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An Examination of the Influence of Environmental Conditions on Spring Survey Catches of Atlantic Mackerel

by

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CRD 95-13 Assessment of the Georges Bank haddock stock for 1994. By L. O'Brien and R.W. Brown.

CRD 95-14 An examination of the influence of environmental conditions on spring survey catches of Atlantic mackerel. By J.K.T. Brodziak and S.-W. Ling.

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CRD 95-19 Report of the 20th Northeast Regional Stock Assessment Workshop (20th SAW): SAW Public Review Workshop.

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INTRODUCTION

Environmental conditions have been found to influence recreational catches of Atlantic mackerel (*Scomber scombrus*) in the northwest Atlantic (Overholtz *et al.* 1991). Here we examine whether Atlantic mackerel catches on the NEFSC spring bottom trawl survey during 1968-1994 were associated with four environmental variables: average depth, bottom water temperature, surface water temperature, and wind speed.

MATERIALS AND METHODS

Research survey data from the NEFSC spring bottom trawl survey during 1968-1994 were collected for all useable stations from Cape Hatteras to Georges Bank (NEFSC offshore survey strata 1-25 and 61-76). Useable stations during 1968-1981 consisted of random tows with no substantial tearup of gear. Useable stations during 1982-1994 consisted of random tows that were representative with no substantial tearup of gear. For each useable station, measurements of the total number of mackerel captured, the average depth (m), bottom water temperature (C), surface water temperature (C), and wind speed (nm/h) were collected.

Perry and Smith (1994) developed a nonparametric univariate test of association between an environmental factor and fish catch during a survey. Their randomization test uses the maximum absolute difference between the cumulative distribution function of the environmental factor and the catch-weighted cumulative distribution function as a test statistic to evaluate whether a significant association exists. The test proceeds as follows. First, the observed cumulative distribution and associated catch-weighted cumulative distribution of the environmental variable are determined and the test statistic is computed. Second, environmental measurements are randomly assigned (with replacement) to catches and the corresponding test statistic is computed; this step is repeated so as to generate a distribution of test statistics under the null hypothesis of random association between catch and environmental factor. Third, the observed test statistic is compared to the distribution of test statistics from the randomization procedures to evaluate whether the null hypothesis of random association can be rejected. Software to apply this randomization test and to compute the cumulative and catch-weighted cumulative distributions of the environmental factor has been developed[1].

We applied the univariate randomization test to mackerel catches from the spring survey during 1968-1994 for four environmental variables: average depth (m), bottom water temperature (C), surface water temperature (C), and wind speed (nm/h). Stations where an environmental variable was not measured were excluded from the test for that variable. No wind speed data were recorded during the 1968 spring survey. A total of 2000 randomizations were used for a total of 2001 test statistics (the original data pairing was included, as in Perry and Smith (1994)).

RESULTS

Results of the univariate randomization test of association between catches of Atlantic mackerel and average depth, bottom temperature, surface temperature, and wind speed (Table 1) indicate significant associations existed in certain years. The association between mackerel catch and average depth was significant in 1973, 1977, 1978, 1990, and 1991. The association between mackerel catch and bottom temperature was significant in 1968, 1969, 1971, 1977, 1978, 1980, 1981, 1988, 1993, and 1994. The association between mackerel catch and surface temperature was significant in 1968, 1969, 1970, 1971, 1973, 1976, 1978, 1979, 1981, 1985, 1992, 1993, and 1994. The association between mackerel catch and wind speed was significant in 1982, 1988, 1993, and 1994.

The interquartile range of the cumulative and catch-weighted cumulative distributions of the environmental variable were computed for significant associations (Table 2). Differences in the interquartile range of the two distributions identify how mackerel catches varied in relation to each environmental variable when a significant association was found.

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[1] Available from senior author upon request.

Table 1. Results of univariate randomization test of association between catches of Atlantic mackerel (number of fish) and average depth, bottom temperature, surface temperature, and wind speed during the NEFSC spring bottom trawl survey, 1968-1994. Table entries are the probabilities of random association[1] (of having a test statistic greater than or equal to the observed value by chance alone) between mackerel catches and the environmental factor.

	ENVIRONMENTAL FACTOR			
YEAR	AVERAGE DEPTH	BOTTOM TEMPERATURE	SURFACE TEMPERATURE	WIND SPEED
1968	0.29	<0.01*	<0.01*	NO DATA
1969	0.67	0.02*	<0.01*	0.72
1970	0.70	0.07	0.03*	0.22
1971	0.34	<0.01*	<0.01*	0.11
1972	0.39	0.22	0.86	0.59
1973	0.01*	0.25	<0.01*	0.25
1974	0.63	0.59	0.65	0.87
1975	0.80	0.32	0.65	0.98
1976	0.18	0.21	0.05*	0.31
1977	0.01*	<0.01*	0.10	0.44
1978	0.03*	<0.01*	<0.01*	0.60
1979	0.14	0.13	0.01*	0.47
1980	0.07	<0.01*	0.11	0.23
1981	0.88	0.02*	0.02*	0.19
1982	0.49	0.96	0.69	<0.01*
1983	0.28	0.62	0.59	0.15
1984	0.11	0.57	0.78	0.99
1985	0.59	0.08	0.01*	0.20
1986	0.60	0.27	0.54	0.30
1987	0.75	0.82	0.76	0.87
1988	0.81	<0.01*	0.80	0.01*
1989	0.26	0.73	0.43	0.19
1990	0.04*	0.47	0.17	0.93
1991	<0.01*	0.41	0.23	0.51
1992	0.23	0.10	<0.01*	0.84
1993	0.52	<0.01*	<0.01*	0.02*
1994	0.74	<0.01*	<0.01*	0.03*

[1] Associations significant at the =0.05 level are indicated with an asterisk.

Table 2. Interquartile ranges of unweighted cumulative and catch-weighted cumulative distributions of average depth (m), bottom temperature (C), surface temperature (C), and wind speed (nm/h) for years where the null hypothesis of random association was rejected.

AVERAGE DEPTH (m)

YEAR	INTERQUARTILE RANGE UNWEIGHTED	CATCH-WEIGHTED
1973	42-87	152-166
1977	46-90	77-146
1978	42-86	31-183
1990	43-85	39-58
1991	48-91	30-36

BOTTOM TEMPERATURE (C)

YEAR	INTERQUARTILE RANGE UNWEIGHTED	CATCH-WEIGHTED
1968	3.4-6.4	6.1-7.0
1969	4.0-6.3	4.9-6.2
1971	3.8-7.6	9.0-9.5
1977	5.0-6.7	6.5-10.2
1978	4.2-5.9	7.2-10.7
1980	5.3-8.5	10.2-11.1
1981	5.1-6.7	6.3-9.3
1988	4.6-8.1	9.0-10.1
1993	4.1-6.1	6.7-7.2
1994	4.7-7.7	6.2-9.7

SURFACE TEMPERATURE (C)

YEAR	INTERQUARTILE RANGE UNWEIGHTED	CATCH-WEIGHTED
1968	3.1-4.9	5.5-6.4
1969	3.9-5.1	5.8-6.1
1970	4.2-6.8	6.0-7.0
1971	3.5-5.3	5.3-7.2
1973	5.0-6.7	9.8-10.0
1976	5.5-7.4	6.8-7.1
1978	4.4-5.6	5.7-7.0
1979	4.8-7.1	6.7-8.4
1981	5.6-6.7	6.7-8.3
1985	4.7-6.3	6.3-6.4
1992	4.0-6.3	5.2-6.2
1993	4.2-5.1	5.2-6.5
1994	4.8-5.9	5.7-6.9

WIND SPEED (nm/h)

YEAR	INTERQUARTILE RANGE UNWEIGHTED	CATCH-WEIGHTED
1982	9-16	30-38
1988	9-19	16-26
1993	9-19	8-10
1994	8-19	7-15

For average depth, a total of 5 out of 27 associations (19%) were significant at the =0.05 level. The interquartile range of the catch-weighted cumulative distribution was deeper than the unweighted range in 1973, 1977, and 1978. This suggests that mackerel were generally found in deeper water during these spring surveys. In contrast, the interquartile range of the catch-weighted distribution was shallower than the unweighted range in 1990 and 1991. This suggests that mackerel were more associated with shallow water during these spring surveys.

For bottom temperature, a total of 10 out of 27 associations (37%) were significant at the =0.05 level. The interquartile range of the catch-weighted cumulative distribution was warmer than the unweighted range in 1968, 1969, 1971, 1977, 1978, 1980, 1981, 1988, 1993, and 1994. This suggests that mackerel catches were associated with warmer bottom temperatures during these spring surveys.

For surface temperature, a total of 13 out of 27 associations (48%) were significant at the =0.05 level. The interquartile range of the catch-weighted cumulative distribution was warmer than the unweighted range in 1968, 1969, 1970, 1971, 1973, 1978, 1979, 1981, 1985, 1993, and 1994. This suggests that mackerel catches were associated with warmer surface temperatures during these spring surveys. The interquartile range of the catch-weighted cumulative distribution was within the unweighted range in 1976 and 1992. During these spring surveys, this suggests that mackerel catches were not associated with extremes of surface temperature.

For wind speed, a total of 4 out of 26 associations (15%) were significant at the =0.05 level. The interquartile range of the catch-weighted cumulative distribution was greater than the unweighted range in 1982 and 1988. Mackerel catches during these spring surveys were associated with higher wind speeds. In contrast, the interquartile range of the catch-weighted cumulative distribution was lower than the unweighted range in 1993 and 1994. Mackerel catches during these spring surveys were associated with lower wind speeds.

We calculated the average, standard deviation, and coefficient of variation of the median value of average depth (m), bottom temperature (C), surface temperature (C), and wind speed (nm/h) from the unweighted cumulative and catch-weighted cumulative distributions functions for each variable over the period 1968-1994 (Table 3). This was done to see if there were any clear differences in the central tendency, measured by the median, of these distributions. With the exception of surface water temperature, much greater variability was observed in the median of the catch-weighted distribution than in that of the unweighted distribution. This differs from the study of Perry and Smith (1994) who examined associations of groundfish with environmental factors. There appears to be no pattern in the central tendency of mackerel association with either depth or wind speed. For bottom and surface temperature, these data indicate that mackerel catches are generally associated with warmer temperatures, although there is substantial variability in this association.

Table 3. Average, standard deviation, and coefficient of variation of the median value of average depth (m), bottom temperature (C), surface temperature (C), and wind speed (nm/h) from the unweighted cumulative and catch-weighted cumulative distributions functions for each environmental variable over the period 1968-1994.

ENVIRONMENTAL FACTOR	CUMULATIVE DISTRIBUTION	AVERAGE[1]	STANDARD DEVIATION[1]	CV[1]
DEPTH	UNWEIGHTED	63.1	2.1	0.033
	CATCH-WEIGHTED	70.9	29.7	0.419
BOTTOM TEMPERATURE	UNWEIGHTED	5.62	0.63	0.111
	CATCH-WEIGHTED	7.27	2.13	0.294
SURFACE TEMPERATURE	UNWEIGHTED	5.41	0.71	0.132
	CATCH-WEIGHTED	6.32	1.06	0.167
WIND SPEED	UNWEIGHTED	11.6	3.1	0.269
	CATCH-WEIGHTED	14.2	7.0	0.497

[1] Statistic for the median of the cumulative distribution.

DISCUSSION

Because Atlantic mackerel is a fast-swimming species that undergoes extensive migrations in the Northwest Atlantic, it is not surprising to find variability in the association of mackerel catches with environmental conditions during spring NEFSC surveys. The only consistent pattern of association was that mackerel were generally captured in waters with warmer bottom and surface temperatures. This pattern is consistent with Overholtz *et al.* (1991) who found a positive association between spring surface water temperature and recreational catches of mackerel off the Northeast coast of the U.S. Our findings indicate that water temperature influences the spring distribution of Atlantic mackerel in the northwest Atlantic and that mackerel can be considered to generally avoid surface and bottom water temperatures below 5 C during the spring. However, the variability in the association of mackerel with warmer waters also suggests that water temperatures are not the sole determinant of mackerel distribution during spring, but instead, are a characteristic of the preferred habitat for this highly mobile species.

LITERATURE CITED

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