The Ancillary Harvest of Atlantic Menhaden, *Brevoortia tyrannus*, Roe on the North Carolina Coast

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Introduction

Extraction of fish roe for food is a common practice worldwide and includes a diverse array of fish families. Historically, roe from sturgeon (Acipenseridae) has long been processed into caviar and is often referred to as "black gold," since it may be one of the highest priced fisheries products in the world (Iversen, 1990). As worldwide demand for fish roe has increased in recent years (Iversen, 1990), roe products have been developed and prepared from such diverse species groups as the lumpfish (Cyclopteridae) in the North Atlantic (Stevenson and Baird, 1988), flyingfishes (Exocoetidae) in the tropics, capelin (Osmeridae) in more boreal waters (Iversen, 1990), and striped mullet (Mugilidae) along the southeastern United States (Leard et al., 1995).

In U.S. coastal waters, herrings of the family Clupeidae are among the most sought-after fishes for their roe. By far, the most lucrative herring roe fisheries occur in Alaska for the Pacific herring, *Clupea harengus pallasi*, with smaller quantities of Atlantic herring, *Clupea harengus harengus*, harvested for the roe trade off New England; most processed roe from these fisheries is exported to Japan (Herrfurth, 1986). Along the U.S. southeastern coast, several anadromous, alosine clupeids, namely, the blueback herring, *Alosa aestivalis*; the hickory shad, *A. mediocris*; and the American shad, *A. sapidissima*, are highly esteemed for their flesh and roe, and are targeted by traditional riverine and inshore fisheries (Smith, 1907; Manooch, 1984).

On a coastal basis, the migratory, estuarine-dependent Atlantic menhaden, *Brevoortia tyrannus*, is probably the most abundant clupeid on the U.S. Eastern Seaboard. Atlantic menhaden form large, nearshore surface schools from spring through December, and are the targets of a large, industrial purse-seine fishery for fish meal, fish oil, and fish solubles (Smith, 1991). Between 1995 and 1999, annual landings for reduction have averaged about 260,000 t yr^{-1}, although participation in the fishery by 1999 had dwindled to two factories and about 15 vessels, down from five factories and about 35 vessels in 1990. Historical estimates of maximum sustainable yield from the fishery range from 370,000 to 470,000 t yr^{-1} (ASMFC, 1999).

During fall and winter Atlantic menhaden migrate south around the North Carolina capes, and support a temporal segment of the purse-seine fishery called the Fall Fishery (Smith et al., 1987; Smith, 1999). Schools of roe-bearing fish are often harvested by purse-seine vessels from the Carteret County port of Beaufort, North Carolina, and are landed at a local reduction factory. At various points in the harvest and processing operations, small amounts of menhaden roe are manually extracted from whole fish for local consumption, and the carcasses are returned to the reduction process-

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ABSTRACT—Gravid Atlantic menhaden, Brevoortia tyrannus, *are available along the central coast of North Carolina during the fall and are harvested by the purse-seine fleet from the port of Beaufort. Virtually all of the catch, sexually immature fish included, is reduced to fish meal, fish oil, and fish solubles; however, minor quantities of roe from ripening female menhaden are extracted for local consumption. Routine and selective port sampling information was used to characterize the seasonal and biostatistical nature of the roe menhaden catches at Beaufort. Fishermen recognize two size classes of roe Atlantic menhaden: "forerunners," which are usually the smallest and earliest adult menhaden encountered in the Fall Fishery, and "mammy shad," which are the largest menhaden harvested and produce the greatest roe yields. Roe is extracted from female fish at various points along the reduction process stream and by several techniques. Vessel crewmen and factory personnel extract menhaden roe for personal and local consumption. Undetermined quantities of menhaden roe are channeled into local retail seafood markets. Wholesale prices are about $20 per gallon of roe, while retail prices are about $5 per pound. Carteret County, North Carolina, is probably the only area on the U.S. Atlantic and Gulf coasts where menhaden roe is sold in retail seafood markets. The potential of extracting menhaden roe for foreign markets is discussed.*

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ing stream. Although crew members of menhaden vessels from Reedville, Va., and numerous ports in Louisiana and Mississippi extract small quantities of roe for home consumption[1], the practice appears unique and endemic to the area surrounding the port of Beaufort to the extent that minor quantities of menhaden roe enter local retail seafood markets. In this paper we describe 1) the seasonality and availability of roe Atlantic menhaden in the vicinity of the port of Beaufort, North Carolina, 2) the biological characteristics of the roe fish harvested, and 3) the roe extraction techniques and disposition.

Observations

Seasonality and Availability of Roe Menhaden Along the North Carolina Coast

Atlantic menhaden stratify by size and age along the U.S. east coast during summer, with the oldest and largest fish migrating as far north as the Gulf of Maine (Nicholson, 1972). Although spawning occurs during every month of the year (Judy and Lewis, 1983; Ahrenholz, 1991), spawning intensity is thought to increase as adults move south along the Mid Atlantic U.S. coast during October and November, peaks off the North Carolina coast in winter, and continues at lower levels as adults move north again in spring (Ahrenholz, 1991). Most Atlantic menhaden attain sexual maturity as late age-2 fish just prior to turning age-3 (Higham and Nicholson, 1964; Lewis et al., 1987).

All age classes of Atlantic menhaden in the coastal population from age-0 to 5+ may be available during the Fall Fishery, although catches and fishing effort are highly weather-dependent (Smith et al., 1987). Two size classes of ripening adult fish are recognized by menhaden fishermen in the Beaufort area (Fig. 1). "Forerunners," so called because they are usually the first spawners encountered in the Fall Fishery (Frye, 1978), are the smallest and youngest fish of the two groups. We suspect that the earliest "forerunners" to appear off the North Carolina coast may be local fish which have recently attained sexually maturity. Their roe sacs are relatively small, and fishermen sometimes forego opportunities to extract roe from "forerunners" because of low roe yields. "Mammy shad" are the largest and oldest class of spawners occurring in the Fall Fishery. Catches of "mammy shad" are much anticipated because of their relatively high roe yields.

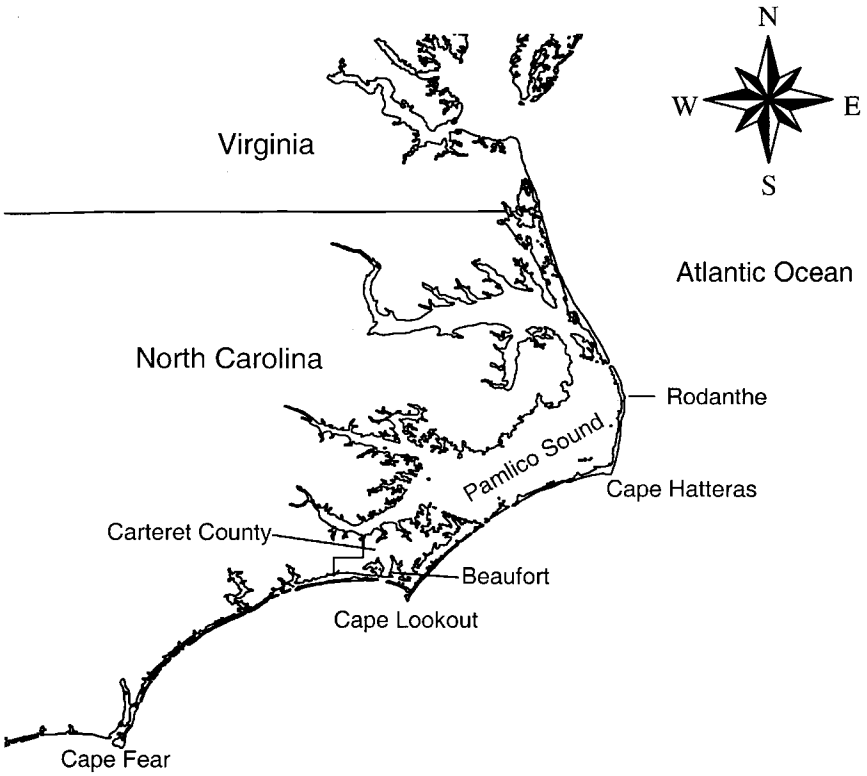

Figure 1.—Coastal North Carolina, showing the North Carolina capes and Carteret County.

A review of port sampling records at Beaufort for recent years (since 1988) revealed information on the frequency of landings of roe menhaden at Beaufort (Fig. 2). Initial catches of roe fish off the North Carolina coast occurred as early as 12 October 1989, but most frequently occurred in early to mid-November. Early runs of roe fish are usually of the "forerunner" class, which may be encountered by vessels from Beaufort as far north as Rodanthe near Cape Hatteras (Fig. 1). Initial catches of "mammy shad" most often occur south of Cape Hatteras during mid- to late December. Peak catches are made between Christmas and New Year's near Cape Lookout, with final catches of roe fish made farther south toward Cape Fear in early January.

Biological Characteristics of Roe Menhaden

Size and age frequency distributions of adult Atlantic menhaden were acquired through routine port sampling efforts (Smith, 1991), and selected sampling efforts directed at catches with ripening fish during fall 1988 and 1989. Specimens were sexed, measured for fork length (FL), weighed to the nearest gram, and a scale patch was removed for ageing (June and Roithmayr, 1960). Ripe ovaries were removed and weighed to the nearest gram. Gonadosomatic indices (GSI) were calculated [(gonad weight/body weight) × 100] to express gonad weight of females as a percent of body weight. To verify that gonads were in a ripening stage, a small portion of selected gonads were preserved in 10% buffered formalin solution, sectioned by standard histological techniques, then examined under a compound microscope.

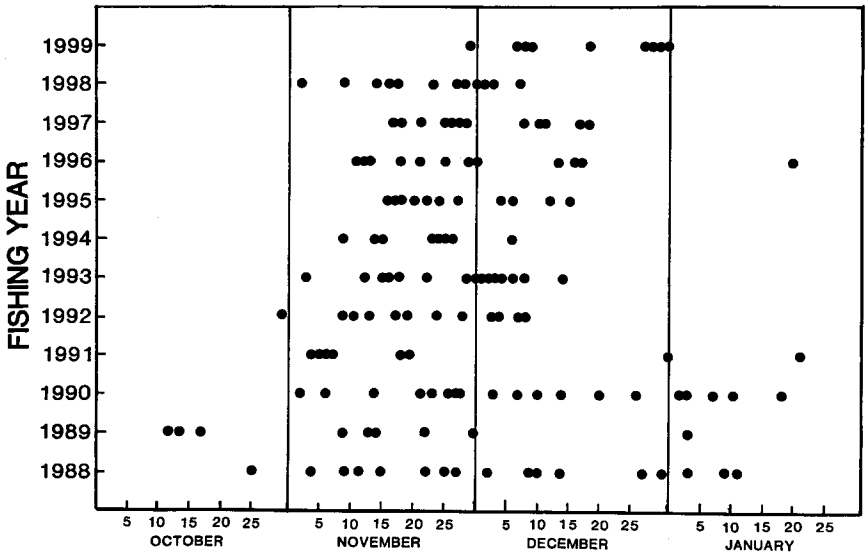

Figure 2.—A scatter plot of dates when roe menhaden were landed at Beaufort, North Carolina, 1988–1999 ("Fishing year" includes January of the following calendar year).

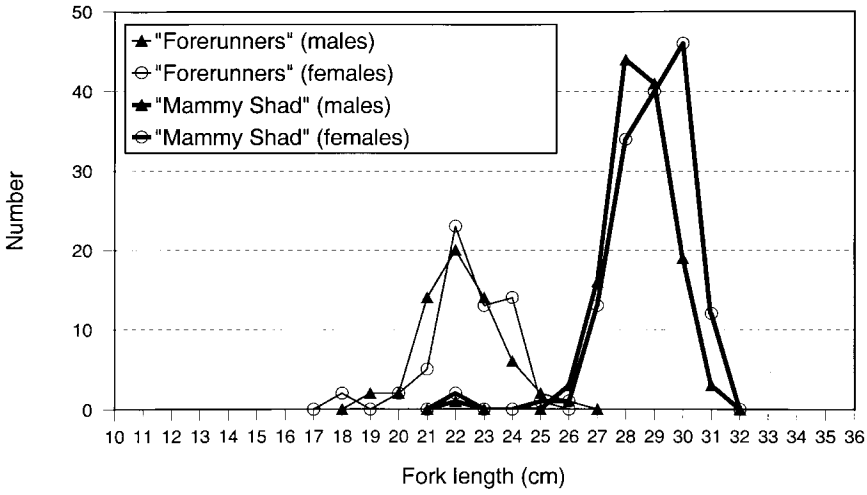

Figure 3.—Fork length frequency histogram (cm FL) of male and female "forerunners" and "mammy shad" (roe Atlantic menhaden) landed at Beaufort, N.C., in 1989 and 1988, respectively.

Males in the "forerunner" class of Atlantic menhaden from samples in November 1989 ranged from 19 to 26 cm FL and 120 to 309 g; females ranged from 18 to 25 cm FL and 97 to 294 g (Fig. 3, Table 1). Overall age composition (sexes combined, n = 63) was 79% age-2 fish and 21% age-3 fish (Fig. 4). Mean weight of ovaries in the "forerunner" sample was 14.2 g, and mean GSI was 6.4%.

The "mammy shad" class of Atlantic menhaden sampled in December 1988 was larger than "forerunners" in all morphometric categories (Table 1), as well as being older (Fig. 4). Males in the "mammy shad" class of Atlantic menhaden ranged from 22 to 31 cm FL and 164 to 567 g; females ranged over the same FL interval and weighed from 169 to 608 g (Fig. 3). Overall age composition (n = 274) was 3% age-2, 41% age-3, 36% age-4, 20% age-5, and 1% age-6 fish (Fig. 4). Mean weight of ovaries in the "mammy shad" sample was 26.9 g, and mean GSI was 6.2%. A simple scatter plot of ovary weight on FL (Fig. 5) showed two distinct clusters of resultant points.

Table 1.—Statistical information (FL, body weight, ovary weight, and gonadosomatic indexes) for female "forerunner" and "mammy shad" Atlantic menhaden landed at Beaufort, N.C., in 1989 and 1988, respectively.

Variable	Mean	S. D.	Min.	Max.
"Forerunners"(n=59)				
Fork length (mm)	224	13.3	178	245
Weight (g)	217	40.9	97	294
Ovarian weight (g)	14.2	6.5	1	30
GSI	6.4	2.5	1	11.6
"Mammy shad" (n=149)				
Fork length (mm)	289	14.4	216	313
Weight (g)	425	64.3	169	608
Ovarian weight (g)	26.9	10.8	1.4	65.4
GSI	6.2	2.0	0.3	12.1

Roe Extraction and Disposition

The colloquial phrase in coastal North Carolina for removing roe from gravid menhaden is "breaking roe." Literally with the ventral surface of the fish held outwards, a fisherman grasps a menhaden by the head with one hand and the caudal peduncle with the other hand, and "breaks" the fish nearly in half opening the visceral cavity in a ventral to dorsal direction beginning near the vent (Fig. 6, 7). "Roe breakers" usually wear gloves as the menhaden's ventral scutes are sharp and cutting. In another and less-strenuous technique, the blade of a pocket knife is inserted into the vent and a long incision is made along one flank of the body cavity. With the viscera exposed, the yellow to yellow-orange colored ovaries are readily apparent. They are physically pulled from the body cavity and dropped into a nearby container. If the fish are fresh and well chilled, the ovarian membrane remains intact and is free of most other visceral parts. Externally, male and female menhaden are indistinguishable except for size. Fisherman tend to be selective, choosing the largest and most rotund specimens as having a high probability of being females with large roe sacs. Males are generally sleeker and less rotund in body shape. Ripe testes of males are called "white roe," and are returned to the reduction process stream.

Crew members and plant personnel break roe for personal consumption, while undetermined quantities are chan-

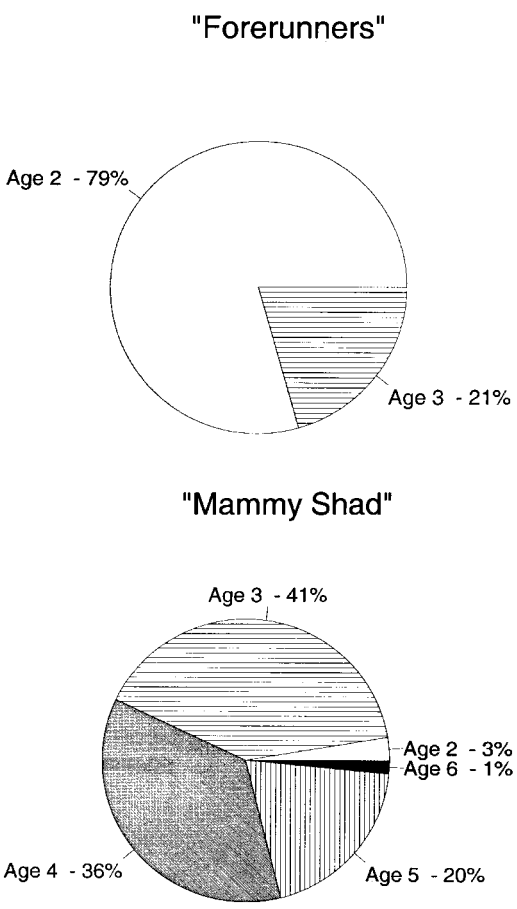

Figure 4.—Age composition "forerunners" and "mammy shad" (roe Atlantic menhaden, sexes combined) landed at Beaufort, N.C., in 1989 and 1988, respectively.

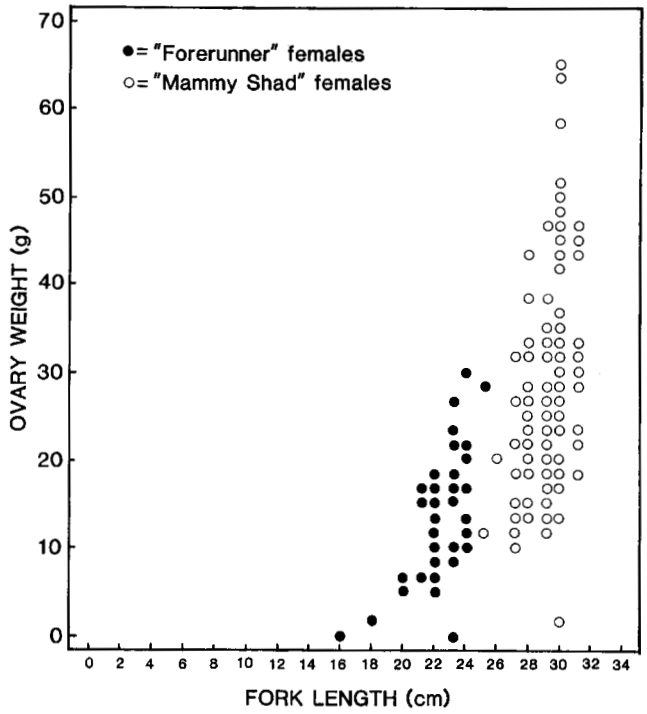

Figure 5.—Scatter plot of ovary weight (g) on fork length (cm) for "forerunners" and "mammy shad" Atlantic menhaden landed at Beaufort, North Carolina.

neled into local retail seafood markets. Several vantage points in the harvest and reduction operations provide access to the roe menhaden. Vessel crewmen get initial opportunities to "break" roe fish on top of the fish hold in between purse-seine sets on the fishing grounds or while returning to port. Carcasses are simply returned to the fish hold. Factory personnel and a few local watermen gain access to roe menhaden as the fish are unloaded into the fish plant. As a vessel's fish holds are partially flooded, fish and water are pumped to the factory. The fish pass across de-watering screens, are counted volumetrically, and then are shunted into one of two holding bins or "raw boxes" prior to being steam cooked. The fish are transported to the raw boxes by a series of conveyors or "drag lines," which supply continuous lines of fish to the "roe breakers" at several opportunistic vantage points. Carcasses are conveniently returned to the drag lines. The final chance to extract roe comes in the raw box only if the cooking operation has not commenced. Fish tumble into the raw box from an overhead drag line and pile on the raw box floor. "Roe breakers" don rain gear and boots, enter the raw box, and break roe near the base of the ever-increasing mound of fish (Fig. 8).

The container of choice for collecting menhaden roe is a plastic 5-gallon bucket. Depending on the size of the fish, efficient "roe breakers" may fill the bucket in a few hours. "Wholesale" purchases of roe are usually volumetric and by the gallon in a plastic jug or jar, although one-half gallon and quart amounts are occasionally sold in sealtight plastic bags. Through the 1980's and 1990's "wholesale" purchase price of roe was fairly stable at about $20 per gallon. Roe from initial catches of gravid fish in November, or during fishing years when roe fish are scarce, often commands a higher price of $25 per gallon. On the other hand, when roe fish are abundant the price may fall to $18 per gallon. At local retail seafood stores menhaden roe is known as "shad roe," and prices average about $5 per pound. One well established restaurant in the area often advertises "shad roe" on its marquee in December. Local aficionados of menhaden roe usually prepare individual roe sacs for table fare by breading them in cornmeal followed by deep-fat frying. Fried roe is served as a meal with several vegetables, and is especially popular during the Christmas Holidays among long-time Carteret County residents.

Discussion

Most roe products are exceptionally valuable relative to the given species'

Figure 6.—Factory employee “breaks” a roe Atlantic menhaden at Beaufort Fisheries, Inc., in Beaufort, North Carolina. Note exposed roe sacs of “broken” fish, drag line of fish moving upward, and five gallon bucket of menhaden roe at bottom and left.

flesh. For example, landings of lumpfish roe in Newfoundland climbed to over 3,000 t in 1987; however, Stevenson and Baird (1988) reported negligible landings of lumpfish carcasses; lumpfish flesh is not highly regarded table fare, and with high water content and low protein and oil yields, it is unsuitable for reduction. Thus, Newfoundland fishermen tend to cull lumpfish carcasses at sea (Stevenson and Baird, 1988). “In the round” catches of striped mullet, *Mugil cephalus*, along the southeastern U.S. coast have traditionally been marketed for local consumption (Leard et al., 1995). In recent decades, directed and lucrative fisheries for roe mullet have developed during fall and early winter. Most processed mullet roe is exported to Asian markets, while carcasses from the roe fishery are usually in such poor condition that they are sold for bait (Degner et al., 1989, cited in Leard et al., 1995). In the

northeast Pacific during the late 1980's, the practice of "roe stripping" in the Alaska pollock, *Theragra chalcogramma*, fishery, that is, extracting roe and discarding female carcasses and males in the round, was scrutinized for its wastefulness of edible fish protein (Alverson, 1990).

Could an export market for menhaden roe develop, as did Asian markets for striped mullet roe that developed in the U.S. southeast in the 1980's? The answer is probably "no" for two reasons. First, the roe menhaden season along the central North Carolina coast is relatively short at only about two months. Moreover, availability of adult menhaden is highly variable, as is the winter weather off the North Carolina capes. Reliable and marketable quantities of menhaden roe would be difficult to guarantee to foreign concerns. Second, the menhaden reduction plants are generally not constructed to handle food-grade processed products. Roe processed for human consumption would obviously require more stringent handling criteria than currently exist at menhaden reduction facilities. Thus, consumption of menhaden roe will probably remain endemic to a few coastal communities where roe menhaden are harvested for reduction. Moreover, judging from the litany of closures of Atlantic menhaden reduction factories in recent decades (Smith et al., 1987; Smith, 1991; ASMFC, 1999), the practice of "breaking roe" may become a ritual of the past in the not too distant future.

Figure 7.—"Broken" Atlantic menhaden (28 cm [upper] and 30 cm [lower] FL) with respective roe sacs.

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Figure 8.—"Breaking roe" of Atlantic menhaden in the "raw box" at Beaufort Fisheries, Inc., in Beaufort, North Carolina, before the cooking process begins.

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