Fishery-Dependent Indices of Adult Atlantic Menhaden Abundance

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Introduction

The Atlantic Menhaden Technical Committee initially reviewed all fishery-dependent datasets from Atlantic coast states, and of the 14 datasets evaluated, 10 were found to be unsuitable for various reasons (Table 1). The remaining four datasets were explored more fully and used to create state-specific indices of relative abundance (Table 2). A review of all possible fishery-independent (FI) and fishery-dependent (FD) datasets revealed that FD indices had significant positive correlations with FI indices, within their respective regions. Furthermore, because the FI datasets had longer time series and were generally of a higher quality (i.e., fewer issues of concern), all FD indices were removed from consideration in assessment models.

Table 1. Fishery-dependent datasets reviewed, but excluded from analysis

State	Gear	Years	Reason for exclusion
NH	Gillnet	1989-2012	targeted menhaden in 1990s, but switched to other spp in 2000s
RI	Fish Trap	2007-2012	short time series
NY	Gillnet	2004-2012	paper format only; ~30% reporting compliance pre-2012
NY	Pound Net	2004-2012	paper format only; ~30% reporting compliance pre-2012
DE	Gillnet	1985-2012	target spp switches between bass and menhaden seasonally
VA	Pound Net	1993-2012	~50% of landings reported as "bait" (i.e. no species info)
NC	Pound Net	1994-2012	no effort data
NC	Pound Net	1994-2012	no effort data
NC	Gillnet	1994-2012	no effort data
VTR	Gillnet/Pound Net	1994-2012	low data quality (i.e., abundant misreporting)

Table 2. Fishery-dependent datasets reviewed, and retained for analysis

State	Gear	Years	Season (Peak CPUE)	Effort	Soak time	Ages/Lengths	Avg n/yr	% Zeros
MA	Pound Net	2002-2012	Apr-Sep (May)	hauls	Yes*	No	43	64%
NJ	Gillnet	1997-2012	Jan-Dec (August)	net-feet	Yes	No	143	2%
MD	Pound Net	1992-2012	Jan-Dec (Apr-May)	hauls	Yes*	Yes (2005 on)	235**	51%
PRFC	Pound Net	1989-2012	Feb-Dec (Mar)	net-days	No	Yes (2009 on)	6	?

**soak time calculated based on interval between consecutive trips*

***This is the number of monthly summarized records per year. Avg number of trips/yr ~3000.*

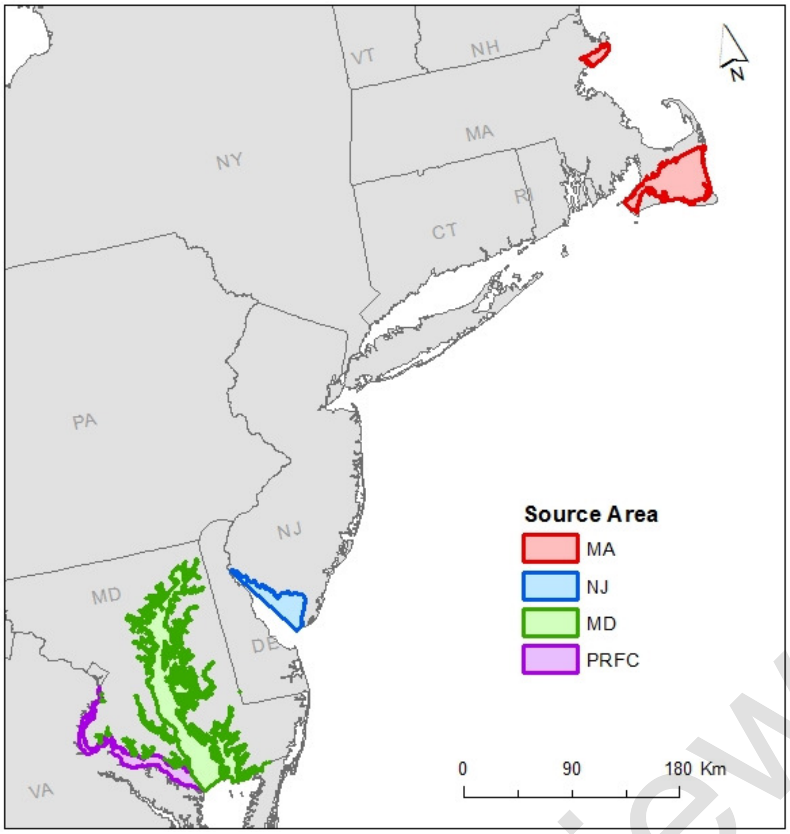

Figure 1. Map of fishery areas from which source data were collected.

Methods

Due to a high prevalence of zero catches in these data, a delta-GLM approach was used to create annual indices of abundance (i.e., NEFSC *dglm* function in R). In all cases, CPUE was designated as the response variable. A forward stepwise process was used to introduce predictor variables and establish a suite of candidate models. A preferred model was selected based on three pieces of information:

1) Bayesian Information Criterion (**BIC**) – the lowest value identified the suite of predictors that best explained the variance of the underlying data. The BIC is less likely to identify complex models than Akaike's Information Criterion (AIC), due to a higher penalty for including additional parameters.
2) Percent of the null deviance explained by additional terms **(% Deviance**) - according to Maunder and Punt (2004), even the BIC can select for unnecessarily complex models, given the large number of observations typically used to create CPUE indices. The authors suggest that if the addition of a term explains less than ~ 2% of the null deviance, it may not improve model performance
3) Influence of additional terms on the annual index **(% Influence**) – As Bentley et al. (2011) point out, just because a term explains a large amount of variance, its inclusion in the model may do

little to improve the annual index. For example, MONTH may be a highly significant predictor of CPUE; but, if the seasonality of the fishery changes little from year to year, the annual index will remain unaffected. Likewise, a marginally significant predictor (in terms of ΔBIC or %Deviance) may wield substantial influence over the index, if there is a major distribution shift in that predictor over the time series. Influence values can be interpreted as the average annual amount of change caused to the index by the addition of the last term in the model. Predictors with influence >5% were retained, even if the model did not have the lowest BIC.

Once a preferred model was selected, standard errors around the annual index values were estimated via the jackknife procedure of the *dglm* function. All plots of index trends were Z-transformed to place them on the same scale.

Massachusetts

Trip-level catch and effort data were collected from the Massachusetts Pound Net fishery from 1989-present, however, only monthly summary data exist from 1989-2002. Due to the high prevalence of zero catches, the summarized dataset contains only 1 to 7 positive observations per year, which was deemed insufficient to inform an annual index of abundance. Therefore, just the trip-level dataset from 2002-2012 was used to create the index.

This fishery typically occurs between April and September, with the majority of catch and effort occurring in May. No records of menhaden catch have occurred outside of April-June; therefore, the dataset was restricted to these months. Even within this core season, 86% of the trips caught zero menhaden.

A total of 10 permits were active over the 11-year time series. Eight permits were either active in less than 50% of the years or contributed less than 5% of the total positive trips and were therefore censored from the dataset. Even after these restrictions, the remaining two permits caught zero menhaden on 64% of the trips.

No age samples have been collected from this fishery. However, in communicating with several fishermen, only adults are caught due to the large mesh, the location of the nets, and the general behavior of the fish (i.e., only adults enter the pound). Age samples do exist from the nearby Rhode Island fish trap fishery that may be applicable to these data.

The fully saturated model (log(CPUE)~YEAR+PERMIT+MONTH+SOAK) achieved the lowest BIC score; however, the addition of MONTH and SOAK explained only a small fraction of the deviance and exerted little influence. In contrast, PERMIT held had substantial influence over the annual index, owing to changes in permit activity over the time series. Therefore, log(CPUE)~YEAR+PERMIT was selected as the preferred model for Massachusetts.

Table 3. Candidate models for the Massachusetts pound net index. The lowest AIC and BIC values for the lognormal GLM of non-zero values are shown in bold. The % Deviance is the deviance explained by the addition of the last term in the model divided by the null deviance. Influence is the average annual amount of change to the index caused by the addition of last term in the model (Bentley et al., 2011). The preferred model is shown in bold.

Form	AIC	BIC	% Deviance	Influence
YEAR	665.98	706.14	35.1%	NA
YEAR + PERMIT	663.10	716.66	3.3%	19.0%
YEAR + PERMIT + MONTH	666.81	727.06	0.1%	2.0%
YEAR + PERMIT + MONTH + SOAK	**512.93**	**571.48**	0.1%	NA

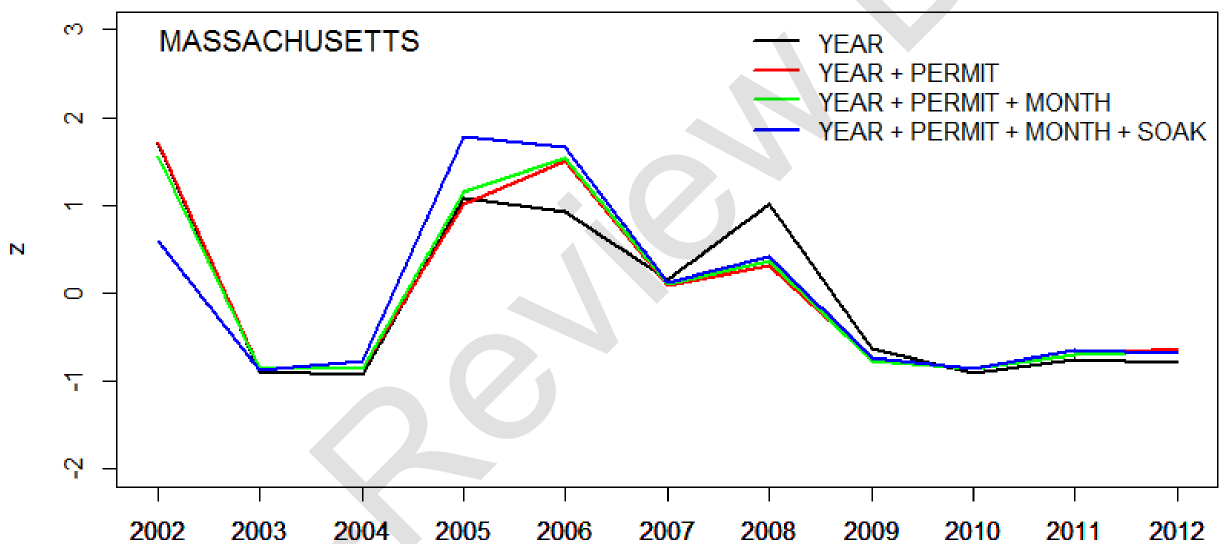

Figure 2. Candidate models for the Massachusetts pound net index.

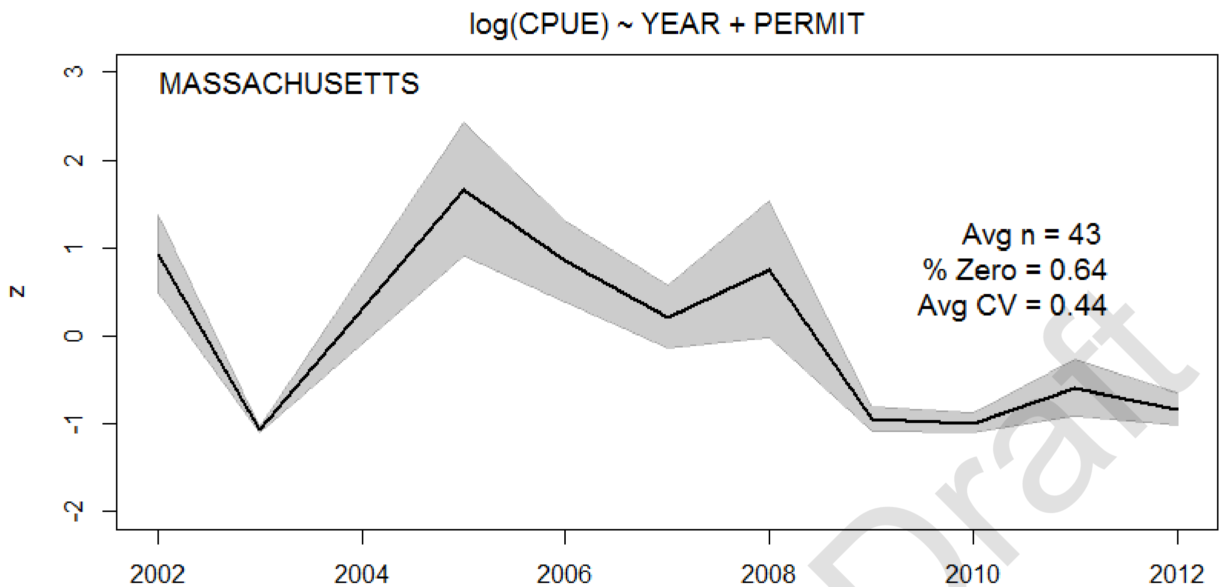

Figure 3. Delta-lognormal Index of adult menhaden abundance from the Massachusetts pound net fishery. Shaded area represents +/- 1 standard error.

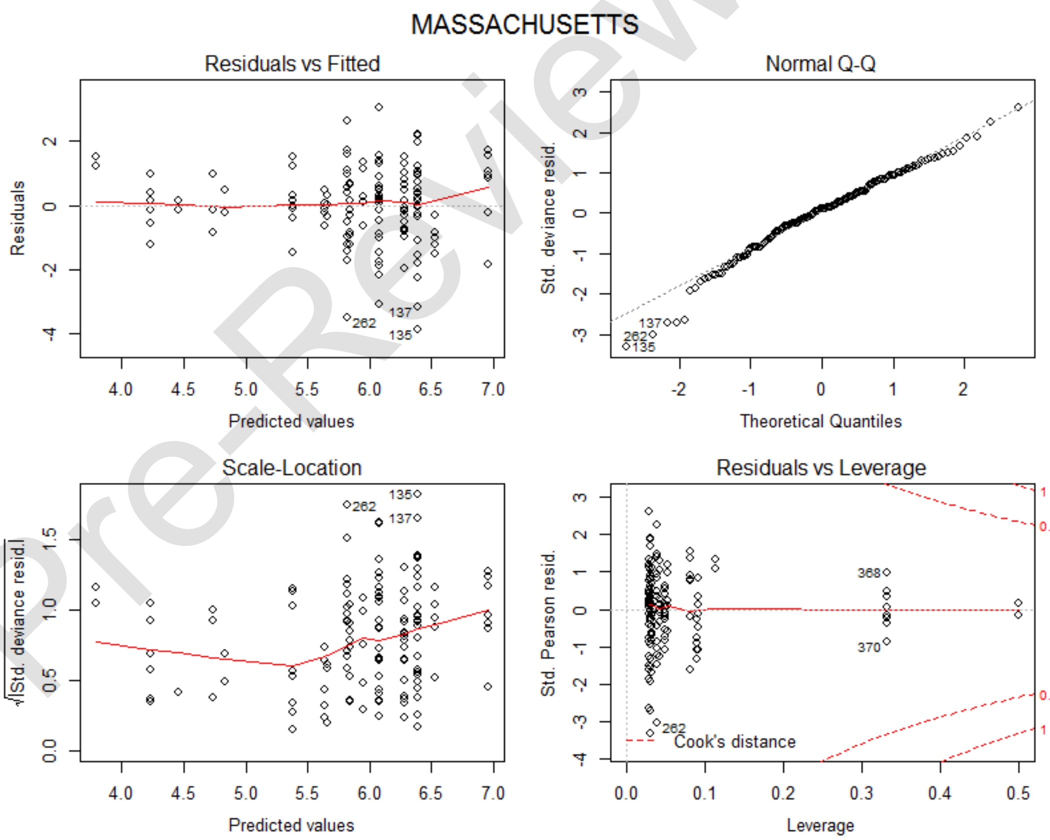

Figure 4. Diagnostic plots for the preferred Massachusetts pound net model: log(CPUE)~YEAR+PERMIT+MONTH

New Jersey

The New Jersey gillnet fishery occurs in all months of the year, with peak effort in August. While menhaden are caught in all months, less than 5% of the positive trips occur in the months of December, January, and February; therefore, these months were censored form the dataset. Non-standardized location information is provided with each trip record (e.g. “1 mile off wildwood”). Locations were reviewed and assigned to one of two areas: “Delaware Bay” or “Ocean.” Trips occurring in the “Ocean” were few and restricted to the earlier portion of the time series. As such, the dataset was limited to trips assigned to “Delaware Bay.” Mesh sizes from 2 to 5 inches were reported for this fishery; however, 97% of trips fell between 2.75 and 3.5 inches. Trips with mesh sizes outside this range were omitted from the dataset. The hours between setting and hauling the nets are reported with each trip and ranged between 0.5 and 48 hrs, with 63% of the trips reporting a soak time of 24 hours. Due to concerns over the influence of soak time and saturation on CPUE, the dataset was restricted to only 24-hour sets. While the limitations placed on this dataset resulted in a very low number of zero-menhaden trips (2%), the catches were dominated by a single permit-holder (98%), causing concern over the reliability of the NJ gillnet fishery as an index of abundance.

The model with lowest BIC value included only MONTH as a predictor variable. The addition of PERMIT or MESH only marginally improved the model, explaining <1% of the model deviance and exerting <5% influence on the annual index. Therefore, log(CPUE)~YEAR+MONTH was selected as the preferred form of the New Jersey gillnet index.

Table 5. Candidate models for the New Jersey gillnet index

Form	AIC	BIC	% Deviance	% Influence
YEAR	6637.2	6734.3	8.8%	NA
YEAR + MONTH	6243.4	**6386.2**	15.3%	11.3%
YEAR + MONTH + PERMIT	**6228.5**	6399.8	0.8%	2.7%
YEAR + MONTH + PERMIT + MESH	**6228.5**	6399.8	0.0%	0.0%

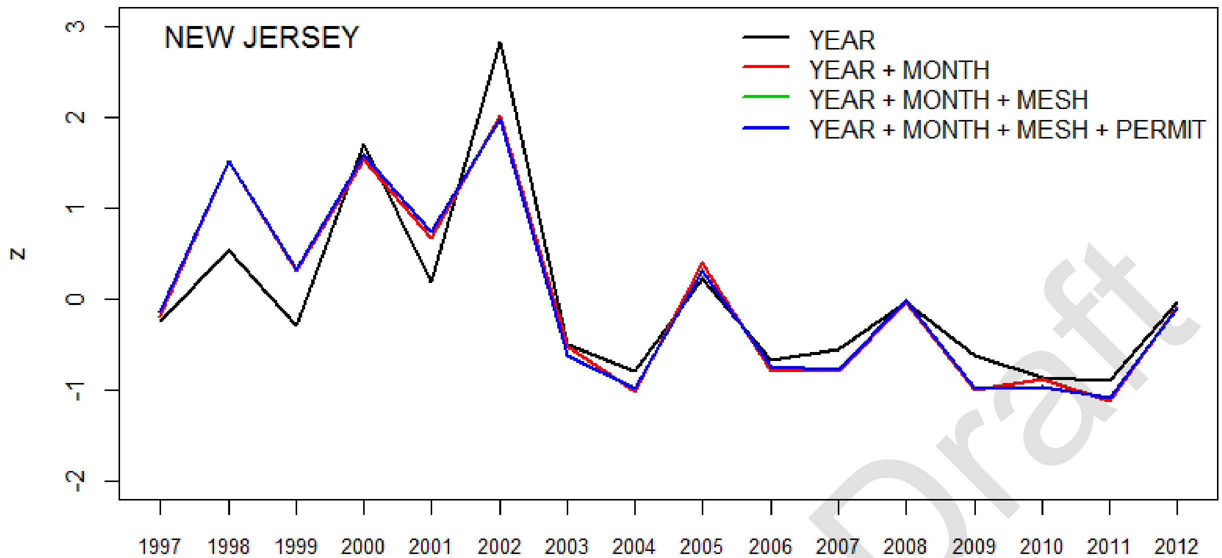

Figure 8. Candidate models for the New Jersey gillnet index

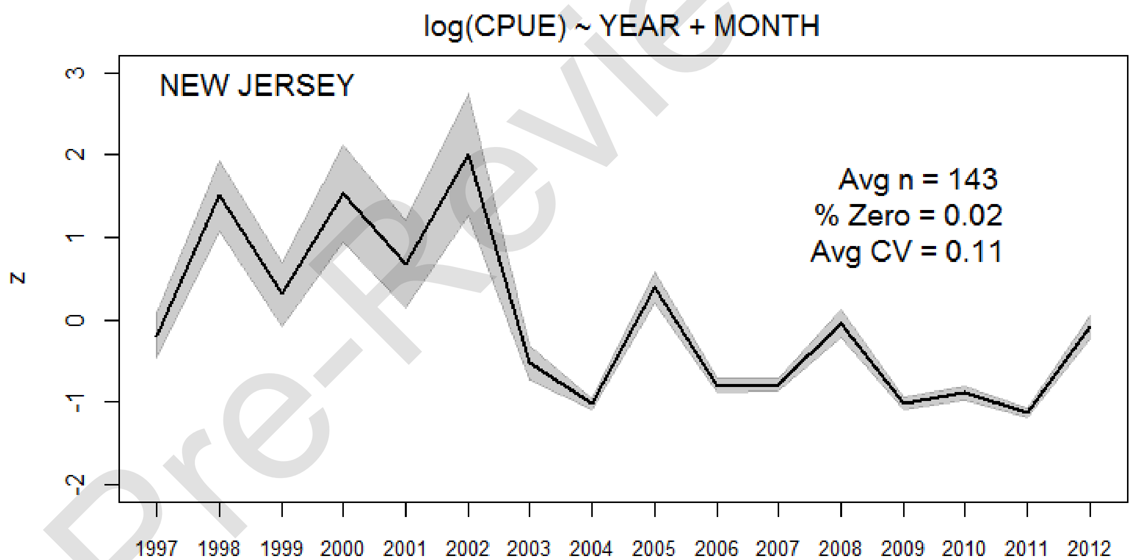

Figure 9. Delta-lognormal GLM Index of adult menhaden abundance from the New Jersey gillnet fishery. Shaded area represents +/- 1 standard error.

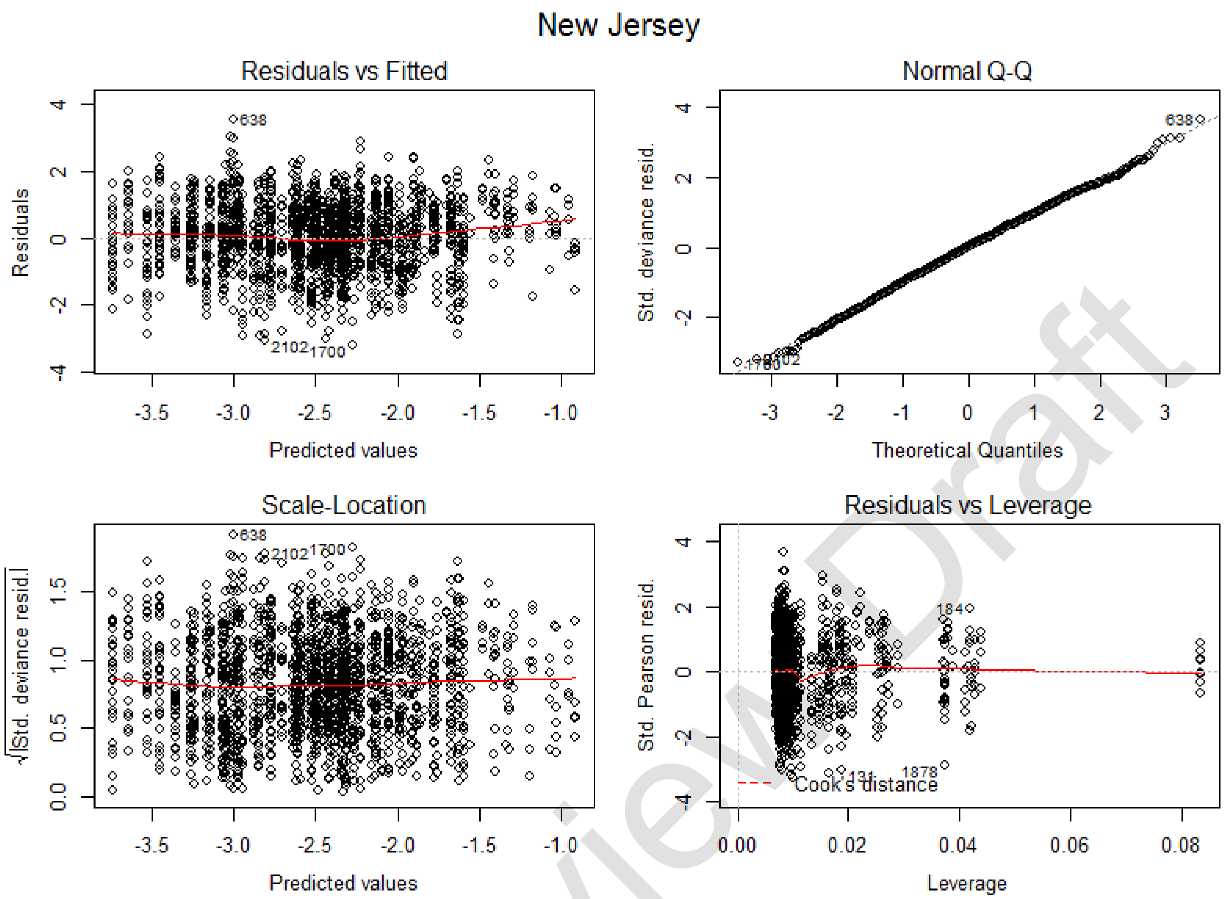

Figure 10. Diagnostic plots for the preferred New Jersey gillnet model: log(CPUE)~YEAR+MONTH

Maryland

Trip-level data are available from 2005-2012, while monthly summary data (catch, hauls per month by permit, area) extend back to 1992. The higher number of observations in the trip-level data would achieve a much lower CV than the monthly summarized dataset; however, the benefit of 13 additional years likely outweighs the cost of an increase in CV. Therefore, only the monthly summarized values were used to create the Maryland index. Menhaden are caught by this fishery in all months; however, the months between December and March each had less than 5% of the total positive trips and were omitted from the dataset. Likewise, some areas had fewer than 5% of the reported catch of menhaden and were removed from the dataset. Due to the large number of participants in this fishery (n permits = 337), an alternative metric was used to restrict permits (i.e., all permit holders contributed less than 5% to the total number of positive trips). Specifically, any permit holder that caught zero menhaden on greater than 75% of their trips was omitted. The limitations placed on the Maryland pound net dataset resulted in 33% of the total trips having zero menhaden catch.

The model with PERMIT and MONTH achieved the lowest BIC score. The addition of AREA to the model had marginal values for % deviance and influence; therefore, in the interest of parsimony, log(CPUE) ~ YEAR+PERMIT+MONTH was selected as the preferred model.

Table 6. Candidate models for the Maryland pound net index

Form	AIC	BIC	% Deviance	% Influence
YEAR	12995.3	13129.4	7.5%	NA
YEAR + PERMIT	11961.3	12449.0	27.3%	7.7%
YEAR + PERMIT + MONTH	11781.1	**12311.5**	3.7%	3.8%
YEAR + PERMIT + MONTH + AREA	**11752.0**	12465.3	1.6%	5.0%

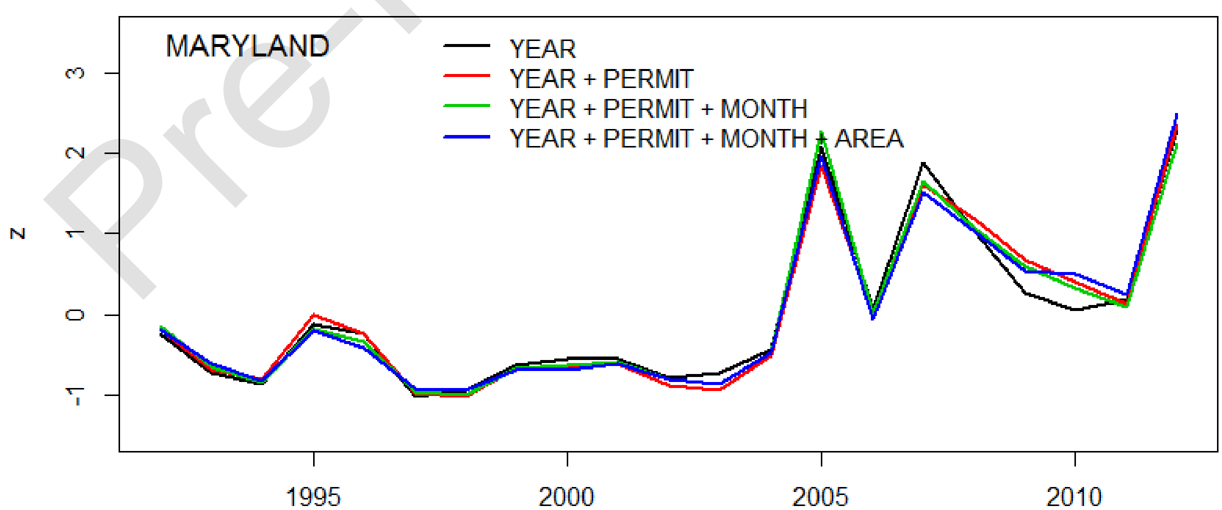

Figure 12. Candidate models for the Maryland pound net index

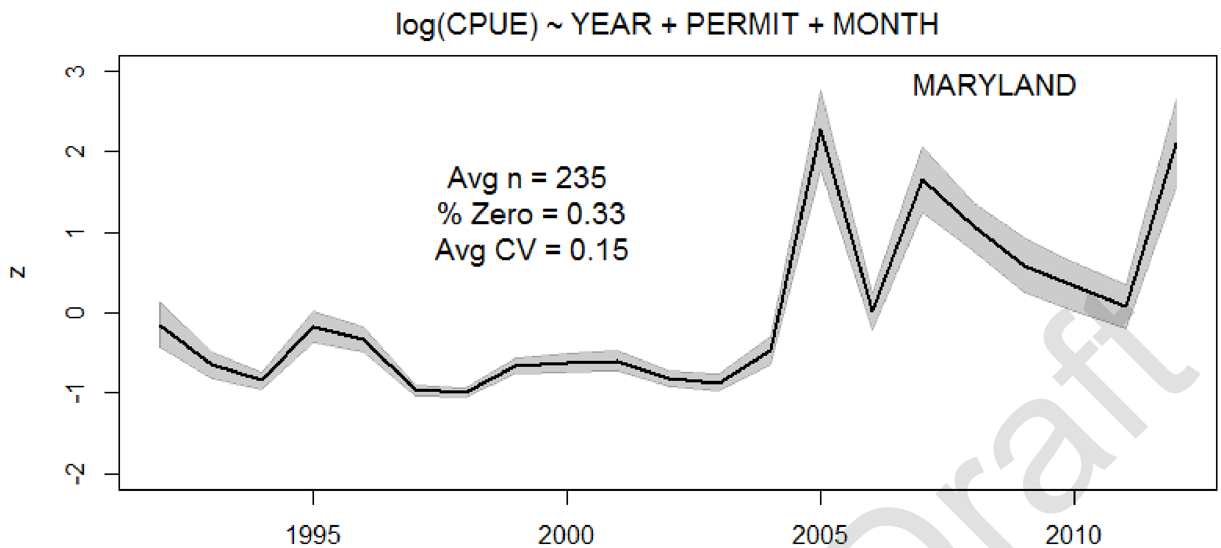

Figure 13. Delta-lognormal GLM Index of adult menhaden abundance from the Maryland pound net fishery. Shaded area represents +/- 1 standard error.

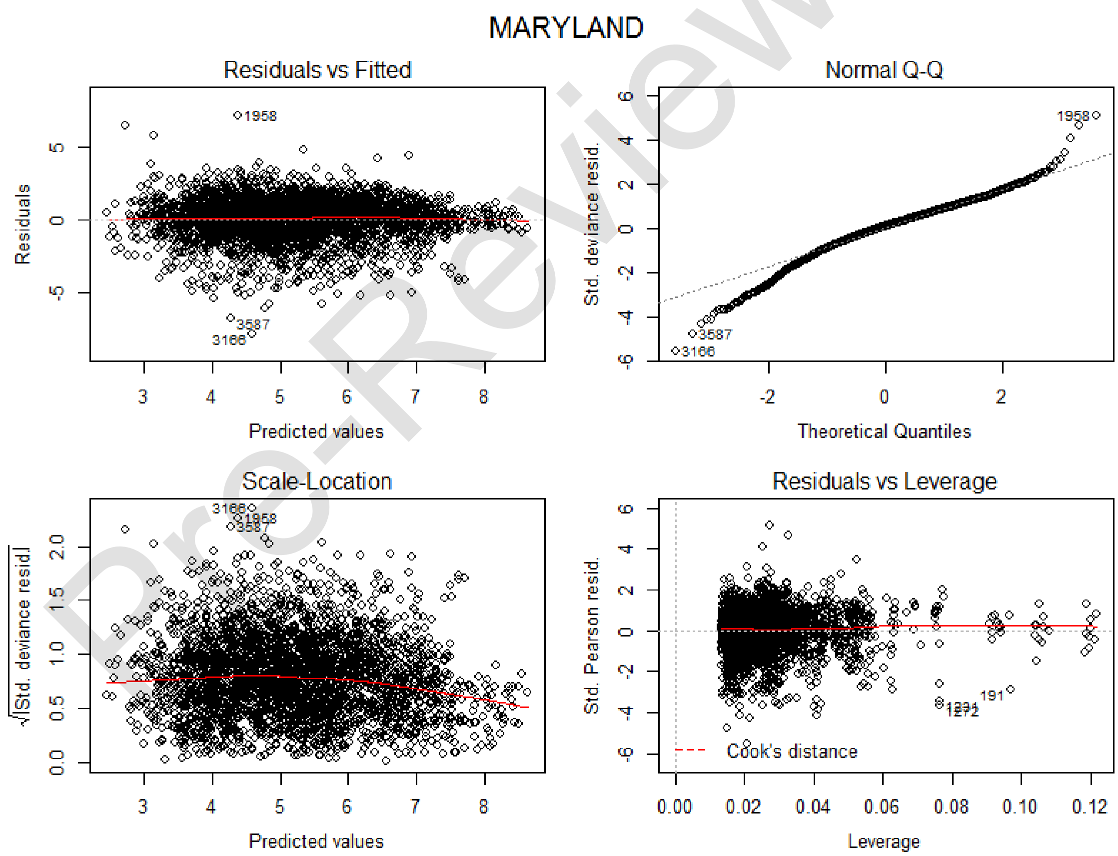

Figure 14. Diagnostic plots for the preferred Maryland pound net model: log(CPUE)~YEAR+PERMIT+MONTH

Potomac River Fisheries Commission (PRFC)

The PRFC pound net dataset is comprised of various temporal resolutions: annual (1964-1988); monthly (1989-1990); weekly (1991-1998); and daily (1999-2012). Effort data are only available from 1989 on, and the units are the total number of net-days fished in all periods. In previous menhaden assessments, a PRFC pound net index was extended back to 1964, using a loose relationship between the number of permits issued and net-days fished ($r2 = 0.49$, $p=0.10$).

Net-days with zero menhaden catch are represented only in the most recent time period (1999-2012) and comprise 20% of records. Initial examination of these daily data revealed that incorporation of zero-catch records did not significantly alter the index trend. Therefore, all data with effort information were summarized to the monthly resolution and used to develop an index.

This fishery occurs in all months except January, but since less than 5% of the total records came from February, data from this month were omitted. Similarly, landing ports with less than 5% of the total number of records were removed from the dataset.

The model with PORT and MONTH as predictors was selected as the preferred model, as it achieved the lowest BIC and the addition of AREA did not materially improve selection criteria.

Table 7. Candidate models for the PRFC pound net index

Form	AIC	BIC	% Deviance	% Influence
YEAR	4382.7	4514.3	8.8%	NA
YEAR + PORT	4105.2	4273.7	16.8%	6.0%
YEAR + PORT + MONTH	3885.4	**4096.0**	11.3%	3.0%
YEAR + PORT + MONTH + AREA	**3882.1**	4124.2	0.7%	1.0%

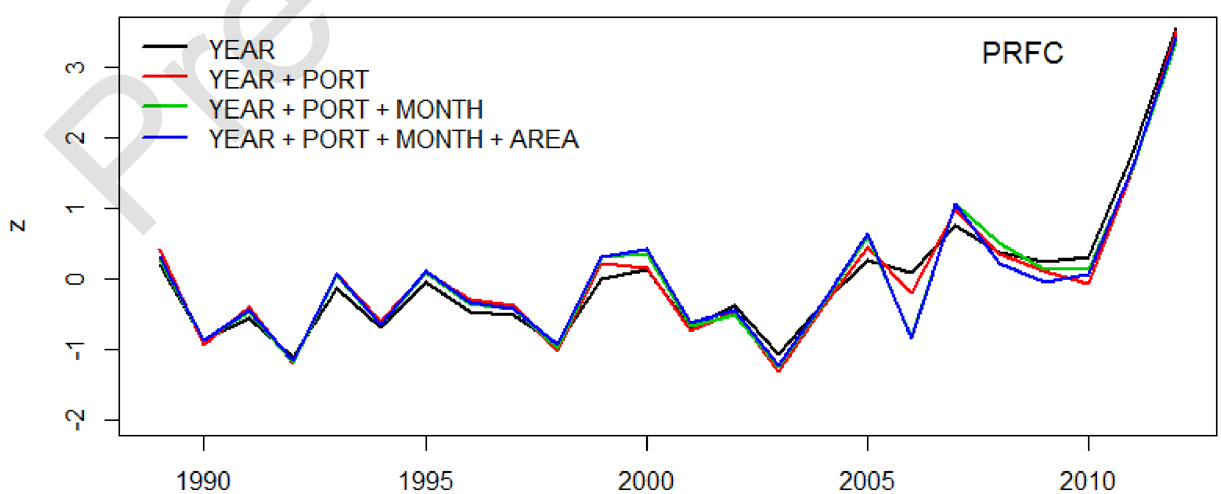

Figure 15. Candidate models for the PRFC pound net index

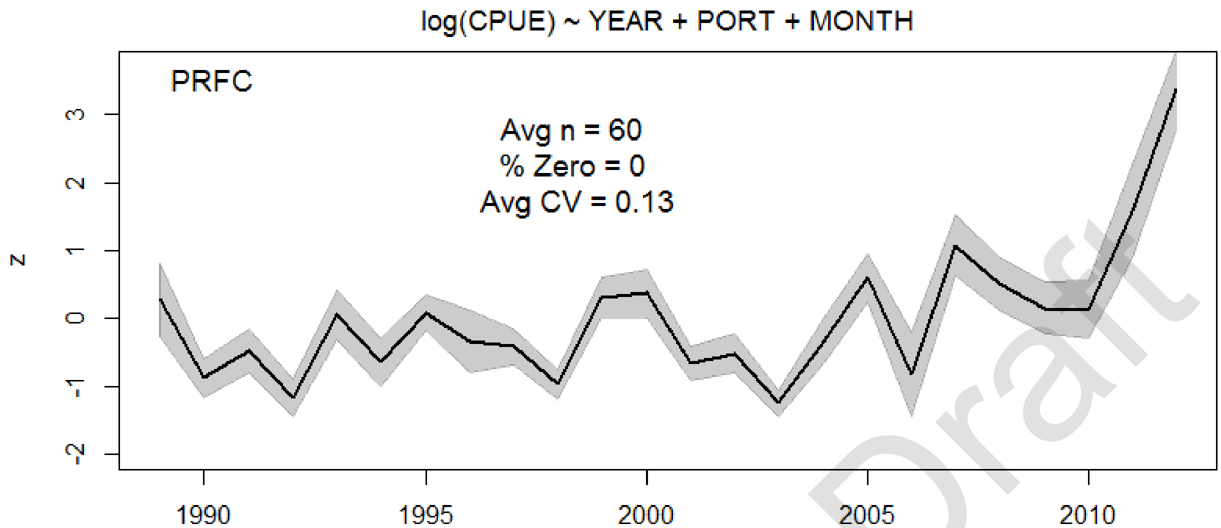

Figure 16. GLM Index of adult menhaden abundance from the PRFC pound net fishery. Shaded area represents +/- 1 standard error.

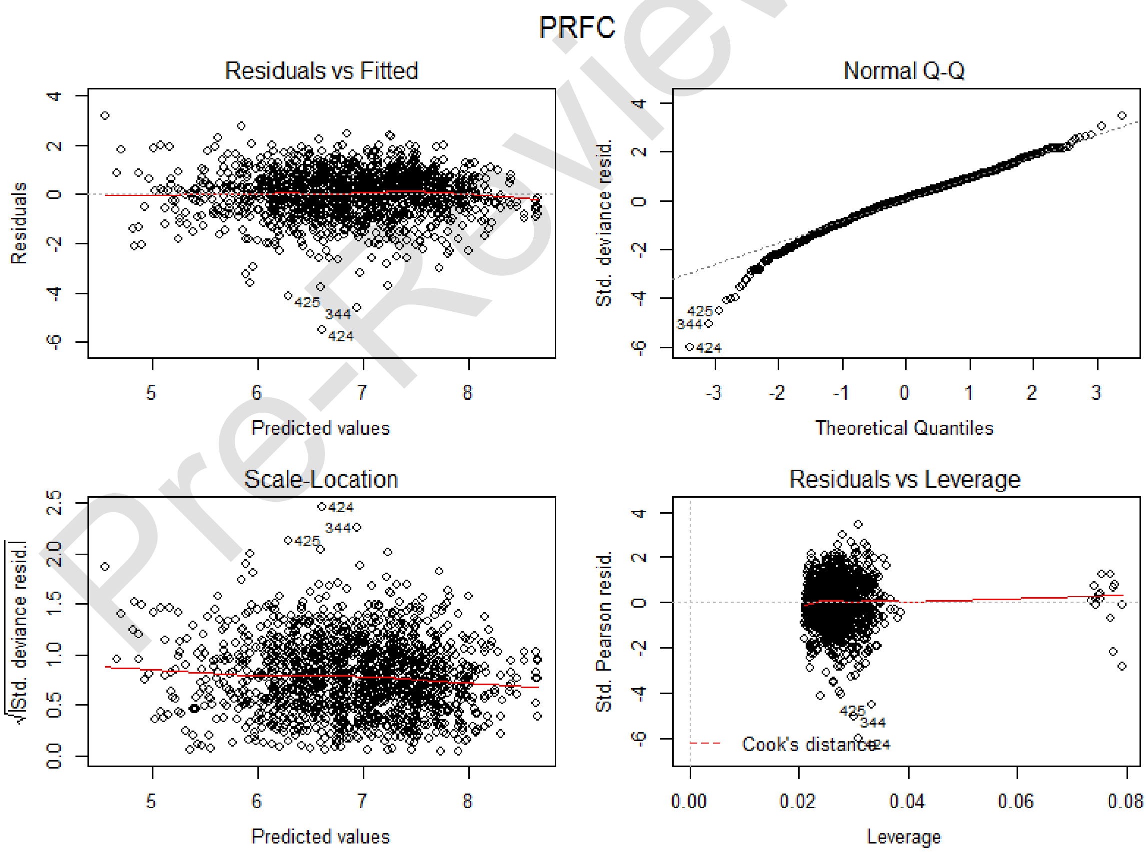

Figure 17. Diagnostic plots for the preferred PRFC pound net model: log(CPUE)~YEAR+PERMIT+MONTH

References

Bentley, N., Kendrick, T. H., Starr, P. J., and Breen, P. A. 2012. Influence plots and metrics: tools for better understanding fisheries catch-per-unit-effort standardizations. ICES Journal of Marine Science, 69: 84-88.

Maunder, M. N., Punt, A. E. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research, 70: 141-159.