Appendix C-4

Weakfish
CPUE estimates calculated with GLM and GAM standardizations

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Abstract

Current management of weakfish in the US is hampered by disparities among the various survey catch rate indices that are used for stock assessment. To improve consistency among the indices we calculated standardizations of catch rate based on geographic and environmental data collected in each survey, using generalized linear models (GLM) and generalized additive models (GAM). Results of the analyses showed that GAM gives better fit for modeling weakfish catch rates than GLM. Comparisons by cross-correlation showed that standardization with GAM or GLM improved consistency (positively or negatively) among most surveys when high or low years were correlated. Juvenile weakfish surveys tended to have higher positive correlation than adult surveys.

Introduction

Weakfish (*Cynoscion regalis*) is a commercially and recreationally valuable migratory fish that inhabits the western Atlantic coastal waters from Nova Scotia to northern Florida. Current management of weakfish in the US is hampered by disparities among the survey catch rate indices collected by various state agencies that are included in the stock assessments. The disparities include different gear types that are used, different variables that are measured, and different methods for summarizing data; e.g., arithmetic vs. geometric mean catches. Many spatial, temporal, and environmental factors are known to influence the catch rates of fishes, and standardizing catch rate indices in relation to these factors improves their utility in stock assessments (Harley et al. 2001; Maunder and Punt 2004). Our objective in this paper is therefore to develop standardizations of weakfish catch rate indices using generalized linear and/or generalized additive models, in an effort to increase the consistency of the catch rate indices among different survey databases.

Methods

Catch-per-unit-effort (CPUE) estimates of weakfish are compiled from survey data provided by state, inter-state, and federal agencies along the Atlantic coast. All available survey databases comprise differences in the time range covered, sampling intensity, the gear that was used, and the environmental and geographic variables that were measured along with weakfish catches. Therefore, available survey databases were used opportunistically to calculate weakfish CPUE estimates on the scale of inter-annual (yearly) variation and the scale of annual (usually monthly) variation. CPUE estimates were calculated by numbers of weakfish using four methods: arithmetic mean ($\overline{N}$ where N is the number of weakfish caught per sample for, e.g., a given year in a given survey), geometric mean ($\exp(\overline{\log(N+1)})-1$, Gottschall et al. 2008), generalized linear model GLM (McCullagh and Nelder 1989), and generalized additive model GAM (Wood 2006).

GLM and GAM were calculated using the environmental and geographic variables of the surveys as predictor variables. Geographic coordinates (i.e., latitude and longitude), when available, were particularly important because Moran's Index tests (Moran, 1950) calculated on several survey data sets showed strong spatial autocorrelation among catch samples. Variables that were not significant in the GLM or GAM models (model coefficients $p \geq 0.10$) were removed by backward selection. Variables were also excluded if they were missing from >20% of samples, or reduced the total number of useable samples by >20% (e.g., two variables might be missing from just 15% of samples each, but if they were non-overlapping so as to reduce the total number of useable samples by 30%, then the lesser significant of the two would be excluded). Because of high proportions of zero catches in many surveys, GLM and GAM were calculated using a delta-lognormal approach (Lo et al. 1992), as follows: presence or absence (0/1) of weakfish catch, and catch numbers of only

positive catch, were first analyzed separately by either GLM or GAM. Presence / absence was modeled on the binomial distribution, while positive catches were log-transformed and modeled on the normal distribution. Fit of the log positive catches to the normal distribution was verified by chi-square tests. The year (or month) effects in both the presence/absence and the positive catch models were extracted by setting all other variables to their median (Maunder and Punt 2004) and calculating the sum of variables × their GLM (or GAM) coefficients. The presence / absence proportions and positive catch model predictions were then back-transformed to linear domain, and multiplied together to give relative estimates of yearly (or monthly) average CPUE. GLM and GAM values were scaled to the arithmetic means of each survey. Year and month were always treated as categorical variables in the analyses. Environmental and geographic variables were treated as continuous unless otherwise noted in the survey summaries, below. For each survey, the goodness of fit of the GLM and GAM were compared by the Akaike information criterion (AIC; Akaike 1973).

Results

Catch rate standardization

GLM and GAM yearly standardizations of catch rate indices are summarized in Table 1 for the three coast-wide surveys (NMFS, MRFSS, and SEAMAP), in Table 2 for the adult surveys (RI, NJ, DE, MD and NC), and in Table 3 for juvenile surveys (CT, NY, DE, VIMS, NC and Maryland 'blue crab'). Time series of yearly log-transformed standardized CPUE are also plotted together in Figures 1 and 2.The designation of an 'adult' survey actually means that all age classes were targeted. Each survey is separately described below and all versions of its yearly and monthly indices (arithmetic mean, geometric mean, GLM, GAM) are listed in the Appendix. Numbers of samples in the Appendix tables refer to useable samples, i.e., after data were edited for errors or omissions. Significance values of GLM and GAM variables for each survey, together with R^2 of the models, are also summarized as tables in the Appendix.

NMFS

The NMFS fall survey by the NEFSC includes 1894 samples from 1972 to 2006 (Tables A1 and A2), taken with a Yankee #36 bottom trawl (18 m headrope, 24 m footrope). Samples were geographically referenced by latitude and longitude (range: 34.90 to 41.60° N and 69.52 to 76.07° W), and depth and bottom temperature were measured in the survey as environmental variables. Both depth and bottom temperature were included in the GLM and GAM analyses. However, bottom temperature was not recorded for 328 samples, reducing the total number of data entries analyzed to 1566. Significance values of model variables are given in Table A3.

Log catch rate generally increased from south to north and decreased from west to east (i.e., nearshore to offshore) (Fig. 3).

MRFSS

The MRFS survey includes 13477 samples for weakfish from 1981 to 2007 (Tables A4 and A5). Catch and effort data are collected by telephone interview and angler intercept sampling (see www.st.nmfs.noaa.gov/st1/recreational/overview/overview.html for procedures and data access). Samples, coming from recreational fishers, did not have latitude and longitude data but were referenced to the state where the catch was taken. We used state as an ordinal index from south to north: FL = 1, GA = 2, SC = 3, NC = 4, VA = 5, MD = 6, DE = 7, NJ = 8, NY = 9, CT = 10, RI = 11, MA = 12, NH = 13, ME = 14, and treated this index as a continuous variable in the GLM and

GAM analyses. The approximate distance from shore of the catch was categorized in the MRFS survey as "inland", "ocean ≤3 mi.", "ocean >3 mi.", and in a few cases "ocean ≤10 mi.", or "ocean >10 mi.". We likewise transferred these categories to an ordinal index as distances 1, 2, 3, 6.67, and 10 respectively, and treated this index as a continuous variable. However, for GAM this index had to be excluded because it resulted in too few distinct values for smoothing. The one other variable available for analysis of these data (and used for both GLM and GAM) was the fishing mode, consisting of categories "beach/bank", "man made", "private/rental", "party/charter", "shore", and "charter". Significance values of model variables are given in Table A6.

The along-coast state index showed a parabolic relationship to log catch rate: catch increased south-to-north until approximately the mid-Atlantic, the decreased again further north (Fig. 4).

SEAMAP

The SEAMAP survey database includes 4388 samples from 1990 to 2006 (Tables A7 and A8), collected from tows of paired 22.9-m mongoose-type Falcon trawl nets (ASMFC 2000). Samples ranged from 28.76 to 35.23° N and 75.59 to 81.44° W, and environmental variables included depth, bottom temperature, and bottom salinity. However, bottom temperature was excluded from GLM as non-significant, and both bottom temperature and depth were excluded from GAM as non-significant. Three samples were removed from analyses due to missing data entries. Significance values of model variables are given in Table A9.

Log catch rate increased south-to-north from approximately 31°N to 33°N, and generally decreased west to east (Fig. 5).

RI fall trawl survey

The RI fall trawl survey collected 565 samples from 1979 to 2007 (Tables A10 and A11). This survey did not report any zero catches, and therefore the presence / absence component of the GLM and GAM analyses was not used. Latitude and longitude were not given but data were indexed by area (Narragansett Bay, Rhode Island Sound, Block Island Sound), and 11 strata nested within areas. Numbers of samples per strata were very uneven (6 strata had <10 data, 4 strata had between 15 and 69 data, and one stratum had 389 data). Therefore strata were not used for analysis, but area was used as a categorical variable. Since both other available variables (year and month) were categorical too, only GLM was calculated. Significance values of model variables are given in Table A12.

NJ trawl survey

The New Jersey trawl survey collected 3430 samples from 1988 to 2006 (Tables A13 and A14). Samples were referenced by start latitude and longitude and end latitude and longitude, which were averaged per sample. Average latitude and longitude ranged from 38.52 to 40.48° N and from 73.74 to 75.05° W. Other recorded variables included start depth, end depth, minimum depth, and maximum depth, which were averaged per trawl, and tow duration. Average depth was significant and used in both GLM and GAM analyses, while tow duration was not significant. Significance values of variables in the model are given in Table A15.

Log catch rate increased south to north and decreased west to east (Fig. 6).

DE 30-ft trawl survey

The Delaware 30-ft trawl survey collected 2246 samples from 1966 to 2007. Years 1972-1973, 1975-1978, and 1985-1989 were skipped (Tables A16 and A17). Beginning and end latitude and

longitude were averaged per sample, and average latitude and longitude ranged from 38.80 to 39.39° N and from 75.02 to 75.48° W. Variables depth, tow duration, bottom salinity and bottom temperature were included in both GLM and GAM analyses. Surface salinity, surface temperature, surface DO, and bottom DO were excluded from the analyses as non-significant. Variables of weather, tide, and sea state were not examined. Significance values of model variables are given in Table A18.151 samples were removed from analyses due to missing data entries.

Log catch rate increased and decreased variably with latitude, albeit over a survey range of only 0.6 degrees. Log catch rate decreased with longitude from 75.3°W to 75.1°W (Fig. 7).

MD coastal bay survey

The Maryland coastal bay survey included 956 samples from 1972 to 2007. Samples were taken by beach seine (BCHS), bottom trawl (BTRW), and 25-ft trawl (T25). BTRW accounted for 879 of the samples (92%) and therefore only samples by this method were used, to prevent a confounding gear factor. Bottom trawls were not taken in the years 1974, 1983, and 1988 (only beach seines were taken), and therefore these years are excluded from the analyses (Tables A19 and A20). This survey did not report any zero catches, and therefore the presence / absence component of the GLM and GAM analyses was not used. The 20 different sample sites were the only catch information besides date included in the data file, and were used as a categorical variable. Since only categorical variables were available for analysis, only GLM was used. Significance values of model variables are given in Table A21.

NC Pamlico Sound Gillnet survey

The North Carolina Pamlico Sound survey collected 2142 samples from 2001 to 2007 (Tables A22 and A23). Sample latitude and longitude ranged from 35.05 to 35.82° N and 75.47 to 76.52° W. Environmental variables measured in the surveys included depth, bottom temperature, DO, and salinity, and surface temperature, DO, and salinity. Bottom temperature, bottom DO and surface temperature were not significant and excluded from GLM, while bottom DO and surface temperature were not significant and excluded from GAM. Significance values of variables used in the models are given in Table A24. 45 samples were removed from analyses due to missing data entries.

Log catch rate decreased slightly with latitude increasing from 35.6 to 35.8°N. Log catch rate increased slightly west to east from 76.4°W to 75.8°W, then decreased from 75.8°W to 75.5°W (Fig. 8).

Connecticut trawl survey

The Connecticut trawl survey collected 3492 samples from 1989 to 2008, except 1991 (Tables A25 and A26). Sample latitude and longitude ranged from 40.87 to 41.33° N and from 71.19 to 73.71° W. Environmental variables in the surveys included depth, tow duration, surface temperature, salinity, DO and conductivity, and bottom temperature, salinity, DO and conductivity. Bottom type was also scored in the survey but was not considered for analysis. Bottom DO and conductivity and surface DO and conductivity had too few measures to be included in analyses. Bottom salinity and bottom temperature were not significant and excluded from GLM, while bottom salinity was not significant and excluded from GAM. 294 additional samples were removed from analyses due to missing data entries in the environmental variables. Significance values of variables used in the models are given in Table A27.

Log catch rate varied intermittently with latitude over the range of the survey (40.8°N to

41.4°N). Log catch rate first increased slightly then decreased with longitude west to east (Fig. 9).

NY juvenile trawl survey

The New York juvenile trawl survey collected 8092 samples from 1987 to 2007 (Tables A28 and A29). Latitude and longitude were not included in the data file, but samples were referenced to 77 stations. No other environmental variables were included in the data file. Since only the categorical variables year, month, and station were available, only GLM was calculated. Significance values of model variables are given in Table A30.

DE 16-ft trawl survey

The Delaware 16-ft trawl survey, targeted on juvenile fish, includes 7228 samples from 1980 to 2007 (Tables A31 and A32). Beginning latitude and longitude and ending latitude and longitude were averaged per sample. Average latitude and longitude ranged from 38.88 to 39.75° N and 75.21 to 75.60° W. Variables included depth, tow duration, surface temperature, surface salinity, and surface dissolved oxygen (DO). Surface DO and surface salinity were not significant and excluded from GLM, while depth, duration, and surface DO were not significant and excluded from GAM. 757 samples were removed from analyses due to missing data entries. Significance values of model variables are given in Table A33.

Log catch rate decreased south to north from 39.3°N to 39.5°N, and decreased west to east from 75.5°W to 75.4°W (Fig. 10).

VIMS y-o-y trawl survey

The VIMS young-of-year trawl survey collected 20877 samples from 1988 to 2007 (Tables A34 and A35). Sample latitude and longitude ranged from 36.85 to 38.19° N and from 75.73 to 76.98° W. Variables included trawl depth, Secchi depth (water transparency), temperature, salinity and DO, and, as a categorical variable, the river the sample was taken from. Salinity and Secchi depth were not significant and were excluded from GLM and GAM analyses. 1043 samples were removed from analyses due to missing data entries. Significance values of model variables are given in Table A36.

Log catch rate increased and decreased variably with latitude, and generally decreased with longitude over the range of the survey (Fig. 11).

NC juvenile trawl survey

The North Carolina juvenile trawl survey collected 1685 samples from 1987 to 2007 (Tables A37 and A38). Sample latitude and longitude ranged from 34.95 to 36.08° N and from 75.52 to 76.97° W. This survey did not report any zero catches, and therefore the presence / absence component of the GLM and GAM analyses was not used. Survey variables included depth, surface temperature, DO and salinity, and bottom temperature, DO and salinity. Bottom temperature, surface temperature and surface salinity, as well as latitude, were not significant and excluded from the GLM analysis. Depth, bottom temperature, surface temperature and surface salinity were excluded from the GAM analysis. Significance values of model variables are given in Table A39.

Log catch rate peaked at the intermediate latitude over the range of the survey (approx. 35°N to 36.1°N). Log catch rate increased with longitude from 77°W to 75.8°W, then decreased with longitude from 75.8°W to 75.5°W (Fig. 12).

Maryland Chesapeake "blue crab" survey

The Maryland "blue crab" survey collected 1190 samples from 1989 to 2008 (Tables A40 and A41). Latitude and longitude were not included in the data file, but samples were assigned to nine areas. The areas were treated as categorical variables. The survey also recorded wind speed, salinity, depth and temperature measurements. However, all combinations of these environmental variables were either not significant or excluded too many samples through missing data. Only the categorical variables year, month, and area were analyzed, and therefore only GLM was calculated. The survey had too few zero catches (<7%) to derive a presence / absence model that converged, and therefore only a single CPUE model in the normal distribution was calculated. Catches were log-transformed as log(N + 1) instead of log(N) to include the zero catches that were recorded. Significance values of model variables are given in Table A42.

Comparison between GLM and GAM models

AIC values calculated from GAM were lower than AIC values from GLM for all survey CPUE indices in which the two models could be compared, except one (Delaware 16 ft. trawl; Table 4). As noted for some individual surveys, above, GAM cannot be calculated when only categorical data are available to include in the model. In all cases in Table 4, the presence/absence models were more improved by using GAM vs. GLM than the positive catch models (for example, for the NMFS survey the ratio of GLM over GAM AIC for presence/absence is 11998.2/10206.5 ≅ 1.18; an improvement of 18%, the ratio of GLM over GAM AIC for positive catch is 12433.3/11628.0 ≅ 1.07; an improvement of 7%). The results suggest that GAM is better than GLM for modeling catch rates of weakfish. Therefore GAM was used in the following consistency analyses.

Consistency among indices

Log catch rate generally increased south-to-north and decreased west-to-east over surveys spanning at least 2° of latitude or longitude respectively. Spatially more restricted surveys were more variable.

Cross-correlation analyses of yearly CPUE indices showed no consistent pattern of positive or negative correlation among adult surveys, for either geometric mean or GAM/GLM standardized CPUE indices. GAM/GLM standardized CPUEs more frequently showed negative correlations than geometric mean CPUEs, especially in the SEAMAP and Maryland surveys. Most correlations were not very strong, with only 4 geometric correlations and 3 GAM/GLM correlations > ±0.5 (Tables 5 and 6). However, pair-wise plots of the adult surveys' CPUE indices suggest that correlations are stronger when only salient years are considered, i.e., those years in which catches were higher or lower than usual. Figure 13 shows the geometric and GAM/GLM pair-wise plots of the NMFS survey vs. the other adult surveys; in effect the data corresponding to the first row or column of Tables 5 and 6. On each plot a subsample was selected by eye, consisting of a block of the data that were highest or lowest on the x-axis and highest or lowest on the y-axis. These data are shaded in black on each plot and fitted with a linear regression. Subsamples were selected separately for the geometric and GAM/GLM indices of each survey pair, but with the constraint that they had to have the same number of data, and could only be selected by making one 'cut' along each axis. For example (Figure 13, top row), low NMFS CPUE co-occurred with any size of MRFSS CPUE, but high NMFS CPUE only co-occurred with low MRFSS CPUE. The linear regressions indicate that indices of salient years correlated more strongly with GAM/GLM standardization than with geometric mean for the NMFS survey vs. MRFSS, SEAMAP, RI, NJ, and DE, and less strongly or indifferently for the NMFS survey vs. MD and NC. Among all adult survey pairs, GAM/GLM indices of salient years correlated more strongly than geometric indices of salient years in 14 of 28

comparisons, and correlated more poorly in 4 comparisons (Tables 7 and 8). More strongly correlated GAM/GLM indices occurred especially in the NMFS and MRFSS surveys.

Among juvenile surveys, cross-correlations were positive for geometric indices in 13 of 15 comparisons, and positive for GAM/GLM standardized indices in 14 of 15 comparisons (Tables 9 and 10).GAM/GLM standardized indices were more strongly positive than the corresponding geometric indices in 10 of the 15 comparisons.

Discussion

The 14 surveys analyzed in this study presented a high diversity in their patterns of inter-annual CPUE variability. Coast-wide and adult surveys showed relatively little consistency in their tendencies to be positively or negatively correlated with each other, for both geometric mean and GAM/GLM standardized indices. When only years of higher or lower than usual CPUE were considered, GAM/GLM correlations were typically stronger than geometric mean correlations, suggesting that exceptionally strong or weak yearly catches occur in relation to geographic and environmental conditions, while average yearly catches don't. Of the three broadest surveys, NMFS and SEAMAP were positively correlated with each other over salient (high/low) years, while both were negatively correlated with MRFSS. Although it can't be verified from the available data, a possible explanation for this pattern is that weakfish were further inshore some years and more likely to be taken in the recreational fishery, while further offshore in other years and more likely to be captured in the surveys.

Juvenile surveys showed much more consistently positive cross-correlations than adult surveys. This suggests that the inconsistency among adult surveys may largely be due to variability in the age class distributions that different surveys – using different equipment – capture. In addition, some of the state-wide surveys that are more restricted to nearshore embayments may have captured local subpopulations (e.g., Thorrold et al. 2001) that are more distinct from each other than the overall weakfish stock. More detailed analyses of size/age distributions within the different surveys will likely be useful in resolving these questions.

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Table 1. Summary of yearly GLM and GAM CPUE standardizations for coast-wide weakfish surveys.

Year	NMFS		MRFSS		SEAMAP	
	GLM	GAM	GLM	GAM	GLM	GAM
1972	45.696	160.871				
1973	134.668	95.469				
1974	79.345	62.627				
1975	93.467	120.150				
1976	208.078	252.409				
1977	104.461	89.489				
1978	125.966	162.478				
1979	132.597	160.136				
1980	190.607	115.854				
1981	75.968	82.151	0.098	0.148		
1982	136.621	83.983	0.045	0.064		
1983	103.618	123.044	0.101	0.136		
1984	298.990	265.316	0.182	0.089		
1985	292.836	201.726	0.236	0.108		
1986	131.395	108.814	0.207	0.173		
1987	29.230	28.933	0.145	0.131		
1988	14.217	10.200	0.115	0.080		
1989	145.636	133.904	0.078	0.066		
1990	121.816	83.889	0.071	0.054	16.558	44.204
1991	87.236	64.502	0.080	0.073	10.587	34.687
1992	49.265	42.708	0.056	0.053	9.514	35.278
1993	34.159	43.714	0.102	0.082	4.268	17.896
1994	216.526	190.233	0.129	0.143	4.980	20.190
1995	388.507	384.356	0.123	0.131	8.612	30.480
1996	176.093	185.752	0.199	0.169	11.245	35.217
1997	46.998	35.781	0.168	0.183	5.431	20.529
1998	54.462	47.842	0.161	0.179	8.195	32.341
1999	342.856	340.655	0.121	0.174	6.143	22.384
2000	214.908	191.984	0.166	0.196	11.188	33.146
2001	93.215	105.926	0.102	0.120	17.469	46.824
2002	204.121	240.488	0.102	0.115	4.637	20.967
2003	707.552	593.502	0.043	0.050	11.559	40.473
2004	255.548	263.958	0.098	0.115	13.528	41.899
2005	241.607	256.965	0.079	0.109	7.881	32.597
2006	600.830	849.290	0.052	0.091	10.070	38.306
2007			0.033	0.062		

Table 2. Summary of yearly GLM and GAM CPUE standardizations for states' adult weakfish surveys.

Year	RI	NJ		DE		MD	NC	
	GLM	GLM	GAM	GLM	GAM	GLM	GLM	GAM
1966				246.840	121.522			
1967				136.597	93.710			
1968				63.825	81.686			
1969				169.587	144.138			
1970				234.109	152.384			
1971				368.205	210.422			
1972						4.604		
1973						5.698		
1974				64.298	27.112			
1975						52.877		
1976						86.563		
1977						4.564		
1978						29.689		
1979	12.145			26.813	51.640	11.244		
1980	46.050			17.057	37.644	22.791		
1981	58.100			13.978	32.445	104.490		
1982	57.910			36.012	54.971	39.662		
1983	16.858			32.232	60.836			
1984	38.980			23.216	24.105	5.391		
1985	34.956					7.583		
1986	11.610					50.215		
1987	19.358					156.013		
1988	19.568	81.915	8.351			9.765		
1989	10.137	44.501	30.721			15.357		
1990	64.315	26.260	7.088	19.419	39.224	25.501		
1991	34.391	49.852	32.367	74.751	57.253	51.628		
1992	31.508	22.886	30.354	17.617	43.255	31.418		
1993	26.020	28.200	23.772	80.430	99.656	21.295		
1994	87.130	53.636	54.054	49.284	82.335	16.630		
1995	9.295	101.073	153.508	181.130	199.226	16.672		
1996	165.436	148.785	277.406	237.120	293.148	6.487		
1997	108.072	141.378	114.073	140.978	198.421	4.512		
1998	29.996	19.049	21.592	316.731	196.982	9.783		
1999	20.648	37.108	39.913	164.496	245.189	18.591		
2000	32.200	39.814	45.519	125.841	260.535	11.708		
2001	58.833	53.517	31.719	149.125	163.924	21.899	2.678	1.873
2002	33.456	197.973	195.490	204.106	116.800	9.294	1.342	1.468
2003	246.854	92.913	65.222	93.277	142.299	5.881	1.018	1.420
2004	19.180	245.019	220.879	59.774	81.985	8.068	1.058	1.163
2005	105.235	131.107	152.807	32.859	45.505	5.760	1.167	1.292
2006	6.941	22.579	32.730	82.233	105.427	14.340	0.891	0.905
2007	78.251			103.979	91.555		0.506	0.539
2008								

Table 3. Summary of yearly GLM and GAM CPUE standardizations for states' juvenile weakfish surveys.

Year	CT		NY	DE		MD(blue crab)	VIMS		NC	
	GLM	GAM	GLM	GLM	GAM	GLM	GLM	GAM	GLM	GAM
1980				12.116	9.889					
1981				19.766	17.541					
1982				24.776	24.957					
1983				13.530	12.612					
1984				18.437	28.226					
1985				2.249	24.066					
1986				28.425	27.733					
1987			3.904	20.623	18.753				13.669	13.430
1988			0.977	18.167	22.226		14.276	17.422	17.277	16.481
1989	1.348	0.609	0.152	23.922	24.670	10.276	16.201	11.433	11.305	11.776
1990	0.628	0.554	0.201	25.242	23.848	14.574	14.377	8.567	17.817	15.807
1991			28.780	38.577	40.395	19.394	9.363	8.318	9.872	9.387
1992	0.982	0.585	6.328	40.047	43.430	30.694	15.450	21.378	19.690	18.275
1993	0.836	0.652	1.432	38.966	47.640	22.144	12.418	13.834	14.354	15.324
1994	1.125	1.240	16.677	54.135	61.629	23.681	12.342	13.859	18.676	19.551
1995	0.377	0.460	6.622	45.430	47.161	53.642	16.084	17.908	19.755	19.520
1996	0.760	0.883	56.713	36.791	38.679	46.622	13.819	14.767	23.117	23.806
1997	1.755	1.198	1.705	47.419	52.432	44.013	12.915	15.169	24.530	25.922
1998	0.283	0.914	1.103	32.846	37.557	38.454	10.304	9.545	28.397	27.731
1999			51.880	33.377	36.227	52.043	15.731	17.293	30.380	32.394
2000	1.678	1.672	100.122	63.135	50.196	56.037	16.717	22.554	26.094	26.742
2001	1.552	1.407	42.470	21.618	20.362	69.271	22.344	19.102	14.857	15.245
2002	1.316	0.986	95.765	20.555	18.364	32.382	15.444	14.499	12.362	11.846
2003	0.845	2.001	47.478	31.441	31.460	32.456	11.634	13.983	12.803	13.024
2004	1.181	1.298	6.749	26.766	29.277	15.945	10.504	8.708	18.064	17.821
2005	1.114	1.020	10.111	52.974	49.500	32.193	8.801	8.766	15.963	15.160
2006	0.335	0.440	5.206	17.794	17.814	7.629	13.868	15.705	22.869	23.041
2007	1.530	1.541	105.074	43.132	38.389	5.307	14.628	13.584	18.849	18.415
2008	0.060	0.337				8.355				

Table 4. Comparison of AIC from GLM and GAM for surveys in which both models were used. The lowest AIC by row (for positive catch or presence/absence) is highlighted in yellow.

Surveys	GAM		GLM	
	Positive catch	Present/Absent	Positive catch	Present/Absent
MRFSS	11628.0	10206.5	12433.3	11998.2
NMFS	3495.9	1866.2	4204.8	2026.7
SEAMAP	7580.2	5260.9	7695.5	5741.7
NJ	4351.8	2683.6	4459.0	2895.0
DE 30	5368.0	1358.4	5466.9	1429.9
CT	2547.5	2028.3	2576.0	2171.8
DE 16	14766.8	4216.0	14680.9	4343.2
VIMS	27277.8	15451.7	27541.2	16781.5
NC juv.	4764.1	*	4837.9	*
NC gill.	1902.0	2414.4	1928.0	2524.7

Table 5. Cross-correlation of annual CPUEs of coastal wide and adult weakfish surveys averaged by geometric mean. Negative correlations are highlighted in yellow.

NMFS	MRFSS	SEAMAP	RI	NJ	DE	MD	NC
1	-0.238	0.235	0.125	0.202	0.202	0.470	-0.600
-0.238	1	-0.209	-0.068	0.154	0.530	0.014	0.805
0.235	-0.209	1	0.414	0.148	0.088	0.265	0.189
0.125	-0.068	0.414	1	0.280	0.290	0.233	0.029
0.202	0.154	0.148	0.280	1	0.491	0.065	-0.278
0.202	0.530	0.088	0.290	0.491	1	0.003	0.374
0.470	0.014	0.265	0.233	0.065	0.003	1	0.655
-0.600	0.805	0.189	0.029	-0.278	0.374	0.655	1

Table 6. Cross-correlation of annual CPUEs of coast-wide and adult weakfish surveys standardized by GAM, or GLM if GAM was not appropriate. Negative correlations are highlighted in yellow.

NMFS	MRFSS	SEAMAP	RI	NJ	DE	MD	NC
1	-0.145	0.206	0.278	0.157	0.226	-0.254	-0.597
-0.145	1	-0.383	-0.091	0.322	0.688	0.074	0.495
0.206	-0.383	1	0.152	-0.054	-0.159	-0.195	0.153
0.278	-0.091	0.152	1	0.294	0.213	-0.158	0.180
0.157	0.322	-0.054	0.294	1	0.259	-0.172	-0.170
0.226	0.688	-0.159	0.213	0.259	1	-0.334	0.544
-0.254	0.074	-0.195	-0.158	-0.172	-0.334	1	0.155
-0.597	0.495	0.153	0.180	-0.170	0.544	0.155	1

Table 7. Cross-correlation of salient annual CPUEs of coastal wide and adult weakfish surveys averaged by geometric mean. Negative correlations are highlighted in yellow.

NMFS	MRFSS	SEAMAP	RI	NJ	DE	MD	NC
1	-0.769	0.787	0.747	-0.590	-0.598	0.980	0.599
-0.769	1	-0.589	-0.515	0.590	0.692	-0.898	0.898
0.787	-0.589	1	0.887	0.642	0.748	0.609	0.295
0.747	-0.515	0.887	1	-0.393	0.627	0.875	0.063
-0.590	0.590	0.642	-0.393	1	0.710	-0.623	0.680
-0.598	0.692	0.748	0.627	0.710	1	0.152	0.528
0.980	-0.898	0.609	0.875	-0.623	0.152	1	0.941
0.599	0.898	0.295	0.063	0.680	0.528	0.941	1

Table 8. Cross-correlation of salient annual CPUEs of coast-wide and adult weakfish surveys standardized by GAM, or GLM if GAM was not appropriate. Negative correlations are highlighted in yellow.

NMFS	MRFSS	SEAMAP	RI	NJ	DE	MD	NC
1	-0.839	0.908	0.867	-0.913	-0.979	-0.960	-0.597
-0.839	1	-0.611	-0.750	0.932	0.890	-0.912	0.896
0.908	-0.611	1	0.884	0.754	0.755	-0.399	0.595
0.867	-0.750	0.884	1	-0.363	0.625	-0.516	0.258
-0.913	0.932	0.754	-0.363	1	0.606	-0.619	0.404
-0.979	0.890	0.755	0.625	0.606	1	-0.671	0.805
-0.960	-0.912	-0.399	-0.516	-0.619	-0.671	1	0.962
-0.597	0.896	0.595	0.258	0.404	0.805	0.962	1

Table 9. Cross-correlation of annual CPUEs of juvenile weakfish surveys averaged by geometric mean. Negative correlations are highlighted in yellow.

CT	NY	DE	MD (blue crab)	VIMS	NC
1	0.364	0.149	0.093	0.182	-0.346
0.364	1	0.070	0.040	0.202	0.312
0.149	0.070	1	0.065	-0.064	0.325
0.093	0.040	0.065	1	0.478	0.458
0.182	0.202	-0.064	0.478	1	0.267
-0.346	0.312	0.325	0.458	0.267	1

Table 10. Cross-correlation of annual CPUEs of juvenile weakfish surveys standardized by GAM or GLM if GAM was not appropriate. Negative correlations are highlighted in yellow.

CT	NY	DE	MD (blue crab)	VIMS	NC
1	0.445	0.132	0.160	0.020	-0.248
0.445	1	0.007	0.217	0.323	0.113
0.132	0.007	1	0.195	0.091	0.336
0.160	0.217	0.195	1	0.583	0.412
0.020	0.323	0.091	0.583	1	0.359
-0.248	0.113	0.336	0.412	0.359	1

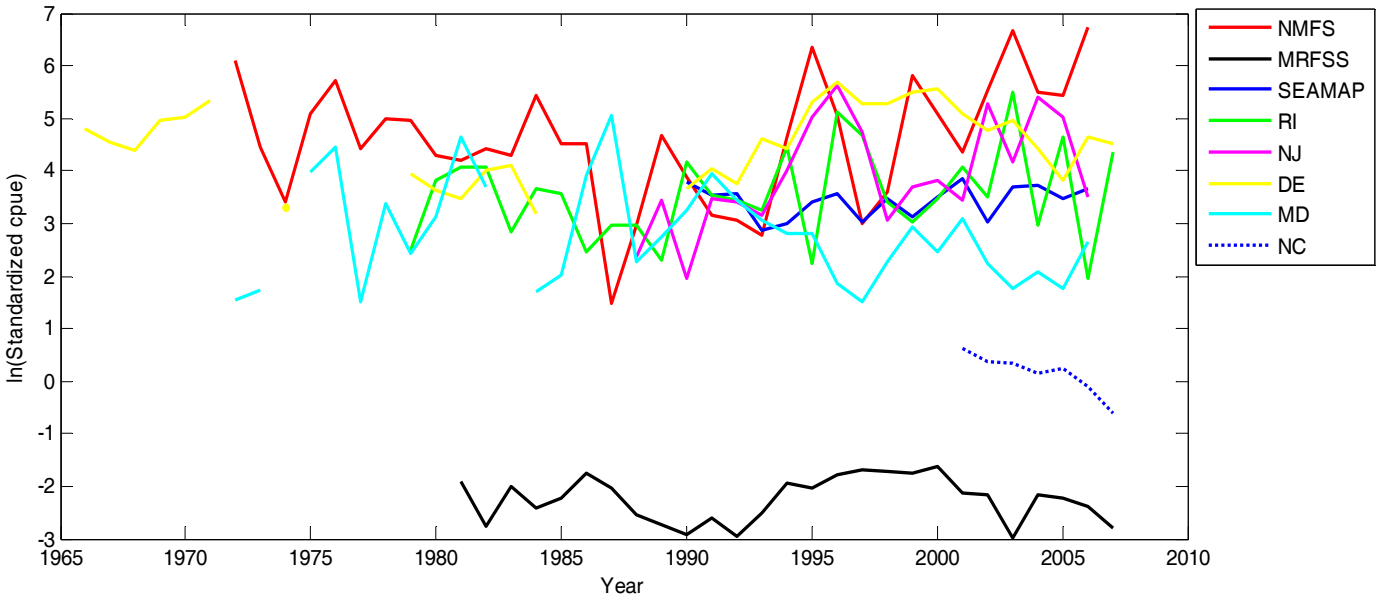

Figure 1. Summary of the standardized abundance indices (coast-wide and state adult surveys).

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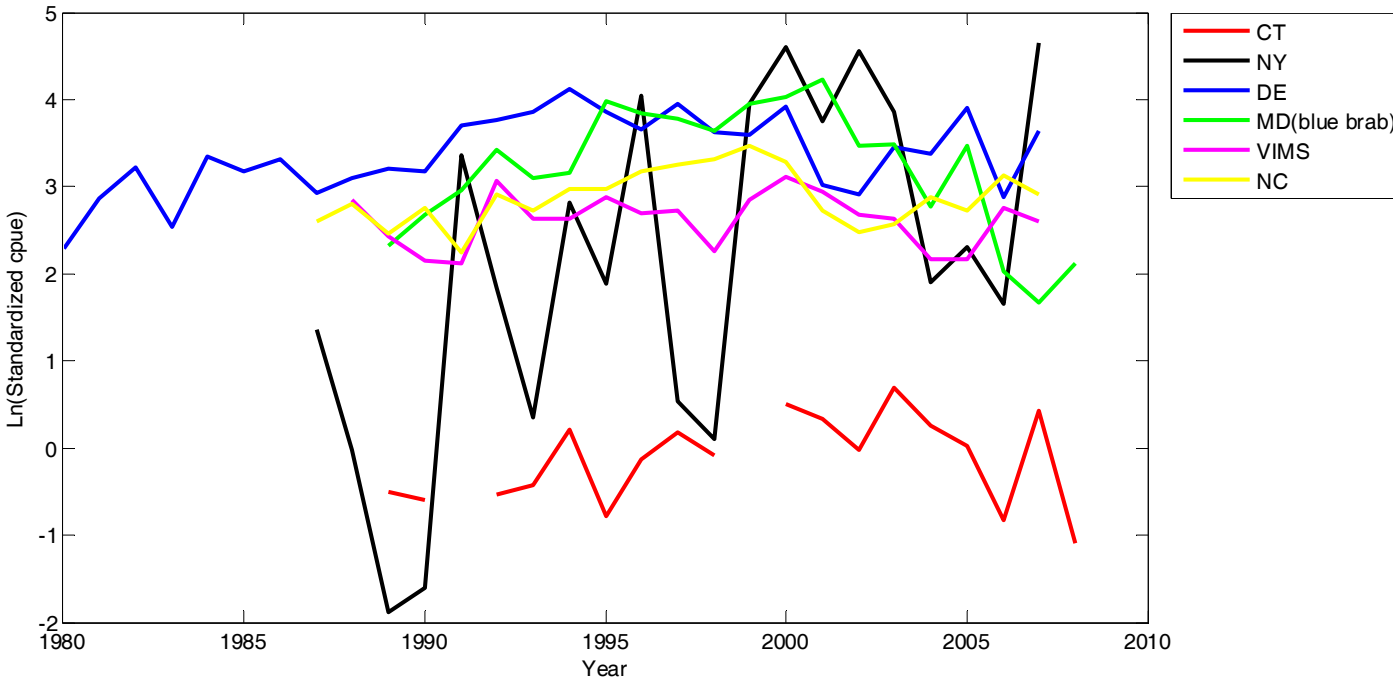

Figure 2. Summary of the standardized abundance indices (state juvenile surveys)

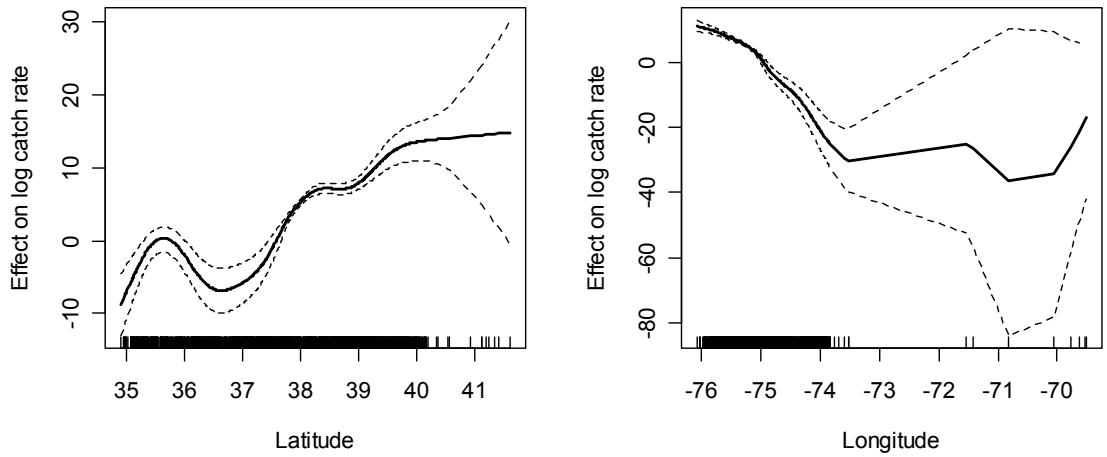

Figure 3. NMFS survey: Effect of latitude and longitude on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

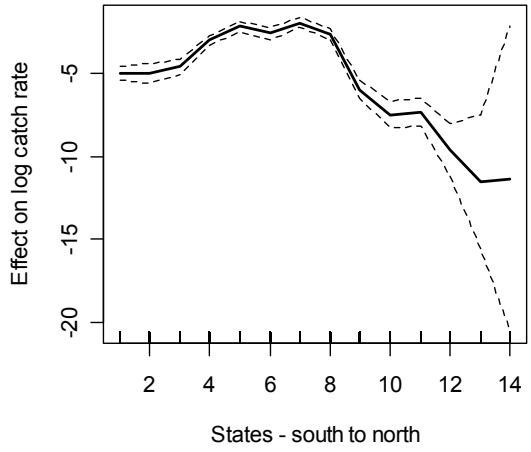

Figure 4. MRFS survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

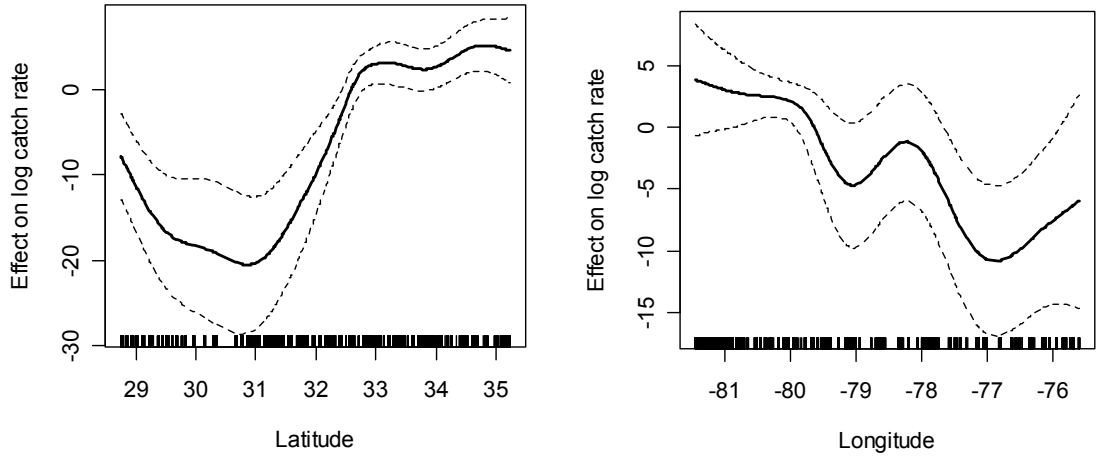

Figure 5. SEAMAP survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals

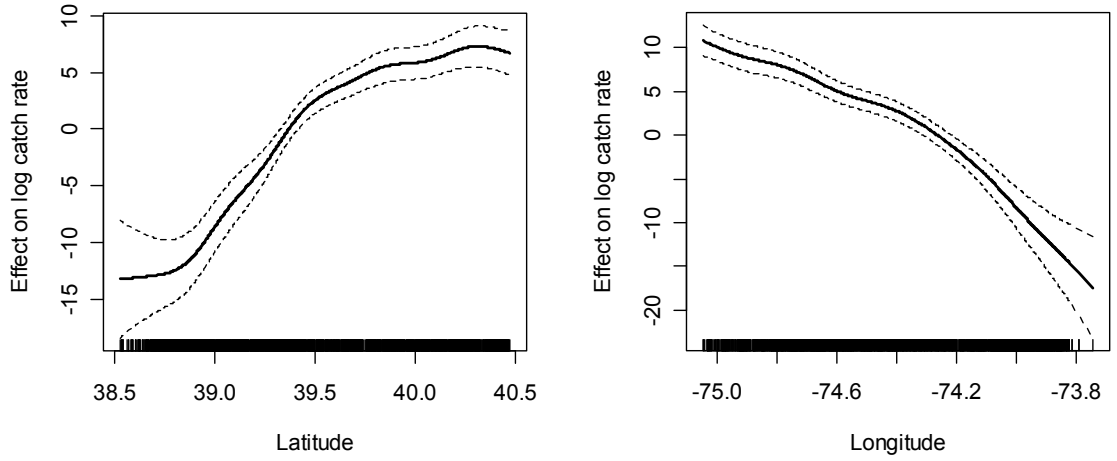

Figure 6. New Jersey survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

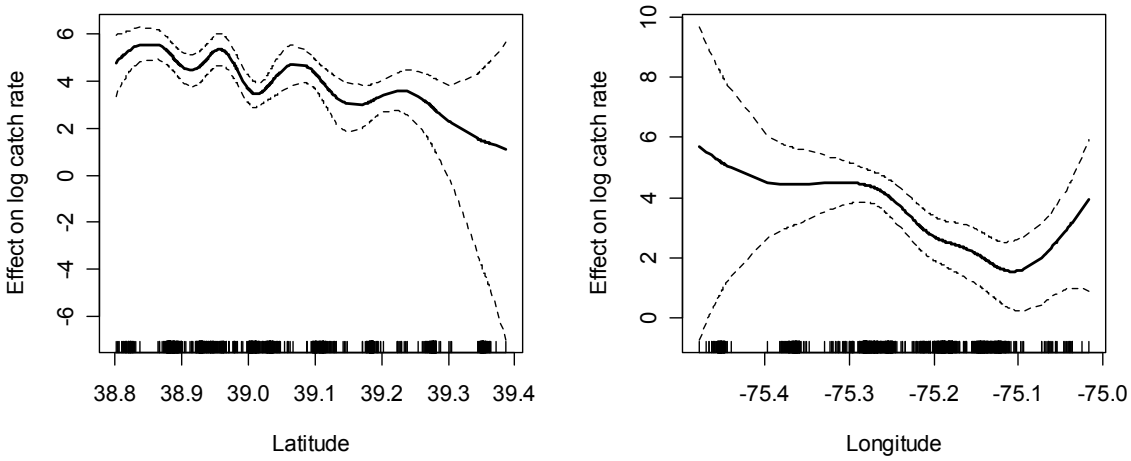

Figure 7. Delaware 30 ft. trawl survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

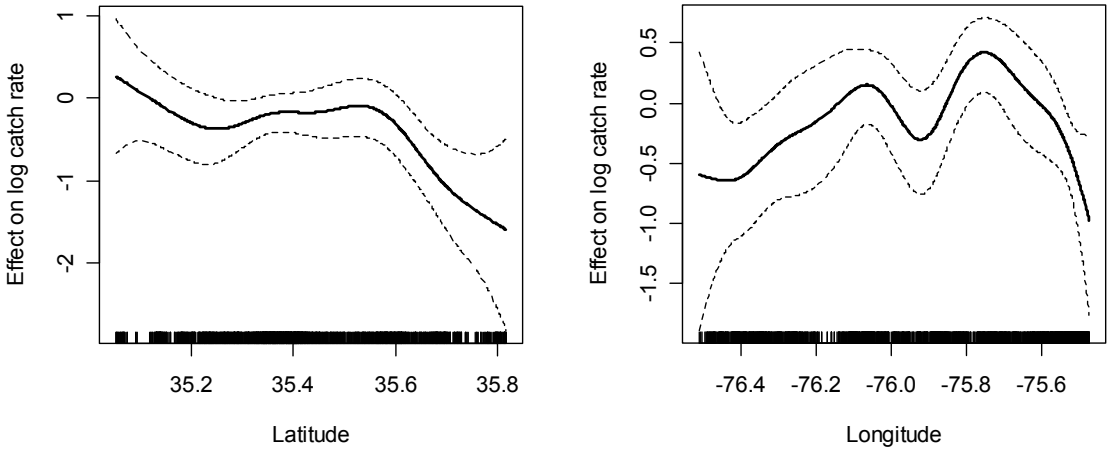

Figure 8. North Carolina gillnet survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

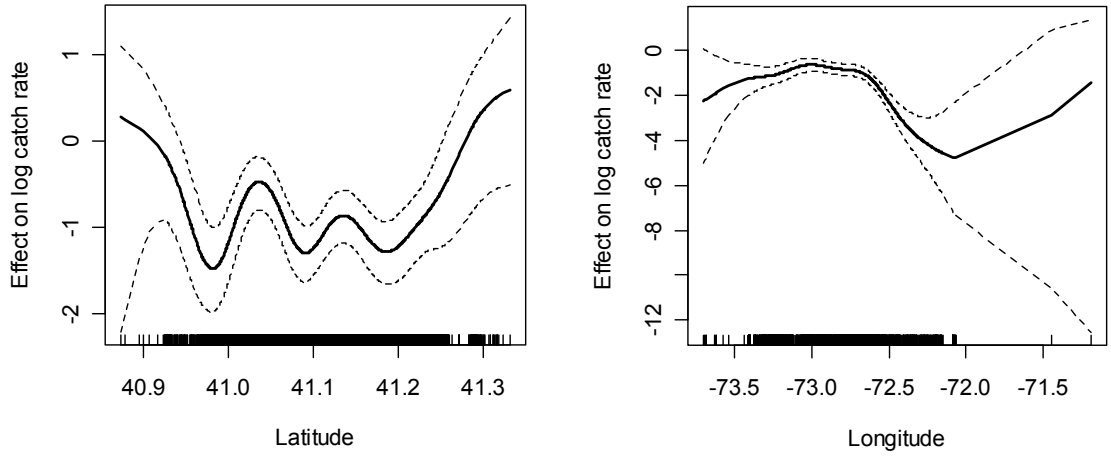

Figure 9. Connecticut survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

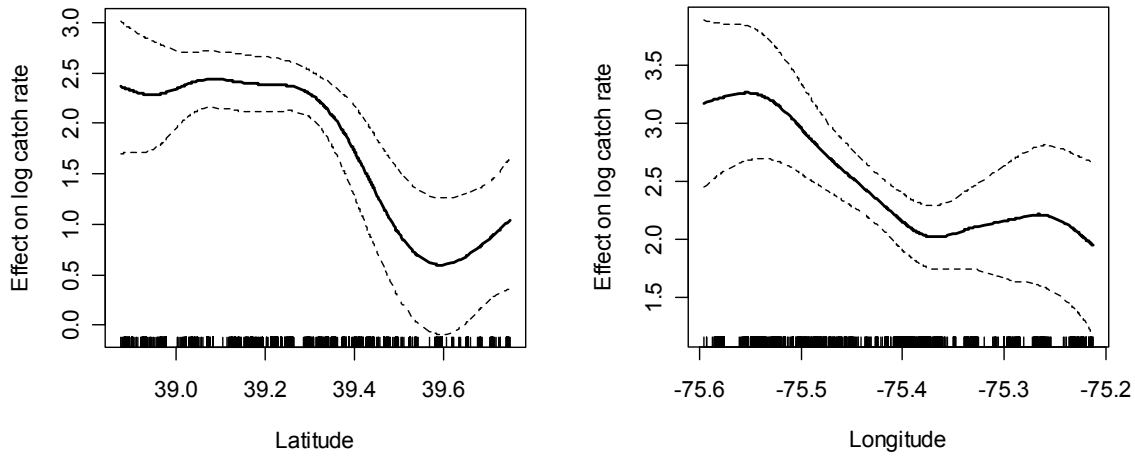

Figure 10. Delaware 16 ft. trawl survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

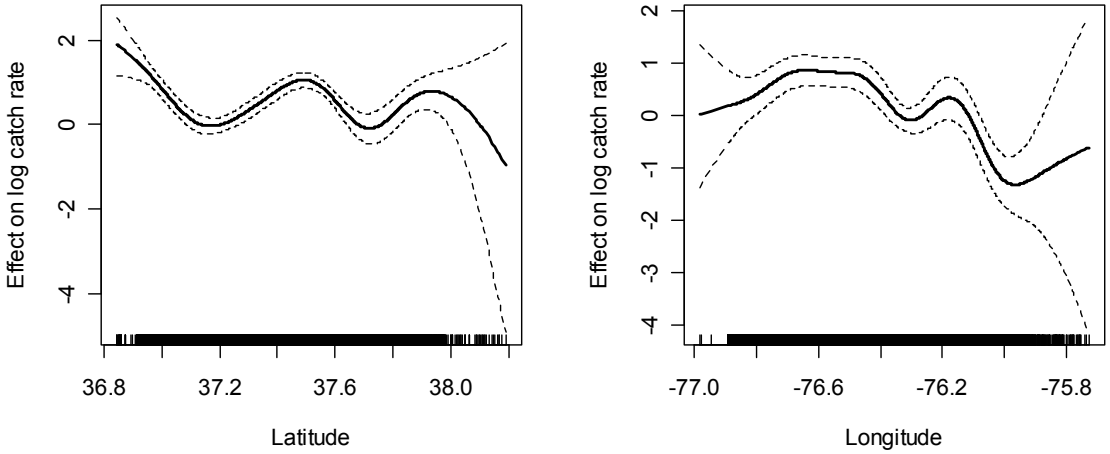

Figure 11. VIMS survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

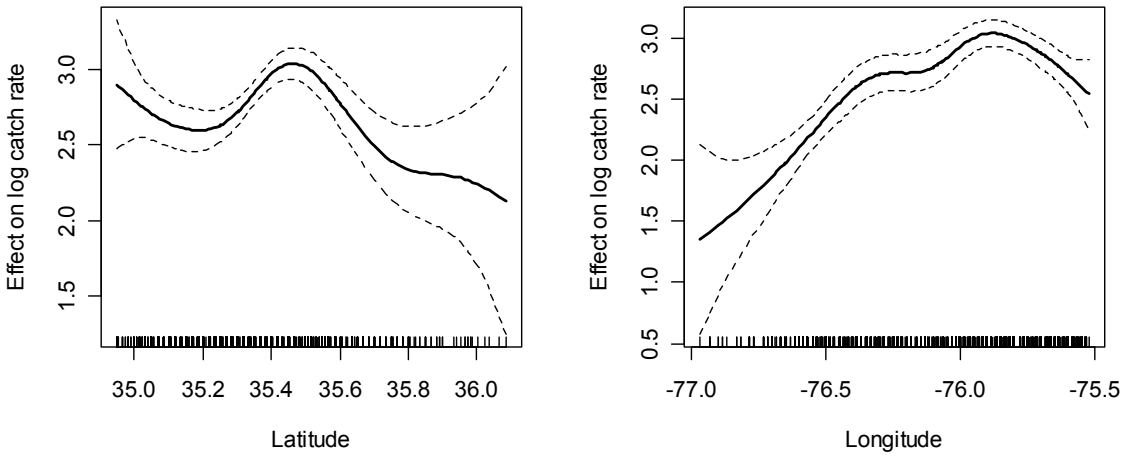

Figure 12. North Carolina juvenile survey: Effect of the along-coast state index on log catch rate. Dotted lines around the trend line represent the 95% confidence intervals.

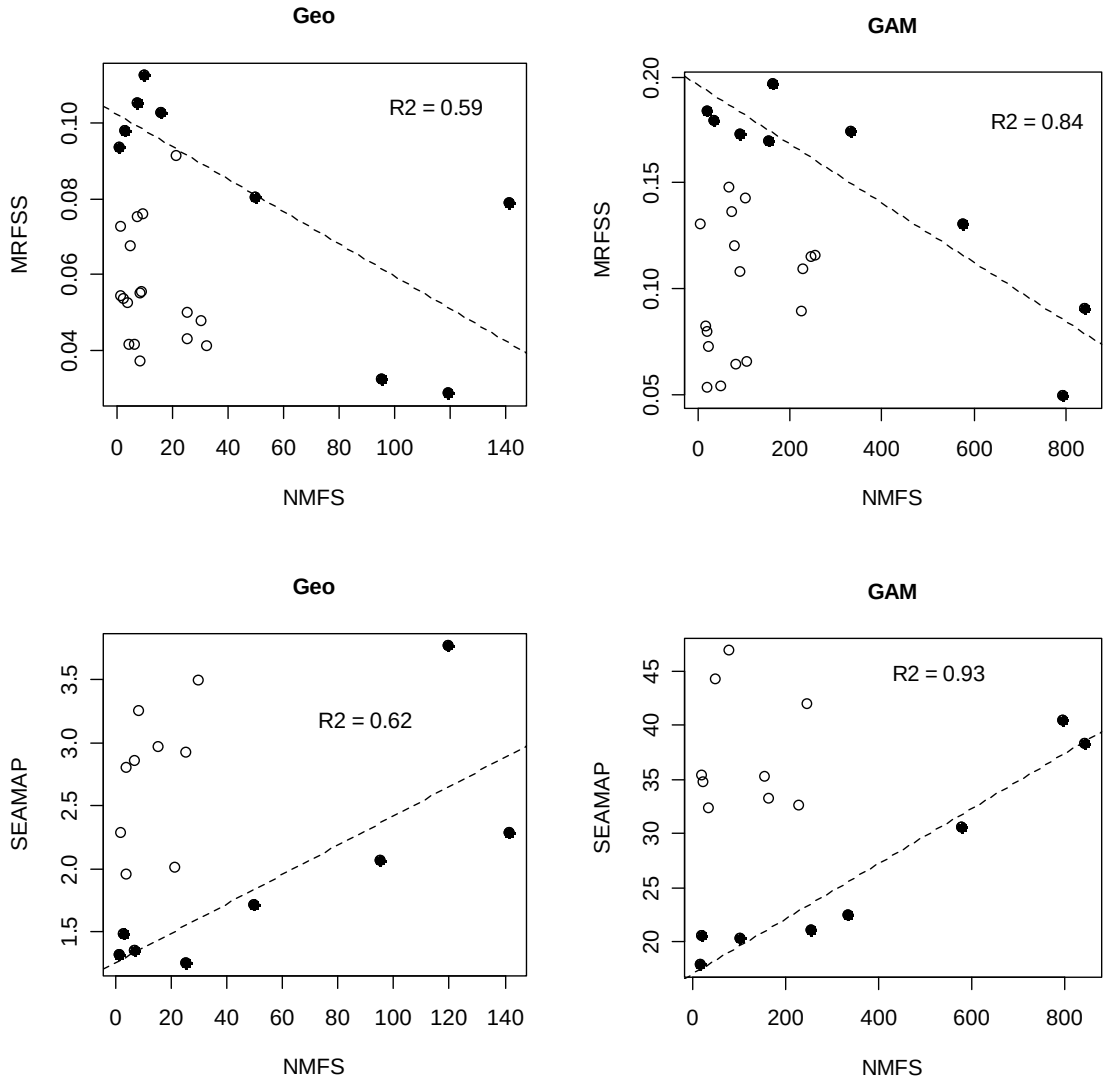

Figure 13. Pairwise plots of NMFS CPUE indices vs . those of other adult surveys, with black shading indicating the salient (high or low) yearly indices that are most likely to have significant correlations (shown as dotted lines).

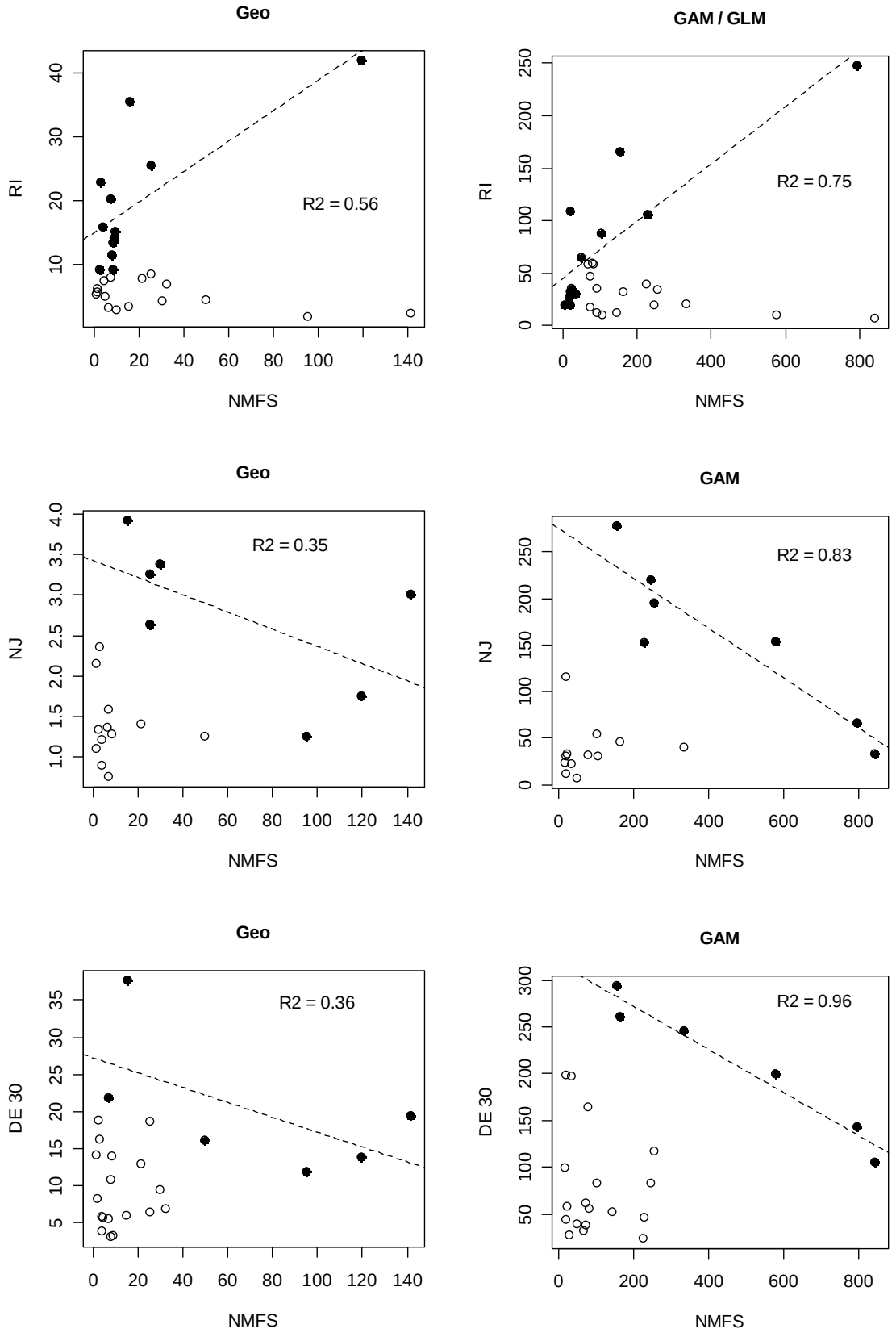

Figure 13 cont.

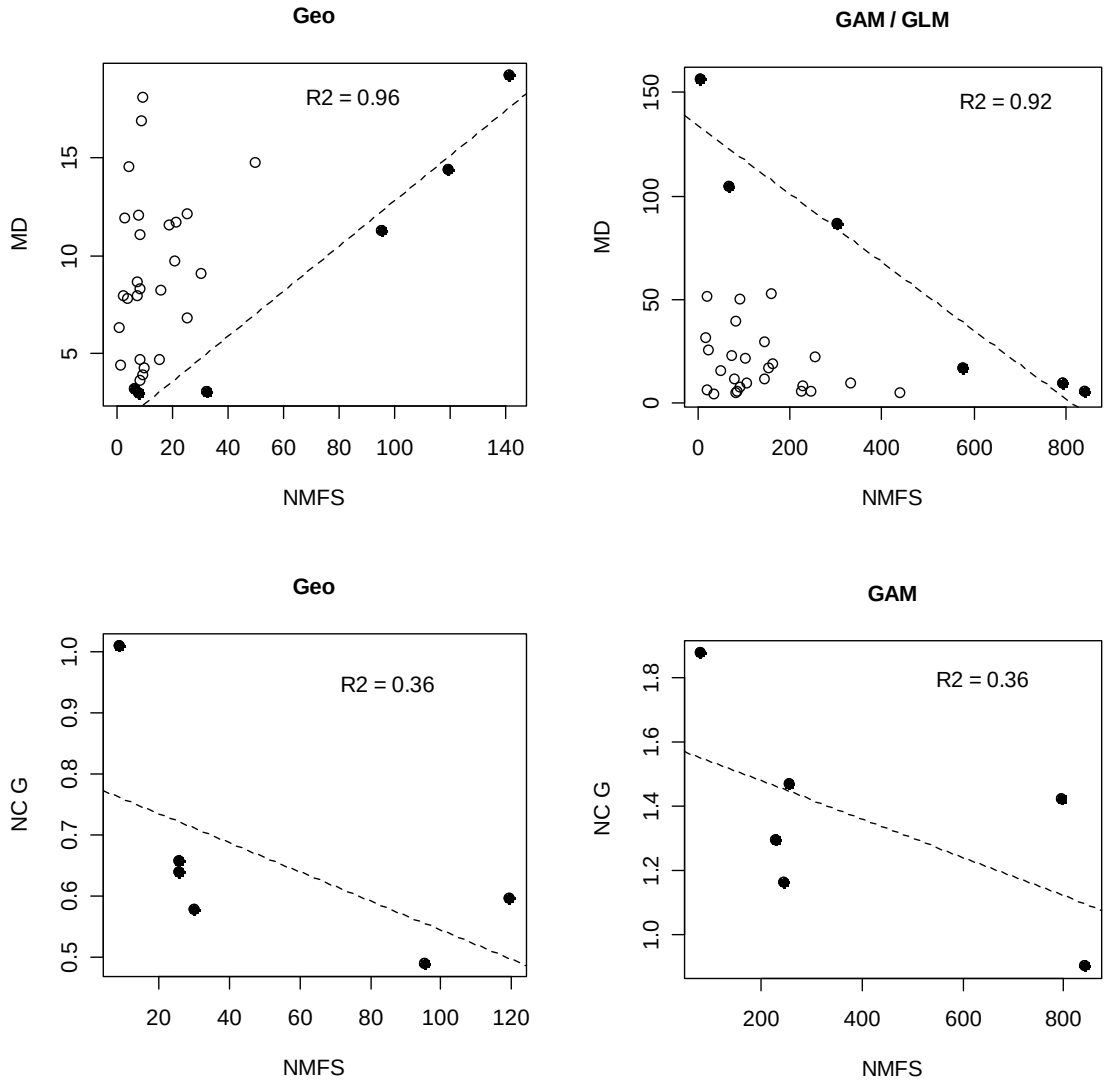

Figure 13 cont.

Appendix.

Table A1. NMFS survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1972	80	57.438	8.592	45.69604	160.8706
1973	72	86.653	7.797	134.6679	95.46888
1974	55	149.891	2.520	79.34548	62.62724
1975	63	59.333	8.419	93.46729	120.1499
1976	49	187.388	20.770	208.0777	252.4089
1977	48	196.167	9.291	104.4608	89.48942
1978	49	296.959	19.023	125.9659	162.4776
1979	47	160.681	15.126	132.5966	160.1355
1980	37	105.459	8.001	190.6066	115.854
1981	50	191.280	9.102	75.96795	82.15111
1982	32	39.313	8.250	136.6211	83.98266
1983	53	55.604	4.663	103.618	123.0438
1984	43	210.209	32.264	298.9904	265.3157
1985	23	30.391	8.129	292.8357	201.726
1986	36	54.833	9.888	131.3955	108.814
1987	13	4.077	0.610	29.23047	28.93322
1988	14	131.214	1.282	14.21662	10.19952
1989	18	47.111	6.323	145.6362	133.9036
1990	18	176.722	3.969	121.816	83.88865
1991	55	90.473	2.283	87.23552	64.50227
1992	31	111.677	4.125	49.26488	42.70775
1993	51	13.451	1.369	34.1585	43.71365
1994	52	141.135	7.231	216.5262	190.2331
1995	40	460.200	141.957	388.5071	384.3564
1996	47	168.915	15.652	176.0929	185.7516
1997	51	37.078	2.903	46.99831	35.78076
1998	47	123.872	7.162	54.46245	47.84231
1999	49	384.612	49.758	342.8563	340.655
2000	51	374.176	21.311	214.9083	191.9837
2001	52	154.788	8.679	93.21527	105.926
2002	53	328.717	25.609	204.1207	240.488
2003	48	586.625	119.729	707.5523	593.5019
2004	44	266.136	30.171	255.5483	263.9581
2005	47	329.383	25.628	241.6068	256.9651
2006	48	290.625	95.527	600.8297	849.2897

Table A2. NMFS survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
9	1113	189.801	70.755	47.367	44.103
10	326	193.699	69.682	34.166	42.889
11	121	40.471	27.985	34.468	52.790
12	6	458.167	187.079	742.952	719.171

Table A3. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the NMFS CPUE. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		< 0.001	< 0.001	< 0.001	< 0.001
Latitude		< 0.001	< 0.001	0.002	0.425
Depth		< 0.001	0.004	0.043	< 0.001
Bottom temperature		< 0.001	< 0.001	0.635	0.485
Month	9	0.016	0.310	0.026	0.299
	10	0.012	0.323	0.010	0.466
	11	0.004	0.074	0.002	0.191
	12	n/a	n/a	n/a	n/a
Year	1972	0.038	0.407	0.003	0.310
	1973	< 0.001	< 0.001	0.005	< 0.001
	1974	< 0.001	< 0.001	< 0.001	< 0.001
	1975	0.006	0.008	0.014	0.021
	1976	0.015	0.025	0.047	0.126
	1977	< 0.001	0.003	< 0.001	0.022
	1978	< 0.001	0.022	< 0.001	0.041
	1979	< 0.001	0.003	< 0.001	0.015
	1980	< 0.001	< 0.001	0.002	< 0.001
	1981	< 0.001	0.002	< 0.001	0.012
	1982	< 0.001	0.147	0.002	0.989
	1983	< 0.001	< 0.001	< 0.001	< 0.001
	1984	0.003	0.129	0.097	0.418
	1985	0.002	0.048	0.152	0.473
	1986	< 0.001	< 0.001	< 0.001	0.008
	1987	< 0.001	< 0.001	< 0.001	< 0.001
	1988	< 0.001	< 0.001	< 0.001	< 0.001
	1989	< 0.001	< 0.001	0.002	0.003
	1990	< 0.001	< 0.001	< 0.001	< 0.001
	1991	< 0.001	< 0.001	< 0.001	< 0.001
	1992	< 0.001	< 0.001	< 0.001	< 0.001
	1993	< 0.001	< 0.001	< 0.001	< 0.001
	1994	< 0.001	< 0.001		< 0.001
	1995	0.031	0.877		0.671
	1996	< 0.001	0.002		0.011
	1997	< 0.001	< 0.001		< 0.001
	1998	< 0.001	< 0.001		< 0.001
	1999	0.018	0.136		0.326
	2000	< 0.001	0.001		0.006
	2001	< 0.001	< 0.001		< 0.001
	2002	0.001	0.023		0.059
	2003	0.454	0.679		0.799
	2004	0.004	0.011		0.058
	2005	0.003	0.013		0.033
	2006	n/a	n/a	n/a	n/a
R^2		0.380	0.283	0.251	0.219
Composite R^2		0.242		0.181	

Table A4. MRFSS yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1981	462	0.162	0.076	0.098	0.148
1982	498	0.081	0.037	0.045	0.064
1983	496	0.122	0.068	0.101	0.136
1984	537	0.063	0.041	0.182	0.089
1985	552	0.092	0.055	0.236	0.108
1986	475	0.288	0.113	0.207	0.173
1987	451	0.184	0.094	0.145	0.131
1988	441	0.148	0.073	0.115	0.080
1989	467	0.054	0.042	0.078	0.066
1990	468	0.099	0.053	0.071	0.054
1991	465	0.091	0.054	0.080	0.073
1992	457	0.068	0.041	0.056	0.053
1993	451	0.090	0.054	0.102	0.082
1994	485	0.198	0.075	0.129	0.143
1995	478	0.139	0.079	0.123	0.131
1996	467	0.179	0.103	0.199	0.169
1997	481	0.162	0.098	0.168	0.183
1998	474	0.191	0.105	0.161	0.179
1999	476	0.124	0.080	0.121	0.174
2000	483	0.150	0.091	0.166	0.196
2001	486	0.080	0.055	0.102	0.120
2002	488	0.066	0.050	0.102	0.115
2003	500	0.053	0.029	0.043	0.050
2004	483	0.067	0.048	0.098	0.115
2005	651	0.063	0.043	0.079	0.109
2006	645	0.043	0.032	0.052	0.091
2007	660	0.039	0.027	0.033	0.062

Table A5. MRFSS wave (bi-monthly) CPUE averages.

Wave	N	Arith. Mean	Geo. Mean	GLM	GAM
1	273	0.028	0.015	0.030	0.085
2	2167	0.018	0.013	0.027	0.028
3	2944	0.117	0.067	0.104	0.089
4	3030	0.111	0.073	0.094	0.115
5	2905	0.238	0.115	0.241	0.193
6	2158	0.038	0.027	0.054	0.039

Table A6. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the MRFSS CPUE. Blank spaces indicate that the area index was not included as a variable in GAM. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
State index		< 0.001	< 0.001	< 0.001	< 0.001
Area index				< 0.001	< 0.001
Mode	beach/bank	n/a	n/a	n/a	n/a
	charter	< 0.001	< 0.001	< 0.001	< 0.001
	man made	0.633	< 0.001	0.205	< 0.001
	party	< 0.001	0.986	< 0.001	0.435
	party/charter	< 0.001	0.008	< 0.001	< 0.001
	private/rental	< 0.001	< 0.001	< 0.001	< 0.001
	shore	0.013	< 0.001	0.003	0.078
Wave	1	n/a	n/a	n/a	n/a
	2	0.203	< 0.001	0.037	0.322
	3	0.017	< 0.001	0.003	< 0.001
	4	0.005	< 0.001	0.027	< 0.001
	5	0.480	< 0.001	< 0.001	< 0.001
	6	0.038	0.066	0.016	0.039
Year	1981	n/a	n/a	n/a	n/a
	1982	0.124	0.012	0.312	0.008
	1983	0.166	0.184	0.465	0.528
	1984	0.582	0.036	0.872	0.007
	1985	0.024	0.286	0.171	0.699
	1986	0.557	0.090	0.746	0.005
	1987	0.005	0.003	0.119	< 0.001
	1988	0.027	0.568	0.330	0.513
	1989	< 0.001	0.029	< 0.001	< 0.001
	1990	< 0.001	0.594	< 0.001	0.064
	1991	< 0.001	0.203	0.002	0.007
	1992	< 0.001	0.569	< 0.001	0.065
	1993	< 0.001	0.153	0.020	0.007
	1994	0.006	< 0.001	0.115	< 0.001
	1995	< 0.001	< 0.001	0.033	< 0.001
	1996	0.048	< 0.001	0.580	< 0.001
	1997	0.018	< 0.001	0.175	< 0.001
	1998	0.001	< 0.001	0.065	< 0.001
	1999	< 0.001	< 0.001	0.007	< 0.001
	2000	0.006	< 0.001	0.045	< 0.001
	2001	< 0.001	< 0.001	0.002	< 0.001
	2002	< 0.001	< 0.001	< 0.001	< 0.001
	2003	< 0.001	0.003	< 0.001	< 0.001
	2004	< 0.001	< 0.001	0.001	< 0.001
	2005	< 0.001	< 0.001	0.008	< 0.001
	2006	< 0.001	0.004	0.001	< 0.001
	2007	< 0.001	0.017	< 0.001	< 0.001
R^2		0.393	0.313	0.215	0.191
Composite R^2		0.052		0.014	

Table A7. SEAMAP yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1990	231	21.381	2.801	16.558	44.204
1991	233	18.339	2.283	10.587	34.687
1992	234	24.906	1.960	9.514	35.278
1993	234	37.333	1.318	4.268	17.896
1994	234	13.107	1.354	4.980	20.190
1995	234	19.000	2.282	8.612	30.480
1996	232	17.289	2.966	11.245	35.217
1997	234	15.991	1.487	5.431	20.529
1998	234	44.893	2.854	8.195	32.341
1999	234	16.415	1.712	6.143	22.384
2000	234	14.239	2.012	11.188	33.146
2001	306	24.072	3.244	17.469	46.824
2002	303	10.904	1.258	4.637	20.967
2003	302	28.805	3.759	11.559	40.473
2004	302	62.288	3.495	13.528	41.899
2005	302	147.818	2.922	7.881	32.597
2006	302	30.639	2.062	10.070	38.306

Table A8. SEAMAP monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
4	953	62.313	2.447	75.677	30.922
5	512	40.693	3.111	31.156	38.149
7	1242	22.899	1.994	39.225	56.561
8	220	15.695	2.103	26.837	36.876
9	19	3.579	1.244	31.441	22.655
10	1215	14.113	2.203	25.092	26.905
11	224	86.906	2.421	16.771	34.131

Table A9. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the SEAMAP CPUE. Blank spaces indicate that depth was not included as a variable in the GAM. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		< 0.001	< 0.001	< 0.001	< 0.001
Latitude		< 0.001	< 0.001	< 0.001	0.060
Depth				< 0.001	0.638
Bottom salinity		< 0.001	< 0.001	< 0.001	< 0.001
Month	4	n/a	n/a	n/a	n/a
	5	0.307	0.200	0.109	0.014
	7	< 0.001	0.029	< 0.001	0.057
	8	0.570	0.435	0.342	0.332
	9	0.926	0.253	0.652	0.959
	10	0.043	0.232	0.048	0.083
	11	0.637	0.027	0.851	0.020
Year	1990	n/a	n/a	n/a	n/a
	1991	0.435	0.258	0.217	0.269
	1992	0.789	0.041	0.458	0.054
	1993	0.044	< 0.001	0.050	< 0.001
	1994	0.047	< 0.001	0.029	< 0.001
	1995	0.494	0.007	0.296	0.021
	1996	0.401	0.442	0.056	0.668
	1997	0.183	< 0.001	0.237	< 0.001
	1998	0.843	< 0.001	0.410	0.003
	1999	0.053	0.002	0.016	0.017
	2000	0.348	0.212	0.231	0.498
	2001	0.795	0.886	0.641	0.249
	2002	0.155	< 0.001	0.179	< 0.001
	2003	0.663	0.036	0.986	0.501
	2004	0.570	0.044	0.389	0.540
	2005	0.168	< 0.001	0.230	< 0.001
	2006	0.046	< 0.001	0.008	< 0.001
R^2		0.256	0.146	0.202	0.061
Composite R^2		0.114		< 0.001	

Table A10. Rhode Island fall trawl survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM
1979	11	9.636	3.337	12.145
1980	26	32.346	11.364	46.050
1981	44	63.773	15.124	58.100
1982	40	33.725	13.310	57.910
1983	22	9.682	4.893	16.858
1984	10	31.200	6.788	38.980
1985	32	37.156	9.107	34.956
1986	21	5.048	2.802	11.610
1987	8	8.375	5.288	19.358
1988	14	32.571	5.524	19.568
1989	10	5.300	3.054	10.137
1990	19	60.263	15.766	64.315
1991	17	58.294	9.069	34.391
1992	20	25.400	7.332	31.508
1993	14	18.214	6.142	26.020
1994	13	49.000	20.215	87.130
1995	4	2.750	2.310	9.295
1996	17	235.824	35.453	165.436
1997	27	138.185	22.898	108.072
1998	17	32.588	7.896	29.996
1999	17	8.882	4.349	20.648
2000	21	17.857	7.636	32.200
2001	19	42.737	13.990	58.833
2002	20	16.800	8.431	33.456
2003	32	259.875	41.927	246.854
2004	9	8.778	4.236	19.180
2005	29	177.828	25.480	105.235
2006	7	2.143	1.798	6.941
2007	25	59.200	16.995	78.251

Table A11. Rhode Island fall trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM
9	468	72.511	12.556	59.317
10	96	22.125	5.333	29.040
11	1	1.000	1.000	7.279

Table A12. Significance (*p*-values) of predictor variables used in the GLM for the Rhode Island survey CPUE. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. The last line of the table is the R^2 of the model.

Variable		GLM
		Positive catch
Area	BIS	n/a
	NB	< 0.001
	RIS	< 0.001
Month	9	n/a
	10	0.980
	11	0.727
Year	1979	n/a
	1980	0.065
	1981	0.025
	1982	0.024
	1983	0.662
	1984	0.149
	1985	0.121
	1986	0.941
	1987	0.603
	1988	0.557
	1989	0.817
	1990	0.029
	1991	0.169
	1992	0.199
	1993	0.344
	1994	0.012
	1995	0.794
	1996	< 0.001
	1997	0.003
	1998	0.242
	1999	0.490
	2000	0.182
	2001	0.041
	2002	0.167
	2003	< 0.001
	2004	0.594
	2005	0.002
	2006	0.530
	2007	0.011
R^2		0.252

Table A13. New Jersey trawl survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1988	68	65.971	2.144	81.915	8.351
1989	192	42.411	1.366	44.501	30.721
1990	171	14.865	0.900	26.260	7.088
1991	189	58.481	1.332	49.852	32.367
1992	191	15.298	1.210	22.886	30.354
1993	187	66.658	1.095	28.200	23.772
1994	186	78.957	1.576	53.636	54.054
1995	188	91.479	3.008	101.073	153.508
1996	189	119.233	3.910	148.785	277.406
1997	187	62.684	2.360	141.378	114.073
1998	188	20.622	0.761	19.049	21.592
1999	186	58.527	1.247	37.108	39.913
2000	187	67.374	1.409	39.814	45.519
2001	186	57.677	1.279	53.517	31.719
2002	188	164.473	3.252	197.973	195.490
2003	188	85.287	1.742	92.913	65.222
2004	187	179.882	3.381	245.019	220.879
2005	186	158.199	2.636	131.107	152.807
2006	186	129.484	1.252	22.579	32.730

Table A14. New Jersey trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
1	348	0.086	0.042	0.025	0.154
2	171	0.029	0.011	0.231	0.037
3	23	0.000	0.000	0.000	0.000
4	662	0.363	0.137	0.073	0.316
5	24	10.958	2.067	16.494	17.015
6	675	93.287	1.429	9.004	12.166
7	39	35.103	1.652	17.765	5.937
8	630	135.479	2.955	38.750	46.250
9	102	174.078	7.447	67.021	272.652
10	644	161.120	8.586	502.652	166.633
11	86	93.302	4.751	54.984	162.056
12	26	6.731	0.824	3.538	27.321

Table A15. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the New Jersey survey CPUE. Blank spaces indicate that month 3 (March) never had positive catch. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		< 0.001	< 0.001	< 0.001	< 0.001
Latitude		< 0.001	< 0.001	0.002	< 0.001
Depth		0.017	< 0.001	< 0.001	< 0.001
Month	1	n/a	n/a	n/a	n/a
	2	0.729	0.041	0.574	0.017
	3		1.000		0.958
	4	0.519	< 0.001	0.553	< 0.001
	5	0.053	< 0.001	0.042	< 0.001
	6	0.001	< 0.001	0.002	< 0.001
	7	0.036	0.001	0.638	0.133
	8	< 0.001	< 0.001	< 0.001	< 0.001
	9	< 0.001	< 0.001	< 0.001	< 0.001
	10	< 0.001	< 0.001	< 0.001	< 0.001
	11	< 0.001	< 0.001	< 0.001	< 0.001
	12	0.006	< 0.001	0.009	< 0.001
Year	1988	n/a	n/a	n/a	n/a
	1989	0.181	0.045	0.493	0.073
	1990	0.803	0.920	0.951	0.845
	1991	0.120	0.062	0.164	0.044
	1992	0.268	0.016	0.687	0.093
	1993	0.396	0.050	0.962	0.122
	1994	0.009	0.084	0.025	0.149
	1995	< 0.001	< 0.001	0.004	< 0.001
	1996	< 0.001	< 0.001	< 0.001	< 0.001
	1997	0.031	< 0.001	< 0.001	< 0.001
	1998	0.541	0.042	0.727	0.071
	1999	0.036	0.121	0.067	0.148
	2000	0.040	0.034	0.079	0.032
	2001	0.096	0.126	0.131	0.080
	2002	< 0.001	< 0.001	< 0.001	< 0.001
	2003	0.003	0.088	0.004	0.048
	2004	< 0.001	0.003	< 0.001	0.001
	2005	< 0.001	< 0.001	< 0.001	< 0.001
	2006	0.087	0.147	0.065	0.049
R^2		0.395	0.383	0.306	0.325
Composite R^2		0.079		0.062	

Table A16. Delaware 30-ft trawl survey yearly CPUE averages.

Year	N	Arith.mean	Geo.mean	GLM	GAM
1966	56	202.054	44.818	246.840	121.522
1967	75	140.960	10.987	136.597	93.710
1968	37	143.892	6.471	63.825	81.686
1969	40	170.075	19.729	169.587	144.138
1970	37	142.351	25.265	234.109	152.384
1971	38	203.184	33.142	368.205	210.422
1974	18	52.833	18.744	64.298	27.112
1979	91	27.209	5.987	26.813	51.640
1980	92	24.099	3.174	17.057	37.644
1981	98	15.194	3.226	13.978	32.445
1982	41	38.390	10.817	36.012	54.971
1983	38	31.921	5.721	32.232	60.836
1984	45	17.489	6.825	23.216	24.105
1990	55	25.400	5.862	19.419	39.224
1991	72	52.648	7.626	74.751	57.253
1992	86	54.372	3.816	17.617	43.255
1993	82	113.976	14.067	80.430	99.656
1994	71	223.971	5.617	49.284	82.335
1995	86	212.174	19.299	181.130	199.226
1996	76	346.760	37.109	237.120	293.148
1997	83	129.195	16.359	140.978	198.421
1998	80	158.150	21.722	316.731	196.982
1999	85	142.482	17.036	164.496	245.189
2000	66	198.697	12.876	125.841	260.535
2001	69	96.087	13.932	149.125	163.924
2002	68	194.672	19.482	204.106	116.800
2003	63	83.516	14.248	93.277	142.299
2004	83	69.519	9.741	59.774	81.985
2005	85	42.447	6.467	32.859	45.505
2006	90	129.764	11.618	82.233	105.427
2007	89	82.438	8.809	103.979	91.555

Table A17. Delaware 30-ft trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
1	24	0.000	0.000	0.000	0.000
2	21	0.000	0.000	0.000	0.000
3	162	0.013	0.009	3.255	6.542
4	187	8.770	1.555	48.150	45.741
5	211	135.029	15.089	149.129	124.141
6	219	204.124	25.726	116.181	118.988
7	210	249.548	33.683	89.830	114.896
8	251	196.799	41.033	107.451	109.719
9	233	167.589	49.680	181.007	189.873
10	201	101.164	35.929	272.733	212.557
11	209	15.635	3.703	81.732	111.310
12	167	2.192	0.357	31.395	42.694

Table A18. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the Delaware survey CPUE. Blank spaces indicate that depth was not used as a variable in GAM, and positive catches were not observed in months 1 and 2 (January and February). "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		< 0.001	0.002	0.013	< 0.001
Latitude		< 0.001	< 0.001	0.010	< 0.001
Depth				< 0.001	0.276
Duration		0.005	0.270	< 0.001	0.601
Bottom temperature		< 0.001	< 0.001	< 0.001	< 0.001
Bottom salinity		0.151	0.006	0.005	0.003
Month	1		n/a		n/a
	2		1.000		0.998
	3	n/a	1.000	n/a	0.980
	4	0.385	1.000	0.289	0.974
	5	0.096	1.000	0.029	0.973
	6	0.104	1.000	0.038	0.975
	7	0.102	1.000	0.049	0.977
	8	0.100	1.000	0.048	0.977
	9	0.047	1.000	0.018	0.975
	10	0.035	1.000	0.010	0.972
	11	0.108	1.000	0.089	0.973
	12	0.421	1.000	0.423	0.975
Year	1966	n/a	n/a	n/a	n/a
	1967	0.467	0.571	0.701	0.499
	1968	0.401	0.484	0.172	0.094
	1969	0.629	0.813	0.988	0.163
	1970	0.620	0.209	0.930	0.731
	1971	0.208	0.750	0.939	0.938
	1974	0.004	0.266	< 0.001	0.110
	1979	0.006	0.932	0.002	0.428
	1980	0.001	0.104	< 0.001	0.031
	1981	< 0.001	0.039	< 0.001	0.010
	1982	0.075	0.131	0.250	0.166
	1983	0.160	0.412	0.195	0.925
	1984	< 0.001	0.110	< 0.001	0.119
	1990	0.015	0.018	0.013	0.004
	1991	0.055	0.132	0.015	0.061
	1992	0.020	0.024	0.039	0.006
	1993	0.636	0.381	0.432	0.165
	1994	0.372	0.203	0.153	0.043
	1995	0.084	0.418	0.358	0.100
	1996	0.006	0.160	0.037	0.623
	1997	0.122	0.781	0.444	0.529
	1998	0.134	0.599	0.482	0.806
	1999	0.024	0.808	0.120	0.270
	2000	0.027	0.485	0.158	0.656
	2001	0.327	0.736	0.936	0.556
	2002	0.949	0.708	0.457	0.335
	2003	0.447	0.156	0.444	0.114
	2004	0.517	0.035	0.412	0.017
	2005	0.037	0.011	0.021	0.003
	2006	0.940	0.106	0.936	0.045
	2007	0.658	0.081	0.465	0.008
R^2		0.402	0.531	0.324	0.485
Composite R^2		0.050		0.049	

Table A19. Maryland coastal bay survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM
1972	3	6.333	4.667	4.604
1973	1	3.000	3.000	5.698
1975	17	29.412	8.299	52.877
1976	14	17.143	9.650	86.563
1977	7	5.571	3.854	4.564
1978	22	54.955	11.514	29.689
1979	9	6.222	4.662	11.244
1980	1	12.000	12.000	22.791
1981	16	53.750	18.054	104.490
1982	12	18.667	11.014	39.662
1984	6	6.167	3.060	5.391
1985	10	6.100	3.632	7.583
1986	4	5.250	4.244	50.215
1987	4	31.000	6.310	156.013
1989	21	4.095	3.203	9.765
1990	39	13.744	7.782	15.357
1991	36	16.583	7.896	25.501
1992	31	44.516	14.478	51.628
1993	28	8.036	4.414	31.418
1994	48	20.125	7.944	21.295
1995	48	77.417	19.122	16.630
1996	49	24.286	8.204	16.672
1997	44	33.932	11.881	6.487
1998	45	29.444	8.599	4.512
1999	40	109.600	14.689	9.783
2000	38	43.526	11.685	18.591
2001	37	47.919	16.818	11.708
2002	17	15.176	6.814	21.899
2003	57	43.158	14.328	9.294
2004	49	22.959	9.039	5.881
2005	56	31.964	12.071	8.068
2006	29	23.828	11.264	5.760
2007	41	20.098	8.355	14.340

Table A20. Maryland coastal bay survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM
4	3	1.000	1.000	6.690
5	8	1.250	1.181	2.249
6	26	3.308	2.018	8.068
7	242	71.789	19.689	20.410
8	310	30.397	12.085	13.280
9	200	12.410	6.482	27.263
10	84	5.476	3.255	29.250
11	6	6.833	3.769	25.253

Table A21. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the Maryland coastal bay survey CPUE. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last line of the table is the R^2 of the model.

Variable		GLM
		Positive catch
Site	T001	n/a
	T002	0.237
	T003	0.431
	T004	0.335
	T005	0.011
	T006	0.014
	T007	< 0.001
	T008	< 0.001
	T009	< 0.001
	T010	< 0.001
	T011	< 0.001
	T012	< 0.001
	T013	< 0.001
	T014	< 0.001
	T015	< 0.001
	T016	< 0.001
	T017	< 0.001
	T018	< 0.001
	T019	< 0.001
	T020	< 0.001
Month	4	n/a
	5	0.745
	6	0.424
	7	< 0.001
	8	< 0.001
	9	0.003
	10	0.051
	11	0.075
Year	1972	n/a
	1973	0.056
	1975	0.642
	1976	0.835
	1977	0.230
	1978	0.477
	1979	0.194
	1980	0.472
	1981	0.645
	1982	0.407
	1984	0.272
	1985	0.552
	1986	0.696
	1987	0.688
	1989	0.066
	1990	0.913
	1991	0.595
	1992	0.639

	1993	0.228
	1994	0.446
	1995	0.336
	1996	0.924
	1997	0.799
	1998	0.855
	1999	0.842
	2000	0.951
	2001	0.524
	2002	0.493
	2003	0.437
	2004	0.909
	2005	0.659
	2006	0.934
	2007	0.756
R^2		0.517

Table A22. North Carolina gillnet survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
2001	230	1.661	1.008	2.678	1.873
2002	306	1.529	0.658	1.342	1.468
2003	316	1.241	0.596	1.018	1.420
2004	317	1.366	0.576	1.058	1.163
2005	297	1.300	0.639	1.167	1.292
2006	317	1.082	0.490	0.891	0.905
2007	314	0.481	0.284	0.506	0.539

Table A23. North Carolina gillnet survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
2	94	0.096	0.062	0.187	0.249
3	188	0.559	0.290	0.632	0.845
4	185	3.341	1.459	3.166	2.756
5	221	2.330	1.022	1.883	1.783
6	220	0.664	0.339	0.666	0.640
7	222	0.563	0.286	0.569	0.670
8	222	0.671	0.414	0.774	0.828
9	206	1.015	0.648	1.243	1.162
10	216	1.639	0.944	1.777	1.602
11	213	1.080	0.628	1.173	1.217
12	110	0.864	0.381	0.748	1.068

Table A24. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the North Carolina gillnet survey CPUE. Blank spaces indicate that bottom temperature was not included as a variable in GLM. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		0.001	< 0.001	0.902	0.009
Latitude		0.207	< 0.001	0.004	< 0.001
Depth		0.079	< 0.001	0.883	0.003
Bottom temperature		0.716	< 0.001		
Bottom salinity		0.073	0.006	0.156	0.007
Surface DO		0.316	0.018	0.051	< 0.001
Surface salinity		0.055	< 0.001	0.280	< 0.001
Month	2	n/a	n/a	n/a	n/a
	3	0.202	0.018	0.248	0.003
	4	0.001	< 0.001	0.002	< 0.001
	5	0.019	< 0.001	0.016	< 0.001
	6	0.525	0.100	0.473	0.026
	7	0.762	0.048	0.730	0.046
	8	0.677	0.013	0.621	0.005
	9	0.373	0.001	0.333	< 0.001
	10	0.071	< 0.001	0.053	< 0.001
	11	0.156	< 0.001	0.194	< 0.001
	12	0.074	0.017	0.083	0.006
Year	2001	n/a	n/a	n/a	n/a
	2002	0.680	0.026	0.335	< 0.001
	2003	0.454	0.002	0.825	< 0.001
	2004	0.624	< 0.001	0.367	< 0.001
	2005	0.619	0.002	0.515	< 0.001
	2006	0.206	< 0.001	0.151	< 0.001
	2007	0.004	< 0.001	0.004	< 0.001
R^2		0.176	0.176	0.127	0.118
Composite R^2		0.155		0.096	

Table A25. Connecticut trawl survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1989	155	1.143	0.295	1.348	0.609
1990	60	0.270	0.205	0.628	0.554
1992	155	0.624	0.397	0.982	0.585
1993	239	0.625	0.395	0.836	0.652
1994	240	2.065	0.611	1.125	1.240
1995	200	0.367	0.270	0.377	0.460
1996	200	0.639	0.402	0.760	0.883
1997	155	0.679	0.535	1.755	1.198
1998	133	0.277	0.181	0.283	0.914
1999	26	0.000	0.000	0.000	0.000
2000	199	2.394	0.761	1.678	1.672
2001	199	1.449	0.618	1.552	1.407
2002	199	1.258	0.571	1.316	0.986
2003	200	1.100	0.553	0.845	2.001
2004	199	1.310	0.569	1.181	1.298
2005	200	1.094	0.519	1.114	1.020
2006	120	0.376	0.240	0.335	0.440
2007	200	2.002	0.684	1.530	1.541
2008	119	0.034	0.024	0.060	0.337

Table A26. Connecticut trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
4	501	0.004	0.003	0.006	0.521
5	709	0.061	0.043	0.138	0.606
6	672	0.213	0.150	0.256	0.342
7	43	0.122	0.087	0.137	0.086
8	52	0.181	0.133	0.126	0.131
9	596	2.527	1.409	3.285	1.193
10	534	3.031	1.414	2.000	1.818
11	86	1.703	1.320	1.771	1.703
12	5	1.000	0.741	1.122	2.311

Table A27. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the CT trawl survey CPUE. Blank spaces indicate where bottom salinity was not included in GAM or positive catch GLM, and positive catches were not recorded in 1988 or 1999. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		< 0.001	< 0.001	0.040	< 0.001
Latitude		0.024	< 0.001	0.028	
Depth		0.004	< 0.001	0.036	0.096
Duration		< 0.001	0.101	< 0.001	0.095
Bottom temperature		0.001	< 0.001		< 0.001
Bottom salinity					0.066
Month	4	n/a	n/a	n/a	n/a
	5	0.799	0.995	0.947	0.169
	6	0.766	0.401	0.956	0.294
	7	0.420	0.173	0.292	0.738
	8	0.862	0.119	0.854	0.414
	9	0.357	0.703	0.344	0.327
	10	0.301	0.227	0.374	0.002
	11	0.673	0.009	0.821	< 0.001
	12	0.522	< 0.001	0.702	< 0.001
Year	1988		n/a		
	1989	n/a	1.000	n/a	n/a
	1990	< 0.001	1.000	0.005	0.131
	1992	< 0.001	1.000	< 0.001	0.001
	1993	< 0.001	1.000	< 0.001	< 0.001
	1994	0.007	1.000	< 0.001	< 0.001
	1995	< 0.001	1.000	0.006	< 0.001
	1996	< 0.001	1.000	< 0.001	< 0.001
	1997	< 0.001	1.000	< 0.001	< 0.001
	1998	< 0.001	1.000	< 0.001	< 0.001
	1999		1.000		0.976
	2000	0.180	1.000	0.212	< 0.001
	2001	< 0.001	1.000	0.004	< 0.001
	2002	< 0.001	1.000	0.001	< 0.001
	2003	0.015	1.000	0.012	< 0.001
	2004	< 0.001	1.000	< 0.001	< 0.001
	2005	< 0.001	1.000	< 0.001	< 0.001
	2006	< 0.001	1.000	< 0.001	0.044
	2007	0.016	1.000	0.030	< 0.001
	2008	0.046	1.000	0.053	0.240
R^2		0.268	0.533	0.229	0.488
Composite R^2		0.196		0.174	

Table A28. New York juvenile trawl survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM
1987	354	0.862	0.328	3.904
1988	426	0.254	0.106	0.977
1989	420	3.274	0.574	0.152
1990	430	1.058	0.264	0.201
1991	398	25.894	4.440	28.780
1992	411	10.727	1.205	6.328
1993	414	2.056	0.428	1.432
1994	428	27.182	1.725	16.677
1995	376	3.005	0.914	6.622
1996	409	88.814	5.004	56.713
1997	379	29.900	2.745	1.705
1998	395	2.382	0.515	1.103
1999	400	17.235	2.221	51.880
2000	420	67.183	3.899	100.122
2001	414	46.498	3.249	42.470
2002	415	54.860	2.604	95.765
2003	392	23.862	1.363	47.478
2004	408	22.532	2.127	6.749
2005	182	66.349	2.714	10.111
2006	244	36.033	4.776	5.206
2007	377	59.488	3.470	105.074

Table A29. New York juvenile trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM
4	8	0.000	0.000	0.000
5	1221	0.034	0.012	0.109
6	1351	10.495	0.453	11.642
7	1453	69.522	4.561	55.257
8	1391	55.884	6.055	74.277
9	1272	16.237	2.310	7.006
10	1339	3.370	0.683	7.304
11	57	0.053	0.032	0.000

Table A30. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the New York juvenile survey CPUE. The blank space indicates that no positive catches were recorded in month 4 (April). "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last line of the table is the R^2 of the model.

Variable		GLM	
		Positive catch	Present/Absent
Station	1	n/a	n/a
	2	< 0.001	< 0.001
	3	0.001	< 0.001
	4	0.103	0.344
	5	0.364	0.054
	6	0.953	0.205
	7	0.651	0.014
	8	0.461	0.370
	9	< 0.001	< 0.001
	10	< 0.001	< 0.001
	11	0.528	0.383
	12	0.295	0.011
	13	0.085	0.003
	14	< 0.001	< 0.001
	15	< 0.001	< 0.001
	16	< 0.001	< 0.001
	17	< 0.001	< 0.001
	18	< 0.001	< 0.001
	19	< 0.001	0.016
	20	0.012	0.004
	21	0.018	0.124
	22	< 0.001	< 0.001
	23	< 0.001	< 0.001
	24	< 0.001	< 0.001
	25	0.388	0.028
	26	< 0.001	< 0.001
	27	< 0.001	< 0.001
	28	< 0.001	< 0.001
	29	< 0.001	< 0.001
	30	< 0.001	< 0.001
	31	< 0.001	< 0.001
	32	< 0.001	0.004
	33	0.165	0.607
	34	0.032	0.868
	35	0.114	0.332
	36	0.181	0.929
	37	0.073	0.516
	38	< 0.001	< 0.001
	39	< 0.001	< 0.001
	40	< 0.001	< 0.001
	41	0.031	0.330
	42	0.289	0.032
	43	< 0.001	< 0.001
	44	< 0.001	< 0.001

	45	< 0.001	< 0.001
	46	0.001	< 0.001
	47	0.160	0.314
	48	< 0.001	< 0.001
	49	< 0.001	< 0.001
	50	< 0.001	< 0.001
	51	0.035	0.725
	52	0.001	0.128
	53	< 0.001	< 0.001
	54	< 0.001	< 0.001
	55	< 0.001	< 0.001
	56	< 0.001	< 0.001
	57	0.178	0.992
	58	0.068	0.407
	59	0.017	0.019
	60	0.037	0.005
	61	0.003	< 0.001
	62	< 0.001	< 0.001
	63	< 0.001	< 0.001
	64	< 0.001	< 0.001
	65	< 0.001	< 0.001
	66	< 0.001	< 0.001
	67	< 0.001	< 0.001
	68	< 0.001	0.104
	69	0.013	0.028
	70	< 0.001	< 0.001
	71	0.146	0.876
	72	0.002	0.085
	73	< 0.001	< 0.001
	74	< 0.001	< 0.001
	75	< 0.001	0.007
	76	0.051	0.795
	77	0.078	0.429
Month	4		n/a
	5	n/a	0.969
	6	< 0.001	0.953
	7	< 0.001	0.939
	8	< 0.001	0.936
	9	< 0.001	0.941
	10	0.005	0.947
	11	0.838	0.961
Year	1987	n/a	n/a
	1988	0.339	< 0.001
	1989	< 0.001	0.004
	1990	0.272	0.269
	1991	< 0.001	< 0.001
	1992	< 0.001	< 0.001
	1993	0.019	0.545
	1994	< 0.001	< 0.001
	1995	< 0.001	< 0.001
	1996	< 0.001	< 0.001
	1997	< 0.001	< 0.001
	1998	0.009	< 0.001

	1999	< 0.001	< 0.001
	2000	< 0.001	< 0.001
	2001	< 0.001	< 0.001
	2002	< 0.001	< 0.001
	2003	< 0.001	< 0.001
	2004	< 0.001	< 0.001
	2005	< 0.001	< 0.001
	2006	< 0.001	< 0.001
	2007	< 0.001	< 0.001
R^2		0.440	0.474
Composite R^2		0.100	

Table A31. Delaware 16-ft. trawl survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1980	193	12.843	3.919	12.116	9.889
1981	189	15.452	4.117	19.766	17.541
1982	229	18.811	5.788	24.776	24.957
1983	226	10.454	3.355	13.530	12.612
1984	185	30.351	5.544	18.437	28.226
1985	133	7.271	1.431	2.249	24.066
1986	203	30.722	6.404	28.425	27.733
1987	176	18.589	4.288	20.623	18.753
1988	165	21.540	3.393	18.167	22.226
1989	138	16.291	4.102	23.922	24.670
1990	193	32.026	8.739	25.242	23.848
1991	276	31.347	7.460	38.577	40.395
1992	275	31.640	7.591	40.047	43.430
1993	168	34.196	7.271	38.966	47.640
1994	267	51.864	10.188	54.135	61.629
1995	264	55.727	10.011	45.430	47.161
1996	279	50.838	6.302	36.791	38.679
1997	279	59.194	8.436	47.419	52.432
1998	317	26.097	5.472	32.846	37.557
1999	231	32.709	6.372	33.377	36.227
2000	257	43.371	10.074	63.135	50.196
2001	240	25.609	4.533	21.618	20.362
2002	275	26.344	3.526	20.555	18.364
2003	275	28.585	4.465	31.441	31.460
2004	253	26.292	3.639	26.766	29.277
2005	240	65.038	10.772	52.974	49.500
2006	273	14.326	3.298	17.794	17.814
2007	272	34.728	7.247	43.132	38.389

Table A32. Delaware 16-ft. trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
4	866	0.099	0.040	0.258	0.434
5	886	2.608	0.812	5.095	6.062
6	962	20.490	3.356	15.665	15.165
7	936	88.764	29.840	81.128	76.784
8	955	57.216	23.366	59.375	57.151
9	954	39.119	14.906	40.799	47.053
10	912	12.798	4.867	18.774	23.383

Table A33. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the Delaware 16-ft. trawl survey CPUE. Blank spaces indicate that depth and tow duration were not included as variables in the GAM. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		0.001	0.005	< 0.001	< 0.001
Latitude		< 0.001	< 0.001	< 0.001	< 0.001
Depth				0.010	0.788
Duration				0.017	0.775
Surface temperature		< 0.001	< 0.001	< 0.001	0.002
Surface salinity		0.002	< 0.001	0.544	< 0.001
Month	4	n/a	n/a	n/a	n/a
	5	0.003	< 0.001	0.002	< 0.001
	6	< 0.001	< 0.001	< 0.001	< 0.001
	7	< 0.001	< 0.001	< 0.001	< 0.001
	8	< 0.001	< 0.001	< 0.001	< 0.001
	9	< 0.001	< 0.001	< 0.001	< 0.001
	10	< 0.001	< 0.001	< 0.001	< 0.001
Year	1980	n/a	n/a	n/a	n/a
	1981	0.002	0.233	0.010	0.747
	1982	< 0.001	0.003	< 0.001	0.042
	1983	0.300	0.078	0.469	0.335
	1984	< 0.001	0.141	< 0.001	0.579
	1985	< 0.001	0.983	< 0.001	0.425
	1986	< 0.001	0.005	< 0.001	0.031
	1987	< 0.001	0.410	0.002	0.852
	1988	< 0.001	0.246	< 0.001	0.185
	1989	< 0.001	0.080	0.002	0.444
	1990	< 0.001	0.228	< 0.001	0.947
	1991	< 0.001	0.004	< 0.001	< 0.001
	1992	< 0.001	< 0.001	< 0.001	0.001
	1993	< 0.001	< 0.001	< 0.001	0.001
	1994	< 0.001	< 0.001	< 0.001	< 0.001
	1995	< 0.001	< 0.001	< 0.001	< 0.001
	1996	< 0.001	< 0.001	< 0.001	0.005
	1997	< 0.001	< 0.001	< 0.001	0.001
	1998	< 0.001	0.002	< 0.001	0.076
	1999	< 0.001	< 0.001	< 0.001	0.022
	2000	< 0.001	< 0.001	< 0.001	< 0.001
	2001	< 0.001	0.133	< 0.001	0.838
	2002	< 0.001	0.758	< 0.001	0.307
	2003	< 0.001	0.124	< 0.001	0.762
	2004	< 0.001	0.069	< 0.001	0.914
	2005	< 0.001	0.025	< 0.001	0.347
	2006	< 0.001	0.424	0.008	0.860
	2007	< 0.001	0.019	< 0.001	0.109
R^2		0.322	0.499	0.297	0.471
Composite R^2		0.180		0.161	

Table A34. VIMS trawl survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1988	710	21.259	1.704	14.276	17.422
1989	716	18.894	1.490	16.201	11.433
1990	709	16.422	1.445	14.377	8.567
1991	650	9.752	1.206	9.363	8.318
1992	658	15.895	1.965	15.450	21.378
1993	589	19.474	1.558	12.418	13.834
1994	662	9.956	1.544	12.342	13.859
1995	635	12.898	2.076	16.084	17.908
1996	1152	13.773	1.677	13.819	14.767
1997	1189	12.373	1.727	12.915	15.169
1998	1254	12.510	1.407	10.304	9.545
1999	1321	14.760	2.002	15.731	17.293
2000	1351	13.928	2.054	16.717	22.554
2001	1107	27.046	2.778	22.344	19.102
2002	1088	14.619	1.893	15.444	14.499
2003	1194	11.899	1.486	11.634	13.983
2004	1222	10.639	1.408	10.504	8.708
2005	1211	7.701	1.386	8.801	8.766
2006	1193	10.293	1.808	13.868	15.705
2007	1223	12.303	1.900	14.628	13.584

Table A35. VIMS trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
1	1072	0.006	0.003	0.037	0.888
2	1562	0.002	0.001	0.013	0.499
3	1143	0.001	0.001	0.022	0.087
4	1661	0.337	0.109	0.798	1.840
5	1828	2.231	0.813	4.292	5.972
6	1850	3.518	1.047	4.757	3.885
7	1809	20.837	3.617	14.780	7.634
8	1754	37.365	7.987	31.658	16.285
9	1861	49.988	10.823	45.306	36.644
10	1869	27.544	5.995	30.718	40.378
11	1781	9.389	2.181	13.893	28.001
12	1644	1.207	0.251	1.916	10.311

Table A36. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the VIMS CPUE. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. Last two lines of the table are the R^2 of each model, and the composite R^2 resulting from multiplying the respective two components of the delta-lognormal method, i.e., positive catch × presence/absence.

Variable		GAM		GLM	
		Positive catch	Present/Absent	Positive catch	Present/Absent
Longitude		< 0.001	< 0.001	0.094	< 0.001
Latitude		< 0.001	< 0.001	0.007	0.114
Depth		< 0.001	< 0.001	< 0.001	< 0.001
DO		< 0.001	< 0.001	0.009	0.279
Temperature		< 0.001	< 0.001	< 0.001	< 0.001
River	AT	n/a	n/a	n/a	n/a
	CL	0.260	0.289	0.444	0.970
	CP	0.668	0.084	0.576	0.096
	GW	0.754	0.102	0.736	0.536
	JA	0.053	0.165	0.234	0.816
	JE	0.796	0.570	0.297	0.301
	MB	0.363	0.003	0.624	0.125
	ME	0.174	0.013	0.363	0.119
	MN	0.102	0.003	0.423	0.018
	MS	0.906	0.027	0.483	0.144
	MW	0.500	0.185	0.881	0.406
	PK	0.111	0.070	0.476	0.326
	PM	0.545	0.106	0.574	0.637
	PO	0.132	0.449	0.200	0.213
	RA	0.163	0.334	0.403	0.725
	YK	0.169	0.045	0.644	0.259
Month	1	n/a	n/a	n/a	n/a
	2	0.597	0.968	0.679	0.341
	3	0.942	0.047	0.913	0.119
	4	0.411	0.009	0.667	< 0.001
	5	0.491	< 0.001	0.787	< 0.001
	6	0.295	< 0.001	0.471	< 0.001
	7	0.735	< 0.001	0.986	< 0.001
	8	0.748	< 0.001	0.478	< 0.001
	9	0.315	< 0.001	0.180	< 0.001
	10	0.332	< 0.001	0.194	< 0.001
	11	0.542	< 0.001	0.295	< 0.001
	12	0.991	< 0.001	0.740	< 0.001
Year	1988	n/a	n/a	n/a	n/a
	1989	0.634	0.003	0.900	0.057
	1990	0.297	< 0.001	0.702	< 0.001
	1991	< 0.001	0.234	< 0.001	0.322
	1992	0.032	< 0.001	0.152	< 0.001
	1993	0.009	0.379	0.028	0.340
	1994	0.003	0.220	0.006	0.323
	1995	0.003	< 0.001	0.010	0.002
	1996	0.004	0.125	0.024	0.415
	1997	< 0.001	< 0.001	< 0.001	0.001

	1998	< 0.001	0.753	< 0.001	0.774
	1999	0.010	0.005	0.045	0.018
	2000	0.007	< 0.001	0.017	< 0.001
	2001	0.287	0.032	0.647	0.051
	2002	< 0.001	0.021	0.003	0.078
	2003	< 0.001	0.012	< 0.001	0.279
	2004	< 0.001	0.790	< 0.001	0.654
	2005	< 0.001	0.042	< 0.001	0.448
	2006	< 0.001	< 0.001	< 0.001	0.002
	2007	< 0.001	0.010	< 0.001	0.028
R^2		0.293	0.427	0.264	0.375
Composite R^2		0.158		0.118	

Table A37. North Carolina juvenile trawl survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM	GAM
1987	85	12.741	7.084	13.669	13.430
1988	120	17.042	9.110	17.277	16.481
1989	93	12.677	6.512	11.305	11.776
1990	69	19.768	13.095	17.817	15.807
1991	65	12.846	8.315	9.872	9.387
1992	72	18.472	14.603	19.690	18.275
1993	77	15.143	10.678	14.354	15.324
1994	86	20.547	14.831	18.676	19.551
1995	88	19.068	14.949	19.755	19.520
1996	83	23.373	17.938	23.117	23.806
1997	87	21.977	17.494	24.530	25.922
1998	71	22.676	18.398	28.397	27.731
1999	104	31.202	27.250	30.380	32.394
2000	101	22.455	19.541	26.094	26.742
2001	67	17.239	11.482	14.857	15.245
2002	63	13.127	9.260	12.362	11.846
2003	77	13.039	9.714	12.803	13.024
2004	67	17.836	13.352	18.064	17.821
2005	67	17.687	12.145	15.963	15.160
2006	78	21.462	16.400	22.869	23.041
2007	65	20.323	14.887	18.849	18.415

Table A38. North Carolina juvenile trawl survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM	GAM
1	1	1.000	1.000	3.320	1.763
3	35	1.629	1.458	2.487	2.688
6	701	16.693	11.894	16.589	17.348
7	53	37.604	32.360	31.234	30.614
9	785	21.146	15.519	22.472	23.907
10	50	21.680	19.257	24.307	23.615
12	60	5.767	3.456	5.110	5.584

Table A39. Significance (*p*-values) of predictor variables used in the GAMs and GLMs for the North Carolina juvenile survey CPUE. Blank spaces indicate that depth was not used as a variable in the GAM, and latitude was not used as a variable in the GLM. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. The last line of the table is the R^2 of each model.

Variable		GAM	GLM
		Positive catch	Positive catch
Longitude		< 0.001	< 0.001
Latitude		< 0.001	
Depth			< 0.001
Bottom DO		0.002	0.005
Surface DO		< 0.001	0.005
Month	1	n/a	n/a
	3	0.674	0.843
	6	0.021	0.038
	7	0.005	0.009
	9	0.009	0.017
	10	0.010	0.017
	12	0.247	0.354
Year	1987	n/a	n/a
	1988	0.144	0.085
	1989	0.379	0.241
	1990	0.319	0.099
	1991	0.033	0.065
	1992	0.061	0.024
	1993	0.414	0.707
	1994	0.017	0.042
	1995	0.017	0.016
	1996	< 0.001	< 0.001
	1997	< 0.001	< 0.001
	1998	< 0.001	< 0.001
	1999	< 0.001	0.003
	2000	< 0.001	< 0.001
	2001	0.506	0.618
	2002	0.492	0.643
	2003	0.866	0.784
	2004	0.111	0.106
	2005	0.519	0.377
	2006	0.002	0.003
	2007	0.086	0.061
R^2		0.311	0.272

Table A40. Maryland Chesapeake “blue crab” survey yearly CPUE averages.

Year	N	Arith. Mean	Geo. Mean	GLM
1989	18	4.944	3.071	10.276
1990	37	19.108	5.189	14.574
1991	26	24.846	6.175	19.394
1992	53	26.736	10.259	30.694
1993	44	31.955	6.020	22.144
1994	36	29.694	9.110	23.681
1995	99	29.131	12.113	53.642
1996	65	68.062	14.857	46.622
1997	63	40.778	14.022	44.013
1998	58	68.362	20.506	38.454
1999	55	35.018	14.424	52.043
2000	84	57.190	14.369	56.037
2001	88	53.182	20.174	69.271
2002	69	39.971	9.418	32.382
2003	60	25.400	10.985	32.456
2004	60	7.167	3.587	15.945
2005	59	28.729	7.421	32.193
2006	71	13.563	3.973	7.629
2007	87	6.586	2.478	5.307
2008	58	4.690	1.928	8.355

Table A41. Maryland Chesapeake “blue crab” survey monthly CPUE averages.

Month	N	Arith. Mean	Geo. Mean	GLM
5	16	1.750	1.566	4.570
6	141	39.624	8.155	17.362
7	262	44.805	14.229	43.673
8	331	41.610	11.209	48.918
9	328	21.448	6.665	29.435
10	105	5.952	2.841	11.791
11	7	2.000	1.784	1.442

Table A42. Significance (*p*-values) of predictor variables used in the GLM for the Maryland "blue crab" survey CPUE. "n/a" entries indicate that a parameter was not reported for one category of a categorical variable, in order to avoid over-fitting the model. The last line of the table is the R^2 of the model.

Variable		GLM
		Positive catch
Site	CHR	n/a
	CPR	0.110
	EBY	0.663
	FBY	0.535
	LCP	0.531
	NTK	0.933
	PAX	0.009
	POC	< 0.001
	TNG	< 0.001
Month	5	n/a
	6	< 0.001
	7	< 0.001
	8	< 0.001
	9	< 0.001
	10	0.008
	11	0.767
Year	1989	n/a
	1990	0.341
	1991	0.102
	1992	0.001
	1993	0.029
	1994	0.021
	1995	< 0.001
	1996	< 0.001
	1997	< 0.001
	1998	< 0.001
	1999	< 0.001
	2000	< 0.001
	2001	< 0.001
	2002	< 0.001
	2003	< 0.001
	2004	0.200
	2005	< 0.001
	2006	0.014
	2007	0.136
	2008	0.339
R^2		0.433