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Species profile of Atlantic thread herring,

Opisthonema oglinum (Lesueur 1818)

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and

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INTRODUCTION

The purpose of this report is to present a summary of the existing biological, ecological, and fisheries information that may be useful in evaluating the expansion of the commercial exploitation of the Atlantic thread herring in the Gulf of Mexico. Published and unpublished data mainly from the southeastern United States owing to the present commercial fishery in this area were used.

NOMENCLATURE AND TAXONOMY

Current scientific name - Opisthonema oglinum (Lesueur 1818)
Preferred common name --- Atlantic thread herring
Other common names ------ Hairyback, shad herring, bristle herring
Class ---------- Osteichthyes
Order ---------- Clupeiformes
Family ---------- Clupeidae

MORPHOLOGY AND IDENTIFICATION (from Hildebrand 1963 and Whitehead 1978)

Thread herring can be distinguished from the other marine clupeids occurring in the same area by the filamentous extension of the last dorsal ray (Fig. 1). Fin ray counts are as follows: dorsal 17-21; anal 21-25; pectoral 15-17; pelvic 8. Ventral scutes are 32-36 in number and scales 43-50. Maximum size is 30 cm; it commonly reaches 20-25 cm. The body is fusiform and moderately compressed with belly scutes forming a distinct keel (Fig. 1). Gill rakers are fine and numerous, increasing with the size of the fish. No hypo-maxilla is present. The dorsal fin is centrally located on the body with the pelvic fin lying below the dorsal fin. The anal fin is well behind the dorsal fin. The back and upper sides are blueish green, sometimes with dark horizontal lines and the rest of the body is silvery. A dark shoulder spot lies behind the gill cover and is about the size of the pupil. Fins are mainly translucent with dark tips on the dorsal and caudal lobes.

DISTRIBUTION AND RANGE

Thread herring are widely distributed in the waters of the western Atlantic (Fig. 2) from the Gulf of Maine to southern Brazil (Berry and Barrett 1963). It is a tropical and subtropical marine species (Hildebrand 1963) that is most abundant in coastal waters within 20 fathoms (Klima 1971). Thread herring appear to be more concentrated south of Cape Hatteras, North Carolina and in the eastern Gulf of Mexico than elsewhere (Reintjes 1979). It has been caught throughout the entire Gulf of Mexico during exploratory fishing cruises by the NMFS. Catches have been made from the Mississippi delta to the east coast of Florida in every season of the year and off Louisiana and Texas in every month except June, July, and December (Klima 1971). The major areas of

concentration and commercial fishing grounds in the Gulf of Mexico are shown in Figure 3.

SEASONAL AND MIGRATORY MOVEMENTS

Adult thread herring generally follow a seasonal north-south and inshore-offshore migration pattern along the west coast of Florida. Schools of fish move south in the fall and concentrate in the winter within 10 miles of shore (Kinnear and Fuss 1971). Fall migration along the south Atlantic coast was reported to occur at a rate of 6 to 7 miles per day from Beaufort, North Carolina to Fernandina Beach, Florida (Pristas and Cheek 1973). Houde (1977) found thread herring eggs and larvae over the inner continental shelf from April to August at depths <30 m (98 ft) within 50 km (31 mi) off the west Florida coast. Juveniles were present in the same areas as adults and were found in estuarine waters during July and August. Adults and juveniles form schools near the surface and generally remain in schools throughout their life. School size increases in the fall prior to migration farther offshore (Benson 1982). Thread herring use the entire water column, although off Fort Myers, Florida, they appear to be concentrated in the upper 10 feet. A decreasing catch per unit of effort has been found with increasing depth (Kinnear and Fuss 1971).

BIOLOGY

Spawning areas and season

Thread herring spawn over a wide area in the Gulf of Mexico and south Atlantic. They spawn over a period of several months. Collections of eggs and larvae from the eastern Gulf of Mexico by Houde (1977) indicated that spawning extended from February to September with a peak from April to August. Most spawning was reported within 50 km offshore over the inner continental shelf at depths less than 30 m, and virtually all spawning occurred within 100 km offshore at depths less than 50 m (Fig. 4). Houde also reported that the primary spawning area was located in coastal waters from Tampa Bay to just south of Fort Myers, Florida (Fig. 5). Prest (1971) indicated an April through July season for thread herring in the St. Petersburg, Florida area. Most of the fish in the Fort Myers area were reported by Fuss et al. (1969) to spawn from March through August with a peak in June. The spawning cycle in the northern Gulf of Mexico was similar (Kemmerer 1977). Thread herring larvae were noted off south Texas only during August and September (Finucane et al. 1978) which would indicate a summer spawning cycle for that area. Hildebrand (1963) reported that they also spawn off Beaufort, North Carolina, in May and June. Herrema et al. (1985) collected thread herring in spawning condition off the St. Lucie, Florida, power plant from February through May and in August.

Frequency of spawning

Spawning frequency for thread herring is not well known in United States waters. Preliminary data on oocyte stages from fish collected off northwest Florida indicate that they may be multiple spawners (L.A. Collins pers. comm.). Brazilian thread herring are reported to spawn once a year (Mota Alves and Sawaya 1975). Examination of oocytes from fish from Biscayne Bay, Florida indicates only one primary modal group (Martinez 1972).

Age and size at first maturity

The size at first maturity was determined by Berkeley and Houde (1984) from ripe or ripening gonads and was based on the gonad index of thread herring collected from the northeastern Gulf of Mexico. They indicated that females first reached maturity at 145 mm FL and males at 125 mm FL. Age of these fish would probably be 1+ or 2+. Some south Florida females were sexually mature at 135 mm FL (Prest 1971) when they were 1 to 3 years old (Fuss et al. 1969). Histological examination of Brazilian thread herring gonads by Mota Alves and Sawaya (1975) showed the minimum size at first maturity for males to be 100 mm, for females 110 mm FL, and that 50% of these fish were mature at 110-115 mm.

Fecundity

Little information is available from the literature on thread herring fecundity. Estimates of 13,638 to 50,339 eggs were given by Prest (1971) for 48 fish collected off St. Petersburg, Florida. These fish had a mean fecundity of 30,922. Fecundity estimates for 9 thread herring from Biscayne Bay ranged from 34,617 to 67,888 eggs. These fish were 138 to 175 mm SL and weighed 54 to 109 g. The fecundity-weight relationship was expressed as $F = 663W - 5{,}694$ (Martinez 1972), where F = number of eggs and W = weight in grams.

Early life history

The egg and larval development of thread herring (Fig. 6) has been described from wild-caught eggs and laboratory-reared larvae by Richards et al. (1974). Eggs ranged from 1.10 to 1.28 mm in diameter with a single oil globule. Larvae ranged from 4 to 24 mm SL. Eggs and early larval stages are pelagic. Eggs hatch in less than 24 hours at temperatures of 25° to 30°C (Houde 1977). An excellent key to the eggs and larvae of Gulf of Mexico clupeid fishes is given by Houde and Fore (1973).

Recruitment

Lengths of thread herring varied on a seasonal basis, which reflect individual growth and recruitment into the fishery. Recruitment probably takes place at about 105 mm FL during the late spring or early summer when the fish are age I (Houde et al. 1983). In the early Florida purse seine fishery, recruitment occurred at 100 mm or larger (Reintjes 1979).

Age and growth

The most comprehensive study on age and growth of thread herring was completed by Houde et al. (1983) from collections of fish sampled from the northeastern Gulf of Mexico during 1981-82. Age was determined from otolith marks and ranged from 0 to 6+ for fish from 115-225 mm FL with a mean weight of 71.8 g. A large part of the total growth occurred during the first year when more than 50% of the fish were age 1+. About 5-6% of the catch were age 4+ or older. The von Bertalanffy growth model for thread herring was $L_t = 215.50(1-e^{-0.38(t+0.98)})$ where L = length at time and t = time in years. Fast growth combined with high mortality indicates that this fish could be exploited at a young age. Estimates of growth rates for Atlantic fish were reported by Hildebrand (1963) to be about 35 to 60 mm during their first year and 90 to 120 mm by the end of their second summer.

Size and age

Age and mean size classes (fork lengths) were computed for thread herring from the Gulf of Mexico by Houde et al. (1983). They reported the following age and size classes: Age I (108.2 mm); Age II (152.4 mm); Age III (171.0 mm); Age IV (179.5 mm); Age V (186.8 mm) and Age VI (202.7 mm). The maximum size of this fish was reported as 300 mm total length by Hildebrand (1963). Reintjes (1979) believes a maximum age of 7 or 8 years is reasonable.

Length-weight relationship

The length-weight relationships were calculated for thread herring collected off northwest Florida by Berkeley and Houde (1984). The length-weight relationship for females was $W = 7.78 \times 10^{-6}\ FL^{3.15}$ and, for males it was $W = 8.03 \times 10^{-6}\ FL^{3.15}$ where W = weight in grams and FL = fork length in mm. A Venezuelan study by Etchevers (1975) showed the following length-weight relationship: $P = 1.07 \times 10^{-5}(LT)^{2.9615}$ where P is weight in grams and LT is total length in mm. Reintjes (1979) calculated the length-weight relationship of both sexes (225 fish) ranging from 33 to 190 mm FL as $W = 1.435(FL)^{3.037}$ for Atlantic coast fish, where W = weight in grams and FL = fork length in mm.

Mortality

Thread herring appears to have a high mortality rate. Berkeley and Houde (1984) computed the instantaneous mortality rate and estimated that the annual mortality rate was about 60% which corresponds to a survival rate of 40%. Based on otolith analysis about 70% of the commercial catch in the northern Gulf of Mexico consisted of 2-year old fish and only about 3% reached their third year of life. Scale samples taken from commercial catches in the northern Gulf of Mexico also indicated that thread herring do not live very long (C. M. Roithmayr pers. comm).

Food habits

Few studies on the food habits of larval and juvenile thread herring have been reported in the literature. Kinch (1979) did examine stomachs of 167 juveniles (26 to 75 mm) from a canal near Marco Island, Florida and noted that they were non-selective feeders with a high proportion of mud, detritus, and organic debris in the gut. Carr and Adams (1973) examined the stomachs of 56 juveniles (21 to 40mm SL) near Crystal River, Florida, and found 42 to 76% veliger larvae, and 23 to 33 % detritus.

Adult thread herring feed on a variety of phytoplankton and zooplankton which are strained from the water by their numerous gill rakers. Copepods were the preferred food of these fish from Chesapeake Bay (Hildebrand 1963). Dominant food organisms from fish collected off Fort Myers, Florida included copepods, pelecypods, gastropods, and larval stages of barnacles together with plant detritus, fish scales and sediment (Fuss and Kelly 1968). In the Caribbean, Randall (1967) found the major prey items in the stomachs of 23 thread herring (127 to 177 mm SL) to be copepods, 26.6%; polychaetes, 22.4%; and shrimps and shrimp larvae, 17.1% by volume. The diet of Brazilian thread herring consisted of crustaceans, and mollusks with microscopic algae, planktonic eggs and occasional rotifers, fishes, annelids and insects (Furtado-Ogawa 1970). Another Brazilian food study by Filho (1979) noted that their main diet consisted of crustacean larvae, copepods and diatoms together with sand and small amounts of plant material, polychaetes and fish.

Predators

Thread herring is an important prey species that is eaten by a variety of carnivorous fish, sea birds, and marine mammals (Reintjes 1979). Predator species have not been identified for larval fish. Thread herring comprise about 1% by number and volume of food consumed by juvenile king mackerel (Naughton and Saloman 1981).

Mackerel, bluefish, and crevalle jack have shown a preference for eating schooling fish such as herrings. Beaumariage (1973) found that 59% of the food eaten by king mackerel in Florida waters consisted of thread herring and scaled sardine. Menezes (1969) found thread

herring to be dominant in king mackerel stomachs sampled off Brazil. A similar food preference was noted by DeVane (1978) in Onslow Bay, North Carolina where they occurred in 28% of the stomachs of king mackerel sampled during the spring and summer. A more recent study by Saloman and Naughton (1983a) showed that thread herring were present in the stomachs of king mackerel collected in five out of six areas in the coastal waters of the Gulf of Mexico and south Atlantic. They noted that the highest frequency of occurrence (6.8%) and total volume (7.8%) of thread herring were found in stomachs of king mackerel collected off Louisiana.

A study on the food preference of Spanish mackerel, by Saloman and Naughton (1983b) noted that these fish are a major predator on small schooling fish such as engraulids, clupeids, and carangids in the Gulf of Mexico and south Atlantic. According to Manooch (1984), thread herring, menhaden, mullet, anchovies, shrimp, and squid are favorite foods of Spanish mackerel. Stomachs of this fish examined off south Florida by Klima (1959) indicated that they feed on clupeids, which included thread herring. Examination of the food eaten by Brazilian mackerel showed that thread herring was the dominant prey (Menezes 1970).

Bluefish feed on a variety of fish including thread herring along the Atlantic coast (Wilk 1977). Bluefish prefer schooling coastal fishes in the Gulf of Mexico and south Atlantic. Thread herring were a prey item eaten by bluefish off southeast Florida, south Florida, and northwest Florida (Naughton and Saloman 1984). Another predator, the crevalle jack, was reported by Saloman and Naughton (1984) to have eaten thread herring from Florida waters.

Schooling behavior

Schools of thread herring generally prefer the shallow coastal waters. Schools are seldom found in water depths over 18 m and are usually in water 11 m or less. Schools occur most frequently in the upper 3 m of the water column. Thread herring exhibit migratory behavior in the eastern Gulf and along the eastern U.S. coast, moving north in spring, and south in fall (Kinnear and Fuss 1971, Pristas and Cheek 1973). During the winter, thread herring schools are concentrated within 16 km of the shore along the lower west coast of Florida. Schools of juveniles are often mixed with schools of juvenile scaled sardine, and Spanish sardine (Fuss et al. 1969, Springer and Woodburn 1960). Schools of thread herring are known for their speed and agility, making them often difficult to encircle (Butler 1961).

Environmental relationships

Habitat preferences

Satellite studies (Kemmerer 1977) in the northern Gulf of Mexico indicate that thread herring prefer warmer water than menhaden (29.8°C as

compared to 28.5°C). Thread herring are also found in bluer water with greater visibilities (Secchi disc visibility of 3.81 m as compared to 1.06 m for menhaden) and in waters that are more saline.

Temperature

Thread herring are subtropical or tropical in their temperature preferences. During the summer, adult occurrence peaks at water temperatures of 26 to 29°C, and during the winter they are absent at temperatures below 17°C off southeast Florida (Kinnear and Fuss 1971). Seasonal comparisons of thread herring catches by trawling in the Gulf of Mexico from 1950 to 1985 as related to surface and bottom temperatures are given in Tables 1 and 2. Juveniles (40 to 150 mm FL) occurred at temperatures ranging from 5.0 to 34.9°C in Louisiana waters (Perret et al. 1971) and in estuaries along the west coast of Florida at 5 to 36°C (McNulty et al. 1974). During purse seine operations in the eastern Gulf of Mexico in 1981-82, they were captured at temperatures ranging from 23 to 28°C with a mean of 25.9°C (C. M. Roithmayr pers. comm.). Larvae and eggs in the same area were collected at a surface temperature of 18.5 to 30.9°C and 22.5 to 30.3°C, respectively. The greatest abundance of larvae occurred at 25 - 30°C. The occurrence of thread herring eggs and larvae (<5 mm) in relation to surface temperatures off the west coast of Florida is given in Figure 7.

Salinity

Thread herring generally prefer high salinities. Adult fish collected off the southwest Florida coast were most abundant at 32 to 34°/oo (Kinnear and Fuss 1971). In the eastern Gulf of Mexico thread herring were captured during purse seine operations at salinities from 35 to 36 °/oo (C. M. Roithmayr pers. comm.). Juveniles in coastal and estuarine waters of Louisiana occurred at salinities ranging from 5°/oo to 29°/oo, but were most abundant above 15°/oo (Perret et al. 1971). Larvae in the eastern Gulf of Mexico (Fig. 7) were collected at surface salinities of 27.3 to 36.9°/oo and were most abundant at 35.0 to 36.5°/oo (Houde 1977).

STOCKS

Sex ratios

Early studies of thread herring indicated a cyclic fluctuation in the sex ratio of males to females on a seasonal basis. In the summer fishery off St. Petersburg Beach, a ratio of about 1 male to 5 females was reported while the winter population off Fort Myers was about 1 to 1 (Fuss 1968). The low percentage of males to females during the spawning season suggests that some males migrate from the spawning area (Reintjes 1979). Samples of thread herring taken by Houde et al. (1983) from the

bait fishery off northwest Florida indicate a predominance of males. During 1981, the male to female ratio was 1.6:1 and during 1982 it was 1.75:1.

Stock identification

Little information is available on stocks of thread herring. Some preliminary electrophoretic analysis suggests that Gulf of Mexico fish may be separate from the east coast fish (A. G. Johnson, pers. comm.). Fish tagged along the southeastern Atlantic coast were not recovered in the Gulf of Mexico (Pristas and Cheek 1973).

Stock size

Houde (1977) reported an adult biomass of 108,000 to 372,000 metric tons in the eastern Gulf, based on egg abundances, giving a potential yield of 27,500 to 186,200 metric tons. If thread herring are equally abundant throughout the gulf, these figures may be expanded by a factor of 3 to 4 to estimate total gulf yield.

COMMERCIAL FISHERIES

History

Early efforts to fish thread herring commercially were first attempted in the St. Petersburg, Florida area during 1958. Lampara and single-boat purse seine gear produced good catches. However poor weather, transportation problems, and inadequate reduction facilities, caused the fishery to be discontinued in 1960 (Butler 1961). During 1967, a reduction plant was located at Charlotte Harbor near Fort Myers, Florida (Fuss 1968). This purse seine fishery produced about 15,000 tons of thread herring in 1967 and 1968. Legislation prohibiting purse seining of food fish in state waters essentially ended this fishery (Reintjes 1979).

Few conflicts exist among domestic fishermen in this fishery. Often fish houses put catch limits on boats fishing for them. If demand warranted, most dealers probably could at least double their present production if handling and storage facilties were expanded (Reintjes 1979).

Fishing areas and ports

The fishing grounds for the single boat purse seine vessels are shown in Figure 3. Thread herring are fished in the coastal waters between the Mississippi River Delta and Pascagoula, Mississippi; the Florida panhandle between Pensacola and Apalachicola, Florida; and the

west-central Florida coast between St. Petersburg and Sarasota. The principal ports of landing include Yscloskey, Louisiana; Pascagoula, Mississippi; and in Florida the ports of Panama City, Port St. Joe, and Cortez (Roithmayr 1983). The haul seine fishery is located mainly in the Florida panhandle between Port St. Joe and Pensacola. The fishery is seasonal and extends from March through November within about 10 km of the coast (Reintjes 1979).

Vessels, types and gear

The number of boats fishing for thread herring and other coastal pelagic fish in the Gulf of Mexico varies between seasons and probably includes about 12 purse seine boats and about an equal number of haul seine boats. The typical purse seine boats using power blocks are 45 to 65 feet in length. The nets are about 750 yards long and 45 to 50 feet deep. Mesh size is usually about 1 inch stretch mesh. Haul seine boats vary in size from about 23 to 50 feet in length. The beach seine net is about 400 to 750 yards long with a mesh size of 1 inch stretch in the pocket (Reintjes 1979). In the northern Gulf of Mexico, purse seiners fish nets about 550 yards long and 96 feet deep. A crew of five or six is usually required to purse the net. Some recently designed purse seine boats can fish in waters to a depth of 210 feet. These vessels have a 365 horsepower, eight cylinder, diesel engine that uses about 16 gallons of fuel per hour and have a holding capacity of 50 tons (Roithmayr 1983).

Detection and capture

In purse seine operations, a spotter plane is often used to locate the fish and to direct the boat while the school of fish is pursed. Some boats use visual observations and others use sonar to locate fish. Haul seiners usually work along the coast and intercept schools as they move down the beach. Once the school has been detected standard purse seine procedures are followed. The seiner runs in a circle after first attaching one end of the seine net to an outboard-powered skiff. When the two vessels meet the circle is completed. A large lead weight is then dropped overboard to insure that the net stays on the bottom and to keep the net near the boat. The purse rings and leadline are hauled in by the power block and the fish are loaded aboard by means of a large brail or dipnet.

Commercial landings

Commercial landings of thread herring from the west coast of Florida from 1967 to 1983 are given in Table 3. Prior to 1967, thread herring were included in the menhaden landing statistics. This fishery fluctuated over the years and operated almost entirely within state waters. The landing statistics for Florida in 1967 and 1968 reflect the increased purse seining effort during these years off the lower and

central west coast. Most thread herring are now caught from the Florida panhandle between Port St. Joe and Pensacola where they are used mainly for bait and pet food. The low catches of thread herring in 1977 and 1978 are apparently due to their scarcity in the Florida panhandle during those years (Reintjes 1979). Some thread herring are caught by the shrimp trawl fishery in the north-central and northwestern Gulf of Mexico but are discarded. In the northern gulf the menhaden fleet may catch 20,000 to 50,000 m t which are included in the menhaden landing statistics. These fish are reduced to meal and oil. Small catches of thread herring are made by commercial handline fishermen as bait for king mackerel and other species (Reintjes 1979). Mean catch rates for thread herring in lbs/hr from trawling by research vessels in the Gulf of Mexico are shown in Figures 8-11.

Processing techniques

Thread herring caught by purse or haul seines are iced aboard the boat after capture. At the processing plant they are then boxed and frozen for bait. A more recent development in use by some purse seiners from the Port St. Joe area now includes the use of a salt water (brine) system to improve the quality of the catch by reducing spoilage and physical damage. A brine spray refrigerated seawater system is used. This allows the catch to be quickly chilled and permits extended fishing trips. The quality of this product was judged superior to regular iced fish (G. Raffield pers. comm.).

Composition and nutritional value

Canned thread herring have a good potential for human food consumption because of their relatively high levels of unsaturated fatty acids and a predominance of triglycerides as a lipid class which is increased in a fish oil packing medium. Consumption of this product may reduce the serum cholesterol and triglyceride levels in some people. Protein and lipid concentrations are also increased by canning (Hale and Brown 1983).

Thread herring are not generally used as a fresh or frozen food in domestic markets because of their small size, bony structure and readily oxidizable fat content. The nutritional quality of the protein in raw thread herring and the proximate composition of their amino acid profile indicates that the quality of whole gutted fish would be acceptable as a food source (Sidwell and Ambrose 1975). Hale (1974) found the proximate composition of thread herring from the gulf to be: protein, 20.65%; fat, 3.22%; moisture, 73.23% and ash, 3.68%. Additional data on the chemical and nutritional composition of whole fish and raw muscle is given by Sidwell (1981).

Baseline information on the occurrence of chemical contaminants such as hydrocarbons, chlorinated pesticides, and polychorinated biphenols

(PCB) is needed to provide early warning of potential seafood safety problems and help in evaluating interactions of multiple contaminants which could influence the overall quality of the fish.

Markets

The south Atlantic and Gulf of Mexico have some potential for additional markets for thread herring. The main market for this fish is food for aquatic birds and animals in zoos and as an inexpensive bait for recreational and commercial fishermen (M. E. Smith pers. comm.). If sufficient quantities are available and cost is low, it could be utilized as a substitute for menhaden. Thread herring as a canned product could also substitute for canned sardines for human consumption. Large development and investment efforts will be necessary to get canned products of this fish into foreign or domestic markets. Port facilities with freezing and canning facilities will need to be expanded to support any additional fishery. The export market for thread herring may have limitations. Fish from the Gulf of Mexico are not large enough to satisfy the European market. All attempts to introduce this fish in the orient have failed (M. E. Smith pers. comm.). Of the developing African nations, Nigeria appears to have the best potential for export of this fish. Additional research on processing, packaging, and storage of frozen fish for a high quality export market is needed. Other products such as smoked, salted, dried, and pickled fish should also be explored for domestic as well as export use. Additional market research will be required to provide information on market potentials and to help insure an economically stable fishery.

RECREATIONAL FISHERY

Thread herring are bought or caught for use as bait by recreational fishermen. The economic and biological impact of this recreational fishery is unknown since no documentation of catches and bait prices is available.

INFORMATION NEEDS

Biology

There is a lack of information on stocks and their geographic and seasonal distribution pattern throughout the entire range of this species. The role of thread herring in predator-prey dynamics needs to be better understood. Information is needed on all phases of life history, food habits, movements, and migration patterns. Schooling behavior and schooling characteristics need to be defined. Probably the most important needs are to determine population age structure, growth rates, recruitment and mortality rates.

Fisheries

Better catch and effort data are needed, especially on commercial and recreational bait catches, industrial trawl fishery catches, menhaden purse seine catches of thread herring, and shrimp fishery discards. Monitoring of the fishery as expansion occurs is needed for size, age, and sexual maturity. Surveys should be expanded to determine abundance and distribution.

LITERATURE CITED

BEAUMARIAGE, D.S. 1973. Age, growth, and reproduction of king mackerel, Scomberomorus cavalla, in Florida. Fla. Mar. Res. Publ. 1, 45 p.

BENSON, N.G. 1982. Life history requirements of selected finfish and shellfish in Mississippi Sound and adjacent areas. U.S. Fish Wildl. Serv., FWS/OBS-81/51, 97 p.

BERKELEY, S.A. and E.D. HOUDE. 1984. Age, growth and mortality of coastal herrings in the eastern Gulf of Mexico. Final report to the Gulf and So. Atl. Fish. Devel. Found., Inc., Proj. #21-12-32272, pag. var.

BERRY, F.H. and I. BARRETT. 1963. Gillraker analysis and speciation in the thread herring genus Opisthonema. Inter-Am. Trop. Tuna Comm. Bull. 7(2):111-190.

BUTLER, J.A. 1961. Development of a thread herring fishery in the Gulf of Mexico. Commer. Fish. Rev. 23(9):12-17.

CARR, W.E. and C.A. ADAMS. 1973. Food habits of juvenile marine fishes occupying seagrass beds in the estuarine zone near Crystal River, Florida. Trans. Amer. Fish. Soc. 102(3):511-540

DEVANE, J.C., Jr. 1978. Food of king mackerel, Scomberomorus cavalla, in Onslow Bay, North Carolina. Trans. Am. Fish. Soc. 107(4):583-586.

ETCHEVERS, S.L. 1975. La relacion longitud-peso en 7 peces de interes comercial en nororiente de Venezuela. Bol. Inst. Oceanogr. Univ. Oriente 14(2):243-246.

FILHO, A.D.V. 1979. Estudo ecologico da regiao de Itamaraca, Pernambuco, Brasil. IV. Alimentacao da sardinha bandeira, Opisthonema oglinum (Le Sueur, 1817), no Canal de Santa Cruz. Trab. Oceanogr. Univ. Fed. P.E., Recife 14:105-116.

FINUCANE, J.H., L.A. COLLINS, L.E. BARGER and J.B. MCEACHRAN. 1978. Ichthyoplankton/mackerel eggs and larvae. NOAA final rep. to BLM, Environmental studies of the South Texas outer continental shelf, 1977. SEFC, Galveston Lab., 504 p.

FURTADO-OGAWA, E. 1970. Alimentacao da sardinha-bandeira, Opisthonema oglinum (Le Sueur), no estado do Ceara. Arq. Cien. Mar 10(2):201-202.

FUSS, C.M., Jr. 1968. The new thread herring fishery in eastern Gulf of Mexico. Commer. Fish. Rev. 30(6):36-41.

FUSS, C.M., Jr. and J.A. KELLY, Jr. 1968. Biology of thread herring. In: Sykes, J.E. Report of the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida, fiscal year 1967. U.S. Fish Wildl. Serv. Circ. 290:14-15.

FUSS, C.M., Jr., J.A. KELLY, Jr., and K.W. PREST, Jr. 1969. Gulf thread herring: aspects of the developing fishery and biological research. Proc. Gulf Caribb. Fish. Inst. 21:111-125.

HALE, M.B. 1984. Proximate chemical composition and fatty acids of three small coastal pelagic species. Mar. Fish. Rev. 46(1):19-21.

HALE, M.B. and T. BROWN. 1983. Fatty acids and lipid classes of three underutilized species and changes due to canning. Mar. Fish. Rev. 45 (4-6):45-48.

HERREMA, D.J., B.D. PEERY, N. WILLIAMS-WALLS and J.R. WILCOX. 1985. Spawning periods of common inshore fishes of the Florida east coast. Northeast Gulf Sci. 7(2):153-155.

HILDEBRAND, S.F. 1963. Family Clupeidae. In: Bigelow, H.B. Fishes of the western North Atlantic. Sears Found. Mar. Res., Yale Univ., Mem. I, pt. III:257-454.

HOUDE, E.D. 1977. Abundance and potential yield of the Atlantic thread herring, Opisthonema oglinum, and aspects of its early life history in the eastern Gulf of Mexico. Fish. Bull. 75(3):493-512.

HOUDE, E.D. and S.A. BERKELEY. 1982. Gulf of Mexico "coastal herrings." Summary doc. prep. for the Southeast Fisheries Center Stock Assessment Workshop, Miami, FL, 3-7 Aug. 1982. UMCEES Ref. No. 82-102 CBL, 17 p.

HOUDE, E.D. and P.L. FORE. 1973. Guide to identity of eggs and larvae of some Gulf of Mexico clupeid fishes. Fla. Dep. Nat. Resour. Mar. Res. Lab. Leafl. ser. IV-Immature vertebrates, pt. 1(23), Pisces, 15 p.

HOUDE, E.D., C. GRALL, and S.A. BERKELEY. 1983. Population parameter estimates for three shoaling pelagic fishes in the eastern Gulf of Mexico. Int. Counc. Explor. Sea, Pelagic Fish Comm., C.M. 1983/H:43, 11 p.

KEMMERER, A.J. 1977. LANDSAT menhaden and thread herring resources investigation. Southeast Fisheries Center Contrib. no. 77-16F; MARMAP Contrib. no. 145, pag. var.

KINCH, J.C. 1979. Trophic habits of the juvenile fishes within artificial waterways—Marco Island, Florida. Contrib. Mar. Sci. 22:77-90.

KINNEAR, B.S. and C.M. FUSS, Jr. 1971. Thread herring distribution off Florida's west coast. Commer. Fish. Rev. 33(7-8):27-39.

KLIMA, E.F. 1959. Aspects of the biology and the fishery for Spanish mackerel, Scomberomorus maculatus (Mitchill), of southern Florida. Fla. Board Conserv. Mar. Res. Lab. Tech. Ser. 27, 39 p.

KLIMA, E.F. 1971. Distribution of some coastal pelagic fishes in the western Atlantic. Commer. Fish. Rev. 33(6):21-34.

MANOOCH, C.S., III. 1984. Fisherman's guide—Fishes of the southeastern United States. N.C. State Mus. Nat. Hist., Raleigh, N.C., 362 p.

MARTINEZ, S. 1972. Fecundity, sexual maturation and spawning of scaled sardine (Harengula pensacolae). M.S. Thesis, Univ. Miami, 51 p.

MCNULTY, J.K., et al. 1974. Data of the biology phase, Florida portion, Cooperative Gulf of Mexico Estuarine Inventory. U.S. Natl. Mar. Fish. Serv. Data Rep. 95, 229 p.

MENEZES, M.F. 1969. Alimentacao da cavala, Scomberomorus cavalla (Cuvier), em aguas costeiras do estado do Ceara. Arq. Cien. Mar. 9(1):15-20.

MENEZES, M.F. 1970. Alimentacao da serra Scomberomorus maculatus (Mitchill), em aguas costeiras do estado do Ceara. Arq. Cien. Mar. 10(2):171-176.

MOTA ALVES, M.I. and P. SAWAYA. 1975. Sobre a reproducao da sardinha-bandeira, Opisthonema oglinum (Le Sueur), na costa do estado do Ceara (Brasil). Arq. Cien. Mar 15(1):19-28.

NAUGHTON, S.P. and C.H. SALOMAN. 1981. Stomach contents of juveniles of king mackerel (Scomberomorus cavalla) and Spanish mackerel (S. maculatus). Northeast Gulf Sci. 5(1):71-74.

NAUGHTON, S.P. and C.H. SALOMAN. 1984. Food of the bluefish (Pomatomus saltatrix) from the U.S. south Atlantic and Gulf of Mexico. U.S. NOAA Tech. Memo. NMFS-SEFC-150, 37 p.

PERRET, W.S., et al. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase I, Area description and Phase IV, Biology. Section I: Fishes and invertebrates collected in trawl and seine samples in Louisiana estuaries. La. Wildlife and Fish. Comm., New Orleans, pp. 39-111.

PREST, K.W. 1971. Fundamentals of sexual maturation, spawning, and fecundity of thread herring (Opisthonema oglinum) in the eastern Gulf of Mexico. Mimeo, Natl. Mar. Fish. Serv., St. Petersburg Beach, FL.

PRISTAS, P.J. and R.P. CHEEK. 1973. Atlantic thread herring (Opisthonema oglinum)-movements and population size inferred from tag returns. Fish. Bull. 71(1):297-301.

RANDALL, J.E. 1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr. Miami 5:665-847.

REINTJES, J.W. 1979. Coastal herrings and associated species; a profile of species or groups of species, their biology, ecology, current exploitation with economic and social information. Southeast Fisheries Center, Natl. Mar. Fish. Serv., Beaufort, NC, 170 p.

RICHARDS, W.J., R.V. MILLER and E.D. HOUDE. 1974. Egg and larval development of the Atlantic thread herring, Opisthonema oglinum. Fish. Bull. 72(4):1123-1136.

ROITHMAYR, C.M. 1983. Purse seine fishing for coastal pelagic species in the northern Gulf of Mexico. In: Nickelson, R., III (comp.) Proceedings of the 8th annual Tropical and Subtropical Fisheries Conf. of the Americas. Texas A&M Univ. Sea Grant Pub. TAMU-SG-83-112:85-101.

SALOMAN, C.H. and S.P. NAUGHTON. 1983a. Food of the king mackerel, Scomberomorus cavalla, from the southeastern United States including the Gulf of Mexico. U.S. NOAA Tech. Memo. NMFS-SEFC-126, 25 p.

SALOMAN, C.H. and S.P. NAUGHTON. 1983b. Food of the Spanish mackerel, Scomberomorus maculatus, from the Gulf of Mexico and southeastern seaboard of the United States. U.S. NOAA Tech. Memo. NMFS-SEFC-128, 22 p.

SALOMAN, C.H. and S.P. NAUGHTON. 1984. Food of the crevalle jack (Caranx hippos) from Florida, Louisiana and Texas. U.S. NOAA Tech. Memo. NMFS-SEFC-134, 34 p.

SIDWELL, V.D. 1981. Chemical and nutritional composition of finfishes, whales, crustaceans, mollusks, and their products. U.S. NOAA Tech. Memo. NMFS F/SEC-11, 432 p.

SIDWELL, V.D. and M.E. AMBROSE. 1975. Nutritional and chemical evaluation of the protein of various finfish and shellfish. In: Friedman, M. (ed.) Nutrition and clinical nutrition. Marcel Dekker, New York, pp. 197-209.

SPRINGER, V.G. and K.D. WOODBURN. 1960. An ecological study of the fishes of the Tampa Bay area. Fla. Bd. Conserv. Mar. Lab. Prof. Pap. Ser. 1, 104 p.

U.S. DEP. COMMER., NOAA. 1985. Gulf of Mexico coastal and ocean zones strategic assessment: Data atlas. NOAA, NOS. Rockville, MD. unpag.

WHITEHEAD, P.J.P. 1978. Clupeidae. In: Fischer, W. (ed.) FAO species identification sheets for fishery purposes. Western Central Atlantic (Fishing area 31). FAO, Rome, v. 2.

WILK, S.J. 1977. Biological and fisheries data on bluefish, Pomatomus saltatrix (Linnaeus). U.S. Natl. Mar. Fish. Serv., Sandy Hook Lab., Tech. Ser. Rep. 11, 56 p.

Table 1. Seasonal comparison of catches of Atlantic thread herring from trawling by research vessels in the Gulf of Mexico, 1950-1985, in relation to bottom temperatures.[1]

December - February				March - May				June - August				September - November				Yearly Totals			
Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)[2]	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)
13	12	0	0.0	13	2	0	0.0	13	4	0	0.0	13	5	0	0.0	13	23	0	0.0
14	32	0	0.0	14	10	0	0.0	14	2	0	0.0	14	3	0	0.0	14	47	0	0.0
15	21	0	0.0	15	15	0	0.0	15	1	0	0.0	15	2	0	0.0	15	39	0	0.0
16	55	1	10.0	16	58	0	0.0	16	8	0	0.0	16	14	0	0.0	16	135	1	10.0
17	45	0	0.0	17	129	0	0.0	17	42	0	0.0	17	35	1	3.0	17	251	1	3.3
18	84	0	0.0	18	249	1	10.0	18	75	0	0.0	18	58	2	10.0	18	466	3	10.0
19	64	2	10.0	19	294	0	0.0	19	147	0	0.0	19	78	2	10.0	19	583	4	10.0
20	19	0	0.0	20	148	2	10.0	20	123	0	0.0	20	58	3	10.0	20	348	5	10.0
21	35	3	10.0	21	149	3	23.3	21	281	0	0.0	21	145	2	10.0	21	610	8	6.7
22	54	0	0.0	22	53	0	0.0	22	238	2	10.0	22	303	5	10.0	22	648	7	10.0
23	87	0	0.0	23	59	0	0.0	23	219	6	100.0	23	448	7	10.0	23	613	13	1.9
24	93	0	0.0	24	18	1	10.0	24	164	5	14.0	24	517	23	19.6	24	792	29	5.5
25	5	0	0.0	25	—	—	—	25	86	4	55.0	25	131	5	30.0	25	222	9	2.6
26	9	0	0.0	26	3	0	0.0	26	266	14	11.4	26	163	6	16.7	26	441	20	7.7
27	—	—	—	27	2	0	0.0	27	164	23	17.8	27	82	2	10.0	27	248	25	3.5
28	—	—	—	28	—	—	—	28	118	6	23.3	28	15	3	10.0	28	133	9	5.3
29	—	—	—	29	—	—	—	29	60	10	14.0	29	3	1	10.0	29	63	11	7.3
30	—	—	—	30	—	—	—	30	9	2	10.0	30	2	1	10.0	30	11	3	10.0
31	2	1	10.0	31	—	—	—	31	7	2	10.0	31	—	—	—	31	9	2	10.0
32	—	—	—	32	—	—	—	32	1	1	10.0	32	—	—	—	32	1	1	10.0
33	—	—	—	33	—	—	—	33	—	—	—	33	1	0	0.0	33	1	0	10.0
34	—	—	—	34	—	—	—	34	—	—	—	34	—	—	—	34	—	—	—

[1]Data from MRFS, Pascagoula, MS, May 1985
[2]Average number of pounds per hour per tow in which thread herring were present using a trawl with a 40 foot head rope.

Table 2. Seasonal comparison of catches of Atlantic thread herring from trawling by research vessels in the Gulf of Mexico, 1950-1985, in relation to surface temperatures.[1]

December - February				March - May				June - August				September - November				Yearly Totals			
Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)[2]	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)	Temp. (°C)	Number of trawls	No. of trawls catching herring	Average catch (lbs/hr)
13	139	1	10.0	13	10	0	0.0	13	--	--	--	13	1	0	0.0	13	142	1	10.0
14	216	0	0.0	14	17	0	0.0	14	--	--	--	14	2	0	0.0	14	235	0	0.0
15	61	0	0.0	15	40	0	0.0	15	--	--	--	15	--	--	--	15	101	0	0.0
16	211	3	10.0	16	106	0	0.0	16	--	--	--	16	19	0	0.0	16	336	3	10.0
17	233	3	10.0	17	192	2	10.0	17	1	0	0.0	17	101	2	10.0	17	527	7	10.0
18	306	3	10.0	18	390	1	10.0	18	--	--	--	18	75	2	10.0	18	772	6	10.0
19	240	0	0.0	19	903	3	10.0	19	1	0	0.0	19	206	2	10.0	19	1350	5	10.0
20	127	0	0.0	20	343	9	12.2	20	--	--	--	20	166	10	31.0	20	637	19	22.6
21	86	0	0.0	21	446	7	10.0	21	1	0	0.0	21	627	79	15.3	21	1160	26	13.9
22	168	0	0.0	22	460	9	16.7	22	1	0	0.0	22	1088	34	14.1	22	1717	43	14.7
23	134	0	0.0	23	298	8	10.0	22	17	0	0.0	23	1594	49	15.3	23	2043	57	14.6
24	31	0	0.0	24	213	1	10.0	24	28	0	0.0	24	1244	39	16.7	24	1516	40	16.5
25	1	0	0.0	24	48	1	10.0	25	26	0	0.0	25	384	16	21.9	25	459	17	21.2
26	--	--	--	26	77	0	0.0	26	279	13	13.8	26	699	20	15.0	26	1055	33	14.5
27	--	--	--	27	109	0	0.0	27	549	32	33.4	27	538	18	13.3	27	1196	50	26.2
28	3	0	0.0	28	25	0	0.0	28	1029	62	19.0	28	408	0	0.0	28	1462	62	19.0
29	2	0	0.0	29	1	0	0.0	29	1009	31	15.8	29	392	4	10.0	29	1402	35	15.1
30	--	--	--	30	--	--	--	30	367	11	10.0	30	64	2	20.0	30	431	13	11.5
31	--	--	--	31	--	--	--	31	236	9	14.4	31	21	2	10.0	31	257	11	15.5
32	--	--	--	32	--	--	--	32	41	1	10.0	32	1	0	0.0	32	42	1	10.0
33	--	--	--	33	--	--	--	33	--	--	--	33	--	--	--	33	--	--	--
34	--	--	--	34	--	--	--	34	--	--	--	34	--	--	--	34	--	--	--

[1]Data from NMFS, Pascagoula, MS, May 1985.
[2]Average number of pounds per hour per tow in which thread herring were present using a trawl with a 40 foot head rope.

Table 3. Florida west coast landings of Atlantic thread herring from 1967-1983 [1].

Year	Pounds	Metric tons	Value ($)
1967	7,746,585	3,521.2	64,836
1968	12,006,010	5,457.3	123,458
1969	5,590,445	2,541.1	61,314
1970	519,794	236.3	16,107
1971	918,285	417.4	32,225
1972	804,963	365.9	27,790
1973	952.572	433.0	43,246
1974	731.543	332.5	34,980
1975	860,835	391.3	50,314
1976	286,016	130.0	12,213
1977	190,345	66.3	8,988
1978	55,626	25.2	2,423
1979	511,973	232.2	42,753
1980	116,015	52.6	7,748
1981	492,341	223.3	40,468
1982	294,846	133.7	14,250
1983	210,486	95.5	13,347

[1]Data source: U.S. Dept. of Commerce, NOAA, NMFS, Current Fisheries Statistics 1967-1983. Florida landings, annual summaries.

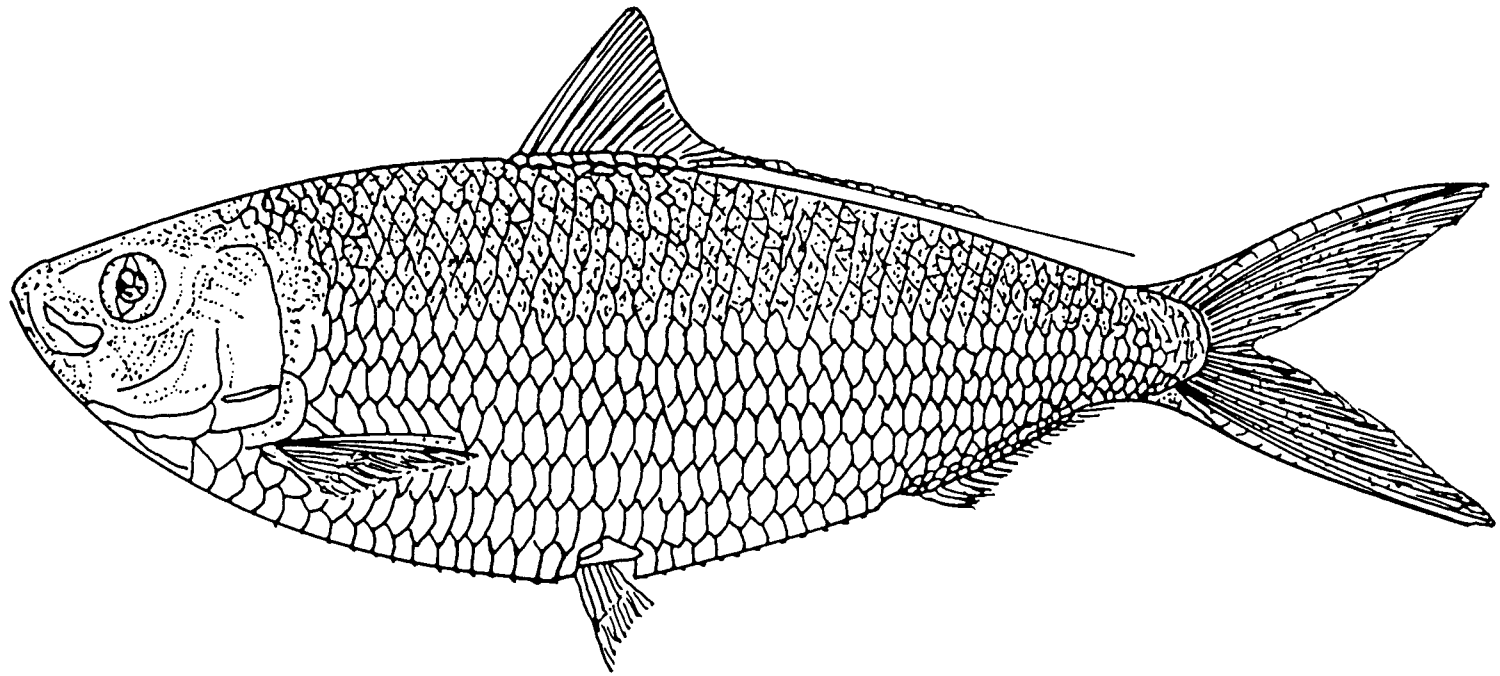

Figure 1. Adult Atlantic thread herring, Opisthonema oglinum (Lesueur 1818) (from Hildebrand 1963).

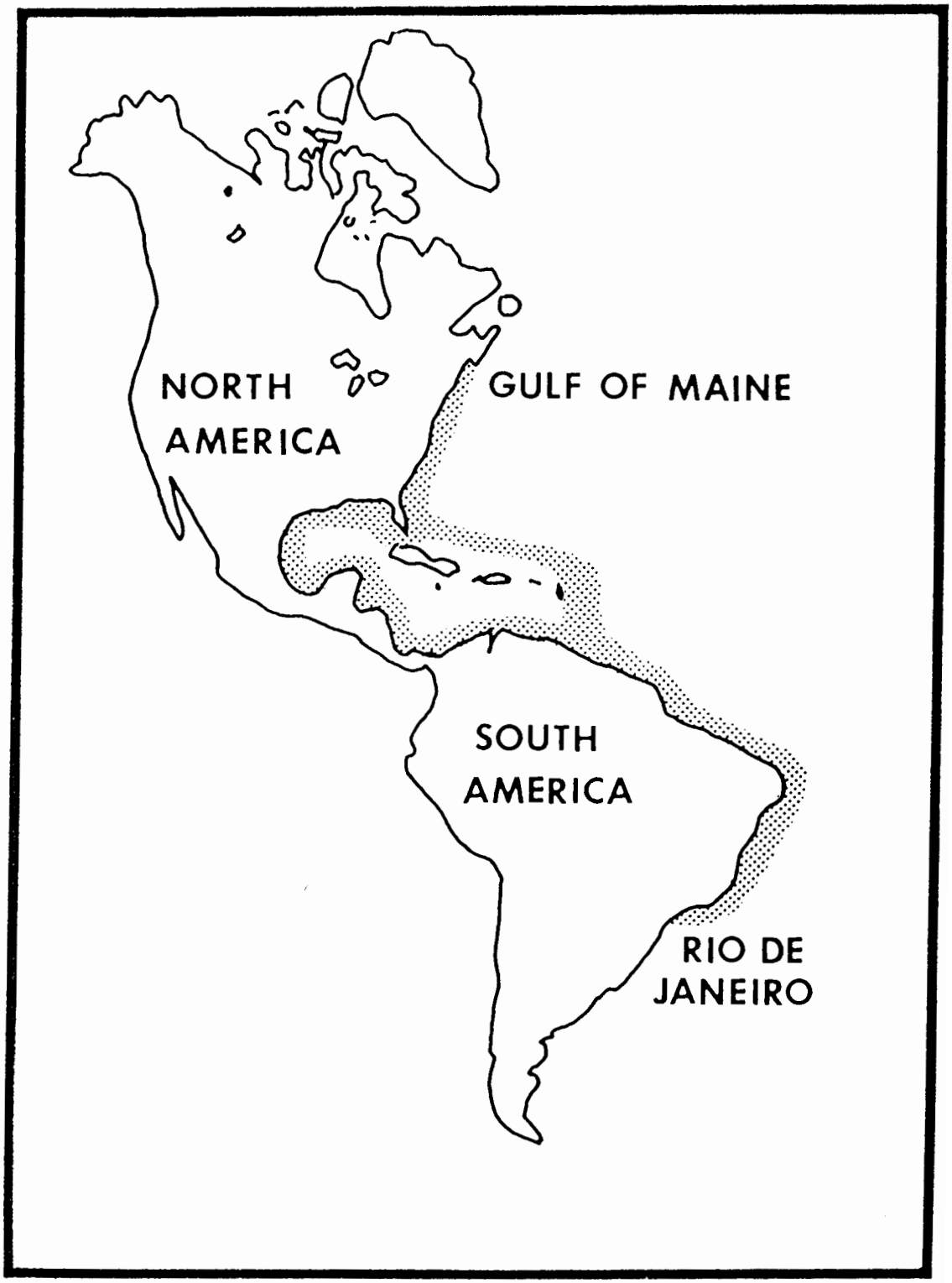

Figure 2. Distribution of Atlantic thread herring in the western Atlantic.

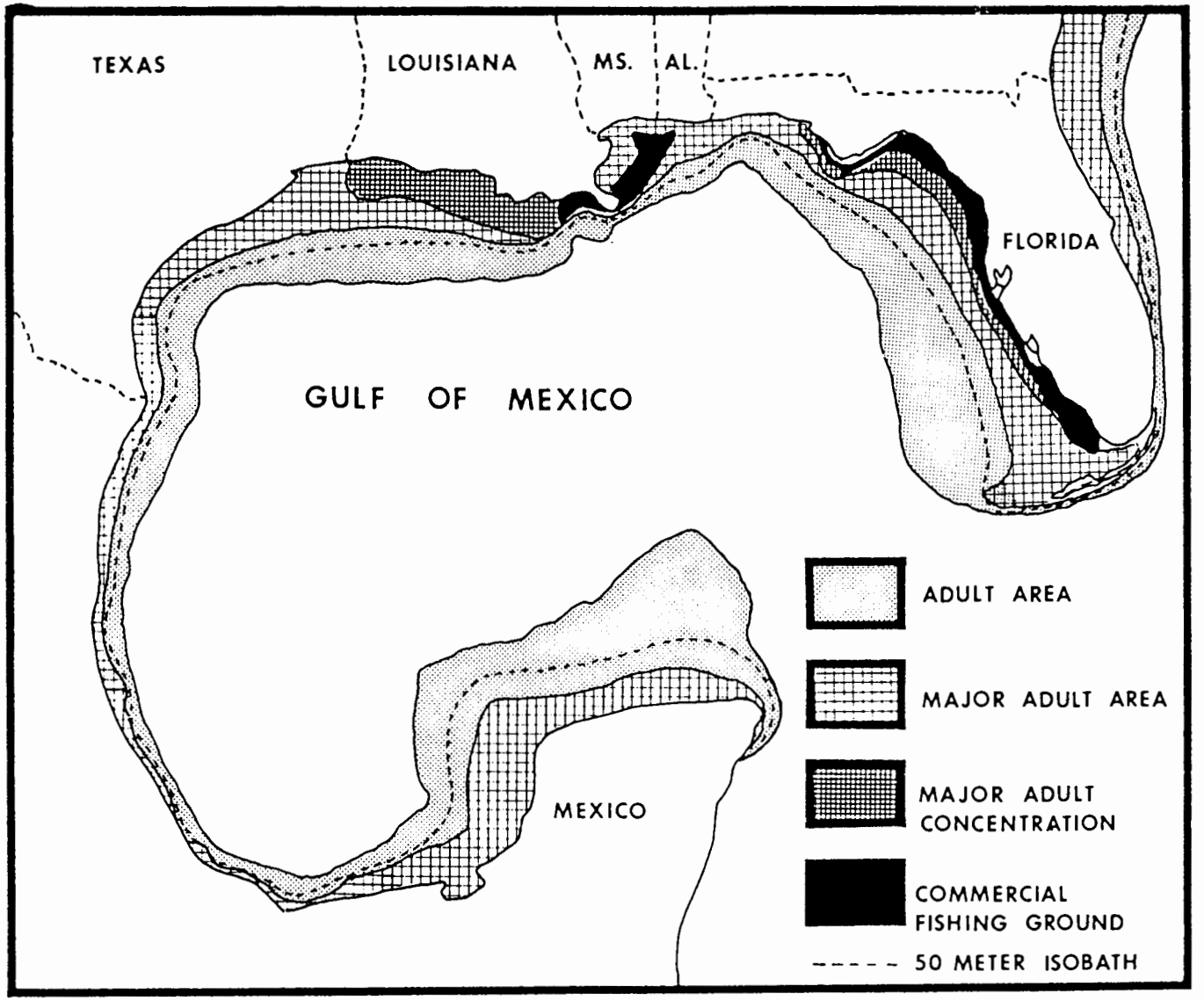

Figure 3. Distribution of adult Atlantic thread herring in the Gulf of Mexico showing major areas of concentration and commercial fishing grounds. (Taken from U.S. Dep. Comm., NOAA (1985).

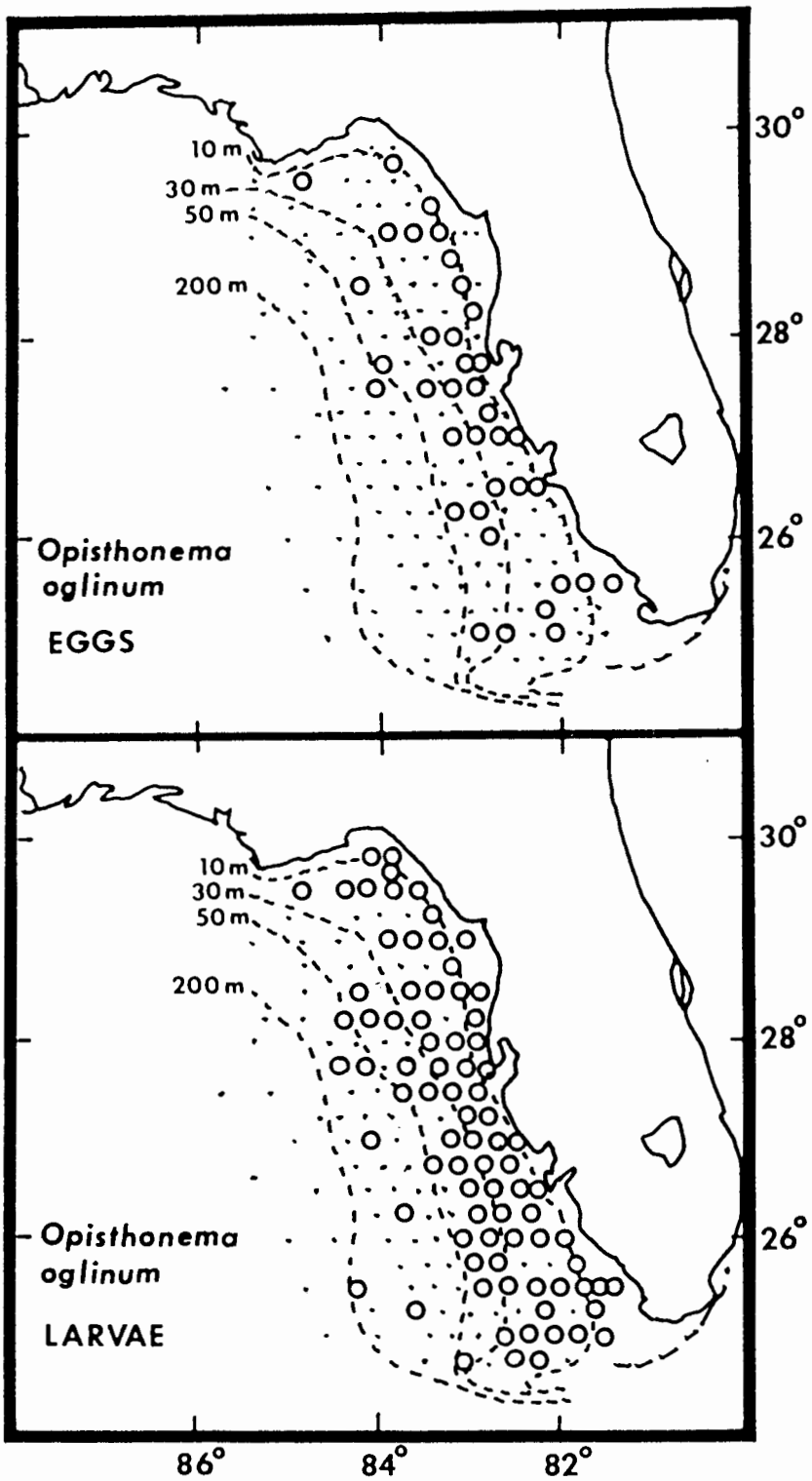

Figure 4. Collection of Atlantic thread herring eggs and larvae at stations along the west coast of Florida during 1971-74; stations where thread herring were caught are shown by circles (from Houde 1977).

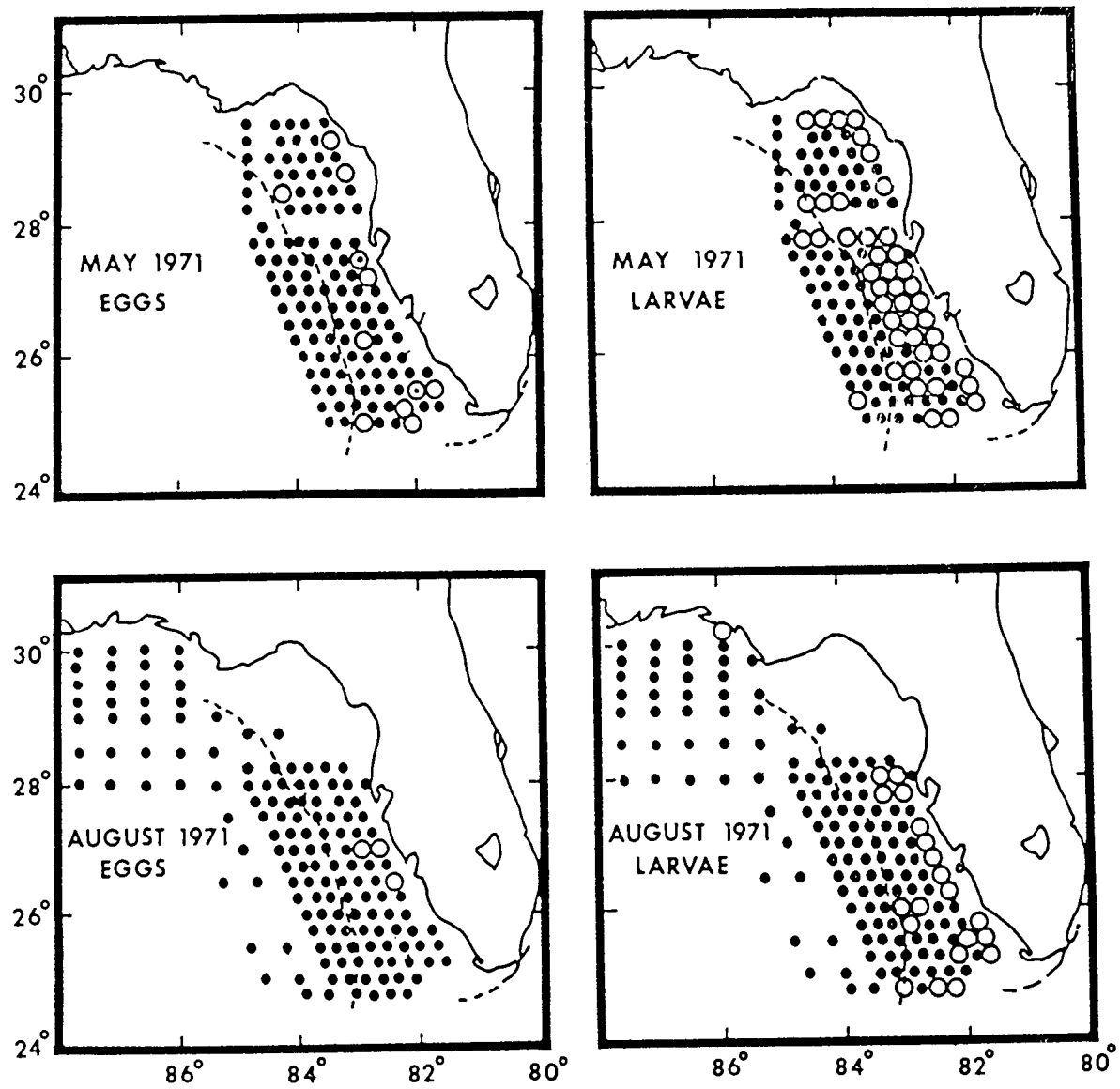

Figure 5. Distribution and abundance of Atlantic thread herring eggs and larvae off the west Florida coast; stations where thread herring were caught are shown in open circles during May and August 1971 (from Houde 1977).

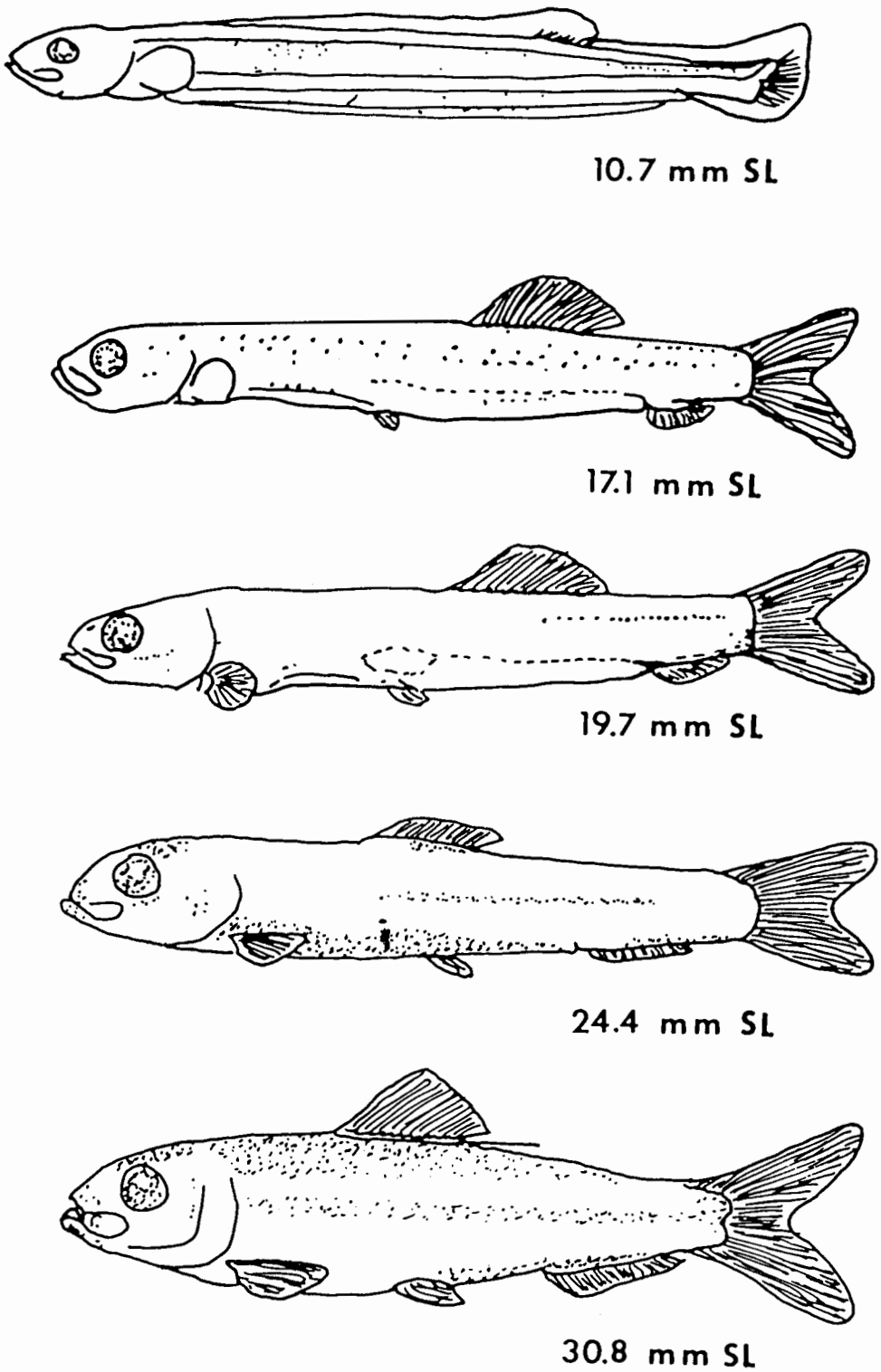

Figure 6. Larval and juvenile development of the Atlantic thread herring, Opisthonema oglinum (from Richards et al. 1974).

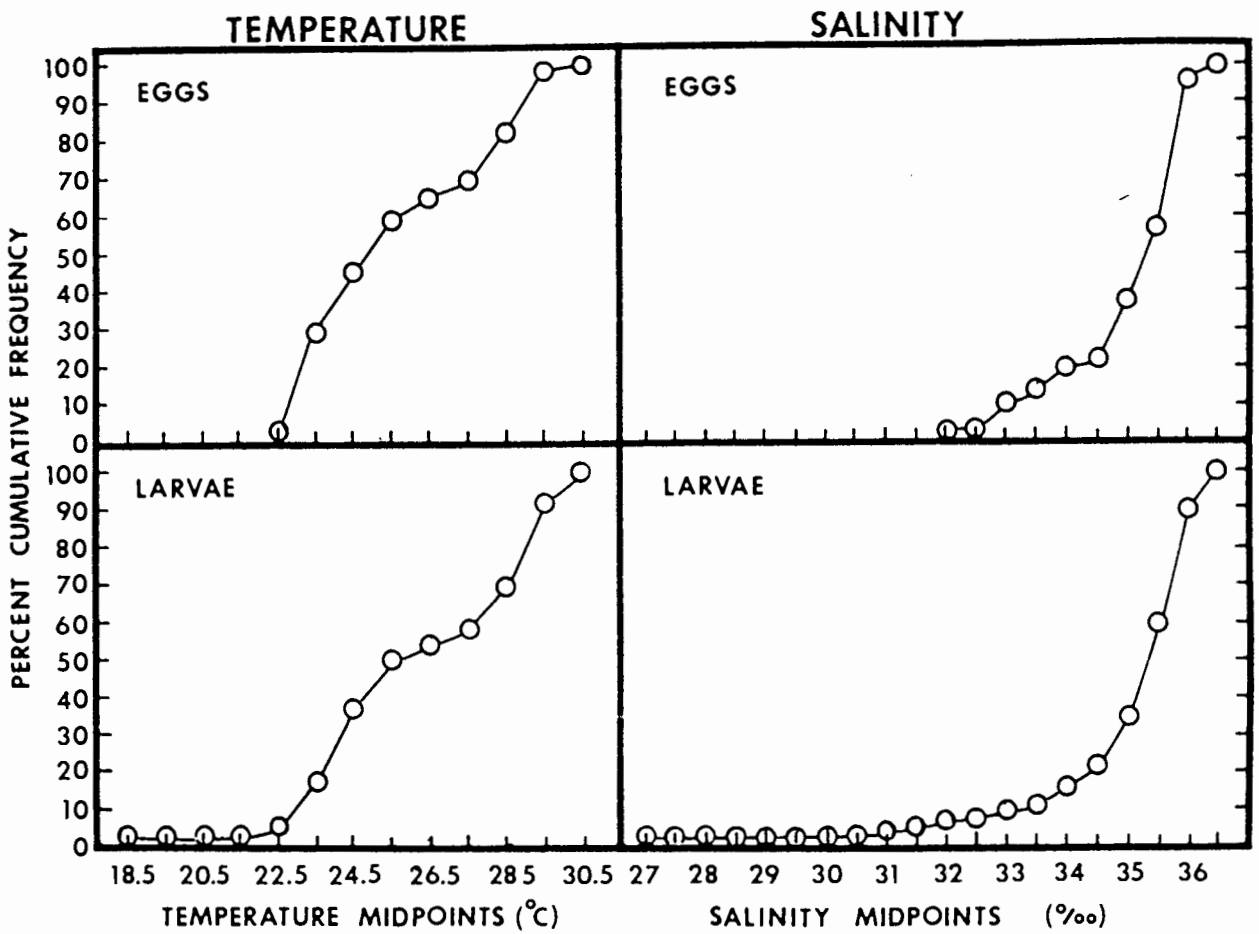

Figure 7. Occurrence of Atlantic thread herring eggs and larvae (<5 mm) in relation to surface temperatures and salinities off the west coast of Florida during 1971-74 (from Houde 1977).

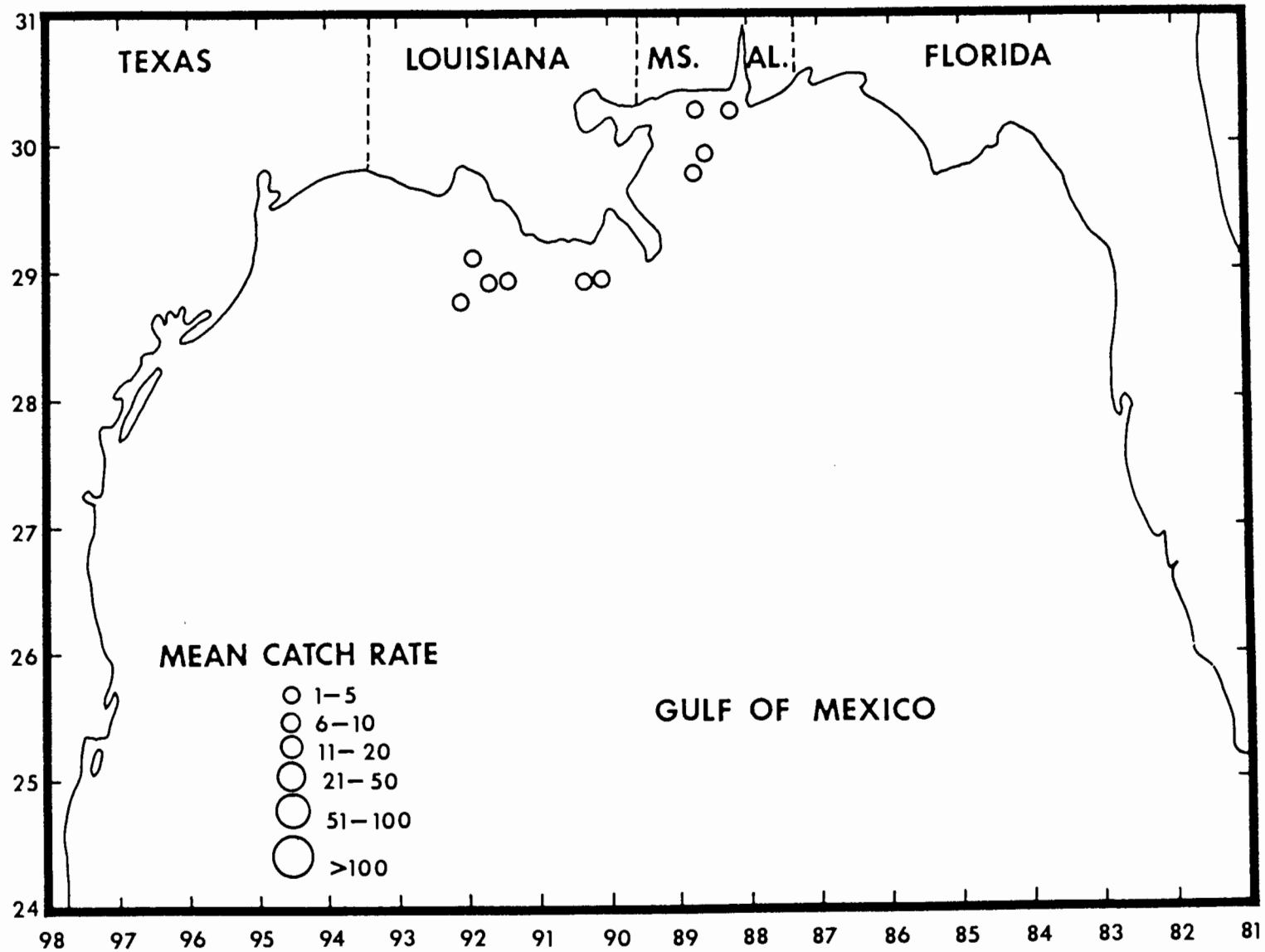

Figure 8. Mean catch rates of Atlantic thread herring in lbs/hr collected by a 40 ft trawl from December-February, 1950-1985 (data provided by NMFS, Pascagoula, Mississippi).

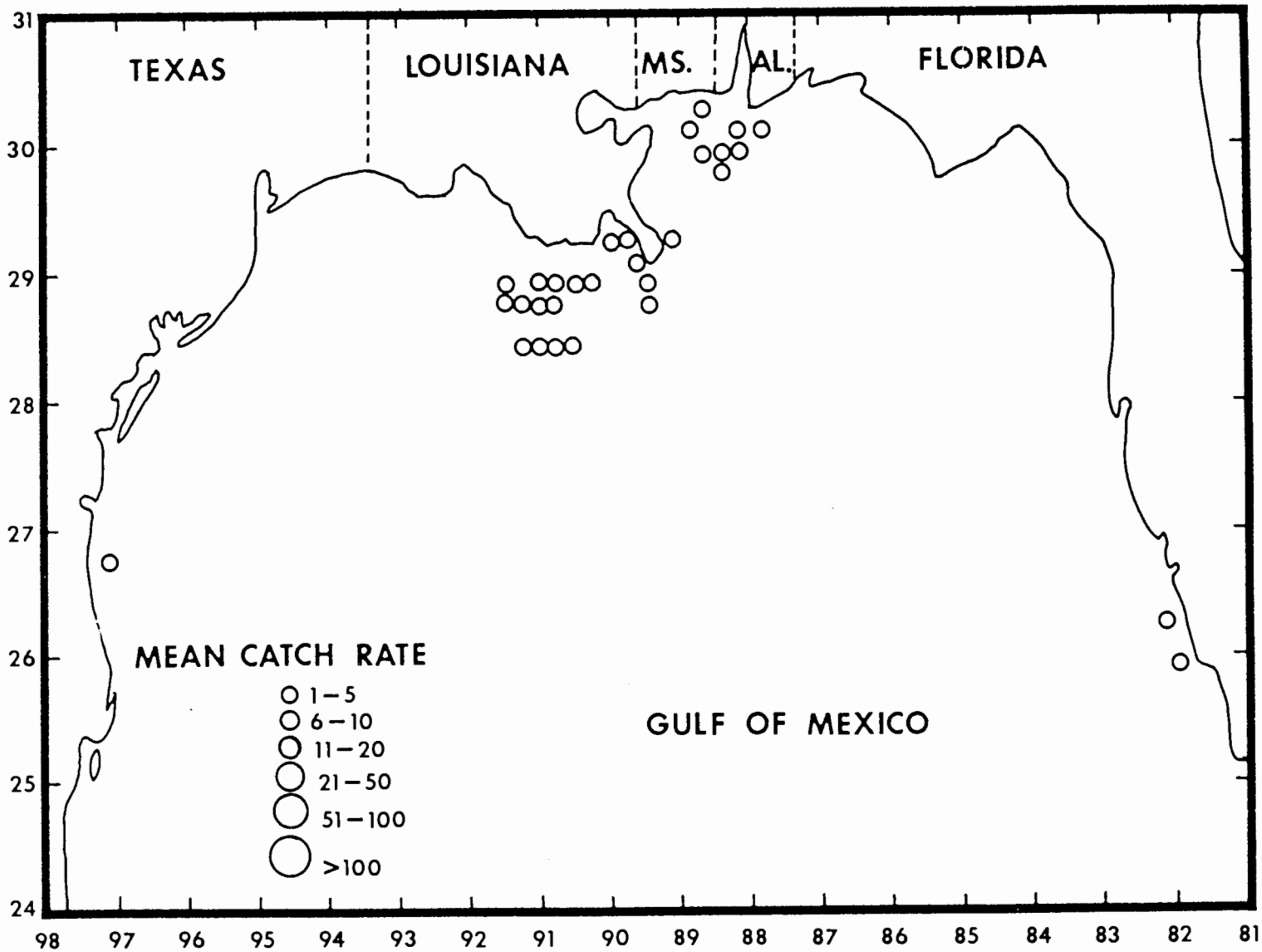

Figure 9. Mean catch rates of Atlantic thread herring in lbs/hr collected by 40 foot trawls from March-May 1950-85 (data provided by NMFS, Pascagoula, Mississippi).

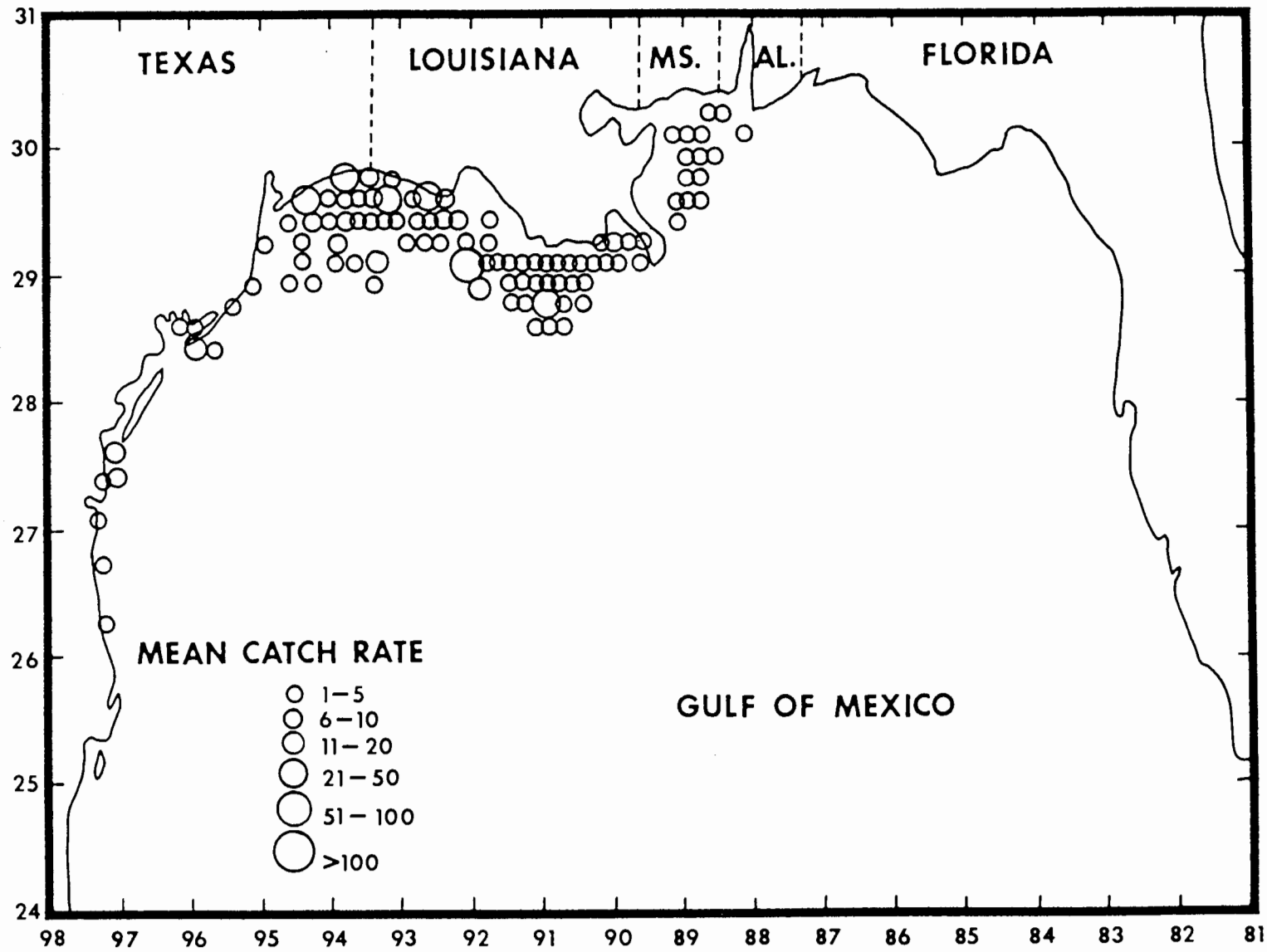

Figure 10. Mean catch rates of Atlantic thread herring in lbs/hr collected by 40 foot trawls from June-August, 1950-85 (data provided by NMFS, Pascagoula, Mississippi).

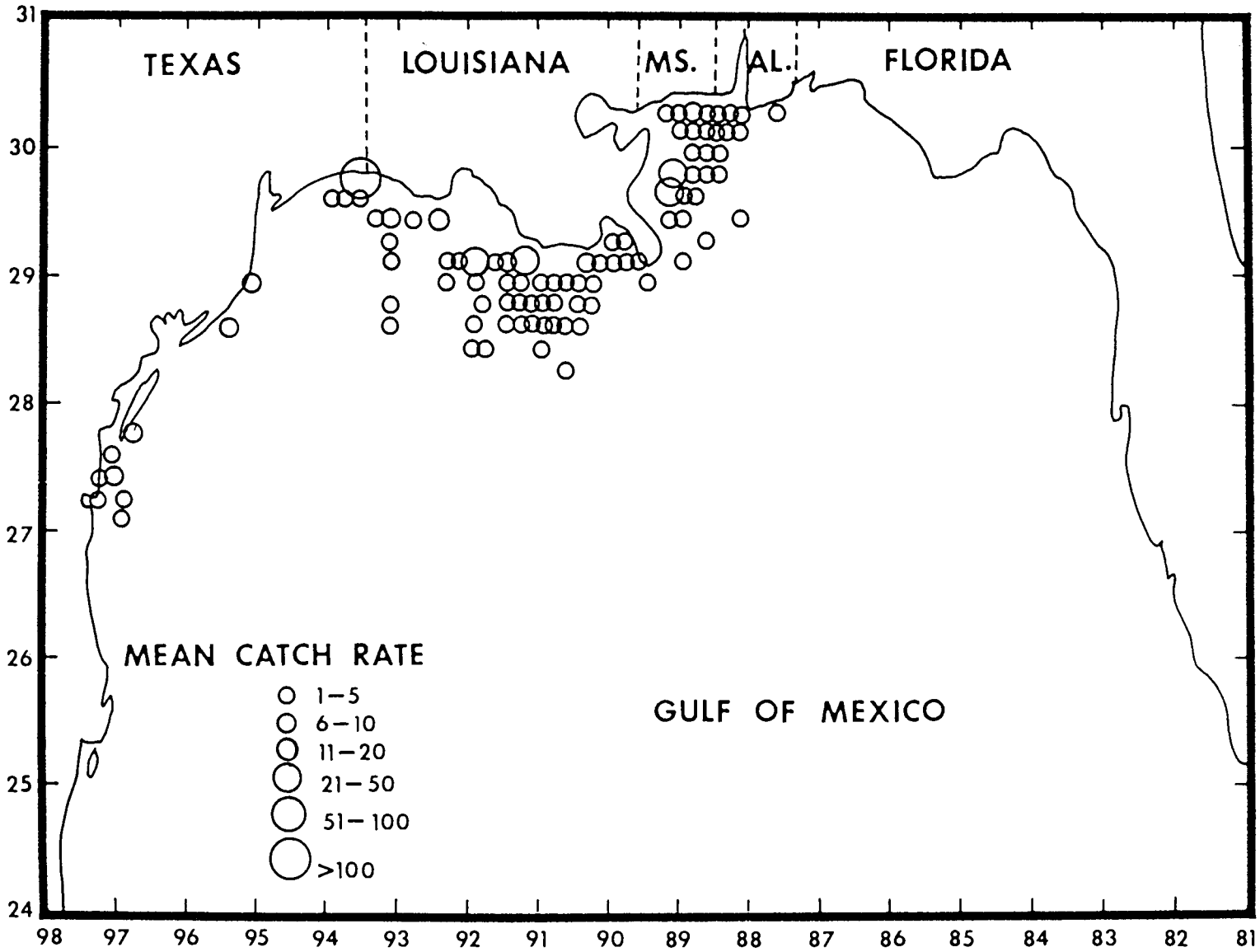

Figure 11. Mean catch rates of Atlantic thread herring in lbs/hr collected by 40 foot trawls from September-November, 1950-85 (data provided by NMFS, Pascagoula, Mississippi).