Abundance and Potential for Fisheries Development of Some Sardine-like Fishes in the Eastern Gulf of Mexico[1]

EDWARD D. HOUDE
Division of Biology and Living Resources
Rosenstiel School of Marine and Atmospheric Science
University of Miami
Miami, FL 33149

ABSTRACT

A survey of eggs and larvae of sardine-like fishes was carried out in the Eastern Gulf of Mexico from 1971 to 1974 to determine adult biomass of these fishes and to evaluate their potential yield to commercial fisheries. The aggregate spawning biomass of sardine-like fishes was approximately 1.1 million metric tons during that period. Thread herring (*Opisthonema oglinum*) biomass averaged 241,000 metric tons; scaled sardine (*Harengula jaguana*) biomass averaged 184,000 metric tons; and round herring (*Etrumeus teres*) mean biomass was 379,000 metric tons. No estimates were obtained for Spanish sardine (*Sardinella* spp.) biomass, but it may be about 250,000 metric tons. The menhaden (*Brevoortia* spp.) resource apparently is small in the Eastern Gulf and its biomass was not estimated. The potential, maximum sustainable harvest of all sardine-like species on an annual basis likely does not exceed 525,000 metric tons from the Eastern Gulf of Mexico.

INTRODUCTION

Sardine-like fishes are abundant in the Eastern Gulf of Mexico. Catches of these fishes could add significantly to the Gulf menhaden fishery, and thus make valuable contributions to fishmeal and oil production in the United States. Among species that have been considered in this respect are thread herring *(Opisthonema oglinum)*, Spanish sardines *(Sardinell* spp.*)*, scaled sardines *(Harengula jaguana)*, and round herring *(Etrumeus teres)*. The thread herring, in particular, was thought to have good potential for fisheries development (Bullis and Carpenter, 1968; Fuss, Kelly, and Prest, 1969; Klima, 1971; Wise, 1972). However, there were no reliable estimates of stock size for any of these fishes in the Eastern Gulf of Mexico.

The Sea Grant program at the University of Miami began investigating the sardine-like (clupeid) stocks in the Eastern Gulf during 1971. Surveys of clupeid eggs and larvae were carried out from 1971 through 1974, the major objective being to obtain estimates of adult spawning stock and to determine fishery potential. I gave an earlier report on those surveys in which I justified the technique, gave background information on survey development, and made some preliminary stock estimates (Houde, 1973). Fishery-independent stock estimates, obtained from egg and larvae surveys, have proved to be a good technique

[1]This paper is a contribution from the Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida 33149.

for obtaining biomass estimates. Estimates within an order of magnitude of true stock size, when no fishery exists from which extensive biological or catch-effort data can be obtained, are possible using this method. Other objectives of the surveys were to determine spawning areas and spawning seasons for the various species, and to investigate the biology of early life stages.

METHODS

Survey methods and data summaries for the 17 cruises were recently published (Houde, et al., in press). Houde (1973) also outlined methods used to collect fish eggs and larvae to obtain abundance estimates. A total of 867 plankton collections was made using double oblique tows of a 61-cm paired Bongo net sampler with 505-μm and 333-μm mesh nets. The sampling area ranged from the 10-m to the 200-m depth contour (nearshore to more than 230 km offshore) in the Eastern Gulf. Most stations were located inside the 50-m contour (Fig. 1). Station data for each cruise have been tabulated and charts illustrating positions of each station have been drawn (Houde, et al., in press). Seasonal abundances of fish eggs, fish larvae, and zooplankton volumes from 1972 to 1974 cruises were illustrated on contour charts (Houde and Chitty, in press).

Estimates of annual abundance of spawned clupeid eggs were obtained to determine adult biomass. Saville (1964) and Ahlstrom (1968) have discussed the rationale that allows the relationship between number of spawned eggs and adult standing stock to be determined. In addition to estimates of spawned eggs it is necessary to know the relative fecundity (eggs spawned per g of body wgt) and the sex ratio of the stock. I determined relative fecundities from gonad analyses and assumed that sex ratios were one to one. My estimates of annual spawning were obtained from the plankton collections, using techniques similar to those described by Sette and Ahlstrom(1948) and Smith (1972). Estimating errors are large using these techniques, but I believe that my standing stock estimates of adult thread herring, scaled sardines, and round herring will be useful to predict potential for fisheries development of these stocks.

RESULTS

Stock estimates were obtained for thread herring, scaled sardines, and round herring. I was not successful in obtaining stock estimates for Spanish sardines and made no attempt to estimate menhaden biomass in the Eastern Gulf. Menhaden eggs and larvae were uncommon in our plankton collections, leading me to believe that the biomass is small in this area. Spanish sardine eggs and larvae were common but the possibility of two species being present, the inability to define the spawning season, and difficulty in estimating relative fecundity made it impossible to estimate stock size.

Thread Herring

Thread herring spawn during the spring and summer months in the Eastern Gulf. The season probably extends from April through August over most of this

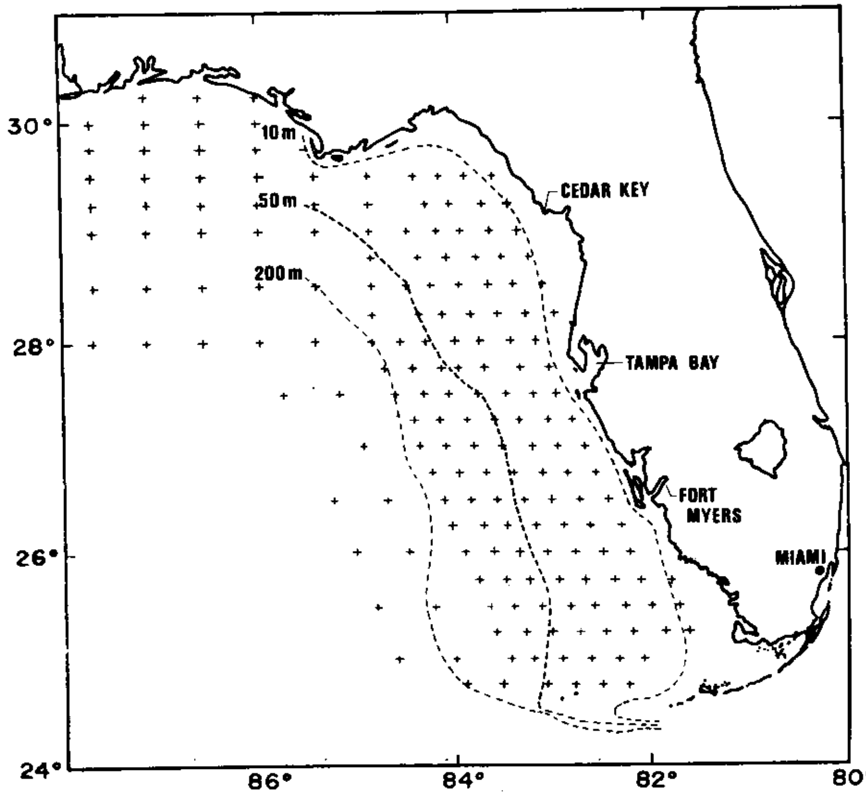

Figure 1. Sampling area and stations for Gulf of Mexico ichthyoplankton cruises from 1971 to 1974.

area, but some spawning may occur as early as February in the southeastern sector. This corresponds well with the spawning season reported by Fuss, et al. (1969) who determined the spawning season from examination of gonad development in adult thread herring from the Eastern Gulf of Mexico. I collected eggs when sea surface temperature ranged from 22.5 to 30.5 °C. Most spawning occurs within 30 miles of the coast and virtually all spawning is within 60 miles of the shore. The distribution and abundance of eggs for June-July 1973 is illustrated in Figure 2. Spawning was most intense between latitudes 26°00'N and 28°00'N (Ft. Myers to Tampa Bay). Egg distribution data indicate that the biggest part of the adult spawning population is located there during the spring and summer months. Kinnear and Fuss (1971) reported north-south migrations by thread herring in the Eastern Gulf. They found schools migrating north in spring and south in fall, presumably in response to changing temperature conditions. Such migrations must occur, but it seems apparent from my egg and larvae distribution data that a large part of the population remains in the Ft. Myers-Tampa Bay area even in the summer months.

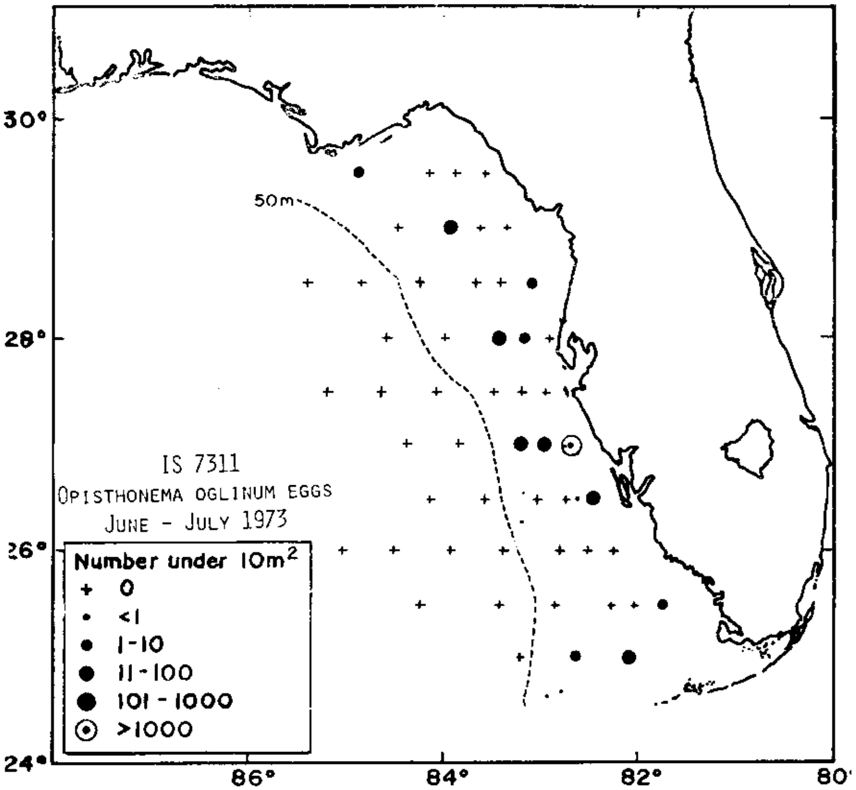

Figure 2. Distribution and abundance of thread herring *(Opisthonema oglinum)* eggs during June-July 1973 in the Eastern Gulf of Mexico.

Estimates of thread herring egg abundance were obtained for 1971, 1972, and 1973 (Table 1). The annual spawning estimates ranged from 14.1 x 10^{12} to 110.6 x 10^{12} eggs. Biomass estimates, based on eggs spawned, ranged from a low of 47,000 metric tons (m.t.) in 1972 to 372,000 m.t. in 1973. The 1972 estimate almost certainly is a poor one because Hurricane Agnes interrupted the one cruise scheduled at the peak of the thread herring spawning season in June of that year. The mean biomass estimate for 1971 and 1973 (Table 2) is 241,000 m.t.

The estimates that I have obtained are only for adult stock. It is possible that some part of the juvenile stock of thread herring, and also of other clupeids, could contribute to the fishable stock in the Eastern Gulf. The fishable biomass may be greater than the adult biomass if fish less than one year old (less than approximately 130 mm in length) are acceptable to a fishery. However, it seems unlikely that the fishable stock of thread herring on Florida's west coast could have exceeded 450,000 m.t. from 1971 to 1973.

Table 1. Estimates of annual spawning and adult biomass for three species of clupeid fishes from the Eastern Gulf of Mexico.

SPECIES	YEAR	EGGS SPAWNED ($x 10^{12}$)	BIOMASS (metric tons)
Thread Herring	1971	32.4	109,000
	1972	14.1	47,000
	1973	110.6	372,000
Scaled Sardines	1971	4.1	16,000
	1972	39.1	148,000
	1973	102.6	387,000
Round Herring	1971-1972	111.0	718,000
	1972-1973	19.4	131,000
	1973-1974	42.5	287,000

Scaled Sardines

Scaled sardines spawn during spring and summer in the Eastern Gulf. The spawning season apparently begins in March and continues through August. A few eggs and larvae were collected in a February cruise in 1971, south of latitude 26°00'N, indicating that some spawning occurs during winter in the southernmost part of the survey area. I believe that spawning prior to March is negligible compared to that in April through August. Scaled sardine eggs were collected when surface temperatures ranged from 21.0 to 31.0°C. They were most abundant within 20 miles of the coast, where water depth was less than 20 m. There was no single area on the Florida west coast where spawning was observed to be most intense.

Distribution and abundance of eggs in the May 1974 cruise (Figure 3) reflect the nearshore occurrence of this species. In that cruise several stations were sampled where water depths were only 4 to 10 m; these stations were located closer to shore than any in previous survey cruises. Biggest catches of scaled sardine eggs were made at those stations; mean abundance there exceeded mean abundance at regular stations by a factor of 1.85. I believe that scaled sardine eggs were undersampled during most of the survey cruises because our stations were too far offshore. This could have resulted in an underestimate of scaled sardine biomass, perhaps by as much as 30%. There was no evidence, based on the May 1974 cruise, that eggs of other clupeid species were more abundant nearer to shore than at our regular stations.

Scaled sardine annual spawning estimates ranged from 4.1×10^{12} eggs in 1971 to 102.6×10^{12} eggs in 1973 (Table1). The apparent increase in spawning between 1971 and 1973 probably is real and may represent a recovery of this population from the severe red tides of 1971 in coastal areas of the Eastern Gulf. Adult biomass estimates ranged from a low value of only 16,000 m.t. to a high of 387,000 m.t. (Table 1). Mean biomass for the 3 years is 184,000 m.t. If the stock was underestimated by as much as 30%, because of undersampling, then the mean estimate might be as high as 263,000 m.t.

Table 2. Estimated potential yields of three species of clupeid fishes from the Eastern Gulf of Mexico. Estimated yields are given for three possible levels of M, the natural mortality coefficient.

SPECIES	MEAN BIOMASS ESTIMATE (metric tons)	ESTIMATED MAXIMUM SUSTAINABLE YIELD (metric tons)		
		M=0.50	M=0.75	M=1.00
Thread Herring*	241,000	60,250	90,375	120,500
Scaled Sardines	184,000	46,000	69,000	92,000
Round Herring	379,000	94,750	142,125	189,500
Aggregate Potential Yield		201,000	301,500	402,000

*1971 and 1973 data only.

Round Herring

Round herring spawn during the cooler months in the Eastern Gulf. Eggs were collected from November to May; peak spawning took place during January and February. Eggs were present when surface temperatures ranged from 18.5 to 26.5°C but most were collected when surface temperature was less than 25°C. Fore (1971) reported spawning by this species from December to March in the Northern Gulf of Mexico, mostly between the 25- and 110-m depth contours. Eggs were collected in our survey at stations between the 30- and 200-m contours, but most were found where depth was less than 100 m. The distribution and abundance of eggs in January 1973 are illustrated in Figure 4. Some spawning probably occurred beyond the limits of the survey area, but the major part of the adult population is found on the continental shelf between 100- and 200-km offshore. There were two areas of intense spawning. The more important of these was west of Tampa Bay (27°30'N to 28°30'N) and the second area was north of Dry Tortugas (25°00'N to 25°30'N, 82°00'W to 82°30'W) (Fig. 4).

Total eggs spawned during three seasons were estimated. In 1971-1972, the estimate was 111.0 x 10^{12} eggs, in 1972-1973 it was 19.4 x 10^{12} eggs, and in 1973-1974 it was 42.4 x 10^{12} eggs (Table 1). Adult biomass estimates corresponding to those egg estimates were 718,000 m.t., 131,000 m.t., and 287,000 m.t. The mean estimate for the three spawning seasons was 379,000 m.t. Although the estimates are not very precise it is apparent that a large stock of this species is present in the Eastern Gulf.

FISHERY POTENTIAL

Aggregate biomass of thread herring, scaled sardines, and round herring, based on the sum of the three mean estimates, is 814,000 m.t. In addition, the stock of

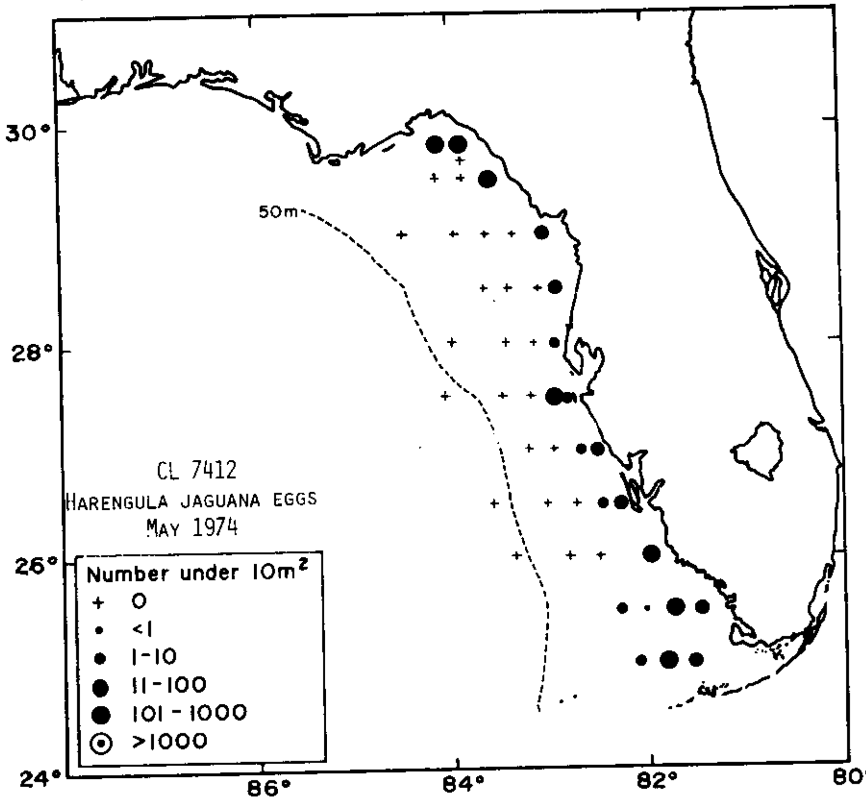

Figure 3. Distribution and abundance of scaled sardine *(Harengula jaguana)* eggs during May 1974 in the Eastern Gulf of Mexico.

Spanish sardines must be large, perhaps about the same size as the thread herring stock. If the Spanish sardine adult stock is 250,000 m.t., then the aggregate clupeid biomass is about 1,100,000 m.t. in the Eastern Gulf. Menhaden biomass apparently is small, but it would contribute some additional amount to the stock estimate.

A preliminary estimate of potential annual yield can be obtained from the biomass estimates using a technique proposed by Alverson and Pereyra (1969) and Gulland (1971 and 1972). They proposed that a potential yield estimate could be obtained from the relationship,

$$C_{max} = X M B_o$$

where

C_{max} = maximum sustainable yield
X = 0.5, the fraction of initial stock size at which maximum sustainable yield can be obtained

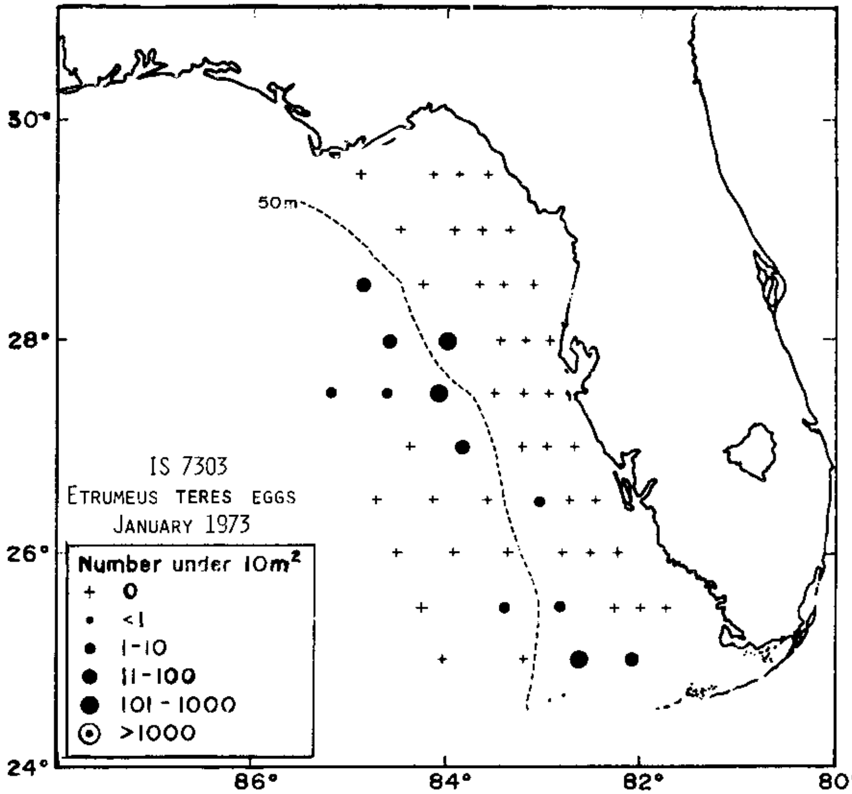

Figure 4. Distribution and abundance of round herring *(Etrumeus teres)* eggs during January 1973 in the Eastern Gulf of Mexico.

M = the instantaneous rate of natural mortality

B_0 = the initial stock size (i.e., the virgin biomass)

My mean estimates of stock size can be assumed to approximate the virgin biomass because none of the stocks is significantly exploited. No estimates of M are available for any of these stocks. Because they are virtually unexploited, M ≅ Z, the total mortality coefficient. Total annual mortality of subtropical and tropical clupeid species is high, M often being in the range 0.50 to 1.00 (e.g., Beverton, 1963), which corresponds to annual mortality rates of 39 to 63%. Setting M equal to 0.50, 0.75, and 1.00, I have calculated the potential annual yields for thread hearring, scaled sardines, and round herring (Table 2). Estimated total aggregate potential yield ranges from 201,000 to 402,000 m.t.; none of these species seems capable of supporting a fishery exceeding 200,000 tons on an annual basis. If Spanish sardine biomass is 250,000 m.t., they could contribute from 62,500 to 125,000 m.t. to the annual yield, raising the total aggregate yield to a maximum of about 525,000 m.t.

The mortality coefficient (M or Z) could be higher than the values that I have used in Table 2. Short-lived fishes with life spans of from 3 to 5 years might be expected to have M values exceeding 1.00 (Tanaka, 1960). If this is true for any of the Eastern Gulf clupeid stocks, then my estimates of potential yield are too low. For example, if life span is 4 years, then M would equal approximately 1.15, and my yield estimates should be increased by 15%. Good data on age structure and mortality rates of the Eastern Gulf clupeid stocks need to be obtained in future research on these fishes.

CONCLUSIONS

A large potential fishery resource is present in the Eastern Gulf that likely could support a 500,000 m.t. annual yield. Although none of the stocks seems as abundant as Gulf menhaden in the Northern Gulf of Mexico, in aggregate Eastern Gulf clupeids must total more than 1,000,000 m.t. A legal ban on purse seining, excepting baitfishing, within 3 leagues of the west Florida coast and a lack of knowledge of availability of fish are constraints on development of these fisheries. The purse seine ban makes it impossible to harvest scaled sardines, and a large part of the thread herring population also is inaccessible. Round herring and much of the Spanish sardine resource are located offshore but may be unavailable to standard purse seining techniques. Unless there is a combination of change in Florida law and advances in fishery technology, the latent clupeid resources in the Eastern Gulf may remain undeveloped for many years.

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