S E D A R

Southeast Data, Assessment, and Review

SEDAR 27-DW07
Habitat Description for the Gulf Menhaden Stock in the U.S. Gulf of Mexico

Prepared by
Steve VanderKooy
Gulf States Marine Fisheries Commission
Ocean Springs, Mississippi
March 2011

SEDAR is a Cooperative Initiative of:
The Caribbean Fishery Management Council
The Gulf of Mexico Fishery Management Council
The South Atlantic Fishery Management Council
NOAA Fisheries Southeast Regional Office
NOAA Fisheries Southeast Fisheries Science Center
The Atlantic States Marine Fisheries Commission
The Gulf States Marine Fisheries Commission

SEDAR
The South Atlantic Fishery Management Council
4055 Faber Place #201
North Charleston, SC 29405
(843) 571-4366

Description of the Habitat of the Gulf Menhaden

General Conditions

Gulf menhaden range throughout the Gulf of Mexico from the Yucatan Peninsula to Tampa Bay, Florida; however, they are most abundant in the north-central Gulf (Christmas et al. 1982). Gulf menhaden are found in a wide range of salinities, from offshore to freshwater, since their life cycle includes offshore spawning, mostly during winter, with recruitment to and maturation in coastal rivers, bays, bayous, and other nearshore habitats. Upon maturation, the fish return to offshore waters to complete the life cycle.

While juveniles and adults are typically found in open water with non-vegetated bottoms, larvae and early juveniles are often found associated with estuarine marsh edges where adequate forage and protection from predators can be found (Reintjes 1970). Upon entering estuaries, postlarvae occupy quiet, low salinity waters to bottom depths of 6.6 feet (Fore and Baxter 1972). After transformation, most juvenile menhaden remain in nearshore estuaries until they are approximately 100 mm fork length (FL; Lassuy 1983).

Physical Habitat

Gulf menhaden are found throughout the northern Gulf of Mexico and utilize a number of brackish and freshwater habitats. Larvae arrive in the upper estuaries in the early spring after riding the prevailing currents from the offshore spawning grounds (June and Chamberlin 1959, Christmas et al. 1982, Minello and Webb 1997).

The Gulf of Mexico is bordered by 207 estuaries (Buff and Turner 1987) that extend from Florida Bay to the Lower Laguna Madre. Perret et al. (1971) reported 5.62 million ha of estuarine habitat in the five Gulf states including 3.2 million ha of open water and 2.43 million ha of emergent tidal vegetation (Lindall and Saloman 1977) and includes 1 million ha of salt marsh (USEPA 1992). Emergent vegetation is not evenly distributed along the Gulf coast with the majority of the Gulf's salt marshes (63%) being located in Louisiana. These areas provide structure for protection and foraging areas to larval and early juvenile gulf menhaden (Minello and Webb 1997).

Salinity

Offshore spawning necessitates that gulf menhaden eggs and larvae be euryhaline. Gulf menhaden eggs and larvae have been collected in waters with salinities ranging from 6-36 ppt (Fore 1970, Christmas and Waller 1975); 88% of the eggs were collected from waters over 25 ppt. Collections of eggs and larvae were made throughout the Gulf of Mexico at the peak of spawning from waters ranging in salinity from 20.7-36.6 ppt (Christmas et al. 1975; Table 1). As the larvae move inshore, they require low salinity waters to complete metamorphosis from the larval body form to the deeper bodied juvenile/adult form. June and Chamberlin (1959) observed that arrival in estuaries may be essential to the survival of larvae and their metamorphosis to juveniles based on food availability and lower salinities. Combs (1969) found that gonadogenesis occurred only in menhaden larvae that arrived in euryhaline, littoral habitats.

Table 1 Optimum salinity and temperature conditions for the egg and larval stages based on the habitat suitability indices (HSI) for gulf menhaden (Christmas et al. 1982) based on the lowest mean monthly winter value.

Life History Stage	**Salinity (ppt)**	**Temperature (°C)**
eggs/yolk-sac larvae (marine)	25-36	14-22
feeding larvae (marine)	15-30	15-25
feeding larvae/juveniles (estuarine)	5-13	5-20

The value of low salinity marsh habitat to juvenile gulf menhaden is well-known, but not well-documented. Only a few studies have looked at the dependence of nektonic menhaden on low salinity marshes as nursery habitat. Gunter and Shell (1958) reported that young menhaden enter upper marshes with salinities around 0.9 ppt at Grand Lake, part of the Mermentau River Basin, Louisiana. Copeland and Bechtel (1974) investigated the environmental parameters associated with several commercial and recreational species and reported juvenile gulf menhaden were most frequently collected in primary rivers and secondary streams at salinities ranging from 0-15 ppt. The authors point out that these low salinity waters supported the greatest numbers of juvenile menhaden (Copeland and Bechtel 1974). Likewise, Chambers (1980) found a similar relationship among young gulf menhaden and both freshwater and low salinity, brackish areas in the upper Barataria Basin of Louisiana.

Tolan and Nelson (2009) determined that, after examining a number of abiotic factors in three tidal streams in the Matagorda Bay estuary, salinity was the driving factor in determining fish assemblages. Juvenile and sub-adult gulf menhaden were found be the most abundant species in all three tidal creeks over the course of their study and community responses were based on the prevailing salinity regime more than dissolved oxygen.

Age compositions of commercial gulf menhaden port samples in recent decades have shown trends toward older fish (age-2s) in the landings (Figure 1, and see S27-DW05). Presumably, this might be a signal for relatively weak incoming year classes (age-1 fish). However, subsequent fishing years have seen relatively strong contributions from age-2 fish. Several hypotheses have been offered (Smith 2010) to explain these observations: 1) fishery contraction over time from the extremes (Florida and Texas) of the range of gulf menhaden where smaller and younger gulf menhaden tend to be more abundant, 2) redistribution over time of age-1 fish toward most 'inside' waters (due to marsh habitat loss) where they become unavailable to the fishery, and 3) a 'corralling effect' that hypoxic waters in the Gulf might have on the distribution of gulf menhaden (Smith 2010).

Recent observations by Haley et al. (2010) found larval and juvenile menhaden 79 river miles upstream on the Alabama River, near the Claiborne Lock and Dam. Although the authors did not record station salinities, the drought situation that occurred during their sampling season may have pushed the salt wedge, and consequently associated ichthyoplankton, farther upriver than during 'normal' years.

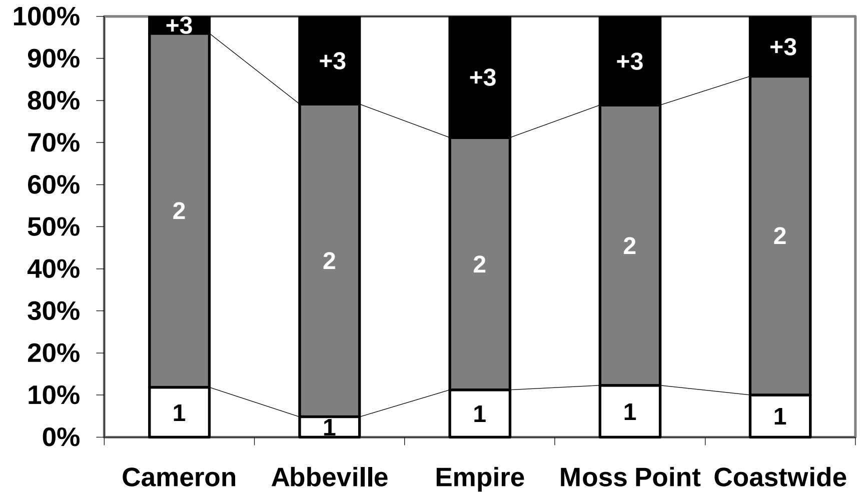

Figure 1 Age composition (1s, 2s, +3s) of gulf menhaden at Gulf of Mexico reduction ports for 2009 (n = 3,449; Smith 2010).

Temperature

Gulf menhaden occupy a wide range of habitats; therefore, temperature may be more critical to egg development than to juveniles and adults, although gulf menhaden are occasionally victims of large fish kills related to freeze events (Hildebrand and Gunter 1951, McEachron et al. 1994).

Turner (1969) collected eggs and larvae from stations off northern Florida at surface water temperatures ranging from 11.0°C (February) to 18°C (March). In southern Florida, samples were taken from 16°C (January) to 23°C (March), and in Mississippi Sound, temperatures ranged from 10°C (January) to 15°C (December).

Larval and juvenile menhaden have been collected in Gulf estuaries at temperatures ranging from 5-35°C (Table 1; Christmas and Waller 1973, Perret et al. 1971, Swingle 1971). Reintjes and Pacheco (1966) cited references indicating that larval menhaden may suffer mass mortalities when water temperatures are below 3°C for several days or fall rapidly to 4.5°C. Likewise, juvenile and adult menhaden suffer cold kills during periods of freezing winter conditions, especially in narrow or shallow tidal areas.

McEachron et al. (1994) documented one such cold kill in Texas. In December 1983, the entire Texas coast suffered a freeze that was one of the most severe in recorded history. Water temperatures dropped about 15°C in about 10 days to near 0.0°C and remained between 0.0-5.0°C for about seven days. Two more cold-kill events occurred in February of 1989 and December of 1989 which resulted in additional widespread fish kills. Coastwide, about 980,000 gulf menhaden died in 1983 and around 600,000 died in the two freezes of 1989. Gulf menhaden that succumbed to the cold ranged in size from 80-130 mm TL.

Cold kills of gulf menhaden are uncommon in the central northern Gulf. Overstreet (1974) suggests that:

> "Lack of proper acclimation probably determines why mass mortalities occur more frequently in Texas and Florida than in Mississippi. Fishes in Mississippi, living in water normally cooler than in Texas, are necessarily acclimated to lower temperatures. Consequently, a sudden drop to near-freezing levels would affect those fishes less."

Dissolved Oxygen (DO)

Large fish kills occur in summer as well, often resulting from plankton blooms and low dissolved oxygen (DO) or hypoxic conditions. Mass fish mortalities, which include gulf menhaden, attributed to low DO concentrations have occurred in most Gulf estuaries (Crance 1971, Christmas 1973, Etzold and Christmas 1979).

Postlarvae and juveniles are frequently killed by anoxic conditions in backwaters (e.g., dead-end canals) during summer. Hypoxic and anoxic conditions may also occur in more open estuarine areas as a result of phytoplankton blooms. In Louisiana, west of the Mississippi River delta, low DOs in nearshore Gulf waters may serve to concentrate schools of gulf menhaden closer to shore as they avoid hypoxic areas known as the 'dead zone'. The 'dead zone' results from increased levels of nutrient influx from freshwater sources coupled with high summer water temperatures, strong salinity-based stratification, and periods of reduced mixing (Justić et al. 1993). Most life history stages of gulf menhaden, from eggs to adults, occur inshore (i.e., inshore of the 10 fathom curve) of areas where historically the hypoxic zone 'sets up' by midsummer. Gulf menhaden appear to be only moderately susceptible to low DOs and probably move out of hypoxic areas, resulting in displacement rather than mortality.

Preliminary analyses of menhaden logbook data suggest that, during some years, exceptionally low catches of gulf menhaden off the central Louisiana coast may have been a result of hypoxic waters impinging upon nearshore waters in midsummer (Smith 2000). The close association that gulf menhaden have with estuaries during the summer tends to decrease the effects these offshore hypoxic areas have on the population.

Habitat Elasticity

O'Connell et al. (2004) examined the fish assemblages that occurred in the Lake Pontchartrain estuary from roughly 1950-2000 using museum specimens and collections. Over the 50 years of records, they found that, although the estuary had deteriorated substantially in environmental quality, gulf menhaden did not change in their frequency or position within the estuary while a number of other species had. Overall the assemblage shifted from a croaker-dominated complex to an anchovy-dominated complex, suggesting that gulf menhaden are very elastic in their ability to handle changing conditions, that is, short and long-term environmental changes (O'Connell et al. 2004).

References

Buff, V. and S. Turner. 1987. The Gulf Initiative. pages 784-792 *In*: Magoon et al. (eds). Coastal Zone 1987, Proceedings of the Fifth Symposium on Coastal and Oceans Management. May 26-29, 1987. Vol. 1.

Chambers, D.G. 1980. An analysis of nekton communities in the upper Barataria Basin, Louisiana. M.S. Thesis. University of Delaware. 286 pp.

Christmas, J.Y. 1973. Area description: Phase I. pages 1-71 *In*: J.Y. Christmas (ed). Cooperative Gulf of Mexico estuarine inventory and study, Mississippi. Gulf Coast Research Laboratory. Ocean Springs, Mississippi.

Christmas, J.Y. and R.S. Waller. 1975. Location and time of menhaden spawning in the Gulf of Mexico. Gulf Coast Research Laboratory, Ocean Springs, Mississippi. 20 pp.

Christmas, J.Y., J.T. McBee, R.S. Waller, and F.C. Sutter, III. 1982. Habitat suitability models: gulf menhaden. U.S. Department of Interior, Fish and Wildlife Service, FWS/OBS 82/10.23. 23 pp.

Combs, R.M. 1969. Embryogenesis, histology and organology of the ovary of *Brevoortia patronus*. Gulf Research Reports 2(4):333-434.

Copeland, B.J. and T.J. Bechtel. 1974. Some environmental limits of six Gulf coast estuarine organisms. Contributions in Marine Sciences 18:169-203.

Crance, J.H. 1971. Description of Alabama estuarine areas-cooperative Gulf of Mexico estuarine inventory. Alabama Marine Resources Bulletin 6:85 pp.

Etzold, D.J. and J.Y. Christmas (editors). 1979. A Mississippi marine finfish management plan. Mississippi-Alabama Sea Grant Consortium, MASGP-78-046. 36 pp.

Fore, P.L. and K.N. Baxter. 1972. Diel fluctuations in the catch of larval gulf menhaden, *Brevoortia patronus*, at Galveston Entrance, Texas. Transactions of the American Fisheries Society 101(4):729-732.

Gunter, G. and W.E. Shell, Jr. 1958. A study of an estuarine area with water-level control in the Louisiana Marsh. Proceedings of the Louisiana Academy of Sciences 21:5-34.

Haley, T.H., R.K. Bolton, and C.E. Johnston. 2010. Invasion of gulf menhaden in the Alabama River. Southeast Fisheries Council Proceedings 52:13-15.

Hildebrand, H.H., and G. Gunter. 1951. Destruction of fishes and other organisms on the south Texas coast by the cold wave of January 28- February 3, 1951. Ecology 32(4):731-736.

June, F.C. and J.L. Chamberlin. 1959. The role of the estuary in the life history and biology of Atlantic menhaden. Proceedings of the Gulf and Caribbean Fisheries Institute. p. 41-45.

Justić, D., N.N. Rabalais, R.E. Turner, and W.J. Wiseman, Jr. 1993. Seasonal coupling between riverborne nutrients, net productivity, and hypoxia. Marine Pollution Bulletin. 26(4):184-189.

Lassuy, D.R. 1983. Gulf menhaden, species profiles: life histories and environmental requirements (Gulf of Mexico). U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/11.2, U.S. Army Corps of Engineers, TREL-82-4. 13 pp.

Lindall, W.N., Jr. and C.H. Saloman. 1977. Alteration and destruction of estuaries affecting fishery resources of the Gulf of Mexico. Marine Fisheries Review 39(9):1-7.

McEachron, L.W., G.C. Matlock, C.E. Bryan, P. Unger, T.J. Cody, and J.H. Martin. 1994. Winter mass mortality of animals in Texas bays. Northeast Gulf Science 13(2):121-138.

Minello, T.J. and J.W. Webb, Jr. 1997. Use of natural and created *Spartina alterniflora* salt marshes by fishery species and other aquatic fauna in Galveston Bay, Texas, USA. Marine Ecology Progress Series 151:165-179.

O'Connell, M., R. Cashner, and C. Schieble. 2004. Fish assemblage stability over fifty years in the Lake Pontchartrain estuary; Comparisons among habitats using canonical correspondence analysis. Estuaries and Coasts 27(5):807-817.

Overstreet, R.M. 1974. An estuarine low-temperature fish-kill in Mississippi, with remarks on remarks on restricted necropsies. Gulf Coast Research Reports 4(3):328-350.

Perret, W.S., W.R. Latapie, J.F. Pollard, W.R. Mock, G.B. Adkins, W.J. Gaidry, and C.J. White. 1971. Fishes and invertebrates collected in trawl and seine samples in Louisiana estuaries. Section I. pages 39-105 *In*: Cooperative Gulf of Mexico estuarine inventory and study. Phase IV, Biology. Louisiana Wildlife and Fisheries Commission, Baton Rouge, Louisiana.

Reintjes, J.W. 1970. The gulf menhaden and our changing estuaries. Proceedings of the Gulf and Caribbean Fisheries Institute 22:87-90.

Reintjes, J.W. and A.L. Pacheco. 1966. The relation of menhaden to estuaries. *In*: R.F. Smith, A.H. Swartz, and W.H. Massman (eds). A symposium on estuarine fisheries. American Fisheries Society Special Publication 3:50-58.

Smith, J.W. 2010. Review of the 2009 Gulf Menhaden Fishery, and Forecast for the 2010 Menhaden Fisheries. A Presentation to the Gulf States Marine Fisheries Commission's State Federal Fisheries Management Committee's Menhaden Advisory Committee. March 8, 2010. Orange Beach, Alabama.

Smith, J.W. 2000. Distribution of catch in the gulf menhaden, *Brevoortia patronus*, purse seine fishery in the northern Gulf of Mexico from logbook information: Are there relationships to the hypoxic zone? pages 311-319 *In:* Rabalais, N.N. and R.E. Turner (eds). Coastal hypoxia: consequences for living resources and ecosystems. American Geophysical Union.

Swingle, H.A. 1971. Biology of Alabama's estuarine areas-cooperative Gulf of Mexico estuarine inventory. Alabama Marine Resources Bulletin 5:1-123.

Tolan, J. and J. Nelson. 2009. Relationships among nekton assemblage structure and abiotic conditions in three Texas tidal streams. Environmental Monitoring and Assessment 159(1):15-34.

U.S. Environmental Protection Agency. 1992. Report on the Status and Trends of Emergent and Submerged Vegetated Habitats of Gulf of Mexico Coastal Waters, U.S.A. Gulf of Mexico Program, Habitat Degradation Subcommittee. T. Duke and W.L. Kruczynski (eds.). John C. Stennis Space Center, MS. EPA 800-R-92-003, 161 pp.