Distribution of Sexually Immature Components of 10 Northwest Atlantic Groundfish Species Based on Northeast Fisheries Center Bottom Trawl Surveys, 1968-86

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ABSTRACT

Analyses of data obtained from research vessel survey cruises over a 19-year period reveal distinctive patterns in the geographic occurrence of immature fish. These occurrences provide qualitative evidence for potentially significant fishing mortality of the sexually immature components of 10 species in the Gulf of Maine-Georges Bank-Southern New England region, where substantial overlap exists between unregulated mesh/exempted fishing areas and the distributions of these immature fish.

INTRODUCTION

If one goal of fishery management is to prevent recruitment overfishing, then it becomes important to define season and area combinations where juvenile mortality is likely to occur. While numerous distribution studies of Northwest Atlantic groundfish exist (Bigelow and Schroeder 1953; Leim and Scott 1966; Bowman 1981; Grosslein and Azarovitz 1982; Scott 1988), most do not specifically consider juvenile distribution patterns. A study by Bowman et al. (1987) on food habits and distribution of juveniles for 17 species was based upon fish of age 1 or less, but did not cover the full period to sexually maturity. Bowman (1981) examined the distribution and abundance of juveniles for 15 species, but not to the geographic and seasonal resolution necessary for evaluation from management perspectives.

This study describes distribution of juveniles of the 10 groundfish species in the Gulf of Maine-Georges Bank-Southern New England region (Figure 1) subject to regulation under the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan (FMP), and evaluates the distribution patterns with respect to regulatory areas established by the FMP. Regulated species include haddock (Melanogrammus aeglefinus), Atlantic cod (Gadus morhua), yellowtail flounder (Limanda ferruginea), American plaice (Hippoglossoides platessoides), witch flounder (Glyptocephalus cynoglossus), redfish (Sebastes fasciatus), pollock (Pollachius virens), white hake (Urophycis tenuis), windowpane (Scophthalmus aquosus), and winter flounder (Pseudopleuronectes americanus). Under the FMP, otter-trawl stretch mesh size is regulated at 5.5 inches (140 mm) for most of Georges Bank and the Gulf of Maine (Figure 2); exempted small-mesh fisheries are allowed in the area extending from Cape Cod north along the inshore segment of the Gulf of Maine. Mesh size is generally not regulated in areas west and south of Cape Cod including the southern flank of Georges Bank; however, the Nantucket Shoals region is included in the large-mesh area and is regulated December through March (Figure 2). In addition, a spawning area closure to protect yellowtail flounder is in effect from March/April to May. Results presented herein may be used to assess qualitatively the impacts of management measures (e.g., effects of small-mesh areas) on the mortality of juvenile fish.

METHODS

Data have been obtained from annual Northeast Fisheries Center (NEFC) spring and autumn bottom trawl surveys (Grosslein 1969; Azarovitz 1981) conducted since 1968 during March to May and September to November, respectively. NEFC survey coverage within the study area is shown in Figure 3; sampling intensity within strata is summarized in Table 1. Maturity ogives were inspected to determine the smallest length at which individuals of each species were observed to be sexually mature (Table 2); immature fish were defined as those falling below that length. Catches (as number per tow) of immature fish were plotted by survey haul location. Data from 1968-86 surveys have been aggregated and plotted for each species by season (spring and autumn). Year-around regulated mesh areas delineated by the FMP (Figure 2) are superimposed for reference purposes; the seasonal areas (Nantucket Shoals and Southern New England spawning closure) are superimposed on spring plots only. Mean values of depth were calculated for juveniles of each species (Table 3).

RESULTS

Haddock

Immature haddock are most concentrated at depths near or less than 100 m during both spring and autumn (Table 3, Figures 4 and 5). In spring, concentrations appear from just south of Jeffreys Ledge to Cape Cod, and along the southern edge of Georges Bank. In autumn, these aggregations remain and are augmented by concentrations on Georges Bank extending from the Northeast Peak and along the Northern Edge to the Great South Channel region. The potential for juvenile mortality exists in the southern Gulf of Maine exempted area and the southern portion of Georges Bank during both seasons.

Atlantic Cod

Immature Atlantic cod are generally found at depths less than 100 m (Table 3, Figures 6 and 7). In the spring, concentrations occur between Jeffreys Ledge and Cape

1 Specific coordinates are described in Federal Register, 50 CFR Part 651, September 17, 1987.
Figure 1. Gulf of Maine, Georges Bank, and Southern New England regions of the Northwest Atlantic Ocean, showing geographic features referred to in this study.

Cod and in the Nantucket Shoals region, and are widely distributed over Georges Bank. Distributions in autumn are more restricted, occurring primarily inshore of the 100-m isobath and principally in three areas: Massachusetts Bay, southeast of Cape Cod, and the Northeast Peak of Georges Bank. Seasonal mesh regulations on Nantucket Shoals (Figure 2) have been established specifically to protect juvenile cod from December to March; however, juvenile mortality may occur in the southern Gulf of Maine exempted area during both seasons. A detailed account of juvenile cod distribution is given by Wigley and Serchuk (submitted).

Yellowtail Flounder

Immature yellowtail flounder are usually found well inshore of 100 m (Table 3). In the Gulf of Maine, they are concentrated between Massachusetts Bay and Cape Cod Bay, and along outer Cape Cod in both spring and autumn (Figures 8 and 9). Immature individuals are found during spring along the southern edge of Georges Bank where their distribution is within the regulated mesh area. In autumn, concentrations shift to the north, near the Great South Channel, but primarily eastward to slightly deeper waters along the southeastern part of Georges Bank. In Southern
New England, immature fish are found mid-shelf at depths around 45 m in spring and 60 m in autumn (Table 3). Spring distribution is generally northward of the spawning area closure. Significant juvenile mortality may occur in the Southern New England region where mesh size is unregulated.

**American Plaice**

Immature American plaice are strongly concentrated along and inside the 100-m isobath in the western Gulf of Maine during spring and autumn (Table 3, Figures 10 and 11). They are found scattered in the deeper waters of the western and central Gulf of Maine, and on the northern edge of Georges Bank. For the most part, immature American plaice are unprotected by the regulated mesh area. Significant discarding of juvenile plaice has been observed in association with the small-mesh shrimp fishery in the western Gulf of Maine during December through May (Stephen H. Clark, NEFC, personal communication).

**Witch Flounder**

Immature witch flounder in the New England region concentrate between Cape Cod and Cape Ann, inshore of Jeffreys Ledge, and intermittently across the northern Gulf of Maine (Table 3, Figures 12 and 13). Distribution does not appear to shift widely between spring and autumn. As with American plaice, witch flounder juvenile aggregations do not occur within the regulated area, and are subject to mortality incurred from the shrimp fishery.

**Redfish**

Immature redfish are distributed over the entire Gulf of Maine (Table 3, Figures 14 and 15), but appear most concentrated from Stellwagen Bank north along the western side of the Gulf of Maine during spring. In autumn, this distribution extends northward into the central Gulf of Maine. Some juvenile mortality may occur in the exempted small-mesh fisheries prosecuted in the western Gulf of Maine.

**Pollock**

Immature pollock are distributed in the northern Gulf of Maine, and between Cape Cod and Jeffreys Ledge at depths less than 90 m (Table 3, Figures 16 and 17) in both spring and autumn. Juveniles also appear along the Northeast Peak of Georges Bank in the spring.
**White Hake**

Immature white hake are common in the spring along the 100-m contour and in deeper waters from Cape Cod northward into the Gulf of Maine; however, some catches have been observed inshore of 100 m in Cape Cod Bay and Massachusetts Bay. During autumn, they are also concentrated along the 100-m contour. Immature white hake are more abundant in the central Gulf of Maine in the spring than autumn. The pattern is reversed for Georges Bank: juveniles are absent in spring, but relatively common in autumn over Georges Bank (Table 3, Figures 18 and 19). Significant juvenile mortality may occur in the western and northern Gulf of Maine, particularly in the autumn, in the exempted fishery area.

**Windowpane**

Immature windowpane are concentrated in Southern New England during both seasons at depths around 30 m (Table 3, Figures 20 and 21). In spring, concentrations extend along the southern boundary of the regulated mesh area of Georges Bank. However, in autumn, immature fish are concentrated in the central area of Georges Bank within the regulated area. The potential for high juvenile mortality exists in the Southern New England region except during the spring when juvenile windowpane aggregations coincide with the spawning area closure.

**Winter Flounder**

Sampling of immature winter flounder from inshore stocks by the NEFC surveys may not be representative: immature individuals are distributed close to estuaries and in shallower waters inside the limits of the survey. Concentrations are observed at 25 m during spring in Cape Cod Bay, and south and west of Narragansett Bay (Table 3, Figure 22), and may be subjected to significant mortality in these areas. In autumn, juvenile fish are dispersed throughout the region (Figure 23). Extremely few individuals have been observed along the outer edge of the shelf. Immature winter flounder occurring on Georges Bank are within the regulated mesh area.

**DISCUSSION**

The summary distributions of immature fish presented above are based on extensive data sets obtained over a period of 19 years. They reveal distinct patterns of geographic occurrence which are useful for management purposes. There are substantial overlaps between exempted fishing/unregulated mesh areas created by the New England Fishery Management Council's Northeast Multispecies FMP and distributions of the sexually immature components of many stocks.
The Gulf of Maine exempted fishery area, where small-mesh fisheries (i.e., northern shrimp and silver hake) have been prosecuted traditionally, encompasses seasonal concentrations of juveniles for eight Gulf of Maine stocks: haddock, Atlantic cod, yellowtail flounder, American plaice, witch flounder, redfish, pollock, and white hake.

The unregulated mesh area extending along the southern edge of Georges Bank includes areas with relatively high concentrations of immature haddock and windowpane during the spring. Southern New England stocks of Atlantic cod, yellowtail flounder, windowpane, and winter flounder are potentially vulnerable to juvenile fishing mortality over their range due to the absence of mesh restrictions in the area.

This study suggests that it may be possible to reduce juvenile mortality considerably by different configurations of area/seasonal closures than those currently employed. As more catch and discard data become available from the NEFC Domestic Sea Sampling Program (initiated in 1989), greater spatial and temporal resolution will be possible.
Table 2. Length at which fish are first observed to be mature (i.e., fraction mature below this length = 0)

<table>
<thead>
<tr>
<th>Species</th>
<th>Length (cm)</th>
<th>Source</th>
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</thead>
<tbody>
<tr>
<td>Haddock</td>
<td>31</td>
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</tr>
<tr>
<td>Atlantic cod</td>
<td>37</td>
<td>Morse 1979</td>
</tr>
<tr>
<td>Yellowtail flounder</td>
<td>20</td>
<td>Morse 1979</td>
</tr>
<tr>
<td>American plaice</td>
<td>20</td>
<td>Morse 1979</td>
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<tr>
<td>Witch flounder</td>
<td>25</td>
<td>Morse 1979</td>
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<td>Redfish</td>
<td>22*</td>
<td>Perlmutter &amp; Clarke 1949</td>
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<td>Pollock</td>
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<td>White hake</td>
<td>34</td>
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<tr>
<td>Windowpane</td>
<td>24</td>
<td>Bigelow and Schroeder 1953</td>
</tr>
<tr>
<td>Winter flounder</td>
<td>20</td>
<td>Morse 1979</td>
</tr>
</tbody>
</table>

*Estimated values.

Table 3. Mean depth, standard deviation, and range of depth for juveniles of 10 species from NEFC spring and autumn bottom trawl surveys, 1968-86

<table>
<thead>
<tr>
<th>Species</th>
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<th>Autumn</th>
</tr>
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<tr>
<td></td>
<td>No.</td>
<td>Mean Depth (m)</td>
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<td>61.7</td>
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<td>Redfish</td>
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<td>Windowpane</td>
<td>10931</td>
<td>26.6</td>
</tr>
<tr>
<td>Winter flounder</td>
<td>4099</td>
<td>25.6</td>
</tr>
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</table>
REFERENCES CITED


Figure 4. Distribution (as number per tow) of sexually immature haddock (<31 cm) based on spring NEFC bottom trawl survey cruises, 1968-86

Figure 5. Distribution (as number per tow) of sexually immature haddock (<31 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86
Figure 6. Distribution (as number per tow) of sexually immature Atlantic cod (<37 cm) based on spring NEFC bottom trawl survey cruises, 1968-86

Figure 7. Distribution (as number per tow) of sexually immature Atlantic cod (<37 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86
Figure 8. Distribution (as number per tow) of sexually immature yellowtail flounder (<20 cm) based on spring NEFC bottom trawl survey cruises, 1968-86

Figure 9. Distribution (as number per tow) of sexually immature yellowtail flounder (<20 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86
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Figure 11. Distribution (as number per tow) of sexually immature American plaice (<20 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86
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Figure 15. Distribution (as number per tow) of sexually immature redfish (<22 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86
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Figure 17. Distribution (as number per tow) of sexually immature pollock (<30 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86
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Figure 21. Distribution (as number per tow) of sexually immature windowpane (<24 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86
Figure 22. Distribution (as number per tow) of sexually immature winter flounder (<20 cm) based on spring NEFC bottom trawl survey cruises, 1968-86

Figure 23. Distribution (as number per tow) of sexually immature winter flounder (<20 cm) based on autumn NEFC bottom trawl survey cruises, 1968-86