreet and Heard 1978). The most sought after fish are those less than 2.2 kg, larger fish being unpopular due to presence of parasites in the flesh and the belief that larger fish have a poor taste (Adkins et al. 1979; Benson 1982; Boothby and Avault 1971). Hybridization experiments with this species show promise in producing an excellent sport fish (Anon. 1983). Fishing is primarily by rod and reel, or pole and line in surf, island passes, and estuaries especially during seasonal runs in the spring and fall (Benson 1982; Boothby and Avault 1971; Franks 1970; Matlock 1980).

Ecological: Marine, littoral, crepuscular predators that indiscriminately feed on the bottom or in the water column, usually in shallow water (Benson 1982; Boothby and Avault 1971; Gunter 1945; Holt et al. 1983; Pearson 1929; Simmons and Breuer 1962; Ward and Armstrong 1980; Zimmerman 1969).

Indicator: A study funded by the University of Florida has found evidence that metal poisoning has occurred among large (7-18 kg) red drum (Cardeilhac et al. 1981).

Range
Overall: In the western Atlantic from the Gulf of Maine off Massachusetts to Florida, and in the Gulf of Mexico from Florida to Tuxpan, Mexico (Boothby and Avault 1971; Holt et al. 1983; Hoese and Moore 1977; Lux 1969; Matlock 1980; Matlock 1987; Overstreet 1983; Simmons and Breuer 1962; Ward and Armstrong 1980; Welsh and Breder 1924; Yokel 1966). New Jersey probably represents the northern boundary where this species occurs as a regular part of the marine fauna. The exact southern end of the range is unknown but probably occurs between Tuxpan and Tecolutla, due to the absence of bays or estuaries south of Nautla (403 km south of Tuxpan) (Yokel 1966). Centers of abundance exist in the waters of Chesapeake Bay, North Carolina, and the Gulf of Mexico (Matlock 1980; Ward and Armstrong 1980; Yokel 1966).

Within Study Area: Rio Grande River to Mobile, Alabama (Boothby and Avault 1971; Holt et al. 1983; Hoese and Moore 1977; Matlock 1980; Matlock

1987; Overstreet 1983; Simmons and Breuer 1962; Ward and Armstrong 1980; Welsh and Breder 1924; Yokel 1966). Centers of abundance occur in Texas and Mississippi (Ward and Armstrong 1980; Yokel 1966). Higher abundance in Mississippi waters may be due to the benefits of the extensive estuaries present in nearby Louisiana and low fishing effort (Yokel 1966).

Life Mode

Eggs, larvae, and early juveniles are planktonic and pelagic (Breuer 1957; Peters and McMichael 1987; Ward and Armstrong 1980). Juveniles and adults are pelagic and nektonic (Benson 1982; Breuer 1957; Gunter 1945; Holt et al. 1981a; Osburn et al. 1982; Peters and McMichael 1987; Ward and Armstrong 1980). Juveniles are often found in schools, but adults are largely solitary when living in shallow water (Adkins et al. 1979; Benson 1982; Breuer 1957; Christmas and Waller 1973; Osburn et al. 1982; Overstreet 1983; Pearson 1929; Peters and McMichael 1987; Simmons and Breuer 1962). Some schools in the Gulf of Mexico are associated with schools of *Pogonias cromis, Megalops atlanticus, Caranx crysos, Euthynnus alletteratus*, and *Trachinotus carolinus*, at least when near shore, although they do not randomly mix with schools of other species. Large schools can contain 150,000 to 200,000 individuals and first appear about April and disappear offshore from September to October. Schools are often spread out more during summer than in spring or autumn (Overstreet 1983; Perret et al. 1980). Activity seems to be equally divided between night and day (Benson 1982; Minello and Zimmerman 1983; Peters and McMichael 1987; Zimmerman 1969).

Habitat

Type:

Eggs and larvae: Spawning occurs in nearshore waters close to barrier island passes and channels. Larvae and post-larvae are carried by tidal currents into the shallow inside waters of bays and estuaries (Benson 1982; Heffernan 1973; Holt et al. 1981a; Pearson 1929; Peters and McMichael 1987; Yokel 1966). Larvae move through the passes and tend to seek shallow, slack water along the sides of the channels to prevent being carried offshore during periods of ebb tide (King 1971). As larvae enter inside waters, they seek grassy quiet coves, tidal flats, and lagoons where the vegetation protects them from predators and swept back offshore during ebb tides, and they can avoid rough waters until they are strong enough to swim actively (Holt et al. 1983; Overstreet 1983; Pearson 1929; Perret et al. 1980; Simmons and Breuer 1962; Ward and Armstrong 1980; Yokel 1966). Eggs from captive spawns develop best in polyhaline to euhaline waters, while early larvae are found in mesohaline to euhaline waters. Older larvae and post larvae are euryhaline (Arnold et al. 1979; Crocker et al. 1981; Holt et al. 1981a; Overstreet 1983; Perret et al. 1980; Peters and McMichael 1987; Vetter et al. 1983; Ward and Armstrong 1980; Yokel 1966).

Juveniles: Euryhaline (Benson 1982; Crocker et al. 1981; Crocker et al. 1983; Daniels and Robinson 1986; Gunter 1942; Gunter 1956; Holt et al. 1981a; Perret et al. 1980; Peters and McMichael 1987; Simmons 1957; Simmons and Breuer 1962; Yokel 1966). Found in a wide variety of habitats perhaps due to their movements from bay shores to quiet backwater areas as they grow and begin to disperse through the bay (Peters and McMichael 1987). Prefer shallow, protected, open waters of estuaries, coves, and secondary bays with depths up to 3.05 m, but may also be found near the mouths of tidal passes. Juveniles have also been reported from tidal pools, marsh habitats, depressions in marshy areas, boat basins, bayous, flats, channels, reefs, back bays, around islands, near river mouths, and occasionally the surf along the Gulf of Mexico in the spring following hatching. Older juveniles tend to move into slightly deeper, more open waters and into primary bays (Benson 1982; Breuer 1957; Osburn et al. 1982; Christmas and Waller 1973, Crocker et al. 1981; Holt et al. 1981a; Overstreet 1983; Pafford 1981; Pearson 1929; Perret et al. 1980; Peters and McMichael 1987; Simmons and Breuer 1962; Reid 1955; Simmons 1957; Swingle 1971; Ward and Armstrong 1980; Yokel 1966; Zimmerman 1969.

Adult: Euryhaline (Benson 1982; Crocker et al. 1981; Daniels and Robinson 1986; Gunter 1942; Gunter 1956; Holt et al. 1981a; Simmons and Breuer 1962). Occasionally found in shallow bays, but tend to spend more time in marine habitats after their first spawning. They are typically found in the Gulf of Mexico in littoral and shallow nearshore waters off beaches (Benson 1982; Overstreet 1983; Pafford 1981; Perret et al. 1980; Ross et al. 1983; Ward and Armstrong 1980). Often caught in more offshore waters, as far as 25 km from shore in depths up to 40 m, and are commonly reported from depths of 40 to 70 m; occasionally caught on Gulf reefs (Benson 1982; Heffernan 1973; Lux 1969; Overstreet 1983; Ross et al. 1983).

Substrate:

Larvae/early juveniles: Newly hatched larvae are found in the Gulf surf over pure sand bottoms, but prefer muddy bottoms after entering bays and estuaries. Occur in inshore waters over substrates of mud, sand, or sandy mud bottoms as well as in and among patchy sea grass meadows. Small fish are probably more successful at capturing prey in the less dense vegetation areas while living in areas of greater sea grass density may help them to avoid predation (Benson 1982; Holt et al. 1983; Overstreet 1983; Perret et al. 1980; Pearson 1929; Simmons and Breuer 1962; Ward and Armstrong 1980; Yokel 1966). Normally associated with such sea grasses as *Halodule beaudettes*, *Ruppia maritima*, and *Thallasia testudinum* (Perret et al. 1980; Zimmerman 1969).

Large juveniles/adults: Common over muddy, sandy, or oyster reef bottoms with little or no sea grass (Perret et al. 1980; Yokel 1966).

Physical/chemical: Tolerance to the environment changes with age (life history), season, and geography (Crocker et al. 1981).

Temperature: Eggs/larvae: Eggs and newly hatched larvae tend to be stenothermal, but become more eurythermal at 10 da and older (Crocker et al. 1981). Eggs and larvae from captive spawns have developed over a temperature range of 20 to 30° C with optimal survival at 25° C, while higher temperatures (30 and 35° C) were associated with poor yolk sac larvae survival (Holt et al. 1981a; Lee et al. 1984; Overstreet 1983). Larvae and post-larvae have been collected in the wild from 18.3 to 31.0° C (Peters and McMichael 1987; Perret et al. 1980; Yokel 1966).

Juveniles: Eurythermal, found in waters ranging in temperature from 2.0 to 34.9° C (Adkins et al. 1979; Barret et al. 1978; Bonin 1977; Christmas and Waller 1973; Daniels and Robinson 1986; Franks 1970; Gunter 1945; Holt et al. 1981a; Peters and McMichael 1987; Perret et al. 1971; Perret et al. 1980; Simmons and Breuer 1962; Tarver and Savoie 1976; Yokel 1966). Appear to prefer temperatures ranging from 10 to 30° C (Ward and Armstrong 1980). Juveniles in heated discharge waters have survived up to 35° C, but at 39° C some mortality occurred, apparently from handling stress (Overstreet 1983). Large numbers have been reported killed in sudden severe cold spells, but normally fish will move into deeper waters during periods of extreme temperatures (Adkins et al. 1979; Simmons and Breuer 1962).

Adults: Eurythermal, collected over a temperature range from 2.0 to 33° C (Juneau 1975; Daniels and Robinson 1986; Perret et al. 1980; Simmons and Breuer 1962; Ward and Armstrong 1980; Yokel 1966). Adults considered more susceptible to the effects of winter cold waves than smaller fish (Yokel 1966), and normally move into deeper waters for refuge (Simmons and Breuer 1962).

Salinity: All life stages are sensitive to high salinities when combined with high temperatures, but this is influenced by the size of the fish (Simmons 1957). Eggs and larvae in particular are sensitive to environmental conditions (Overstreet 1983).

Eggs: Eggs from captive spawns develop successfully into feeding larvae at salinities of 10 to 40 ppt in a temperature of 25° C. Below 10 ppt hatch rate is poor, and below 25 ppt eggs sink resulting in losses from fungal infection, crowding, and low oxygen (Vetter et al. 1983). High salinities coupled with high temperatures were associated with poor yolk-sac larvae survival (Holt et al. 1981a). Salinities reported best for 24 h survival and hatch are 30 ppt at 25° C and 34 to 36.5 ppt at 23 to 26° C (Lee et al. 1984; Neff et al. 1982; Overstreet 1983).

Larvae: Larvae from captive spawns were more stenohaline than older life stages, particularly during the first two weeks after hatching with best survival around 30 ppt (Crocker et al. 1981; Holt et al. 1981a; Overstreet 1983). One article reports tolerance from <1 to 50 ppt and a preference of 20 to 40 ppt salinity (Ward and Armstrong). Larvae and post-larvae collected in the wild were found in a salinity range of 16 to 36.4 ppt (Peters and McMichael 1987; Yokel 1966).

Juveniles/adults: Euryhaline (Benson 1982; Crocker et al. 1981; Daniels and Robinson 1986; Gunter 1942; Gunter 1956; Holt et al. 1981a; Perret et al. 1980; Simmons and Breuer 1962; Yokel 1966). Very efficient osmoregulators with the ability to tolerate abrupt changes in salinity which is especially important to juveniles in the estuarine environment. Juveniles appear more tolerant to low salinity, whereas adults that are less dependent on estuarine areas and spend more time at sea are more tolerant of high salinity (Crocker et al. 1983; Yokel 1966). Collected regularly from a salinity range of 0 to 45 ppt, but only rarely at 50 ppt or above (Crocker et al. 1981; Barret et al. 1978; Bonin 1977; Christmas and Waller 1973; Daniels and Robinson 1986; Franks 1970; Gunter 1945; Holt et al. 1981a; Juneau 1975; Perret et al. 1971; Perret et al. 1980; Peters and McMichael 1987; Simmons 1957; Simmons and Breuer 1962; Tarver and Savoie 1976; Ward and Armstrong 1980; Yokel 1966). Large juveniles and adults appear to prefer salinities from 20 to 40 ppt, with maximum growth for juveniles occurring at 35 ppt (Benson 1982; Bonin 1977; Crocker et al. 1981; Holt et al. 1981a; Perret et al. 1980; Ward and Armstrong 1980). One report found small juveniles (17-58 mm TL) at greatest abundance in salinities below 15 ppt (Gunter 1945).

Other:
Oxygen: Fry can not survive low D.O.'s of 0.6-1.8 ppm (Overstreet 1983). Large juveniles have been reported in waters with D.O.'s of 5.2 and 8.4 ppm (Barret et al. 1978).

NH_3: The maximum concentration allowing normal growth of larvae was 0.11 mg/liter, but older fish were found able to tolerate higher concentrations (Holt and Arnold 1983).

Movements and Migrations
Relatively non-migratory with no significant movements, but does have broad random movements, loosely coordinated temperature induced migrations, and strong offshore or deep water spawning migrations (Adkins et al. 1979; Moe 1972; Osburn et al. 1982; Perret et al. 1980; Simmons and Breuer 1962; Ward and Armstrong 1980). Tagging studies have shown little intra-bay movement or bay-Gulf travel, except perhaps for short periods, and a few individuals with some extensive movement, but very infrequently (Beaumariage 1969; Osburn et al. 1982; Pafford 1981; Simmons and Breuer 1962). These studies also show fish tagged in the Gulf of Mexico remained there, perhaps permanently (Simmons and Breuer 1962; Simmons and Hoese 1959).

Eggs, larvae, and early juveniles are carried by tides and currents in late fall into the shallow estuaries and bays with peaks occurring in October. Larvae tend to move through barrier island passes in mid-channel surface waters with the tidal current (Bass and Avault 1975; Benson 1982; Holt et al. 1981a; King 1971). Fish move from bay shores farther into the estuary to quiet back water areas as they grow, eventually occupying secondary bays considerable distances from their original point of entry (Perret et al. 1980; Peters and McMichael 1987; Yokel 1966). Young drum will leave these shallow areas when ca. 40-120 mm or 85-100 mm TL and move into primary bays and somewhat deeper waters (>1.8 m). This movement may be accelerated by cold (Osburn et al. 1982; Pearson 1929; Peters and McMichael 1987; Yokel 1966). Movement of sub-adults (<3 years) in bays appears limited with schools remaining in a single locale for several months (Osburn et al. 1982). Most movements by this group apparently consist of responses to temperature and salinity, and foraging which can be considerable even if the fish remain within a small general area (Overstreet 1983; Pafford 1981). As juveniles approach 200 mm TL during their first spring, they may remain in deep water areas of bays or congregate near passes usually occurring in large aggregations (Peters and McMichael 1987; Simmons and Hoese 1959). Sub-adults may remain in the bays year-round, but older fish move out into the open Gulf in late fall and winter, and possibly during summer (Matlock 1987; Perret et al. 1980). This seasonal movement is a gradual one with fish disappearing offshore presumably to spawn (Benson 1982; Pearson 1929). Class I juveniles leaving the bay system in the fall probably reenter with older juveniles the following spring in a more contracted migration (Benson 1982; Pearson 1929; Ward and Armstrong 1980). Migrating fish may use salinity gradients as predictive cues for directed movements from estuarine to oceanic habitats and back (Owens et al. 1982)

Results from recent studies suggest large offshore fish may have a more extensive migration over time than was previously thought. This migration may be dictated by abundance of specific food items in which case the red drum might continually migrate in a relatively consistent pattern in order to optimize rich areas seasonally (Overstreet 1983; Overstreet and Heard 1978; Pafford 1981).

Reproduction
Mode: Fertilization in captive fish is by externally broadcast sexual products.

Mating and Spawning: Onset and duration vary with photoperiod, water temperature, and possibly other factors (Holt et al. 1981a; Overstreet 1983), but typically lasts from late summer through early winter, usually beginning in September and ending in early January, with peaks in mid-September through October and then declining (Benson 1982; Boothby and Avault 1971; Christmas and Waller 1973; Gunter 1945; Heffernan 1973; Holt et al. 1981a; Lee et al. 1984; Matlock 1987; Overstreet 1983; Perret et al. 1980; Welsh and Breder 1924; Yokel 1966). Occurs in nearshore coastal waters on the Gulf side of barrier islands usually in or near passes and channels between islands where currents can carry eggs to shallow inside waters (Benson 1982; Breuer 1957; Gunter 1945; Higgins and Lord 1926; Holt et al. 1981a; Lee et al. 1984; Matlock 1987; Pearson 1929; Peters and McMichael 1987; Perret et al. 1980; Yokel 1966). One study estimated spawning occurring 7.3 to 21.9 m offshore of a natural pass in Texas (Heffernan 1973). Spawning activities are initiated in early evening or night (Guest 1978; Holt et al. 1981b; Overstreet 1983).

Reproductive Capacity: Captive fish spawn repeatedly and produce large numbers (ca. 106/ spawn) of small buoyant eggs (Vetter et al. 1983). Estimated number of oocytes from a 758 mm SL female was 61,998,776 when calculated by volumetric means, or 94,513,172 using the gravimetric method

(Overstreet 1983). In one experiment, 10-12 spawns/fish over 90-100 days were typical, with one captive fish spawning 31 times over 90 days, while another reported 3 females spawning 52 times in 76 days, producing an estimated 6 x 107 eggs. Captive spawns were around 1 million/spawn during the first 45 days, dropping to 10-100 thousand thereafter. The maximum recorded spawn was 2,058,000/fish during one night (Arnold et al. 1979; Overstreet 1983). A maximal single spawn apparently exists, estimated as 30,000,000 for 9-14 kg fish (Overstreet 1983).

Growth and Development

Egg: Oviparous, spherical, and buoyant. Mean diameter of 0.95 mm and a range of 0.86-0.98 mm. Usually one and up to six clear oil globules averaging 0.27 mm (0.24-0.31 mm) present. The perivitelline space varies in size, but is generally less than 2% of the egg diameter (Holt et al. 1981b; Vetter et al. 1983). Eggs spawned at 24° C and 28 ppt hatch in 19-20 h (Arnold et al. 1979), 22 h when spawned at 23° C and 36 ppt (Vetter et al. 1983), and 28-29 h at 22-23° C (Holt et al. 1981b). Live eggs float with oil globule on top, and animal pole downward. Eggs 1.5 h after fertilization (AF) are in 1-4 cell stage; morula stage occurs ca. 2.5 h AF; blastula forms by 3 h AF and many are in gastrula stage. Somites form 14 h AF. Eye lenses evident in the optic vesicles at 17-19 h AF and tail begins to elongate and bend with curvature of egg. Section of brain evident at 24-29 h AF; tail lengthened past oil globule and free of yolk sac; moderately developed finfold present around posterior 2/3's of embryo (Holt et al. 1981b). Hatching usually occurs in late summer to early winter, peaking in September-October (Matlock 1987).

Larvae: Fish less than 8.0 mm SL are larvae, while those 8-15 mm SL fish are considered transitional juveniles (Peters and McMichael 1987). Larvae are either transparent with no pigment patterns at hatching, or have a compressed band of dendritic melanophores on the ventral surface of the body in the yolk-sac region (Holt et al. 1981b). Newly hatched larvae are negatively buoyant with SL range of 1.71-1.79 mm (mean 1.74). At 25° C, on the third day after hatching, the mouth forms, eyes are pigmented, and more time is spent swimming to stay near surface. Swim bladder is well developed by day 4 and larvae remain in a horizontal position in the water column with little effort (Holt et al. 1981b). Four to 5 mm TL fish have yolk-sac present, dorsal and ventral fin folds continuous to caudal fin, caudal fin well developed as are ventral fins, but rays of dorsal and ventral fins indistinct, ventrals and pectorals obscure (Peters and McMichael 1987). At 7 mm TL, yolk-sac has disappeared and only a small membrane between the ventral and anal fins remains of larval fin fold.

Temperature has a pronounced effect on larval growth (Holt et al. 1981b; Lee et al 1984). The yolk-sac stage can range from 40 h at 30° C to 85 h at 20° C (Holt et al. 1981a; Holt et al. 1981b), and larval growth can average 17.74 µ/da at 24° and 30.25 µ/da at 28° C. Two distinct growth periods are evident in early larval development. One extends from hatching through depletion of the yolk-sac, while the other begins with the onset of active feeding. Growth rate in terms of SL was low in the first stage and averaged less than 0.06 mm/da or more (Lee et al. 1984).

Juvenile: 8.0 mm SL to ca. 40 mm TL (Gunter 1945; Peters and McMichael 1987). Above 10 mm TL, pigment rapidly appears with distinctive color patterns at ca. 25 mm TL. Twenty to 50 dark distinct blotches present at this point from the lateral line to the dorsal fin on each side of the trunk. At 36 mm TL, a pronounced chromatophore enlargement at the base of the upper caudal fin appears that results in the characteristic black ocelli. At 42 mm TL, juveniles are morphologically identical to adults except for a slightly more pointed caudal fin and lack of distinct ocelli. Ocelli faintly visible at 50 mm TL and very apparent at 75 mm TL. Brown lateral blotches enlarge with fish until 150 mm TL, and then tend to fade and finally disappear (Pearson 1929; Simmons and Breuer 1962). Growth tends to be sporadic in juveniles averaging 18.8 mm TL/mo or 20.4 mm SL/mo for the first 7.5 mo of life (Bass and Avault 1975). Other estimates based on Texas fishes report: 320-360 mm SL first year growth; 500 mm SL second year; 550-600 third year; 875 mm SL sixth year; 925 mm SL seventh year; 975-1000 mm SL eighth year (Miles 1950). Modally averages run: 340 mm SL first year; 540 mm SL second year; 640 mm third year; 750 mm SL fourth year; 840 mm SL fifth year; 330-356 mm first year; 484-559 second year; 660-762 mm third year; 890-965 fourth or fifth year (Johnson et al. 1977).

Sexual maturity occurs at the end of the third, fourth, or fifth year with 5 year old fish constituting the bulk of the spawning population. Males reach maturation during their third year and females mature in their fourth or fifth year (Benson 1982; Johnson et al. 1977; Pearson 1929; Simmons and Breuer 1962). Generally mature at ca. 700-800 mm TL (Miles 1950; Simmons and Breuer 1962), but smaller ripe fish are occasionally found. Mature fish have been collected in Texas as small as 425 mm TL. Males are presumed to mature at a smaller size than females and have been reported from Mississippi to reach maturity at 320-395 mm. Another study reported ripe males 500 mm SL and ripe females 550 mm SL from samples (Gunter 1945; Miles 1950; Perret et al. 1980). In Florida, a 630 mm FL ripe female was collected (Yokel 1966).

Adult: Average adult size is 800-850 mm SL (Miles 1949; Pearson 1929). This is a long lived fish, surviving over eight years (Johnson et al. 1977) Largest recorded fish is 1520 mm TL (Pearson 1929).

Food and Feeding

Diet consists of food items belonging to five major groups: copepods, mysid shrimp, amphipods, decapods, and fish (Bass and Avault 1975). Utilization of these groups is determined by their size and availability (Bass and Avault 1975; Boothby and Avault 1971; Overstreet and Heard 1978). The major prey of larvae are copepods, including cyclopoids, calanoids, and harpacticoids as well as various zooplankton (Bass and Avault 1975; Benson 1982; Peters and McMichael 1987). Larvae up to 9 mm TL subsist on copepods and their nauplii that range from 0.4-1.5 mm TL (Bass and Avault 1975). The calanoid *Acartia* sp. occur most frequently, but species of cyclopoids, harpacticoids, and calagoids are also found. Although they appear in juveniles 10-39 mm TL, copepods cease to be important in volume by 10-19 mm TL. Mysid shrimp, particularly *Mysidopsis almyra*, appear from 10-169 mm TL, but are most important in small juveniles 10-49 mm, TL constituting 70-100% of their diet (Bass and Avault 1975; Peters and McMichael 1987). Fish 30 mm TL and over eat small crustaceans like schizopods and amphipods (Darnell 1958). Gammarid amphipods are consistently found in 10-109 mm TL fish and are a dominant food item in fish 30-60 mm TL (Bass and Avault 1975; Peters and McMichael 1987). Generally at least five species including the genera *Ampelisca* and *Carinogammarius* are a minor part of the diet, but are moderately important in fish 30-49 mm TL. A large variety of decapods are eaten by fish 8-120 mm TL. The first to appear are caridean shrimp, usually *Palaemonetes pugio*, as well as *Hippolyte zostericola*, *Crangon spp.*, and Apheid shrimp. These are eaten until fish reach 150-159 mm TL. Penaeid shrimp, *Penaeus setiferus*, *P. duorarum*, and *P. aztecus*, enter the diet of fish 70-79 mm, and become important at 90-99 mm TL and larger (Bass and Avault 1975; Miles 1949; Overstreet and Heard 1978; Peters and McMichael 1987). At 100-175 mm TL, the chief food items are small penaeid shrimp, palaemonetid shrimp, small mullet, silversides, gobies, and small crabs (Simmons and Breuer 1962). *Callinectes sapidus* and *C.* spp. appear at 40-49 mm TL and assume importance at 70-79 mm TL. Other crabs are found predominantly in larger juveniles (>105 mm TL) and include *Uca* sp., *Sesarma reticulatum*, *Rithropanopeus harrisii*, *Menippe* spp., *Eupagurus* spp., *Libinia dubia*, and *Neopanope texana*, but are generally unimportant (Bass and Avault 1975; Miles 1949; Peters and McMichael 1987). Crabs predominate in the diet of fish 184-625 mm TL, particularly *Callinectes sapidus* and *Rithropanopeus harrisii*, as well as some fish (Darnell 1958).

Fish play a substantial role in the diet of juveniles ≥ 15 mm TL, but were most abundant in juveniles > 90 mm TL (Bass and Avault 1975; Peters and McMichael 1987). Juveniles 20-29 mm Tl began eating other sciaenids, usually *Leiostomus xanthurus* and some *Micropogon undulatus*. Other fish include: *Myrophis punctatus*, *Brevoortia patronus*, *Anchoa* sp., *Synodus foetens*, *Mugil* sp., *Menidia beryllina*, *Gobionellus boleostema*, and *Citharichthys spilosopterus*.

Food habits vary little in fish 250-924 mm SL (Boothby and Avault 1971). Smaller fish generally eat smaller-sized items, but the three main groups, shrimp, crabs, and fish, were eaten by all size classes. No noticeable difference has been observed between the diets of males and females (Boothby and Avault 1971). Red drum 245-745 mm TL have been found to consume algae, grass, eggs, cysts, detritus, mud and sand, annelids, ostracods, amphipods, fish, penaeid shrimp, squid, blue crabs, *Palaemonetes vulgaris*, *Panopeus herbstii*, *Neopanope texana*, *Crago* sp., *Calianassa jamaicense*, *Mugil* sp., *Myrophis punctatus*, *Gobiosoma bosci*, *Cyprinodon variegatus*, *Sygnathus scovelli*, *Anchoa mitchilli*, *Arius felis*, *Luciana parva*, *Leiostomus xanthurus*, and *Symphurus plagiusa* (Breuer 1957; Bryan 1971; Diener et al. 1974; Gunter 1945; Knapp 1949; Pearson 1929; Reid 1955; Reid et al. 1956; Simmons 1957). Although crustaceans as a group exceed fish in frequency of occurrence and per cent volume, fish are consumed more frequently, in greater numbers, and in greater volume than shrimp or crabs alone. Plant and substrate material that occurs in stomach contents is probably taken incidentally during feeding activities. Fish are generally more prevalent in the diet of red drum during winter and spring months, *Brevoortia* sp. being a favorite. Crustaceans become increasingly more important during late spring and by summer are the main staple and continue as such until late fall. Shrimp appear more frequently in the spring, summer, and fall. Crabs are more frequent than shrimp only in the winter (Boothby and Avault 1971).

Other organisms eaten by juveniles contributed little to stomach content volume with the possible exception of polychaetes, especially *Glycera americana* (Bass and Avault 1975; Peters and McMichael 1987). These were eaten by 30-139 mm TL fish, but were most important to 60-79 mm TL (Bass and Avault 1975; Overstreet and Heard 1978). Echinoderms are eaten regularly by large fish, but are not an important diet item (Overstreet and Heard 1978).

In addition to the main food species are the following occasional specific animals: molluscs- *Barnea truncata*; *Petricola pholodiformes*; *Sinum perspectivum*; crustaceans- *Callinectes simulis*; *Hepatus epheliticus*; *Ovalipes ocellatus*; *Pagurus longicarpus*; *Portunus gibbesi*; *Squilla* sp.; echinoderms- *Mellita quinquiesperforata*; *Sclerodactyla briareus*; fishes- *Fundulus majalis*; *Menticirrhus americanus*; *Lagodon rhomboides*; *Opsanus tau*, *Trachinotus carolinus*; and *Trinectes maculatus* (Boothby and Avault 1971; Miles 1949; Overstreet and Heard 1978; Pearson 1929). Isopods, bivalve siphons, bivalves, and a marsh rat have also been reported from stomach contents, but these items have never been abundant (Pearson 1929; Peters and McMichael 1987).

Ecological Interactions and Notes

Several organisms are known to parasitize red drum possibly as a consequence of the diverse foods consumed (Overstreet 1983; Perret 1980; Yokel 1966). Known parasites include: Sporozoans- *Hennequya ocellata*; Trematodes- unidentified; Cestodes- *Poecilan cistrium robustum* (known as spaghetti worm) infecting muscles and often resulting in fish being discarded; Copepods- parasitized most heavily by this group, contains *Brachiella qulosa*, *B. intermedia*, *Echetus typicus*, *Lernaeenicus radiatus*, *Caliqus latifrons*, *C. repax*, *C. bonito*, *C. haemulonis*, and *Lernanthropus paenulatus*; Isopods- *Nerocila* sp. (Perret et al. 1980; Simmons 1957; Yokel 1966).

Barnacles, *Balanus improvisus*, are known to attach to the flanks of red drums (Overstreet 1983).

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SCIENTIFIC NAME:	Sciaenops ocellatus	REGION:	Gulf of Mexico
COMMON NAME:	Red drum	STATE:	Texas
ESTUARY NAME:	Galveston Bay	INVESTIGATOR:	Tom Czapla

SALINITY ZONE	LIFE STAGE	J	F	M	A	M	J	J	A	S	O	N	D	R
TIDAL FRESH 0.0 - 0.5 ppt	ADULTS	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	2
	SPAWNING	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	1
	JUVENILES	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	2
	LARVAE	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	1
	EGGS	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	1
MIXING 0.5 - 25.0 ppt	ADULTS	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Common	Common	Common	Rare	2
	SPAWNING	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	1
	JUVENILES	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	2
	LARVAE	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Common	Common	Common	Not present	1
	EGGS	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	1
SEAWATER >25.0 ppt	ADULTS	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Common	Common	Common	Common	2
	SPAWNING	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	3
	JUVENILES	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	2
	LARVAE	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Common	Common	Common	Not present	2
	EGGS	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	Not present	3

Peaks: Juveniles peak in fall

Legend:

Relative Abundance:

- = Not Present
- .... = No Data
- = Rare
- = Common
- = Abundant
- = Highly Abundant

Data Reliability (R):

1 = Highly Certain

2 = Moderately Certain

3 = Reasonable Inference

Appendix 5. Personal Communications (Letter code corresponds to Appendix 6)

A.	Baxter, K. N.	National Marine Fisheries Service, Galveston
B.	Benefield, R. L.	Texas Parks and Wildlife Department, Seabrook
C.	Bryan, C. E., III	Texas Parks and Wildlife Department, Austin
D.	Campbell, P.	Texas Parks and Wildlife Department, Rockport
E.	Chaney, A.	Texas A&I University, Kingsville
F.	Clark, J.	Texas Parks and Wildlife Department, Austin
G.	Dailey, J.	Texas Parks and Wildlife Department, Palacios
H.	Dansby, B.	Texas Parks and Wildlife Department, Brownsville
I.	Edwards, R.	Pan Am University, Edinburg
J.	Forsythe, J.	Marine Biomedical Institute, Galveston
K.	Fuls, B.	Texas Parks and Wildlife Department, Flour Bluff
L.	Green, L.	Texas Parks and Wildlife Department, Rockport
M.	Hildebrand, H. H.	Flour Bluff, TX
N.	LeBlanc, C.	Texas Parks and Wildlife Department, Port Arthur
O.	Mambretti, J.	Texas Parks and Wildlife Department, Port Arthur
P.	Martin, J.	Texas Parks and Wildlife Department, Flour Bluff
Q.	Marwitz, S.	Texas Parks and Wildlife Department, Port O'Conner
R.	Meador, K.	Texas Parks and Wildlife Department, Rockport
S.	Rice, K.	Texas Parks and Wildlife Department, Brownsville
T.	Sheridan, P. F.	National Marine Fisheries Service, Galveston
U.	Trimm, D.	Texas Parks and Wildlife Department, Seabrook
V.	Tunnell, J.	Corpus Christi State University, Corpus Christi
W.	Wagner, T.	Texas Parks and Wildlife Department, Port O'Conner
X.	Weixelman, M.	Texas Parks and Wildlife Department, Palacios
Y.	Wood, C.	Texas A&I University, Kingsville
Z.	Zimmerman, R. J.	National Marine Fisheries Service, Galveston

Appendix 6. Personal communications and primary references

Scientific/Common Name	Sabine Lake
Argopecten irradians Bay scallop	N, O
Crassostrea virginica American oyster	127, 150, 350; N, O
Rangia cuneata Common rangia	5, 350, 368; N, O
Mercenaria species Hard clam	N, O
Lolliguncula brevis Bay squid	350; N, O
Penaeus aztecus Brown shrimp	127, 150, 207, 242, 246, 247, 350, 368; N, O
Penaeus duorarum Pink shrimp	127, 150, 242, 246, 247; N, O
Penaeus setiferus White shrimp	126, 127, 150, 207, 242, 246, 247, 350, 352, 368; N, O
Palaemonetes pugio Grass shrimp	368; N, O
Menippe adina Gulf stone crab	N, O
Callinectes sapidus Blue crab	126, 127, 242, 273, 350, 368; N, O
Carcharhinus leucas Bull shark	L, N, O
Megalops atlanticus Tarpon	N, O
Alosa alabamae Alabama shad	N, O
Brevoortia patronus Gulf menhaden	242, 313, 349; N, O
Dorosoma cepedianum Gizzard shad	349; N, O
Anchoa mitchilli Bay anchovy	242, 349; N, O
Arius felis Hardhead catfish	313, 349; N, O
Cyprinodon variegatus Sheepshead minnow	349; N, O
Fundulus grandis Gulf killifish	349; N, O
Menidia species Atlantic silversides	N, O
Centropomus undecimalis Snook	N, O
Pomatomus saltatrix Bluefish	349; N, O
Caranx hippos Crevalle jack	349; N, O
Trachinotus carolinus Florida pompano	N, O
Lutjanus griseus Gray snapper	N, O
Archosargus probatocephalus Sheepshead	126, 313, 349; N, O
Lagodon rhomboides Pinfish	242, 349; N, O
Bairdiella chrysoura Silver perch	N, O
Cynoscion arenarius Sand seatrout	126, 242, 313, 349; N, O
Cynoscion nebulosus Spotted seatrout	126, 242, 313, 349; N, O
Leiostomus xanthurus Spot	242, 313, 349; N, O
Micropogonias undulatus Atlantic croaker	126, 242, 313, 349; N, O
Pogonias cromis Black drum	126, 242, 313, 349; N, O
Sciaenops ocellatus Red drum	94, 126, 242, 313, 349; N, O
Mugil cephalus Striped mullet	126, 242, 313, 349; N, O
Gobiosoma robustum Code goby	N, O
Scomberomorus maculatus Spanish mackerel	242, 349; N, O
Paralichthys albigutta Gulf flounder	N, O
Paralichthys lethostigma Southern flounder	242, 313, 349; N, O

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	Galveston Bay
Argopecten irradians Bay scallop	258, 334; B, U
Crassostrea virginica American oyster	18, 126-128, 143, 161, 162-173, 210, 241, 294, 299, 306, 334, 343; B, U
Rangia cuneata Common rangia	5, 10, 191, 210, 258, 299, 334; B, U
Mercenaria species Hard clam	92, 174, 190, 241, 258, 334; B, U
Lolliguncula brevis Bay squid	8, 51, 68, 153, 154, 210, 241, 258, 299, 306, 334; B, U, J
Penaeus aztecus Brown shrimp	1, 5, 13, 14, 19-21, 54-56, 76, 82, 85, 126-128, 191-194, 203, 207, 237, 238, 241-244, 246-260, 292, 296, 299, 301, 303, 306, 310, 334, 356, 359, 360, 369, 371, 373; A, B, U
Penaeus duorarum Pink shrimp	19-21, 76, 127, 128, 203, 237, 241, 242, 246-260, 334, 356, 360; A, B, U
Penaeus setiferus White shrimp	1, 5, 8, 10, 14, 19-21, 55, 56, 76, 77, 82, 85, 107, 126-128, 178, 191-194, 203, 207, 210, 237, 241-244, 246-260, 296, 299, 301, 303, 306, 310, 332, 334, 356, 360, 369, 372; A, B, U
Palaemonetes pugio Grass shrimp	5, 56*, 82*, 85*, 178, 191, 192, 210, 241, 258, 296, 299, 334, 360, 361; B, U
Menippe adina Gulf stone crab	85, 162, 164, 191, 258, 299, 334; B, U
Callinectes sapidus Blue crab	3, 5, 8, 10, 16, 20, 21, 56, 61, 68, 73, 82, 85, 112, 126-128, 191-193, 210, 241, 242, 285, 262, 271-274, 296, 299, 302, 306, 334, 357, 360; B, U
Carcharhinus leucas Bull shark	12, 26, 116, 258, 291, 298, 300, 310; B, L, U
Megalops atlanticus Tarpon	291; B, U
Alosa alabamae Alabama shad	B, U
Brevoortia patronus Gulf menhaden	5, 8, 10, 15, 56, 82, 85, 93, 109, 113, 114, 156, 175, 178, 191-193, 204, 205, 210, 236, 240-242, 258, 291, 298, 300, 305, 306, 308, 310, 313, 329; B, U
Dorosoma cepedianum Gizzard shad	5, 8, 56, 82, 85, 114, 204, 210, 241, 258, 291, 298, 300, 305, 306, 308, 310, 329; B, U
Anchoa mitchilli Bay anchovy	5, 8, 15, 56, 82, 85, 102, 113, 114, 156, 178, 191, 192, 204, 210, 236, 241, 258, 291; B, U 298, 300, 305, 306, 308, 310, 329,
Arius felis Hardhead catfish	5, 8, 15, 56, 85, 93, 102, 113, 114, 204, 205, 210, 240-242, 258, 291, 298, 300, 305, 306, 308, 210, 313, 329, 330, 331; B, U
Cyprinodon variegatus Sheepshead minnow	2, 8, 56, 82, 85, 114, 190, 192, 204, 212, 213, 241, 258, 291, 298, 300, 306, 308, 310, 329, 342; B, U
Fundulus grandis Gulf killifish	2, 8, 56, 82, 102, 190, 192, 204, 241, 258, 291, 298, 300, 306, 308, 310, 329, 342; B, U
Menidia species Atlantic silversides	2, 5, 8, 56, 82, 102, 113, 178, 192, 241, 258, 305, 308, 310, 329; B, U
Centropomus undecimalis Snook	241; B, U
Pomatomus saltatrix Bluefish	8, 204, 258, 291, 300, 310; B, U
Caranx hippos Crevalle jack	8, 15, 85, 114, 156, 204, 205, 241, 258, 291, 298, 300, 305, 308, 329; B, U
Trachinotus carolinus Florida pompano	8, 114, 126, 258, 291, 305, 308, 310; B, U
Lutjanus griseus Gray snapper	258, 291; B, U
Archosargus probatocephalus Sheepshead	5, 8, 15, 32, 35-38, 93, 114, 126, 156, 205, 210, 215, 240-242, 258, 269, 270, 288, 290, 298, 300, 305, 306, 308, 310, 313, 329, 351, 352; B, U
Lagodon rhomboides Pinfish	2, 5, 8, 56, 82, 93, 102, 114, 156, 178, 204, 205, 240-242, 258, 291, 300, 305, 306, 308, 310, 313, 329; B, U
Bairdiella chrysoura Silver perch	8, 85, 102, 114, 156, 204, 205, 241, 258, 291, 298, 300, 305-308, 310, 329; B, U
Cynoscion arenarius Sand seatrout	5, 8, 15, 17, 56, 82, 85, 93, 102, 113, 114, 126, 156, 178, 192, 204, 205, 210, 240-242, 258, 261, 288, 291, 298, 300, 305-308, 313, 329-331; B, U
Cynoscion nebulosus Spotted seatrout	5, 8, 9, 32, 35-38, 56, 93, 94, 102, 114, 126, 156, 190, 191, 205, 210, 215, 216, 240-242, 258, 269, 270, 288, 290, 291, 298, 300, 305, 306, 308, 310.313, 329, 351, 352; B, U
Leiostomus xanthurus Spot	2, 5, 8, 15, 56, 82, 85, 93, 102, 113, 114, 156, 178, 190, 191, 204, 205, 210, 240-242, 258, 291, 300, 306, 308-610, 313, 329-331; B, U
Micropogonias undulatus Atlantic croaker	5, 8, 15, 32, 56, 82, 85, 93, 102, 104, 113, 114, 126, 156, 190-192, 204, 205, 210, 236, 240-242, 258, 288, 290, 291, 298, 300, 305-310, 313, 329-331, 351, 352, 365; B, U
Pogonias cromis Black drum	5, 8, 32, 35-38, 56, 85, 93, 102, 114, 126, 156, 190, 191, 204, 205, 210, 215, 216, 240-242, 258, 269, 270, 288, 290, 291, 298, 300, 305, 306, 308, 310, 313, 329, 351, 352; B, U
Sciaenops ocellatus Red drum	5, 8, 32, 35-38, 56, 93, 94, 102, 114, 126, 149, 156, 190, 191, 204, 205, 215, 216, 230-232, 240-242, 258, 269, 270, 288-291, 298, 305-308, 310, 313, 329, 351, 352, 363; B, U
Mugil cephalus Striped mullet	2, 5, 8, 56, 82, 85, 93, 113, 114, 126, 156, 178, 190, 191, 204, 205, 210, 241, 242, 258, 291, 298, 300, 306, 308, 310, 313, 329; B, U
Gobiosoma robustum Code goby	114, 204, 241, 258, 291; B, U
Scomberomorus maculatus Spanish mackerel	204, 242, 258, 291, 305, 310; B, U
Paralichthys albigutta Gulf flounder	85, 114, 178, 229241, 291; B, U
Paralichthys lethostigma Southern flounder	5, 8, 32, 35-38, 82, 85, 93, 102, 114, 156, 190-192, 210, 215, 216, 229, 240-242, 258, 263, 269, 270, 288, 290, 291, 298, 300, 305-308, 310, 313, 329, 346, 351, 352; B, U

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	Brazos River
Argopecten irradians Bay scallop	
Crassostrea virginica American oyster	194
Rangia cuneata Common rangia	
Mercenaria species Hard clam	
Lolliguncula brevis Bay squid	51, 194
Penaeus aztecus Brown shrimp	55, 194
Penaeus duorarum Pink shrimp	194
Penaeus setiferus White shrimp	6, 55, 194
Palaemonetes pugio Grass shrimp	194
Menippe adina Gulf stone crab	194
Callinectes sapidus Blue crab	194
Carcharhinus leucas Bull shark	26
Megalops atlanticus Tarpon	6, 194
Alosa alabamae Alabama shad	
Brevoortia patronus Gulf menhaden	6, 194
Dorosoma cepedianum Gizzard shad	6, 194
Anchoa mitchilli Bay anchovy	6, 194
Arius felis Hardhead catfish	6, 194
Cyprinodon variegatus Sheepshead minnow	6, 194
Fundulus grandis Gulf killifish	6, 194
Menidia species Atlantic silversides	194
Centropomus undecimalis Snook	
Pomatomus saltatrix Bluefish	194
Caranx hippos Crevalle jack	194
Trachinotus carolinus Florida pompano	194
Lutjanus griseus Gray snapper	
Archosargus probatocephalus Sheepshead	194
Lagodon rhomboides Pinfish	6, 194
Bairdiella chrysoura Silver perch	194
Cynoscion arenarius Sand seatrout	194, 335
Cynoscion nebulosus Spotted seatrout	6, 194
Leiostomus xanthurus Spot	6, 194
Micropogonias undulatus Atlantic croaker	6, 194
Pogonias cromis Black drum	194, 316
Sciaenops ocellatus Red drum	194, 316
Mugil cephalus Striped mullet	6, 194
Gobiosoma robustum Code goby	
Scomberomorus maculatus Spanish mackerel	194
Paralichthys albigutta Gulf flounder	
Paralichthys lethostigma Southern flounder	194

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	Matagorda Bay
Argopecten irradians Bay scallop	G, X
Crassostrea virginica American oyster	98, 100, 126, 127, 143, 161, 163, 165, 166, 168, 169, 197, 199, 209, 264, 361; G, X
Rangia cuneata Common rangia	98; G, X
Mercenaria species Hard clam	G, X
Lolliguncula brevis Bay squid	5, 51, 68, 98, 99, 153, 275; G, X
Penaeus aztecus Brown shrimp	5, 19-21, 55, 98-100, 127, 128, 193, 198, 207, 237, 242, 246, 248, 249, 251-257, 259, 260, 275, 277-279, 301, 361; G, X
Penaeus duorarum Pink shrimp	20, 21, 98, 127, 237, 242, 246, 248, 249, 251-257, 259, 260, 275, 277-279; G, X
Penaeus setiferus White shrimp	5, 19-21, 55, 98, 100, 126-128, 193, 198, 207, 237, 242, 246, 248, 249, 251-257, 259, 260, 275, 277-279, 301, 361; G, X
Palaemonetes pugio Grass shrimp	99*, 275; G, X
Menippe adina Gulf stone crab	275; G, X
Callinectes sapidus Blue crab	5, 20, 21, 61, 62, 73, 99, 100, 126-128, 200, 242, 245, 272, 273, 275, 361; G, X
Carcharhinus leucas Bull shark	116; G, L, X
Megalops atlanticus Tarpon	228; G, X
Alosa alabamae Alabama shad	G, X
Brevoortia patronus Gulf menhaden	5, 93, 97, 99, 208, 240, 242, 275, 313, 361, 364; G, X
Dorosoma cepedianum Gizzard shad	97, 99, 208, 275; G, X
Anchoa mitchilli Bay anchovy	5, 97, 198, 208, 275, 361; G, X
Arius felis Hardhead catfish	5, 93, 97, 208, 240, 242, 275, 363; G, X
Cyprinodon variegatus Sheepshead minnow	97, 99, 208, 342, 361, 364; G, X
Fundulus grandis Gulf killifish	97, 342; G, X
Menidia species Atlantic silversides	97, 99, 208, 275; G, X
Centropomus undecimalis Snook	G, X
Pomatomus saltatrix Bluefish	275; G, X
Caranx hippos Crevalle jack	97, 208, 275; G, X
Trachinotus carolinus Florida pompano	G, X
Lutjanus griseus Gray snapper	G, X
Archosargus probatocephalus Sheepshead	32, 35-38, 93, 97, 126, 198, 208, 215, 240, 242, 263, 275, 276, 288, 290, 313, 351; G, X
Lagodon rhomboides Pinfish	93, 97, 99, 208, 240, 242, 275, 313; G, X
Bairdiella chrysoura Silver perch	97, 208, 275; G, X
Cynoscion arenarius Sand seatrout	5, 93, 97, 99, 126, 198, 208, 240, 242, 275, 288, 290, 313; G, X
Cynoscion nebulosus Spotted seatrout	5, 32, 35-38, 93, 94, 97, 99, 126, 198, 206, 208, 215, 216, 240, 242, 263, 275, 276, 288, 290, 313, 351, 361, 364; G, X
Leiostomus xanthurus Spot	5, 93, 97, 198, 208, 240, 242, 275, 313, 361, 364; G, X
Micropogonias undulatus Atlantic croaker	5, 32, 93, 97, 99, 126, 198, 208, 240, 242, 275, 288, 290, 313, 351, 361, 364; G, X
Pogonias cromis Black drum	32, 35-38, 78, 93, 94, 97, 126, 198, 215, 216, 240, 242, 263, 275, 276, 288, 290, 313, 338, 351, 361, 364; G, X
Sciaenops ocellatus Red drum	5, 32, 35-38, 93, 94, 97, 99, 126, 149, 198, 206, 215, 216, 230, 231, 234, 240, 242, 263, 275, 276, 288-290, 313, 338, 351, 361, 364; G, X
Mugil cephalus Striped mullet	5, 93, 97, 99, 108, 126, 208, 242, 275, 313, 361, 364; G, X
Gobiosoma robustum Code goby	97, 208, 275; G, X
Scomberomorus maculatus Spanish mackerel	97, 208, 242, 275; G, X
Paralichthys albigutta Gulf flounder	229; G, X
Paralichthys lethostigma Southern flounder	5, 32, 35-38, 93, 97, 99, 198, 206, 208, 215, 216, 229, 240, 242, 263, 275, 276, 288, 290, 313, 351, 361, 364; G, X

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	San Antonio Bay
Argopecten irradians Bay scallop	293; Q, W
Crassostrea virginica American oyster	18, 58, 60, 65, 66, 71, 126, 128, 143, 157, 161, 163, 165, 167-169, 210, 239, 293, 294; Q, W
Rangia cuneata Common rangia	5, 141, 210, 239, 293; Q, W
Mercenaria species Hard clam	157, 293; Q, W
Lolliguncula brevis Bay squid	5, 58, 153, 210; Q, W
Penaeus aztecus Brown shrimp	5, 19-21, 58, 64, 70, 75, 127, 128, 140, 157, 201, 207, 210, 237, 239, 242, 246, 248, 249, 251-257, 259, 260, 301; Q, W
Penaeus duorarum Pink shrimp	19-21, 58, 128, 157, 201, 237, 242, 246, 248, 249, 251-257, 259, 260, 301; Q, W
Penaeus setiferus White shrimp	5, 19-21, 51, 58, 64, 70, 75, 126-128, 141, 157, 201, 207, 210, 237, 239, 242, 246, 248, 249, 251-257, 259, 260, 301; Q, W
Palaemonetes pugio Grass shrimp	5, 58*, 83210, 239*; Q, W
Menippe adina Gulf stone crab	58, 60, 210, 239; Q, W
Callinectes sapidus Blue crab	5, 20, 21, 58, 60, 63, 68, 69, 73, 127, 128, 141, 157, 201, 210, 239, 272, 273, 339; Q, W
Carcharhinus leucas Bull shark	116, 157; L, Q, W
Megalops atlanticus Tarpon	59, 341; Q, W
Alosa alabamae Alabama shad	Q, W
Brevoortia patronus Gulf menhaden	5, 58, 93, 210, 240, 242, 313; Q, W
Dorosoma cepedianum Gizzard shad	58, 59, 210; Q, W
Anchoa mitchilli Bay anchovy	5, 58, 59, 62, 67, 121, 210; Q, W
Arius felis Hardhead catfish	5, 58, 59, 93, 157210, 240, 242, 313, 339; Q, W
Cyprinodon variegatus Sheepshead minnow	58121, 157, 210, 342; Q, W
Fundulus grandis Gulf killifish	121, 157, 210, 342; Q, W
Menidia species Atlantic silversides	5, 58, 59, 121, 210; Q, W
Centropomus undecimalis Snook	59; Q, W
Pomatomus saltatrix Bluefish	Q, W
Caranx hippos Crevalle jack	58, 121; Q, W
Trachinotus carolinus Florida pompano	59; Q, W
Lutjanus griseus Gray snapper	58; Q, W
Archosargus probatocephalus Sheepshead	5, 32, 38, 58, 59, 93, 126, 157, 201, 210, 215, 240, 242, 288, 290, 313, 339, 351; Q, W
Lagodon rhomboides Pinfish	5, 58, 59, 62, 67, 93, 121, 240, 242, 313, 339; Q, W
Bairdiella chrysoura Silver perch	58, 121, 157, 339; Q, W
Cynoscion arenarius Sand seatrout	5, 58, 59, 93, 157, 210, 240, 242, 288, 290, 313, 339; Q, W
Cynoscion nebulosus Spotted seatrout	5, 32, 35, 36, 38, 59, 62, 67, 72, 93, 121, 126, 157, 201, 210, 215, 216, 240, 242, 288, 290, 313, 339, 351; Q, W
Leiostomus xanthurus Spot	5, 58, 59, 62, 67, 93, 121, 157, 210, 240, 242, 313, 339; Q, W
Micropogonias undulatus Atlantic croaker	5, 32, 58, 59, 62, 67, 93, 121, 157, 210, 240, 242, 288, 290, 313, 339, 351; Q, W
Pogonias cromis Black drum	5, 32, 36, 38, 58, 59, 62, 67, 72, 78, 93, 121, 126, 201, 210, 215, 216, 240, 242, 288, 290, 313, 338, 339, 351; Q, W
Sciaenops ocellatus Red drum	5, 32, 35-38, 59, 62, 67, 72, 93-95, 121, 126, 149, 201, 215, 216, 231, 240, 242, 288-290, 313, 338, 339, 344, 358; Q, W
Mugil cephalus Striped mullet	5, 58, 59, 93, 108121, 126, 157, 210, 242, 313; Q, W
Gobiosoma robustum Code goby	210; Q, W
Scomberomorus maculatus Spanish mackerel	59, 242; Q, W
Paralichthys albigutta Gulf flounder	201, 229; Q, W
Paralichthys lethostigma Southern flounder	5, 32, 37, 38, 58, 59, 62, 67, 71, 93, 121, 157, 201, 210, 215, 216, 229, 240, 242, 288, 290, 313, 339, 351; Q, W

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	Aransas Bay
Argopecten irradians Bay scallop	160, 293, 371; D, R
Crassostrea virginica American oyster	86, 126, 128, 142, 143; D, R
Rangia cuneata Common rangia	141, 293; D, R
Mercenaria species Hard clam	92, 293, 314; D, R
Lolliguncula brevis Bay squid	5, 84, 120, 148, 153, 159, 314; D, R
Penaeus aztecus Brown shrimp	5, 19-21, 80, 81, 84, 88, 111, 117, 120, 125, 127, 128, 140, 147, 148, 159, 193, 207, 237, 242, 246, 248, 249, 251-257, 259, 260, 296, 301, 319, 322, 325; D, R
Penaeus duorarum Pink shrimp	19-21, 84, 88, 111, 120, 127, 128, 148, 159, 160, 193, 237, 242, 246, 248, 249, 251-257, 259, 290, 319, 322, 325, 370; D, R
Penaeus setiferus White shrimp	5, 19-21, 51, 111, 117, 120, 126-128, 141, 147, 148, 159, 193, 207, 237, 242, 246, 248, 249, 251-257, 259, 260, 296, 301, 319, 322, 325, 370; D, R
Palaemonetes pugio Grass shrimp	5, 147*, 148*, 160, 296, 370; D, R
Menippe adina Gulf stone crab	120, 125, 148, 157, 314, 370; D, R
Callinectes sapidus Blue crab	5, 20, 21, 61, 68, 73, 84, 117, 120, 125, 127, 128, 141, 147, 148, 160, 242, 272, 273, 296, 317, 321, 324, 370; D, R
Carcharhinus leucas Bull shark	12, 116, 158, 326, 370; D, L, R
Megalops atlanticus Tarpon	118, 347; D, R
Alosa alabamae Alabama shad	D, R
Brevoortia patronus Gulf menhaden	4, 5, 25, 84, 127, 117, 118, 147, 158, 159, 240, 242, 311, 313, 314; D, R
Dorosoma cepedianum Gizzard shad	118, 125, 147, 148, 311, 314; D, R
Anchoa mitchilli Bay anchovy	4, 5, 23, 118, 121, 122, 147, 148, 158, 159, 182, 242, 268, 311, 370; D, R
Arius felis Hardhead catfish	5, 84, 93, 117, 118, 119, 125, 147, 148, 159, 240, 242, 268, 313, 314, 326, 370; D, R
Cyprinodon variegatus Sheepshead minnow	23, 84, 118, 121, 122, 147, 148, 212, 213, 311, 314, 342; D, R
Fundulus grandis Gulf killifish	23, 118, 122, 147, 148, 311, 314, 342; D, R
Menidia species Atlantic silversides	4, 5, 23, 117, 118, 121, 122, 125, 147, 148, 158, 160, 182, 311, 314, 370; D, R
Centropomus undecimalis Snook	347; D, R
Pomatomus saltatrix Bluefish	84, 118, 158, 314, 347; D, R
Caranx hippos Crevalle jack	84, 118, 121, 147, 158, 347, 370; D, R
Trachinotus carolinus Florida pompano	118, 122, 126, 158, 347; D, R
Lutjanus griseus Gray snapper	125, 347; D, R
Archosargus probatocephalus Sheepshead	4, 5, 23, 32, 35, 36-38, 84, 93, 117, 118, 125, 126, 160, 215, 240, 242, 288, 290, 313, 314, 318, 320, 326, 351, 370; D, R
Lagodon rhomboides Pinfish	4, 5, 23, 25, 53, 84, 93, 117, 118, 121, 125, 147, 148, 158, 160, 182-184, 240, 242, 268, 313, 314, 326, 370; D, R
Bairdiella chrysoura Silver perch	4, 23, 25, 84, 117, 118, 121, 125, 147, 148, 158, 160, 177, 182, 268, 314, 326, 370; D, R
Cynoscion arenarius Sand seatrout	4, 5, 84, 93, 117, 118, 126, 158, 240, 242, 268, 288, 290, 313, 314, 326, 370; D, R
Cynoscion nebulosus Spotted seatrout	4, 5, 23, 32, 35-38, 49, 84, 93, 117, 118, 121, 125, 147, 148, 177, 182, 215, 216, 240, 242, 268, 288, 290, 295, 297, 313, 314, 318, 320, 323, 327, 347, 351, 370; D, R
Leiostomus xanthurus Spot	4, 5, 23, 93, 117, 118, 121, 125, 147, 148, 158-160, 182, 240, 242, 268, 313, 314, 370; D, R
Micropogonias undulatus Atlantic croaker	4, 5, 23, 25, 32, 84, 93, 118, 122, 125, 126, 147, 148, 158, 159, 182, 240, 242, 268, 288, 290, 295, 313, 314, 326, 351, 370; D, R
Pogonias cromis Black drum	4, 5, 25, 32, 35-38, 78, 93, 117, 118, 121, 126, 147, 148, 158, 215, 216, 240, 242, 288, 290, 313, 320, 323, 326, 338, 351, 370; D, R
Sciaenops ocellatus Red drum	4, 5, 23, 25, 32, 35-38, 93, 94, 117, 118, 121, 122, 126, 147-149, 158, 160, 179, 182, 215, 216, 230-232, 235, 240, 242, 288-290, 295, 313, 314, 318, 320, 323, 326, 338, 344, 347, 351, 370; D, R
Mugil cephalus Striped mullet	4, 5, 23, 84, 93, 108, 117, 118, 121, 125, 126, 147, 158, 160, 242, 267, 268, 311, 313, 314, 370; D, R
Gobiosoma robustum Code goby	4*, 23, 158, 160, 182-184, 314, 370; D, R
Scomberomorus maculatus Spanish mackerel	84, 118, 158, 242, 268, 312, 326, 347, 370; D, R
Paralichthys albigutta Gulf flounder	4*, 23, 118, 158, 182, 229, 268, 354; D, R
Paralichthys lethostigma Southern flounder	4*, 5, 23, 25, 32, 35-37, 84, 93, 118, 121, 148, 160, 182, 215, 216, 229, 240, 242, 268, 288, 290, 313, 314, 318, 320, 323, 326, 340, 351, 354, 370; D, R

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	Corpus Christi Bay
Argopecten irradians Bay scallop	160, 176, 371; K
Crassostrea virginica American oyster	86, 128, 151, 160, 176, 219, 222, 314; K
Rangia cuneata Common rangia	176; K
Mercenaria species Hard clam	92, 176, 314; K
Lolliguncula brevis Bay squid	5, 24, 84, 129, 153, 159, 314; K
Penaeus aztecus Brown shrimp	5, 20, 21, 24, 80, 81, 84, 88, 111, 127, 128, 129, 151, 159, 176, 207, 220, 221, 225, 237, 242, 246, 248, 249, 251-257, 259, 260, 301; K
Penaeus duorarum Pink shrimp	20, 21, 24, 84, 88, 111, 127, 128, 129, 159, 160, 237, 242, 246, 248, 249, 251-257, 259, 260, 301, 37O; K
Penaeus setiferus White shrimp	5, 20, 21, 24, 51, 111, 126, 127, 128, 129, 151, 159, 207, 220, 221, 225, 237, 242, 246, 248, 249, 251-257, 259, 260, 301, 370; K
Palaemonetes pugio Grass shrimp	345, 370; K
Menippe adina Gulf stone crab	176, 314, 370; K
Callinectes sapidus Blue crab	5, 20, 21, 24, 61, 68, 73, 84, 127, 128, 129, 151, 160, 176, 217, 224, 227, 242, 272, 273, 370; K
Carcharhinus leucas Bull shark	12, 116, 158, 326; K, L
Megalops atlanticus Tarpon	370; K
Alosa alabamae Alabama shad	K
Brevoortia patronus Gulf menhaden	4, 5, 25, 84, 93, 151, 158, 159, 195, 240, 242, 313, 314; K
Dorosoma cepedianum Gizzard shad	314; K
Anchoa mitchilli Bay anchovy	4, 5, 23, 24, 122, 129, 158, 159, 182, 370; K
Arius felis Hardhead catfish	5, 24, 84, 93, 125, 159, 195, 240, 242, 313, 314, 326, 370; K
Cyprinodon variegatus Sheepshead minnow	23, 84, 101, 122, 314, 342; K
Fundulus grandis Gulf killifish	23, 101, 314, 342; K
Menidia species Atlantic silversides	4, 23, 122, 125, 129, 158, 160, 182, 195, 314, 370; K
Centropomus undecimalis Snook	347; K
Pomatomus saltatrix Bluefish	84, 129, 158, 314, 347; K
Caranx hippos Crevalle jack	24, 84, 158, 347, 370; K
Trachinotus carolinus Florida pompano	122, 126, 158, 347; K
Lutjanus griseus Grey snapper	125, 347; K
Archosargus probatocephalus Sheepshead	4, 5, 23, 24, 32, 35, 36, 38, 84, 93, 125, 126, 129, 148, 160, 195, 215, 218, 223, 226, 240, 242, 288, 290, 313, 314, 326, 351, 370; K
Lagodon rhomboides Pinfish	4, 5, 23, 24, 25, 53, 84, 93, 125, 129, 158, 160, 182-184, 195, 240, 242, 313, 314, 326, 370; K
Bairdiella chrysoura Silver perch	4, 23, 24, 25, 84, 125, 158, 177, 182, 195, 314, 326, 370; K
Cynoscion arenarius Sand seatrout	4, 5, 28, 84, 93, 126, 129, 158, 160, 195, 240, 242, 288, 290, 313, 314, 326, 370; K
Cynoscion nebulosus Spotted seatrout	4, 5, 23, 32, 35-38, 49, 84, 93, 125, 126, 129, 151, 177, 182, 206, 215, 216, 218, 223, 226, 240, 242, 295, 297, 313, 314, 327, 347, 351, 370; K
Leiostomus xanthurus Spot	4, 5, 23, 24, 93, 125, 129, 151, 158-160, 182, 195, 240, 242, 288, 290, 370; K
Micropogonias undulatus Atlantic croaker	4, 5, 23-25, 32, 84, 93, 122, 125, 126, 129, 151, 158, 159, 182, 195, 240, 242, 288, 290, 295, 313, 314, 326, 351, 370; K
Pogonias cromis Black drum	4, 5, 25, 32, 35, 36, 38, 78, 93, 126, 129, 158, 215, 216, 218, 223, 226, 240, 242, 288, 290, 313, 326, 338, 351, 370; K
Sciaenops ocellatus Red drum	4, 5, 7, 23, 25, 32, 35-38, 93-95, 122, 125, 129, 149, 158, 160, 179, 182, 206, 215-217, 223, 226, 231, 232, 240, 246, 288-290, 295, 313, 314, 326, 338, 344, 347, 351, 370; K
Mugil cephalus Striped mullet	4, 5, 23, 24, 84, 93, 108, 125, 126, 129, 151, 158, 160, 195, 242, 267, 313, 314, 370; K
Gobiosoma robustum Code goby	4*, 23, 155, 158, 160, 182-184, 314, 370; K
Scomberomorus maculatus Spanish mackerel	84, 129, 158, 242, 312, 326, 347, 370; K
Paralichthys albigutta Gulf flounder	4*, 23, 158, 182, 229, 354; K
Paralichthys lethostigma Southern flounder	4*, 5, 7, 23-25, 32, 36-38, 84, 93, 129, 147, 160, 182, 195, 206, 215, 216, 218, 223, 226, 229, 240, 242, 288, 290, 313, 314, 326, 340, 351, 354, 370; K

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	Laguna Madre
Argopecten irradians Bay scallop	29, 57, 366; H, S, V
Crassostrea virginica American oyster	28, 29, 39, 45, 50, 126, 127, 143, 163, 168, 186, 285, 294, 337; H, S, V
Rangia cuneata Common rangia	H, S, V
Mercenaria species Hard clam	28, 29, 174; H, S, V
Lolliguncula brevis Bay squid	5, 28, 29, 39, 57*, 152, 153, 328, 337; H, S, V
Penaeus aztecus Brown shrimp	5, 19-21, 28, 29, 39, 43, 45, 50, 57, 111, 127, 149, 132, 134, 136, 152, 185, 188, 193, 207, 237, 242, 246, 248, 249, 251-257, 259, 260, 285, 296, 301, 336, 353; H, S, V
Penaeus duorarum Pink shrimp	19, 20, 21, 29, 43, 45, 111, 127, 128, 132, 134, 136, 185, 188, 193, 237, 242, 246, 248, 249, 251-257, 259, 260, 285, 301, 336, 353; H, S, V
Penaeus setiferus White shrimp	5, 19, 20, 21, 28, 29, 39, 43, 45, 50, 111, 127, 128, 132, 134, 136, 152, 185, 188, 193, 207, 237, 242, 246, 248, 249, 251-257, 259, 260, 285, 301, 328, 336, 353; H, S, V
Palaemonetes pugio Grass shrimp	5, 29, 43*, 152*, 296, 336, 345; H, S, V
Menippe adina Gulf stone crab	336, 337; H, S, V
Callinectes sapidus Blue crab	5, 20, 21, 28, 29, 39, 43, 45, 50, 61, 68, 73, 127, 128, 130, 131, 135, 138, 152, 187, 189, 242, 272, 273, 285, 296, 328, 336, 337; H, S, V
Carcharhinus leucas Bull shark	12, 116; H, I, L, S
Megalops atlanticus Tarpon	29, 50, 336; H, I, S
Alosa alabamae Alabama shad	H, I, S
Brevoortia patronus Gulf menhaden	5, 29, 39, 43*, 45*, 50, 57, 93, 152, 180, 240, 242, 313, 328, 336; H, I, S
Dorosoma cepedianum Gizzard shad	29, 45, 50, 130, 152, 315, 336; H, I, S
Anchoa mitchilli Bay anchovy	5, 30, 39, 45, 50, 57, 150, 152, 180, 315, 328, 336, 337; H, I, S
Arius felis Hardhead catfish	5, 28, 29, 39, 43, 45, 50, 93, 130, 150, 152, 180, 240, 242, 313, 315, 328, 336, 337; H, I, S
Cyprinodon variegatus Sheepshead minnow	29, 43, 50, 57, 123, 139, 150, 152, 180, 315, 328, 336, 342; H, I, S
Fundulus grandis Gulf killifish	29, 43, 50, 57123, 180, 336, 342; H, I, S
Menidia species Atlantic silversides	123, 150, 152, 180, 313, 328, 336; H, I, S
Centropomus undecimalis Snook	337; H, I, S
Pomatomus saltatrix Bluefish	328, 336; H, I, S
Caranx hippos Crevalle jack	29, 39*, 50, 180, 328, 336; H, I, S
Trachinotus carolinus Florida pompano	126, 180, 328, 336; H, I, S
Lutjanus griseus Gray snapper	29*, 180, 328; H, I, S
Archosargus probatocephalus Sheepshead	5, 28, 29, 32-38, 42-48, 50, 93, 126, 130, 133, 137, 139, 180, 215, 240, 242, 263, 288, 290, 313, 328, 336, 351; H, I, S
Lagodon rhomboides Pinfish	5, 29, 30, 39, 45, 50, 57, 93, 139, 150, 180, 240, 242, 313, 328, 336, 337; H, I, S
Bairdiella chrysoura Silver perch	29, 30, 39, 50, 57, 150, 152, 180, 328, 336; H, I, S
Cynoscion arenarius Sand seatrout	5, 30, 45, 50, 93, 126, 130, 152, 180, 240, 242, 288, 290, 313, 336; H, I, S
Cynoscion nebulosus Spotted seatrout	5, 28, 29, 30, 32-48, 50, 57, 93, 126, 130, 133, 137, 139, 150, 152, 180, 215, 216, 240 242, 288, 290, 313, 328, 336, 337, 351; H, I, S
Leiostomus xanthurus Spot	93, 130, 139, 150, 152, 180, 240, 242, 313, 328, 336; H, I, S
Micropogonias undulatus Atlantic croaker	5, 30, 39, 43, 45, 50, 5793, 126, 130, 150, 152, 180, 240, 242, 288, 290, 313, 315, 328, 336, 351; H, I, S
Pogonias cromis Black drum	5, 28-39, 41-48, 50, 93, 126, 130, 133, 137, 139, 150, 152, 180, 215, 216, 240, 242, 288, 290, 313, 328, 336-338, 351; H, I, S
Sciaenops ocellatus Red drum	5, 28-30, 32-39, 41-48, 50, 5793, 94, 126, 130, 133, 137, 139, 149, 150, 152, 180, 215, 216, 230, 231, 249, 312, 288, 290, 313, 315, 328, 336-338, 351; H, I, S
Mugil cephalus Striped mullet	5, 28*, 29, 39, 43, 45, 50, 57, 93, 108, 126, 130, 139, 150, 152, 180, 242, 267, 313, 315, 328, 336; H, I, S
Gobiosoma robustum Code goby	57, 180; H, I, S
Scomberomorus maculatus Spanish mackerel	29, 30, 50, 123, 242, 328; H, I, S
Paralichthys albigutta Gulf flounder	29, 150, 229, 336; H, I, S
Paralichthys lethostigma Southern flounder	5, 28-30, 32-39, 41-48, 50, 93, 123, 130, 133, 137, 150, 152, 180, 215, 216, 240, 242, 288, 290, 313, 336, 351; H, I, S

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

Appendix 6, continued. Personal communications and primary references.

Scientific/Common Name	Baffin Bay
Argopecten irradians Bay scallop	P
Crassostrea virginica American oyster	281; P
Rangia cuneata Common rangia	P
Mercenaria species Hard clam	P
Lolliguncula brevis Bay squid	89, 210; P
Penaeus aztecus Brown shrimp	27, 87, 210, 340; P
Penaeus duorarum Pink shrimp	340; P
Penaeus setiferus White shrimp	27, 89, 210, 340; P
Palaemonetes pugio Grass shrimp	210, 345; P
Menippe adina Gulf stone crab	89, 340; P
Callinectes sapidus Blue crab	27, 87, 89, 210, 340; P
Carcharhinus leucas Bull shark	L, P
Megalops atlanticus Tarpon	27, 89; P
Alosa alabamae Alabama shad	P
Brevoortia patronus Gulf menhaden	89, 110, 202, 210, 340, 358; P
Dorosoma cepedianum Gizzard shad	27, 89, 110, 202, 340, 358; P
Anchoa mitchilli Bay anchovy	89, 105, 106, 202, 210, 340; P
Arius felis Hardhead catfish	27, 87, 89, 110, 202, 340, 358; P
Cyprinodon variegatus Sheepshead minnow	27, 87, 89, 105, 106, 202, 210, 340, 342; P
Fundulus grandis Gulf killifish	27, 89, 202, 340, 342; P
Menidia species Atlantic silversides	27, 87, 89, 105, 106, 202, 210, 340; P
Centropomus undecimalis Snook	27; P
Pomatomus saltatrix Bluefish	P
Caranx hippos Crevalle jack	340, 358; P
Trachinotus carolinus Florida pompano	P
Lutjanus griseus Gray snapper	P
Archosargus probatocephalus Sheepshead	89, 340; P
Lagodon rhomboides Pinfish	27, 87, 89, 110, 202, 210, 340, 358; P
Bairdiella chrysoura Silver perch	27, 89, 110, 202, 340, 358; P
Cynoscion arenarius Sand seatrout	27, 89, 110, 340, 358; P
Cynoscion nebulosus Spotted seatrout	27, 87, 89105, 106, 110, 202, 210, 340, 358; P
Leiostomus xanthurus Spot	27, 89105, 106, 110, 202, 210, 340, 358; P
Micropogonias undulatus Atlantic croaker	27, 87, 89, 105, 106, 110, 202, 210, 340, 358; P
Pogonias cromis Black drum	27, 87, 89, 90105, 106, 110, 202, 210, 214, 338, 340, 358; P
Sciaenops ocellatus Red drum	27, 87, 89, 110, 202, 210, 338, 340, 344, 358; P
Mugil cephalus Striped mullet	27, 87, 89, 110, 202, 210, 340, 358; P
Gobiosoma robustum Code goby	89; P
Scomberomorus maculatus Spanish mackerel	P
Paralichthys albigutta Gulf flounder	340; P
Paralichthys lethostigma Southern flounder	27, 87, 89, 110, 202, 210, 340, 358; P

Numbers correspond to references listed in the Literature Cited section, pp. 90 - 107
Letters correspond to individuals listed in the Personal Communications section, p. 80.

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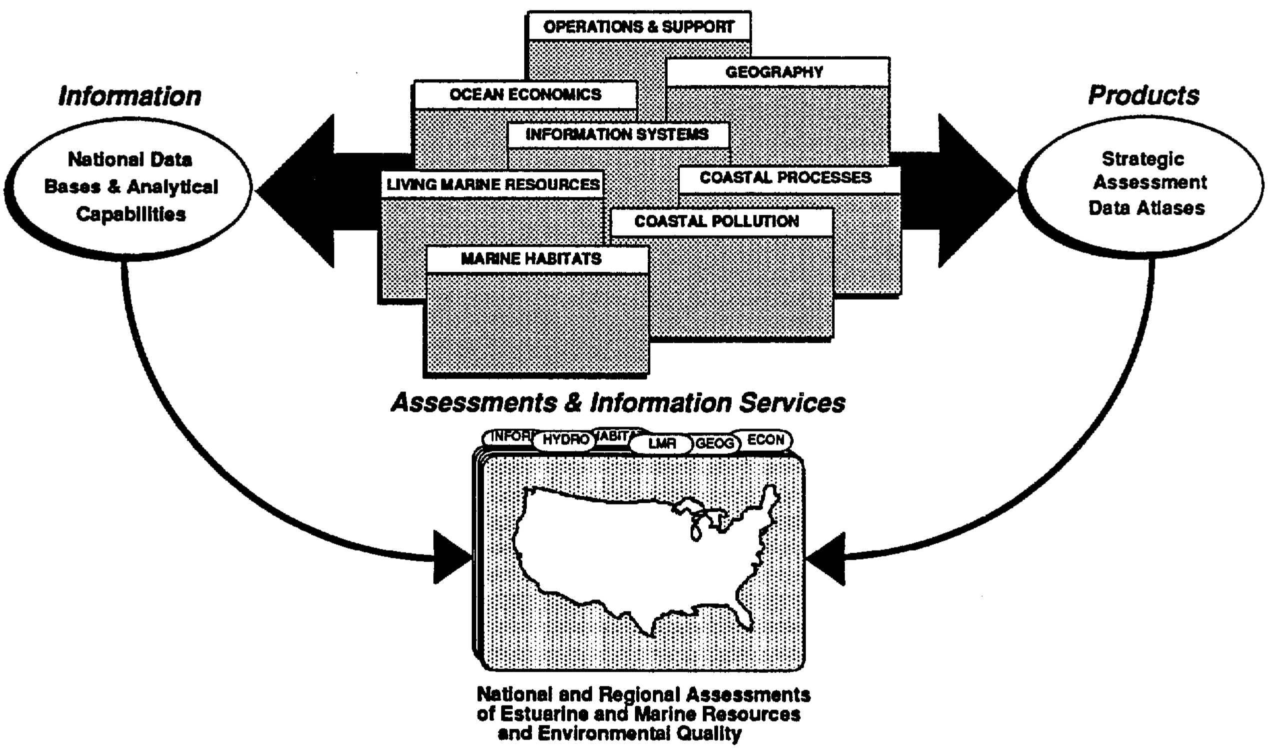
*The references with numbers that contain decimals were added after the matrix (Appendix 4) was developed.

NOAA's Program of Strategic Assessments

The major activities of the Strategic Assessment Program are focused on assembling information and providing assessment services required for decisionmaking about the estuarine and marine resources of the USA. The information and assessments that are developed help identify strategies for balanced conservation and use of these resources for maximum benefit to the Nation. Recent projects completed by the Branch include the *Bering, Chukchi, Beaufort Seas Strategic Assessment Data Atlas*, along with two *National Estuarine Inventory Data Atlases* and one pre-publication edition of the *West Coast of North America Data Atlas*. A continuing effort to expand and improve the National Estuarine Inventory (NEI) has resulted in the publication of NEI supplement reports. Several data bases, including the Estuarine Living Marine Resources (ELMR) data base, are being completed (see inside front cover). Data and analytical capabilities are being made more accessible through improvements in the Computer Mapping and Analysis System (Cmas) and development of the Coastal Ocean Management, Planning, and Assessment System (COMPAS). Assessment reports examining pesticide use in estuarine drainage areas, susceptibility of estuaries to nutrients, and quality of coastal shellfishing waters are also being completed.

STRATEGIC ASSESSMENT PROGRAM



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