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N O T E

Effects of First-time Spawners on Stock-recruitment Relationships for Two Groundfish Species

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Abstract

Recent experimental studies suggest that first-time spawning fish may not be as reproductively fit as repeat spawners. Traditional stock-recruitment models consider all mature fish as equivalent contributors to the spawning stock biomass. In this study we examine the effects of discounting first-time spawners on the stock-recruitment relationship of two species with varying life histories: Georges Bank haddock (*Melanogrammus aeglefinus*), a fast maturing gadoid, and Gulf of Maine witch flounder (*Glyptocephalus cynoglossus*), a slow maturing pleuronectid. Proportions of first-time spawning haddock ranged from 3 to 62 percent of the spawning stock biomass during 1963–96. Exclusion of all first-time spawners from spawning stock biomass improved the Ricker stock-recruitment relationship by 39 percent. For witch flounder, proportions of first-time spawners were less variable, never exceeding about 30 percent. Adjusting the spawning stock biomass for first-time spawners did not improved the overall relationship for witch flounder.

Key words: first-time spawners, stock-recruitment, spawning stock biomass

Introduction

Recent experimental studies (Knutsen and Tilseth, 1985; Hislop, 1988; Chambers *et al.*, 1989; Kjesbu, 1989; Kjorsvik *et al.*, 1990; Buckley *et al.*, 1991; Trippel and Morgan, 1994; Kjesbu, 1994; Trippel *et al.*, 1997) suggest that first-time spawning fish may not be as reproductively fit as repeat spawners, i.e., they may produce inferior gametes and/or be inexperienced with respect to spawning behavior. During the past two decades, truncated age structure and increased and variable proportions of first-time spawners for many Northwest Atlantic groundfish populations have been observed coincident with high levels of exploitation. Traditional stock-recruitment models consider all mature fish as equivalent contributors to spawning stock biomass. In this study, the effects of discounting first-time spawners on the stock-recruitment relationship are examined. Two species with varying life histories were selected: Georges Bank haddock (*Melanogrammus aeglefinus*), a fast-maturing gadoid, and Gulf of Maine witch flounder (*Glyptocephalus cynoglossus*), a slow-maturing pleuronectid.

Methods

Haddock stock size-at-age data for the period 1963–96 were derived from a virtual population analysis (VPA) conducted by Brown (MS 1997). Witch flounder stock size-at-age data for the period 1982–93 were obtained from a VPA conducted by Wigley and Mayo (MS 1996). Maturity-at-age ogives were derived from data collected during Northeast Fisheries Science Center (NEFSC) spring research vessel bottom trawl surveys from 1963 to 1997. For haddock, fifteen ogives were used over the study period (see Brown MS 1997 for details; Table 1); for witch flounder, ogives were derived for 1981–85, 1986–91, and 1992–94, corresponding to periods of similar maturation patterns (Table 1).

Numbers of mature fish at age were estimated annually by applying the appropriate maturity ogive for that year to VPA stock size-at-age values. Estimates of first-time spawners for each age group were then derived by subtracting the percentage of mature fish in that age group from that of the previous age group; repeat spawners are represented

by the remainder. An example of this method is given for Georges Bank haddock for 1982:

Age	% mature	% first-time	% repeat
1	0	0	0
2	31	31	0
3	67	36	31
4	100	33	67
5+	100	0	100

Mean weights-at-age (reported for haddock in Brown (MS 1997) and for witch flounder by Wigley and Mayo (MS 1996)) were then applied to the numbers of first-time and repeat spawners to estimate these two components of spawning stock biomass (mt). Given uncertainty as to appropriate levels of first-time spawner inefficiency, first-time spawning biomass was discounted by five percentage levels: 0%, 25%, 50%, 75% and 100%. For each level, first-time spawners were discounted and then summed with repeat spawners to derive total adjusted spawning stock biomass.

Exploratory stock-recruitment analyses were conducted using each of the five estimates of adjusted spawning stock biomass for each species. In this study, the use of stock-recruitment model was for comparative purposes only (i.e. to perform a sensitivity analysis on the influence of first-time spawners) and not an attempt to derive definitive stock-recruitment relationships. Indices of recruitment were numbers of age 1 fish for haddock (Brown, MS 1997) and numbers of age 2 fish for witch flounder (Wigley and Mayo, MS 1996). Coefficients of determination (r^2) were used as the criterion for evaluating the goodness of fit of stock-recruitment relationships and incremental discounting of first-time spawning at various levels.

Results

The proportion of first-time spawning haddock varied considerably, ranging from 3% in 1970 to 62% in 1977 (Fig. 1a). Best fits for haddock stock-recruitment data were obtained using the Ricker model and by omitting the anomalous 1963 year-class from the analyses. Of the five discounting levels, the exclusion of all first-time spawners resulted in a 39% increase in the r^2 value relative to the baseline run comprised of all spawners (Table 2, Fig. 2a).

For witch flounder, the proportion of first-time spawners varied little during the study period, never exceeding 31% of spawning stock biomass (Fig. 1b). Adjusting spawning stock biomass by discounting for first-time spawners did not improve the Ricker stock-recruitment relationship in any scenario (Table 2, Fig. 2b).

TABLE 1. Percent mature at age for female Georges Bank haddock and female Gulf of Maine witch flounder.

	Haddock[1]					Witch flounder[2]									
Time	Age				Time	Age									
Period	1	2	3	4	Period	1	2	3	4	5	6	7	8	9	10
1963–67	0	0	78	100											
1968–72	0	28	76	100											
1973–76	0	34	92	100											
1977	0	61	100	100											
1978	0	26	99	100											
1979	0	8	71	100											
1980	0	41	100	100											
1981	0	52	94	100											
1982	0	31	67	100	1982–85	0	0	2	8	25	52	80	94	99	100
1983	0	11	39	100											
1984	12	33	94	100											
1985–89	24	65	92	98	1986–91	0	0	2	20	65	95	100	100	100	100
1990–92	10	56	94	99	1992–94	0	0	0	7	35	72	95	100	100	100
1993–94	7	30	71	94											
1995–96	2	34	94	100											

[1] Taken from Brown, 1997.
[2] Taken from Wigley and Mayo, 1994.

Conclusion

This study suggests that, depending on species, the proportions of first-time spawners within a stock may account for a substantial and varying proportion of the stock's reproductive potential. In the case of witch flounder, the low variability observed in the number of first-time spawners contributed to a stable stock-recruitment relationship as evidenced by relative insensitivity of the coefficients of determination (r^2) values to various assumptions about the contributions of first-time spawners. Haddock

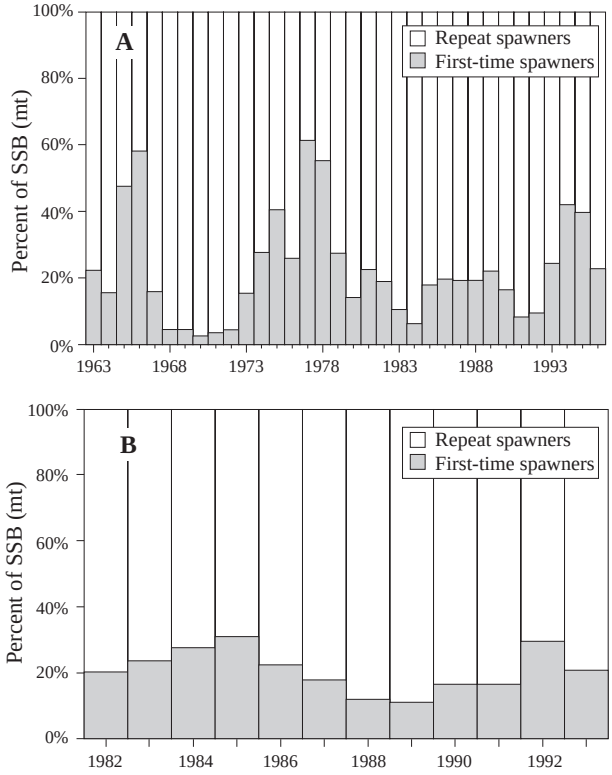

Fig. 1. Percent composition of first-time and repeat spawning stock biomass (SSB) by year for (**A**) Georges Bank haddock and (**B**) Gulf of Maine witch flounder.

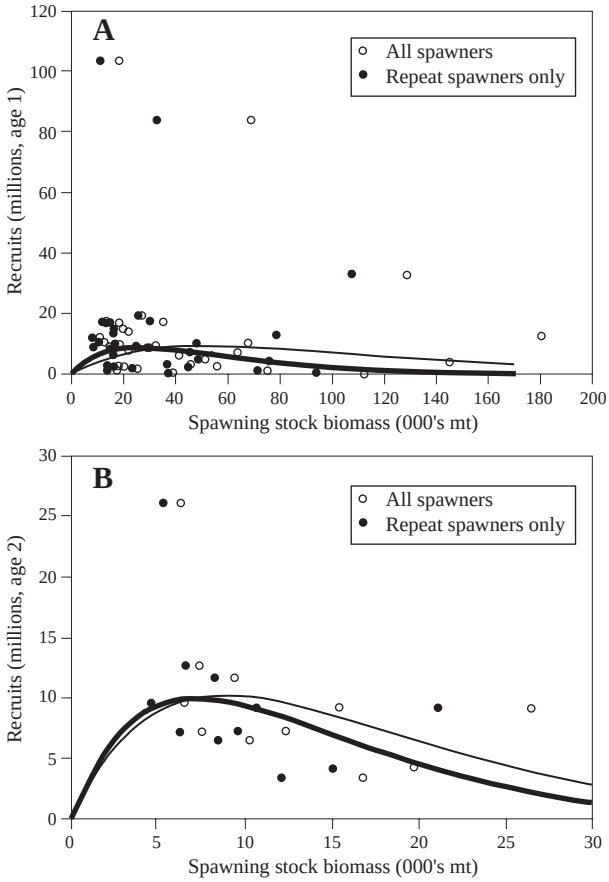

Fig. 2. Fitted Ricker stock-recruitment relationships for (**A**) Georges Bank haddock and (**B**) Gulf of Maine witch flounder for all spawners (open circle, thin line) and repeat spawners only (closed circle, thick line).

TABLE 2. Coefficients of determination (r^2) obtained from fitting a Ricker stock-recruitment relationship to Georges Bank haddock and Gulf of Maine witch flounder under various assumptions of the viability of spawning products of first-time spawners.

Discounting Assumptions	Haddock	Witch Flounder
All spawners (baseline)	0.240	0.652
75% first-time spawners	0.256	0.642
50% first-time spawners	0.276	0.630
25% first-time spawners	0.302	0.617
no first-time spawners	0.334	0.602

stock-recruitment relationships exhibited a high degree of sensitivity to the composition of the spawning stock. For species such as haddock, stock rebuilding strategies which include minimum levels of spawning stock biomass may be compromised by failure to consider the age-structure of the spawning stock.

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