SPAWNING AND FECUNDITY OF ATLANTIC MACKEREL, SCOMBER SCOMBRUS, IN THE MIDDLE ATLANTIC BIGHT

WALLACE W. MORSE

ABSTRACT

Collections of Atlantic mackerel, Scomber scombrus, were made during spring 1977 from Maryland to Rhode Island. Length-weight relationships were determined for total and fork lengths and total and gutted weights. Spawning time was determined from gonad somatic indices and peak spawning occurred between 21 April and 4 May. Egg diameter frequencies from running ripe ovaries indicated five to seven egg batches are spawned by each female during the spawning season. Fecundity was estimated and ranged from 285,000 to 1,980,000 for fish between 307 and 438 mm fork length. Fecundity was related to fork length, gutted weight, and age.

The Atlantic mackerel, Scomber scombrus Linnaeus, is a schooling, pelagic species ranging from the Gulf of St. Lawrence to North Carolina in the northwest Atlantic and from Norway to Spain in the northeast Atlantic. The northwest Atlantic population has been separated into northern and southern contingents on the basis of size composition, spawning times, summer distributions, and tagging studies (Sette 1950; Moores et al. 1975; MacKay2). The northern contingent spawns in the southern Gulf of St. Lawrence from about the end of May to mid-August (Ware 1977). The southern contingent spawns from mid-April to June from North Carolina to Massachusetts (Berrien 1978).

Fecundity estimates of northwest Atlantic mackerel are limited to a few observations ranging from about 500,000 to 1,000,000 eggs (Brice 1898: 208-213; Sette 1943). Fecundity of northeast Atlantic mackerel ranged from approximately 130,000 to 1,100,000 eggs for fish 28.5-46.0 cm total length (Macer3; Lockwood4). This paper presents the results of a fecundity and spawning time investigation of the southern contingent.

METHODS

Atlantic mackerel were collected between 9 April and 21 May 1977 from recreational and commercial catches from Maryland to Rhode Island (Table 1). Length frequencies of males and females are shown in Figure 1. All fish were measured to the nearest millimeter fork length (FL) and total length (TL), and weighed to the nearest gram total weight (TW) and gutted or somatic weight (GW). Otoliths were extracted for age determination. Ovaries of all mature females were exsected, weighed to the nearest 0.01 g, and preserved in 10% Formalin.5

Preliminary observations of eggs from ovaries in the spawning condition revealed that three egg types were present: 1) small, translucent eggs; 2)

TABLE 1.—Catch data of Atlantic mackerel sampled in 1977.

<table>
<thead>
<tr>
<th>Date</th>
<th>Port</th>
<th>Female</th>
<th>Male</th>
<th>Capture method</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 April</td>
<td>Ocean City, Md.</td>
<td>16</td>
<td>8</td>
<td>Otter trawl</td>
</tr>
<tr>
<td>16 Cape</td>
<td>Ocean City</td>
<td>15</td>
<td>10</td>
<td>Hook and line</td>
</tr>
<tr>
<td>20 Barnegat</td>
<td>N.J.</td>
<td>20</td>
<td>25</td>
<td>Hook and line</td>
</tr>
<tr>
<td>27 Greenport</td>
<td>N.Y.</td>
<td>84</td>
<td>36</td>
<td>Pound net</td>
</tr>
<tr>
<td>28 Belford,</td>
<td>N.J.</td>
<td>10</td>
<td>15</td>
<td>Otter trawl</td>
</tr>
<tr>
<td>28 Sheepshead</td>
<td>Bay, N.Y.</td>
<td>6</td>
<td>16</td>
<td>Hook and line</td>
</tr>
<tr>
<td>30 Sheepshead</td>
<td>Bay, N.Y.</td>
<td>9</td>
<td>12</td>
<td>Hook and line</td>
</tr>
<tr>
<td>1 May Sheepshead</td>
<td>Bay, N.Y.</td>
<td>6</td>
<td>17</td>
<td>Hook and line</td>
</tr>
<tr>
<td>4 Barnegat</td>
<td>N.J.</td>
<td>18</td>
<td>36</td>
<td>Hook and line</td>
</tr>
<tr>
<td>5 Barnegat</td>
<td>N.J.</td>
<td>39</td>
<td>66</td>
<td>Hook and line</td>
</tr>
<tr>
<td>7 Sheepshead</td>
<td>Bay, N.Y.</td>
<td>11</td>
<td>19</td>
<td>Hook and line</td>
</tr>
<tr>
<td>8 Point Pleasant, N.J.</td>
<td>17</td>
<td>8</td>
<td>Hook and line</td>
<td></td>
</tr>
<tr>
<td>9 Point Judith, R.I.</td>
<td>42</td>
<td>43</td>
<td>Hook and line</td>
<td></td>
</tr>
<tr>
<td>11 Seimar, N.J.</td>
<td>5</td>
<td>20</td>
<td>Hook and line</td>
<td></td>
</tr>
<tr>
<td>14 Sheepshead</td>
<td>Bay, N.Y.</td>
<td>12</td>
<td>38</td>
<td>Hook and line</td>
</tr>
<tr>
<td>15 Sheepshead</td>
<td>Bay, N.Y.</td>
<td>4</td>
<td>33</td>
<td>Hook and line</td>
</tr>
<tr>
<td>17 Sandy Hook,</td>
<td>N.J.</td>
<td>22</td>
<td>29</td>
<td>Hook and line</td>
</tr>
<tr>
<td>18 Point Judith</td>
<td>32</td>
<td>48</td>
<td>Otter trawl</td>
<td></td>
</tr>
<tr>
<td>22 Sheepshead</td>
<td>Bay, N.Y.</td>
<td>77</td>
<td>21</td>
<td>Hook and line</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>449</td>
<td>517</td>
<td></td>
</tr>
</tbody>
</table>
larger opaque, yolked eggs; and 3) large translucent eggs. There appeared to be no clear size separation between egg types, which is indicative of serial spawners (Hickling and Rutenberg 1936). Therefore, the method described by Hislop and Hall (1974) for whiting, *Merlangus merlangus*, was used to determine which eggs would be shed during the current spawning season. Since yolk deposition indicates eggs are ripening for spawning, random samples of 300 eggs were measured from ovaries at successive maturity stages to determine the average minimum size of yolked eggs. Eggs 0.20 mm and larger contained yolk and were included for fecundity estimation. Ovaries were classified into four maturity stages based upon macroscopic examination and the occurrence of mature eggs (Table 2). Egg diameter frequencies of yolked eggs from ovaries in the developing, ripe, running ripe, and partially spent condition are shown in Figure 2.

Ovaries in the ripe condition (Figure 2b) were used for fecundity estimations. If large translucent eggs (1.00-1.35 mm) were present in the lumen of the ovary, which is indicative of the running ripe condition (Figure 2c), the ovary was not utilized for fecundity because some eggs may have been shed and fecundity would be underestimated.

Suitable ovaries were removed from the Formalin solution, placed in glacial acetic acid for 5 min, and washed, and the eggs were separated with a gentle...
stream of water and agitated in a 0.20 mm mesh sieve. Following removal of the ovarian tissue, the eggs were air dried on blotter paper for 2-3 min and weighed (±0.01 g), and two subsamples were removed and weighed (±0.01 mg). All eggs in each subsample were counted and the mean used to calculate total egg numbers based on the weight of all eggs in the ovary. If the two subsample counts differed by 10% or more, additional samples were taken until two counts differed by <10%.

Ages were determined from otoliths as described by Steven (1952).

**RESULTS**

The allometric relationships of length-weight were expressed by the power function:

\[ Y = aX^b \]  

(1)

where \( X \) is length, \( Y \) is weight, and \( a \) and \( b \) are constants. Equation (1) was converted to the linear form by a logarithmic (base 10) transformation to:

\[ \log Y = \log a + b \log X \]  

(2)

The interrelationships between length measurements and between weight measurements were expressed by the linear function:

\[ Y = a + bX \]  

(3)

where \( Y \) and \( X \) are both length or both weight. All data were fitted using least-squares regression techniques.

Predictive regression equations were calculated using all observations for males and females and an analysis of covariance applied to determine possible sex related differences. No significant differences (\( P = 0.05 \)) were indicated between sexes and sexes were therefore pooled. The pooled regression equations and associated statistics are presented in Table 3.

To determine the peak spawning time the mean gonad somatic index (GSI = percent ovary weight of the gutted weight) was calculated for each week of the sampling period (Figure 3). It appears that individual fish attain their maximum GSI just prior to spawning the first egg batch and a decline in GSI occurs as successive batches are spawned. This was shown by comparing the mean GSI of each maturity stage (Table 4) which showed an increase from stage 1 to 3 and a rapid decrease at stage 4. Similar results were reported by Kaiser (1973) for horse mackerel, *Trachurus murphyi*. He found that gonad somatic indices reflected maturation changes of the ovaries and a sharp decline in the mean GSI coincided with the appearance of the earliest spawning females. In this study the weekly mean GSI increased during the first 3 wk of sampling, peaked between 21 April and 4 May, and then declined steadily through the end of the sampling (22 May). All females examined from the last sampling week were partially spent and indicated spawning was nearly completed within the study area.
The egg diameter frequencies shown in Figure 2 indicate Atlantic mackerel are serial spawners, i.e., several batches of eggs are shed by individuals throughout the spawning season. The presence of multiple modes in the egg diameter frequencies (Figure 2a-c) and ripening eggs in partially spent ovaries (Figure 2d) are indicators of serial spawning (Clark 1935; MacGregor 1957). A cytological study by Bara (1960) has shown that eggs are not shed continuously as stated by Cunningham (1889) but are shed in several batches during the 2-mo spawning period.

The potential number of batches spawned was estimated by determining the ratio of ripe eggs to all yolked eggs in six running ripe ovaries. Atlantic mackerel eggs, from plankton samples, ranged from 1.01 to 1.29 mm diameter (Berrien 1975; Ware 1977); therefore, in this study, eggs 1.05 mm and larger were assumed to constitute the next egg batch to be spawned. The ratios ranged from 13.7 to 21.7% and averaged 17.0%. Thus the potential number of batches spawned per individual was five to seven and averaged six batches.

Fecundity estimates ranged from 285,000 to 1,980,000 eggs for fish between 307 and 438 mm FL. Preliminary plots indicated a curvilinear relationship existed for fecundity-length and a linear relationship for fecundity-weight and fecundity-age. However, correlation coefficients \( r \) were higher for the logarithmic relationships of fecundity-weight and fecundity-age, therefore, all variables were transformed and linear regression equations of the form \( \log Y = a + b(\log X) \) were calculated. Data plots and the equations relating fecundity to fork length, gutted weight, and age are shown in Figures 4-6.

### DISCUSSION

Spawning by the southern contingent of Atlantic mackerel apparently peaked during the 2-wk period between 21 April and 4 May 1977. This 2-wk period represents the mean peak spawning time within the study area (Maryland to Rhode Island) since there is a north and eastward progression of spawning during the spring migration (Bigelow and Schroeder 1953; Berrien 1978). Berrien et al. observed the north and east progression in plankton mackerel egg densities. They found spawning intensity in the Middle Atlantic Bight was low during mid-April and increased rapidly by late April, and maximum egg densities occurred about 25 April. Spawning continued at a reduced rate throughout May and then decreased steadily during June. Very similar results are indicated from my analysis of gonad somatic indices during the 1977 spawning season.

---

MORSE: SPAWNING AND FECUNDITY OF ATLANTIC MACKEREL

Observations of spawning times of various temperate-water fish have indicated peak spawning dates may be relatively fixed. Cushing (1969) postulated an indirect link between the fixity of spawning season and the primary production cycle. Ware (1977) investigated the relationship of spawning time of Atlantic mackerel at St. Georges Bay, Nova Scotia, to the size and abundance of 80 μm plankton. He found the mean peak egg production date was 1 July ± 1 wk and coincided with the maximum abundance of summer plankton. It would appear, at least for the southern contingent, that the time of peak spawning is more variable than that indicated for St. Georges Bay. Sette (1943) determined maximum spawning occurred during mid-May (1928-32) off Middle Atlantic and southern New England States. Ichthyoplankton surveys during the mackerel spawning season in 1966 and 1975-77 (Berrien 1978; Berrien et al. see footnote 6; Berrien and Anderson7) within the Middle Atlantic Bight indicated spawning peaked during May in 1966 and 1975 and during April in 1976 and 1977. In fact, eggs were collected as early as 13 April in 1977. Berrien and Anderson (see footnote 7) attribute the April 1976 spawning peak to increased water temperatures within the study area.

The factors controlling the spawning time of Atlantic mackerel are unclear. The regularity shown by Ware (1977) would indicate internal control or a constant external stimulus such as photoperiod. Sette (1943) presented evidence indicating water temperature is a limiting factor controlling migration and in turn the timing of spawning in a fixed location. Cushing (1967, 1969) suggested that some fish spawn at a relatively fixed date that is linked to planktonic productivity and that changes in plankton production would cause dramatic changes in year-class success. It appears that a variable spawning date, as shown by the southern contingent — linked to the factors affecting plankton productivity, e.g., temperature, photoperiod, nutrient content — would increase the chances for larval survival.

The fecundity estimates presented here must be considered as maximum potential egg production because, as reported by Macer (see footnote 3), resorption may significantly reduce the number of eggs spawned. Preliminary observations by Macer indicated an average of 11.4% of yolked eggs were being resorbed. Bara (1960) observed degeneration in a "few" mature eggs though no quantitative data were presented. Studies are needed to define the extent and possible annual changes of resorption rates and their relationship to fecundity.

ACKNOWLEDGMENTS

I wish to thank Darryl Christensen and others who provided samples from the recreational catches throughout the course of this study. I appreciate the critical reviews and comments by E. Anderson and S. J. Wilk. Special thanks to M. Montone for typing this manuscript and M. Cox for preparation of the figures.

LITERATURE CITED

BARA, G.

BERRIEN, P. L.

BIGELOW, H. B., AND W. C. SCHROEDER.  

BRICE, J. J.  

CLARK, F. N.  

CUNNINGHAM, J. T.  

CUSHING, D. H.  

HICKLING, C. F., AND E. RUTENBERG.  

HISLOP, J. R. G., AND W. B. HALL.  

KAINER, C. E.  

MACGREGOR, J. S.  

MOORES, J. A., G. H. WINTERS, AND L. S. PARSONS.  

SEITTE, O. E.  


STEVEN, G. A.  

WARE, D. M.  