SEASONAL AND AREAL ABUNDANCE OF GULF MENHADEN IN LOUISIANA ESTUARIES

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Abstract: Otter trawl data from the Louisiana Department of Wildlife and Fisheries' shrimp monitoring program from 1966 through 1979 were used to determine seasonal and areal abundance of gulf menhaden in five areas along the Louisiana coast. Catches were highest in western Louisiana. Overall peaks in late winter/spring and lows in late summer/fall of catches coincide with the influx of larvae from offshore and emigration of juveniles to the Gulf, respectively.

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The largest commercial fishery in the United States is the gulf menhaden *(Brevoortia patronus)* purse seine fishery (Christmas and Etzold 1977). Gulf menhaden spawn offshore from about October to April. Larvae immigrate into estuarine nursery areas, juveniles remain in nursery areas for 5 - 10 months, and then emigrate offshore where they complete their life cycle.

Much information has been obtained on Atlantic menhaden *(Brevoortia tyrannus)*; however, research on juvenile gulf menhaden has been less extensive. As part of a comprehensive project, juvenile gulf menhaden data from the Louisiana Department of Wildlife and Fisheries' (LDWF) shrimp monitoring program were examined to determine the relationship between abundance of juveniles in estuaries to later commercial harvest levels (Guillory and Bejarano 1980). The purpose of this paper is to present data obtained from this LDWF survey on seasonal and areal abundance of gulf menhaden in Louisiana estuaries.

This study was conducted in cooperation with the U.S. Department of Commerce, National Marine Fisheries Service, Public Law 88-309, as amended, Project No. 2-364-R. Dr. Vernon Wright of Department of Experimental Statitstics, Louisiana State University, performed the statistical analysis.

METHODS

Otter trawl survey data were obtained from 5 areas on the Louisiana Coast (Fig. 1). Area numbers in this paper do not coincide with coastal study area numbers used by LDWF. Area 1 lies east of the Mississippi River to Bayou Terre aux Boeufs and includes the following major water bodies: Breton Sound, Black Bay, Bay Gardene, Little Lake, Bay Crabe, American Bay, California Bay, Quarantine Bay, and Grand Bay. Area 2 is bounded on the east by Grand Bayou and on the west by Bayou Lafourche. The major systems are Barataria and Caminada Bays. Area 3 lies between Bayou Lafourche on the east and Bayou Sale on the west. Timbalier Bay, Terrebonne Bay, and Lake Pelto are found in this area. Area 4 is defined by Bayou Sale on the east and Point au Fer on the west. Caillou Bay, Caillou Lake, Lake Merchant, Lake Decade, and Four League Bay are the major estuaries. Area 5 is comprised of the Calcasieu Lake system in western Louisiana. Detailed physical, chemical, and hydrological descriptions of each area were presented in Perret et al. (1971) and Barrett (1971). Stations were selected within each area to represent typical habitats in each area. Some stations were sampled for only 1 - 2 years, but each area had 2 - 4 stations which were sampled for the entire period.

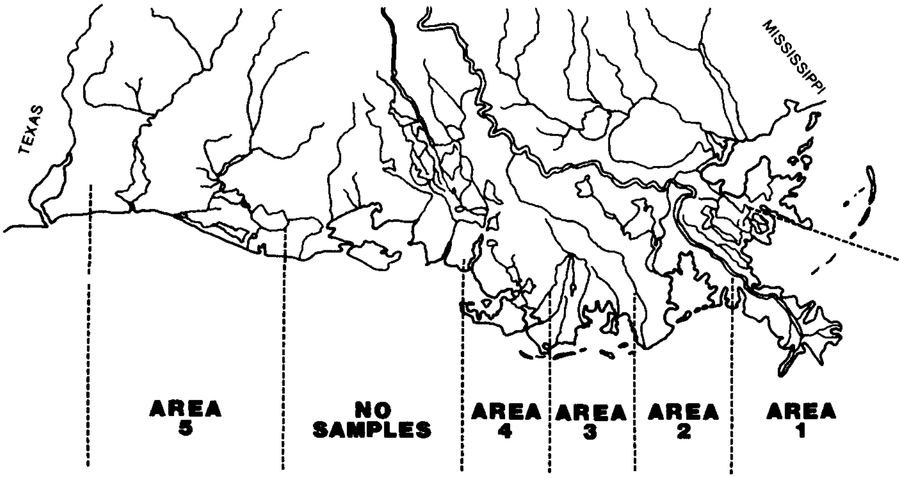

Fig. 1. Location of study areas along the Louisiana coast.

Gear and sampling techniques were standardized at the inception of the shrimp monitoring program in 1966. Samples were taken with a 4.9-m otter trawl with 19.9-mm bar mesh wings and 6.4-mm bar mesh tail. The trawl was towed for 10 minutes at approximately 3 knots. In general, each station was sampled weekly or biweekly year round.

An analysis of variance on both the number of menhaden per trawl sample (C/E) and the percent frequency of samples containing 1 or more menhaden (%F) was conducted using the General Linear Models (GLM) procedure in the SAS software package (SAS Institute Inc. 1979). The term significant is used in this paper only when a statistical test indicated significance at $P \leq 0.05$.

RESULTS AND DISCUSSION

There was considerable variation in annual C/E of gulf menhaden from the period 1966 through 1979 (Table 1). The annual C/E ranged from 2.1 to 84.4. These annual fluctuations did not appear to be attributed to long term trends but were probably related to variations in environmental conditions during crucial larval stages. The influence of environmental conditions on juvenile gulf menhaden remains under investigation.

Table 1. Annual sampling effort (S), catch per effort (C/E), and percent frequency of occurrence (%F) of gulf menhaden collected with 4.9-m otter trawl for 5 areas along the Louisiana coast, 1966 to 1979.

	Area 1			Area 2			Area 3			Area 4			Area 5			Total		
Year	S	C/E	%F	S	C/E	%F	S	C/E	%F	S	C/E	%F	S	C/E	%F	S	C/E	%F
1966										30	12.7	46.7				30	12.7	46.6
1967	18	10.9	50.0	48	10.9	45.8	92	2.6	25.0	165	3.9	43.0	41	20.0	65.8	364	6.7	41.7
1968	92	6.4	33.7	48	58.1	50.0	151	9.8	18.5	241	19.7	52.3	34	174.8	85.3	566	27.5	42.0
1969	22	4.5	45.4	24	8.2	37.5	66	3.4	27.3	126	6.9	33.3	17	61.2	64.7	255	9.5	35.2
1970				146	8.3	42.5				4	8.5	75.0				150	8.4	43.3
1971	86	0.1	5.8	212	11.1	37.7	114	0.3	7.9	79	2.5	39.2	75	23.5	54.7	566	7.7	29.3
1972	67	0.6	14.9	152	1.6	27.6	122	1.0	20.5	126	2.0	28.6	108	4.9	45.4	575	2.1	28.1
1973	73	0.9	12.3	82	1.1	23.2	113	1.0	17.7	131	1.1	28.2	164	17.2	65.8	563	5.7	34.2
1974	77	1.7	20.8	82	0.9	19.5	106	1.6	19.8	121	14.0	48.8	168	37.9	67.8	554	15.2	40.7
1975	63	0.4	11.1	71	1.5	31.0	82	4.6	24.4	108	82.7	51.8	112	63.6	53.6	436	37.9	37.8
1976	77	0.1	9.1	100	1.6	32.0				76	57.2	86.8	112	234.8	67.0	365	84.4	49.3
1977	45	0.4	11.1	75	1.2	30.7				46	13.5	73.9	90	205.2	80.0	256	75.0	52.3
1978	52	1.0	25.0	96	23.5	39.6				60	8.8	73.3	75	4.6	41.3	283	11.2	44.7
1979				60	2.8	26.7				56	10.6	68.7	80	8.2	50.0	196	7.2	45.9
Total	672	1.8	18.2	1196	8.6	23.9	846	3.2	19.5	1369	17.5	47.7	1076	67.1	61.1	5160	21.4	38.7

Data indicated juvenile gulf menhaden density was highest in western Louisiana. Differences in catch rates among areas were statistically significant (F = 23.36; 4 and 5,061 df). Area 5 consistently had the largest C/E, followed in decreasing order by areas 4, 2, 3, and 1. Trends in %F were similar to C/E. Other investigators have also produced data suggesting that gulf menhaden density is highest in western Louisiana. Christmas (1980) reported that commercial catches in the purse seine fishery were highest in western Louisiana. Perret et al. (1971) and Barrett et al. (1978) obtained highest or second highest trawl catches in area 5.

Monthly C/E and %F by area and overall is presented in Table 2. There was no apparent trends in monthly %F. Seasonal trends in C/E were not consistent through all areas. In area 1, low catches precluded any interpretation of seasonal trends. Peak catches in area 2 occurred in April and again in December. Area 3 showed increased catches from May through August. Areas 4 and 5 both showed marked peaks from February through April. The overall seasonal trend from combining all areas suggests peak densities in late winter and spring and declining into late summer/fall. This trend closely paralleled that of area 5 which had the highest C/E and therefore greatly influenced overall C/E.

Overall late winter/spring peaks are related to the seasonal imigration of larval gulf menhaden into the estuaries. Gulf menhaden spawn offshore, extending from about October to April with a peak during January and February (Christmas and Etzold 1977), with larvae reaching estuaries at 3 - 5 weeks of age. The pooled monthly length-frequency histograms, from area 5 for 1967 to 1979 (Fig. 2), illustrate the influx of immigrating gulf menhaden. Highest catches occurred when immigration of age 0 menhaden was greatest. Declining catches after late winter/spring peaks may be associated with the further migration of most age-0 gulf menhaden from higher salinity waters of the lower estuary to lower salinity areas in the extreme upper portions of bays and tributaries that are beyond LDWF sampling stations. Overwintering age-1 gulf menhaden were also found in substantial numbers in late winter/early spring (Fig. 2). Emigration of these age-1 fish to the Gulf by late spring probably also contributed to declining C/E. Emigration of larger juveniles to the Gulf, starting in mid-summer (Christmas and Etzold 1977), may contribute to decreased catches of gulf menhaden during the fall. Also, emigrating gulf menhaden, due to their larger size and faster swimming speed, are probably more difficult to catch than immigrating fish.

Simoneaux (1979) sampled gulf menhaden along a north-south transect in upper Barataria Bay and obtained results which support our observations on seasonal abundance. Simoneaux noted that catches from upper freshwater stations increased from zero during December through March to large numbers in April and then showed a steady decline. This decline was matched by a subsequent rise in catches in southern, more saline stations where catches remained high through July. Emigration of fish into lower open bays and subsequently into the Gulf later reduced gulf menhaden catches in the saline stations.

Monthly C/E for each area suggested that seasonal peaks of gulf menhaden abundance varied from estuary to estuary. Seasonal lows in gulf menhaden abundance did not vary as much as the peaks. Since peaks were associated with the arrival of immigrating gulf menhaden, area differences in peak catches may have been related to differences in spawning dates, distance of spawning sites from nursery grounds, and offshore larval transport mechanisms. These differences

Table 2. Monthly sampling effort (S), catch per effort (C/E), and percent frequency (%F) of gulf menhaden in 4.9-m trawl samples for 5 areas along the Louisiana coast, 1966 to 1979.

	Area 1			Area 2			Area 3			Area 4			Area 5			Total		
	S	C/E	%F	S	C/E	%F	S	C/E	%F	S	C/E	%F	S	C/E	%F	S	C/E	%F
Jan.	45	1.4	20.0	86	6.0	47.7	69	1.0	8.7	85	9.1	31.8	69	17.2	49.3	354	7.4	33.0
Feb.	65	1.7	26.2	95	5.2	48.4	68	1.0	13.2	102	28.8	47.0	82	130.2	65.8	412	34.7	42.2
Mar.	66	1.0	12.1	100	5.8	44.0	68	0.8	17.6	127	43.1	55.9	114	124.7	66.7	475	42.9	44.4
Apr.	73	1.2	19.2	104	19.2	28.8	70	1.4	21.4	124	53.8	52.4	126	203.4	65.1	497	69.4	41.4
May	67	2.2	13.4	120	0.5	25.0	73	9.1	34.2	112	10.7	37.5	101	63.5	66.3	473	17.9	36.5
June	72	1.4	23.6	120	2.7	25.8	67	13.2	28.4	127	6.1	44.9	110	62.4	71.8	496	18.1	40.9
July	50	1.8	10.0	104	5.8	32.7	61	7.1	26.2	127	20.4	54.3	100	32.0	75.0	442	15.7	45.0
Aug.	57	0.8	8.8	107	2.8	28.0	83	3.2	34.9	101	7.6	66.3	102	15.5	65.7	450	6.6	44.0
Sept.	40	0.6	22.5	107	2.0	38.3	61	0.2	8.2	115	7.4	60.0	96	5.1	45.8	419	3.8	40.0
Oct.	51	1.1	27.4	94	1.7	20.2	85	1.5	17.6	135	6.1	53.3	86	4.3	37.2	451	3.4	33.7
Nov.	42	1.4	11.9	80	6.6	31.3	75	0.6	14.7	118	5.8	39.0	54	8.9	50.0	369	4.8	30.8
Dec.	44	8.8	22.7	79	56.9	43.0	67	0.1	4.4	96	4.6	20.8	36	29.5	55.5	322	19.9	27.0

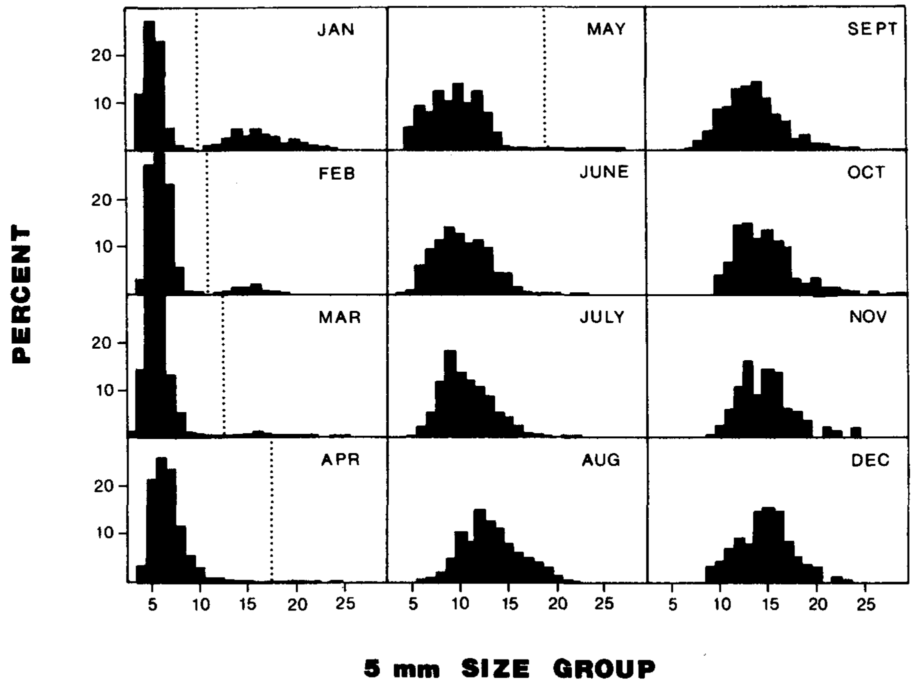

Fig. 2. Monthly length-frequency histograms for gulf menhaden from area 5, 1967 to 1979. (The vertical dotted line separates age-0 and age-1 fish).

would cause corresponding changes in arrival times of age-0 fish into the estuaries. Christmas and Waller (1975) concluded that from the Mississippi Delta to Brownsville, Texas area, spawning peaks were indicated during March in the southern portion and in December in the northern portion.

Monthly C/E for each year from 1967 to 1979 for area 5 revealed that the seasonal influx of immigrating gulf menhaden varied from year to year. Annual differences in peak catches may be related to annual variations in spawning peaks and/or offshore larval transport mechanisms. These yearly changes in seasonal peaks, plus annual/spatial variations in abundance, suggested that conclusions obtained from a one-year survey in one estuary are not necessarily indicative of coastwide, long term gulf menhaden population dynamics. For example, four studies have been conducted in Vermillion Bay, Louisiana and gulf menhaden peak catches have varied in each: March-June in Norden (1966); May-June and January in Juneau and Barrett (1975); December in Dugas (1970); and June-September in Perret and Caillouet (1974).

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