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National Overview and Evolution of NOAA's Estuarine Living Marine Resources (ELMR) Program

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Center for Coastal Monitoring and Assessment
National Centers for Coastal Ocean Science
National Ocean Service

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National Overview and Evolution of NOAA's Estuarine Living Marine Resources (ELMR) Program

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*Formerly a program of the NOS Strategic Environmental Assessments (SEA) Division

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Preface

NOAA's Estuarine Living Marine Program

We take great pride in providing you this comprehensive report: *National Overview and Evolution of NOAA's Estuarine Living Marine Resources (ELMR) Program.* This document complements many of our ELMR program technical reports and peer reviewed literature that has been published over the last 15 years. The impetus behind the development of this document was to provide our user community with a unified document that summarizes the fundamental information contained in the ELMR regional databases and to provide documentation of how the program and its associated methodologies have evolved.

Although the ELMR program is housed within NOAA's National Ocean Service (NOS), the implementation and success of the nationwide program is due to the efforts of hundreds of scientists and managers who have assisted us in compiling the species distribution, relative abundance, and life history information. Their willingness to work with us by providing resources, compiling and providing data, and reviewing the digital data base and associated GIS map products have made the ELMR program a success. We owe a special thanks to our colleagues in the National Marine Fisheries Service, who, over the years, provided many of the principal investigators who aided NOS ELMR scientists in developing the nationwide database.

Our ELMR activities will continue to evolve within NOS's Biogeography Program, and we encourage you to follow the evolution of ELMR and its associated synthesis and research activities on the Web: http://biogeo.nos.noaa.gov.

Sincerely,

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Introduction

In 1985, the National Oceanic and Atmospheric Administration (NOAA) began a program to develop a consistent data base on the presence, distribution, relative abundance, and life history characteristics of ecologically and economically important fishes and invertebrates in the nation's estuaries. The Estuarine Living Marine Resources (ELMR) program was founded by the Biogeography Program* of the of the former Strategic Environmental Assessments (SEA) Division of the National Ocean Service (NOS). Through the years, it has been conducted jointly by NOS, NOAA's National Marine Fisheries Service (NMFS), and other agencies and institutions. The nationwide "Base ELMR" data base was completed in 1994, and includes data for 153 species found in 122 estuaries and coastal embayments in five regions. Regional revisions were completed for the Gulf of Mexico and Southeast in 1998, and plans are under way to update the Mid-Atlantic and North Atlantic regions in 2000-2001. This report provides a national overview of the evolution, accomplishments, and regional results of the ELMR program to date.

The data base is divided into five study regions (Figure 1) and contains the monthly relative abundance of each species' life stage by estuary for three salinity zones (seawater, mixing, and tidal fresh), as identified in NOAA's *National Estuarine Inventory (NEI) Data Atlas-Volume I* and supplement (NOAA 1985a). Regional data summary reports have been published for the North Atlantic (Jury et al. 1994), Mid-Atlantic (Stone et al. 1994), Southeast (Nelson et al. 1991), Gulf of Mexico (Nelson et al. 1992), and West Coast (Monaco et al. 1990). Regional life history summary reports have been published for the West Coast (Emmett et al. 1991) and Gulf of Mexico (Pattillo et al. 1997). Life history tables and summaries for the Southeast, Mid-Atlantic, and North Atlantic regions are being developed.

Since completion of the national ELMR data base in 1994, it has been updated, revised, improved, and applied to specific problems in natural resource management (Table 1). To further refine the spatial resolution of the ELMR framework, a multivariate methodology (Bulger et al. 1993) was applied to derive five bio-salinity zones in four "salinity seasons" for Gulf of Mexico and Southeast estuaries (Christensen et al. 1997). In addition, ELMR data for the adult and juvenile life stages of species have been revised based on recent resource surveys using trawl and other gear. The revised ELMR data were then linked with the seasonal estuarine bio-salinity zones for the Gulf of Mexico and Southeast regions, and incorporated into a Geographic Information System (GIS) to enable spatial organization of the data. The improved ELMR data base has been used for a variety of applications, including Habitat Suitability Modeling (HSM), Environmental Sentitivity Index (ESI) mapping (RPI 1996, 1997), HazMat response (oil spill) planning, and the identification of Essential Fish Habitat (EFH) (NOAA/GMFMC 1998).

*Now the Biogeography Program of the NOS Center for Coastal Monitoring and Assessment

Figure 1. ELMR study regions.

Rationale

Estuaries are among the most productive natural systems and have been shown to be important nursery areas that provide food, refuge from predation, and valuable habitat for many species (Tyler 1971, MacDonald et al. 1984, Langton et al. 1989, Day et al. 1989, Ayvazian et al. 1992). Estuarine organisms that support important commercial and recreational fisheries include bivalves, decapods, and a variety of finfish. In spite of the well documented importance of estuaries to fishes and invertebrates, few consistent and comprehensive data bases exist that allow examinations of the relationships between estuarine species found in or among groups of estuaries. Furthermore, much of the distribution and abundance information for estuarine-dependent species (i.e., species that require estuaries during their life cycle) is for offshore life stages and does not adequately describe estuarine distributions (NOAA 1990a, Darnell et al. 1983).

Only a few sampling programs collect fishes and invertebrates with identical methods across groups of estuaries within a region. Examples include inshore trawl surveys conducted by the Massachusetts Division of Marine Fisheries (Howe et al. 1991), the Maine Department of Marine Resources (MDMR 1993), and the Texas Parks and Wildlife Department (Hammerschmidt and McEachron 1986). Therefore, most existing estuarine fisheries data cannot be compared among estuaries because of the variable sampling strategies. In addition, existing research programs do not focus on how groups of estuaries may be important for regional fishery management, and few compile information for species having little or no economic value.

Because many species use both estuarine and marine habitats during their various life stages, information on their distribution, abundance, temporal utilization and life history characteristics are needed to understand the coupling of estuarine, nearshore, and offshore habitats. Consequently, the ELMR program was developed to integrate fragments of information on these species and their associated habitats into a useful, comprehensive and consistent format. Until recently, a national data base of this type did not exist (Figure 2).

Results from the ELMR program contribute to NOAA's development of a national estuarine assessment capability (NOAA 1985a), identify information gaps, and assess the content and quality of existing estuarine fisheries data. ELMR data are being incorporated into the National Coastal Assessment and Data Synthesis Framework (CA&DS), which integrates national data sets for 138 estuaries within a spatial framework with analytical capabilities (Orlando 1999). In addition, the ELMR data are being used to define Essential Fish Habitat under the revised Magnuson-Stevens Act (NOAA 1996, NOAA/GMFMC 1998).

Base ELMR Data Collection

An initial pilot study was completed in 1986 for U.S. West Coast estuaries to determine the feasibility and scope of a national ELMR program, and to evaluate the proposed ELMR methodology (Monaco 1986). It was determined that the amount of information that could be compiled for each species and estuary on a nationwide basis was limited, and that it would be both time and cost-prohibitive to map each species by life stage for each estuary. Therefore, a spatial frame-

Table 1. ELMR regional data bases and reports, completion dates, revisions/updates, and applications.

Region	Data base and summary report	Life history summary report	Data revisions and updates	Specific applications*
West Coast	1990	1991		
Gulf of Mexico	1992	1997	1998	GWIS, EFH
Southeast	1992	in progress	1998	EFH, ESI
Mid-Atlantic	1994	in progress	in progress	EFH, ESI
North Atlantic	1994	in progress	in progress	EFH, ESI

*Specific applications:

GWIS = Gulfwide Information System.

EFH = Essential Fish Habitat designation.

ESI = Environmental Sensitivity Index maps.

work, using estuarine salinity zones based on the National Estuarine Inventory (NEI), was adopted (NOAA 1985). Figure 2 summarizes the major steps taken to collect and organize this information. The initial steps were to select the estuaries and species for study.

Selection of estuaries. Estuaries in each region were selected from the *National Estuarine Inventory (NEI) Data Atlas-Volume I* (NOAA 1985a). Additional estuaries were added after discussions with regional researchers. The 122 selected estuaries are listed in Table 2 (their locations within each region are shown in Figures 6, 8, 10, 13, and 16).

Data on the spatial and temporal distributions of species were compiled for the tidal fresh (0.0-0.5 parts per thousand (ppt)), mixing (0.5-25.0 ppt), and seawater (> 25 ppt) zones delineated for each estuary in the NEI. Many of the estuaries within each region contain all three salinity zones, but for the purposes of this study, some zones are considered to be absent. For example, the tidal Potomac River in Maryland has no seawater zone, and Morro Bay in California has no tidal fresh zone. Salinity zones that are only seasonally present or are extremely small (<1 km^2) were generally omitted from this large-scale assessment (NOAA 1985a).

The NEI is now being superceded by NOAA's National Coastal Assessment and Data Synthesis Framework (CA&DS), which integrates national data sets for 138 estuaries within a spatial framework with analytical capabilities (Orlando 1999). CA&DS is a national and regional-scale data base and mapping analysis system that provides a capability to access, synthesize, assess and apply nationwide data sets to priority coastal issues, such as estuarine eutrophication, habitat loss, coastal monitoring, and sustainable coastal communities. The spatial framework includes:

• Spatial geographies for 150 estuaries, major rivers, and coastal offshore areas.

• National data sets for coastal resources (including ELMR), environmental quality, and socio-economic activities.

• An interactive web-based data access and mapping system that allows users to view, conduct comparative analyses, and download information.

Selection of species. ELMR staff biologists used the following four criteria, together with data availability, to select species for inclusion in each regional ELMR data base:

• Commercial value — determined by review of catch data and value statistics from NMFS and state agencies (NOAA 1992a, NOAA 1992b).

• Recreational value — determined by relative importance in recreational fisheries that may or may not be commercially exploited. Recreational species were determined by consulting regional experts and NMFS reports (Essig et al. 1991, VanVoorhees et al. 1992).

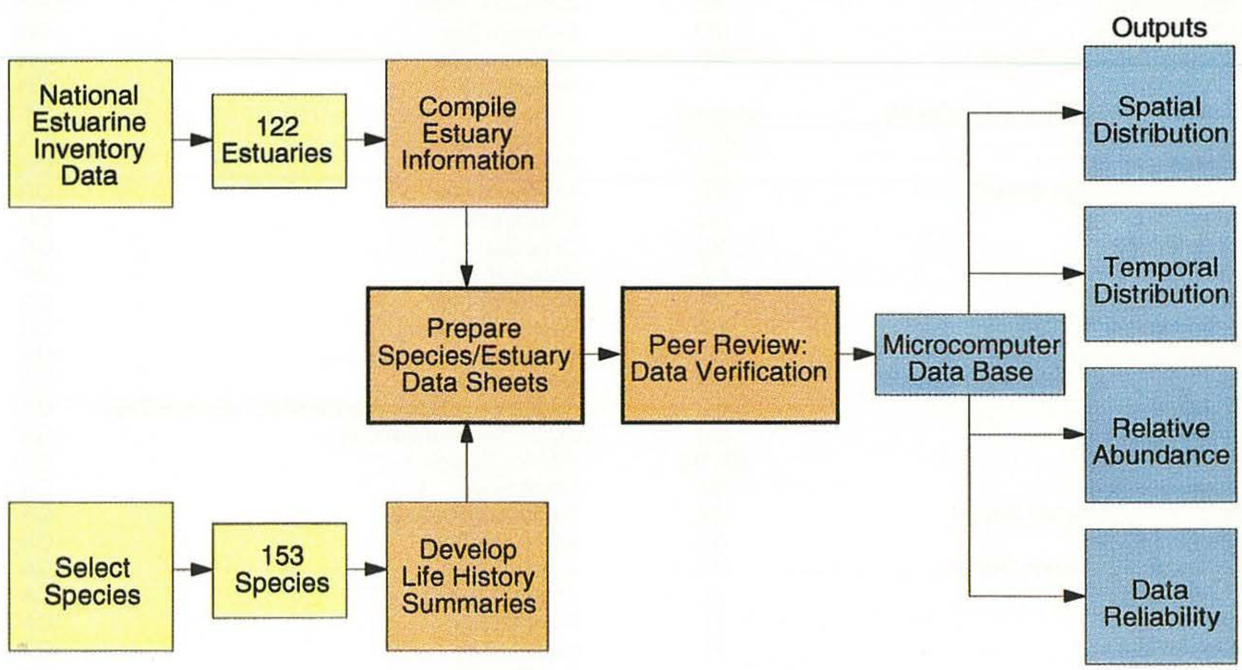


Figure 2. Major steps to complete the National ELMR study, 1985-1994.

Table 2. ELMR estuaries (n=122), by region.

North Atlantic ELMR Estuaries (n=17)	State(s)
Passamaquoddy Bay	ME
Englishman/Machias Bays	ME
Narraguagus Bay	ME
Blue Hill Bay	ME
Penobscot Bay	ME
Muscongus Bay	ME
Damariscotta River	ME
Sheepscot River	ME
Kennebec/Androscoggin Rivers	ME
Casco Bay	ME
Saco Bay	ME
Wells Harbor	ME
Great Bay	NH/ME
Merrimack River	MA
Massachusetts Bay	MA
Boston Harbor	MA
Cape Cod Bay	MA

Mid-Atlantic ELMR Estuaries (n=22)	State(s)
Waquoit Bay	MA
Buzzards Bay	MA
Narragansett Bay	RI/MA
Gardiners Bay	NY
Long Island Sound	CT/NY
Connecticut River	CT
Great South Bay	NY
Hudson River/Raritan Bay	NJ/NY
Barnegat Bay	NJ
New Jersey Inland Bays	NJ
Delaware Bay	DE/NJ/PA
Delaware Inland Bays	DE
Chincoteague Bay	MD/VA
Chesapeake Bay	MD/VA
Potomac River	MD/VA/DC
Rappahannock River	VA
York River	VA
James River	VA
Patuxent River	MD
Chester River	MD
Choptank River	MD
Tangier/Pocomoke Sound	MD

Southeast ELMR Estuaries (n=20)	State(s)
Albemarle Sound	NC/VA
Pamlico Sound	NC
Pamlico and Pungo Rivers	NC
Neuse River	NC
Bogue Sound	NC
New River	NC
Cape Fear River	NC
Winyah Bay	SC
North and South Santee Rivers	SC
Charleston Harbor	SC
St. Helena Sound	SC
Broad River	SC
Savannah River	GA/SC
Ossabaw Sound	GA
St. Catherine / Sapelo Sound	GA
Altamaha River	GA
St. Andrew / St. Simon Sound	GA
St. Johns River	FL
Indian River	FL
Biscayne Bay	FL

Gulf of Mexico ELMR Estuaries (n=31)	State(s)
Florida Bay	FL
Ten Thousand Islands	FL
Charlotte Harbor	FL
Caloosahatchee River	FL
Tampa Bay	FL
Suwanee River	FL
Apalachee Bay	FL
Apalachicola Bay	FL
St. Andrew Bay	FL
Choctawhatchee Bay	FL
Pensacola Bay	FL
Perdido Bay	FL/AL
Mobile Bay	AL
Mississippi Sound	MS/AL/LA
Lake Borgne	LA
Lake Pontchartrain	LA
Breton/Chandeleur Sounds	LA
Mississippi River	LA
Barataria Bay	LA
Terrebonne/Timbalier Bays	LA
Atchafalaya/Vermilion Bays	LA
Calcasieu Lake	LA
Sabine Lake	LA/TX
Galveston Bay	TX
Brazos River	TX
Matagorda Bay	TX
San Antonio Bay	TX
Aransas Bay	TX
Corpus Christi Bay	TX
Laguna Madre	TX
Baffin Bay	TX

West Coast ELMR Estuaries (n=32)	State(s)
Puget Sound	WA
Hood Canal	WA
Skagit Bay	WA
Grays Harbor	WA
Willapa Bay	WA
Columbia River	OR/WA
Nehalem Bay	OR
Tillamook Bay	OR
Netarts Bay	OR
Siletz Bay	OR
Yaquina Bay	OR
Alsea Bay	OR
Siuslaw River	OR
Umpqua River	OR
Coos Bay	OR
Rogue River	OR
Klamath River	CA
Humboldt Bay	CA
Eel River	CA
Tomales Bay	CA
Central San Francisco/San Pablo/Suisun Bays	CA
South San Francisco Bay	CA
Elkhorn Slough	CA
Morro Bay	CA
Santa Monica Bay	CA
San Pedro Bay	CA
Alamitos Bay	CA
Anaheim Bay	CA
Newport Bay	CA
Mission Bay	CA
San Diego Bay	CA
Tijuana River	CA

• Indicator of environmental stress — determined from the literature, discussions with fisheries experts, and from monitoring programs such as NOAA's National Status and Trends Program (O'Connor 1990). These species are typically molluscs or demersal 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 exposure to environmental pollution and/or stress.

• Ecological value — based on several attributes including trophic level, relative abundance, and importance as a key predator or prey species.

Table 3 features the 153 species selected for all five ELMR regions collectively. Note that some species are included in one region only (e.g., dungeness crab on West Coast), whereas other species are considered for several regions (e.g., blue crab in the Mid-Atlantic, Southeast, and Gulf of Mexico). The common and scientific names of fish and invertebrate species are generally those adopted by the American Fisheries Society (Turgeon et al. 1988, Williams et al. 1988, Robins et al. 1991). (Species lists for each of the five ELMR regions are featured in Tables 8, 10, 12, 14, and 16).

For the majority of species considered in the ELMR program, growth and development involve a direct progression through several distinct life stages. Accordingly, the ELMR program has compiled information based on five "typical" life stages: adult (A), spawning adult (S), juvenile (J), larvae (L) and egg (E). Adults were defined as reproductively mature individuals, while juveniles were defined as immature but otherwise similar to adults. Species with a larval stage typically undergo metamorphosis to the juvenile stage; hence, larvae usually differ from juveniles and adults in form. In addition, most species rely on external fertilization via spawning, when gametes combine externally after being released by males and/or females. Therefore, spawning adults were defined as those releasing eggs or sperm, and larvae and eggs included most early life history stages.

The complex life histories of some species, and the subsequent difficulty in placing them into a comprehensive classification scheme, required some deviation from this general classification. The reproductive mode of certain species differs from the norm in that there is internal fertilization of eggs, ovoviviparity, delayed fertilization, etc. For example, mating (M) replaces spawning (S) for crab species, and parturition (P) replaces spawning (S) for shark species. For some species, several distinct larval life stages must be considered collectively as "larvae," including: the phyllosome and puerulus stages of lobster species; the zoea and megalopa stages of crab species; the nauplius, protozoea, mysis, and postlarval stages of shrimp species; and the trochophore, veliger, and pediveliger stages of bivalve molluscs. The leptocephalus stage of tarpon is considered larval, as is the "paralarva" stage of bay squid. Each regional ELMR data summary report identifies cases in which alternate life history stages have been considered, cases in which two or more species are considered as a single unit, comments on specific habitat preferences and behaviors, and other pertinent life history information.

Data sheet development. A data sheet was developed for each species in each estuary to facilitate the review and presentation of the information. Data compiled for each species/life stage included: (1) the salinity zone it occupies (seawater, mixing, tidal fresh), (2) its monthly distribution in those zones, and (3) its relative abundance in those zones. Figure 3 depicts the data sheet for weakfish (*Cynoscion regalis*) in Delaware Bay.

The ELMR program uses the following methodology to evaluate species relative abundance rankings based upon available data that reflect the expected or observed "average" rankings for selected species. Assigning abundance levels is often difficult due to the lack of long-term, consistent sampling surveys for most species within and across many estuaries. However, the existing literature and the field experience of local and regional reviewers provide the basis for reasonably accurate synoptic abundance rankings. For well-studied species, quantitative data were used to estimate the relative abundance within estuaries. The integration of quantitative data and expert review resulted in the "final" level of abundance assigned to a species. The reviews by regional fisheries scientists complemented the quantitative studies, and greatly increased the reliability of species relative abundance information.

Categorical spatial and temporal distribution and relative abundance data were compiled from data sets, technical reports, and peer-reviewed literature on estuarine species. Fisheries data often reveal considerable spatial and temporal heterogeneity due to environmental variation (e.g., wet year, cold year, etc.), biological variation (e.g., high recruitment year, low year class, etc.), and anthropogenic variation (e.g., fishery mortality, sampling error, etc.). Given the inherent variability in fisheries studies, this information was integrated to best define current distribu-

Text continues on p. 9.

Table 3. ELMR species (n=153), by region.

Invertebrates Common Name	Scientific Name	ELMR Regions: North Atlantic (n=58)	Mid-Atlantic (n=62)	Southeast Atlantic (n=40)	Gulf of Mexico (n=44)	West Coast (n=55)
Blue mussel	*Mytilus edulis*	●	●	●		●
Bay scallop	*Argopecten irradians*		●	●	●	
Sea scallop	*Placopecten magellanicus*	●				
Pacific oyster	*Crassostrea gigas*					●
American oyster	*Crassostrea virginica*	●	●	●	●	
Atlantic rangia	*Rangia cuneata*			●	●	
Horseneck gaper	*Tresus capax*					●
Pacific gaper	*Tresus nuttallii*					●
California jacknife clam	*Tagelus californianus*					●
Quahogs	*Mercenaria species*	●	●	●	●	
Pacific littleneck clam	*Protothaca staminea*					●
Manila clam	*Tapes philippinarum*					●
Softshell	*Mya arenaria*	●	●			●
Geoduck	*Panopea abrupta*					●
Bay squid	*Lolliguncula brevis*				●	
Bay shrimp	*Crangon franciscorum*					●
Sevenspine bay shrimp	*Crangon septemspinosa*	●	●			
Brown shrimp	*Penaeus aztecus*		●	●	●	
Pink shrimp	*Penaeus duorarum*			●	●	
White shrimp	*Penaeus setiferus*			●	●	
Daggerblade grass shrimp	*Palaemonetes pugio*	●	●	●	●	
Northern shrimp	*Pandalus borealis*	●	●			
American lobster	*Homarus americanus*	●	●			
Spiny lobster	*Panulirus argus*				●	
Jonah crab	*Cancer borealis*	●				
Atlantic rock crab	*Cancer irroratus*	●				
Dungeness crab	*Cancer magister*					●
Blue crab	*Callinectes sapidus*		●	●	●	
Green crab	*Carcinus maenas*	●				
Gulf stone crab	*Menippe adina*				●	
Stone crab	*Menippe mercenaria*				●	
Green sea urchin	*Strongylocentrotus droehbachiensis*	●				
Fishes						
Bull shark	*Carcharhinus leucas*				●	
Leopard shark	*Triakis semifasciata*					●
Spiny dogfish	*Squalus acanthias*	●				
Skates	*Raja spp.*	●	●			
Atlantic stingray	*Dasyatis sabina*		●			
Cownose ray	*Rhinoptera bonasus*		●			
Shortnose sturgeon	*Acipenser brevirostrum*	●	●			
Green sturgeon	*Acipenser medirostris*					●
Atlantic sturgeon	*Acipenser oxyrhynchus*	●	●	●		
White sturgeon	*Acipenser transmontanus*					●
Ladyfish	*Elops saurus*			●		
Tarpon	*Megalops atlanticus*				●	
American eel	*Anguilla rostrata*	●	●	●		
Blueback herring	*Alosa aestivalis*	●	●	●		
Alabama shad	*Alosa alabamae*				●	
Alewife	*Alosa pseudoharengus*	●	●	●		
American shad	*Alosa sapidissima*	●	●	●		●
Gulf menhaden	*Brevoortia patronus*				●	
Yellowfin menhaden	*Brevoortia smithi*				●	
Atlantic menhaden	*Brevoortia tyrannus*	●	●	●		
Atlantic herring	*Clupea harengus*	●	●			
Pacific herring	*Clupea pallasi*					●
Gizzard shad	*Dorosoma cepedianum*				●	
Deepbody anchovy	*Anchoa compressa*					●
Slough anchovy	*Anchoa delicatissima*					●
Bay anchovy	*Anchoa mitchilli*		●	●	●	
Northern anchovy	*Engraulis mordax*					●
Channel catfish	*Ictalurus punctatus*		●			
Hardhead catfish	*Arius felis*				●	
Surf smelt	*Hypomesus pretiosus*					●
Rainbow smelt	*Osmerus mordax*	●	●			
Longfin smelt	*Spirinchus thaleichthys*					●
Eulachon	*Thaleichthys pacificus*					●
Cutthroat trout	*Oncorhynchus clarki*					●
Pink salmon	*O. gorbuscha*					●
Chum salmon	*O. keta*					●
Coho salmon	*O. kisutch*					●
Steelhead	*O. mykiss*					●
Sockeye salmon	*O. nerka*					●
Chinook salmon	*O. tshawytscha*					●
Atlantic salmon	*Salmo salar*	●	●			
Atlantic cod	*Gadus morhua*	●	●			
Haddock	*Melanogrammus aeglefinus*	●	●			
Silver hake	*Merluccius bilinearis*	●				

Table 3, continued.

Fishes, continued Common Name	Scientific Name	ELMR Regions: North Atlantic (n=58)	Mid-Atlantic (n=62)	Southeast Atlantic (n=40)	Gulf of Mexico (n=44)	West Coast (n=55)
Pacific tomcod	*Microgadus proximus*					●
Atlantic tomcod	*Microgadus tomcod*	●	●			
Pollock	*Pollachius virens*	●	●			
Red hake	*Urophycis chuss*	●	●			
White hake	*Urophycis tenuis*	●				
Oyster toadfish	*Opsanus tau*		●			
Sheepshead minnow	*Cyprinodon variegatus*		●	●	●	
Gulf killifish	*Fundulus grandis*				●	
Mummichog	*Fundulus heteroclitus*	●	●	●		
Topsmelt	*Atherinops affinis*					●
Jacksmelt	*Atherinopsis californiensis*					●
Silversides	*Menidia spp.*	●	●	●	●	
Fourspine stickleback	*Apeltes quadracus*	●				
Threespine stickleback	*Gasterosteus aculeatus*	●				●
Ninespine stickleback	*Pungitius pungitius*	●				
Northern pipefish	*Syngnathus fuscus*	●	●			
Northern searobin	*Prionotus carolinus*	●	●			
Lingcod	*Ophiodon elongatus*					●
Pacific staghorn sculpin	*Leptocottus armatus*					●
Grubby	*Myoxocephalus aenaeus*	●				
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	●				
Shorthorn sculpin	*Myoxocephalus scorpius*	●				
Snook	*Centropomus undecimalis*				●	
White perch	*Morone americana*	●	●	●		
Striped bass	*Morone saxatilis*	●	●	●		●
Black sea bass	*Centropristis striata*		●			
Kelp bass	*Paralabrax clathratus*					●
Barred sand bass	*Paralabrax nebulifer*					●
Yellow perch	*Perca flavescens*		●			
Bluefish	*Pomatomus saltatrix*	●	●	●	●	
Cobia	*Rachycentrum canadum*			●		
Blue runner	*Caranx crysos*				●	
Crevalle jack	*Caranx hippos*				●	
Florida pompano	*Trachinotus carolinus*				●	
Gray snapper	*Lutjanus griseus*			●	●	
Sheepshead	*Archosargus probatocephalus*			●	●	
Pinfish	*Lagodon rhomboides*		●	●	●	
Scup	*Stenotomus chrysops*	●	●			
White seabass	*Atractoscion nobilis*					●
Silver perch	*Bairdiella chrysoura*				●	
Sand seatrout	*Cynoscion arenarius*				●	
Spotted seatrout	*Cynoscion nebulosus*		●	●	●	
Weakfish	*Cynoscion regalis*		●	●		
White croaker	*Genyonemus lineatus*					●
Spot	*Leiostomus xanthurus*		●	●	●	
Southern kingfish	*Menticirrhus americanus*			●		
Northern kingfish	*Menticirrhus saxatilis*		●			
Atlantic croaker	*Micropogonias undulatus*		●	●	●	
Black drum	*Pogonias cromis*		●	●	●	
Red drum	*Sciaenops ocellatus*		●	●	●	
Shiner perch	*Cymatogaster aggregata*					●
Striped mullet	*Mugil cephalus*		●	●	●	
Tautog	*Tautoga onitis*	●	●			
Cunner	*Tautogolabrus adspersus*	●	●			
Ocean pout	*Macrozoarces americanus*	●				
Rock gunnel	*Pholis gunnellus*	●				
American sand lance	*Ammodytes americanus*	●	●			
Pacific sand lance	*Ammodytes hexapterus*					●
Arrow goby	*Clevelandia ios*					●
Gobies	*Gobiosoma species*		●			
Code goby	*Gobiosoma robustum*				●	
Atlantic mackerel	*Scomber scombrus*	●	●			
Spanish mackerel	*Scomberomorus maculatus*			●	●	
Butterfish	*Peprilus triacanthus*	●	●			
Gulf flounder	*Paralichthys albigutta*			●	●	
California halibut	*Paralichthys californicus*					●
Summer flounder	*Paralichthys dentatus*		●	●		
Southern flounder	*Paralichthys lethostigma*			●	●	
Windowpane	*Scophthalmus aquosus*	●	●			
American plaice	*Hippoglossoides platessoides*	●				
Diamond turbot	*Hypsopsetta guttulata*					●
Starry flounder	*Platichthys stellatus*					●
Winter flounder	*Pleuronectes americanus*	●	●			
Yellowtail flounder	*Pleuronectes ferrugineus*	●				
Smooth flounder	*Pleuronectes putnami*	●				
English sole	*Pleuronectes vetulus*					●
Hogchoker	*Trinectes maculatus*		●			

Table 4. ELMR species guilds, by region.

Sessile invertebrates

North Atlantic	Mid-Atlantic	Southeast	Gulf of Mexico	West Coast
Blue mussel	Blue mussel	Blue mussel	Bay scallop	Blue mussel
Sea scallop	Bay scallop	Bay scallop	American oyster	Pacific oyster
American oyster	American oyster	American oyster	Common rangia	Horseneck gaper
Hard clam (quahog)	Hard clam (quahog)	Common rangia	Hard clam (quahog)	Pacific gaper
Softshell clam	Softshell clam	Hard clam (quahog)		California jacknife clam
Green sea urchin				Pacific littleneck clam
				Manila clam
				Softshell calm
				Geoduck

Shrimps and squids

North Atlantic	Mid-Atlantic	Southeast	Gulf of Mexico	West Coast
Daggerblade grass shrimp	Brown shrimp	Brown shrimp	Bay squid	Bay shrimp
Northern shrimp	Grass shrimp	Pink shrimp	Brown shrimp	
Sevenspine bay shrimp	Sevenspine bay shrimp	White shrimp	Pink shrimp	
		Grass shrimp	White shrimp	
			Grass shrimp	

Large crustaceans

North Atlantic	Mid-Atlantic	Southeast	Gulf of Mexico	West Coast
American lobster	American lobster	Blue crab	Spiny lobster	Dungeness crab
Jonah crab	Blue crab		Blue crab	
Atlantic rock crab			Gulf stone crab	
Green crab			Stone crab	

Shallow water fishes

North Atlantic	Mid-Atlantic	Southeast	Gulf of Mexico	West Coast
Mummichog	Bay anchovy	Bay anchovy	Bay anchovy	Deepbody anchovy
Silversides	Sheepshead minnow	Sheepshead minnow	Sheepshead minnow	Slough anchovy
Fourspine stickleback	Mummichog	Mummichog	Gulf killifish	Northern anchovy
Threespine stickleback	Silversides	Silversides	Silversides	Threespine stickleback
Ninespine stickleback	Northern pipefish		Code goby	Pacific sand lance
Northern pipefish	Sand lance			Arrow goby
American sand lance	Gobies			

Pelagic fishes

North Atlantic	Mid-Atlantic	Southeast	Gulf of Mexico	West Coast
Blueback herring	Blueback herring	Ladyfish	Tarpon	American shad
Alewife	Alewife	Blueback herring	Alabama shad	Pacific herring
American shad	American shad	Alewife	Gulf menhaden	Cuttthroat trout
Atlantic menhaden	Atlantic menhaden	American shad	Yellowfin menhaden	Pink salmon
Atlantic herring	Atlantic herring	Atlantic menhaden	Gizzard shad	Chum salmon
Rainbow smelt	Rainbow smelt	White perch	Snook	Coho salmon
Atlantic salmon	Atlantic salmon	Striped bass	Bluefish	Steelhead
White perch	White perch	Black sea bass	Blue runner	Sockeye salmon
Striped bass	Striped bass	Bluefish	Crevalle jack	Chinook salmon
Bluefish	Black sea bass	Cobia	Florida pompano	Surf smelt
Atlantic mackerel	Yellow perch	Spanish mackerel	Silver perch	Lobgfin smelt
Butterfish	Bluefish	Butterfish	Spanish mackerel	Topsmelt
	Atlantic mackerel			Jacksmelt
	Butterfish			Striped Bass
				Kelp bass
				Barred sand Bass
				White seabass
				Shiner perch
				Eulachon

Demersal fishes

North Atlantic	Mid-Atlantic	Southeast	Gulf of Mexico	West Coast
Spiny dogfish	Skates	Atlantic sturgeon	Bull shark	Leopard shark
Skates	Atlantic stingray	American eel	Hardhead catfish	Green sturgeon
Shortnose sturgeon	Cownose ray	Gray snapper	Florida pompano	White sturgeon
Atlantic sturgeon	Shortnose sturgeon	Sheepshead	Gray snapper	Pacific tomcod
American eel	Atlantic sturgeon	Pinfish	Sheepshead	White croaker
Atlantic cod	American eel	Spotted seatrout	Pinfish	Lingcod
Haddock	Channel catfish	Striped mullet	Sand seatrout	Pacific staghorn sculpin
Silver hake	Atlantic cod	Weakfish	Spotted seatrout	California halibut
Atlantic tomcod	Haddock	Spot	Striped mullet	Diamond turbot
Pollock	Atlantic tomcod	Southern kingfish	Spot	English sole
Red hake	Pollock	Atlantic croaker	Atlantic croaker	Starry flounder
White hake	Red hake	Black drum	Black drum	
Northern searobin	Oyster toadfish	Red drum	Red drum	
Grubby	Northern searobin	Gulf flounder	Gulf flounder	
Longhorn sculpin	Pinfish	Summer flounder	Southern flounder	
Shorthorn sculpin	Scup	Southern flounder		
Scup	Spotted seatrout			
Tautog	Weakfish			
Cunner	Spot			
Ocean pout	Northern kingfish			
Rock gunnel	Atlantic croaker			
Windowpane flounder	Black drum			
American plaice	Red drum			
Winter flounder	Tautog			
Yellowtail flounder	Cunner			
Smooth flounder	Mullet			
	Summer flounder			
	Windowpane flounder			
	Winter flounder			
	Hogchoker			

tions and abundances, taking into account the many sources of variability. The integrated quantitative and qualitative relative abundance estimates were then verified through an extensive review process utilizing expert knowledge and field experiences of fisheries scientists, managers, and field biologists.

The relative abundance categories — highly abundant, abundant, common, rare, and not present — were intended to simulate the categories routinely used by fisheries biologists. This type of comprehensive and consistent format is readily understandable by field biologists, fisheries managers, and academic scientists alike. An ordinal relative abundance scheme of this type is often adopted in the field, at least casually, and the ELMR methodology has only defined this classification scheme more rigorously. The abundance of a species life stage was considered relative to that of the same life stage of other "similar species." Similar species were considered to be those having similar life modes and gear susceptibilities (e.g. skates and flounders, bluefish and striped bass). From the ELMR regional species lists, several groups, or guilds, of species were derived, summarized in Table 4. These guilds are:

- Sessile Invertebrates
- Shrimps and Squids
- Large Crustaceans
- Shallow Water Fishes
- Pelagic Fishes
- Demersal Fishes

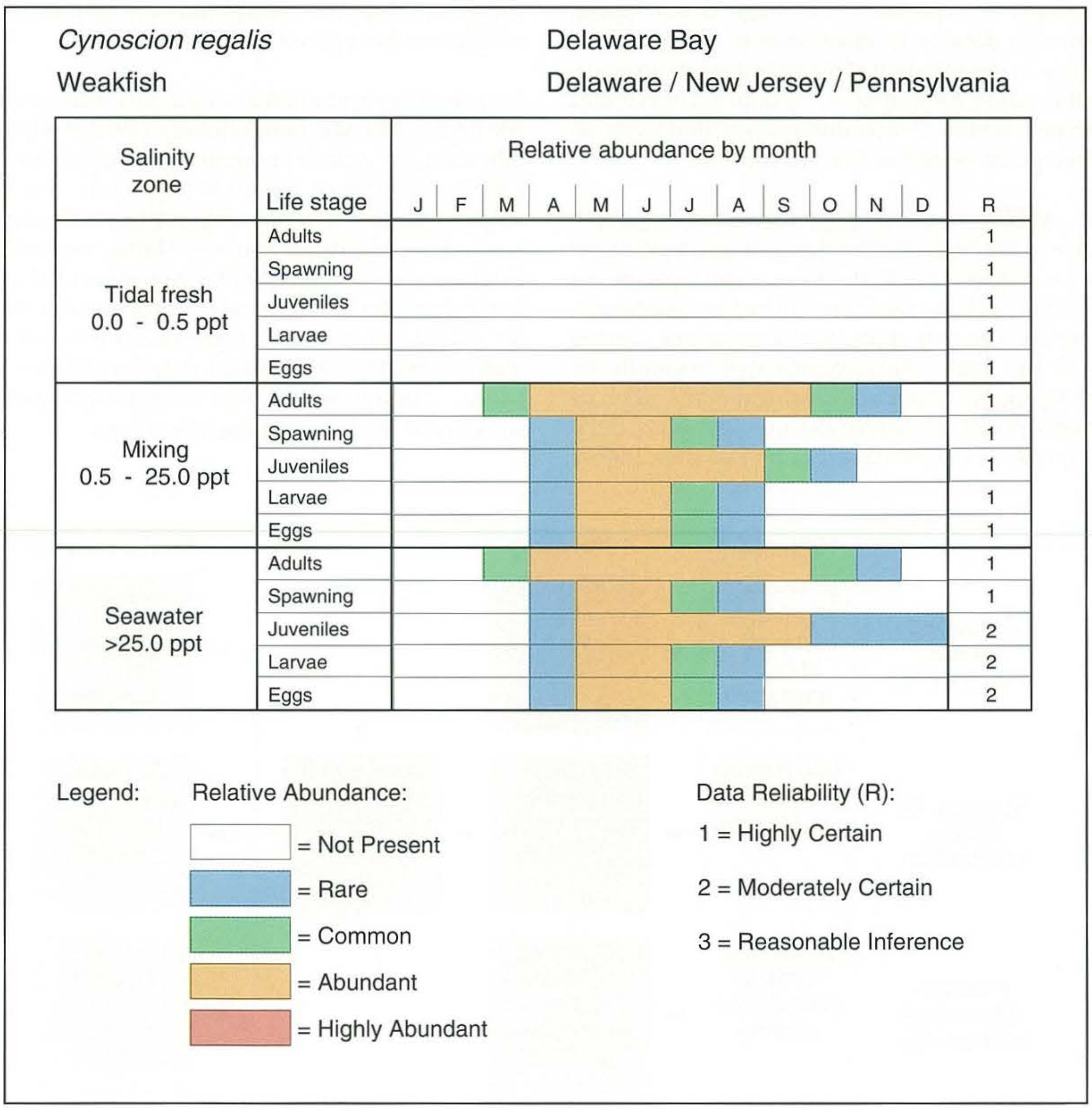


Figure 3. Example of a species/estuary data sheet: weakfish in Delaware Bay.

The species within each guild were used to assess each others' relative abundance based on the following steps:

Step 1. For each species within a guild, each life stage's occurrence by month was assessed in each salinity zone. In any given community, some species are more abundant than others. Based upon the relative abundance of species within a guild, six ELMR relative abundance rankings can be described:
Highly Abundant — species is numerically dominant relative to other species within a guild.
Abundant — species is often encountered in substantial numbers relative to other species in a guild.
Common — species is generally encountered, but not in large numbers; distribution may be patchy.
Rare — species is present, but not frequently encountered.
Not Present — species or life stage is not found, questionable data as to identification of species, or recent loss or degradation of habitat suggests absence.
No Information Available — no data available, and after expert review it was determined that even an educated guess would not be appropriate.

Step 2. Within a guild, it was determined which species had the highest abundance at any time of the year in a particular salinity zone. This species (or several species) was considered to be the "guide species" based upon its numerical dominance during much of the year. This species will normally be ranked as "highly abundant" during months when its occurrence peaks. However, in some situations, if the guide species was considered to be less than highly abundant (but still the most abundant species in this salinity zone), a lower ranking (e.g., abundant or common) was used, and other species rankings were adjusted accordingly.

Step 3. Next, a hierarchical ranking of the remaining species in the guild was constructed based on the ELMR ranking scheme. This hierarchy considered the species peaking approximately one order of magnitude below the guide species' peak to be abundant during months of maximum occurrence. Rare species/life stages are those that are definitely present but not frequently encountered in a given month or salinity zone. This procedure establishes relative abundance categories for each species within a guild. As each species' abundance fluctuates between these categories during the year, so will its relative abundance ranking. Also, it can be seen that this ranking procedure does not always indicate months of peak occurrence for a given species' life stage.

In cases where quantitative data sets were available, the original ELMR methodology (1988-1994) generally used an "order of magnitude" analysis to derive relative abundance rankings (Figure 4). As an example, ELMR relative abundance levels for shallow-water fishes in Wells Harbor, Maine, were derived from survey data reported by Ayvazian et al. (1992). In this field study, bag-seines and trawls were utilized for several months to sample nearshore and open-water habitats and the catch data for shallow water fishes. The numerical data were transformed into categorical data using these algorithms:

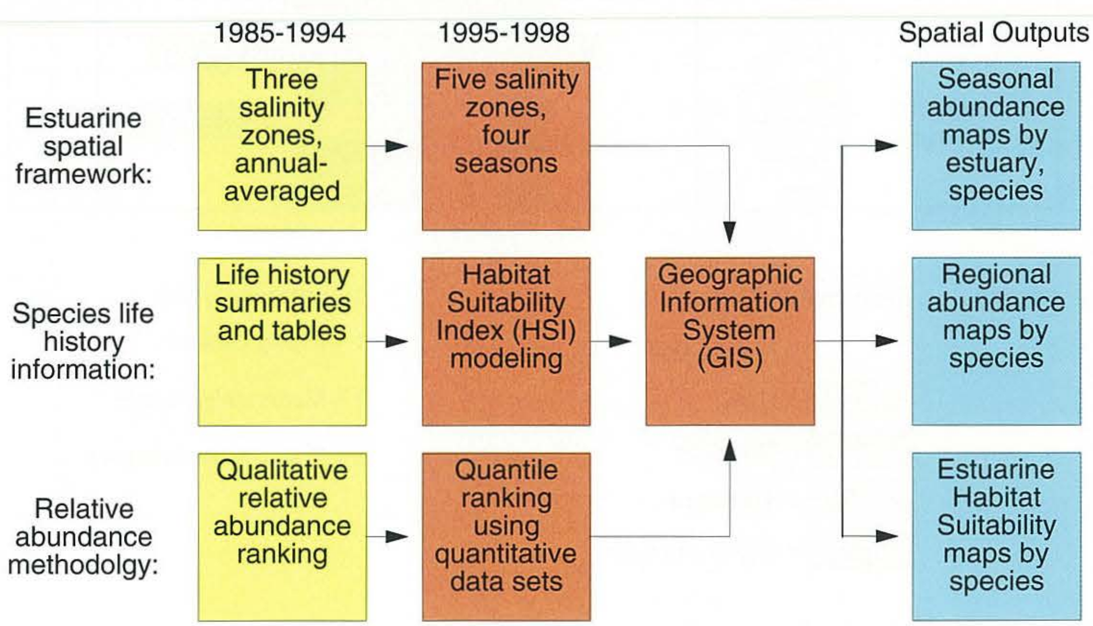


Figure 4. Evolution of the ELMR program, 1985-1998.

x = maximum abundance of the most abundant species (i.e., guide species within a guild)

$y = \log x$

highly abundant = x to $10^{(y-.05y)}$

abundant = $10^{(y-.05y)}-1$ to $10^{(y-.25y)}$

common = $10^{(y-.25y)}-1$ to $10^{(y-.75y)}$

rare = $10^{(y-.75y)}-1$ to 1

The ELMR abundance rankings for Wells Harbor incorporated these derived data, and all other available data, and are summarized in the North Atlantic ELMR report (Jury et al. 1994, Monaco 1995). From 1995 to the present, a "quantile analysis," rather than the "order of magnitude" method, has been used to update and revise the ELMR data base for the Gulf of Mexico, Southeast, Mid-Atlantic, and North Atlantic regions.

Approximately eight years were required to develop the 6,252 data sheets and consult with 441 scientists and managers at 177 institutions (see regional reports for names and affiliations). As stated previously, this review process complemented the information gathered from the literature and published data sets compiled by NOAA.

Life History Summaries and Tables

To complement the distribution and abundance information described above, a life history summary and a set of life history tables have been developed for each species. These summaries and tables have been published for the West Coast (Emmett et al. 1991) and the Gulf of Mexico (Pattillo et al. 1997) regions. The summaries are not intended to be a complete treatise on all aspects of each species' biology, but rather, they provide a concise account of the most important physical and biological factors known to affect a species' occurrence within estuaries. As a supplement to the life history summaries, their content was augmented with additional physical and biological criteria and condensed into three life history tables. These tables present life history characteristics for each species, along with behavioral traits and preferred habitats.

Life History Summaries. A concise life history summary was written for each species to provide an overview of how and when a species uses estuaries and what specific habitats it uses. The summaries emphasize species-specific life history characteristics that relate directly to estuarine spatial and temporal distribution and abundance (e.g., many molluscs have particular salinity and substrate preferences). Information for the species life history summaries was gathered primarily from published and unpublished literature, and experts with species-specific knowledge were also consulted. Summaries were written using a prescribed format and outline (Table 5, next page).

Included with each species life history summary is a relative abundance table based on regional ELMR data, with minor revisions based on review. These tables provide a synopsis of the species' occurrence in the regional estuaries. Information for each table was obtained by summarizing the ELMR data for each month of the year and across all salinity zones to obtain the highest level of abundance for each life stage. Hence, these tables depict a species' highest abundance within an estuary by life stage, but lack temporal and spatial resolution. Examples are provided in Tables 6 and 7, p. 14.

Life History Tables. While the species life history summaries provide brief accounts of important life history attributes, they do not permit a direct and simple assessment of characteristics that a species shares with others. Furthermore, many life history attributes are categorical (e.g., feeding types can be classified as carnivore, herbivore, detritivore, etc.) and more easily viewed in a tabular format. Therefore, information found in the species life history summaries was augmented with additional physical and biological criteria and condensed into three life history tables: Habitat Associations, Biological Attributes, and Reproduction (Figure 5, p. 13). These tables present life history characteristics for each species along with behavior traits and preferred habitats. They reflect the most current information about a species as gathered from published and unpublished literature and can be used to quickly identify species with similar traits. Figure 5 depicts the headers used for these tables in the Gulf of Mexico *Volume II* report (Pattillo et al. 1997).

Text continues on p. 15.

Table 5. Format of species life history summaries (Emmett et al. 1991, Pattillo et al. 1997).

Common Name: the most often used common name.
Scientific Name: the most recent taxonomic genus and species name.
Other Common Names: other names that are sometimes used for a species.
Classification: the most recent taxonomic classification (Phylum, Class, Order, and Family).

Value
Commercial: information on commercial harvest.
Recreational: information on recreational fisheries.
Indicator of Environmental Stress: identifies if a species is an indicator of environmental degradation.
Ecological: the role (e.g., key predator or prey) a species plays in marine/estuarine ecosystems.

Range
Overall: the complete range of a species.
Within Study Area: the range of a species within regional estuaries. In addition, each summary contains a relative abundance table (derived from information in *Volume I* of the series) for the regional estuaries.

Life Mode: the life history strategy of a species and its life stages (e.g., anadromous, estuarine resident).

Habitat
Type: the habitats used by specific life stages (e.g., riverine, neritic, epipelagic).
Substrate: the substrate preferences of specific life stages.
Physical/Chemical Characteristics: the physical and water chemistry preferences of specific life stages (e.g., temperature and salinity).
Migrations and Movements: the movements and migratory behavior of a species/life stage between or within habitats.

Reproduction
Mode: type of reproductive strategy (e.g., oviparous, viviparous) and fertilization (e.g., external, internal).
Mating/Spawning: timing of spawning and description of mating or spawning behavior.
Fecundity: the number of eggs or young produced by an individual.

Growth and Development
Egg Size and Embryonic Development: the size of an egg and length of time for embryonic development.
Age and Size of Larvae: the age and size range of larvae.
Juveniles Size Range: the size range of juveniles.
Age and Size of Adults: the age and size range of adults.

Food and Feeding
Trophic mode: type of feeder (e.g., carnivorous, herbivorous).
Food Items: the types of prey eaten (e.g., copepods, amphipods, larval fish).

Biological Interactions
Predation: predators known to consume a species.
Factors Influencing Populations: biological and physical parameters that are known to influence a species' population abundance (e.g., overfishing, ocean productivity, spawning habitat, parasites).

Personal communications: individuals that provided relevant information.

References: alphabetical listing of literature cited.

Life History Table: Habitat Associations

Habitat Associations

Species / life stage		Domain: Freshwtr.			Domain: Estuarine			Salinity range: NEI			Salinity range: Venice system				
		Lacustrine	Riverine - coastal plain	Riverine - inland	Inlet mouth	Channel	Inter- and subtidal flats	Tidal fresh (0-0.5‰)	Mixing (0.5-25‰)	Seawater (>25‰)	Limnetic (0-0.5‰)	Oligohaline (0.5-5‰)	Mesohaline (5-18‰)	Polyhaline (18-30‰)	Euhaline (>30‰)
Bay scallop *Argopecten irradians*	A						●		●	●				●	●
	S						●		●	●				●	●
	J						●		●	●				●	●
	L						●		●	●				●	●
	E						●		●	●				●	●

Species / life stage		Domain: Estuarine – Temperature range							Domain: Marine		
		0-5°C	5-10°C	11-15°C	16-20°C	21-25°C	26-30°C	>30°C	Beach/surf	Neritic	Oceanic
Bay scallop *Argopecten irradians*	A		●	●	●	●	●	●		●	
	S						●			●	
	J		●	●	●	●	●	●		●	
	L				●	●	●			●	
	E				●	●				●	

Species / life stage		Substrate preference									Depth preference: Littoral	Depth preference: Sublittoral			
		Mud/silt/clay	Sand	Pebble/cobble/gravel	Boulder/rocky outcrop	Shell	Submergent vegetation	Emergent vegetation	Floating vegetation	None	Intertidal	Subtidal	Inner shelf (10-50 m)	Middle shelf (50-100 m)	Outer shelf (100-200 m)
Bay scallop *Argopecten irradians*	A	●	●				●				●	●	●		
	S	●	●				●				●	●	●		
	J	●	●			●	●		●		●	●	●		
	L					●	●	●	●		●	●	●		
	E									●	●	●	●		

Life History Table: Biological Attributes

Biological Attributes

Species / life stage		Life Mode					Spatial Strategy					Mobility			Feed*	
		Epibenthic	Benthic	Demersal	Nektonic	Planktonic	Freshwater resident	Estuarine resident	Marine resident	Coastal migrant	Ocean migrant	Nonmobile	Low mobility	High mobility	Filter feeder	Non-filter feeder
Bay scallop *Argopecten irradians*	A	●						●	●				●		●	
	S	●						●	●							
	J	●						●	●				●		●	
	L	●				●		●	●				●		●	
	E			●		●		●	●				●			

Species / life stage		Prey Items									
		Detritus	Phytoplankton	Zooplankton	Infauna	Epibenthos	Insects	Fish (eggs, larvae)	Fish (juveniles, adults)	Macroalgae	Vascular plants
Bay scallop *Argopecten irradians*	A	●	●	●							
	S										
	J	●	●	●							
	L		●	●							
	E										

Species / life stage		Longevity						Value			
		1 day	1-30 days	1-12 months	1-5 years	5-20 years	>20 years	Recreational	Commercial	Ecological	Indicator of stress
Bay scallop *Argopecten irradians*	A				●			●	●	●	●
	S										
	J			●					●	●	●
	L		●							●	
	E	●									

Life History Table: Reproduction

Reproduction

Species	Fertilization/ development					Mating type			Spawning strategy					Parntl. care		Domain		
	External	Internal	Oviparous	Ovoviviparous	Viviparous	Monogamous	Polygamous	Broadcast spawner	Andromous	Catadromous	Iteroparous	Semelparous	Batch	Protected	Non-protected	Riverine	Estuarine	Marine
Bay scallop *Argopecten irradians*	●		●					●				●	●		●		●	●

Species	Temporal Schedule												Periodicity			
	January	February	March	April	May	June	July	August	September	October	November	December	Annual spawning	2 or more per year	2 or more years	Undescribed
Bay scallop *Argopecten irradians*								●	●	●				●		

Species	Fecundity								Maturation age					
	<100	100-1,000	1,000-10,000	10,000-100,000	100,000-1 million	1-10 million	>10 million	Undescribed	<6 months	0.5 to 1 Year	1 to 3 Years	3 to 5 Years	> 5 Years	Undescribed
Bay scallop *Argopecten irradians*					●					●				

Figure 5. Life history table headers: Habitat Associations, Biological Attributes, and Reproduction.

Table 6. Example of species/life stage occurence table: Relative abundance of dungeness crab in 32 U.S. Pacific Coast estuaries (Emmett et al. 1991).

Estuary	*Life Stage* A	M	J	L	E
Puget Sound	◉	O	●	O	O
Hood Canal	O	O	●	O	O
Skagit Bay	◉	O	●	O	O
Grays Harbor	O		●	O	
Willapa Bay	O		●	O	
Columbia River	O		●	O	
Nehalem Bay	◉		●	●	
Tillamook Bay	◉		●	●	
Netarts Bay	O		●	●	
Siletz River	O		◉	◉	
Yaquina Bay	◉		●	●	
Alsea River	◉		●	●	
Siuslaw River	◉		●	●	
Umpqua River	O		●	●	
Coos Bay	◉	O	●	●	O
Rogue River	O		◉		
Klamath River	O		O		
Humboldt Bay	O		●	◉	
Eel River	O		●	O	
Tomales Bay	O		●	O	
Cent. San Fran. Bay *	√		●	√	
South San Fran. Bay	√		O	√	
Elkhorn Slough	√		√	√	
Morro Bay	√		√		
Santa Monica Bay					
San Pedro Bay					
Alamitos Bay					
Anaheim Bay					
Newport Bay					
Mission Bay					
San Diego Bay					
Tijuana Estuary					
	A	M	J	L	E

* Includes Central San Francisco, Suisun, and San Pablo bays.

Relative abundance:
- ● Highly abundant
- ◉ Abundant
- O Common
- √ Rare
- blank Not present

Life stage:
- A - Adults
- M- Mating
- J - Juveniles
- L - Larvae
- E - Eggs

Table 7. Example of species/life stage occurence table: Relative abundance of spotted seatrout in 31 U.S. Gulf of Mexico estuaries (Pattillo et al. 1997).

Estuary	*Life stage* A	S	J	L	E
Florida Bay	◉	◉	◉	◉	◉
Ten Thousand Islands	O	O	O	O	O
Caloosahatchee River	O	O	O	O	O
Charlotte Harbor	◉	◉	◉	◉	◉
Tampa Bay	O	O	O	O	O
Suwannee River	◉	◉	◉	◉	◉
Apalachee Bay	O	O	O	O	O
Apalachicola Bay	O	O	O	O	O
St. Andrew Bay	◉	O	O	O	O
Choctawhatchee Bay	◉	√	◉	◉	√
Pensacola Bay	O	O	O	O	O
Perdido Bay	O	√	O	O	√
Mobile Bay	◉	√	◉	◉	√
Mississippi Sound	◉	◉	◉	◉	◉
Lake Borgne	◉	◉	◉	◉	◉
Lake Pontchartrain	O	O	O	O	O
Breton/Chandeleur Sounds	◉	O	O	O	O
Mississippi River	◉		◉		
Barataria Bay	O	O	O	O	O
Terrebonne/Timbalier Bays	◉	O	◉	O	O
Atchafalaya/Vermilion Bays	◉	O	O	O	O
Calcasieu Lake	O	O	O	O	O
Sabine Lake	√	√	O	O	√
Galveston Bay	O	O	O	O	O
Brazos River	O	O	O	O	O
Matagorda Bay	O	O	O	O	O
San Antonio Bay	O	O	O	O	O
Aransas Bay	O	O	O	O	O
Corpus Christi Bay	O	O	O	O	O
Laguna Madre	O	O	O	O	O
Baffin Bay	O	O	O	O	O
	A	S	J	L	E

Relative abundance:
- ● Highly abundant
- ◉ Abundant
- O Common
- √ Rare
- blank Not present

Life stage:
- A - Adults
- S - Spawning
- J - Juveniles
- L - Larvae
- E - Eggs

Regional Results

Data summaries. Regional ELMR data summary reports have been published for the North Atlantic (Jury et al. 1994), Mid-Atlantic (Stone et al. 1994), Southeast (Nelson et al. 1991), Gulf of Mexico (Nelson et al. 1992), and West Coast (Monaco et al. 1990). In each regional data summary report, the information compiled for each species and estuary was organized in data summary tables. The information shown represents the expected spatial and temporal distribution of a species in a particular estuary based upon available data. These tables include:

Spatial distribution and relative abundance: The highest level of abundance during the year in each estuary is depicted for each species by life stage, and in each estuary by salinity zone.

Temporal distribution and relative abundance: This table combines data over the three salinity zones, showing the highest level of abundance for a particular life stage by month for each estuary.

Regional presence/absence of ELMR species. Tables 9, 11, 13, 15, and 17 were developed to readily convey the occurrence of each of the ELMR species in the estuaries of each region. These tables (9, 11, 13, 15, 17) are derived from the regional ELMR data sets by taking the maximum abundance value for either the juvenile or adult life stage in any month, in any salinity zone, within a given estuary. Thus, a single relative abundance value is reported for each species in each estuary. Although these occurrence tables provide a useful summary of "ELMR-at-a-glance," they lack the temporal resolution between months, spatial resolution between salinity zones, and distinction between life stages that are some of the inherent strengths of the ELMR data sets. The spawning, egg, and larval life stages are not considered. However, these tables suggest the zoogeographic distribution of species among estuaries and regions.

North Atlantic Region. The location of the 17 selected ELMR North Atlantic estuaries are shown in Figure 6 (next page), and the common and scientific names of the 58 selected ELMR North Atlantic species are listed in Table 8 (p. 17). Results of the ELMR study in the North Atlantic region are summarized in *Distribution and Abundance of Fishes and Invertebrates in North Atlantic Estuaries*, ELMR Report No. 13 (Jury et al. 1994). Life history summaries and tables are still being developed for the species in this region.

The North Atlantic estuaries are located along the coast of the Gulf of Maine, a cold, deep marine basin influenced by the Labrador Current. Compared to areas further south, estuaries in the North Atlantic region have colder and deeper waters, little seasonal variation in temperature, significant freshwater inflow from only a few large rivers, stronger tides, and a predominantly cold-temperate fauna (Gosner 1971, NOAA 1990a, Ayvazian et al. 1992). The Gulf of Maine consists of a deep central basin enclosed by Georges Bank, with water circulating counterclockwise through the gulf — entering through the Northeast Channel and Browns Bank, and exiting via Great South Channel and Nantucket Shoals. The northern coastline is mostly rocky, consisting primarily of granite, schist, and gneiss. In many areas the consolidated rocks are overlaid by glacial till, or sand/gravel deposits. The estuaries of this area are dominated by submerged, glacier-scoured river valleys with unmodified mouths, but there are some exceptions (e.g., Boston Harbor, Wells Harbor). Tides are semidiurnal and peak freshwater inflow occurs during April and May due to the spring runoff. Average precipitation across the region generally ranges from 40 to 46 inches per year.

Cape Cod is generally considered to be the biogeographic boundary between the Virginian province to the south and the Acadian or Scotian province to the north (Briggs 1974). However, it is thought to act as a "selective filter" rather than an absolute barrier (Gosner 1971) because many of the cold-temperate and boreal fauna that dominate the North Atlantic have ranges extending south of the cape, and several eurythermal migrants from the south enter the Gulf of Maine seasonally. The 58 species selected in the North Atlantic region are generally of the cold-temperate or boreal fauna of the Acadian or Scotian biogeographic marine province, with some southern seasonal migrants. Diadromous species include Atlantic and shortnose sturgeon, American eel, Atlantic salmon, alewife, blueback herring, American shad and striped bass.

Table 9 (p. 18) readily conveys the occurrence of the selected 58 ELMR species in each of the 17 North Atlantic estuaries. This table depicts the highest relative abundance of the adult or juvenile life stage of each species, in any month, in any salinity zone within each estuary. The spawning, egg, and larval life stage categories are not considered. This table also suggests the zoogeographic distribution of species among North Atlantic estuaries. For example, blue mussel and mummichog are ubiquitous, but scup are not common north of Massachusetts. Self-sustaining populations of Atlantic salmon are now rare or extirpated through much of their former range, and have, therefore, been proposed for protection under the federal Endangered Species Act (ESA) (NMFS 1997). Shortnose sturgeon have been listed as endangered since 1967, and Atlantic sturgeon have been considered as a candidate species for ESA protection.

To examine seasonal patterns of species presence/absence in North Atlantic estuaries, the numbers of species present (ranked as "rare" or greater) were counted by month and by salinity zone for the adult, juvenile, larval, spawning, and egg life stages. The original ELMR North Atlantic data set (Jury et al. 1994) was used, with revisions for Massachusetts estuaries (RPI 1999). In Figure 7 (p. 20), the numbers of species were averaged across estuaries and plotted by month for these life stages. Although these summaries are not statistical analyses, they do provide insights into the seasonal and geographical distribution of selected species in the estuaries:

- The number of species appeared to be lowest in the tidal fresh zone. However, this could have been partially due to the fact that the selected ELMR species are primarily estuarine, not freshwater. Most of the North Atlantic ELMR species found in fresh water are diadromous, using the tidal fresh zone as a spawning ground or corridor to other breeding areas. In addition, the lack of systematic faunal surveys in many tidal freshwater zones contribute to this apparent lower diversity.

Text continues on p. 21.

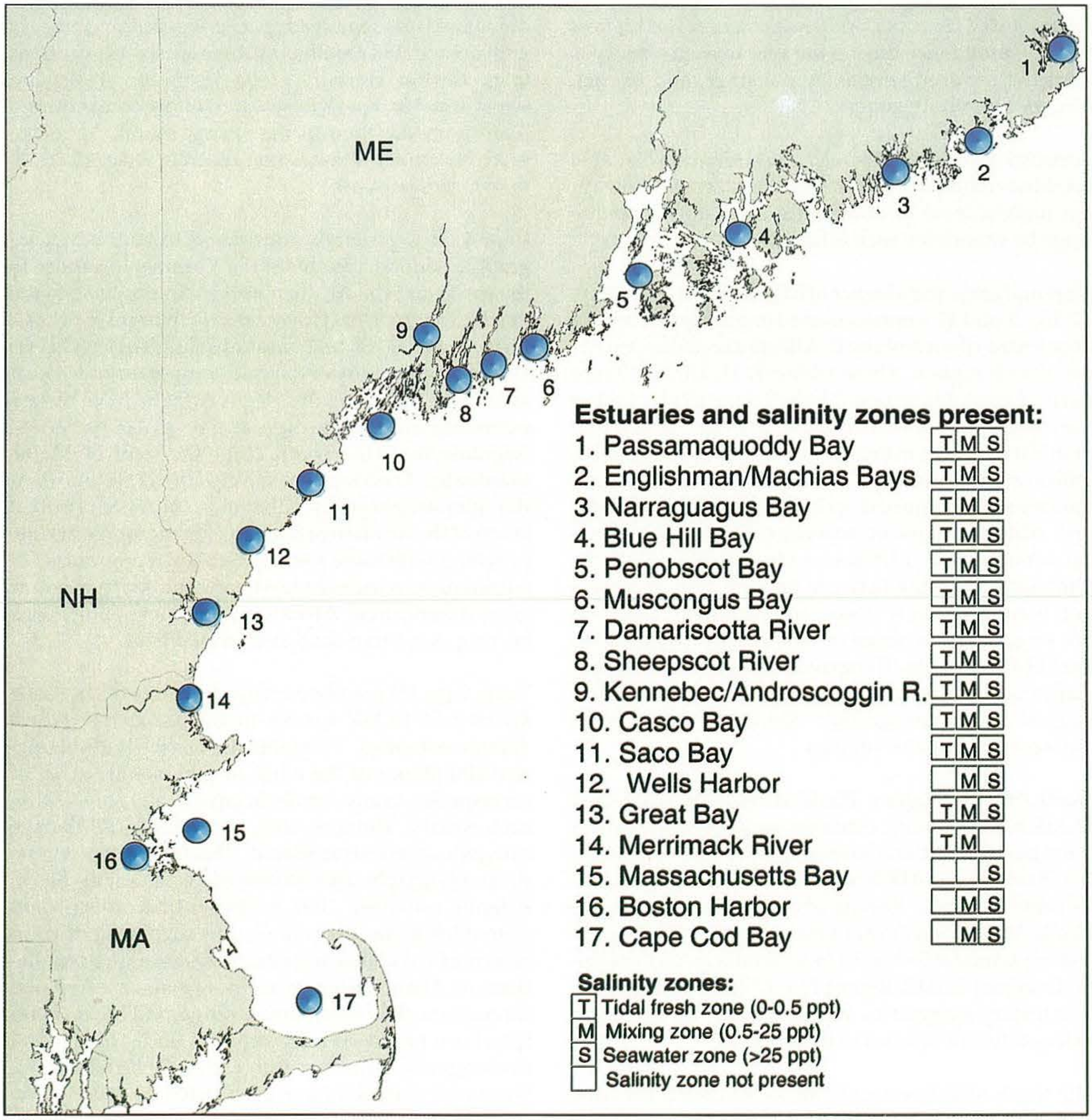


Figure 6. Location of 17 North Atlantic ELMR estuaries and associated salinity zones.

Table 8. ELMR North Atlantic species (n=58).

Common name	Scientific name
Blue mussel	*Mytilus edulis*
Sea scallop	*Placopecten magellanicus*
American oyster	*Crassostrea virginica*
Northern quahog	*Mercenaria mercenaria*
Softshell clam	*Mya arenaria*
Daggerblade grass shrimp	*Palaemonetes pugio*
Northern shrimp	*Pandalus borealis*
Sevenspine bay shrimp	*Crangon septemspinosa*
American lobster	*Homarus americanus*
Jonah crab	*Cancer borealis*
Atlantic rock crab	*Cancer irroratus*
Green crab	*Carcinus maenas*
Green sea urchin	*Strongylocentrotus droebachiensis*
Spiny dogfish	*Squalus acanthias*
Skates	*Raja species*
Shortnose sturgeon	*Acipenser brevirostrum*
Atlantic sturgeon	*Acipenser oxyrhynchus*
American eel	*Anguilla rostrata*
Blueback herring	*Alosa aestivalis*
Alewife	*Alosa pseudoharengus*
American shad	*Alosa sapidissima*
Atlantic menhaden	*Brevoortia tyrannus*
Atlantic herring	*Clupea harengus*
Rainbow smelt	*Osmerus mordax*
Atlantic salmon	*Salmo salar*
Atlantic cod	*Gadus morhua*
Haddock	*Melanogrammus aeglefinus*
Silver hake	*Merluccius bilinearis*
Atlantic tomcod	*Microgadus tomcod*
Pollock	*Pollachius virens*
Red hake	*Urophycis chuss*
White hake	*Urophycis tenuis*
Mummichogs	*Fundulus heteroclitus*
Silversides	*Menidia species*
Fourspine stickleback	*Apeltes quadracus*
Threespine stickleback	*Gasterosteus aculeatus*
Ninespine stickleback	*Pungitius pungitius*
Northern pipefish	*Syngnathus fuscus*
Northern searobin	*Prionotus carolinus*
Grubby	*Myoxocephalus aenaeus*
Longhorn sculpin	*Myoxocephalus octodecemspinosus*
Shorthorn sculpin	*Myoxocephalus scorpius*
White perch	*Morone americana*
Striped bass	*Morone saxatilis*
Bluefish	*Pomatomus saltatrix*
Scup	*Stenotomus chrysops*
Tautog	*Tautoga onitis*
Cunner	*Tautogolabrus adspersus*
Ocean pout	*Macrozoarces americanus*
Rock gunnel	*Pholis gunnellus*
American sand lance	*Ammodytes americanus*
Atlantic mackerel	*Scomber scombrus*
Butterfish	*Peprilus triacanthus*
Windowpane flounder	*Scophthalmus aquosus*
American plaice	*Hippoglossoides platessoides*
Winter flounder	*Pleuronectes americanus*
Yellowtail flounder	*Pleuronectes ferrugineus*
Smooth flounder	*Pleuronectes putnami*

Table 9. Occurrence* of 58 ELMR species in 17 North Atlantic estuaries

* Highest relative abundance of adults or juveniles of a species, in any salinity zone, in any month, within each estuary.

Relative Abundance:
- ● - Highly Abundant
- ◉ - Abundant
- O - Common
- √ - Rare
- blank - Not Present
- na - No data available

Species	Passamaquoddy Bay	Englishman/Machias Bays	Narraguagus Bay	Blue Hill Bay	Penobscot Bay	Muscongus Bay	Damariscotta River	Sheepscot River	Kennebec/Androscoggin Rivers	Casco Bay	Saco Bay	Wells Harbor	Great Bay	Merrimack River	Massachusetts Bay	Boston Harbor	Cape Cod Bay
Blue mussel	●	●	●	●	●	●	●	●	●	●	●	●	●	◉	●	●	●
Sea scallop	◉	◉	◉	◉	◉	O	O	O	√	O	√		O		O	√	◉
American oyster	√							√					●				O
Northern quahog	O			√	√	√	O	√	√	O		√		√	O	O	●
Softshell clam	●	O	●	●	●	●	●	●	●	●	●	●	◉	●	◉	●	●
Daggerblade grass shrimp										√	√	√	O	√	O	O	◉
Northern shrimp	◉	O	O	O	◉	◉	O	◉	O	O	√				◉	O	√
Sevenspine bay shrimp	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
American lobster	O	●	●	●	●	◉	◉	●	◉	●	◉	O	◉	O	◉	◉	◉
Jonah crab	√	◉	◉	◉	O	O	◉	O	●	●	◉	●	O	√	O	O	O
Rock crab	O	●	●	●	●	●	●	●	●	●	●	●	●	O	◉	●	◉
Green crab	◉	◉	◉	◉	◉	●	●	●	●	●	●	●	●	◉	◉	●	●
Green sea urchin	●	●	●	●	●	●	●	●	●	◉	O		O		O	O	O
Spiny dogfish	◉	◉	◉	◉	◉	O	O	O	O	O	O				◉	√	◉
Skates	O	O	O	O	O	O	O	O	O	O	O	√	O	√	◉	◉	●
Shortnose sturgeon					na			√	O					O			
Atlantic sturgeon	√	√	√	√	√	√	√	√	√	√	√		√	O	√	na	√
American eel	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉
Blueback herring	◉	√	O	O	O	√	O	O	√	O	O	◉	◉	◉	O	O	O
Alewife	◉	◉	◉	◉	◉	●	●	●	●	●	●	◉	●	●	◉	◉	◉
American shad	◉	√	O	√	√	√	√	√	O	√	O		√	O	√	√	√
Atlantic menhaden	O	O	O	O	◉	◉	◉	◉	O	◉	O	√	√	O	◉	O	◉
Atlantic herring	●	●	●	●	●	◉	◉	◉	O	◉	◉	●	O	O	◉	◉	◉
Rainbow smelt	◉	O	O	O	◉	◉	◉	◉	◉	◉	◉	O	●	O	◉	◉	O
Atlantic salmon	O	O	O	O	O	√	na	O	O	√	√		√	O			
Atlantic cod	O	◉	◉	◉	O	O	O	◉	O	O	O	√	√	√	O	O	O
Haddock	√	√	√	√	√	√	√	√		√	√				√	√	√
Silver hake	◉	◉	◉	◉	◉	O	O	◉	O	O	O	√	√	√	O	O	O
Atlantic tomcod	◉	◉	◉	◉	◉	◉	O	●	●	◉	◉	◉	◉	O	O	◉	O

Table 9, continued. Occurrence of 58 ELMR species in 17 North Atlantic estuaries

Relative Abundance:
● - Highly Abundant
◉ - Abundant
○ - Common
√ - Rare
blank - Not Present
na - No data available

Species	Passamaquoddy Bay	Englishman/Machias Bays	Narraguagus Bay	Blue Hill Bay	Penobscot Bay	Muscongus Bay	Damariscotta River	Sheepscot River	Kennebec/Androscoggin Rivers	Casco Bay	Saco Bay	Wells Harbor	Great Bay	Merrimack River	Massachusetts Bay	Boston Harbor	Cape Cod Bay
Pollock	◉	○	○	○	○	◉	◉	◉	◉	○	○	√	○	○	◉	○	●
Red hake	○	○	○	○	○	○	○	○	○	○	○	√	○	√	○	○	◉
White hake	◉	○	○	○	◉	○	○	◉	○	○	○	○	○	√	○	○	○
Mummichogs	●	●	●	●	●	●	●	●	●	●	●	●	●	●	◉	●	●
Silversides	○	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●
Fourspine stickleback	○	○	○	○	○	◉	◉	○	◉	○	○	○	○	√	○	○	○
Threespine stickleback	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Ninespine stickleback	○	○	○	○	○	○	○	○	○	○	○	●	○	○	√	○	
Northern pipefish	○	√	√	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Northern searobin				√		√	√	√	√	√	√		√	√	○	√	○
Grubby	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Longhorn sculpin	●	●	●	●	●	●	●	◉	●	●	◉	○	○	√	◉	○	◉
Shorthorn sculpin	○	○	○	○	○	○	○	○	○	○	○	√	√	√	○	√	√
White perch	○	○	○	○	○	○	○	○	○	○	○	√	◉	○		√	√
Striped bass	√	○	○	○	○	○	○	○	○	○	○	○	○	√	○	○	○
Bluefish	√	√	√	√	○	○	○	○	○	○	○	○	○	√	○	○	○
Scup										√	√				○	√	○
Tautog					√	√	√	√	√	√	√	√	√		○	○	○
Cunner	○	○	○	○	○	○	○	○	○	○	○	○	○	√	◉	◉	◉
Ocean pout	◉	○	○	○	○	○	○	○	○	○	○		√		○	○	○
Rock gunnel	○	○	○	○	○	○	○	○	○	○	○	○	○	√	○	○	○
American sand lance	○	○	○	○	○	◉	◉	◉	◉	◉	◉	●	○	◉	◉	○	◉
Atlantic mackerel	○	○	○	○	○	◉	◉	◉	◉	○	○	√	○	√	○	○	◉
Butterfish	√	√	√	√	√	√	√	√	√	√	√		√	√	○	√	○
Windowpane flounder	○	○	○	○	◉	○	○	○	○	○	○	○	○	√	○	○	◉
American plaice	○	○	○	○	○	●	●	●	●	●	●	√	√	√	●	◉	●
Winter flounder	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Yellowtail flounder	√	√	√	√	√	√	√	○	√	○	√	√			◉	◉	○
Smooth flounder	○	○	○	○	○	◉	◉	◉	◉	◉	◉	○	●	√	√	√	

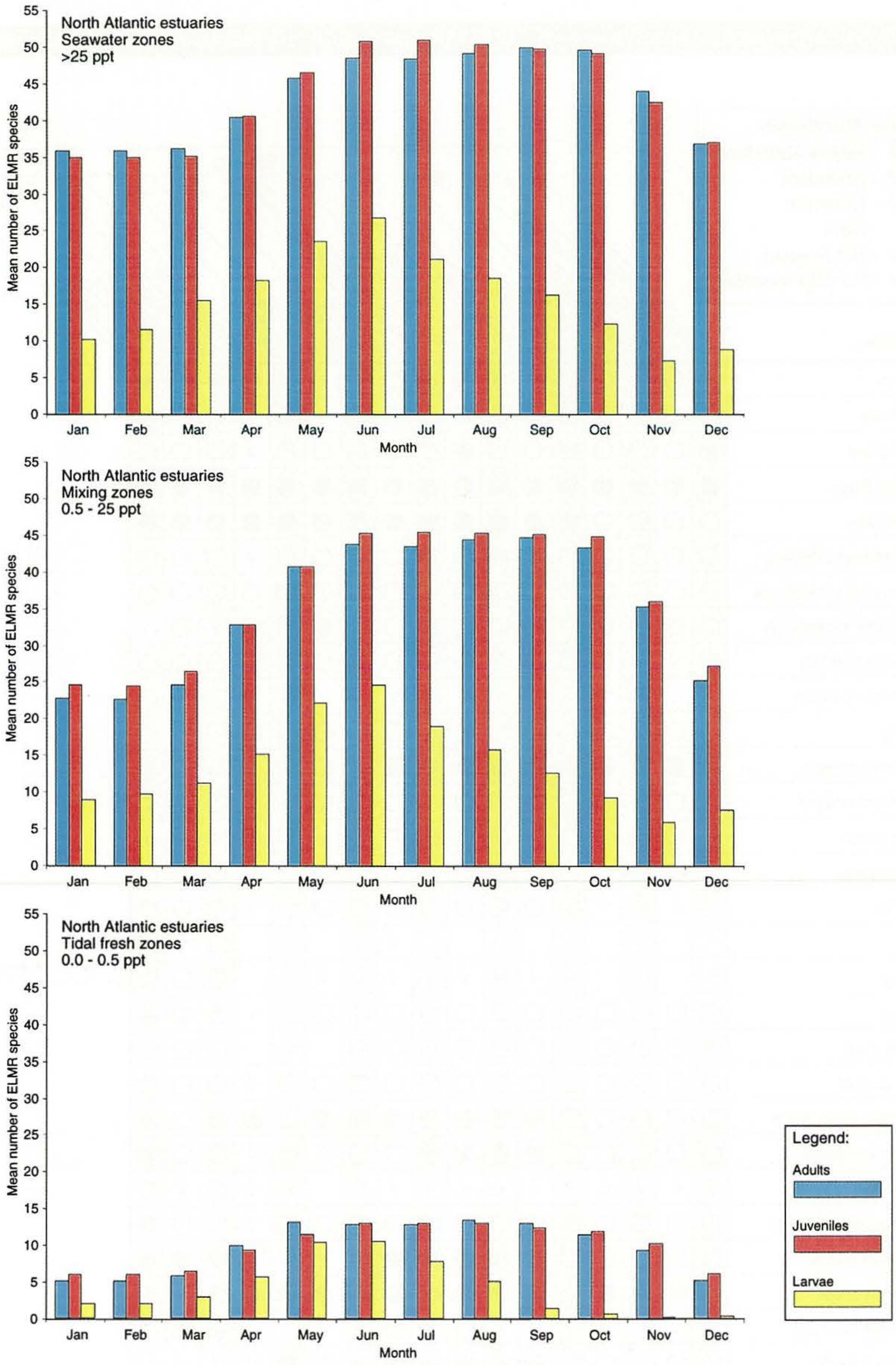


Figure 7. Mean number of ELMR species in North Atlantic estuaries, by salinity zone, month and life stage.

- Juveniles and adults are the predominant life stages present in estuaries, followed by larvae, eggs, and spawning.

- The number of species present as juveniles and adults was highest from June through October, and lowest from December through March, with some notable exceptions (e.g., winter flounder, Atlantic herring).

- The number of species present as larvae in the mixing and seawater zones was highest in June.

Mid-Atlantic Region. The location of the 22 selected ELMR Mid-Atlantic estuaries are shown in Figure 8 (next page), and the common and scientific names of the 61 selected ELMR Mid-Atlantic species are listed in Table 10 (p. 23). Results of the ELMR study in the Mid-Atlantic region are summarized in *Distribution and Abundance of Fishes and Invertebrates in Mid-Atlantic Estuaries*, ELMR Report No. 12 (Stone et al. 1994). Life history summaries and tables are still being developed for the species in this region.

Long Island, Cape Cod, Martha's Vineyard, and Nantucket Island were formed as end moraines marking the southern extent of the most recent Pliestocene glaciation. Sea levels rose as the glaciers melted, drowning the mouths of rivers extending across the Mid-Atlantic continental shelf and forming the estuarine systems present today (NOAA 1985a). Tides are semidiurnal, and range from approximately two meters in Delaware Bay, to less than a meter in tributaries of the Chesapeake Bay (NOAA 1990a).

The 61 species selected in the Mid-Atlantic region are generally of the cold-temperate fauna of the Virginian marine biogeographic province. Other selected species have a freshwater origin, such as the yellow perch and channel catfish common in the low-salinity tidal tributaries of the Chesapeake Bay. Diadromous species include Atlantic and shortnose sturgeon, American eel, alewife, blueback herring, American shad, and striped bass. Table 11 (p. 24) readily conveys the occurrence of the selected 61 ELMR species in each of the 22 Mid-Atlantic estuaries. This table depicts the highest relative abundance of the adult or juvenile life stage of each species, in any month, in any salinity zone within each estuary. The spawning, egg, and larval life stage categories are not considered. This table also suggests the zoogeographic distribution of species among Mid-Atlantic estuaries. For example, a few northern species (Atlantic cod, Atlantic salmon) do not occur in estuaries south of Long Island. Bay scallop does not occur in the low-salinity tributaries of the Chesapeake, whereas channel catfish occur primarily in estuaries with tidal riverine habitat. A few eurythermal and euryhaline species such as grass shrimp and silversides are ubiquitous, considered abundant or highly abundant in all Mid-Atlantic estuaries.

To examine seasonal patterns of species presence/absence in Mid-Atlantic estuaries, the numbers of species present (ranked as "rare" or greater) were counted by month and by salinity zone for the adult, juvenile, larval, spawning, and egg life stages. The original ELMR Mid-Atlantic data set (Stone et al. 1994), with revisions for Massachusetts (RPI 1999) was used. In Figure 9, the numbers of species were averaged across estuaries and plotted by month for these life stages. Although these summaries are not statistical analyses, they do provide insights into the seasonal and geographical distribution of selected species in the estuaries:

- The number of species appears to be lowest in the tidal fresh zone. However, this is partially due to the fact that the selected ELMR species are primarily estuarine, not freshwater species. In addition, the lack of systematic faunal surveys in many tidal freshwater zones contribute to this apparent lower diversity.

- Juveniles and adults are the predominant life stages present in estuaries, followed by larvae, spawning, and eggs.

- The number of species present as juveniles and adults is generally highest from June through October, and lowest from December through March.

- The number of species present as larvae in the mixing and seawater zones is highest from May through July.

Text continues on p. 27.

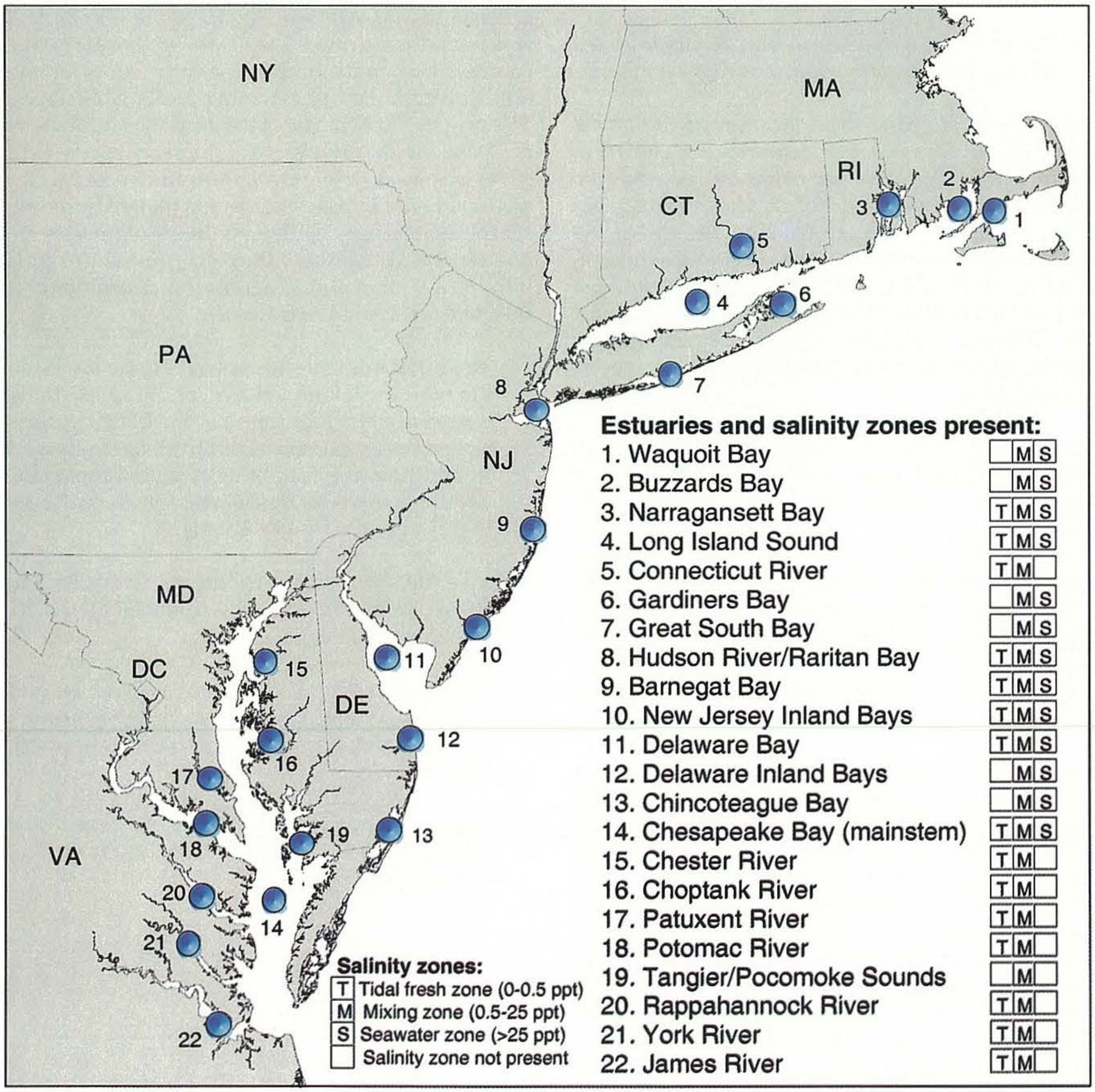


Figure 8. Location of 22 Mid-Atlantic ELMR estuaries and associated salinity zones.

Table 10. ELMR Mid-Atlantic species (n=61)

Common name	Scientific name
Blue mussel	*Mytilus edulis*
Bay scallop	*Argopecten irradians*
American oyster	*Crassostrea virginica*
Northern quahog	*Mercenaria mercenaria*
Softshell clam	*Mya arenaria*
Brown shrimp	*Penaeus aztecus*
Daggerblade grass shrimp	*Palaemonetes pugio*
Sevenspine bay shrimp	*Crangon septemspinosa*
American lobster	*Homarus americanus*
Blue crab	*Callinectes sapidus*
Skates	*Raja species*
Atlantic stingray	*Dasyatis sabina*
Cownose ray	*Rhinoptera bonasus*
Shortnose sturgeon	*Acipenser brevirostrum*
Atlantic sturgeon	*Acipenser oxyrhynchus*
American eel	*Anguilla rostrata*
Blueback herring	*Alosa aestivalis*
Alewife	*Alosa pseudoharengus*
American shad	*Alosa sapidissima*
Atlantic menhaden	*Brevoortia tyrannus*
Atlantic herring	*Clupea harengus*
Bay anchovy	*Anchoa mitchilli*
Channel catfish	*Ictalurus punctatus*
Rainbow smelt	*Osmerus mordax*
Atlantic salmon	*Salmo salar*
Atlantic cod	*Gadus morhua*
Haddock	*Melanogrammus aeglefinus*
Atlantic tomcod	*Microgadus tomcod*
Pollock	*Pollachius virens*
Red hake	*Urophycis chuss*
Oyster toadfish	*Opsanus tau*
Sheepshead minnow	*Cyprinodon variegatus*
Killifishes	*Fundulus species*
Silversides	*Menidia species*
Northern pipefish	*Syngnathus fuscus*
Northern searobin	*Prionotus carolinus*
White perch	*Morone americana*
Striped bass	*Morone saxatilis*
Black sea bass	*Centropristis striata*
Yellow perch	*Perca flavescens*
Bluefish	*Pomatomus saltatrix*
Pinfish	*Lagodon rhomboides*
Scup	*Stenotomus chrysops*
Spotted seatrout	*Cynoscion nebulosus*
Weakfish	*Cynoscion regalis*
Spot	*Leiostomus xanthurus*
Northern kingfish	*Menticirrhus saxatilis*
Atlantic croaker	*Micropogonias undulatus*
Black drum	*Pogonias cromis*
Red drum	*Sciaenops ocellatus*
Mullets	*Mugil species*
Tautog	*Tautoga onitis*
Cunner	*Tautogolabrus adspersus*
American sand lance	*Ammodytes americanus*
Gobies	*Gobiosoma species*
Atlantic mackerel	*Scomber scombrus*
Butterfish	*Peprilus triacanthus*
Summer flounder	*Paralichthys dentatus*
Windowpane flounder	*Scophthalmus aquosus*
Winter flounder	*Pleuronectes americanus*
Hogchoker	*Trinectes maculatus*

Table 11. Occurrence* of 61 ELMR species in 22 Mid-Atlantic estuaries

* Highest relative abundance of adults or juveniles of a species, in any salinity zone, in any month, within each estuary.

Species	Waquoit Bay	Buzzards Bay	Narragansett Bay	Long Island Sound	Connecticut River	Gardiners Bay	Great South Bay	Hudson River/Raritan Bay	Barnegat Bay	New Jersey Inland Bays	Delaware Bay	Delaware Inland Bays	Chincoteague Bay	Chesapeake Bay mainstem	Chester River	Choptank River	Patuxent River	Potomac River	Tangier/Pocomoke Sound	Rappahannock River	York River	James River
Blue mussel	√	●	○	○	○	○	○	◉	○	○	○	○	◉	◉						○	○	○
Bay scallop	◉	◉	○	√	√	○	√					√	√									
American oyster	√	○	○	◉	◉	○	√	√	√	√	●	√	○	○	○	○	○	○	○	◉	○	◉
Northern quahog	●	●	●	◉	◉	◉	●	◉	◉	◉	●	●	●	○						○	◉	◉
Softshell clam	◉	◉	○	○	○	○	○	◉	○	√	◉	√		√	○	○	○	○	○	○	√	√
Brown shrimp						√		√			√	√	○	√				√	√	√	√	√
Daggerblade grass shrimp	◉	●	●	◉	◉	◉	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Sevenspine bay shrimp	●	●	◉	●	◉	◉	●	◉	●	●	◉	●	●	○	○	○	○	○	○	○	○	○
American lobster	○	◉	◉	●	○	○	√	○			○	√		√								
Blue crab	○	○	○	○	○	○	◉	○	●	●	◉	●	●	●	●	●	●	●	●	●	●	●
Skates	√	◉	◉	●	○	○	○	○	○	○	○	○	√	○								
Atlantic stingray				√			√							√						√	√	√
Cownose ray		√	√	√		√	√	√	√	√	√	√	√	◉	○	○	○	○	○	○	○	○
Shortnose sturgeon			√	○	√			○			√											
Atlantic sturgeon		√	√	√	○	○	√	○			√	√		√				√	√	√	√	√
American eel	◉	◉	◉	◉	◉	○	○	◉	○	○	◉	○	●	◉	○	○	○	○	○	○	○	○
Blueback herring	○	○	○	●	●	○	○	●	○	○	◉	√	○	◉	○	○	○	◉	◉	○	○	○
Alewife	○	○	○	●	●	○	○	●	◉	◉	◉	√	√	◉	○	○	○	◉	◉	○	○	○
American shad	√	√	√	◉	●	○	○	●	√	√	◉	√		○	○	○	√	○	○	○	○	○
Atlantic menhaden	○	●	◉	●	◉	◉	◉	◉	◉	◉	◉	◉	◉	●	●	●	●	●	◉	●	●	●
Atlantic herring	√	○	◉	◉	√	○	◉	○	○	○	○	√	√	○						√	√	√
Bay anchovy	√	◉	◉	◉	●	●	●	●	◉	◉	●	●	●	●	●	●	●	●	●	●	●	●
Channel catfish			√	○	◉			√	√	na	○		√	○	○	○	○	○	○	○	○	○
Rainbow smelt	○	○	○	○	○	○		√														
Atlantic salmon				√	○	√	√															
Atlantic cod	√	○	√	√		√																
Haddock		√	√	√		√																
Atlantic tomcod	○	○	○	◉	◉	○	○	◉														
Pollock	○	√	√	○		√	○	√	√	√	√											
Red hake		○	○	◉	○	√	√	○	√	√	○	√	√	○						√	√	√
Oyster toadfish	○	○	○	○	√	○	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Relative abundance:

● - Highly abundant ◉ - Abundant ○ - Common √ - Rare Blank - Not present na - No data available

Table 11, continued. Occurrence of 61 ELMR species in 22 Mid-Atlantic estuaries

Species	Waquoit Bay	Buzzards Bay	Narragansett Bay	Long Island Sound	Connecticut River	Gardiners Bay	Great South Bay	Hudson River/Raritan Bay	Barnegat Bay	New Jersey Inland Bays	Delaware Bay	Delaware Inland Bays	Chincoteague Bay	Chesapeake Bay mainstem	Chester River	Choptank River	Patuxent River	Potomac River	Tangier/Pocomoke Sound	Rappahannock River	York River	James River
Sheepshead minnow	○	○	√	○	○	○	◉	○	○	○	○	○	○	◉	◉	◉	◉	◉	◉	◉	◉	◉
Killifishes	●	◉	◉	◉	◉	◉	●	◉	◉	◉	●	◉	◉	●	●	●	●	●	●	●	●	●
Silversides	●	●	●	●	◉	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Northern pipefish	○	○	○	○	○	○	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Northern searobin	○	○	○	○	○	○	○	○	○	○	○	○	○	◉		√	√	√	√	√	√	√
White perch	√	○	◉	●	●	○	○	●	○	◉	◉	√	○	◉	◉	◉	◉	◉	○	◉	◉	◉
Striped bass	○	○	○	◉	◉	○	◉	◉	√	√	○	○		○	○	○	◉	◉	○	○	○	○
Black sea bass	√	○	○	○		○	○	√	◉	◉	○	○	○	○	√	√	√	√	○	√	√	○
Yellow perch		√	○	◉	◉			○	○	◉	○	√		○	○	○	○	○	√	○	○	○
Bluefish	○	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	○	○	◉	○	○	○	◉	◉	◉	◉	◉
Pinfish			√					√		√	√	√	√	○								○
Scup	○	●	●	●	√	◉	○	◉	○	○	○	○	√	◉					√		√	√
Spotted seatrout									√	√	√	√	√	○	○	○	○	○	○	○	○	○
Weakfish	√	○	○	◉	√	◉	○	◉	○	○	◉	○	◉	○	○	○	○	○	○	○	○	○
Spot		√	○	√	√	√	○	◉	●	●	◉	●	◉	◉	○	◉	○	○	◉	◉	◉	◉
Northern kingfish	√	√	√	√		○	○	○	√	√	√	○	√	√			√	√	√	√	√	√
Atlantic croaker						√		√	√	√	○	○	○	◉	○	○	○	○	○	◉	◉	◉
Black drum			√					√	√	√	√	√		○	√	○	√	○	○	○	○	○
Red drum									√	√	√	√		○	√	√	√	○	○	○	○	○
Mullets	○	√	√	√	√	○	○	○	○	○	○	○	○	○			√	√	√	√	√	√
Tautog	◉	◉	○	○	○	○	◉	◉	○	○	○	√	√	○	√	√	√	√	○	○	○	○
Cunner	●	●	○	○	○	○	◉	√	○	○	√		√									
American sand lance	○	◉	○	◉	○	◉	○	◉	○	○	√		√									
Gobies	√	√	○	○	○	○	○	○	○	○	○	◉	○	◉	◉	◉	◉	◉	◉	◉	◉	◉
Atlantic mackerel	○	○	○	○		○	○	○	√	√	√	√		√						√	√	√
Butterfish	○	●	◉	●	○	○	○	○	○	○	○	○		○		√	√	√	√	√	○	○
Summer flounder	○	○	○	√	○	○	○	○	○	○	○	●	●	○	○	○	○	○	○	○	○	○
Windowpane flounder	○	◉	◉	●	●	○	◉	○	●	●	◉	○	○	○					○		√	√
Winter flounder	●	●	◉	●	●	◉	●	◉	◉	○	○	○	○	√	√	√	√	√	√	√	√	√
Hogchoker	√	○	○	○	◉	○	○	◉	◉	◉	●	●	○	●	●	●	●	●	●	●	●	●

Relative abundance:

● - Highly abundant ◉ - Abundant ○ - Common √ - Rare Blank - Not present na - No data available

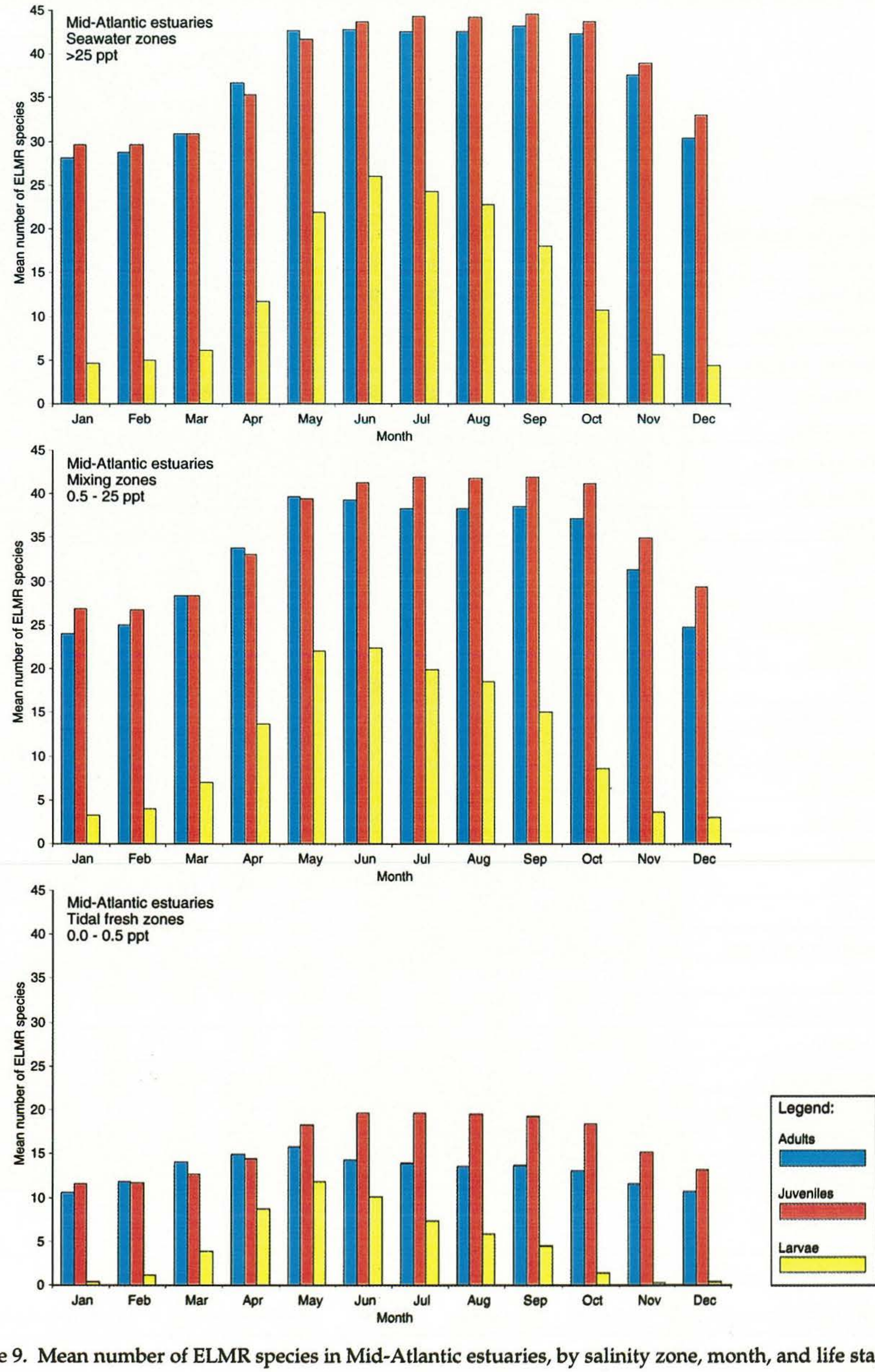


Figure 9. Mean number of ELMR species in Mid-Atlantic estuaries, by salinity zone, month, and life stage.

Southeast Region. The locations of the 20 selected ELMR Southeast estuaries are shown in Figure 10 (next page), and the common and scientific names of the 40 selected ELMR Southeast species are listed in Table 12 (p. 29). Results of the ELMR study in the Southeast region are summarized in *Distribution and Abundance of Fishes and Invertebrates in Southeast Estuaries*, ELMR Report No. 12 (Nelson et al. 1991). Life history tables for Southeast ELMR species have been completed in draft form, but life history summaries are still being developed.

Estuaries of the South Carolina and Georgia coasts are characterized by low-elevation, marshy shorelines with a dendritic pattern of tributary tidal streams. Estuaries of North Carolina and Florida are generally lagoons bounded by extensive barrier islands (NOAA 1985a). Tides are semidiurnal, and range from less than a meter in North Carolina and Florida to two meters in Georgia (NOAA 1990a).

The 40 species selected in the Southeast region are generally of the warm-temperate fauna of the Carolinian marine biogeographic province. Diadromous species include Atlantic sturgeon, American eel, alewife, blueback herring, American shad, and striped bass. The actual fauna of Florida's Biscayne Bay and Indian River includes many species from the tropical Caribbean marine province, including grunts (Haemulidae), snappers (Lutjanidae), groupers and sea basses (Serranidae). Therefore, the selected ELMR species list does not adequately represent the actual south Florida estuarine fauna.

Table 13 (p. 30) readily conveys the occurrence of the selected 40 ELMR species in each of the 20 Southeast estuaries. This table depicts the highest relative abundance of the adult or juvenile life stage of each species, in any month, in any salinity zone within each estuary. The spawning, egg, and larval life stage categories are not considered. This table also suggests the zoogeographic distribution of species among Southeast estuaries. For example, alewife does not occur south of the North Carolina estuaries. Many species common or abundant in Georgia and the Carolinas are rare or completely absent in Biscayne Bay, Florida. A few species, such as blue crab, bay anchovy, and striped mullet are ubiquitous, considered at least common in all 20 Southeast ELMR estuaries.

To examine seasonal patterns of species presence/absence in Southeast estuaries, the revised and updated ELMR data set for North Carolina estuaries was selected (RPI 1996). This data set utilizes five salinity zones: 0-0.5 ppt (tidal fresh), 0.5-5 ppt, 5-15 ppt, 15-25 ppt and >25 ppt. The revised ELMR data also consider the presence of eggs and spawning as a single life history stage (spawning-egg). Numbers of species present, ranked as "rare" or greater, were counted by month and by salinity zone for the adult, juvenile, and larval life stages. In Figure 11 (p. 31) the numbers of species were averaged across estuaries and plotted by month for these life stages. In Figure 12 (p. 32), the annual maximum number of species is plotted by salinity zone for each life stage. Although these summaries are not statistical analyses, they do provide insights into the seasonal and geographical distribution of selected species in the estuaries:

- The number of species appears to be lower in the tidal fresh (0-0.5 ppt) and seawater (>25 ppt) zones. However, this may be partially because the selected ELMR species are primarily estuarine, not freshwater or marine resident species.

- Juveniles and adults are the predominant life stages present in estuaries, followed by larvae and eggs-spawning.

- The number of species present as juveniles and adults is generally highest from June through September, and lowest from December through February.

- The number of species present as larvae is generally highest in the 15-25 ppt zone, and peaks in April.

Text continues on p. 33.

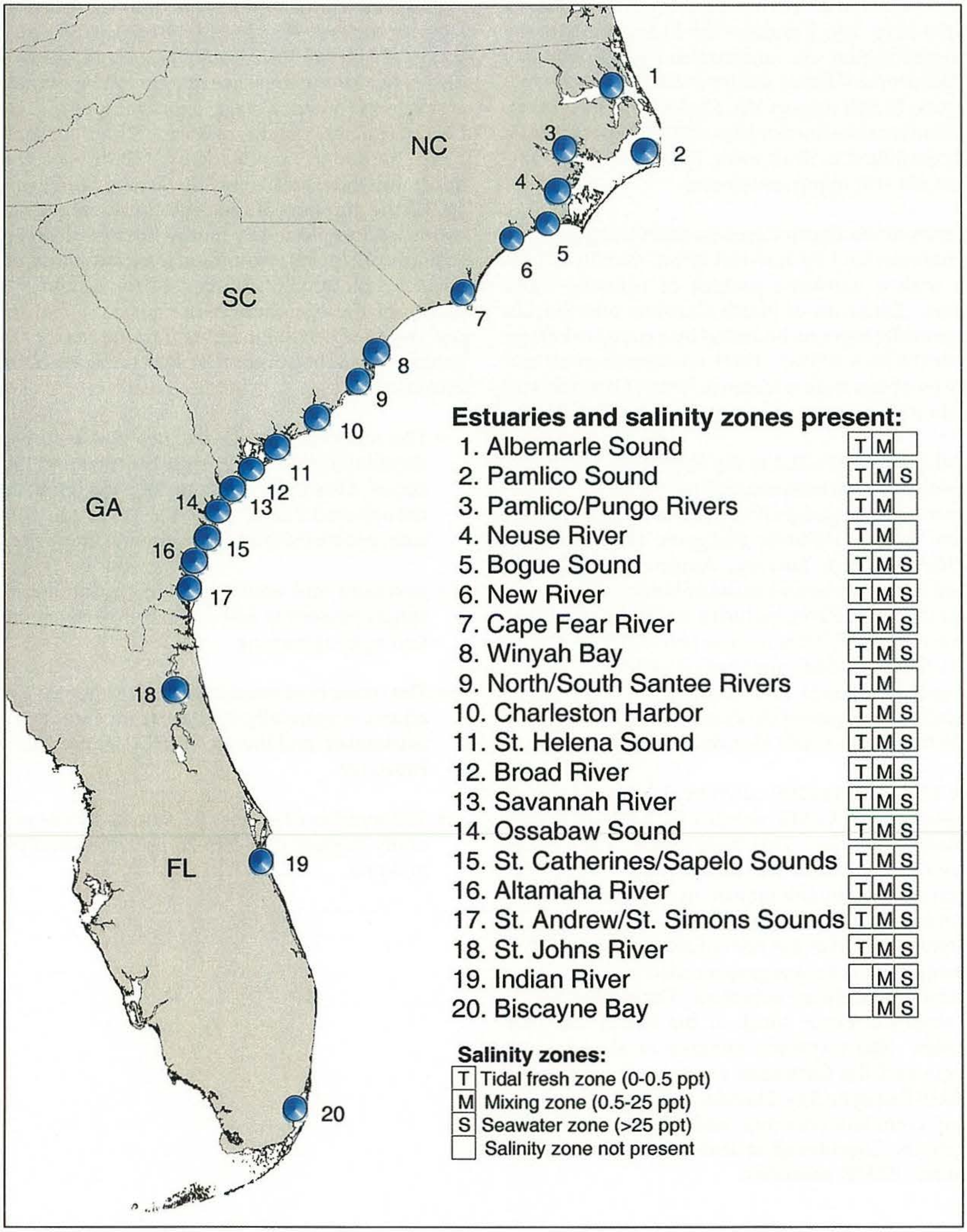


Figure 10. Location of 20 Southeast ELMR estuaries and associated salinity zones.

Table 12. ELMR Southeast species (n=41)

Common Name	Scientific Name
Blue mussel	*Mytilus edulis*
Bay scallop	*Argopecten irradians*
American oyster	*Crassostrea virginica*
Common rangia	*Rangia cuneata*
Hard clam	*Mercenaria* species
Brown shrimp	*Penaeus aztecus*
Pink shrimp	*Penaeus duorarum*
White shrimp	*Penaeus setiferus*
Grass shrimp	*Palaemonetes pugio*
Blue crab	*Callinectes sapidus*
Atlantic sturgeon	*Acipenser oxyrhynchus*
Ladyfish	*Elops saurus*
American eel	*Anguilla rostrata*
Blueback herring	*Alosa aestivalis*
Alewife	*Alosa pseudoharengus*
American shad	*Alosa sapidissima*
Atlantic menhaden	*Brevoortia tyrannus*
Bay anchovy	*Anchoa mitchilli*
Sheepshead minnow	*Cyprinodon variegatus*
Mummichog	*Fundulus heteroclitus*
Silversides	*Menidia* species
White perch	*Morone americana*
Striped bass	*Morone saxatilis*
Bluefish	*Pomatomus saltatrix*
Cobia	*Rachycentron canadum*
Gray snapper	*Lutjanus griseus*
Sheepshead	*Archosargus probatocephalus*
Pinfish	*Lagodon rhomboides*
Spotted seatrout	*Cynoscion nebulosus*
Weakfish	*Cynoscion regalis*
Spot	*Leiostomus xanthurus*
Southern kingfish	*Menticirrhus americanus*
Atlantic croaker	*Micropogonias undulatus*
Black drum	*Pogonias cromis*
Red drum	*Sciaenops ocellatus*
Striped mullet	*Mugil cephalus*
Spanish mackerel	*Scomberomorus maculatus*
Gulf flounder	*Paralichthys albigutta*
Summer flounder	*Paralichthys dentatus*
Southern flounder	*Paralichthys lethostigma*

Table 13. Occurrence* of 41 ELMR species in 20 Southeast estuaries

*Highest relative abundance of adults or juveniles in any salinity zone, in any month.

Relative Abundance:
- ● - Highly Abundant
- ◉ - Abundant
- ○ - Common
- √ - Rare
- Blank - Not Present

Species	Albemarle Sound	Pamlico Sound	Pamlico/Pungo Rivers	Neuse River	Bogue Sound	New River	Cape Fear River	Winyah Bay	N/S Santee River	Charleston Harbor	St. Helena Sound	Broad River	Savannah River	Ossabaw Sound	St. Cath./Sapelo Snd.	Altamaha River	St. And./St. Sim. Snd.	St. Johns River	Indian River	Biscayne Bay
	Estuary																			
blue mussel		√		√	√	√	√													
bay scallop		◉			◉	●	√												√	○
American oyster	○	◉	◉	○	●	●	●	●	○	◉	●	●	○	◉	◉	○	◉	◉	○	○
common rangia	◉	◉	◉	◉	○	○	○	○	○	√	√	√	○	○	○	○	○	○	√	
hard clam		◉			●	●	●	◉	○	◉	○	◉	○	○	○	○	○	○	○	○
brown shrimp	○	◉	◉	◉	●	◉	◉	◉	◉	●	●	◉	○	◉	◉	○	◉	◉	○	√
pink shrimp	○	◉	○	◉	◉	◉	◉	○	◉	○	√	○	○	○	○	√	○	○	◉	●
white shrimp	◉	◉	○	○	○	○	◉	◉	●	●	●	●	●	●	●	◉	●	●	○	√
grass shrimp	○	◉	◉	◉	●	●	●	●	◉	●	◉	◉	◉	◉	●	◉	◉	●	◉	○
blue crab	◉	●	●	●	●	◉	●	●	◉	◉	●	●	◉	◉	◉	◉	◉	●	◉	●
Atlantic sturgeon	○	○	○	○		√	○	○	√	√	○	○	○	○	○	○	○	√		
ladyfish	○	○	○	○	√	√	○	○	√	○	○	○	○	○	○	○	○	○	●	○
American eel	◉	●	◉	●	○	○	◉	◉	○	○	○	○	◉	◉	◉	◉	◉	◉	◉	○
blueback herring	●	●	●	●	√	√	◉	○	○	○	○	○	○	○	○	○	○	○		
alewife	●	◉	○	◉	○	√	√	√												
American shad	◉	○	○	○	√	√	○	○	◉	○	○	√	○	○	√	◉	○	○		
Atlantic menhaden	●	●	●	●	●	●	●	●	●	◉	◉	●	◉	◉	◉	◉	◉	◉	○	
bay anchovy	●	●	◉	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
sheepshead minnow	√	◉	○	◉	◉	◉	◉	○	○	○	◉	○	◉	◉	◉	◉	◉	○	●	○
mummichog	○	●	◉	◉	●	●	●	◉	◉	◉	●	◉	●	●	●	●	●	◉	√	
Atlantic silversides	◉	◉	○	◉	●	●	◉	◉	◉	○	●	●	◉	◉	◉	◉	◉	●	●	◉
white perch	●	○	○	○	√			◉	○	○										
striped bass	◉	○	○	○	√	√	√	○	○	○	○	◉	○	◉	√	○	√	○		
bluefish	○	◉	○	○	◉	○	◉	◉	○	○	○	○	○	○	○	○	○	○	●	√
cobia		○			○	○	○	√	○	○	○	◉	○	○	○	○	○	○		
gray snapper	√	○	√	√	√	√	√	√	○	○	√	√	√	√	√	√	√	○	●	●
sheepshead	√	◉	√	○	◉	◉	◉	○	○	○	○	○	○	○	○	○	○	◉	●	√
pinfish	○	◉	◉	◉	●	●	●	●	○	○	◉	○	○	○	○	○	○	◉	●	●
spotted seatrout	◉	◉	○	○	◉	◉	◉	○	○	○	◉	◉	●	●	●	●	●	○	●	○
weakfish	○	◉	◉	○	◉	◉	◉	○	●	◉	○	◉	◉	◉	◉	◉	◉	◉	○	√
spot	●	●	●	●	●	●	●	●	●	●	◉	◉	●	●	●	●	●	◉	●	○
southern kingfish	○	○	○	○	◉	◉	○	◉	◉	◉	◉	◉	●	●	●	●	●	○	○	√
Atlantic croaker	◉	●	●	●	●	●	●	●	●	●	●	●	◉	●	●	●	●	◉	○	√
black drum	√	○	○	○	√	√	√	○	√	○	○	○	○	○	○	○	◉	◉	●	√
red drum	√	○	○	○	◉	√	○	◉	√	○	○	○	○	◉	◉	●	●	◉	●	√
striped mullet	◉	◉	◉	◉	●	●	●	●	◉	◉	◉	◉	●	●	●	●	●	●	●	○
spanish mackerel	○	○	○	○	◉	◉	○	○	√	○	○	○	○	○	○	○	○	○	√	○
gulf flounder		○			○	○	√	√	√	○		√	√	√	√	√	√	○	●	○
summer flounder	○	◉	○	○	◉	○	○	◉	○	○	○	○	◉	◉	◉	◉	◉	○	○	
southern flounder	◉	◉	◉	◉	◉	◉	◉	◉	◉	○	○	◉	◉	◉	◉	◉	◉	◉	◉	√

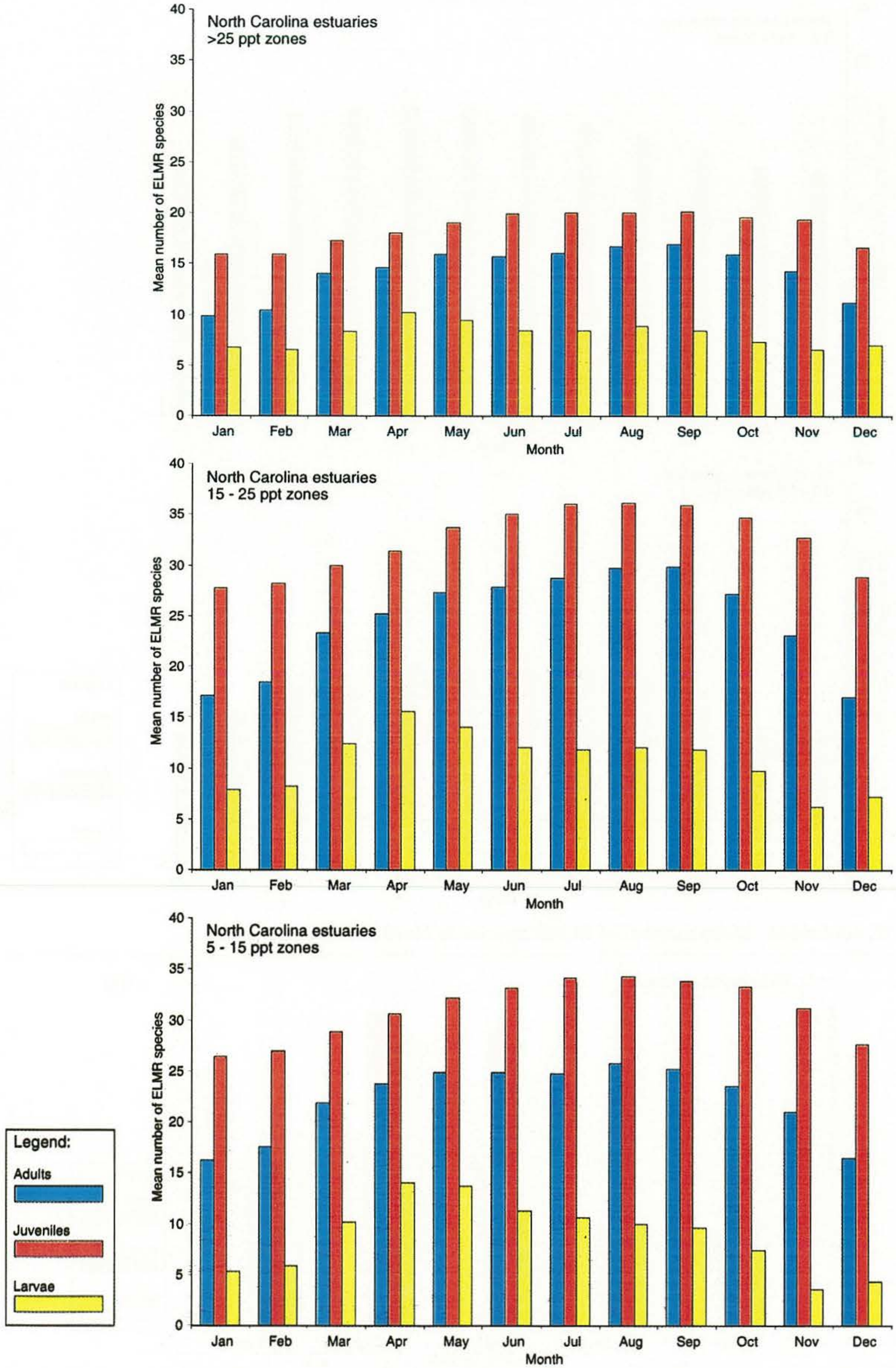


Figure 11. Mean number of ELMR species in North Carolina estuaries, by salinity zone, month, and life stage.

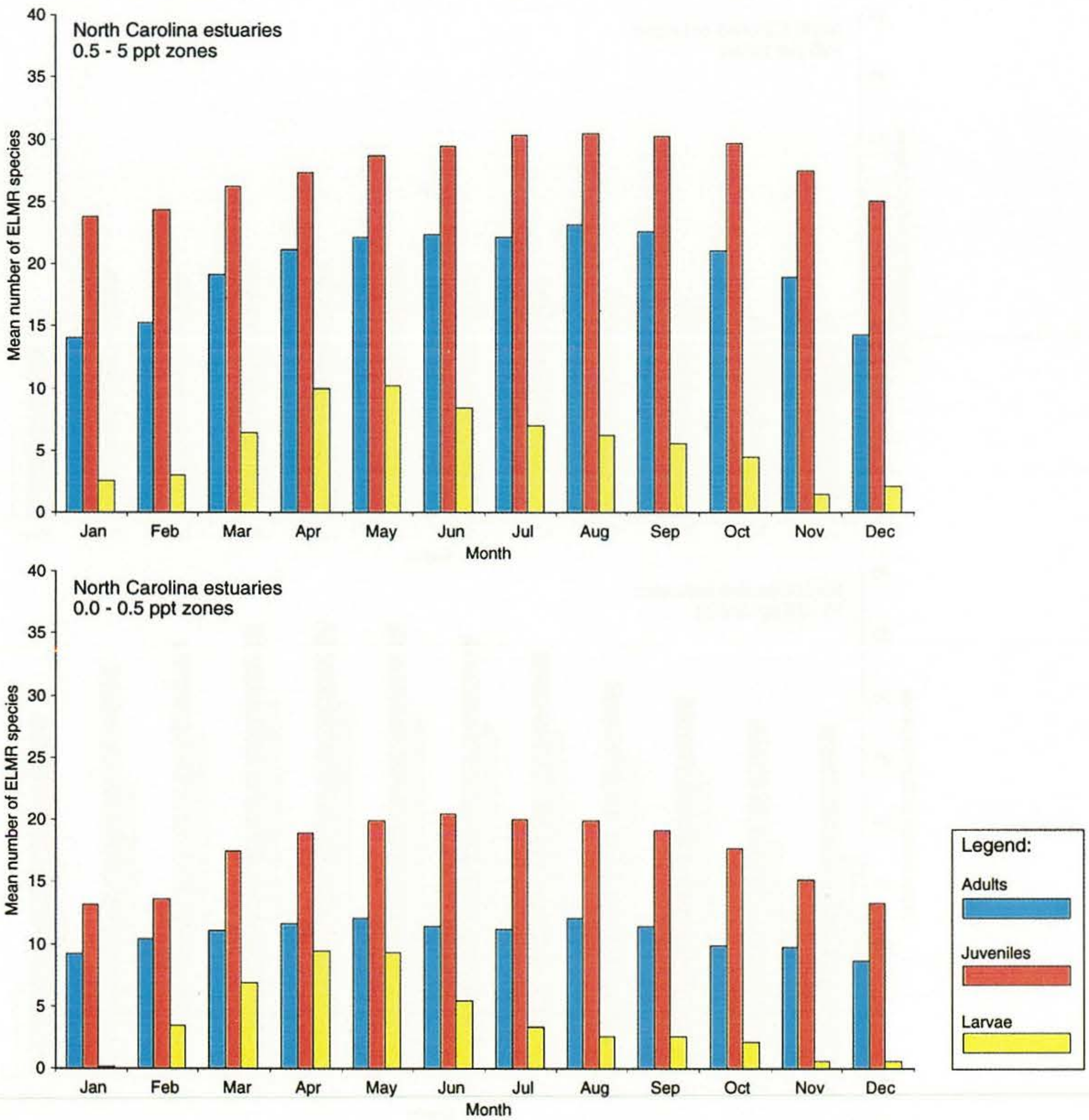


Figure 11, continued. Mean number of ELMR species in North Carolina estuaries.

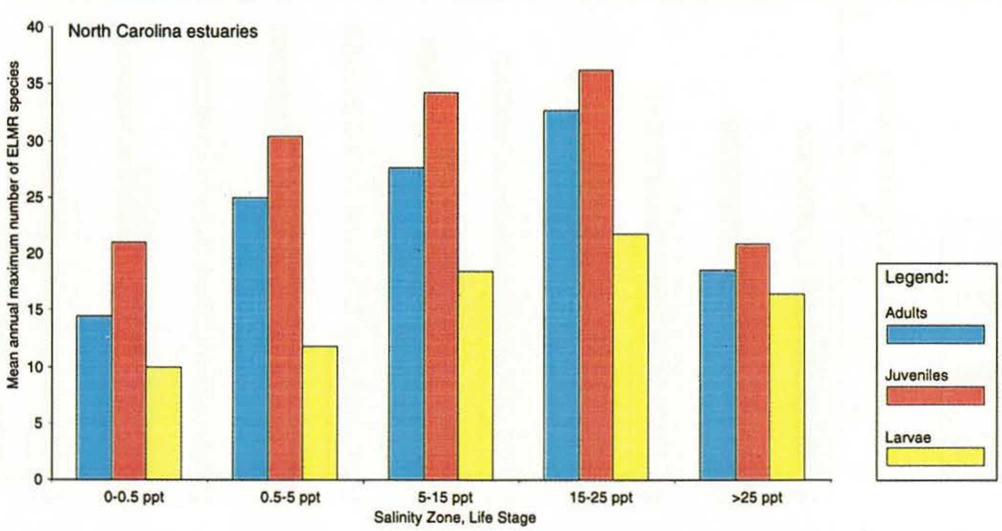


Figure 12. Mean annual maximum number of ELMR species in North Carolina estuaries.

Gulf of Mexico Region. The location of the 31 selected ELMR Gulf of Mexico estuaries are shown in Figure 13 (next page), and the common and scientific names of the 44 selected ELMR Gulf of Mexico species are listed in Table 14 (p. 35). Results of the ELMR study in the Gulf of Mexico region are summarized in *Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries, Volume 1: Data Summaries*, ELMR Report No. 10 (Nelson et al. 1992). These results were also previously published in three separate reports for the Western Gulf of Mexico (Texas) (Monaco et al. 1989); Eastern Gulf of Mexico (Florida, Alabama) (Williams et al. 1990); and Central Gulf of Mexico (Louisiana, Mississippi) (Czapla et al. 1991). Life history summaries and tables for the species in this region were published in *Volume II: Species Life History Summaries* (Pattillo et al. 1997).

Estuaries of the Gulf of Mexico were formed on a vast coastal plain of sedimentary deposits. In Louisiana, the Mississippi River has transported enormous quantities of sediment to coastal waters, building up the delta and alluvial plain. Barrier islands and lagoons are common along the Texas coast. Tidal range is small throughout the region, generally less than a meter (NOAA 1990a). Hurricanes may occasionally impact Gulf estuaries with storm surges and episodic freshwater inflow.

The 44 species selected are generally of the warm-temperate fauna of the Gulf of Mexico portion of the Carolinian marine biogeographic province. The actual fauna of the south Florida estuaries, Florida Bay and Ten Thousand Islands, includes many species from the tropical Caribbean marine province. Therefore, the selected ELMR species list does not adequately represent the actual south Florida estuarine fauna.

Table 15 (p. 36) readily conveys the occurrence of the selected 44 ELMR species in each of the 31 Gulf of Mexico estuaries. This table depicts the highest relative abundance of the adult or juvenile life stage of each species, in any month, in any salinity zone within each estuary. The spawning, egg, and larval life stage categories are not considered. This table also suggests the zoogeographic distribution of species among Gulf of Mexico estuaries. For example, the Florida stone crab is found from Florida Bay to Apalachicola Bay, whereas the closely related Gulf stone crab occurs from Pensacola Bay westward. Some species occur in the higher-salinity estuarine waters of Florida and Texas, but are absent from the low-salinity areas of Louisiana, such as bay scallop, snook, code goby, and gulf flounder. A few euryhaline species, such as blue crab, bay anchovy, and hardhead catfish are ubiquitous, considered at least common in all 31 Gulf of Mexico ELMR estuaries. Alabama shad, an anadromous species closely related to the American shad, is now rare or extirpated through much of its former range (Mettee et al. 1996). It is therefore being considered as a candidate species for protection under the federal Endangered Species Act (NMFS 1997).

To examine seasonal patterns of species presence/absence in Gulf of Mexico estuaries, the revised and updated ELMR data sets (NOAA 1997a) for Florida, Alabama, Mississippi, Louisiana, and Texas were selected and merged. The revised Gulf of Mexico ELMR data set utilizes five salinity zones: 0-0.5 ppt (tidal fresh), 0.5-5 ppt, 5-15 ppt, 15-25 ppt, and >25 ppt. The revised ELMR data consider the presence of eggs and spawning as distinct life stages, just as in the original three-zone ELMR data (Nelson et al. 1992). Numbers of species present, ranked as "rare" or greater, were counted by month and by salinity zone for the adult, juvenile, and larval life stages. In Figure 14 (p. 38), the numbers of species were averaged across estuaries and plotted by month for the adult, juvenile, and larval life stages. In Figure 15 (p. 39), the mean annual maximum number of species is plotted by salinity zone for the adult, juvenile, larval, spawning, and egg life stages.

- The number of species appears to be lower in the tidal fresh (0-0.5 ppt) and seawater (>25 ppt) zones. However, this may have been partially because the selected ELMR species are primarily estuarine, not freshwater or marine resident species.

- Juveniles and adults are the predominant life stages present in estuaries, followed by larvae, eggs, and spawning.

- The number of species present as juveniles and adults is generally highest from March through October, and lowest from December through February. However, this seasonal variation is much less dramatic than in the North Atlantic and Mid-Atlantic regions.

- The number of species present as larvae is generally highest in the 15-25 ppt zone. This number peaks in April in the 15-25 ppt zone, but peaks in September in the >25 ppt zone.

Text continues on p. 40.

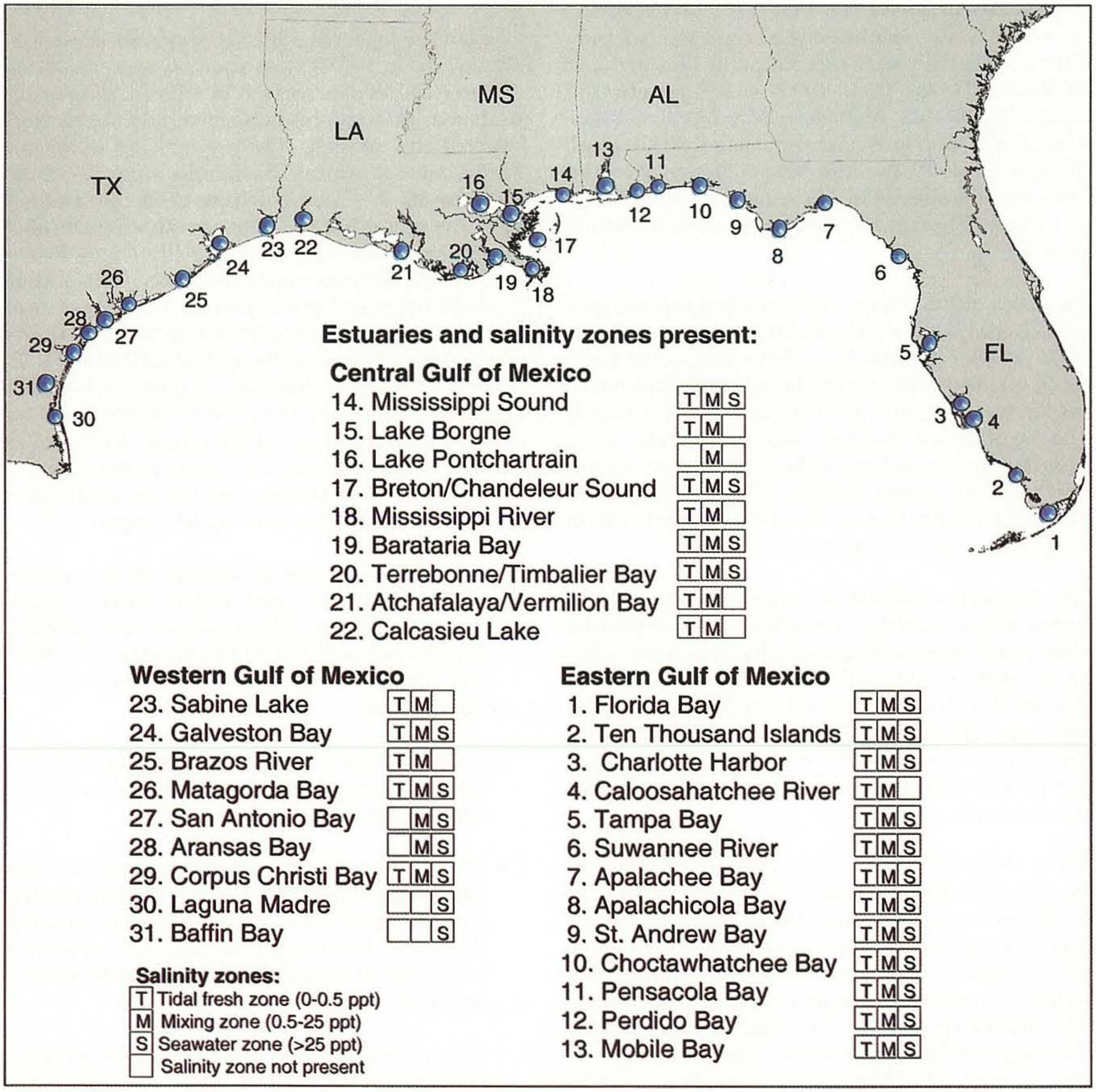


Figure 13. Location of 31 Gulf of Mexico ELMR estuaries and associated salinity zones.

Table 14. ELMR Gulf of Mexico species (n=44).

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

Table 15. Occurrence* of 44 ELMR species in 31 Gulf of Mexico estuaries

*highest relative abundance of adults or juveniles in any salinity zone, in any month.

Species	Florida Bay	Ten Thousand Islands	Caloosahatchee River	Charlotte Harbor	Tampa Bay	Suwannee River	Apalachee Bay	Apalachicola Bay	St. Andrew Bay	Choctawhatchee Bay	Pensacola Bay	Perdido Bay	Mobile Bay	Mississippi Sound	Lake Borgne	Lake Pontchartrain	Breton/Chandeleur Sound	Mississippi River	Barataria Bay	Terrebonne/Timbalier Bay	Atchafalaya/Vermilion Bay	Calcasieu Lake	Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
Bay scallop	√	√	√	√	√		○	√	○		√			○			√							√		√	√	√	√	√	
American oyster		○	◉	○	○	◉	◉	◉	○	○	○	√	◉	○	○	○	◉	√	◉	◉	◉	○	○	●	na	○	◉	○	○	√	
Atlantic rangia			●	●	●	◉	○	◉	○	○	○	◉	◉	○	◉	◉	○	○	◉	◉	○	○	●	◉	na	○	√	√	√		
Hard clam		○		○	◉	○	○		○	○		○	√	○			○		○	√				○	na	○	○	○	○		
Bay squid	√	√	○	○	◉	○	○	◉	◉	○	○	○	○	●	◉	○	○		○	○	○	○	√	○	○	◉	◉	○	○	○	○
Brown shrimp	√	√	√	√				◉	◉	◉	●	●	●	●	●	◉	◉	○	●	●	●	●	◉	●	◉	●	●	●	●	◉	●
Pink shrimp	●	●	◉	◉	●	●	◉	◉	◉	◉	○	○	○	○	√	√	◉		○	√	√			√	○	○	○	○	○	◉	○
White shrimp						√	●	●	○	◉	◉	○	●	●	●	●	○	○	●	◉	●	●	●	●	●	●	●	◉	◉	◉	√
Grass shrimp	○	○	●	●	●	●	●	●	◉	◉	●		●	●	●	○	◉	○	◉	◉	●	●	●	●	◉	●	◉	◉	●	●	●
Spiny lobster	◉	√		√	√		√		√					√																√	
Blue crab	◉	◉	●	◉	◉	●	●	●	●	◉	◉	◉	●	●	●	◉	◉	○	◉	◉	◉	●	●	◉	○	◉	●	●	●	◉	◉
Gulf stone crab						√	○	○	√	√	√	√	○	○	√	√	○	○	○	○	√	○	√	○	na	○	○	○	○	√	○
Florida stone crab	○	○	√	○	○	○	○	√																							
Bull shark	○	○	○	○	○	○	○	○	○	○	○	√	○	○	○	○	◉	√	○	○	○	√	√	○	na	○	○	○	○	√	√
Tarpon	○	○	◉	◉	◉	○	○	○	○	○	○	√	○	○	○	○		○	√	√	√		√	√	na	○	○	√	√	√	√
Alabama shad							√	○	√	√			√	√	√	√	√														
Gulf menhaden	√	√	√	√	●	○	◉	◉	●	●	●	◉	●	●	●	●	●	◉	●	◉	●	●	●	●	◉	●	◉	◉	◉	◉	●
Yellowfin menhaden	◉	●	○	○	◉		√							√	√	√															
Gizzard shad						○	○	○		○	○	√	◉	◉	●	○	○	◉	○	○	○	○	○	○	○	◉	○	√	○	√	◉
Bay anchovy	●	●	●	●	●	●	●	●	◉	●	●	◉	●	●	●	●	◉	●	●	●	●	●	◉	●	●	●	●	●	●	●	●
Hardhead catfish	◉	○	◉	●	○	●	◉	●	●	◉	◉	◉	◉	●	●	◉	◉	●	●	◉	◉	◉	○	◉	○	◉	●	◉	◉	●	●
Sheepshead minnow	◉	○	○	○	●	●	●	◉	◉	◉	◉	○	◉	◉	○	○	○	◉	●	○	◉	◉	◉	◉	◉	◉	◉	◉	◉	●	●

Relative abundance:
● - Highly Abundant ◉ - Abundant ○ - Common √ - Rare Blank - Not present na - No data available

Table 15. continued.

Species	Florida Bay	Ten Thousand Islands	Caloosahatchee River	Charlotte Harbor	Tampa Bay	Suwannee River	Apalachee Bay	Apalachicola Bay	St. Andrew Bay	Choctawhatchee Bay	Pensacola Bay	Perdido Bay	Mobile Bay	Mississippi Sound	Lake Borgne	Lake Pontchartrain	Breton/Chandeleur Sound	Mississippi River	Barataria Bay	Terrebonne/Timbalier Bay	Atchafalaya/Vermilion Bay	Calcasieu Lake	Sabine Lake	Galveston Bay	Brazos River	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Laguna Madre	Baffin Bay
Gulf killifish	○	◉	○	◉	○	◉	◉	○	○	○	○	○	◉	◉	◉	○	○	◉	●	●	◉	◉	◉	◉	◉	◉	◉	◉	○	◉	◉
Silversides	●	◉	●	●	●	◉	●	●	◉	◉	◉	◉	◉	●	◉	◉	○	◉	●	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉	●	●
Snook	○	◉	◉	◉	○	○	○	○											√					√		√		√	√	○	
Bluefish	○	○		○	○	○	○	○	◉	◉	○	○	○	○			√	√	○	√	√	√	√	○	○	√	√	√	√		
Blue runner	√	○		○	○	○	○	○	◉	○	○	○	○	◉					○	√				√							
Crevalle jack	◉	○	○	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	√	○	○	○	○	○	○	◉	○
Florida pompano	●	○	√	◉	○	√	○	√	○	○	○	○	○	◉			○	○	○	○	√	○		○		○	○	○	○	◉	√
Gray snapper	◉	○	√	○	○	○	○	√	○	○	◉	○	○	○			○		○	√		√		√		√	√	√	√	○	√
Sheepshead	○	○	√	√	○	○	√	○	○	○	○	◉	◉	○	◉	○	○	○	◉	◉	○	○	○	○	○	◉	◉	○	○	◉	○
Pinfish	●	●	●	●	●	●	◉	◉	●	◉	●	◉	◉	●	◉	◉	○	○	◉	◉	○	○	○	◉	◉	●	◉	◉	◉	●	◉
Silver perch	◉	◉	◉	◉	◉	◉	○	◉	◉	○	○	○	○	●	●	○	○	○	◉	◉	○	○	○	○	○	○	○	○	○	◉	◉
Sand seatrout	√	◉	●	●	◉	●	●	●	◉	◉	○	○	●	●	●	◉	○	●	◉	◉	◉	◉	√	◉	○	○	○	○	◉	√	○
Spotted seatrout	◉	○	○	◉	○	◉	○	○	◉	◉	○	○	◉	◉	◉	○	◉	◉	○	◉	◉	○	○	○	○	○	○	○	○	○	○
Spot	○	○	○	○	●	◉	●	◉	◉	●	●	◉	●	●	●	○	◉	◉	●	◉	◉	○	◉	◉	◉	◉	◉	◉	◉	●	●
Atlantic croaker	√	√	√	○	√	○	○	●	◉	◉	●	○	●	●	●	●	◉	●	●	●	●	●	◉	●	●	●	●	◉	◉	◉	◉
Black drum	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉	○	◉	◉	○	○	○	○	○	○	○	○	○	○	◉
Red drum	○	√	◉	◉	●	○	○	○	◉	○	○	○	○	○	◉	○	◉	○	○	○	○	◉	○	○	○	○	○	○	○	○	○
Striped mullet	●	●	●	●	●	◉	●	◉	●	◉	◉	◉	◉	●	●	◉	◉	◉	◉	◉	◉	◉	○	◉	○	◉	◉	◉	◉	◉	◉
Code goby	●	●	◉	●	◉	○	○	○	◉	○	○	√		◉	◉	○			√					√	na	○	√	○	○	◉	◉
Spanish mackerel	○	○	√	○	○	○	√	√	◉	○	○	◉	○	◉	√	√	○	√	○	○	○	○	○	○	√	√	√	√	√	√	
Gulf flounder	○	○	√	○	○	○	○	○	◉	○	○	○	○	○										√		√	√	√	√	√	√
Southern flounder	√	√		√	√	○	○	○	○	○	○	○	○	◉	○	○	◉	◉	◉	◉	○	◉	●	●	○	◉	◉	○	○	◉	○

Relative abundance:
● - Highly Abundant ◉ - Abundant ○ - Common √ - Rare Blank - Not present na - No data available

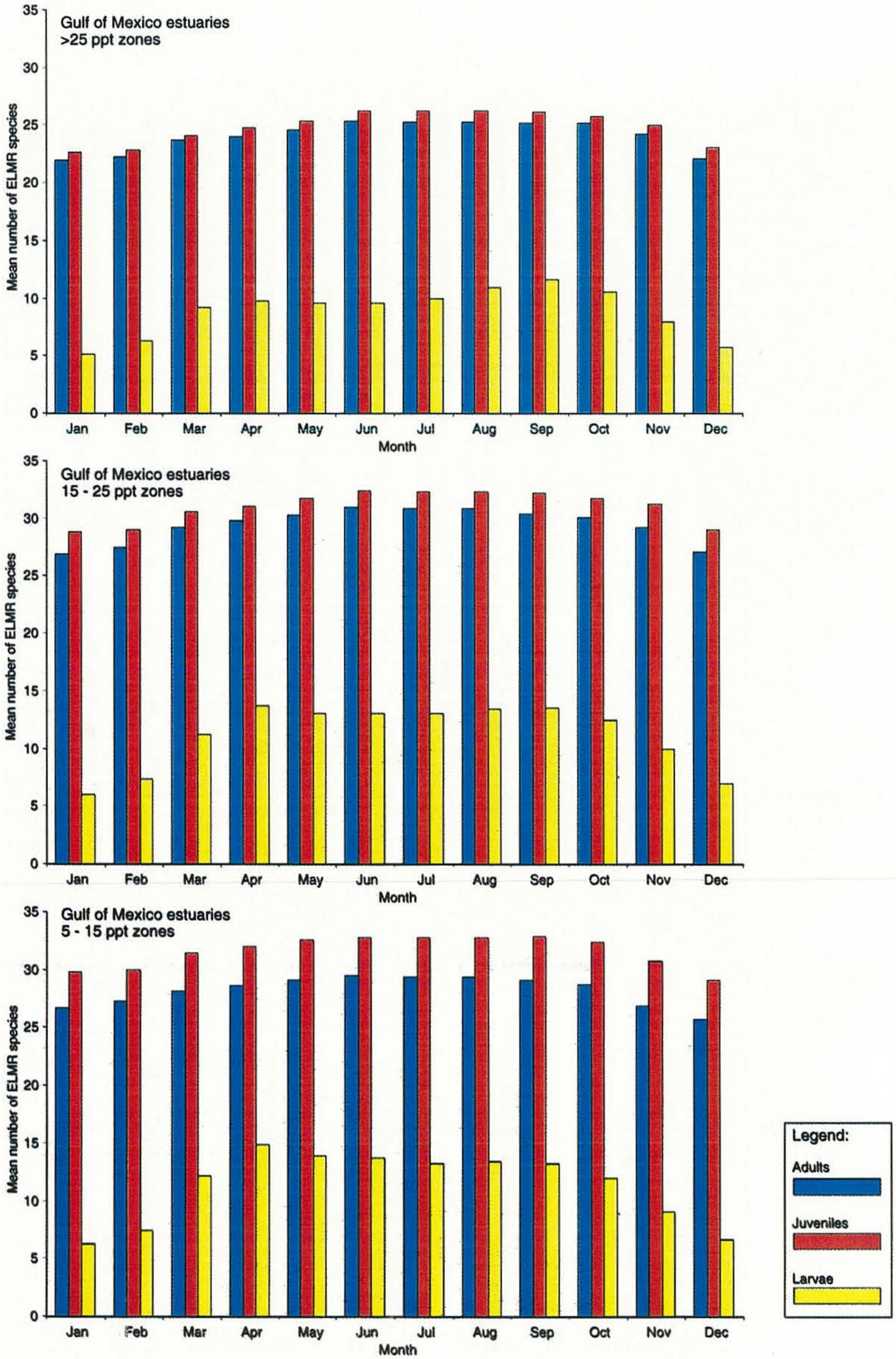


Figure 14. Mean number of ELMR species in Gulf of Mexico estuaries, by salinity zone, month, and life stage.

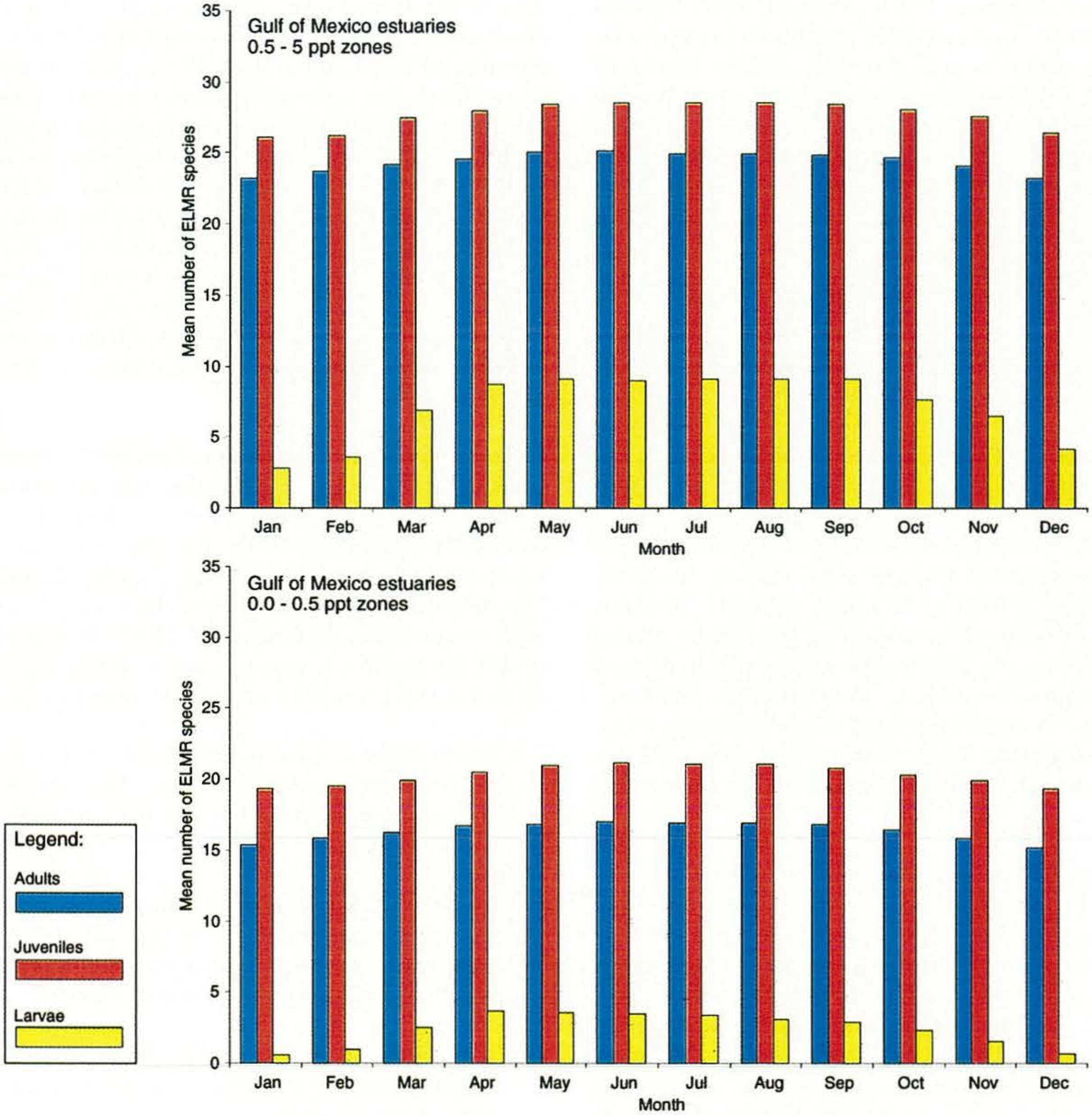


Figure 14, continued. Mean number of ELMR species in Gulf of Mexico estuaries.

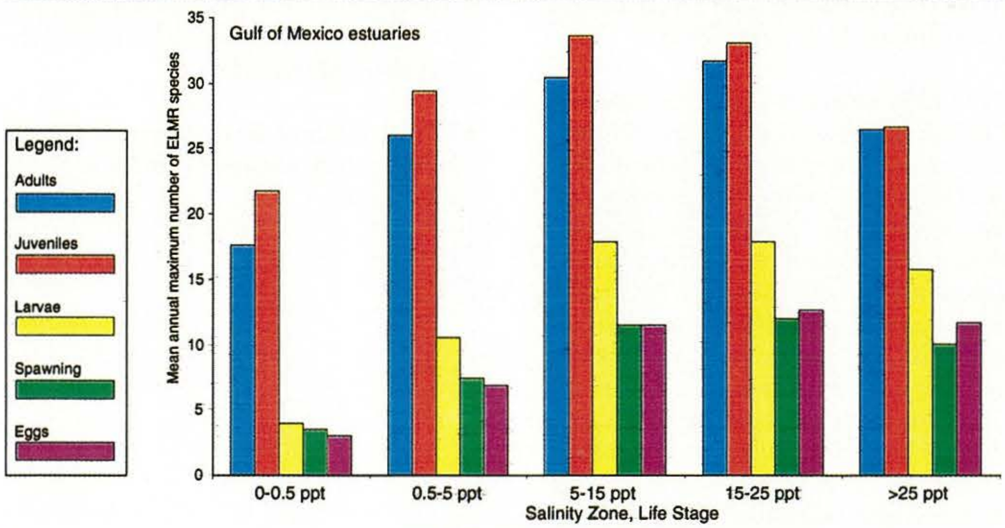


Figure 15. Mean annual maximum number of ELMR species in Gulf of Mexico estuaries.

West Coast Region. The location of the 32 selected ELMR West Coast estuaries are shown in Figure 16, and the common and scientific names of the 47 selected ELMR West Coast species are listed in Table 16 (p. 42). The initial pilot study for NOAA's ELMR program was completed for several West Coast estuaries in 1986 (Monaco 1986). Results for the entire West Coast region are summarized in *Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries, Volume 1: Data Summaries*, ELMR Report No. 10 (Monaco et al. 1990). Life history summaries and tables for the species in this region were published in *Volume II: Species Life History Summaries* (Emmett et al. 1991).

Along the West Coast of the continental U.S., the Coast Range mountains have restricted the extent of low-elevation coastal plain. The San Francisco Bay and Puget Sound estuarine systems were formed when continental valleys sank during orogenic (mountain-building) tectonic activity (NOAA 1990b). Puget Sound was further affected by glacial action during the Pliestocene ice ages. Circulation in the large systems (e.g., Puget Sound, San Francisco Bay, Santa Monica Bay) is dominated by tides, while circulation in riverine systems (e.g., Columbia River, Eel River) is dominated by freshwater inflow.

The 47 species selected for the West Coast are representative of both the cold-temperate fauna of the Oregonian marine biogeographic province, and the warm-temperate Californian province. Although two separate species lists could have been prepared, it was deemed most feasible to consider the entire U.S. West Coast as a single region. It should be noted that the list includes several introduced species. The Pacific oyster and Manila clam were introduced to the U.S. from Japan in the early 1900s. Softshell clam, American shad, and striped bass were introduced from the U.S. East Coast.

Table 17 (p. 43) readily conveys the occurrence of the selected 47 ELMR species in each of the 32 West Coast estuaries. This table depicts the highest relative abundance of the adult or juvenile life stage of each species, in any month, in any salinity zone within each estuary. The spawning, egg, and larval life stage categories are not considered. This table also suggests the zoogeographic distribution of species among West Coast estuaries, and the contrast between the Oregonian and Californian provinces are evident. For example, deepbody anchovy, slough anchovy, kelp bass, and barred sand bass are not scored as present north of Pt. Concepcion. The anadromous sturgeon and salmonid species generally occur from San Francisco Bay northward. Several of the introduced species, such as American shad and striped bass, are now well established and considered abundant in some West Coast estuaries. In contrast, several native stocks of anadromous salmonids have been listed, or are under consideration for listing, under the federal Endangered Species Act (NMFS 1995). Estuarine habitats are essential to these stocks as a rearing area for juveniles migrating seaward, and as a migration corridor for adults returning to spawn in fresh water (Emmett and Schiewe 1997). Therefore, these estuarine habitats must be conserved in order to achieve recovery of the threatened and endangered runs of salmon and steelhead.

To examine seasonal patterns of species presence/absence in West Coast estuaries, the numbers of species present, ranked as "rare" or greater, were counted by month and by salinity zone for the adult, juvenile, larval, spawning, and egg life stages. The original ELMR West Coast data set was used with no revisions (Monaco et al. 1990). In Figure 17 (p. 45), the numbers of species were averaged across estuaries and plotted by month for these life stages.

- The number of species appears to be lowest in the tidal fresh zone. However, this may have been partially due to the fact that the selected West Coast ELMR species are primarily estuarine and marine, not freshwater. Many of the West Coast ELMR species found in fresh water are anadromous salmonids that use the tidal fresh zone as a migration corridor to and from freshwater spawning and rearing areas.

- Juveniles and adults are the predominant life stages present in estuaries, followed by larvae, eggs and spawning.

- The number of species present as juveniles and adults peaks in June, and is lowest from December through March.

- The number of species present as larvae in the mixing and seawater zones is highest in May and June.

Text continues on p. 45.

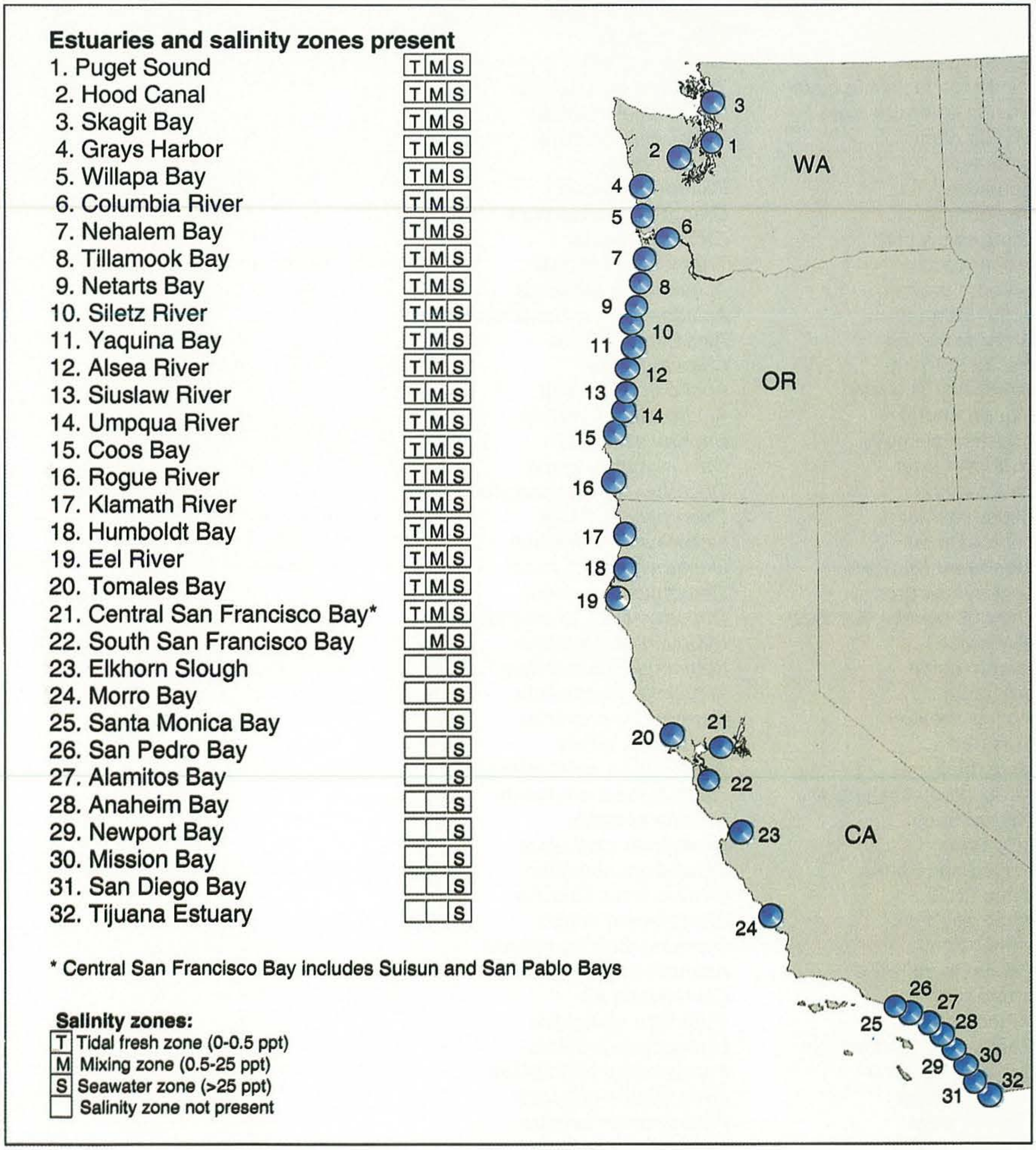


Figure 16. Location of 32 West Coast estuaries and associated salinity zones.

Table 16. ELMR West Coast species (n=47).

Common name	Scientific name
blue mussel	*Mytilis edulis*
Pacific oyster	*Crassostrea gigas*
horseneck gaper	*Tresus capax*
Pacific gaper	*Tresus nuttallii*
California jackknife clam	*Tagelus californianus*
Pacific littleneck clam	*Protothaca staminea*
Manila clam	*Venerupis japonica*
softshell	*Mya arenaria*
geoduck	*Panopea abrupta*
bay shrimp	*Crangon franciscorum*
Dungeness crab	*Cancer magister*
leopard shark	*Triakis semifasciata*
green sturgeon	*Acipenser medirostris*
white sturgeon	*Acipenser transmontanus*
American shad	*Alosa sapidissima*
Pacific herring	*Clupea pallasi*
deepbody anchovy	*Anchoa compressa*
slough anchovy	*Anchoa delicatissima*
northern anchovy	*Engraulis mordax*
cutthroat trout	*Oncorhynchus clarki*
pink salmon	*Oncorhynchus gorbuscha*
chum salmon	*Oncorhynchus keta*
coho salmon	*Oncorhynchus kisutch*
steelhead (3 races)	*Oncorhynchus mykiss*
sockeye salmon	*Oncorhynchus nerka*
chinook salmon (5 races)	*Oncorhynchus tshawytscha*
surf smelt	*Hypomesus pretiosus*
longfin smelt	*Spirinchus thaleichthys*
eulachon	*Thaleichthys pacificus*
Pacific tomcod	*Microgadus proximus*
topsmelt	*Atherinops affinis*
jacksmelt	*Atherinopsis californiensis*
threespine stickleback	*Gasterosteus aculeatus*
striped bass	*Morone saxatilis*
kelp bass	*Paralabrax clathratus*
barred sand bass	*Paralabrax nebulifer*
white croaker	*Genyonemus lineatus*
white seabass	*Atractoscion nobilis*
shiner perch	*Cymatogaster aggregata*
Pacific sand lance	*Ammodytes hexapterus*
arrow goby	*Clevelandia ios*
lingcod	*Ophiodon elongatus*
Pacific staghorn sculpin	*Leptocottus armatus*
California halibut	*Paralichthys californicus*
diamond turbot	*Hypsopsetta guttulata*
English sole	*Pleuronectes vetulus*
starry flounder	*Platichthys stellatus*

Table 17. Occurrence* of 47 ELMR species in 32 West Coast estuaries

* Highest relative abundance of adults or juveniles of a species, in any salinity zone, in any month, within each estuary.

† Includes C. San Fran., Suisun, San Pablo Bays.

Species / Estuary	Puget Sound	Hood Canal	Skagit Bay	Grays Harbor	Willapa Bay	Columbia River	Nehalem Bay	Tillamook Bay	Netarts Bay	Siletz River	Yaquina Bay	Alsea River	Siuslaw River	Umpqua River	Coos Bay	Rogue River	Klamath River	Humboldt Bay	Eel River	Tomales Bay	C. San Francisco Bay†	S. San Francisco Bay	Elkhorn Slough	Morro Bay	Santa Monica Bay	San Pedro Bay	Alamitos Bay	Anaheim Bay	Newport Bay	Mission Bay	San Diego Bay	Tijuana Estuary
Blue mussel	●	◉	●	○	○	○	◉	◉	◉	√	◉	√	◉	●	◉	√		●	○	◉	●	●	◉	◉	◉	●	◉	◉	○	◉	◉	○
Pacific oyster	●	●	○	●	●			●	◉		●			○	●			●		●	√	√	√	●								
Horseneck gaper	◉	◉	◉	○	○		√	◉	◉		◉	○	●	√	●			◉														
Pacific gaper	◉	◉	○	√	√				◉		√							○		◉	√	√	◉	◉	√	◉	√	√	√	√	√	√
California jacknife clam																				√	√		√	○	◉	◉	○	○	○	◉	◉	◉
Pacific littleneck clam	●	●	●	○	○		●	◉	◉		○	√	√		●			◉		◉	√	√	○	○	○	○	◉	◉	○	√	√	◉
Manila clam	●	◉	○	◉	●			○	○		√				○			◉		○	●	●	√									
Softshell clam	◉	○	●	◉	◉	○	●	◉	○	√	●	◉	●	●	●			◉	○	○	◉	◉	○	√								
Geoduck	◉	◉	○						√									√						○		√						
Bay shrimp	◉	○	●	●	●	●	●	●	○	●	●	●	●	●	●			◉	●	◉	●	◉										
Dungeness crab	●	●	●	●	●	●	●	●	●	◉	●	●	●	●	●	◉	○	●	●	●	●	○	√	√								
Leopard shark															√			◉		◉	◉	●	◉	○	○	○	√	√	√	√	√	
Green sturgeon	√			○	○	○		√			○	√	√	○	○	○	○	○	○		○	○										
White sturgeon	√	√		◉	◉	◉	○	○			○	√	√	○	○	○	○	√	√		◉	○										
American shad	√	√	○	◉	◉	●	√	√			◉	◉	◉	◉	●	◉	◉	√	◉		●	○										
Pacific herring	●	●	●	◉	◉	●	◉	◉	◉	○	●	○	○	●	●	○	○	●	◉	●	●	●	◉	○	√	√						
Deepbody anchovy																									√	○	○	◉	◉	◉	◉	
Slough anchovy																										√	●	√	◉	◉	●	√
Northern anchovy	○	○	○	●	●	●	●	●	○	○	◉	○	√	◉	●	●	●	●	○	◉	●	●	●	●	●	●	●	○	◉		○	
Cutthroat trout	○	○	○	○	○	○	◉	○	○	○	○	◉	◉	○	○	○	○	√	○													
Cutthroat trout - Kelts	○	○	○	○	○	○	○	○	○	○	○	○	○	○	√	○	○	√	○													
Steelhead - Fall																	◉															
Steelhead - Half pounder																◉	○		○													
Steelhead - Summer	○	○	○			◉		○		○		○		○		◉	◉		◉													
Steelhead - Winter	○	○	○	◉	◉	◉	◉	○	√	○	○	◉	○	○	◉	◉	◉	○	◉	○	○			√								
Coho salmon	◉	◉	◉	◉	◉	◉	◉	◉	○	◉	●	◉	◉	◉	◉	◉	◉	○	○	○												
Chinook salmon - Fall	◉	◉	◉	●	◉	●	◉	●	√	◉	●	◉	◉	●	●	●	●	○	●		●	◉			√							
Chinook salmon - Late fall																					●	◉										

Relative Abundance: ● - Highly Abundant ◉ - Abundant ○ - Common √ - Rare Blank - Not Present

† Includes C. San Fran., Suisun, San Pablo Bays.

Table 17, continued.

Species	Puget Sound	Hood Canal	Skagit Bay	Grays Harbor	Willapa Bay	Columbia River	Nehalem Bay	Tillamook Bay	Netarts Bay	Siletz River	Yaquina Bay	Alsea River	Siuslaw River	Umpqua River	Coos Bay	Rogue River	Klamath River	Humboldt Bay	Eel River	Tomales Bay	C. San Francisco Bay†	S. San Francisco Bay	Elkhorn Slough	Morro Bay	Santa Monica Bay	San Pedro Bay	Alamitos Bay	Anaheim Bay	Newport Bay	Mission Bay	San Diego Bay	Tijuana Estuary
Chinook salmon - Winter																					●	◉										
Chinook salmon - Spring	◉	◉	◉	●		●		●		◉	●	◉		●	●	●	●				●	◉										
Chinook salmon - Summer						●																										
Chum salmon	●	●	●	◉	●	○	○	◉	●	○	○	○	○	√	○	√	√	√	√													
Pink salmon	●	●	●	√		√					√	√				√	√			√												
Sockeye salmon	◉		√			○																										
Surf smelt	◉	◉	◉	○	○	◉	●	●	●	◉	●	●	●	●	●	◉	○	◉	●	○	√	√	√									
Longfin smelt	○		○	◉	◉	●		√			○	√	√	√	○		○	○	○		●	○										
Eulachon	√		√	○	○	◉							√	○	√	√	◉	√														
Pacific tomcod	◉	○	●	●	●	●	◉	◉	○	○	○	○	○	○	◉	○	√	○	√	○	√	√	√									
Topsmelt				√	√	√	√	○	◉		●	○	◉	○	●			○	○	●	○	●	●	●	◉	◉	●	●	●	●	●	●
Jacksmelt											√				○			○		●	●	●	◉	◉	◉	◉			√	◉	○	
Threespine stickleback	◉	◉	●	●	●	●	◉	○	●	○	◉	◉	●	●	◉	○	◉	●	◉	○	●	◉	○	○								
Striped bass	√		√							√	√		○	○	○		√			○	◉	◉			√				√	√		
Kelp bass																									◉	◉	√	√	√	○	√	√
Barred sand bass																									◉	◉	○	○	○	◉	◉	√
White croaker																		○		○	○	○	◉		●	●	◉	○	○	√	○	√
White seabass			√								√				√			√		√	√	√			○	○		√	√	√	√	√
Shiner perch	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	◉	●	●	●	●	●	●	●	○	○	◉	◉	◉	●	●	√
Pacific sand lance	●	●	●	◉	◉	○	◉	◉	◉	○	○	○	○	◉	○			○	√	○	√	√	√									
Arrow goby	○	○	○	○	○			√	√		○		√	√	○			○		◉	◉	◉	◉	◉	√	○	◉	◉	●	●	◉	◉
Lingcod	○	○	○	○	○	√	○	○	○		○	√	√	○	○			○		○	○	√	√	√	√	√						
Pacific staghorn sculpin	◉	◉	◉	◉	◉	◉	◉	◉	●	◉	●	●	●	●	●	◉	◉	◉	◉	●	●	●	●	●	√	√	◉	◉	√	◉	◉	○
California halibut																		√		○	○	○	○	○	◉	◉	◉	◉	○	◉	◉	◉
Diamond turbot																				√	√	○	○	○	○	○	◉	◉	◉	◉	◉	○
English sole	●	●	◉	◉	◉	◉	◉	●	◉	◉	●	●	◉	◉	◉	√	√	●	○	◉	◉	◉	◉	○	○	○						
Starry flounder	◉	◉	◉	◉	◉	◉	◉	◉	○	◉	◉	◉	○	◉	◉	◉	◉	○	◉	◉	●	○	◉	○								

Relative Abundance: ● - Highly Abundant ◉ - Abundant ○ - Common √ - Rare Blank - Not Present

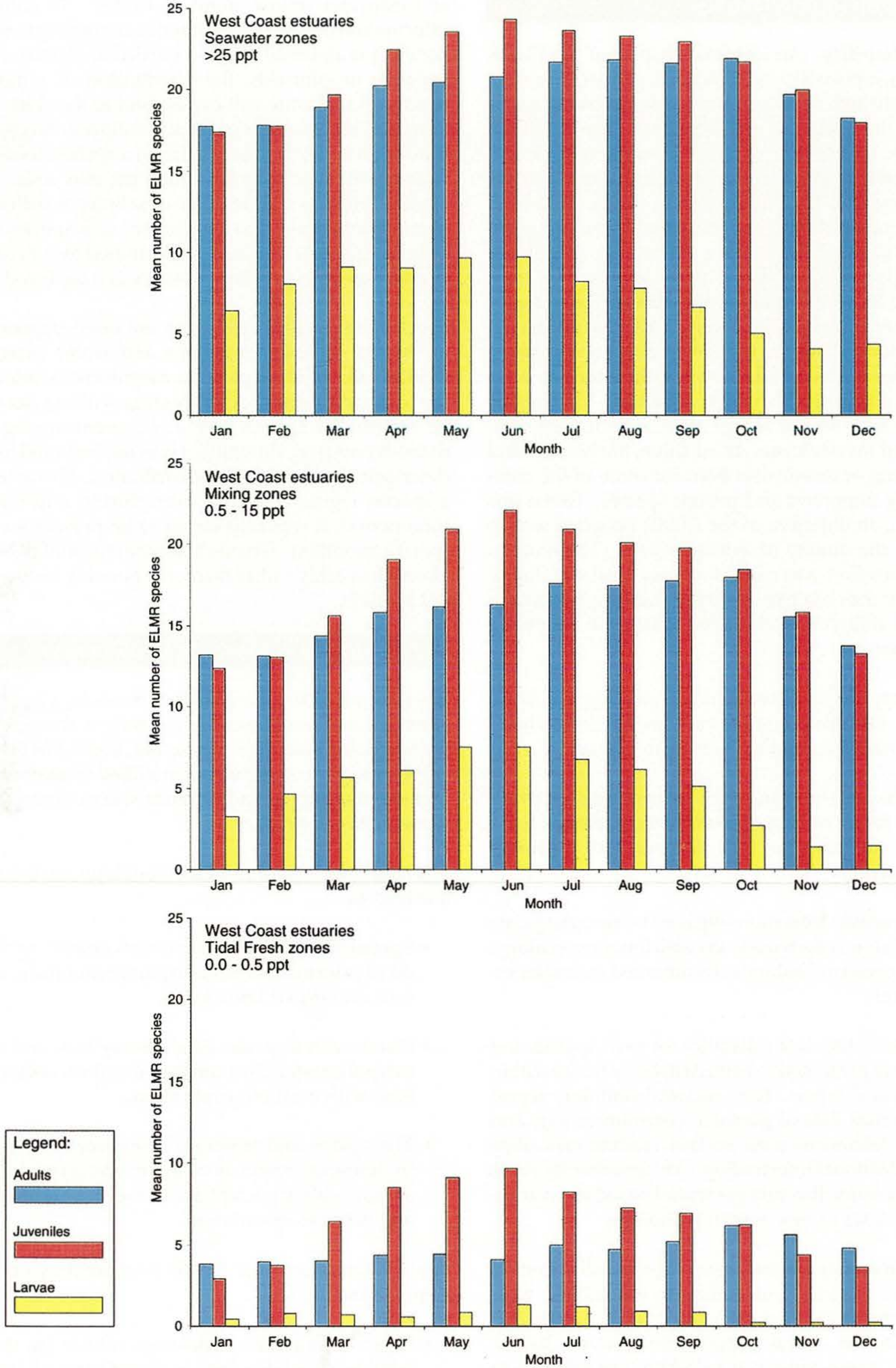


Figure 17. Mean number of ELMR species in West Coast estuaries, by salinity zone, month, and life stage.

Data Content and Quality

Data reliability. An important aspect of the ELMR program, especially since it is based primarily on data sets, published literature, and consultations, is to determine the quality of available data. The quality of available information varied between species, life stage, and estuary, due to differences in gear selectivity, difficulty in identifying larvae, difficulty in sampling various habitats, and the extent of sampling and analysis in particular studies. As a result, spatial and temporal resolution was greater in well studied estuaries and for well studied species. Similarly, the early life history stages and spawning activity are often not as well documented as the juvenile and adult stages. Except for a few species, very little data has been generated on specific habitat affinities. This is particularly true for the forage and/or noncommercial fishes and invertebrates. In addition, life history data are lacking or incomplete even for some of the commercially important and pelagic species. Given this situation, an objective of the ELMR program was to describe the quality of available data. Therefore, a deliberate effort was made to assess the data reliability so that the data base could be used appropriately. Data reliability was classified using the following categories:

- 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 distributions, ecology, and preferred habitats documented in similar estuaries.

Estimates of the data reliability for each species and estuary are presented in Data Reliability tables within each regional report. Each regional summary report also provides lists of personal communications and primary references used so that readers can easily obtain additional information. An opportunity exists to further refine the data presented based upon additional reviews or new research findings.

Variability in space and time. Species distribution data were organized according to the salinity zone boundaries developed for each estuary in the *NEI Data Atlas-Vol. I* and supplement (NOAA 1985a). However, these zones can be highly variable due to the many interactive factors that affect salinity, such as freshwater inflow, wind and tides. To compile information on species distribution according to these zones, it is assumed that if a particular salinity zone expands or contracts, the distribution of a mobile species in that zone will correspond to the shift. For example, if increased freshwater inflow enlarges the tidal fresh zone, the distribution of a species confined to that zone increases to include the new area. If a species tolerates a wide range of salinity, a shift may or may not occur. The assignment of a species in a salinity zone was ultimately determined by where the species has been regularly observed or captured.

Species temporal distributions are often dependent on annual climatic conditions and water currents. Monthly distribution patterns were derived based on the consistent presence of a life stage within a particular month. If a species was only present during unusual events (e.g., drought), it was not included in the description of that species' distribution. However, if a species regularly occurs, even during a restricted time period, it was considered to be present for the specific month(s). Greater temporal resolution, such as on a biweekly rather than on a monthly basis, was not feasible.

Base ELMR Strengths and Weaknesses

It is recognized that the ELMR methodology has both strengths and weaknesses as a means to characterize living marine resources. Therefore, the ELMR framework and data base have been modified to take advantage of the strengths, and to improve upon some of the recognized weaknesses.

The strengths of the ELMR methodology can be summarized as:

- Spatial and temporal framework enables synthesis of information from disparate literature, data sets, and expert knowledge.

- Standardized species lists, estuary lists, and data categories result in a consistent and versatile data base with multiple applications.

- The spatial and temporal framework allows simultaneous overview of many species and estuaries, enabling perception of emergent properties and patterns of variation.

The weaknesses of the ELMR methodology can be summarized as:

- Relative abundance rankings cannot be translated to actual densities or abundances of organisms.

- Relative abundance rankings may not be comparable between estuaries and regions.

- Relative abundance rankings are intended to characterize a "typical" year; therefore, interannual and real-time variations are not encompassed.

Revising and Updating the ELMR Data Base

Although the national ELMR data base was completed in 1994, regional components have been periodically updated to reflect temporal trends in species abundance, and to take advantage of new or improved resource surveys. These updates are based on the analysis of new fishery-independent data sets, and other specialized data sources. Updates within a particular state or region have been initiated in response to specific needs, such as the development of Environmental Sensitivity Index (ESI) maps for HazMat response (oil spill) planning for the states of North Carolina, Georgia and Massachusetts (RPI 1996, 1997). Updates in the Gulf of Mexico and Southeast regions have been initiated in response to the need to designate Essential Fish Habitat (EFH) under the revised Magnuson-Stevens Fishery Management and Conservation Act (NOAA/GMFMC 1998). Table 1 (p. 2) summarizes the status of these updates on a regional basis. The improved data base is also being incorporated into NOAA's National Coastal Assessment and Data Synthesis Framework (CA&DS), which will integrate national data sets for 138 estuaries within a spatial framework with analytical capabilities (Orlando 1999).

To further refine the spatial resolution of the ELMR framework, a multivariate methodology (Bulger et al. 1993) was applied to derive five bio-salinity zones in four "salinity seasons" for Gulf of Mexico and Southeast estuaries (Christensen et al. 1997). The refined salinity zone spatial framework is an extension of the salinity characterization studies completed for Gulf of Mexico and Southeast estuaries (Orlando et al. 1993, Orlando et al. 1994). Precipitation, flow gage data, and monthly salinity averages were evaluated to determine which months would be used to represent the high, low, and transitional salinity periods. A contour modelling procedure was applied to the data to develop the seasonal salinity zones for each estuary. Figure 19 depicts the five bio-salinity zones in four seasons derived for Galveston Bay, Texas (Clark et al. 1999).

ELMR data for the adult and juvenile life stages of species have been revised based on recent resource surveys using trawl and other fishery-indpendent monitoring gear. The revised ELMR data were then linked with the seasonal estuarine bio-salinity zones for the Gulf of Mexico and Southeast regions, and incorporated into a Geographic Information System (GIS) to enable spatial organization of the data and to generate maps. The general procedure for these updates is depicted in Figure 18, and can be summarized as:

(1) Map catch data using GIS.

(2) Model catch data in seasonal salinity zones based on species salinity range.

(3) Peer review of data and maps.

A standard protocol has been developed to derive ELMR relative abundance rankings from fishery-independent monitoring (FIM) data (Christensen and Monaco 1997).

Data preparation. The acquired FIM data are sorted by time (year/month), and location. All associated hydrological data are joined with the biological data sets using a relational data base managment system to

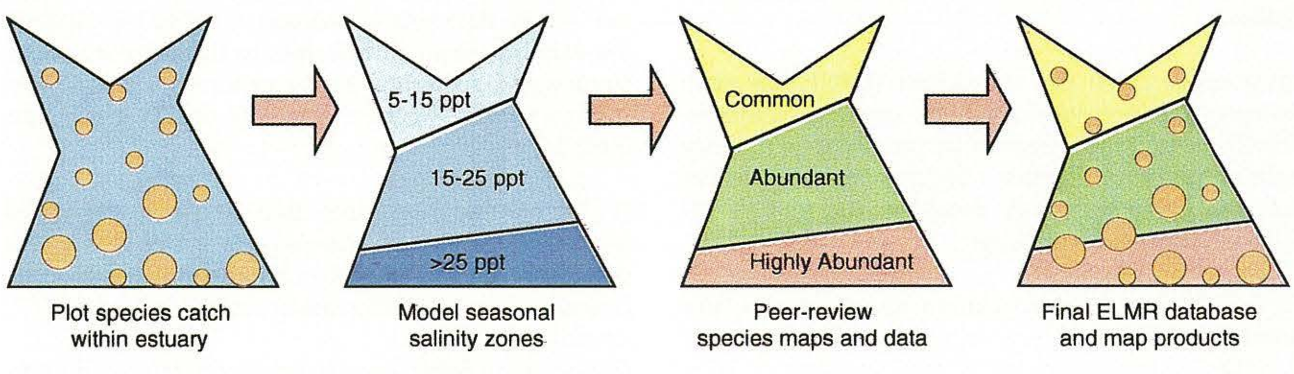


Figure 18. Schematic methodology for revising and updating ELMR database. Relative abundance values are derived from fisheries-independent data, seasonal salinity zones are derived from time-series salinity data, and ELMR data and digital geographies are merged to generate map products which are then peer-reviewed.

ensure that spatial and temporal integrity are maintained. If feasible, the associated salinity data are categorized into one of the five new seasonal salinity zones:

Salinity zone I: 0 - 0.5 ppt.
Salinity zone II: 0.5 - 5 ppt.
Salinity zone III: 5 - 15 ppt.
Salinity zone IV: 15 - 25 ppt.
Salinity zone V: > 25 ppt.

If both surface and bottom salinities are recorded in the FIM data, the following guidelines for salinity data selection are used to define salinity associations:

(1) Use bottom salinity if a trawl is the sampling method and water depths exceed 3 m; otherwise, use depth-averaged salinity.

(2) Use depth-averaged salinity for gill net data if fished at depths not exceeding 50% of the nets height; otherwise, use bottom salinity. For most other passive gear types (e.g., fyke, hoop, and pound nets), use bottom salinity.

(3) Use bottom salinity for bag and beach seines.

(4) If bottom salinity data are not available, use surface salinity.

Data transformation. Survey catch data for each species are classified by species guild (Table 4, p. 8), and sampling gear susceptibility. When multiple sampling gear types are specified in the survey metadata, discrete data sets are created for each sampling strategy. If length-frequency counts are recorded in the data, this information is used to isolate juvenile catch from adults. These data are then separated into discrete gear type/life stage data sets (e.g., trawl/juvenile). In the absence of length-at-capture information, gear type is used to help identify which life stages should be compared based on gear susceptibility.

An average catch per unit effort (CPUE) for each estuary/species/month/salinity zone is calculated. The CPUEs are then ordered by percentile to identify natural statistical breaks. These percentile breaks serve to parse the catch data into the five ELMR relative abundance rankings:

(1) If CPUE = 0, then relative abundance = "not present."

(2) If 1 < CPUE < 10th percentile, then relative abundance = "rare."

(3) If 10th percentile < CPUE < 50th percentile, then relative abundance = "common."

(4) If 50th percentile < CPUE < 90th percentile, then relative abundance = "abundant."

(5) If CPUE > 90th percentile, then relative abundance = "highly abundant."

ELMR data have been quantitatively updated for Texas, Louisiana, Mississippi, Alabama, Florida in the Gulf of Mexico region; North Carolina, South Carolina, Georgia in the Southeast region; and Massachusetts in the Mid-Atlantic and North Atlantic regions. As examples, the application of this methodology to ELMR data for the States of Texas and Massachusetts are described here.

Gulf of Mexico: Texas case example. In 1997, the Gulf Wide Information System (GWIS) project was initiated by the U.S. Department of the Interior's Minerals Management Service (MMS), in cooperation with NOAA, the Gulf of Mexico states (FL, AL, MS, LA, TX) and others (Christensen and Monaco 1998). The objective of the GWIS project is to develop an authoritative data base, as mandated by the Oil Spill Pollution Act of 1990, for oil spill contingency planning in the Gulf of Mexico region (NOAA 1997a). NOAA's role and contribution to GWIS included:

(1) Updating and digitally integrating NOAA's ELMR data into the GWIS data base.

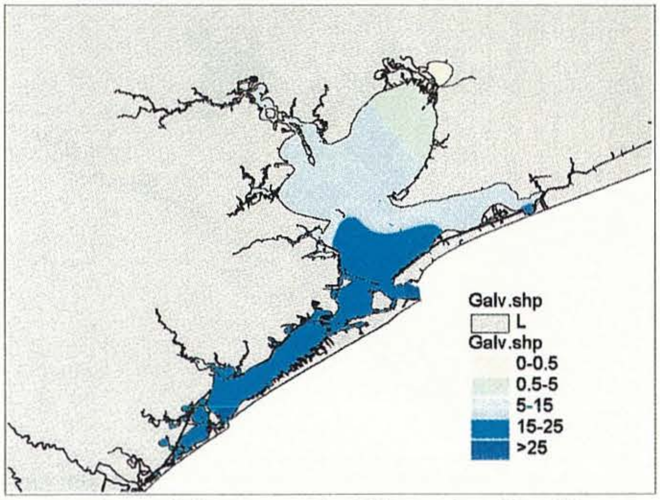
(2) Updating the data for selected coastal and marine fishes in the Gulf of Mexico.

To complete NOAA's contribution to the GWIS project for Texas estuarine waters, the ELMR Program acquired fishery-independent monitoring (FIM) data sets from the Texas Parks and Wildlife Department (TPWD). Estuarine fishery-independent sampling methods include trawl, bag seine, beach seine, and gill net. These data sets were used to revise and update the existing Texas ELMR data to fit the new spatial framework, according to the general procedure described above. Specific elements of this procedure included:

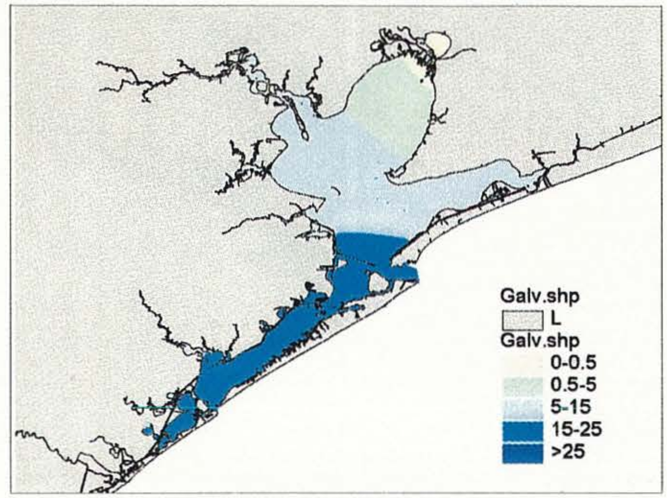
(1) Developing a seasonal, five-salinity-zone spatial framework for Texas estuaries. Figure 19 depicts the salinity zones for Galveston Bay during the low, increasing, high, and decreasing salinity seasons.

(2) Grouping fisheries-independent data according to the revised salinity zones for all Texas estuarine waters.

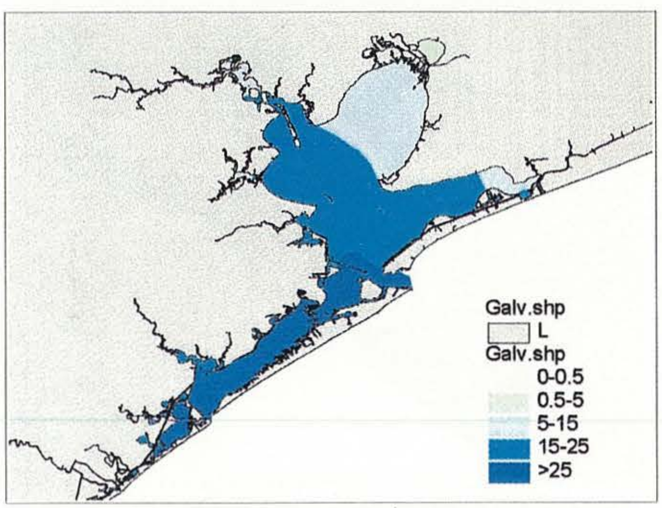
Galveston Bay, Texas



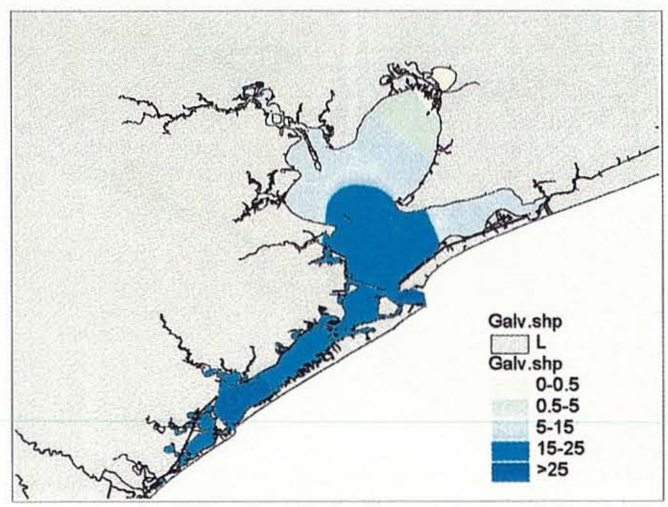
Decreasing salinity time period (November-March)



Low salinity time period (April-June)



High salinity time period (August-October)



Increasing salinity time period (July)

Seasonal estuarine salinity zones

0 - 0.5 ppt

0.5 - 5 ppt

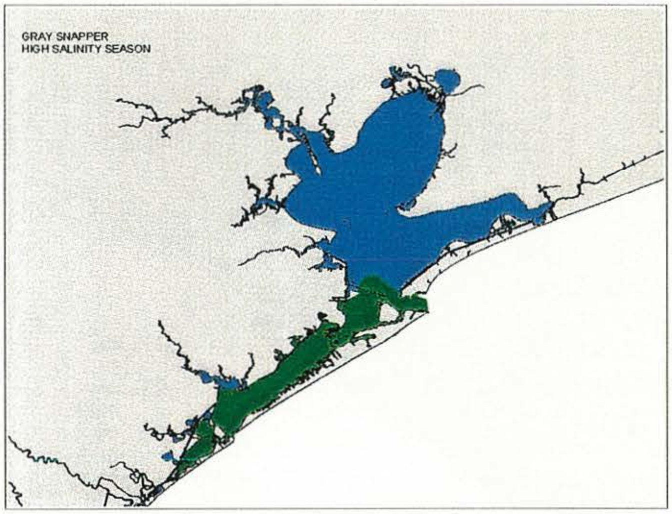
5 - 15 ppt

15 - 25 ppt

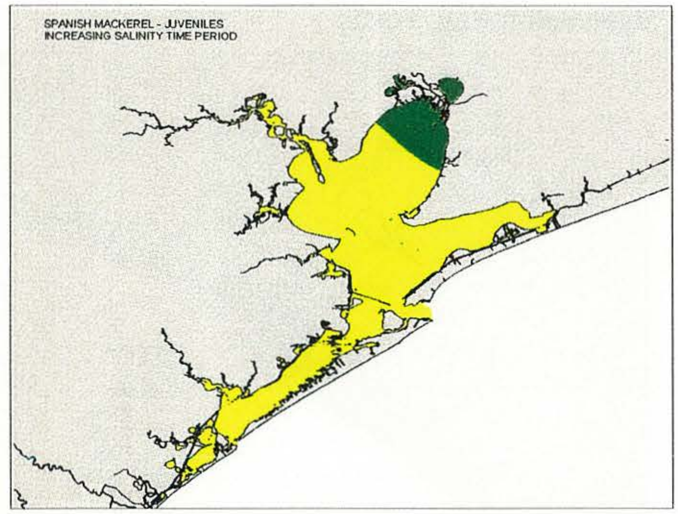
>25 ppt

Figure 19. Revised seasonal estuarine salinity zones for Galveston Bay, Texas.

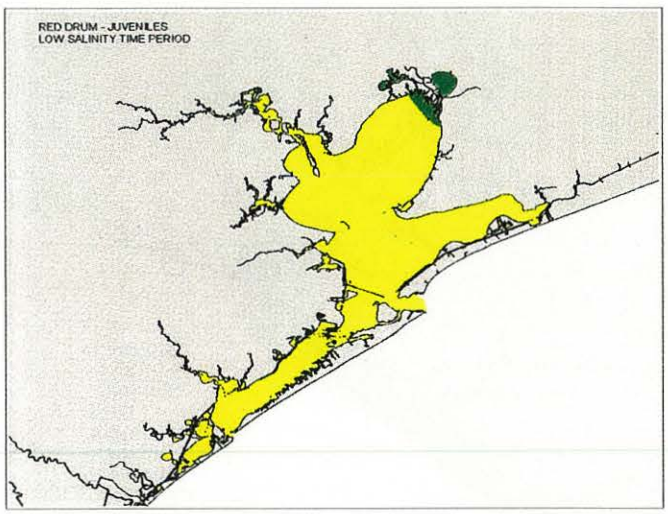
Galveston Bay, Texas



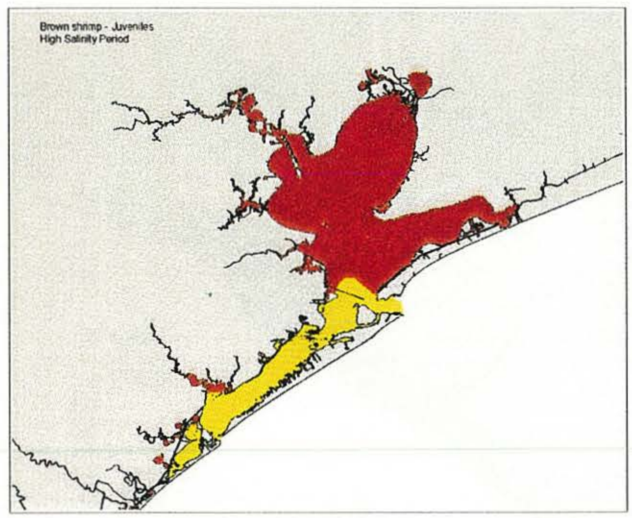
Gray snapper, adults, high salinity season (Aug-Oct)



Spanish mackerel, juveniles, increasing salinity season (Jul)



Red drum, juveniles, low salinity season (Apr-Jun)



Brown shrimp, juveniles, high salinity season (Aug-Oct)

Relative abundance within estuarine salinity zones

Not Present

Rare

Common

Abundant

Highly Abundant

Figure 20. Representative maps of relative abundance of gray snapper, Spanish mackerel, red drum, and brown shrimp, by seasonal salinity zone, in Galveston Bay, Texas.

(3) Classifying species into groups based on species guild, susceptibility to each sampling gear, and life history stage. The six species guilds include shrimps and squids, sessile invertebrates, large decapod crustaceans, shallow water fishes, demersal fishes, and pelagic fishes. The four sampling gear types include bag seine, trawl, beach seine, and gill net. The two life history stages considered for each species include juvenile and adult. The new classifications are treated as separate data sets. For example, it is determined that adult striped mullet are most likely to be sampled by gill net, while juveniles are most susceptible to bag seine.

(4) Relative abundance values are determined within the guild-specific data sets based on the numbers of each species. Species not collected are scored as "not present"; those up to the 10th percentile are scored as "rare"; from the 10th to the 50th percentile as "common"; from the 50th to the 90th percentile as "abundant"; and from the 90th to the 100th as "highly abundant". Monthly relative abundance is calculated for individual species within each guild.

(5) Monthly relative abundance is plotted for each species in each of the five estuarine salinity zones to provide a first-order estimate of relative abundance within the spatial framework.

(6) The fishery-independent sampling data are compared with the ELMR relative abundance estimates in each salinity zone for all months. ELMR relative abundance values are adjusted if the fishery-independent data are substantially different, i.e., two or more levels of relative abundance.

(7) Fishery-independent sampling data and ELMR relative abundance values are mapped together by estuarine salinity zone and season using ArcInfo® and/or ArcView® GIS.

(8) ELMR program staff meet with regional fisheries experts for peer review of draft maps.

(9) Revisions are finalized based on the experts' reviews. Figure 20 depicts the relative abundance of pinfish in Galveston Bay for the low salinity period.

Update of Massachusetts ELMR data. In 1997, NOAA initiated an effort to revise and update Environmental Sensitivity Index (ESI) maps for the coastal zone of Massachusetts, and decided to use ELMR data to characterize the distribution and abundance of fishes and invertebrates in estuaries and coastal waters. However, the existing ELMR data for Massachusetts (Mid-Atlantic and North Atlantic regions) had been compiled six years earlier, and did not reflect recent trends. Therefore, the existing ELMR data were revised and updated using a three-step procedure:

(1) Developing a seasonal salinity zonation scheme based on estuarine salinity data.

(2) Revising ELMR information using recent Massachusetts Coastal Trawl Survey data.

(3) Reviewing species maps with local experts.

The ELMR program derived seasonal salinity zones for Massachusetts from analysis of an estuarine salinity data set provided by the Massachusetts Division of Marine Fisheries (MDMF). This data set consisted primarily of surface salinity values taken for MDMF's shellfish water quality monitoring program. Tributary flow gage and precipitation data were acquired to identify representative years. Precipitation, flow data, and monthly salinity averages were evaluated to determine which months would be used to represent the high, low, and transitional salinity periods. A contour modelling procedure was applied to the data, with these results:

(1) Three salinity zones were delineated:
• Tidal Fresh, 0 to 0.5 ppt.
• Mixing, 0.5 to 25 ppt.
• Seawater, greater than 25 ppt.
(The data did not warrant a five-zone salinity classification scheme, as was derived for estuarine waters of Louisiana and North Carolina.)

(2) The analysis identified four "salinity seasons":
• Low: March through May
• Increasing: June
• High: July through September
• Decreasing: October through February

(3) The results generally agreed with the original *National Estuarine Inventory* (NEI) salinity maps (NOAA 1985a). However, several tributaries with seasonal mixing zones were identified.

(4) Most of the large coastal embayments (Massachusetts Bay, Cape Cod Bay, Buzzards Bay, Vineyard and Nantucket Sounds) are entirely seawater.

(5) The majority of mixing zone habitat is within Merrimack River, Plum Island Sound, Taunton River, and the tidal ponds of Martha's Vineyard.

(6) The majority of tidal fresh habitat is within Merrimack River.

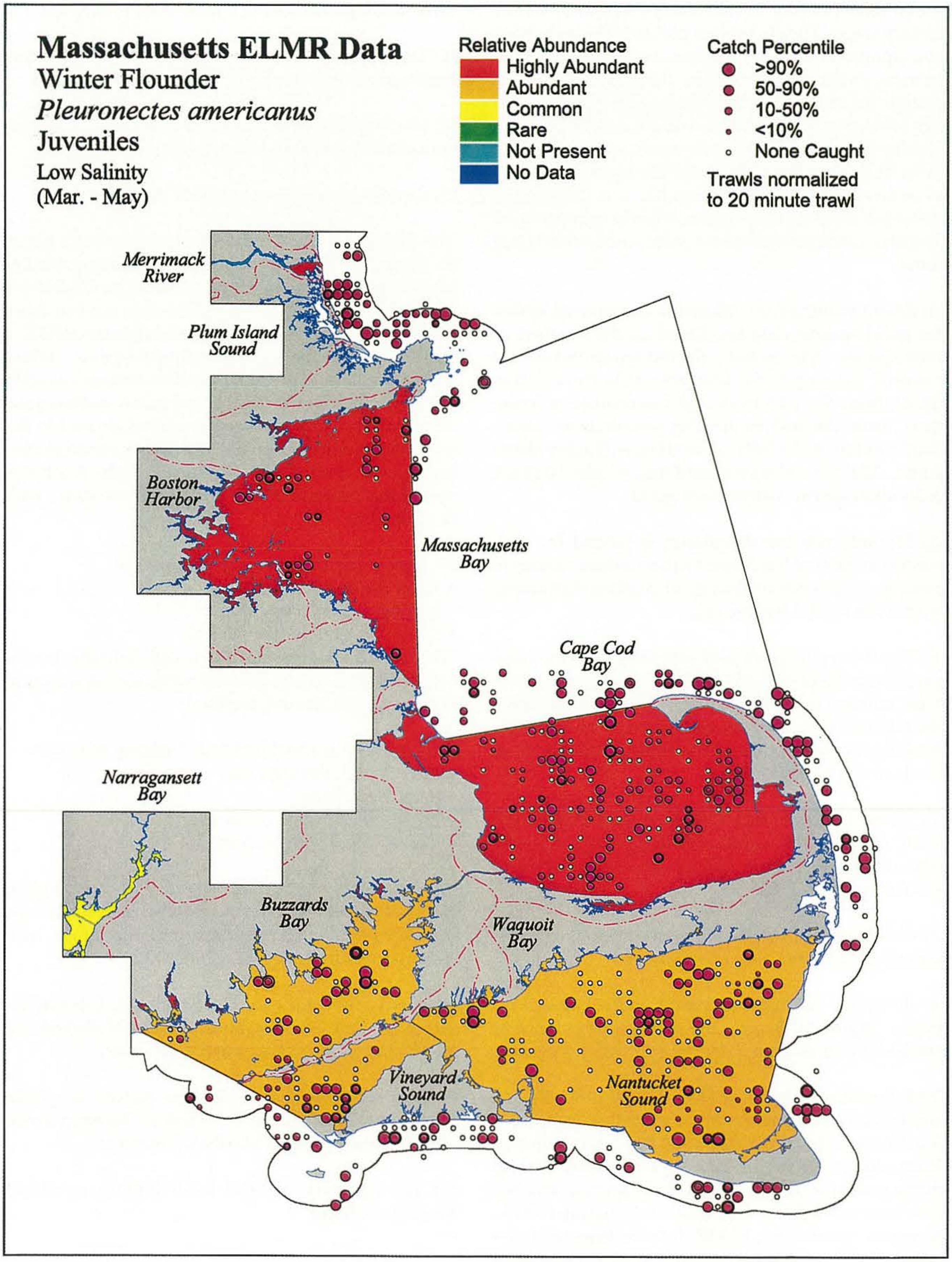


Figure 21. ELMR relative abundance and MDMF trawl survey data for juvenile winter flounder in Massachusetts.

To revise the ELMR data, Massachusetts Coastal Trawl Survey data were acquired through a cooperative agreement. A "quantile analysis" was applied to six recent consecutive years (September 1991 to May 1997) of the data. Survey locations were identified within the boundaries of ELMR estuaries (Buzzards Bay, Massachusetts Bay, Cape Cod Bay). Species were separated into juvenile (J) and adult (A) life stages based on length class. The analysis was applied only to the "demersal fishes" guild, susceptible to the trawl survey sampling gear. Total catch-per-unit-effort for individual species/life stages was summed for six years, but kept separate for May and September, and any catches of 0 were excluded from analysis. Catches for May and September were "stacked," separated into percentiles, and converted to ELMR relative abundance categories using the standard criteria as described on page 48.

Based on this quantile analysis of 1991-1997 trawl survey catch, ELMR data were revised for several species (skates, scup, weakfish, spiny dogfish, silver hake, red hake) in Buzzards Bay, Cape Cod Bay, and/ or Massachusetts Bay. The revised ELMR data and salinity zone boundaries were then merged with a 1:24,000 shoreline boundary to generate seasonal species maps using ArcInfo® software. The seasonal species maps were carefully reviewed in a series of meetings with local and regional fisheries biologists. Final revision of the ELMR data was based on the comments of these experts. Figure 21 depicts the distribution of winter flounder adults in Massachusetts estuarine waters, combining both ELMR and MDMF trawl survey data.

In summary, the ELMR digital maps and associated data base are revised and updated in a four-step procedure:

(1) Map the species catch distribution.

(2) Model the species distribution throughout seasonal salinity zones.

(3) Link the fishery-independent monitoring data with modeled data via GIS.

(4) Peer-review the revised data and associated maps.

ELMR Applications

The methodology and data developed through the ELMR program have been applied to analytical studies, and to specific problems in natural resource management. A few of these applications are described below.

An index to assess the sensitivity of Gulf of Mexico species to changes in estuarine salinity regimes. This study developed an index of biological sensitivity to changes in freshwater inflow for adult and juvenile life stages of the 44 ELMR fish and macroinvertebrate species in 22 Gulf of Mexico estuaries (Christensen et al. 1997). The BioSalinity Index (BSI) provides an innovative approach to quantifying the estuary-specific sensitivity of organisms to changes in estuarine salinity regimes, based upon knowledge of species' salinity habitat preferences, the availability of this preferred habitat, and the relative abundance and spatial and temporal distribution of species. It was found that a significant difference exists between adult and juvenile life stage sensitivity, with juveniles exhibiting a lower sensitivity to salinity changes than adults, and that a considerable disparity exists in species-specific sensitivities among Gulf estuaries. Likewise, when the full complement of 44 species-level BSIs are averaged, marked differences in assemblage-wide sensitivity are evident across estuaries. The availability of preferred salinity habitat had a greater influence on the BSI for estuarine species than did their relative abundance and temporal distribution. In 1995, participants in a Gulf of Mexico freshwater inflow workshop applied the BSI to identify a subset of estuaries that appear more sensitive to changes in freshwater inflow, and are candidates for further study.

Estuarine-catadromy: a life history strategy coupling marine and estuarine environments via coastal inlets. This investigation was undertaken to develop a better understanding of estuarine-catadromous species' larval utilization of estuaries and inlets along the U.S. East Coast from Buzzard Bay, MA to Biscayne Bay, FL (Bulger et al. 1995). Estuarine-catadromous species spend most of their adult stage in the marine environment and spawn there, and in their early life history stages migrate to, and reside in, estuarine environments. This group of species accounts for a large portion of the Gulf and East Coast fisheries harvest, and their larvae's migration through the inlets is of paramount importance. ELMR data were used to characterize 12 larval species' utilizations of 29 estuaries and 59 inlets. A Theoretical Inlet Utilization (TIU) Index was developed as a series of maps to provide a biogeographic perspective. These species' larval abundance rankings were modeled against the physical characteristics of ocean inlets, via ordered stepwise logistic regression, to provide a better understanding of the relationships driving these utilization patterns. The average concordance between larval relative abundance rankings and nine estuarine/ inlet physical variables was 82.6%. The models indicated that additional estuarine/inlet independent variables, such as tidal plume characterizations (e.g., excursion, areal coverage, reflux), may improve the models. With further refinement and a better understanding of the relationships driving larval utilization patterns, improvements in the inlet utilization assessments may be possible. These improvements would aid managers in assessing the potential impacts to estuarine-catadromous larvae from natural and anthropogenic modifications of ocean inlets.

The FLELMR spatial decision support system for coastal resources management. The Florida Estuarine Living Marine Resources (FLELMR) system is a spatial decision-support system being developed by the Florida Marine Reseach Institute (FMRI) (Rubec et al. 1997). FLELMR has been developed as a source of synthesized biological information needed for fisheries management and for assessing potential impacts from oil spills and other perturbations. The system contains information pertaining to the life histories, reproduction and habitat requirements of 91 species of marine fish and invertebrates found in Tampa Bay, Sarasota Bay, Indian River Lagoon and Florida Bay. Text and numeric data are being added to an Oracle® data base. The system is being expanded to include more species, so that researchers can assess the biodiversity and biological integrity of coastal ecosystems. Habitat suitability index (HSI) models have been developed, and are used with the ArcInfo® geographic information system (GIS) to map the distributions of species by life stage (Rubec et al. 1999). The FLELMR system will assist resource management decisions by enabling spatial queries with GIS capabilities.

Environmental Sensitivity Index (ESI) mapping. Environmental Sensitivity Index (ESI) maps are an integral component of coastal oil spill contingency planning and assessment (Battista et al. 1996). The importance of this response tool warrants the development of a more comprehensive, accurate and easily distributed information system. The update of the *ESI Atlas* for coastal North Carolina provided an opportunity, as a pilot study, to augment current analog ESI maps and table with digital formats. The ArcInfo® GIS was used to integrate biogeographic data from the ELMR program and salinity data from the *National Estuarine Inventory* (NEI) with existing ESI data sources. Ultimately, digitally integrated data will be available for display, query and analysis via a custom ArcView® desktop GIS system. Final products from this effort include hard-copy maps, digital data bases, and digital coverages that characterize the relative abundance and distribution of fish and invertebrate species in North Carolina estuaries (RPI 1996). A similar series of products have been completed for Georgia (RPI 1997) and Massachusetts (RPI 1999).

Habitat Suitability Modeling (HSM). NOAA's Biogeography Program is currently developing a GIS-based modeling and assessment capability to investigate potential changes in the spatial extent and patterns of selected fishery habitats as effected by alterations in estuarine habitat. The underlying modeling approach was introduced by the U.S. Fish and Wildlife Service's (USFWS) Habitat Evaluations Procedures Program, whereby models result in a numerical index of habitat suitability ranging from 0.0 - 1.0. Models are based on the assumption that a positive relationship exists between the index and a habitat's carrying capacity for a given species (Schamberger et al. 1982). Our models exhibit a significant departure from USFWS methods by incorporating a spatial component to produce a view of the relative suitability of locations in geographic space through time. The intent is to develop a simple spatial model using GIS technology that offers estuarine resource managers a habitat assessment capability that can be applied to a wide range of estuarine species.

Habitat Suitability Index models are based upon habitat suitability as determined by the combination of environmental variables (i.e., salinity (ppt), water temperature (°C), dissolved oxygen content (mg/l), substrate type, bathymetry (m), and the presence or absence of submerged aquatic vegetation and emergent wetland macrophytes) as they vary in both time and space. The use of GIS technology provides the tools necessary to produce a "seascape" view of the relative suitability of locations in geographic space through time. Two independent methods are currently used to determine suitability across the range of each parameter modeled: (1) Qualitative - species suitability index values (SIs) are generated through an extensive data and literature search for documented tolerances to, and affinities for, each environmental and biological gradient; and (2) Quantitative - Stepwise multiple regression prediction models are developed using empirical data from fisheries-independent data. The former approach is designed to investigate the feasibility of developing reasonably accurate habitat suitability models in locations lacking data to support a more rigorous statistical model, while the latter is designed to address the concept of transferability of models across geographies.

Completed HSM studies include:

(1) *Sheepscot Bay and Casco Bay, Maine*: Multi-species habitat suitability index models, developed in cooperation with the U.S. Fish and Wildlife Service Gulf of Maine Program (Brown et al. 1997).

(2) *Pensacola Bay, Florida*: An assessment of potential impacts from changes in freshwater inflow on oyster populations (Christensen et al. 1997).

(3) *Apalachicola Bay, Florida*: An assessment of potential impacts from changes in freshwater inflow on oyster populations, developed in cooperation with Florida State University, University of South Florida, and Florida A&M University (Christensen et al. 1998).

(4) *Galveston Bay, Texas*: A quantitative definition of Essential Fish Habitat, developed in cooperation with the NOAA/NMFS Galveston Lab. (Clark et al. 1999).

(5) *Tampa Bay and Charlotte Harbor, Florida*: An application of habitat suitability values across estuarine systems to delineate habitat essential to sustainable fisheries, developed in cooperation with the Florida Marine Research Institute and the University of Miami (Rubec et al. 1999).

Products and services for the identification of Essential Fish Habitat (EFH). On October 11, 1996, President Clinton signed the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act (NOAA 1996). Among its provisions is a new requirement that all federal fisheries management plans must be amended to include the description, identification, conservation, and enhancement of Essential Fish Habitat (EFH). EFH is defined as "waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." This information will be used by NOAA/NMFS, in consultation with other federal agencies, concerning any activity or proposed activity that may adversely impact EFH. In order to meet the mandates of the revised Magnuson Act, NOS and NMFS have developed work plans to identify EFH in the Gulf of Mexico (NOAA 1997b), Southeast (NOAA 1997c) and Northeast (NOAA 1998) regions. One of the major tasks assigned to NOS is to provide existing biological data bases and maps, including the ELMR data for estuarine species, and regional data atlases for offshore species. The primary tasks can be summarized as:

(1) Conduct EFH needs assessment.

(2) Provide digital spatial framework.

(3) Provide biological and habitat data bases.

(4) Accelerate development of ArcView® species mapping tool.

Coastal Ocean Resource Assessment (CORA). Coastal Ocean Resource Assessment (CORA) is a custom extension of ArcView® GIS software being developed cooperatively by NOAA's Biogeography Program and the Environmental Systems Research Institute (ESRI) (ESRI 1997). CORA utilizes a Visual Basic user interface to link the capabilities of ArcView® GIS with Oracle® and Microsoft Access® DBMS software. CORA enables the integration and analysis of large, diverse coastal resources data sets, and the generation of maps and summary reports on the distribution, abundance and habitat of coastal fishes and invertebrates.

Gulfwide Information System (GWIS). In 1997, the Gulf Wide Information System (GWIS) project was initiated by the U.S. Department of the Interior's Minerals Management Service (MMS), in cooperation with NOAA, the Gulf of Mexico states (FL, AL, MS, LA, TX) and others. The objective of the GWIS project is to develop an authoritative data base, as mandated by the Oil Spill Pollution Act of 1990, for oil spill contingency planning in the Gulf of Mexico region (NOAA 1997a). NOAA's role and contribution to GWIS is described above in *Gulf of Mexico: Texas case example* (see p. 48). NOAA submitted a final report to MMS in 1998 (Christensen and Monaco 1998).

Coastal Analysis and Data Synthesis (CA&DS). NOAA's National Coastal Assessment and Data Synthesis (CA&DS) system will integrate national data sets for 138 estuaries within a spatial framework with analytical capabilities (Orlando 1999). The incorporation of ELMR data into CA&DS is described in *Selection of estuaries* (see p. 3).

The Future

NOAA's ELMR Program is now part of the Biogeography Program within the Center for Coastal Monitoring and Assessment of the National Ocean Service. The goal of the Biogeography Program is to address three basic questions about estuarine and coastal species and habitats:

- What are the distribution, abundance and life history characteristics of estuarine and coastal marine species?
- What is the spatial extent of various estuarine, coastal and marine habitats?
- What are the functional relationships between species and their associated habitats?

To address these questions, the Biogeography Program will continue to:

- Update and improve the ELMR data base on a regional basis, using available fishery-independent survey data coupled with expert review.

- Refine the spatial characterization of habitats for parameters such as salinity, temperature, bathymetry and substrate, and use GIS to map these parameters.

- Describe the association between species and their habitats by applying Habitat Suitability Modeling (HSM) and Habitat Affinity Index (HAI) methodologies.

- Develop an ELMR-like component for tropical reef species to complement the program's coral reef habitat mapping and reef fish census activities.

- Conduct targeted field research to validate species habitat suitability models.

- Continue to apply available information and methodology to special projects such as Essential Fish Habitat (EFH), Environmental Sensitivity Index (ESI) mapping, and defining boundaries of marine protected areas.

- Make products and services available by publishing and distributing summary reports and analytical papers.

- Ensure that products and services are available in a timely manner through the following Web site:

  http://biogeo.nos.noaa.gov/

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NOAA s Estuarine Living Marine Resources Program

In June 1985, NOAA began a program to develop a comprehensive information base on the life history, relative abundance, and distribution of fishes and invertebrates in estuaries throughout the nation. The Estuarine Living Marine Resources (ELMR) program has been conducted jointly by the National Ocean Service (NOS), the National Marine Fisheries Service (NMFS), and other agencies and institutions. The nationwide ELMR data base was completed in 1994, and includes data for 153 species found in 122 estuaries and coastal embayments. A series of reports and reprints are available free upon request. This report provides a national overview of the ELMR program, and a summary of the regional studies. Three to five salinity zones provide the spatial framework for organizing information on species distribution and abundance within each estuary. The primary data developed for each species include spatial distribution by salinity zone, temporal distribution by month, and relative abundance by life stage, e.g., adult, spawning, juvenile, larva, and egg. In addition, life history summaries and tables are developed for each species.

Additional information on ELMR and the NOAA/NOS Biogeography Program is available from:

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website http://biogeo.nos.noaa.gov

Selected reports and reprints available from NOAA's Biogeography Program include:

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