Appendix I

An Evaluation of Calibration Options for the application of FSV Henry B. Bigelow Skate Indices for Setting Allowable Biological Catch and for Status Determination

New England Fishery Management Council
Skate Plan Development Team
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1.0 Issue

The Northeast Skate Complex Fishery Management Plan (FMP) uses a three year running average of fall and spring (for little skate) survey biomass to determine Allowable Biological Catch (ABC). Setting the ABC for the 2010 and 2011 fishing years, Amendment 3 uses the 2006-2008 surveys by applying the catch/biomass median values which were derived using data processing methods developed by the Data Poor Assessment Workshop (NEFSC 2009) and analytical methods approved by the Council's Scientific and Statistical Committee (SSC) in February 2009 (http://www.nefmc.org/tech/Reports/Reports%20to%20Council%202009/Skates/SSCFeb09%20skates%20_7_.pdf).

In this February 2009 analysis, future biomass tended to increase more often than not and by a greater amount when the catch/biomass ratio was less then the median, and vice versa. Based on this analysis, the SSC approved using the median catch/biomass ratio and the three year average stratified mean survey biomass for setting an aggregate skate ABC. Except for a minor modification to account for differences in sampling strata with the FSV Bigelow, this document does not propose any adjustments and focuses on the method for calibrating FSV Bigelow biomass indices to FSV Albatross IV units.

To use the 2009 and 2010 FSV Bigelow survey data in the ABC specification, the survey data need to be adjusted to FSV Albatross units (or vice versa with some additional analysis of the catch/biomass time series). A base model approach was developed, presented, and reviewed by a special Stock Assessment Workshop (see supporting document "Estimation of Henry B. Bigelow calibration factors" The August 2009 peer review recommended (http://www.nefsc.noaa.gov/nefsc/saw/pdfs/VesselCalibrationReview-Consensus%20Report_Aug%2014_09.pdf) that the method be further developed and reviewed in individual stock assessments, many of which have applied a length-based approach when the relative efficiency in the calibration data appears to vary with length1. Other species where a length-based approach has been applied are cod, haddock, yellowtail flounder, red hake, offshore hake, silver hake, loligo (Brooks et al. 2010 and NEFSC 2011), and winter flounder (analyses pending and may include region and season as explanatory factors).

This document includes a comparative analysis of three models, one of which the SSC should approve for use in setting skate ABC and potentially for making status determination.

[1] This outcome appears to be a common phenomenon for flatfish and other fish that hug the bottom due to the effect that FSV Albatross "cookies' had on catches of these fish.

2.0 Table of Contents

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3.0 Development and analysis of skate calibration models

Building on the methods developed and approved during the August 2009 SAW review (see supporting document "Estimation of Henry B. Bigelow calibration factors") and published in Miller et al 2010, the Skate PDT developed and evaluated alternative models that may be more accurate and perform better for setting Skate ABC and for determining status. The three models are described below in increasing order of complexity.

3.1 Model 1 - Aggregate abundance and biomass catch efficiency by species

Model 1 is a base model published in Miller et al (2010) that estimates the relative catch efficiencies (aggregated over length) of barndoor, clearnose, little, smooth, thorny, and winter skates. Separate calibration models are used by season for little and winter skates. The catch efficiency for little skate was assumed for rosette skate, because of insufficient comparative catch data. Furthermore, there was no attempt to account for variation in swept area among tows or whether length measurements were taken only from a subsample of the catch on a given tow. This is the basis for the data that the NEFSC released to Mr. John Whiteside in response to a FOIA request and for the data used by the NEFSC on January 13, 2011 to determine skate status in 2010. No changes to this model were made during the PDT analysis.

3.2 Model 2 – Aggregate species size based catch efficiency

Model 2 accounts for length effects, variation in swept area among tows, and whether length measurements were taken only from a subsample of the catch on a given tow. The model is described in the "A hierarchical model for relative catch efficiency from gear selectivity and calibration studies" manuscript by Miller (2011, ms). In this manuscript, Miller fits the model to data for Acadian redfish, black sea bass, Atlantic cod, haddock, summer flounder, and winter flounder. Like Model 1, the basic model treats the relative catch efficiency of the two gear/vessels as a beta binomial parameter. However, the data used to fit this model for skates were aggregated across all species in the skate complex by one cm length class, vessel, and station. The reason that it may be appropriate to pool across skate species is that skates may behave more differently at various sizes than they do amongst species due to similar morphology, ecological characteristics, and general behavior. Due to low catches of large fish, catches with lengths greater than 94 cm were assigned a common length of 107 cm, the mean length of fish captured at these large sizes.

The beta-binomial model is hierarchical in nature. It is based on assuming a binomial model at each station for number captured at length by the FSV Bigelow conditional on the number captured by both vessels,

$$N_{Bi}(L) \sim Bin\left(N_i(L), p_i(L)\right),$$

and that the probability parameter is a beta distributed random variable across stations,

$$p_i(L) \sim Beta\left(\pi(L), \phi(L)\right).$$

The mean probability of capture by the Bigelow (π), taking into account the ratio of swept area (SA) and sampling fraction (SF) is modeled as

$$\log\left[\frac{\pi(L)}{1-\pi(L)}\right] = \log\left[\rho(L)\right] + \log\left(SA_B / SA_A\right) + \log\left(SF_B / SF_A\right)$$

where $\rho(L)$ is the relative catch efficiency which is modeled as a smooth function of length, and SA_k and SF_k are the swept areas and sampling fractions for vessel k. This parameterization of the probability of capture derives from the assumption that the ratio of expected catches is

$$\frac{\pi(L)}{1-\pi(L)} = \frac{E\left(N_B(L)\right)}{E\left(N_A(L)\right)} = \frac{q_B(L) SA_B SF_B \delta(L)}{q_A(L) SA_A SF_A \delta(L)} = \rho(L)\frac{SA_B SF_B}{SA_A SF_A}$$

where $\delta(L)$ is the density of available fish (cf. Lewy et al. 2004 and Cadigan and Dowden 2010).

Following Miller (submitted), two different dispersion models were considered,

$$\log\left[\phi(L)\right] = \alpha_1 \log\left(SA_B / SA_A\right) + \alpha_2 \log\left(SF_B / SF_A\right) + \varphi(L)$$

and

$$\log\left[\phi(L)\right] = \varphi(L)\left[SF_A SA_A + \rho(L) SF_B SA_B\right]$$

where $\varphi(L)$ is also a smooth function of length. The latter dispersion model is based on a derivation of the beta-binomial that assumes that the expected catches at length arise from a particular type of gamma distribution (see Miller submitted).

The smoothers, $\log\left[\rho(L)\right]$ and $\varphi(L)$, have the same general form

$$f(L) = \sum_{i=0}^{D} \beta_i g_i(L)$$

where D is the number of terms, $g_i(L)$ are uncorrelated functions of length and β_i are estimated parameters. Following Miller (submitted), we considered two types of smoothers : orthogonal polynomials or regression splines. The smoothers allow the form of the curve relating length to relative catch efficiency to be estimated from the data. When they are used for statistical modeling, the parameters that define the curve are estimated and generally, the fewer the number of parameters (or model degrees of freedom) generates a smoother fit through the data. For orthogonal polynomials the number of parameters is set by the analyst, but for the regression splines, the “smoothness” of the curve can be estimated by incorporating a penalty during the estimation process. There are various types of penalties that can be used, but their form is beyond the scope of this document (see Wood 2006). The type of penalty used in the present analyses is widely used for fitting generalized additive models and are functions of the second derivatives of the regression spline.

Our final Model 2 was chosen from a large set of models where length effects on relative catch efficiency and the beta-binomial dispersion parameter, ϕ, were modeled with two classes of smoothers. The set of models we considered is defined similarly to those for each of the 6 species by Miller (submitted). A suite of models were fit assuming orthogonal polynomial smoothers with varying model degrees of freedom for the smoother of length and varying assumptions on the submodel for the beta-binomial variance parameter. Several regression spline model were also fit with varying assumptions on the submodel for the beta-binomial variance parameter, but the model degrees of freedom associated with the length smoother is estimated simultaneously for these models. The total set of models were compared based on a sample size corrected version of the Akaike Information Criterion (AIC_C; Hurvich and Tsai 1989). The model with the best AIC_C, was chosen as Model 2. However, Model 2 cannot be compared to Model 1 in this way because of the differences in the data used to fit the two models.

3.3 Model 3 – Aggregate catch efficiency by length, region, and season

The set of models considered for determining our Model 3 included length effects on relative catch efficiency like Model 2, but also accounted for effects of survey season (spring, fall, or non-random site-specific stations), or region (North: Gulf of Maine and northern Georges Bank or South: southern Georges Bank , southern New England and Mid-Atlantic, Table 4). We also were interested in determining whether there were differences by depth strata (shallow and deep depth categories in Table 5), but there was insufficient information for some subsets of data to fit corresponding models. Other than including these covariates, the data used to fit this model are identical to those used to fit Model 2. Furthermore, the type of smoother used for our chosen Model 2 was also used by season, and region to fit Model 3. Ultimately, there were two models fitted. The first model included seasonal effects and the second included effects of region within season. These models were compared to each other using AIC_C to determine a final Model 3 and we also used this criterion to compare these models with those in the set from which Model 2 was chosen.

Region is essentially a proxy for bottom type with hard bottom and gravelly sand predominating in the north and sand and sandy mud predominating in the south. Season may reflect differences in net avoidance behavior affected by temperature or other factors. The PDT considered and attempted to explain the relative catch efficiencies characterized by depth, but insufficient samples to fit the data at a finer resolution than region and season.

4.0 Comparison of calibration coefficients

4.1 Statistical fit

4.1.1 Model 1 - Aggregate abundance and biomass catch efficiency by species

The results and statistical fit of Model 1 are shown in the table below and described in Miller et al (2010). The calibration coefficient estimates have small standard errors, but account for the relative catch efficiency for the size frequencies of observed skates in the spring, summer, and fall 2008 calibration studies. Note again that these estimates do not account for differences in swept areas of the two vessels. As such they are not directly comparable to the relative catch efficiencies for Models 2 and 3.

Table 1. Calibration coefficients for seven skate species captured during NEFSC bottom trawl surveys.

Species	Calibration Coefficient (Std Err)	Comment
Little *Leucoraja erinacea*	2.785519 (0.32)	Spring Survey
Winter *Leucoraja ocellata*	2.174334 (0.31)	Fall Survey
Barndoor *Dipturus laevis*	3.661128 (0.51)	Fall Survey
Thorny *Amblyraja radiate*	3.626359 (0.58)	Fall Survey
Smooth *Malacoraja senta*	4.449518 (0.67)	Fall Survey
Clearnose *Raja eglanteria*	6.189401 (0.81)	Fall Survey
Rosette *Leucoraja garmani*	8.813973 (0.98)	Based on the calibration coefficient for little skate in the fall survey comparisons

4.1.2 Model 2 - Aggregate species size based catch efficiency

Before we pooled fish of lengths greater than 94 cm, we fit the same models to the unpooled data. Using these data, the best fit model, as measured by AIC_c , was an orthogonal polynomial (represented by the black smoothed line in the figure below) with 10 parameters to describe the smooth length effects and no length effects on the dispersion parameter (Table 2). Like other species, particularly flat fish, the relative catch efficiency of skates (any species) varies by length. Using either a spline smoother or orthogonal polynomial model, the relative catch efficiency is substantially higher at lengths below 40 cm and also at lengths greater than 94 cm (Figure 1). At small size (i.e. below 40 cm) the skate catches are composed of mainly little skate. Examining the results, the Skate PDT felt that this model fit the data best, particularly at small size, but that the larger skates (i.e. > 94 cm) could be pooled to reduce the effect of large variance on the smoother.

When skates greater than 94 cm were pooled however, the spline smoother with 6.8 estimated effected parameters to describe the length effects on the relative catch efficiency and 8.8 total parameters fit best with respect to AIC_c (rank 1 in Table 3). However, the performance of the best fit model was only marginally better than three other models where orthogonal polynomials were assumed. The models where the form of the beta-binomial dispersion parameter is based on a gamma assumption on the mean catches made by each vessel performed very poorly compared to other models and are not considered further.

Figure 1. Estimated relative catch efficiency (top) and dispersion parameter (bottom) from the best beta-binomial model where relative catch efficiency is modeled as a a penalized thin-plate regression spline (solid red line) or orthogonal polynomial (solid black line) smoother of length and from separate models fit to data in each length class (gray points). Dotted lines and vertical gray lines represent respective approximate 95% confidence intervals. Horizontal gray line in top plots represents equal efficiency of the *Henry B. Bigelow* and *Albatross IV*.

0 20 40 60 80 100 120

Rank	Model Type	# ρ pars	# ϕ Length pars	ϕ Covariates	LL	# parameters	AIC_c	$\Delta(AIC_c)$
1								
2	OP	10	2	SF	-7536.3	13	15098.64	1.33
3	OP	11	1	SF	-7536.39	13	15098.82	1.51
4	OP	10	1	SF,SA	-7536.51	13	15099.05	1.74
5								
6	OP	9	1	SF	-7538.97	11	15099.97	2.66
7	OP	11	2	SF	-7536.07	14	15100.18	2.87
8	OP	10	4	SF	-7535.15	15	15100.35	3.04
9	OP	10	2	SF, SA	-7536.15	14	15100.35	3.04
10	OP	10	3	SF	-7536.17	14	15100.39	3.08

Table 3. Model 2 – size based catch efficiency with pooled lengths > 94 cm: Model type (thin-plate regression spline, SP, orthogonal polynomial, OP), numbers relative catch efficiency, dispersion, and total degrees of freedom, dispersion covariates, and log-likelihood for the 10 best performing models based on AIC_C.

Rank	Model Type	# ρ parameters	# ϕ length parameters	ϕ Covariates	# Total parameters	-LL	AIC_c	$\Delta(AIC_c)$
1	SP	6.80	1	SF	8.80	-7522.98	15063.58	0
2	OP	9	1	SF	11	-7520.85	15063.73	0.15
3	OP	10	1	SF	12	-7520.35	15064.74	1.16
4	OP	9	2	SF	12	-7520.49	15065.01	1.43
5	SP	6.54	10.24	SF	16.78	-7515.75	15065.14	1.56
6	SP	6.81	1	SF, SA	9.81	-7522.88	15065.42	1.84
7	OP	9	1	SF, SA	12	-7520.76	15065.56	1.98
8	OP	10	2	SF	13	-7520.00	15066.04	2.46
9	OP	9	7	SF	17	-7516.00	15066.07	2.49
10	OP	11	1	SF	13	-7520.24	15066.51	2.93

4.1.3 Model 3 - Aggregate catch efficiency by length, region, and season

Allowing the smoother of length to differ by season and region provided the best overall fit with regard to AICc (Table 6). Although the model including seasonal effects only performed much better than Model 2 with an AICc approximately 170 units lower, the model that also included regional effects resulted in a further reduction in AICc of more than 83 units. Examining Figure 3, there appear to be important trends in relative catch efficiency at length, particularly by season. This may reflect the relative availability of species in the spring and fall surveys, particularly little skate. The differences are less by region (north/south), but may still be important.

In the fall calibration survey, the relative catch efficiency of small skates (< 50 cm) is considerably higher than larger skates, implying that the FSV Bigelow catches a greater proportion of little skates than the FSV Albatross. This result is consistent with expectations, because the FSV Albatross trawl uses cookies (possibly allowing small skates to avoid capture, passing under the trawl) whereas the FSV Bigelow trawl does not. For larger skates, the estimated relative catch efficiency is about 3 to 4 in the north region and about 4 to 5 in the south, with a slight increase in relative catch efficiency for pooled skate lengths greater than 94 cm (mean weighted size 107 cm).

In the spring, the smoother through the relative catch efficiency at length is flatter than it is in the fall. In the north, the relative catch efficiency varies from 2 to 7 and in the south, the relative catch efficiency varies between 5 and 15, with a modest increase in relative catch efficiency for small skates. This result in the spring also comports with expectations, because little skate are caught less frequently in the north and in the spring.

Table 4. NEFSC survey strata in north and south regions used in length-based calibration analyses.

North	South
01190-01300	01010-01180
01330-01400	01610-01760
01351	03010-03460
03560	07510-07520
03590-03610	08500-08510
03640-03660	

Table 5. NEFSC survey strata in shallow and deep depth areas we were to consider in length-based calibration analyses.

Shallow	Deep
01010-01020	01030-01040
01050-01060	01070-01080
01090-01100	01110-01120
01130	01140-01150
01160	01170-01180
01190-01210	01220
01230	01240
01250-01260	01270-01300
01330	01340
01390-01400	01351
01610-01620	01360-01380
01650-01660	01630-01640
01690-17000	01670-01680
01730-01740	01710-01720
07510-07520	01750-01760
08500	08510

Table 6. Model type (thin-plate regression spline, SP, orthogonal polynomial, OP), numbers relative catch efficiency, dispersion, and total degrees of freedom, dispersion covariates, and log-likelihood for best performing models based on AIC_C. Model results ranked 1 and 2 are the Model 3 results with the indicated covariates.

Rank	Model Type	# ρ df	# φ length parameters	φ Covariates	# Total parameters	-LL	AIC_c	$\Delta(AIC_c)$
1	SP(Season,Region)	37.02	5	SF	46.02	-7359.32	14811.18	0.00
2	SP(Season)	15.56	4	SF	23.56	-7423.64	14894.53	83.36
3	SP	6.80	1	SF	8.80	-7522.98	15063.58	252.40
4	OP	9	1	SF	11	-7520.85	15063.73	252.55
5	OP	10	1	SF	12	-7520.35	15064.74	253.57
6	OP	9	2	SF	12	-7520.49	15065.01	253.83
7	SP	6.54	10.24	SF	16.78	-7515.75	15065.14	253.96
8	SP	6.81	1	SF, SA	9.81	-7522.88	15065.42	254.24
9	OP	9	1	SF, SA	12	-7520.76	15065.56	254.38
10	OP	10	2	SF	13	-7520.00	15066.04	254.87
11	OP	9	7	SF	17	-7516.00	15066.07	254.90
12	OP	11	1	SF	13	-7520.24	15066.51	255.34

Figure 2. Randomized quantile residuals of the best performing model (as measured by AICc, see Table 1) for Acadian redfish in relation to the predicted number captured by the *Henry B. Bigelow* (left), the total number of fish captured at a station (middle), and their normal quantiles (right).

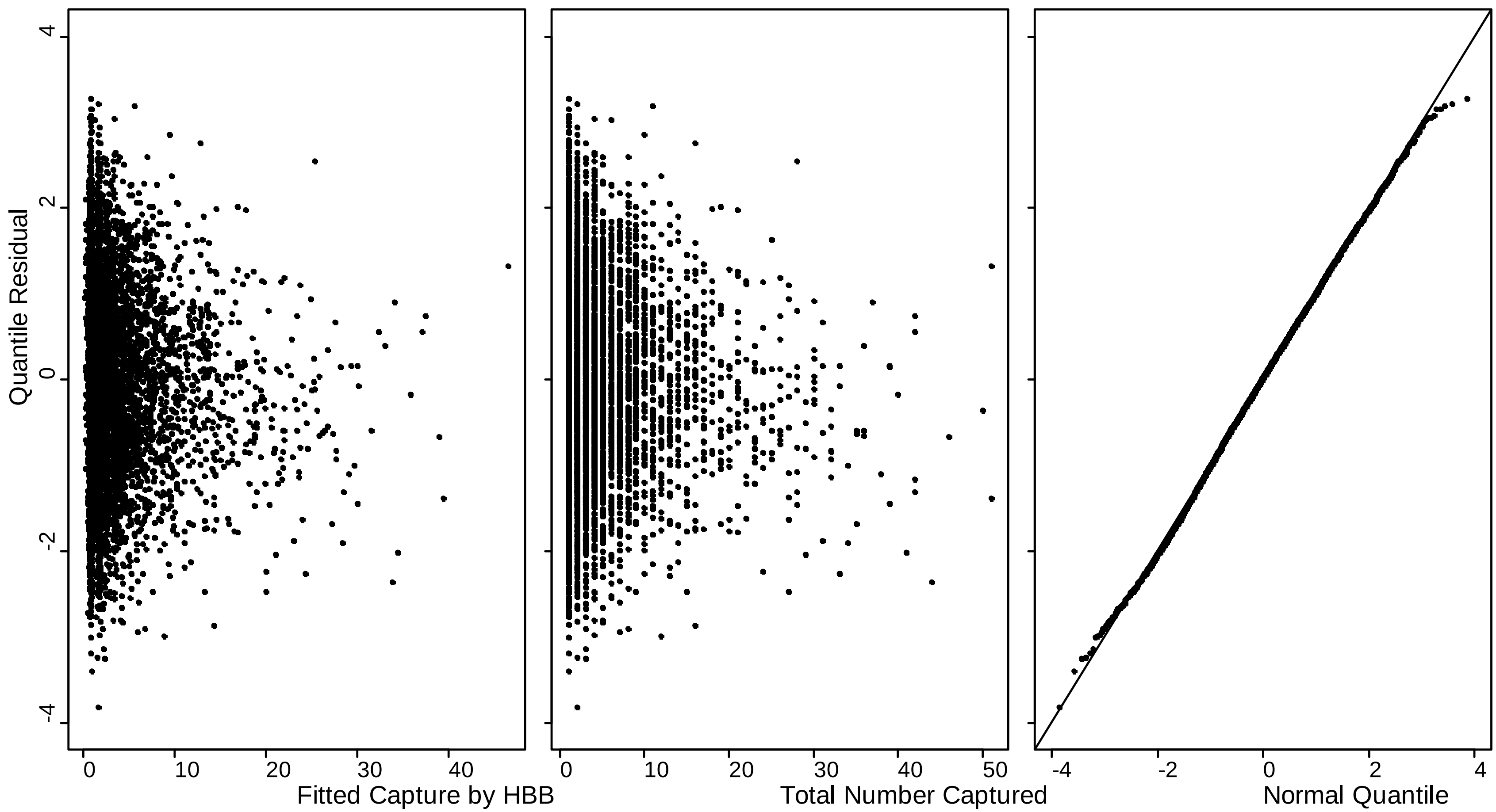
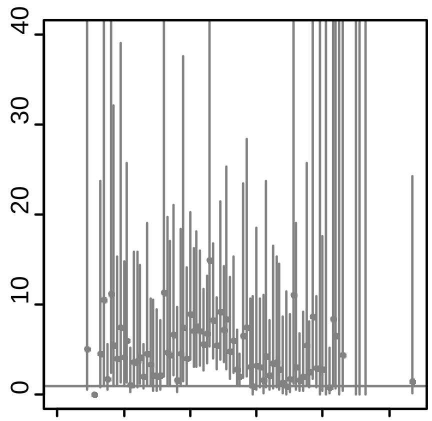


Figure 3. Estimated relative catch efficiency (top) and dispersion parameter (bottom) by season and region (columns) from the best beta-binomial model where relative catch efficiency is modeled as a a penalized thin-plate regression spline smoother of length (solid red line) and from separate models fit to data in each length class (gray points). Dotted red lines and vertical gray lines represent approximate 95% confidence intervals. Horizontal gray line in top plots represents equal efficiency of the *Henry B. Bigelow* and *Albatross IV*.



Appendix

Letting the full set of calibration factor parameters be θ (which depends on the above models used), the beta-binomial likelihood we maximized is

$$L(\theta,\phi)=\prod_{i=1}^{S}\prod_{j=1}^{M}\frac{\text{Beta}\left(a_j+N_{Bij},b_j+N_{Aij}\right)}{\text{Beta}\left(a_j,b_j\right)}\binom{N_{Aij}+N_{Bij}}{N_{Bij}}$$

where $\text{Beta}()$ is the beta function, and N_{Aij} and N_{Bij} are the numbers caught at station i in length class j by the Albatross IV and Bigelow, respectively. The likelihood is parameterized with parameters a and b which are functions of the calibration factor and dispersion parameter ϕ,

$$a_j=\pi\left(l_j\mid\theta\right)\phi\left(l_j\mid\theta\right)$$

and

$$b_j=\left[1-\pi\left(l_j\mid\theta\right)\right]\phi\left(l_j\mid\theta\right).$$

4.2 Advantages and disadvantages of evaluated models

Although the statistical fit to the data for Models 2 and 3 can be compared (see Section 4.1), there are also some important distinctions that may favor one approach over the other as a reliable indicator of stock status and standing biomass. The PDT has listed these important advantages and disadvantages along with important caveats or notes in the table below, for the SSC's consideration.

It is important to note that the three models are listed in increasing complexity (and number of estimated parameters). And even accounting for a penalty to fit more parameters, Model 3 (fitted by length, region, and season) produces the best statistical results, but may be tempered by the qualitative considerations listed below. How well or poorly the calibrated data fit trends in other surveys (see Section 4.4) may also be an important consideration for which model should be chosen to set ABC and determine status.

Table 7. Qualitative attributes of three skate calibration models.

Model 1 – Aggregate abundance and biomass by species		
Advantages	**Disadvantages**	**Caveats or notes**
Species specific, accounts for species specific behavior	Does not account for length, seasonal, or spatial differences in catchability or behavior (net avoidance, etc.)	Species identification of skates < 35 cm may not be appropriately applied to species indices – no species adjustments in calibration data/analysis
Easier to apply than more complicate models	Would not appropriately account for changes in future length frequency	May be a practical model because it is simpler. More complex models may only produce a marginal improvement.
Requires less parameter estimates	Rosette skate requires use of a proxy (using little skate), due	Cannot statistically compare the quality of the fit for Model 1 vs.

	to low sample size (7 positive/positive tows Kathy to check???)	Models 2 and 3
Uses all of the calibration data, including site specific stations for some species (little and winter calibration coefficient models are seasonal)		
Model 2 – Aggregate species abundance by length		
Advantages	**Disadvantages**	**Caveats or notes**
Accounts for behavioral/catchability differences at length, which may be more important that differences among similar skate species of similar lengths.	Does not implicitly account for potential differences in b/c differences among skate species.	Species specific differences may be partially taken into account by relative species composition at length (e.g. little and rosette skates are little, barndoor skates are big)
Uses all of the calibration data, including site specific stations	Does not account for regional or seasonal differences that may be related to bottom type, temperature, or other factors	
Moderately easy to apply	Requires use of length/weight equation for biomass estimates and therefore introduces additional uncertainty	Requires conversion to non integer values of abundance at specific lengths
Would handle changes in future length frequency (i.e. strong and weak year classes) more appropriately than Model 1		
Model 3 – Aggregate species abundance by length, region, and season		
Advantages	**Disadvantages**	**Caveats or notes**
Statistically (lowest AIC), the Model 3 fits the data better than Model 2.	Potential for more pooling or assumptions about the relative catchability of sizes that were not observed in the calibrations in a particular season and region.	Species specific differences may be partially taken into account by relative species composition at length (e.g. little and rosette skates are little, barndoor skates are big) and area (e.g. thorny and smooth skate are in the Gulf of Maine, while clearnose and rosette are in the Mid-Atlantic)
Accounts for behavioral/catchability differences at length, which may be more important that differences among similar skate species of similar lengths.	Does not implicitly account for potential differences in b/c differences among skate species	Requires conversion to non integer values of abundance at specific lengths
Also accounts for regional and seasonal differences, which may	Does not use site specific stations, because they were	

be related to bottom type, temperature, or other factors	conducted during the summer and cannot be applied appropriately to the spring and fall	
Would handle changes in future length frequency (i.e. strong and weak year classes) more appropriately than Model 1	Requires use of length/weight equation for biomass estimates and therefore introduces additional uncertainty	
	More difficult to apply	

4.3 Internal validation with calibration survey data

Another method for examining the best model performance is to compare the 2008 Albatross survey index to a comparable Bigelow survey index using the calibration data as regular survey data. The results should be close, since the calibration factors were derived from these data. The model that is closest to the Albatross value should be the model of choice. The 2008 Bigelow stratified mean number per tow at length for Models 2 and 3SR (and an intermediate model incorporating just seasonal effects-Model 3S) and mean weight per tow for Model 1 were calculated and then the calibration coefficients were applied to the appropriate region/season. To calculate biomass for models 2, 3S and 3SR, the length-weight coefficients by species and season (when available) from Wigley et al. 2003 were applied to the number per tow at length.

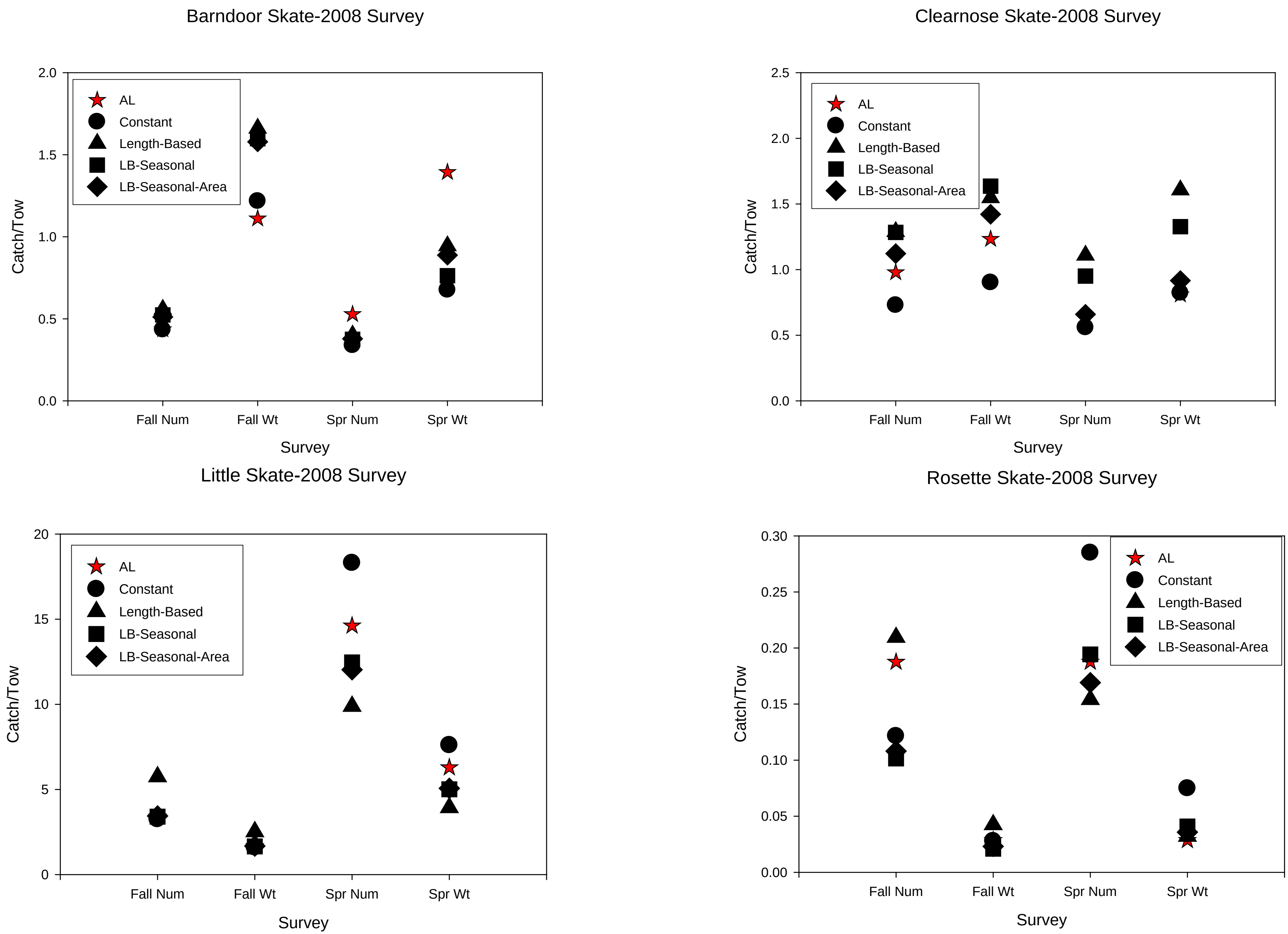
For winter skate, Model 1 indices were the closest to the Albatross 2008 values for the fall survey while the spring survey was more variable (Table 8, Figure 4). All models underestimated the fall indices while the spring was overestimated. For little skate, all models incorporating season as a covariate performed well (Table 8, Figure 4) although for spring biomass, Model 1 was slightly closer to the Albatross value than Models 3S and 3SR. The Model 1 results for barndoor skate were closer to the actual value for the fall survey weight, but the other models fit better for spring and fall number (Table 8 and Figure 4). Results for thorny skate are more ambiguous, with Model 3S performing better than the others for fall weight and number, while Model 3SR was better for spring weight and spring number. Model 3S and 3SR generally matched the smooth skate indices better than the other models, except for spring number, when none of the models performed well. The fall survey indices for clearnose skate were underestimated by Model 1 while Models 2, 3S and 3SR overestimated both number and weight. However, Model 3SR performed the best out of the four models (Table 8 and Figure 4). The spring survey numbers were also closer using Model 3SR while weight was better using Model 1. The rosette skate abundance indices are more variable than the weight, and the best model varies among the four indices (Table xx, Figure xx).

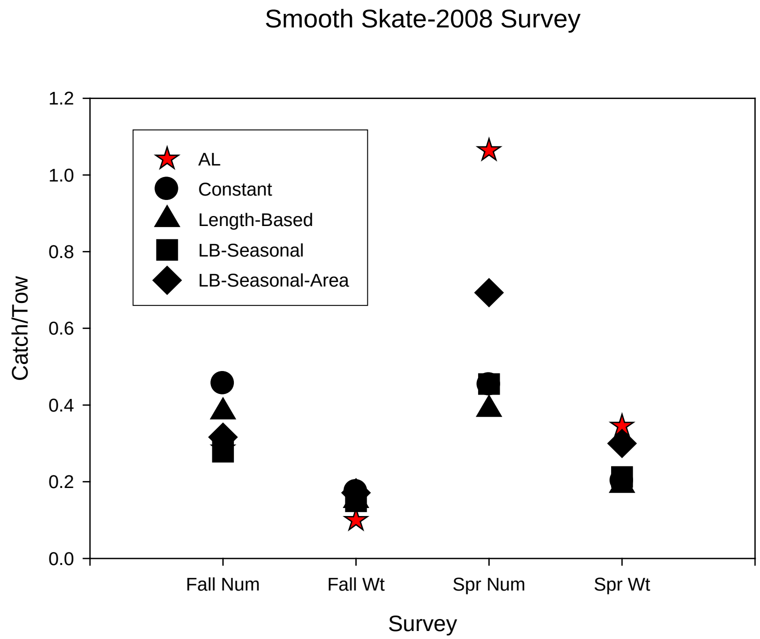
Figure 5shows the length composition from the Albatross 2008 survey and compares the Bigelow survey with no calibration, as well as the four models. For barndoor skate, the constant calibration model appears to match the Albatross data better than any of the length-based methods. Any of the length-based models seem to perform better for clearnose and little skate than the constant. For rosette, smooth and thorny, the number of fish in the Albatross length frequency makes a comparison difficult. For winter skate, none of the models really matches the Albatross length composition. All models underestimate the numbers at length from 60-85cm. The length-based models underestimate the numbers at length from 35-50 cm, while the Model 1overestimates those numbers. All the models are good for the over 85 cm size group which is a small portion of the calibration survey catches and the abundance of skates in general.

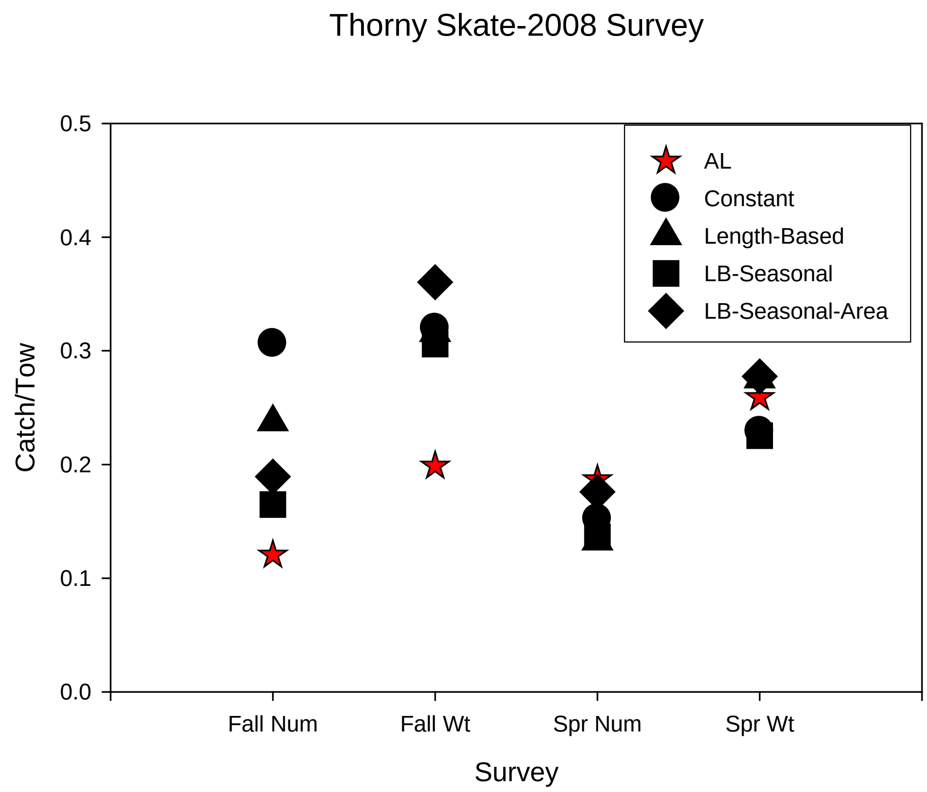
Table 8. Indices of abundance and biomass from the 2008 fall and spring surveys from the Albatross survey (AL) and the Bigelow survey (HBB) calibrated using four different models.

	AL	HBB	Model 1	Model 2	Model 3S	Model 3SR
Fall Number						
winter	3.399	8.088	3.100	2.353	2.354	2.387
little	3.390	32.043	3.254	5.749	3.405	3.442
barndoor	0.435	1.926	0.434	0.557	0.524	0.511
thorny	0.121	1.162	0.307	0.237	0.165	0.189
smooth	0.286	2.000	0.456	0.382	0.278	0.316
clearnose	0.978	4.877	0.729	1.289	1.283	1.122
rosette	0.188	1.196	0.121	0.210	0.101	0.108
Fall Weight						
winter	9.623	18.648	8.576	6.090	6.688	6.761
little	1.661	14.092	1.599	2.520	1.653	1.679
barndoor	1.111	4.458	1.218	1.661	1.597	1.578
thorny	0.199	1.160	0.320	0.316	0.306	0.360
smooth	0.100	0.775	0.174	0.151	0.149	0.171
clearnose	1.233	5.582	0.902	1.547	1.635	1.421
rosette	0.029	0.246	0.028	0.042	0.021	0.023
Spring Number						
winter	1.868	13.820	3.616	3.491	3.380	3.380
little	14.616	56.364	18.300	9.883	12.462	12.034
barndoor	0.528	1.502	0.338	0.400	0.375	0.378
thorny	0.187	0.577	0.152	0.132	0.136	0.176
smooth	1.064	1.987	0.453	0.389	0.455	0.693
clearnose	0.634	3.738	0.559	1.109	0.950	0.659
rosette	0.188	0.878	0.285	0.154	0.194	0.169
Spring Weight						
winter	3.037	19.942	5.363	6.617	5.461	5.483
little	6.291	21.170	7.600	3.934	5.011	5.067
barndoor	1.393	2.475	0.676	0.944	0.763	0.888
thorny	0.259	0.831	0.229	0.275	0.225	0.278
smooth	0.345	0.900	0.202	0.191	0.212	0.300
clearnose	0.809	5.089	0.822	1.606	1.327	0.916
rosette	0.029	0.209	0.075	0.032	0.041	0.036

Figure 4. Comparison of converted FSV Bigelow catches to FSV Albatross units on 2008 calibration surveys.




Smooth Skate-2008 Survey
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Catch/Tow
AL
Constant
Length-Based
LB-Seasonal
LB-Seasonal-Area
Fall Num
Fall Wt
Spr Num
Spr Wt
Survey


Thorny Skate-2008 Survey
0.5
0.4
0.3
0.2
0.1
0.0
Catch/Tow
AL
Constant
Length-Based
LB-Seasonal
LB-Seasonal-Area
Fall Num
Fall Wt
Spr Num
Spr Wt
Survey

Winter Skate-2008 Survey

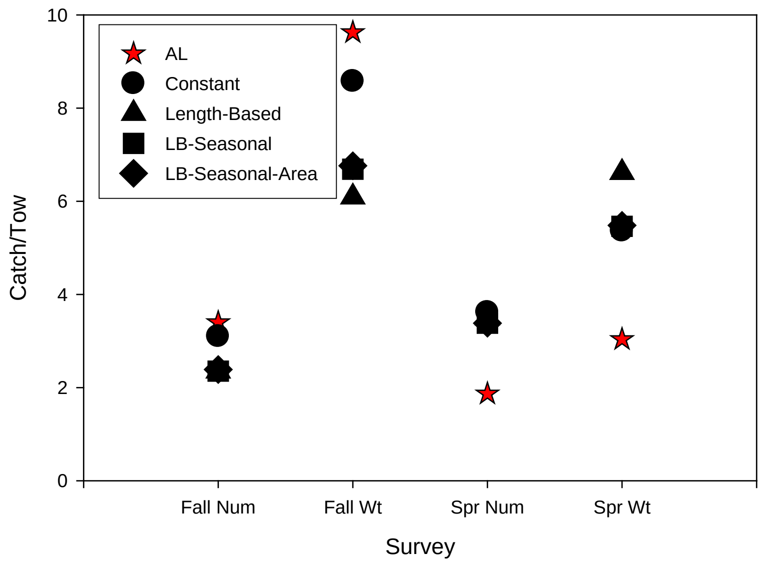
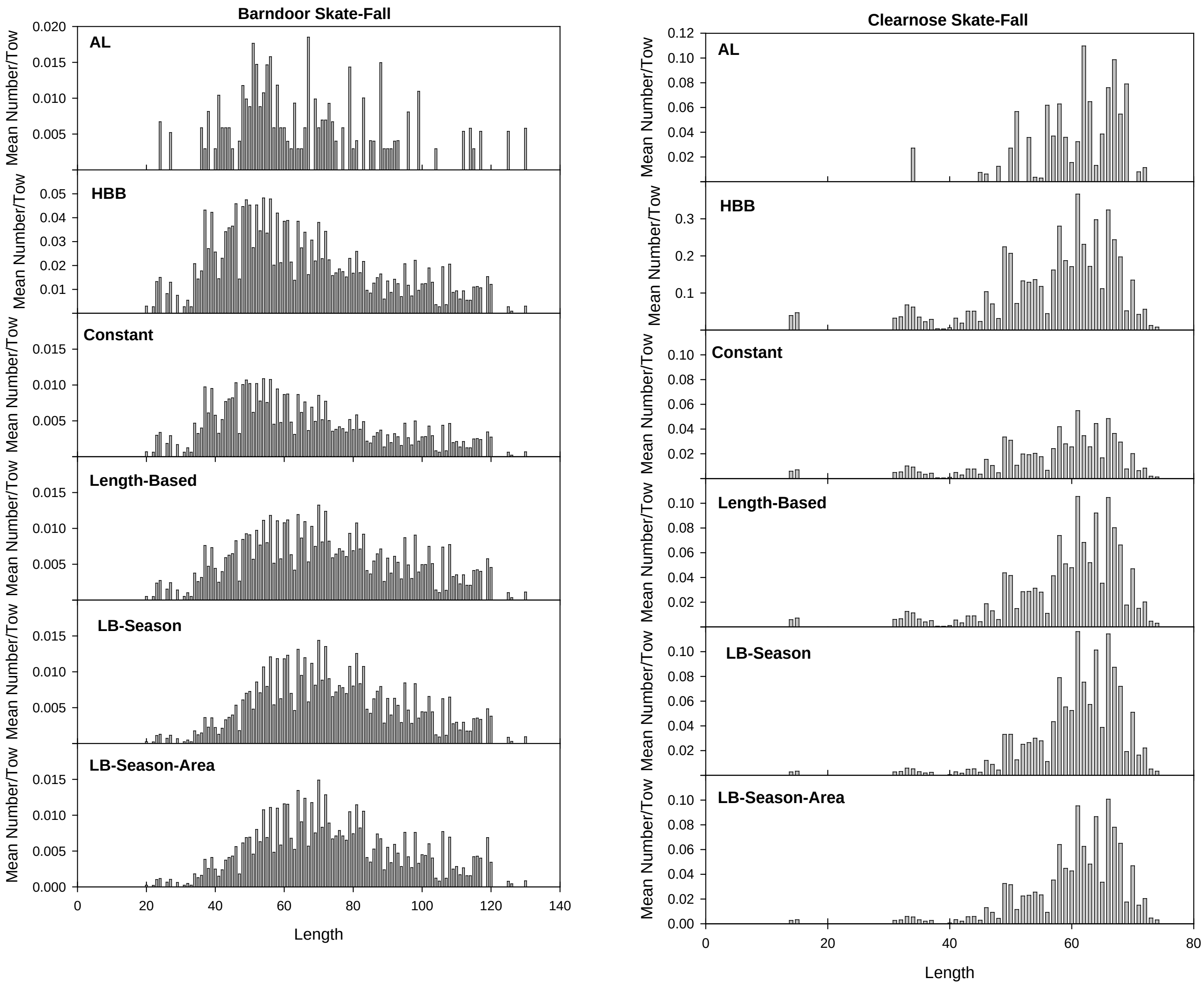
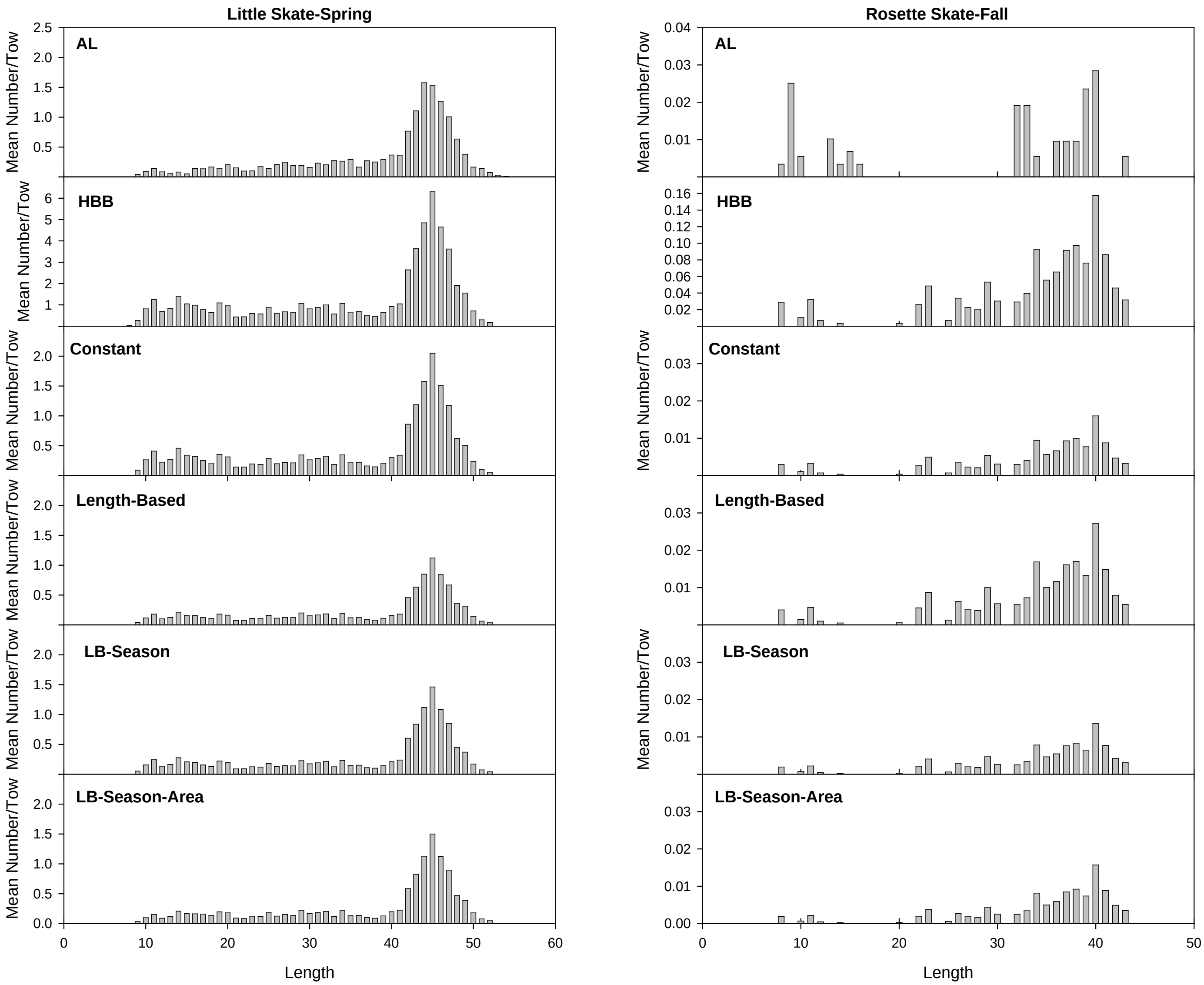
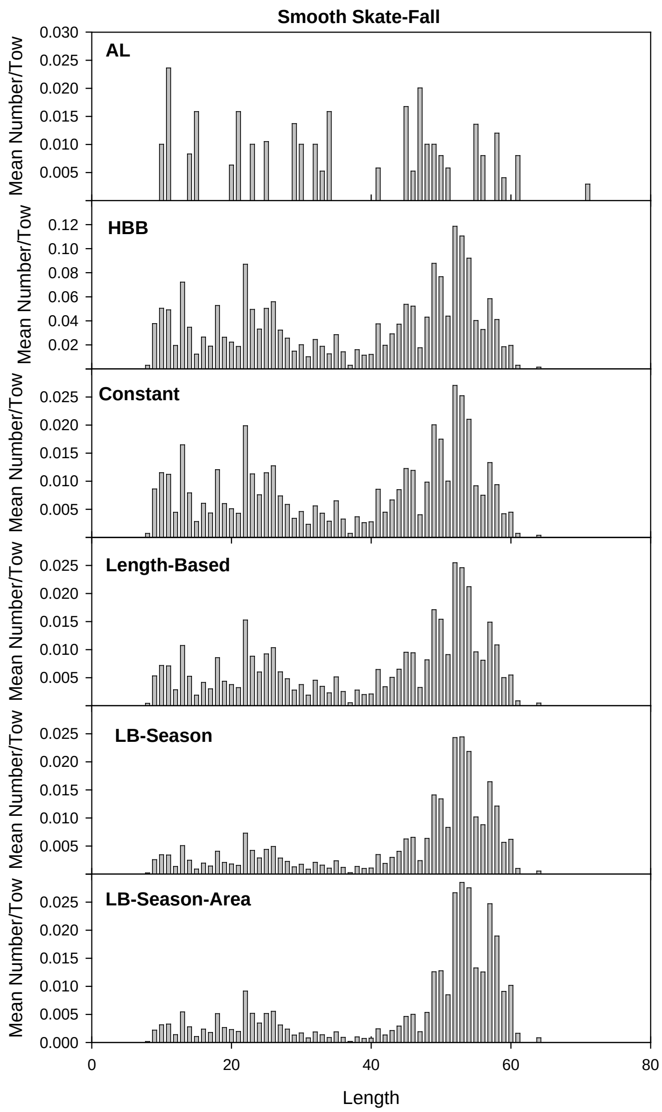
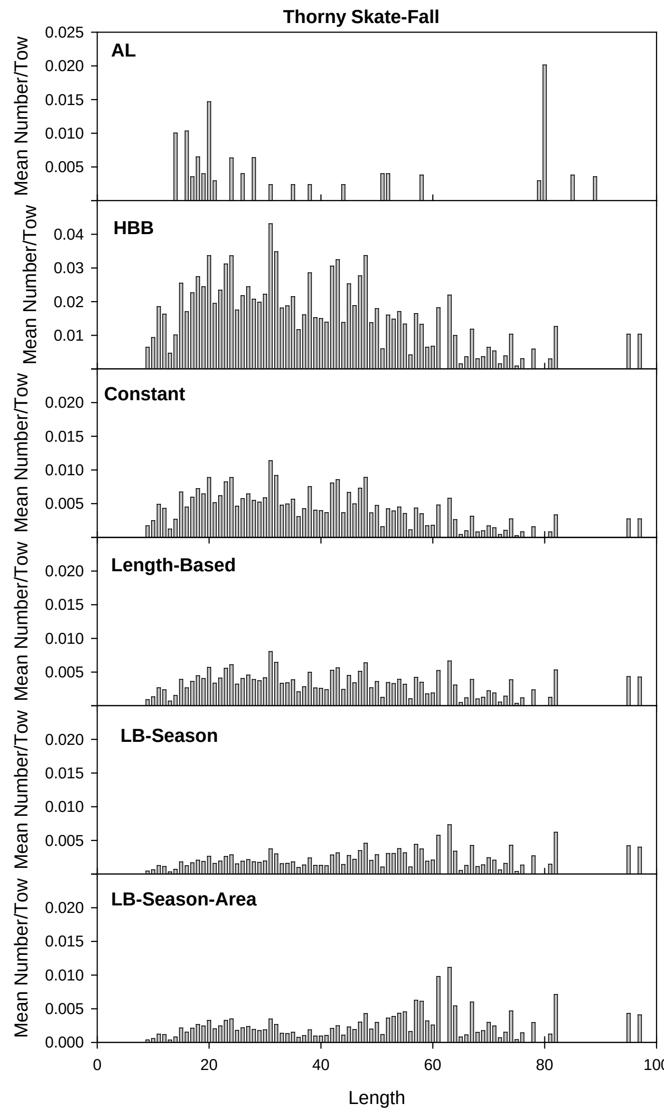


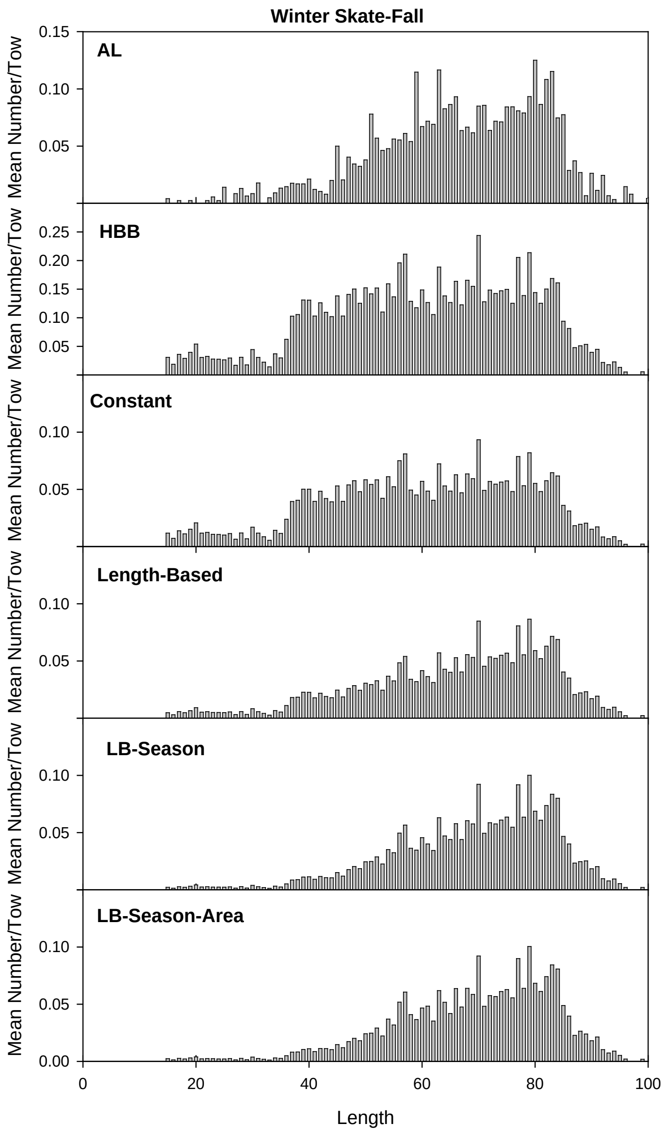
Figure 5.Comparison of 2008 calibration survey and calibrated FSV Bigelow length frequencies.




Little Skate-Spring
Rosette Skate-Fall
AL
HBB
Constant
Length-Based
LB-Season
LB-Season-Area
Mean Number/Tow
Length


Smooth Skate-Fall
AL
HBB
Constant
Length-Based
LB-Season
LB-Season-Area
Mean Number/Tow
Length


Thorny Skate-Fall
AL
HBB
Constant
Length-Based
LB-Season
LB-Season-Area
Mean Number/Tow
Length



4.4 External validation using alternative surveys

Another important factor in judging which model performs best is comparing its performance against external data from other surveys which catch adequate amounts of skates and partially overlap or immediately join adjacent strata in the spring and fall FSV Albatross/Bigelow trawl survey. It is not as important that the values are of the same magnitude as the spring and fall survey, but that the converted FSV Bigelow indices are in a similar range of previous values. Ideally, the comparison is best when there is a high correlation between the comparable survey and the NMFS trawl survey, but this is not necessary. Even though there may be a small or no correlation, data calibrated with one of the three models which fall out of the usual range of the previous time series could be considered to be less meaningful and may point to errors. Some of the differences may relate to the unique characteristics of the comparison, e.g. important mismatches in the chosen survey strata, differences in seasons when the surveys occur (e.g. comparing the summer shrimp survey with the spring and fall trawl survey), changes in the survey timing (e.g. changing the scallop dredge survey from July/August to May/June in 2009), addition of rock chains on the dredge, and possibly species identification (i.e. some surveys may not identify species the same way as the method employed on the NMFS trawl survey).

Except for the NEAMap and SMAST indices of abundance and biomass (only abundance is available for the SMAST survey because the skate lengths have not been measured and species identification is difficult), stratified mean indices of abundance were calculated by the usual means using standard software maintained by the NEFSC. The 2009 and 2010 stratified mean number per tow at length for Models 2 and 3 and mean weight per tow for Model 1 were calculated and then the calibration coefficients were applied to the appropriate region/season/length. For Model 3, the two vecors were then multiplied by the area covered, added together and the divided by the total area covered by both regions. To calculate biomass for models 2, 2a and 3, the length-weight coefficients by species and season (when available) from Wigley et al. 2003 were applied to the number per tow at length. The mean abundance and biomass indices and their CVs for the NEAMap survey were provided by Chris Bonzek at the Virginia Institute of Marine Science. Similarly, the mean indices of abundance and their CVs for the SMAST camera survey were obtained from MacDonald (2010). For spring and fall data through 2008 and all other data, the 95% confidence interval on the mean estimate were computed via the usual method.

The table below provides a summary of species indexed by other surveys and comparable strata in the spring and fall NMFS trawl surveys.

Table 9. Surveys and species used to compare stratified mean abundance and biomass between surveys and the NMFS spring and fall trawl survey.

ASMFC Shrimp trawl (summer)	1990-2010	Smooth Thorny	04010,04030, 04050-04080	01270,01280, 01370,01380
MA DMF (spring, fall)	1979-2010	Little Thorny Winter	09110-09360	03460-03560, 03590-03660
Scallop (summer dredge) & SMAST	1985-1998, 2000-2010	Barndoor (fall) Clearnose Little Rosette Smooth Thorny Winter (fall)	06060-06070, 06100-06110, 06140-06150, 06170-06190, 06210-06310, 06490-06550, 06580-06600	01010, 01020, 01130, 01230, 01250, 01660, 01690, 01700, 01730, 01740
NEAMAP	2007-2010	Clearnose Little Winter	Provided by Chris Bonzek	03020, 03050, 03080, 03110, 03140, 03170, 03200, 03230, 03260, 03290, 03320, 03350, 03380, 03410, 03440-03450

4.4.1 Shrimp survey (smooth and thorny skates)

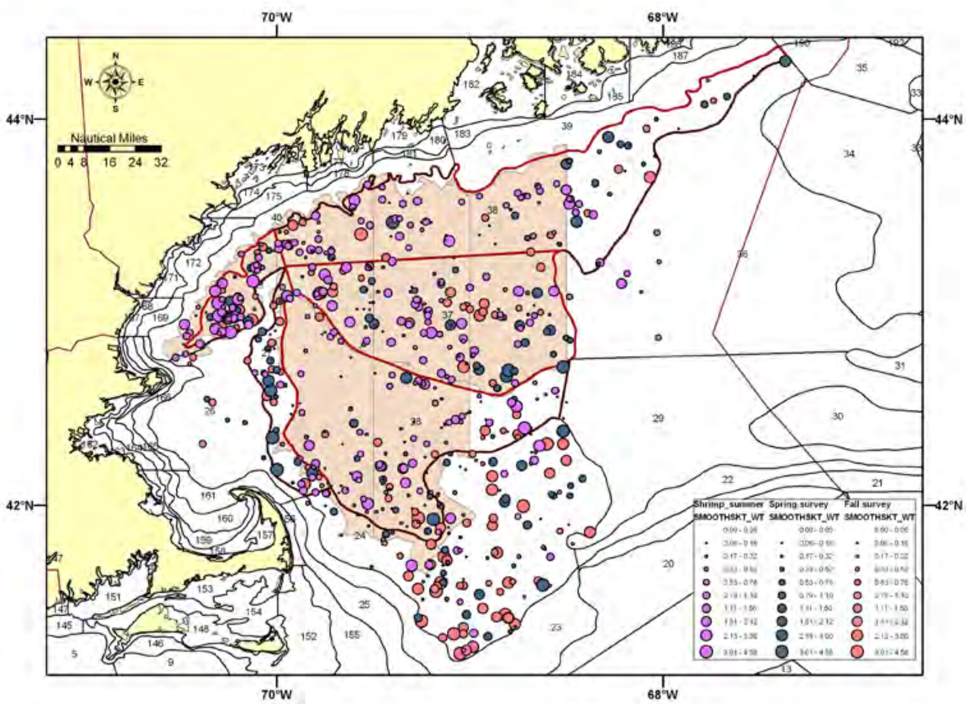
These comparable surveys include the NMFS shrimp survey conducted in the Gulf of Maine, which catches sufficient numbers of smooth and thorny skates. The shrimp survey started measuring finfish in 1985, but not consistently for skates until 1990. Maps of shrimp, fall, and spring survey catches for smooth and thorny skate are shown in Map 1 to Map 2, including the outlines of the shrimp trawl and the spring/fall trawl survey strata used in the comparison. Only smooth and thorny skate are caught in adequate numbers by the Gulf of Maine summer shrimp trawl survey to be useful for comparison.

Certain strata were omitted in the comparison because of inconsistent sampling in the time series. This inconsistency caused the PDT to omit spring and fall stratum 24 and 26, for example. Stratum 24 while having significant catches of smooth and thorny skates in the spring and fall survey has a significant overlap with shrimp survey stratum 412, which is not consistently sampled from year to year. The same holds true for spring and fall stratum 26, which overlaps inconsistently sampled shrimp stratum 402 and 404. On the other hand, spring and fall stratum 27 half overlaps consistently sampled shrimp stratum 401. So in the final choices, the stratum that were compared with the shrimp survey overlapped shrimp strata that were consistently sampled and excluded those that were not (which could result in a mis-leading time series for years when the shrimp strata were not sampled).

The shrimp trawl survey stratified mean abundance and biomass for smooth and thorny skate were compared with similarly computed stratified mean indices from the NMFS spring and fall trawl surveys for the selected strata. The relationships between the annual indices are shown in Figure 6 and Figure 7.

- Calibrated smooth skate abundance and biomass indices are within range of previous NMFS trawl survey data when the shrimp trawl indices were in a similar range as observed 2009 and 2010. Calibration by all three models give plausible results.
- Length based smooth skate abundance calibrations give the highest values in the spring, but in the fall the seasonal and regional (area) model gives the highest values.
- Thorny skate calibrations give values that appear to be somewhat low compared with trawl survey values when the shrimp trawl indices for thorny skate were in similar ranges. This could be related to a movement into deeper water in the more recent surveys.

Map 1. Selected survey strata for the summer shrimp trawl survey (shaded) and the spring/fall bottom trawl survey (red outline) showing catches of smooth skate (kg/tow) from 1990 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 2. Selected survey strata for the <u>summer shrimp trawl survey</u> (shaded) and the spring/fall bottom trawl survey (red outline) showing catches of <u>thorny skate</u> (kg/tow) from 1990 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.

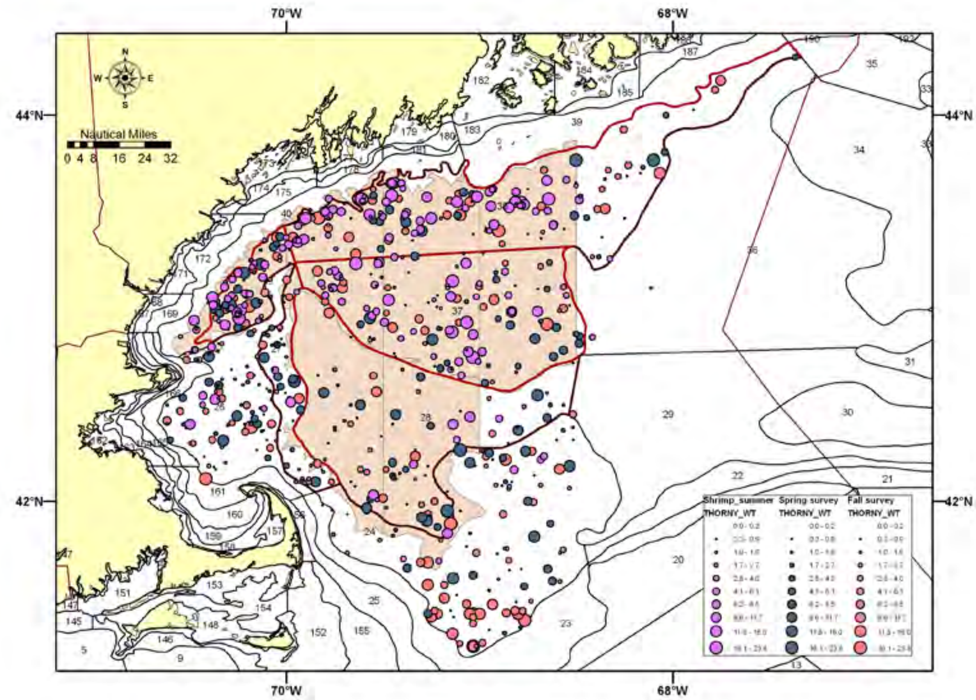


Figure 6. Smooth skate for shrimp survey strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.

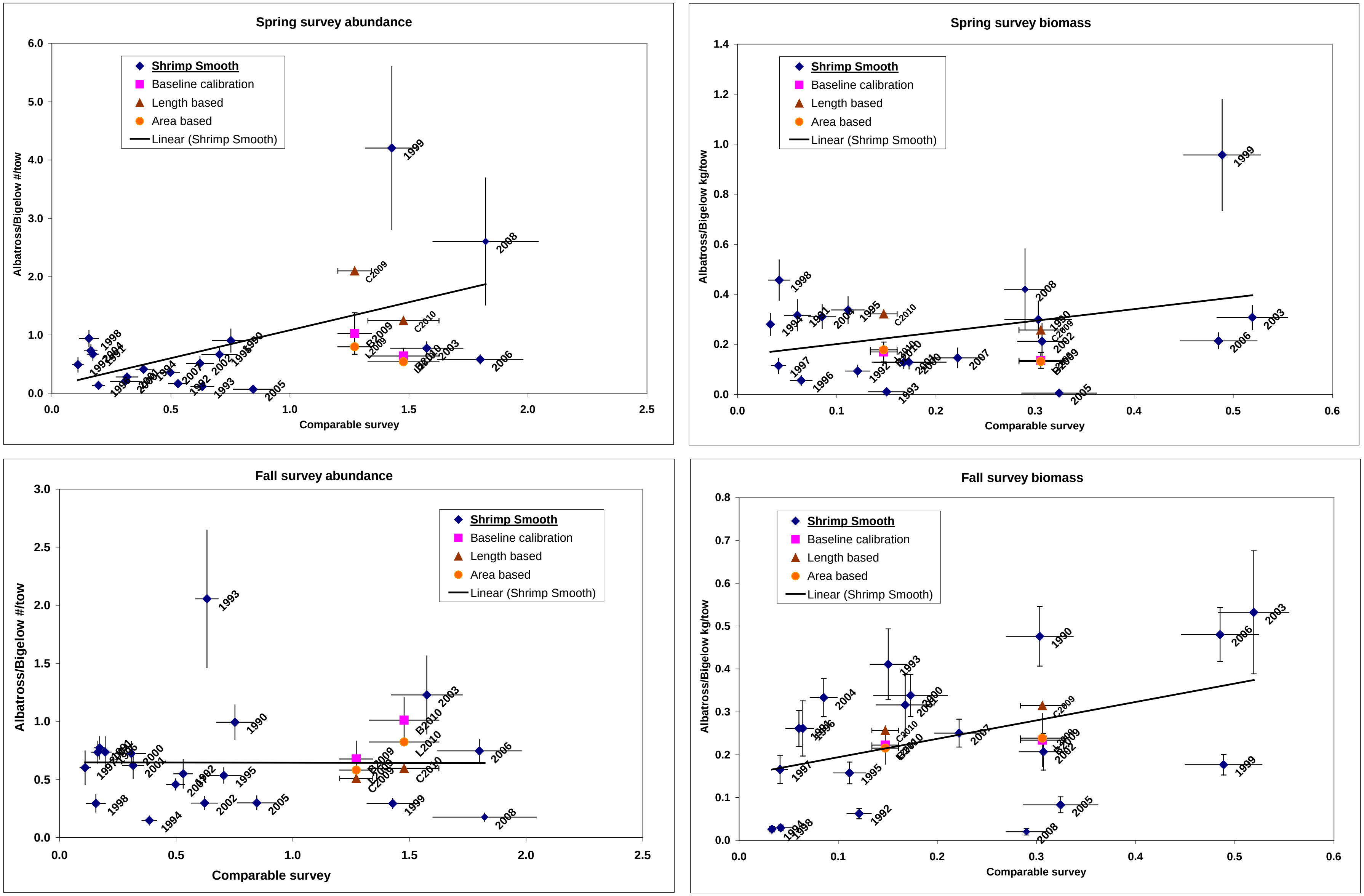
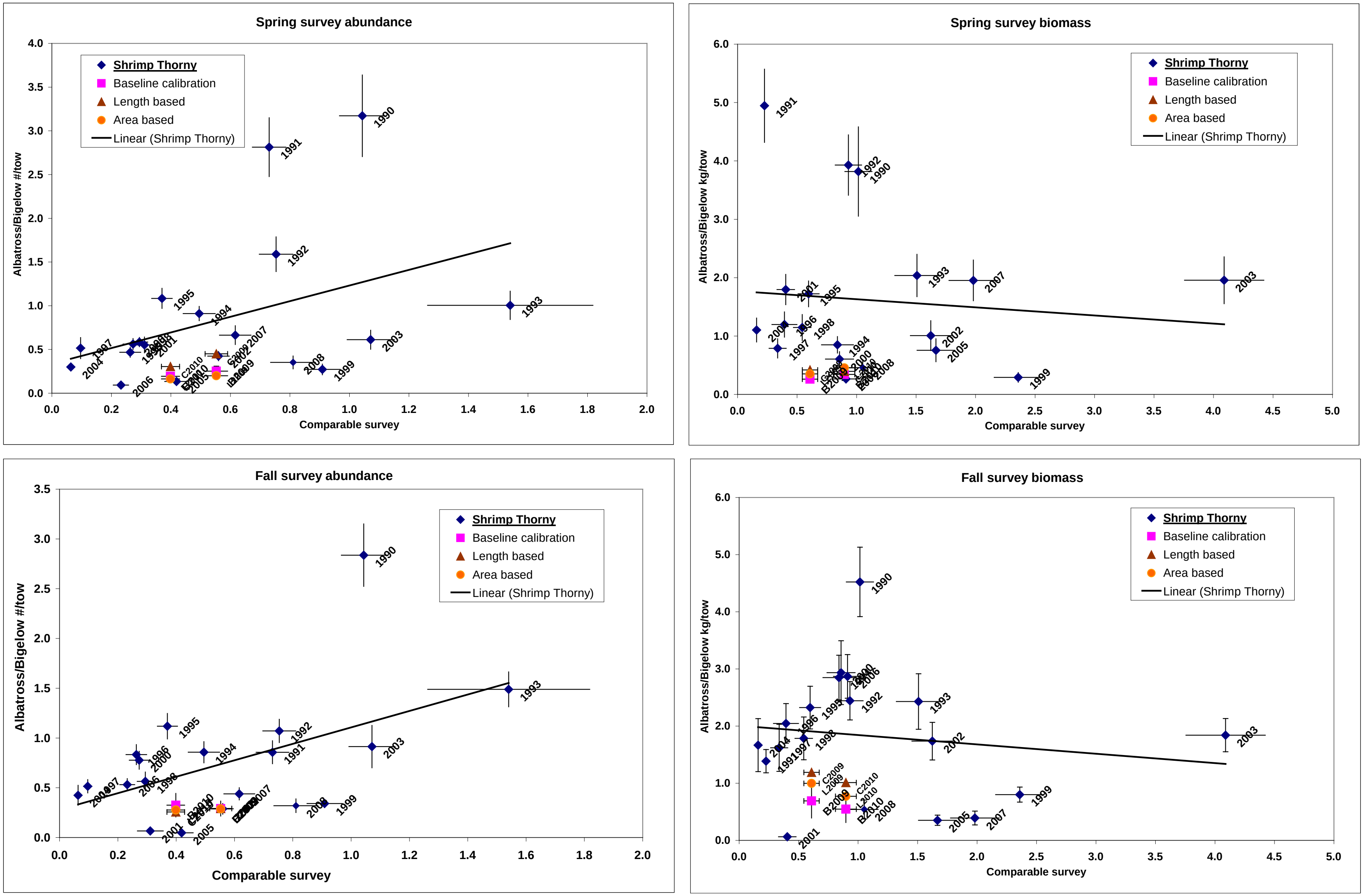


Figure 7. Thorny skate for scallop shrimp strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.



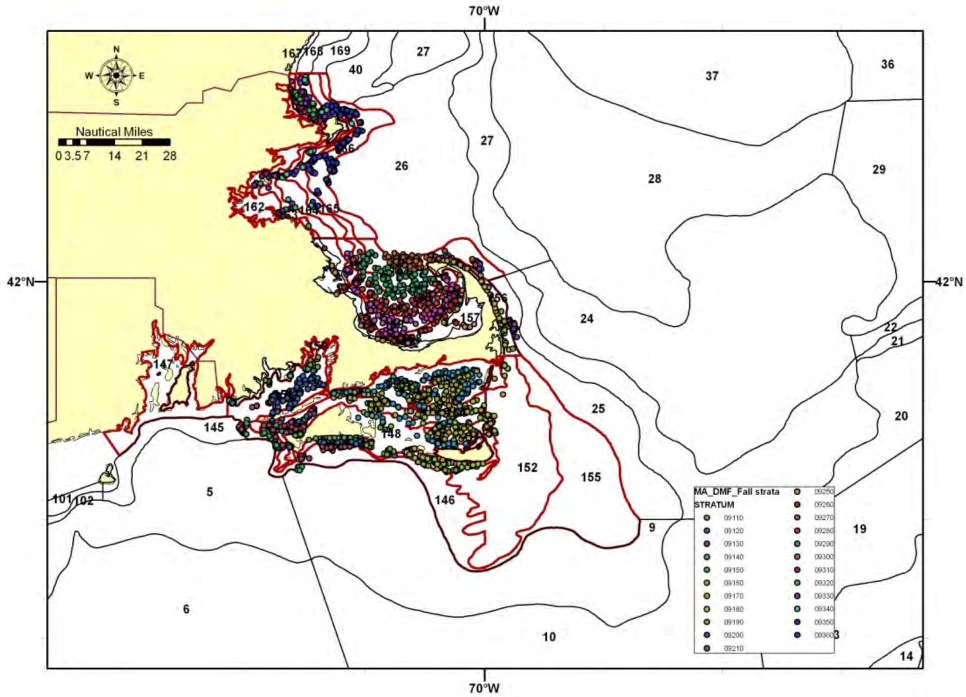
4.4.2 MA DMF spring and fall trawl survey (little, thorny, and winter skates)

The MA DMF spring and fall trawl survey began in 1978, but the inshore strata for the spring and fall north of Cape Cod were not sampled until 1979. Although there is some overlap in the NMFS inshore and the MA DMF strata north of Cape Cod (Map 3), the MA DMF sampling occurs inshore of the sampled NMFS trawl survey strata along the south shore of Cape Cod and Southern MA. Nonetheless, the PDT felt that there was sufficient relationship between the NMFS trawl inshore strata along the entire coastline of MA for comparison with the MA DMF stratified mean indices of abundance and biomass for little, thorny, and winter skates [Map 4 to Map 6 (spring); Map 7 to Map 9 (fall)].

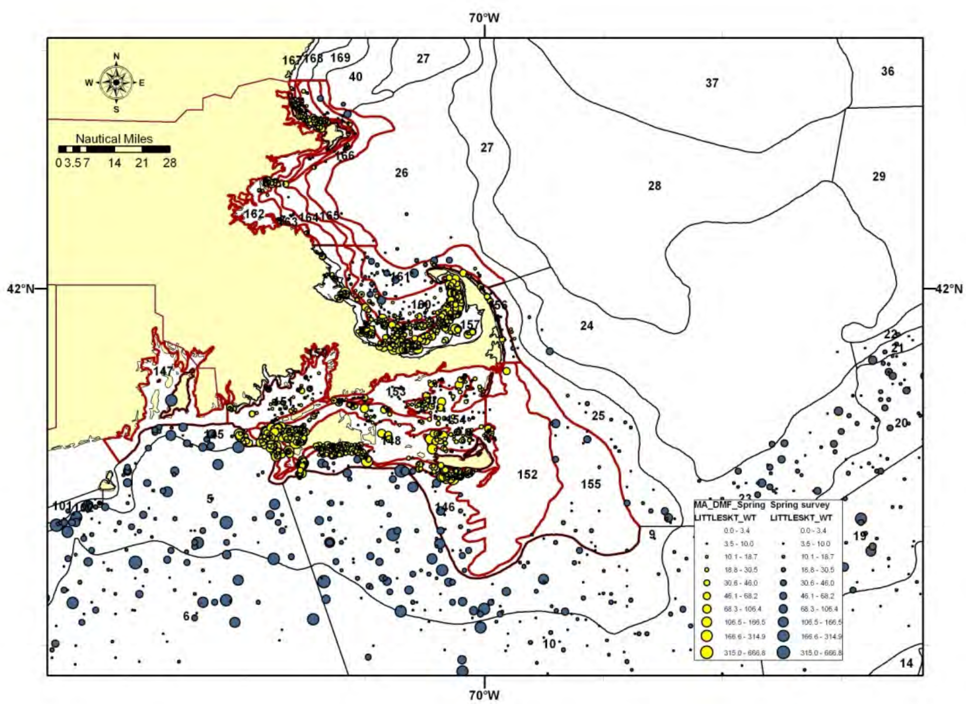
The MA DMF spring and fall trawl survey stratified mean abundance and biomass for little, thorny, and winter skates were compared with similarly computed stratified mean indices from the NMFS spring and fall trawl surveys, respectively, for the selected strata. The relationships between the annual indices are shown in Figure 8, Figure 9, and Figure 10.

- Little skate calibrations appear to give low, but plausible values when compared to similar values during the MADMF time series.
- Thorny skate calibrations appear to give high, but still plausible values in the spring and reasonable values in the fall. The differences in the spring may be related to changes in water temperature and skate distribution along the coastline. The area based calibrations appear to be more comparable to the time series in the spring.
- There does not appear to be much correlation between winter skate indices from the MA DMF trawl survey and from the NMFS trawl survey for inshore strata. The interesting feature is that while winter skate indices of abundance for the offshore strata have increased substantially and are near target values, the winter skate indices for the inshore NMFS trawl strata (except for the fall 2010 survey abundance index) and for the MA DMF surveys are in the lowest quartile for the time series. This could be a migratory, size-related recruitment, or species identification phenomenon.

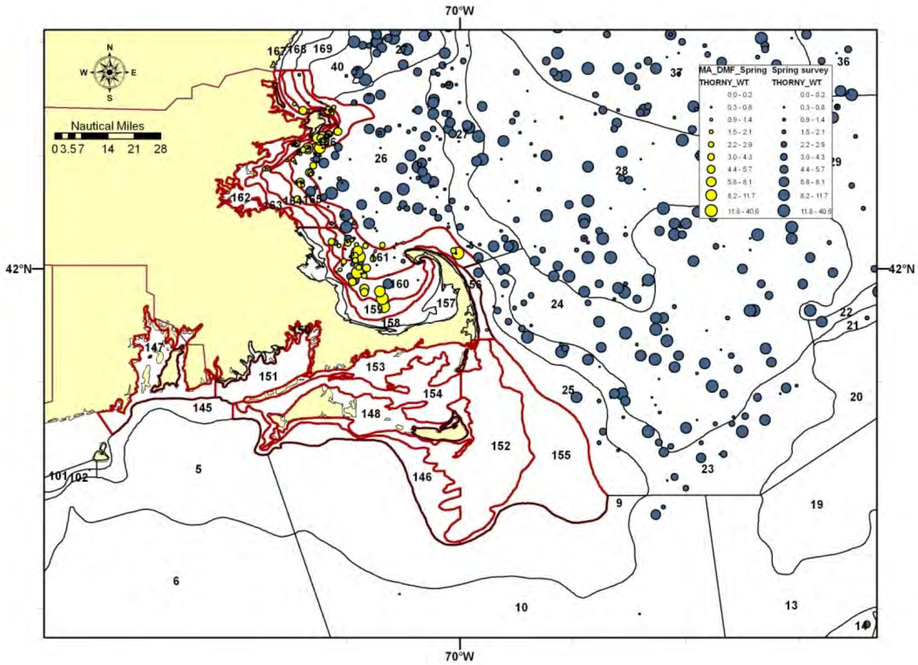
Map 3. Comparison of MA DMF fall survey stations and strata with selected inshore spring/fall bottom trawl survey used for external validation of the calibration model results.



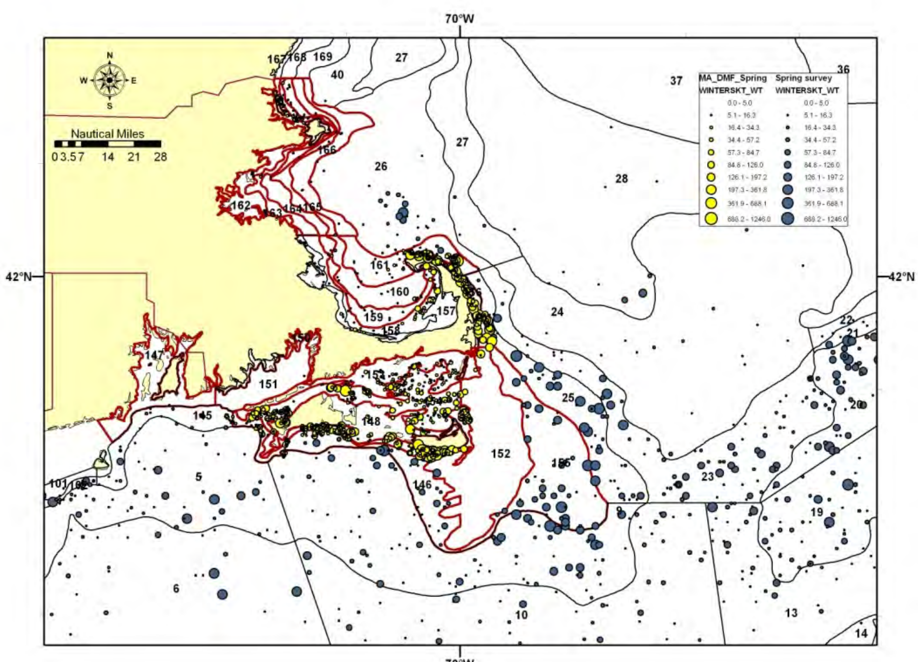
Map 4. Selected survey strata for the MA DMF spring trawl survey and the spring bottom trawl survey (red outline) showing catches of little skate (kg/tow) from 1979 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



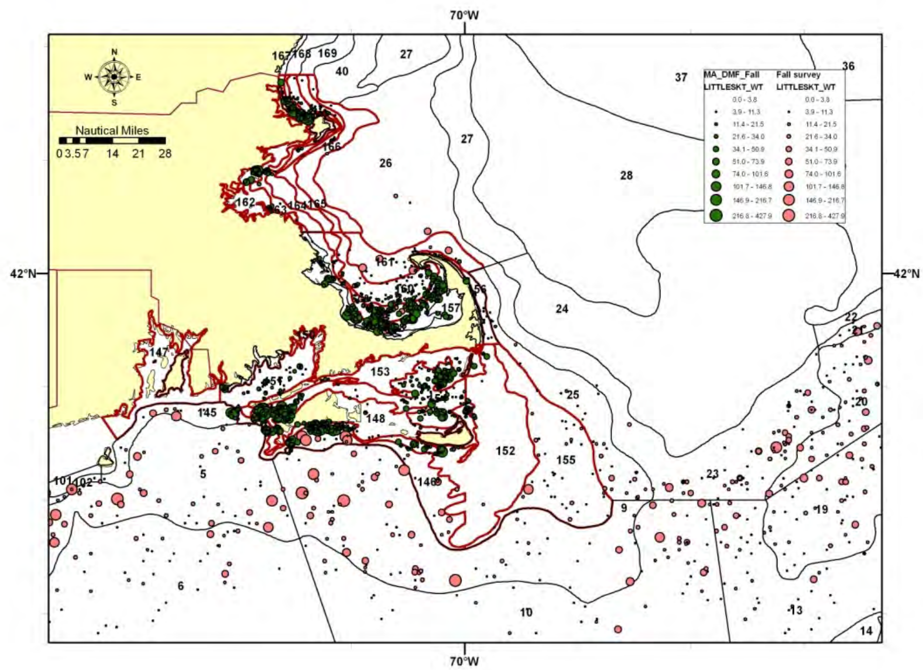
Map 5. Selected survey strata for the MA DMF spring trawl survey (shaded) and the spring bottom trawl survey (red outline) showing catches of thorny skate (kg/tow) from 1979 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



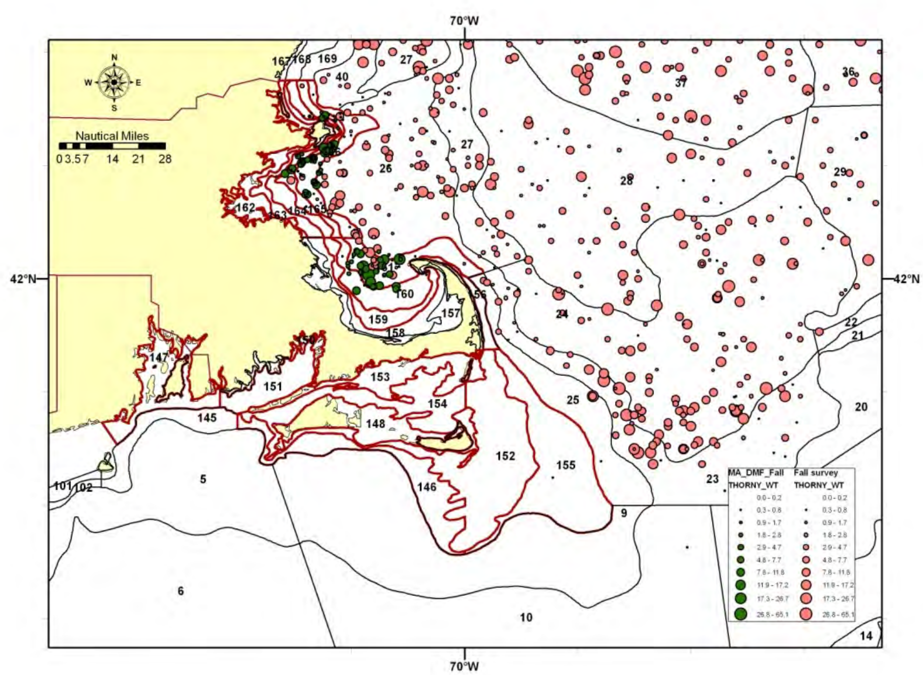
Map 6. Selected survey strata for the MA DMF spring trawl survey (shaded) and the spring bottom trawl survey (red outline) showing catches of winter skate (kg/tow) from 1979 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 7. Selected survey strata for the MA DMF fall trawl survey and the fall bottom trawl survey (red outline) showing catches of little skate (kg/tow) from 1979 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 8. Selected survey strata for the MA DMF fall trawl survey (shaded) and the fall bottom trawl survey (red outline) showing catches of thorny skate (kg/tow) from 1979 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 9. Selected survey strata for the <u>MA DMF fall trawl survey</u> (shaded) and the fall bottom trawl survey (red outline) showing catches of <u>winter skate</u> (kg/tow) from 1979 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.

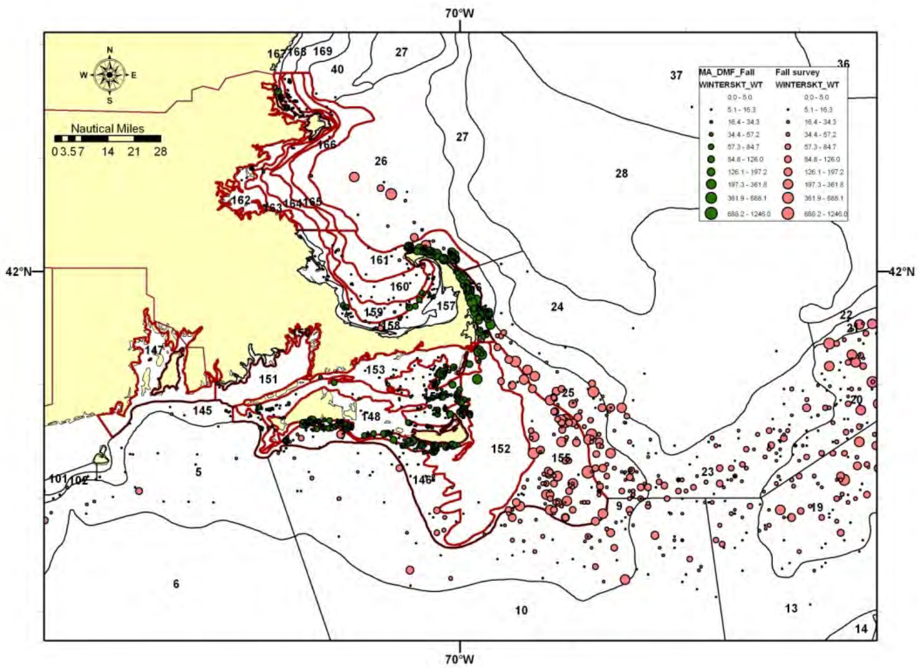


Figure 8. Little skate for MA DMF strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.

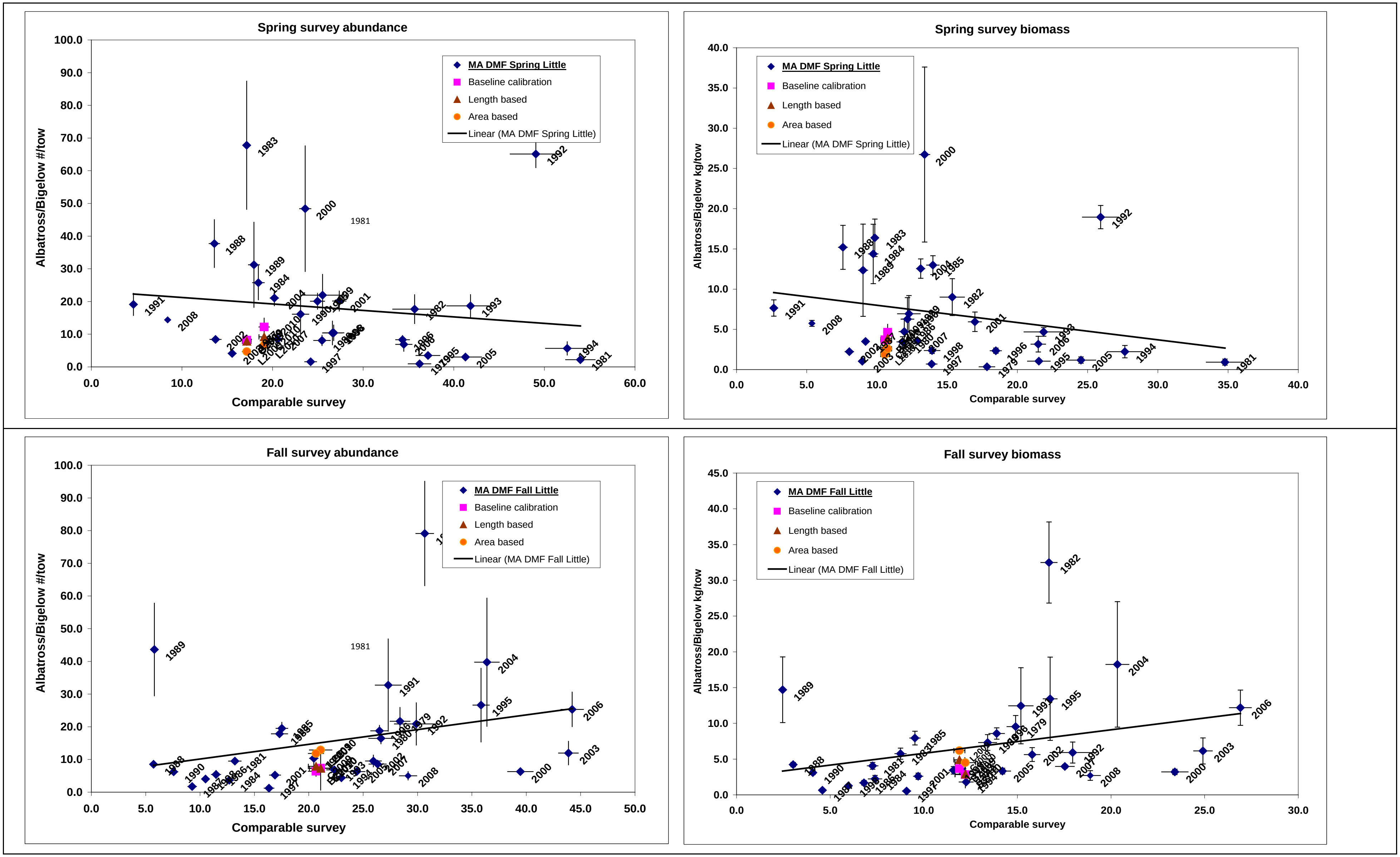


Figure 9. Thorny skate for MA DMF strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.

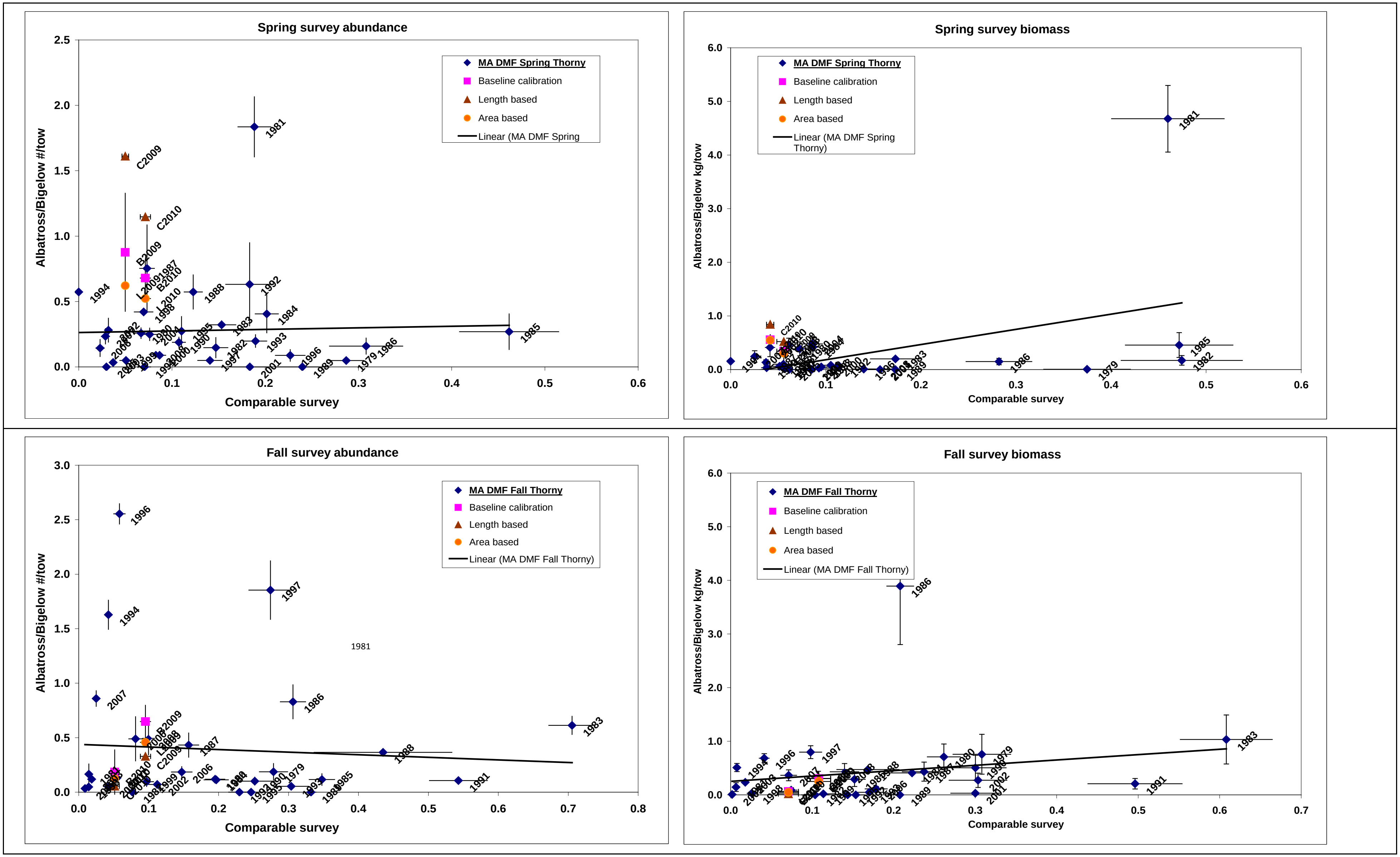
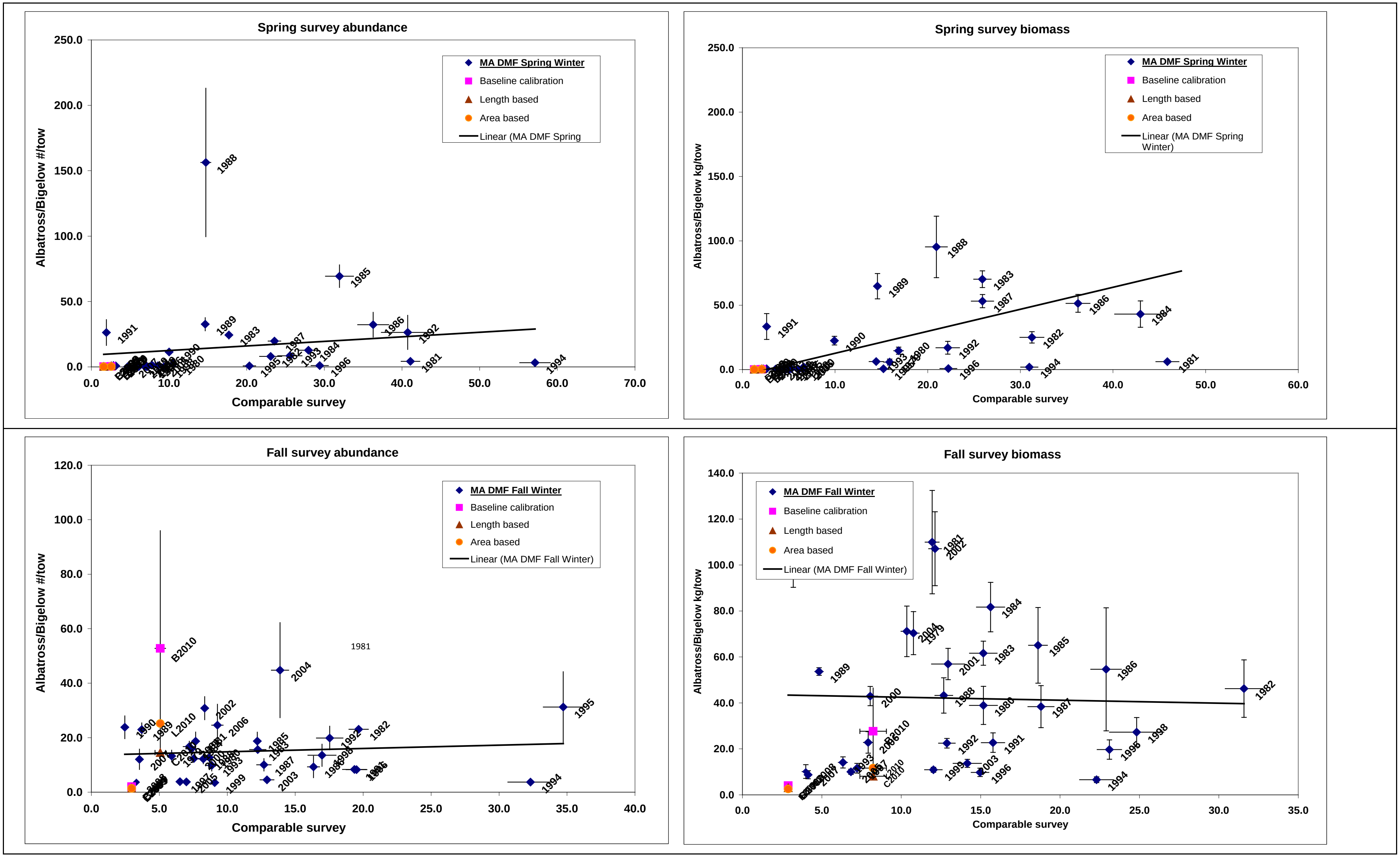


Figure 10. Winter skate for MA DMF strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.



4.4.3 Scallop dredge survey (barndoor, little, rosette, and winter skates)

The scallop dredge survey is conducted annually in the summer months, July and August through 2007 and June and July beginning in 2008 (NEFSC 2010). The summer scallop dredge survey is a coastwide stratified random survey ranging from the DelMarVa region in the south to Georges Bank in the north and east. There is a break in the sampling off Southern New England where mud bottom predominates and few scallops are found. The scallop survey catches significant numbers of barndoor, little, rosette, and winter skates. Smooth and thorny skates are also caught with adequate frequency but were not well represented in the consistently sampled strata that were chosen for this analysis. Clearnose skates are not frequently observed. There is some question about accurate identification of skate species in the scallop survey. And for this reason, the PDT deemed the scallop survey catches of clearnose, smooth, and thorny skates as not being comparable to the catches in the spring and fall trawl survey. Observed catches of these species were however included in an ANY species category, similar to the procedure applied to the SMAST survey comparison where skates are not identified by species.

In the summer scallop dredge survey, finfish were not counted in the scallop survey until 1985 and there also have been changes over time in the sampled strata. For 1985-1998, the number of fish at length were not counted and therefore only mean abundances could be calculated, but for 2000-2010, the length-weight equation could be applied to the numbers at length. The 1999 survey was conducted on the FSV Albatross IV and a commercial vessel, so the annual survey data are in two incompatible data sets and not really useful for computing mean indices of skate abundance and biomass.

Like the other survey comparisons, the PDT chose strata (see Table 9) that were consistently sampled by the scallop survey and had significant overlap with sampled strata for the spring and fall trawl survey. In the Southern New England area, there is a big hole that is no longer sampled by the scallop survey (mud) and it covers half of trawl strata 105, 106, 109, 110, trawl strata that include tows that catch significant amounts of skates but cover areas that were inconsistently sampled by the scallop dredge survey. To get a more direct comparison, these strata were not included. For this same reason, scallop survey strata 33-35, 46, and 47 were also not included. Likewise the scallop strata that overlap Canadian waters are no longer sampled. Since these scallop strata were not consistently sampled, for this purpose they were not chosen to compare with the spring and fall survey which also excluded trawl survey strata that overlap the Hague Line.

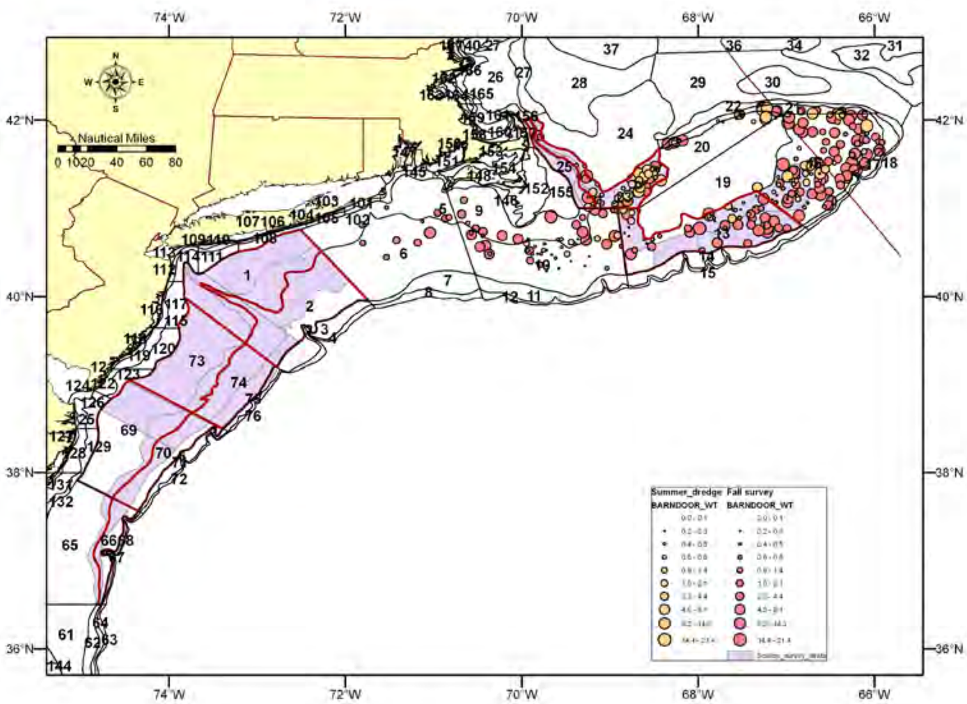
After reviewing the relative distributions of skate catches in the summer dredge survey, the PDT felt that external validation using the scallop survey would only be useful for little, rosette, and thorny skates comparing the scallop dredge catches with the spring and fall bottom trawl survey (Map 11 to Map 13), and barndoor and winter skates with only the fall bottom trawl survey (Map 10 and Map 14). Catches of clearnose and smooth skates in the scallop dredge survey were not frequent enough to provide a satisfactory comparison with the bottom trawl surveys, but were included in an ANY skate catch comparison.

The NMFS scallop dredge survey stratified mean abundance and biomass for little, thorny, and winter skates were compared with similarly computed stratified mean indices from the NMFS spring and fall trawl surveys, respectively, for the selected strata. The relationships between the annual indices are shown in Figure 11, Figure 12, Figure 13, and Figure 14.

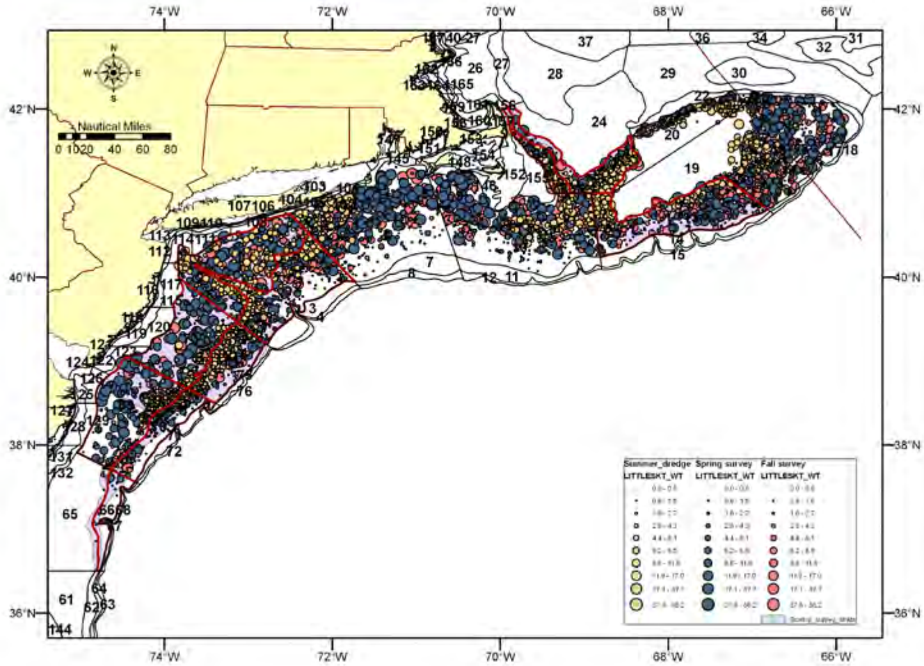
- Within the strata associated with the scallop survey, there is a relatively high correlation between the barndoor skate indices. And while the calibrations for all three models give plausible results, the calibrated 2010 data are less than the 2009 data, yet the indices on the scallop dredge survey increased nearly threefold from 2009 to 2010. Neither the spring nor the fall trawl survey calibrated indices for any model tracked this increase.

- The calibrations for the little skate abundance and biomass indices give plausible results. The aggregate (Model 1) calibration gives the highest values in the spring, but the area based calibration gives the highest values in the fall.
- For rosette skate indices, the models give plausible results but the length based and area based calibrations appear to fit the scallop survey data better. The baseline (Model 1) calibrations coefficients in this case were assumed to be equal to those estimated for little skate.
- For winter skate in strata associated with the scallop survey, the baseline (Model 1) and length based (Model 2) calibrations appear to be more consistent with the winter skate indices in the scallop survey.

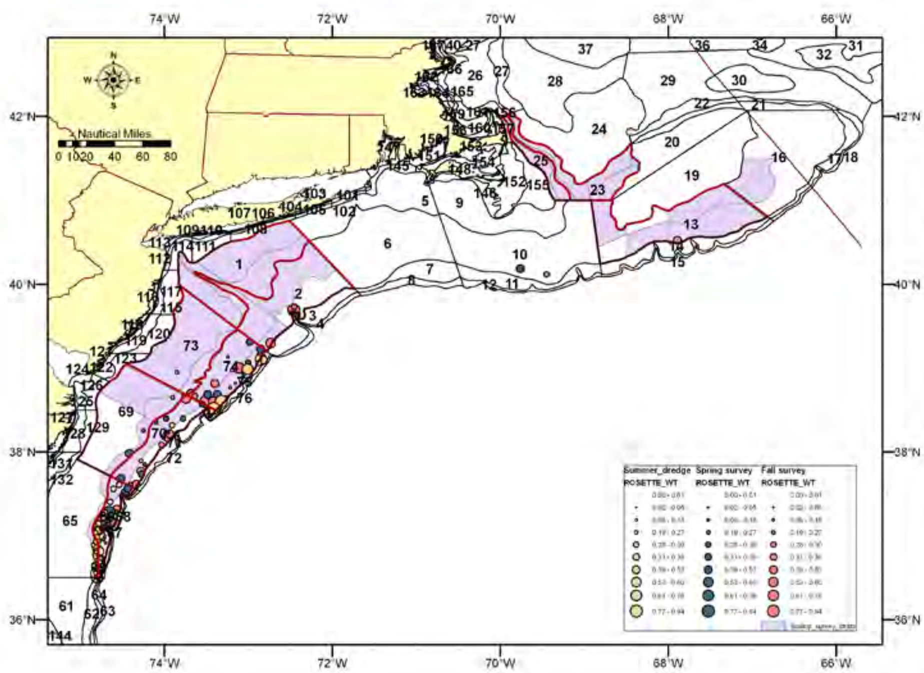
Map 10. Selected survey strata for the summer scallop dredge survey (shaded) and the fall bottom trawl survey (red outline) showing catches of barndoor skate (kg/tow) from 1985 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



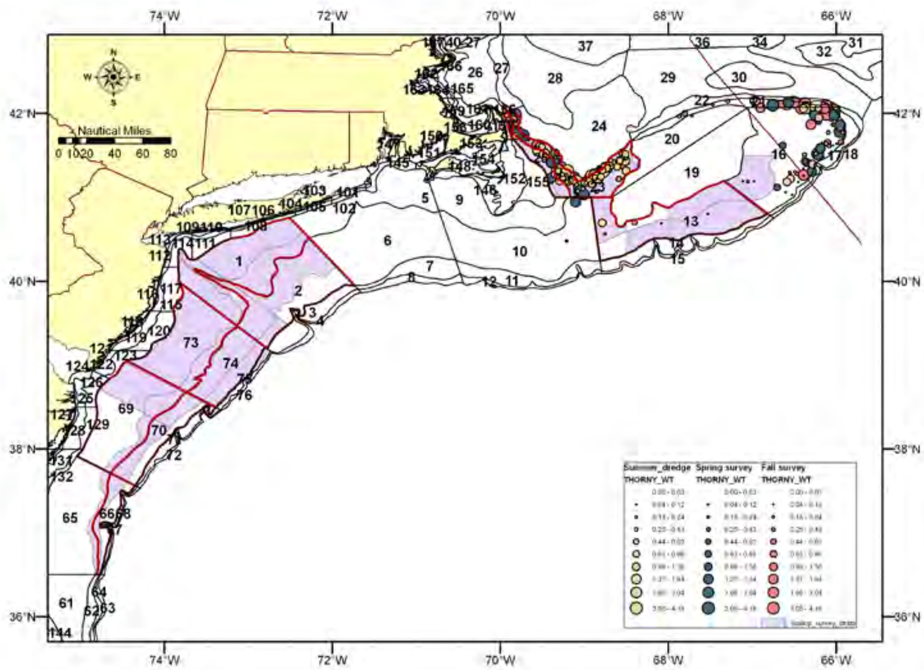
Map 11. Selected survey strata for the summer scallop dredge survey (shaded) and the spring/fall bottom trawl survey (red outline) showing catches of little skate (kg/tow) from 1985 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 12. Selected survey strata for the summer scallop dredge survey (shaded) and the spring/fall bottom trawl survey (red outline) showing catches of rosette skate (kg/tow) from 1985 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 13. Selected survey strata for the summer scallop dredge survey (shaded) and the spring/fall bottom trawl survey (red outline) showing catches of thorny skate (kg/tow) from 1985 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 14. Selected survey strata for the summer scallop dredge survey (shaded) and the fall bottom trawl survey (red outline) showing catches of winter skate (kg/tow) from 1985 to 2009. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.

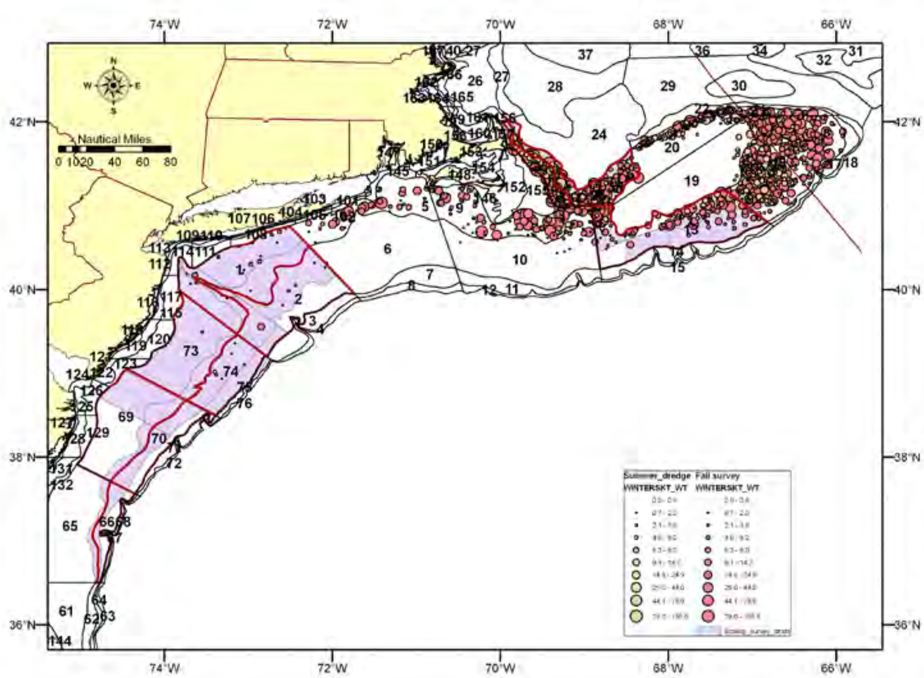


Figure 11. Barndoor skate for scallop survey strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.

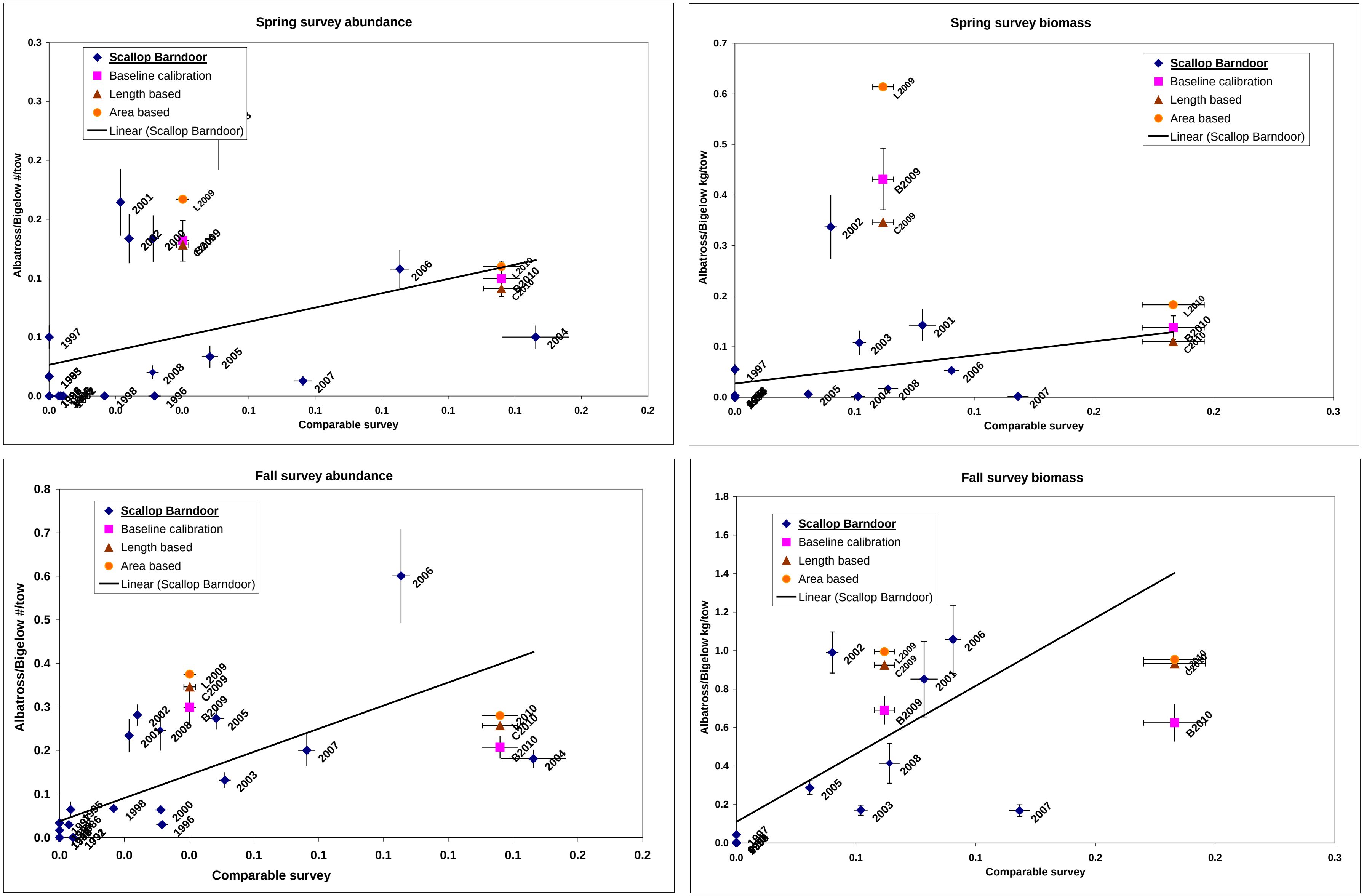


Figure 12. Little skate for scallop survey strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.

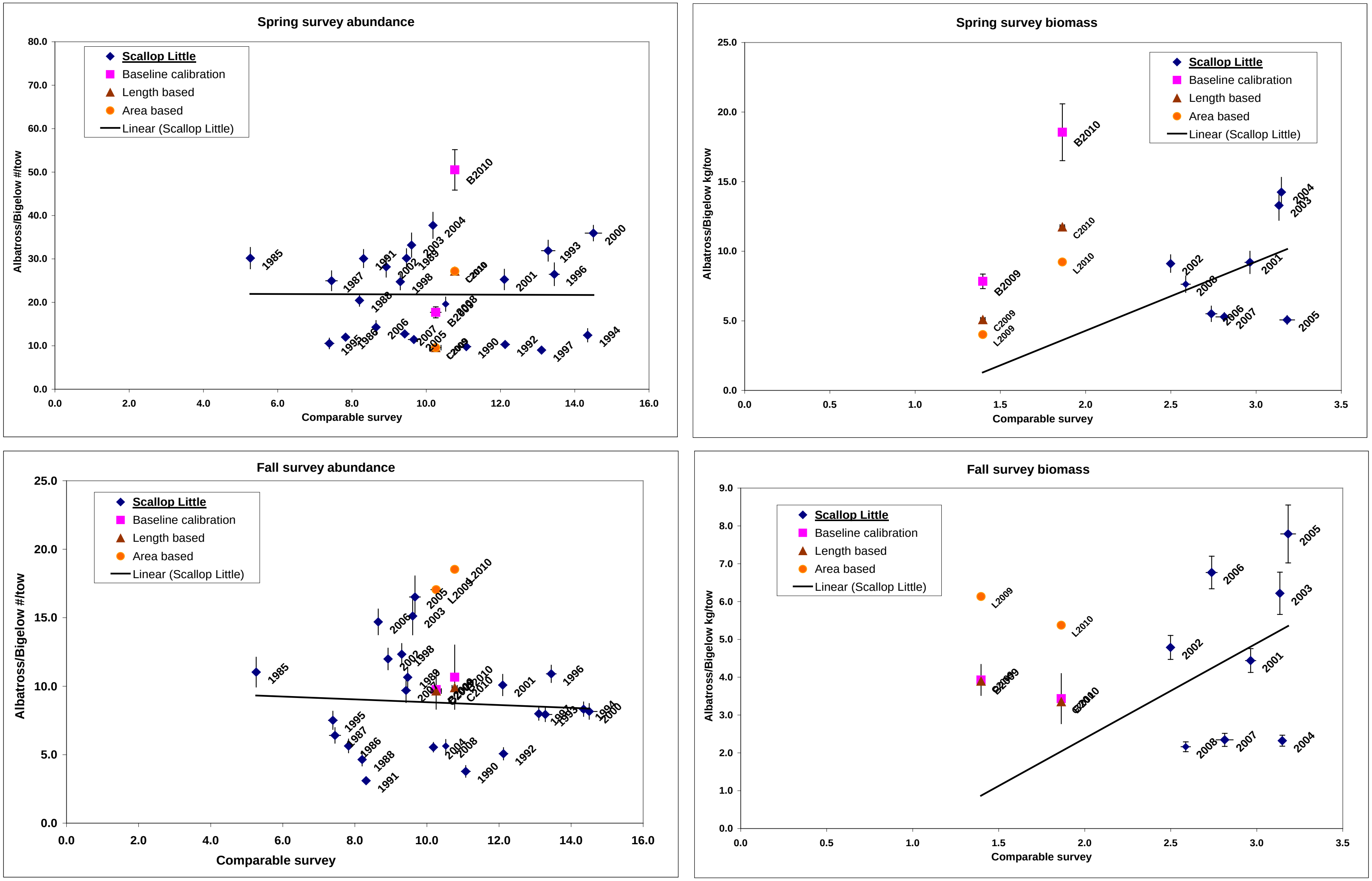


Figure 13. <u>Rosette skate for scallop survey strata</u> – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.

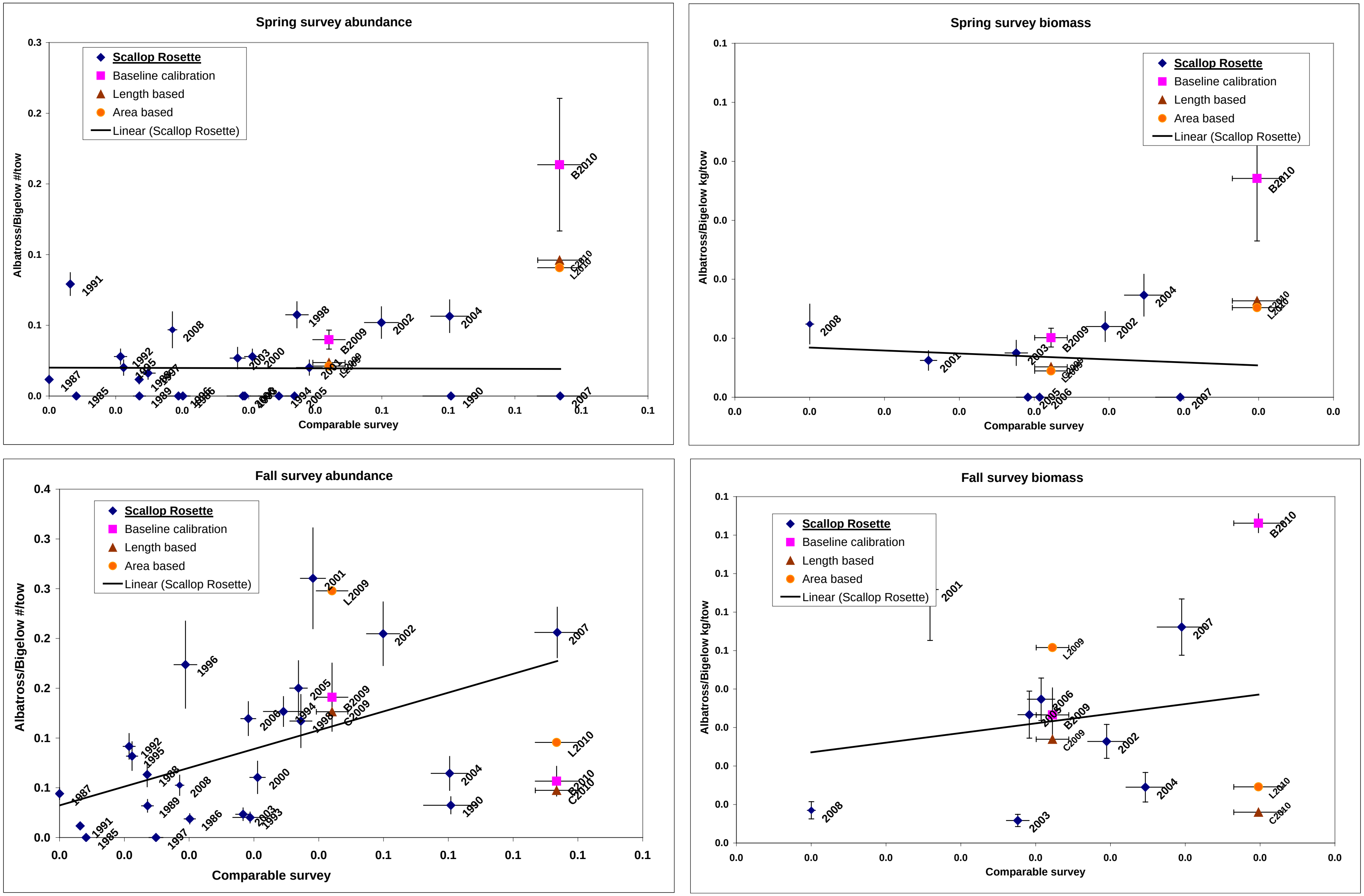
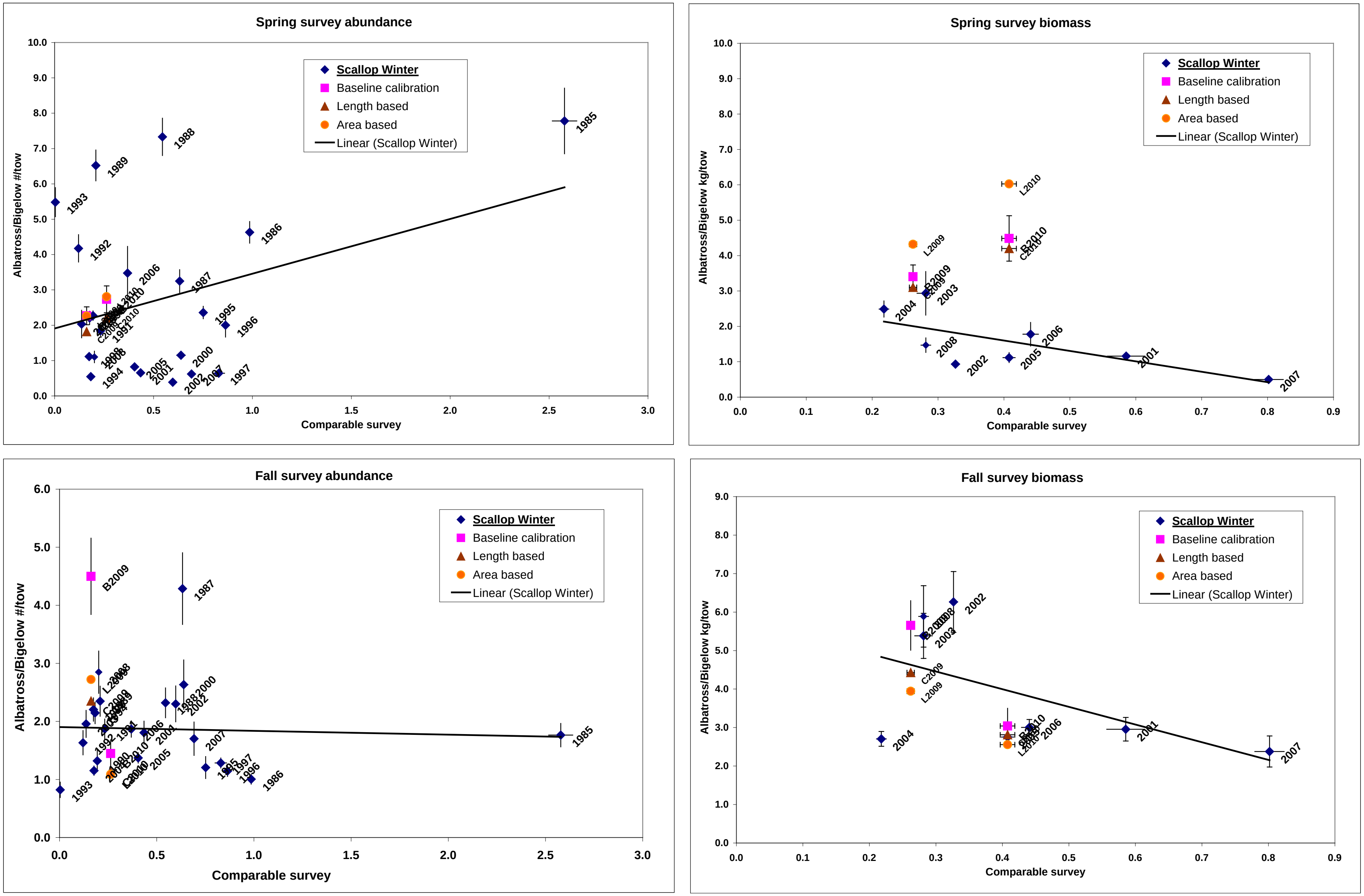


Figure 14. Winter skate for scallop survey strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.



4.4.4 NEAMap spring and fall trawl survey (clearnose, little, and winter skates)

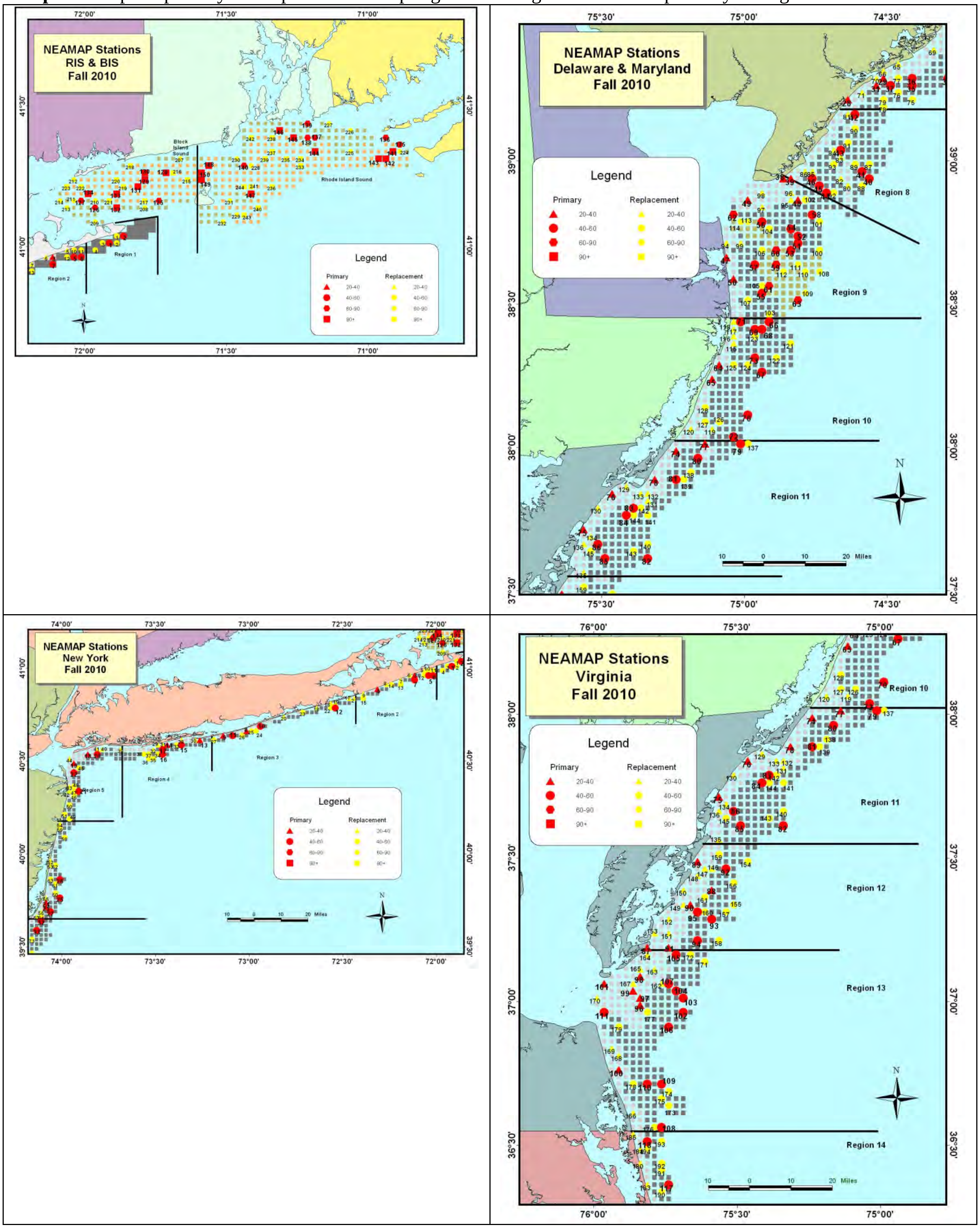
The NEAMap program conducts a coastwide spring and fall inshore trawl survey (Map 15, http://www.neamap.net/projects.html; 2010 NEAMap Trawl Documentation in Background Documents), ranging from NC to MA, to augment and compliment the NMFS trawl survey that occurs further offshore. This survey is sampled from a randomized grid and the PDT chose the offshore band of the inshore strata from the spring and fall trawl survey (Map 16 to Map 18) to compare the NEAMap indices of abundance and biomass. Although the FSV Albatross sampled in shallower inshore strata, only the outer band was chosen because it is consistently sampled by the FSV Bigelow.

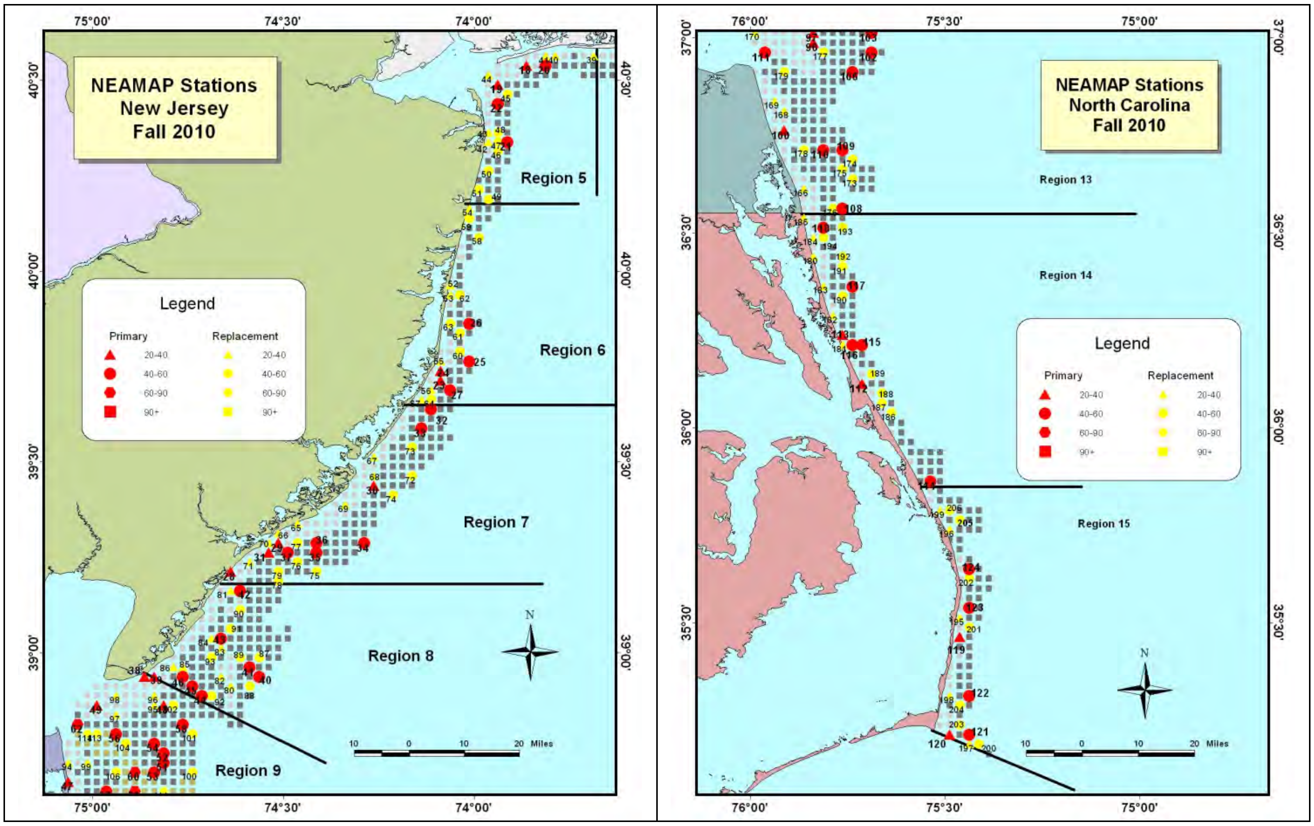
This comparison of annual indices is particularly useful for clearnose and little skates, and to a lesser extent for winter skate. For other skates typically found further offshore (barndoor and rosette) or in the Gulf of Maine (smooth and thorny), the comparison is not useful. It is important to note that due to its inshore and shallow water distribution, this is the only external validation possible for clearnose skate.

The NEAMap spring and fall trawl survey stratified mean abundance and biomass for clearnose, little, and winter skates were compared with similarly computed stratified mean indices from the NMFS spring and fall trawl surveys, respectively, for the selected strata. The relationships between the annual indices are shown in Figure 15, Figure 16, and Figure 17.

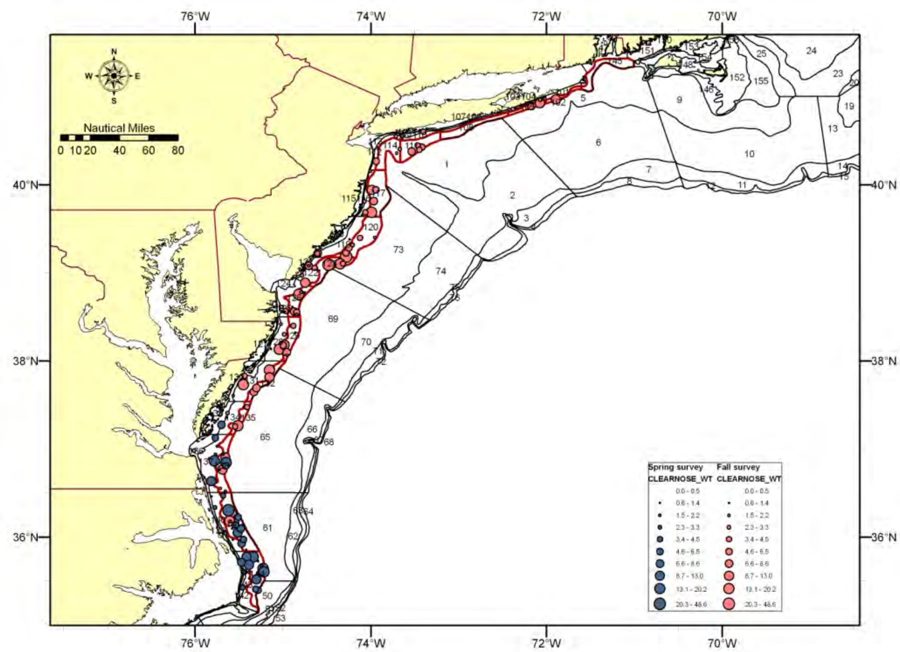
- The NEAMap survey began in the fall of 2008, so only has a short time series and is therefore less useful as a source of external validation.
- This is the only source of external validation of the calibrated clearnose skate indices. The area based (Model 3) calibrations give the highest values, but all three models appear to give plausible results.
- Calibrations of little skate catches also appear to give plausible results for all three models. The baseline (Model 1) calibrations are highest in the spring, but lowest in the fall. This result may be related to differential availability of clearnose skate to the spring and fall surveys, which is taken into account by the area based (Model 3) calibrations.
- The calibrations of winter skates in inshore strata used to compare with the NEAMap survey give plausible values in the spring, but anomalously high values in the fall. The surveys of the inshore strata in the Southern New England area in 2009 and 2010 were approximately a week later in the season compared to 2007 and 2008 which may explain some of the difference, but the survey strata sampled for this comparison are exactly the same.

Map 15. Maps of primary and replacement sampling stations in gridded NEAMap survey during 2010.

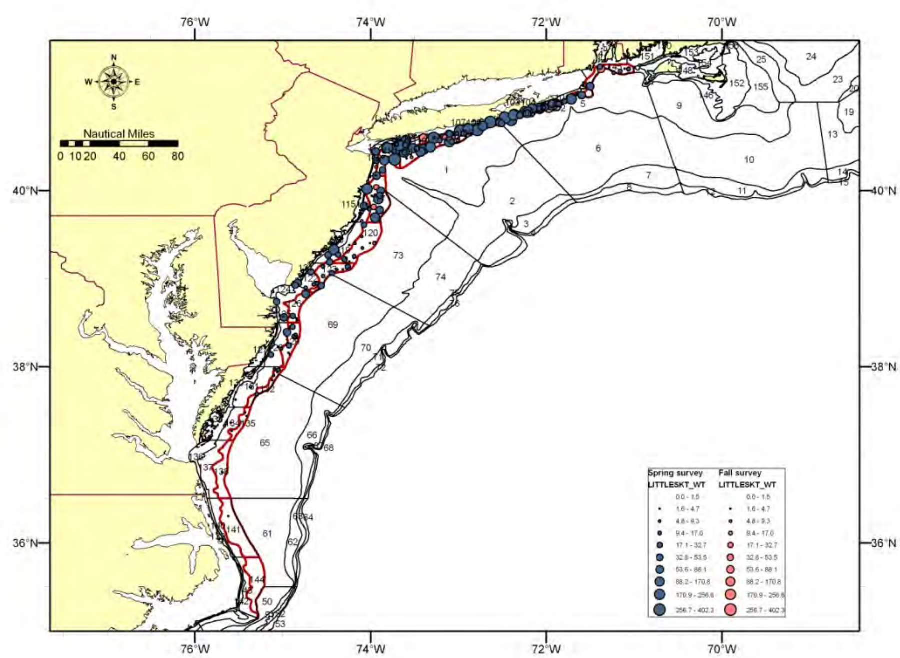



NEAMAP Stations
New Jersey
Fall 2010
Legend
Primary
Replacement
20-40
40-60
60-90
90+
Region 5
Region 6
Region 7
Region 8
Region 9
75°00'
74°30'
74°00'
40°30'
40°00'
39°30'
39°00'
N
Miles
NEAMAP Stations
North Carolina
Fall 2010
Region 13
Region 14
Region 15
76°00'
75°30'
75°00'
37°00'
36°30'
36°00'
35°30'

Map 16. Selected survey strata for the spring/fall bottom trawl survey (red outline) showing catches of clearnose skate (kg/tow) from 2007 to 2010, used to compare with the NEAMap spring and fall trawl survey. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 17. Selected survey strata for the spring/fall bottom trawl survey (red outline) showing catches of little skate (kg/tow) from 2007 to 2010, used to compare with the NEAMap spring and fall trawl survey. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.



Map 18. Selected survey strata for the spring/fall bottom trawl survey (red outline) showing catches of winter skate (kg/tow) from 2007 to 2010, used to compare with the NEAMap spring and fall trawl survey. Tows within the outlined strata for the respective surveys were used for external validation of the calibration model results.

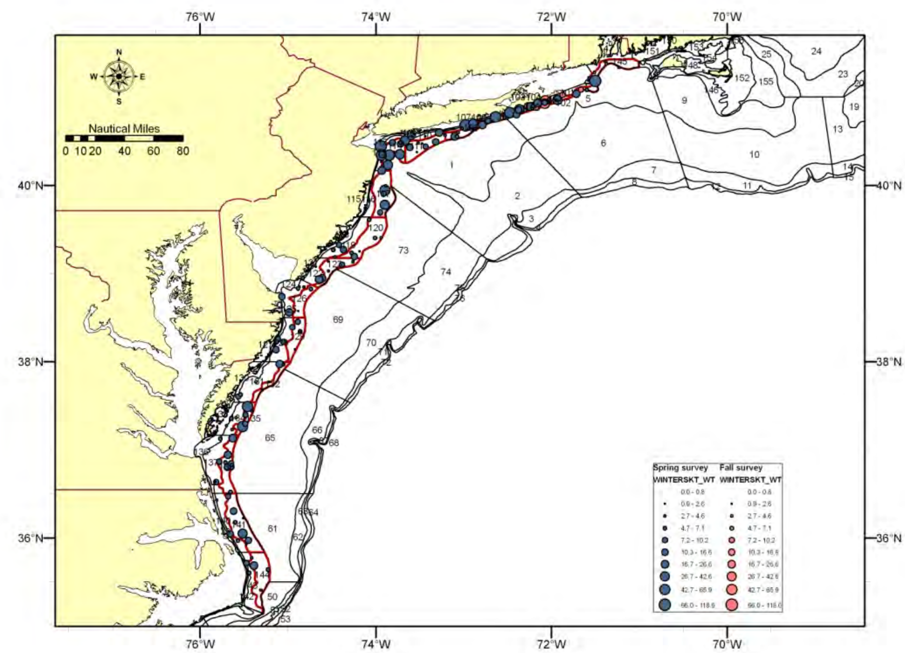


Figure 15. Clearnose skate for NEAMap strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the NEAMap spring and fall trawl survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region).

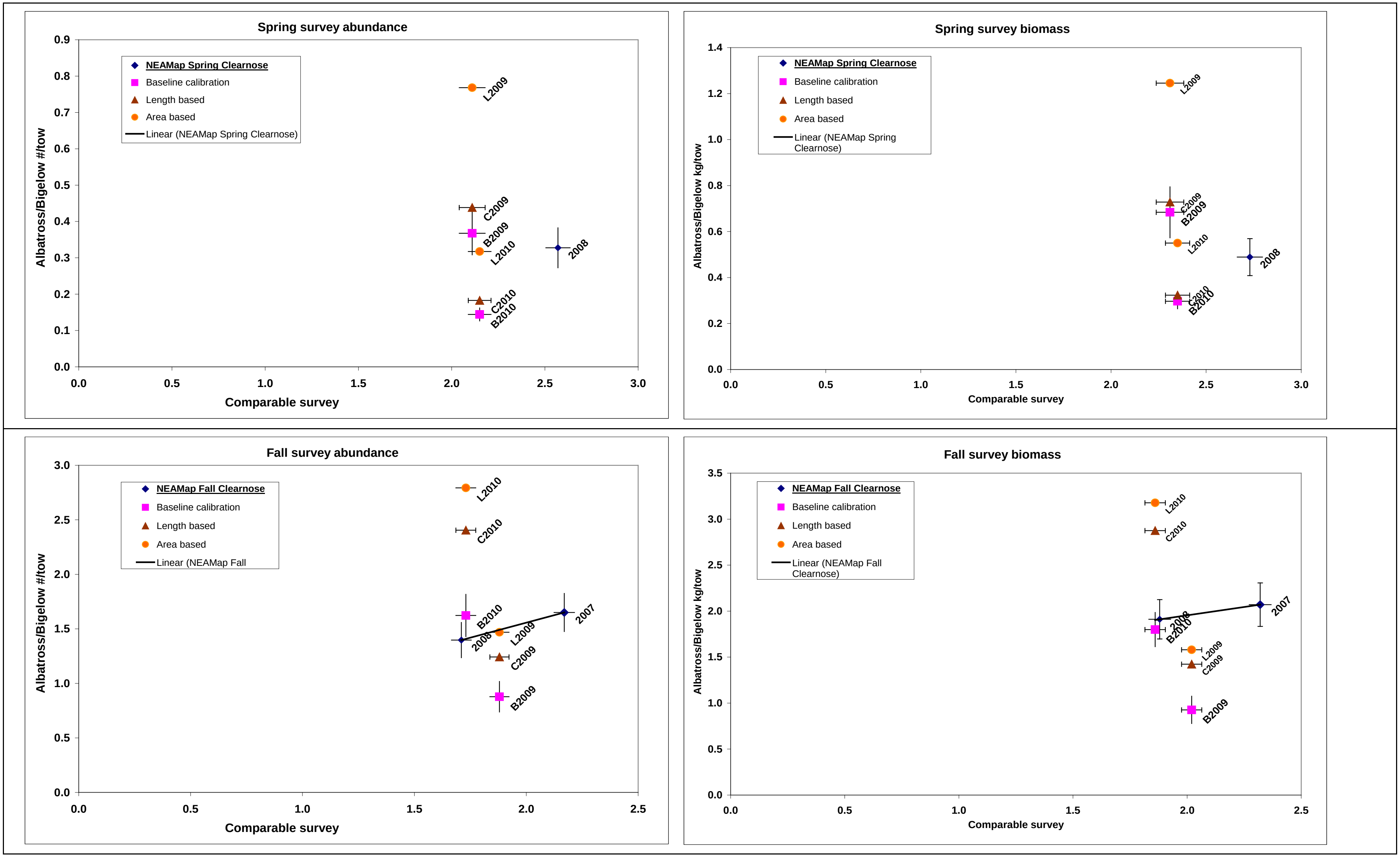


Figure 16. Little skate for NEAMap strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the NEAMap spring and fall trawl survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region).

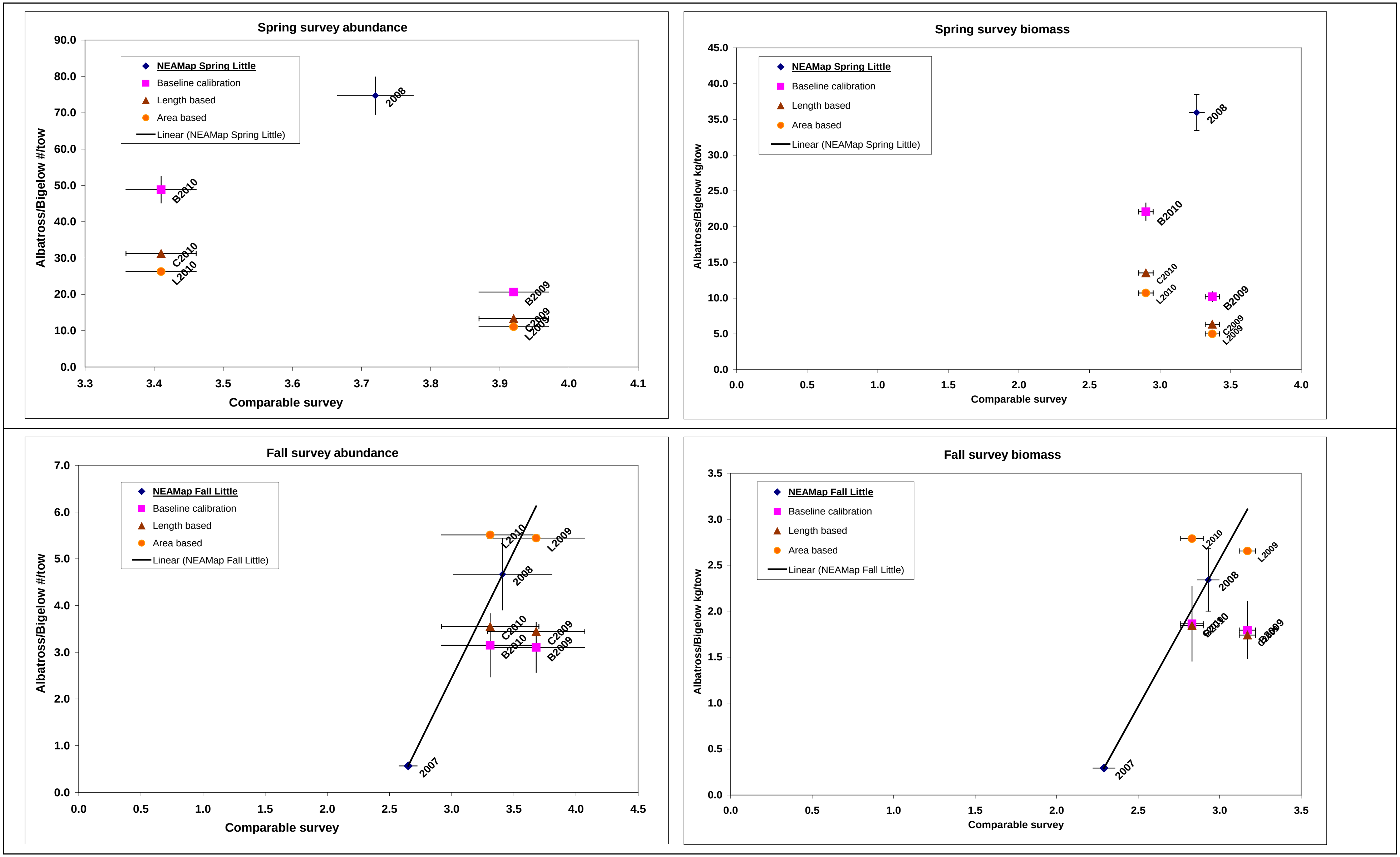
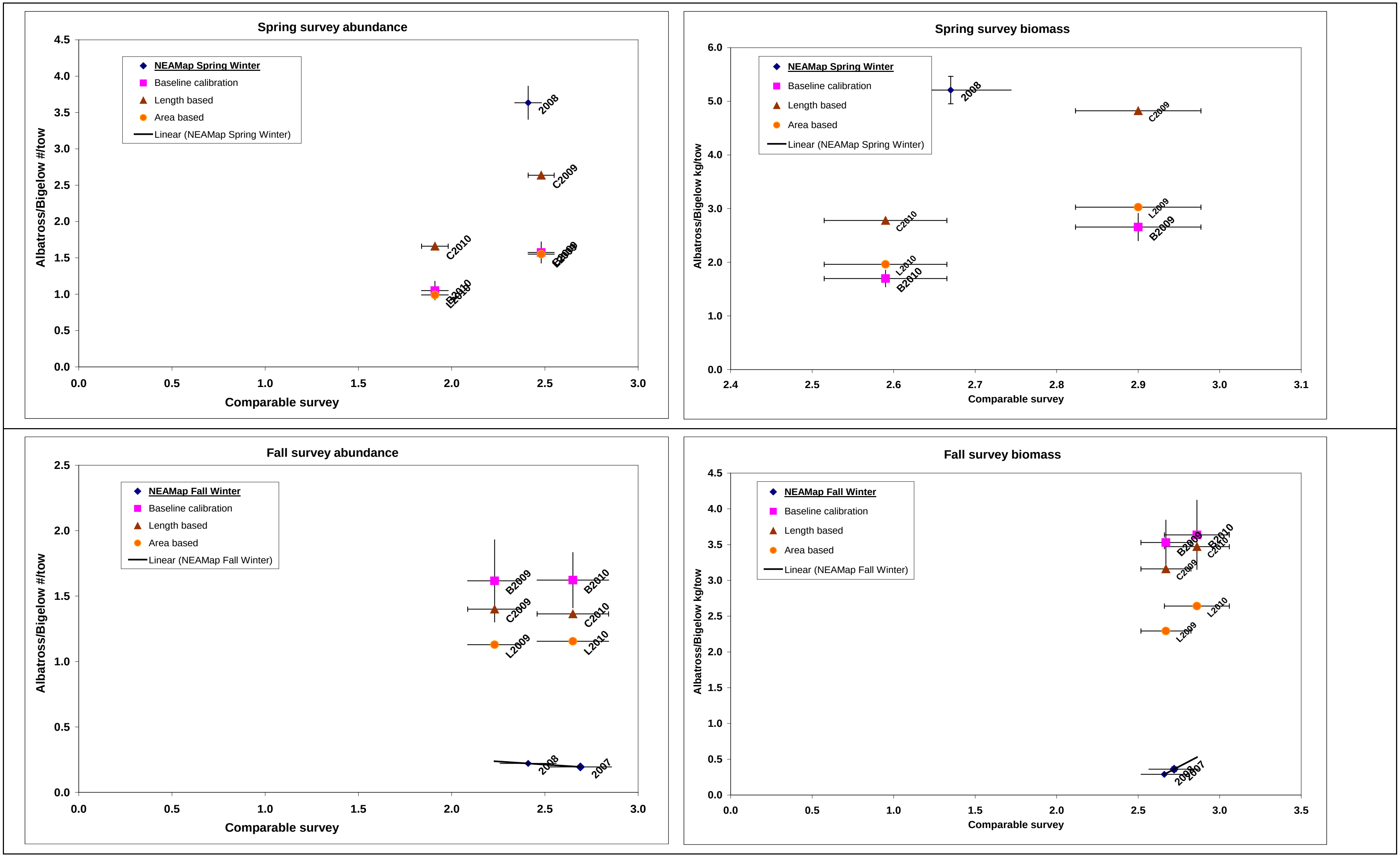


Figure 17. Winter skate for NEAMap strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the NEAMap spring and fall trawl survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region).


Spring survey abundance
Albatross/Bigelow #/tow
Comparable survey
NEAMap Spring Winter
Baseline calibration
Length based
Area based
Linear (NEAMap Spring Winter)
2008
C2009
C2010
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Spring survey biomass
Albatross/Bigelow kg/tow
Comparable survey
NEAMap Spring Winter
Baseline calibration
Length based
Area based
Linear (NEAMap Spring Winter)
2008
C2009
L2009
B2009
C2010
L2010
B2010
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
Fall survey abundance
Albatross/Bigelow #/tow
Comparable survey
NEAMap Fall Winter
Baseline calibration
Length based
Area based
Linear (NEAMap Fall Winter)
B2009
B2010
C2009
C2010
L2009
L2010
2008
2007
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Fall survey biomass
Albatross/Bigelow kg/tow
Comparable survey
NEAMap Fall Winter
Baseline calibration
Length based
Area based
Linear (NEAMap Fall Winter)
C2009
L2010
L2009
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

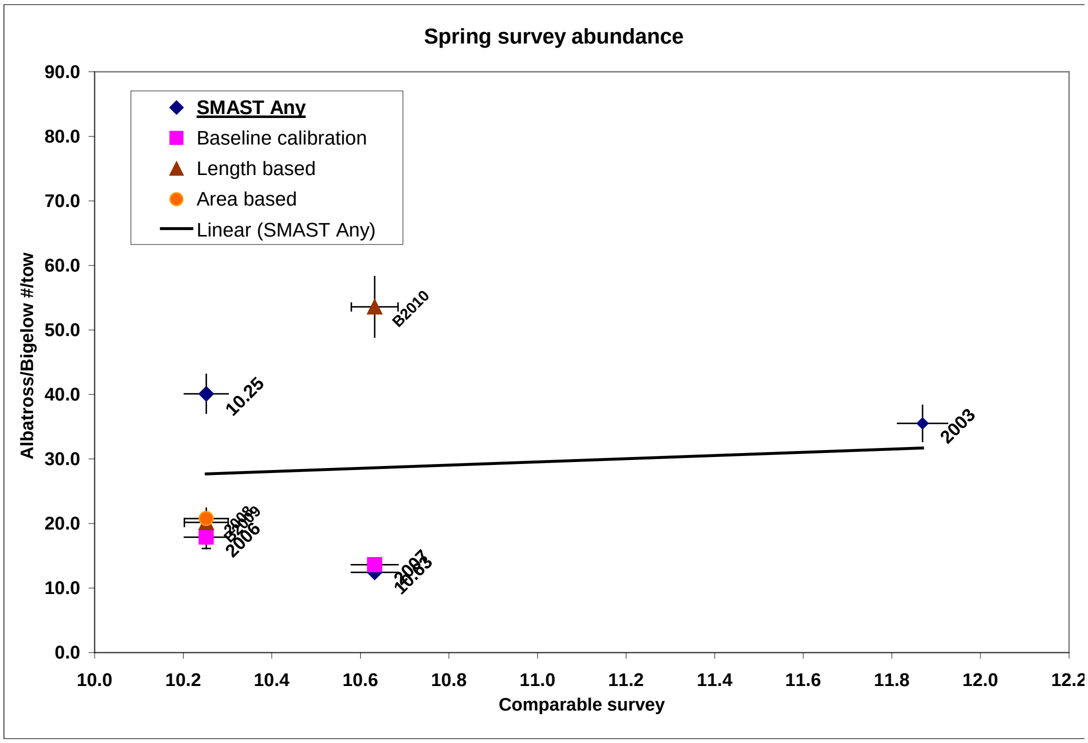
4.4.5 SMAST camera tripod survey (ANY skate species)

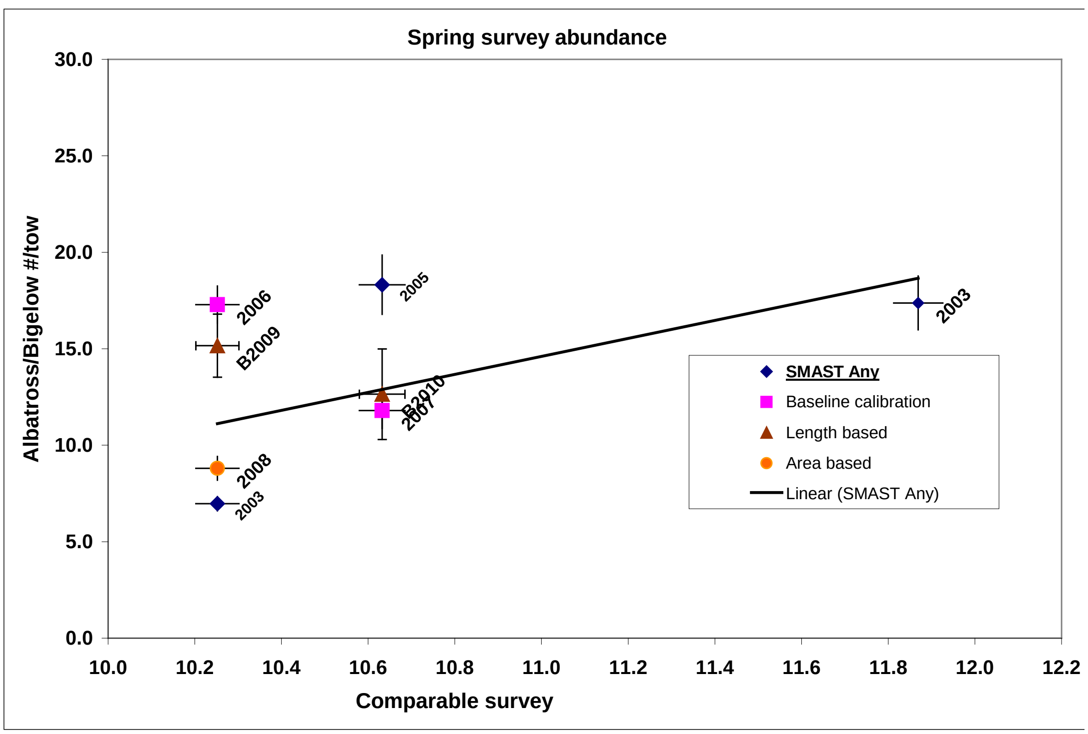
The SMAST survey is conducted coastwide with a grid sampling design. Design based means and CVs were calculated by MacDonald et al (2010) and compared with the same strata that the PDT chose for comparison with the scallop dredge survey (Section 4.4.3). Although this selection of spring and fall trawl survey strata may not be the best choice for the SMAST survey, the PDT felt that it was sufficient for this analysis. And since the images of observed skates have not identified the ‘catches’ by species nor are they measured for length, the PDT compared the SMAST data in MacDonald (2010) with the total mean stratified number per tow for all skates in the trawl survey.

The relationships between the annual indices are shown in Figure 18.

- Skates are not identified by species in the SMAST camera survey, nor are they measured for length, so only the combined abundance for scallop related trawl survey strata were compared with the SMAST survey indices.
- All three model calibrations appear to give plausible values when compared to the SMAST abundance indices.

Figure 18. Any skate for SMAST scallop strata – correlation between FSV Albatross spring (left) and fall (right) surveys and calibrated FSV Bigelow data with the scallop summer dredge survey. Baseline calibration = Model 1, Length based = Model 2, Area based = Model 3 (season, region). Pearson correlation coefficients (r) are calculated by weighting observations by the inverse of the sum of their variance on the means. Therefore the r values will be different than the trend line calculated by Excel.





5.0 Proposed changes in calculating skate stratified mean biomass due to FSV Bigelow sampling

Due in part to vessel capabilities, some inshore strata having shallow depth used in determining the median catch/biomass values are no longer sampled by the FSV Bigelow. In particular, this change in sampling coverage affects the median catch/biomass values and biological reference points for clearnose and little skates.

5.1 Effect on time series and biological reference points

The Henry B. Bigelow is no longer able to sample some shallow inshore strata because the draught of the vessel is too large. The bottom type of one offshore stratum (01330-German Bank off Nova Scotia) is too rough to tow the new net and is no longer sampled. In order to make the time series comparable back in time, the survey indices were recalculated using consistent sets for all species except rosette, which was unaffected by these changes.

The effect on the reference points and the 2008 stratified mean biomass was very minor for four of the six skate species (Table 10, Table 11, and Table 12). The deletion of the German Bank stratum was barely perceptible for winter, thorny, smooth and barndoor skate (Figure 19 to Figure 24). The removal of the inshore strata did affect clearnose and little quite a bit, however (Table 10, Table 11, and Table 12). The little and clearnose skate time series were overall lower due to the removal of high density inshore areas (Figure 19 and Figure 20). The trend, however, was similar, although year-to-year variability was different.

Table 10. Comparison of existing skate biomass targets and those re-calculated using strata sampled by the FSV Bigelow.

	Existing biomass target (mean kg/tow, FSV Albatross units)	Recalculated biomass target (mean kg/tow, FSV Albatross units)
Barndoor	1.60	1.57
Clearnose	0.77	0.66
Little	7.03	6.15
Smooth	0.29	0.27
Thorny	4.12	4.13
Winter	5.60	5.66

Table 11. Comparison of coefficient of variation (CV) for annual biomass means used to set fishing mortality thresholds and CVs re-calculated using strata sampled by the FSV Bigelow.

	CVs for FSV Albatross strata	CVs for FSV Bigelow strata	Existing fishing mortality threshold (% decline in three year moving average)
Barndoor	29.93	24.46	30
Clearnose	29.53	38.75	30
Little	16.48	19.13	20
Smooth	27.49	27.52	30
Thorny	21.09	21.43	20
Winter	19.44	19.46	20

Table 12. Comparison of 2008 stratified mean biomass with FSV Albatross strata and FSV Bigelow strata.

	Mean biomass (kg/tow) FSV Albatross strata	Mean biomass (kg/tow) FSV Bigelow strata	Status change?
Barndoor	1.092	1.111	No
Clearnose	1.725	1.233	No
Little	7.339	6.291	No
Smooth	0.098	0.100	No
Thorny	0.209	0.199	No
Winter	9.500	9.623	No

Figure 19. Clearnose skate: Differences in annual stratified mean biomass (left) and CVs (right) for standard strata sets sampled by the FSV Albatross (All Strata) and by the FSV Bigelow (Strata sampled by HBB).

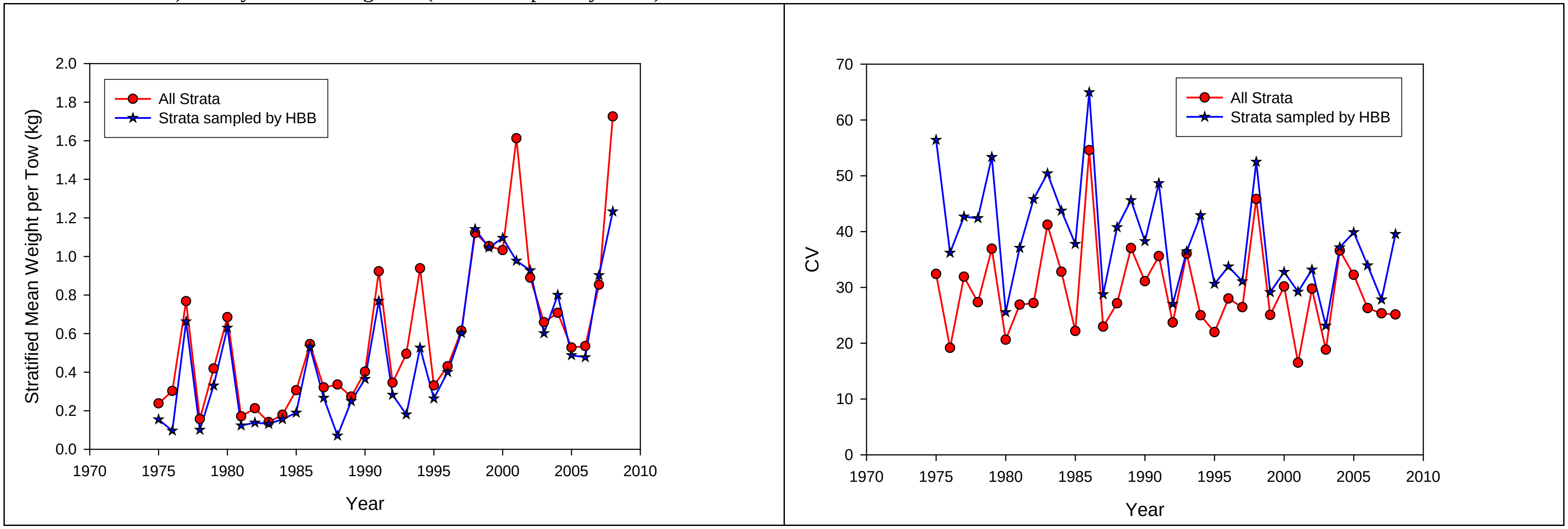


Figure 20. Little skate: Differences in annual stratified mean biomass (left) and CVs (right) for standard strata sets sampled by the FSV Albatross (All Strata) and by the FSV Bigelow (Strata sampled by HBB).

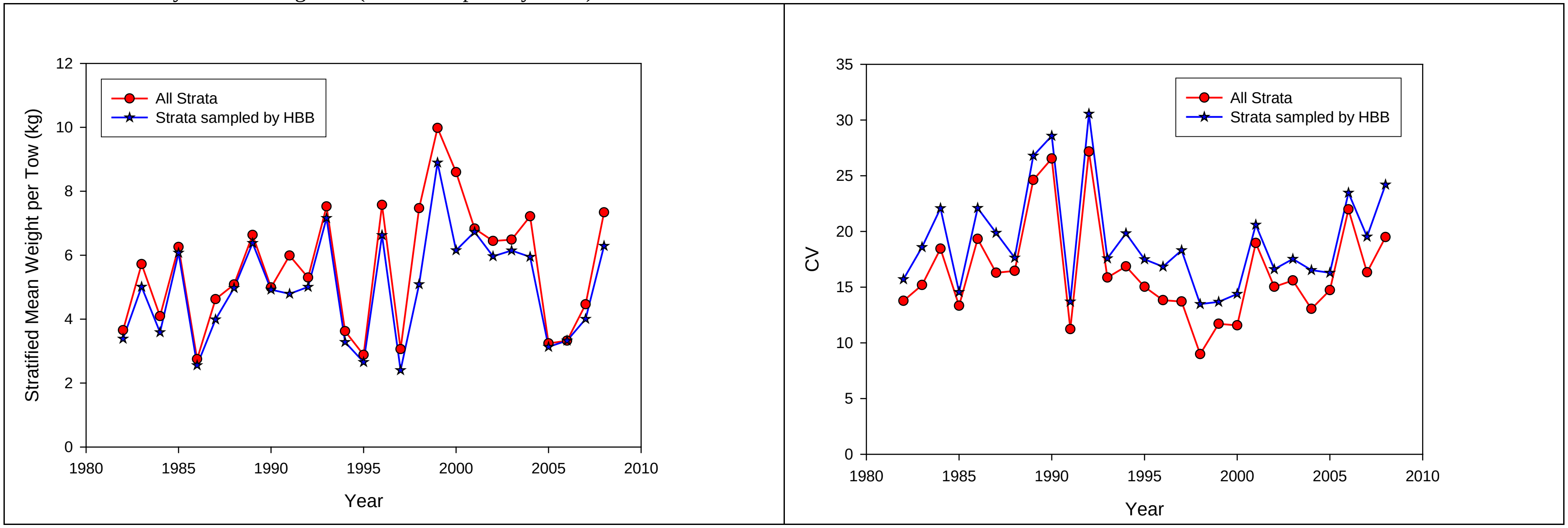


Figure 21. Barndoor skate: Differences in annual stratified mean biomass (left) and CVs (right) for standard strata sets sampled by the FSV Albatross (All Strata) and by the FSV Bigelow (Strata sampled by HBB).

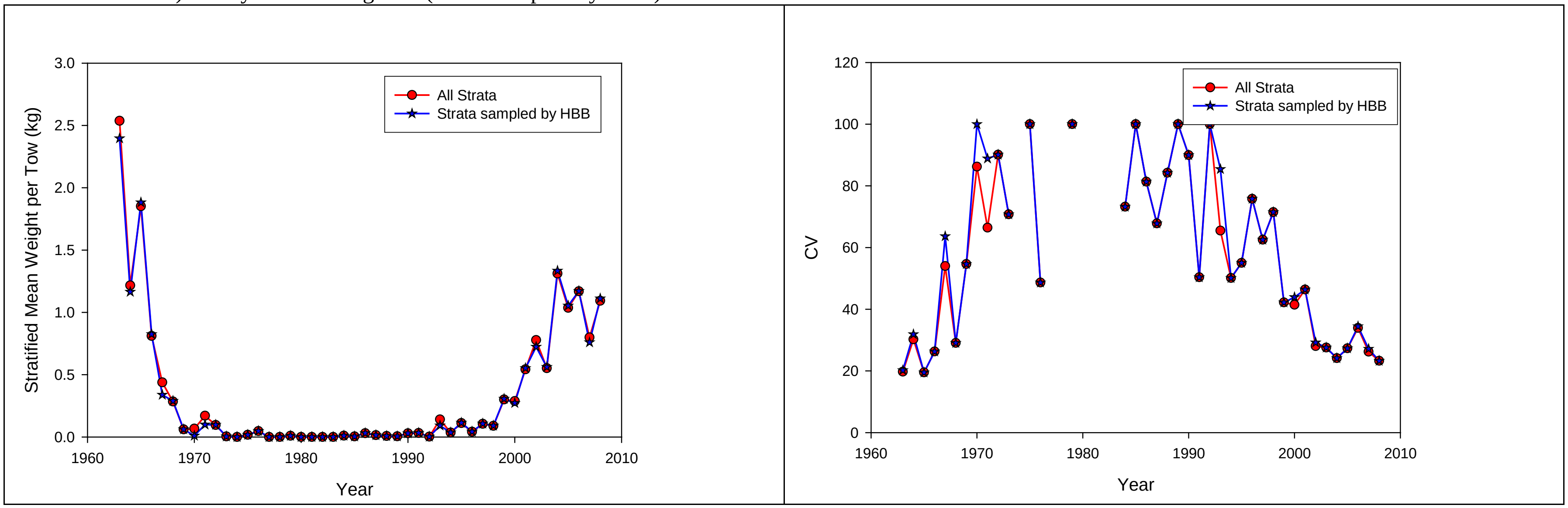


Figure 22. Smooth skate: Differences in annual stratified mean biomass (left) and CVs (right) for standard strata sets sampled by the FSV Albatross (All Strata) and by the FSV Bigelow (Strata sampled by HBB).

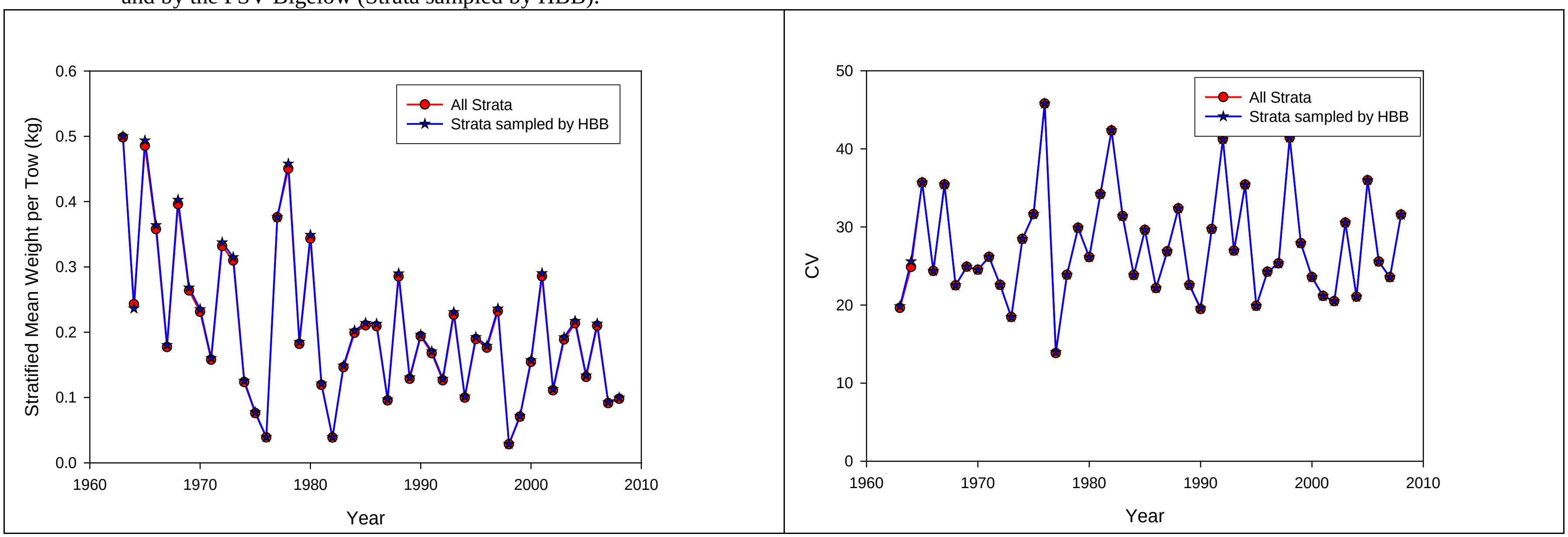


Figure 23. Thorny skate: Differences in annual stratified mean biomass (left) and CVs (right) for standard strata sets sampled by the FSV Albatross (All Strata) and by the FSV Bigelow (Strata sampled by HBB).

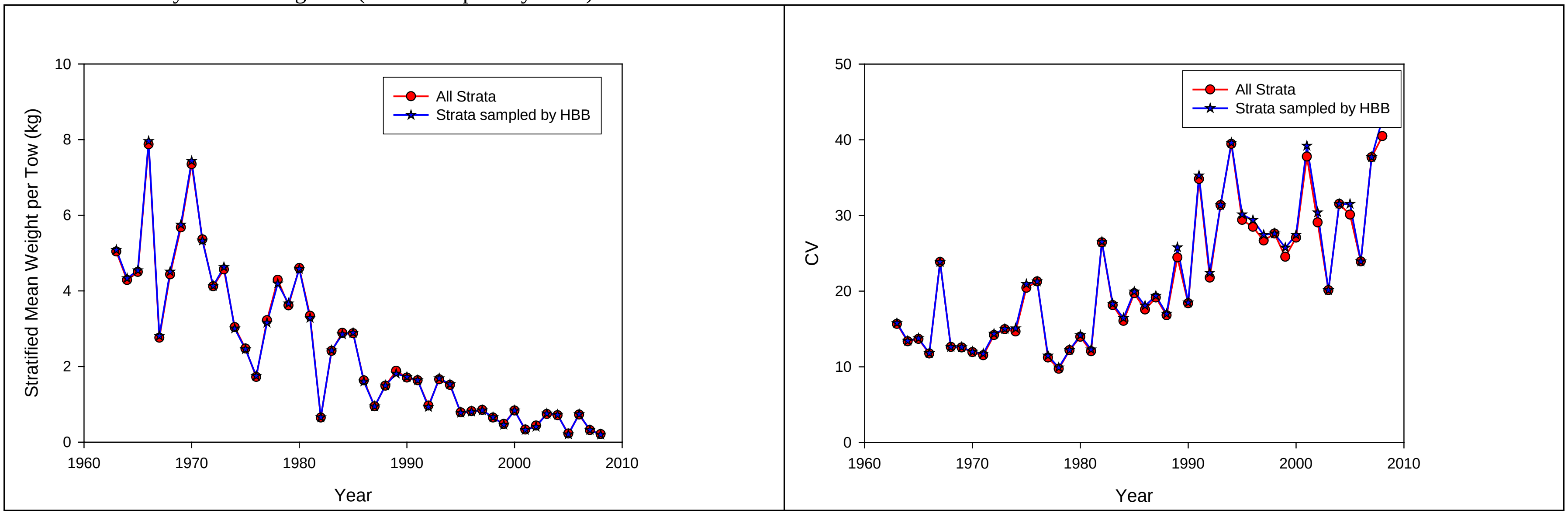


Figure 24. Winter skate: Differences in annual stratified mean biomass (left) and CVs (right) for standard strata sets sampled by the FSV Albatross (All Strata) and by the FSV Bigelow (Strata sampled by HBB).

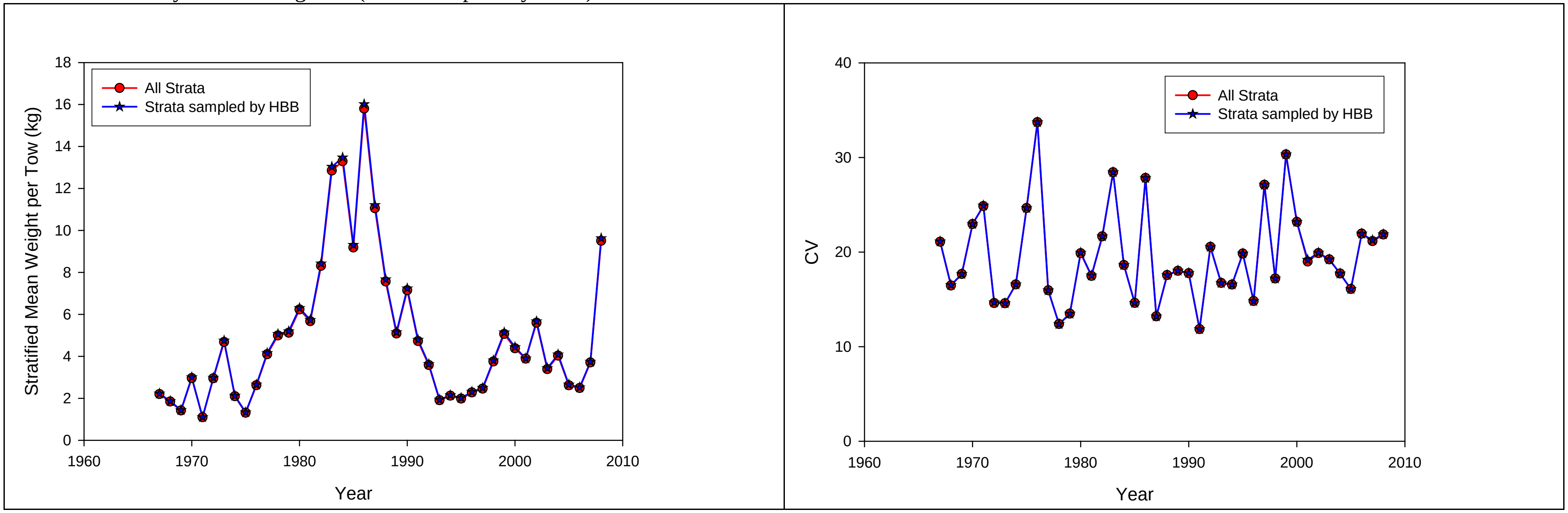
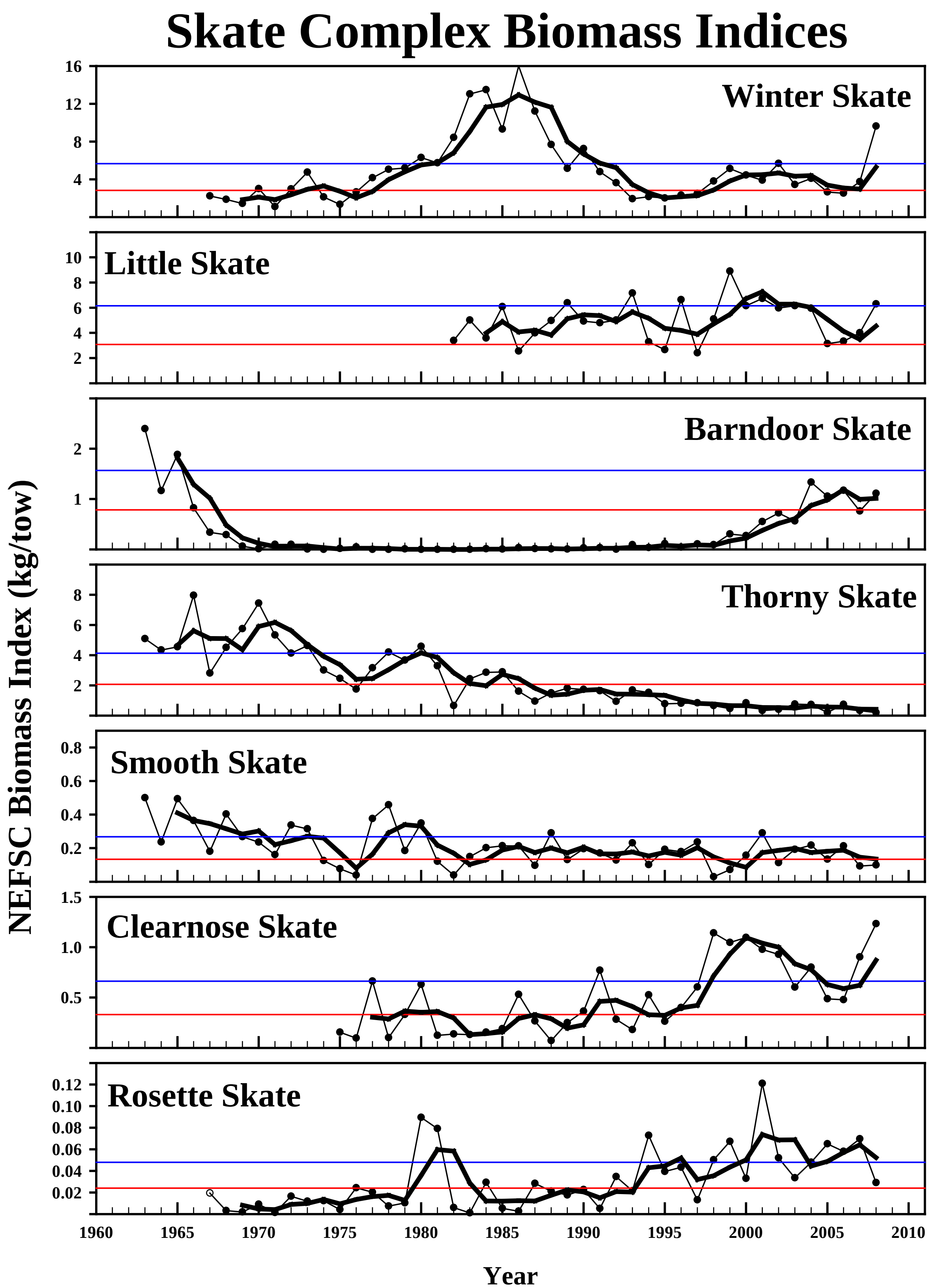


Figure 25. Revised biomass time series and reference points, consistent with strata sampled by the FSV Bigelow.



5.2 Effect on setting ABC

To account for this new inconsistency in the time series, the Skate PDT recalculated the 2010 and 2011 ABCs using the FSV Bigelow strata. Changing the time series raised the clearnose skate catch/biomass median by 10 percent and raised the little skate catch/biomass median by 19 percent. This increase is caused by the stratified mean in the FSV Bigelow strata being 16 and 11 percent lower, respectively, than the stratified mean for the FSV Albatross tows which include inshore strata where clearnose and little skate catches are usually more (see Table 14 to Table 19). Very little change in the annual mean biomass (and resulting catch/biomass median values) were observed for barndoor, rosette, smooth, thorny, and winter skates, consistent with our expectations.

Applying the revised values to the 2006-2008 mean stratified biomass estimates raises the 41,080 mt ABC to 41,946 mt (Table 13). While the catch/biomass median values for clearnose and little skates are higher, this effect on the ABC is muted because the stratified mean for 2006-2008 is correspondingly lower by about the same amount (allowing some variation in geographic distribution).

Table 13. Comparative calculation of catch/biomass values with different strata used to calculate annual mean biomass by species.

Skate ABC specifications using FSV Albatross strata and 2006-2008 survey data.

	Catch		C/B derived catch limits		Catch/biomass		Survey biomass	
Species	Median	80% of median	Median	75% of median	Median	75% of median	kg/tow	
Barndoor	400	320	3,295	2,471	3.230	2.423	1.020	
Clearnose	1,110	888	2,529	1,897	2.440	1.830	1.037	
Little	10,189	8,151	12,047	9,035	2.390	1.793	5.040	
Rosette	47	38	117	88	2.190	1.643	0.053	
Smooth	303	242	226	169	1.690	1.268	0.133	
Thorny	5,209	4,167	1,319	989	3.140	2.355	0.420	
Winter	16,586	13,269	21,548	16,161	4.120	3.090	5.230	
Total	33,844	27,075	41,080	30,810				
ABC (mt)	41,080							
ACT (mt)	30,810	Federal TAL	Wing TAL	Mortality reduct	Bait TAL	Season 1	Season 2	Season 3
TAL (mt)	14,780	13,856	9,214	-27.5%	4,642	1,430	1,722	1,490

Skate ABC specifications using FSV Bigelow strata and 2006-2008 survey data.

	Catch		C/B derived catch limits		Catch/biomass		Survey biomass index	
Species	Median	80% of median	Median	75% of median	Median	75% of median		
Barndoor	400	320	3,265	2,449	3.222	2.417	1.013	
Clearnose	1,110	888	2,347	1,760	2.695	2.021	0.871	
Little	10,189	8,151	13,160	9,870	2.898	2.174	4.541	
Rosette	47	38	108	81	2.090	1.567	0.052	
Smooth	303	242	226	169	1.669	1.251	0.135	
Thorny	5,209	4,167	1,307	981	3.117	2.337	0.420	
Winter	16,586	13,269	21,532	16,149	4.067	3.051	5.294	
Total	33,846	27,076	41,946	31,459				
ABC (mt)	41,946							
ACT (mt)	31,459	Federal TAL	Wing TAL	Mortality reduct	Bait TAL	Season 1	Season 2	Season 3
TAL (mt)	15,092	14,168	9,422	-25.8%	4,746	1,462	1,761	1,524

Table 14. Barndoor skate: Comparison of statistics for the time series through 2007 of annual catch/biomass statistics for the FSV Albatross strata (left) and the FSV Bigelow strata (right). The annual mean biomass for the FSV Bigelow strata are 97% of those for the FSV Albatross strata through 2008. The biomass change represents the number of years and average change of biomass expected based on historical stock dynamics. The catch limit represents the portion of the ABC attributable to the species and does not reflect differences in discarding or landings prohibitions, compared with the observed average in 2004-2006 using the selectivity ogive method to apportion catch by species.

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	21	16	58.5%		
Maximum	64.47	Above median	8	14	-2.2%		
75th percentile	10.27	Below 75th percentile	17	5	136.4%	10,289	670%
75% of 75th percentile	7.70	Below 75%	15	5	124.8%	7,717	477%
Median	3.23	Below Median	13	2	155.1%	3,237	142%
75% of median	2.42	Below 75%	11	2	163.0%	2,428	82%
Percentile	42%						

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	21	16	53.9%		
Maximum	63.38	Above median	8	14	-8.7%		
75th percentile	12.60	Below 75th percentile	16	6	123.0%	12,526	837%
75% of 75th percentile	9.45	Below 75%	15	5	125.1%	9,394	603%
Median	3.22	Below Median	13	2	153.1%	3,204	140%
75% of median	2.42	Below 75%	10	2	145.8%	2,403	80%
Percentile	41%						

Table 15. Clearnose skate: Comparison of statistics for the time series through 2007 of annual catch/biomass statistics for the FSV Albatross strata (left) and the FSV Bigelow strata (right). The annual mean biomass for the FSV Bigelow strata are 84% of those for the FSV Albatross strata through 2008. All other results are as described in Table 14.

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	24	13	12.0%		
Maximum	6.94	Above median	18	7	7.7%		
75th percentile	4.39	Below 75th percentile	10	10	33.2%	2,788	49%
75% of 75th percentile	3.30	Below 75%	9	7	39.4%	2,091	12%
Median	2.44	Below Median	6	6	34.9%	1,551	-17%
75% of median	1.83	Below 75%	3	3	16.9%	1,164	-38%
Percentile	27%						

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	24	13	18.6%		
Maximum	12.63	Above median	16	9	7.1%		
75th percentile	5.96	Below 75th percentile	12	8	46.8%	3,707	98%
75% of 75th percentile	4.47	Below 75%	10	6	53.0%	2,780	48%
Median	2.69	Below Median	8	4	53.5%	1,677	-10%
75% of median	2.02	Below 75%	4	4	11.9%	1,258	-33%
Percentile	34%						

Table 16. Little skate: Comparison of statistics for the time series through 2007 of annual catch/biomass statistics for the FSV Albatross strata (left) and the FSV Bigelow strata (right). The annual mean biomass for the FSV Bigelow strata are 89% of those for the FSV Albatross strata through 2008. All other results are as described in Table 14.

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	27	10	18.9%		
Maximum	7.27	Above median	16	7	15.2%		
75th percentile	3.99	Below 75th percentile	14	7	39.3%	14,678	0%
75% of 75th percentile	3.00	Below 75%	12	5	37.9%	11,009	-25%
Median	2.43	Below Median	11	3	31.1%	8,920	-39%
75% of median	1.82	Below 75%	6	1	31.1%	6,690	-54%
Percentile	24%						

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	27	10	18.8%		
Maximum	8.15	Above median	17	6	16.2%		
75th percentile	4.21	Below 75th percentile	14	7	37.8%	14,678	0%
75% of 75th percentile	3.16	Below 75%	12	4	39.3%	11,009	-25%
Median	2.90	Below Median	10	4	27.9%	10,110	-31%
75% of median	2.17	Below 75%	7	1	34.2%	7,583	-48%
Percentile	26%						

Table 17. Smooth skate: Comparison of statistics for the time series through 2007 of annual catch/biomass statistics for the FSV Albatross strata (left) and the FSV Bigelow strata (right). The annual mean biomass for the FSV Bigelow strata are 101% of those for the FSV Albatross strata through 2008. All other results are as described in Table 14.

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	15	22	9.6%		
Maximum	3.79	Above median	1	17	-22.9%		
75th percentile	2.14	Below 75th percentile	15	14	32.1%	308	14%
75% of 75th percentile	1.60	Below 75%	13	3	56.8%	231	-15%
Median	**1.69**	Below Median	14	5	48.1%	243	-10%
75% of median	1.27	Below 75%	9	0	95.0%	183	-33%
Percentile	24%						

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	15	22	9.2%		
Maximum	3.73	Above median	1	17	-23.9%		
75th percentile	2.10	Below 75th percentile	15	14	32.2%	308	14%
75% of 75th percentile	1.58	Below 75%	13	3	56.8%	231	-15%
Median	**1.67**	Below Median	14	5	48.2%	245	-10%
75% of median	1.25	Below 75%	9	0	94.6%	183	-32%
Percentile	24%						

Table 18. Thorny skate: Comparison of statistics for the time series through 2007 of annual catch/biomass statistics for the FSV Albatross strata (left) and the FSV Bigelow strata (right). The annual mean biomass for the FSV Bigelow strata are 100% of those for the FSV Albatross strata through 2008. All other results are as described in Table 14.

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	11	26	-11.8%		
Maximum	4.65	Above median	3	15	-20.7%		
75th percentile	3.67	Below 75th percentile	10	18	9.8%	1,560	113%
75% of 75th percentile	2.75	Below 75%	4	7	4.1%	1,170	60%
Median	**3.13**	Below Median	8	11	10.5%	1,329	82%
75% of median	2.35	Below 75%	4	3	6.5%	996	36%
Percentile	18%						

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	12	25	-11.8%		
Maximum	4.67	Above median	4	14	-20.9%		
75th percentile	3.68	Below 75th percentile	10	18	10.0%	1,551	112%
75% of 75th percentile	2.76	Below 75%	4	7	4.7%	1,163	59%
Median	**3.12**	Below Median	8	11	10.8%	1,313	79%
75% of median	2.34	Below 75%	4	3	7.4%	985	35%
Percentile	18%						

Table 19. Winter skate: Comparison of statistics for the time series through 2007 of annual catch/biomass statistics for the FSV Albatross strata (left) and the FSV Bigelow strata (right). The annual mean biomass for the FSV Bigelow strata are 101% of those for the FSV Albatross strata through 2008. All other results are as described in Table 14.

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	21	16	15.7%		
Maximum	8.02	Above median	4	14	-24.2%		
75th percentile	5.81	Below 75th percentile	19	7	43.2%	17,065	-5%
75% of 75th percentile	4.36	Below 75%	18	4	49.1%	12,799	-29%
Median	**4.12**	Below Median	17	2	54.5%	12,087	-33%
75% of median	3.09	Below 75%	9	1	52.4%	9,065	-50%
Percentile	24%						

Catch/biomass ratio			Biomass change Up	Down	Average ΔB	Limit (mt)	Δ2004-2006
		All	21	16	15.5%		
Maximum	7.92	Above median	4	14	-24.2%		
75th percentile	5.68	Below 75th percentile	19	7	42.9%	16,853	-6%
75% of 75th percentile	4.26	Below 75%	18	4	48.8%	12,640	-30%
Median	**4.07**	Below Median	17	2	54.2%	12,077	-33%
75% of median	3.05	Below 75%	8	1	55.1%	9,058	-50%
Percentile	24%						

6.0 Effects on setting ABC using 2008 FSV Albatross and calibrated 2009-2010 FSV Bigelow survey data

The existing annual ABC for the 2010 and 2011 fishing years is 41,080 mt, using the FSV Albatross time series catch/biomass median applied to the 2006-2008 fall and spring (for little skate) survey data (Table 13). The Council adopted a 25% buffer to account for management uncertainty, leaving an annual catch target of 30,810 mt. Assuming that the past discard rate (52%) and the proportion of skate landings by state vessels (3%) pertains to the 2010 and 2011 fishing years, the Council approved a 12,848 mt TAL which is allocated by Amendment 3 to the skate wing and skate bait fishery based on historic landings.

These same buffers, assumptions, and allocations are assumed to apply to this analysis and the Council may apply it to the 2011 fishing year if a calibration method and 2011 ABC is approved by the SSC. When data become available, the Skate PDT intends to update the discard and state landings rate with new data through 2010, re-examine whether the 50% discard mortality rate should be adjusted after reviewing new research data, and apply post-season accountability measures if they are needed to recommend an adjusted ABC and TALs for the 2012 and 2013 fishing years in the next specification package. These specifications would be reviewed and possibly approved by the SSC when it meets in June 2011 (tentative date) and the specification package or framework adjustment approved by the Council in September.

Two adjustments are needed to properly use the FSV Bigelow data. The first adjustment is to calculate the stratified mean biomass from the appropriate strata which are consistently sampled by the FSV Albatross and FSV Bigelow. This sampling issue is addressed in Section 5.0 and would increase the ABC by 2.1 percent when the 2006-2008 data are applied. The effect on the ABC may vary when different survey years (e.g. 2007-2009) are used because the relative distribution of skates among various strata may change. The second adjustment is to calibrate the FSV Bigelow tows to FSV Albatross tows and calculate stratified mean biomass.

Three calibration methods are evaluated in this report and a comparison of the effects on the ABC is given below, one set updating the survey series to 2007-2009 as would have occurred for the 2010 and 2011 fishing year specifications[2], the second set updating the survey series to 2008-2010 as will occur for the 2012-2013 specifications. The results are presented in the tables below and summarized in Table 29.

6.1 Model 1 - Aggregate abundance and biomass catch efficiency by species

The calculation of ABC for the surveys ending in 2009 and 2010 using the Model 1 calibration to adjust the FSV Bigelow data are shown in Table 20. The catch/biomass median includes the time series through 2007, is consistent with the FSV Bigelow sampled strata, and does not change with time.

[2] The 2009 survey was not included in the Amendment 3 specifications for 2010 and 2011 because the skate calibration methodology had not been fully vetted and in April 2010 was only available for little and winter skates when the SSC approved the final Amendment 3 ABC.

The three year survey biomass moving average (Table 21), including the Model 1 calibrated survey for 2009 increased by 24% for little skate and 55% for winter skate, but declined by 39% for thorny skate. The three year biomass average for other skates changed by smaller amounts. Although for little skate the 2009 biomass index increased from 6.29 kg/tow on the FSV Albatross in 2008 to 6.55 kg/tow (Model 1 calibrated) on the FSV Bigelow in 2009 and for winter skate increased from 9.62 kg/tow in 2008 to 11.33 kg/tow in 2009, most of the increase comes from dropping 2006 from the three year biomass index, 3.33 and 2.52 kg/tow, respectively (Table 21).

As a result, the calculated ABC using the Model 1 calibrations would increase by 39% to 56,900 mt (Table 20). Similarly the TAL, assuming that the discard rate is 52% of total catch, increases by the same fraction from 14,780 to 20,472 mt and the wing TAL increases from 9,214 to 13,000 mt.

These survey trends and effects on the ABC were similar when the three year average survey biomass is updated for 2010 data, calibrated with Model 1 methods, increasing by another 39% for little skate and by 18% for winter skate (Table 21). The three year average declined less for thorny skate (by 5%). Smooth skate biomass increased by 21% but at low overfished values (so the denominator is small) and the relatively noisy rosette skate three year average declined by 25%.

Updating for 2010 data (and dropping 2007 from the three year moving average) would increase the ABC to 69,353 mt (+69%), increasing the total TAL by the same fraction to 24,953 mt while the wing TAL would increase to 15,979 mt (Table 20). Again, much of the ABC increase is attributable to the relatively higher little and winter skate biomass indices, but also due to dropping the low 2007 values (4.01 and 3.74 kg/tow, respectively) from the average.

Table 20. Comparative calculation of ABC and other skate specifications (mt) using stratified mean biomass indices from FSV Bigelow survey strata, calibrated to FSV Albatross units via Model 1 methods. The survey biomass index is a three year average, kg/two, while the catch/biomass median is in mt/kg, including landings and discards through 2007.

		Catch		C/B derived catch limits		Catch/biomass		Survey biomas	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
Surveys 2007 - 2009	Barndoor	400	320	3,220	2,415	3.222	2.417	0.999	
	Clearnose	1,110	888	2,718	2,039	2.695	2.021	1.009	
	Little	10,189	8,151	16,342	12,256	2.898	2.174	5.639	
	Rosette	47	38	112	84	2.090	1.567	0.053	
	Smooth	303	242	221	166	1.669	1.251	0.133	
	Thorny	5,209	4,167	803	603	3.117	2.337	0.258	
	Winter	16,586	13,269	33,483	25,112	4.067	3.051	8.232	
	Total	33,846	27,076	56,900	42,675				
	ABC (mt)	56,900							
	ACT (mt)	42,675	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Sea
	TAL (mt)	20,472	19,548	13,000	2.3%	6,549	2,017	2,430	
		Catch		C/B derived catch limits		Catch/biomass		Survey biomas	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
Surveys 2008 - 2010	Barndoor	400	320	3,591	2,693	3.222	2.417	1.114	
	Clearnose	1,110	888	2,515	1,887	2.695	2.021	0.933	
	Little	10,189	8,151	22,744	17,058	2.898	2.174	7.848	
	Rosette	47	38	84	63	2.090	1.567	0.040	
	Smooth	303	242	268	201	1.669	1.251	0.161	
	Thorny	5,209	4,167	763	572	3.117	2.337	0.245	
	Winter	16,586	13,269	39,389	29,542	4.067	3.051	9.684	
	Total	33,846	27,076	69,353	52,015				
	ABC (mt)	69,353							
	ACT (mt)	52,015	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Sea
	TAL (mt)	24,953	24,029	15,979	25.8%	8,050	2,479	2,986	

Table 21. Annual fall and spring (for little skate) stratified mean biomass using consistent FSV Bigelow strata with 2009 and 2010 values calibrated to FSV Albatross equivalents using Model 1, and three year moving averages.

Year	Barndoor	Clearnose	Little	Rosette	Smooth	Thorny	Winter
1964	1.16				0.24		
1965	1.88				0.49		
1966	0.82				0.36		
1967	0.34			0.02	0.18		2.23
1968	0.29			0.00	0.40	4.51	1.86
1969	0.06			0.00	0.27	5.75	1.44
1970	0.01			0.01	0.24	7.43	3.00
1971	0.10			0.00	0.16	5.33	1.10
1972	0.10			0.02	0.34	4.13	2.98
1973	0.00			0.01	0.31	4.63	4.75
1974	-			0.02	0.13	3.00	2.12
1975	0.02	0.15		0.01	0.08	2.45	1.33
1976	0.05	0.10		0.02	0.04	1.75	2.65
1977	-	0.66	1.20	0.02	0.38	3.16	4.15
1978	-	0.10	1.24	0.01	0.46	4.19	5.06
1979	0.01	0.33	0.58	0.01	0.19	3.66	5.19
1980	-	0.63	1.97	0.09	0.35	4.58	6.30
1981	-	0.12	1.34	0.08	0.12	3.28	5.73
1982	-	0.14	3.39	0.01	0.04	0.66	8.42
1983	-	0.13	5.01	0.00	0.15	2.42	13.03
1984	0.01	0.16	3.59	0.03	0.20	2.85	13.47
1985	0.00	0.19	6.08	0.01	0.21	2.89	9.31
1986	0.03	0.53	2.56	0.00	0.21	1.60	16.01
1987	0.01	0.27	3.99	0.03	0.10	0.95	11.20
1988	0.01	0.07	4.97	0.02	0.29	1.49	7.67
1989	0.00	0.25	6.38	0.02	0.13	1.81	5.14
1990	0.03	0.36	4.92	0.02	0.20	1.72	7.23
1991	0.03	0.77	4.79	0.01	0.17	1.64	4.79
1992	0.00	0.28	5.01	0.03	0.13	0.93	3.63
1993	0.09	0.18	7.16	0.02	0.23	1.69	1.93
1994	0.04	0.53	3.28	0.07	0.10	1.53	2.15
1995	0.11	0.26	2.66	0.04	0.19	0.78	2.01
1996	0.04	0.40	6.63	0.04	0.18	0.80	2.31
1997	0.11	0.60	2.40	0.01	0.24	0.84	2.49
1998	0.09	1.14	5.09	0.05	0.03	0.66	3.80
1999	0.31	1.05	8.90	0.07	0.07	0.46	5.13
2000	0.27	1.10	6.15	0.03	0.16	0.83	4.44
2001	0.55	0.98	6.73	0.12	0.29	0.32	3.89
2002	0.72	0.93	5.97	0.05	0.11	0.41	5.66
2003	0.56	0.60	6.15	0.03	0.19	0.75	3.43
2004	1.33	0.80	5.95	0.05	0.22	0.72	4.08
2005	1.05	0.49	3.13	0.06	0.13	0.20	2.65
2006	1.17	0.48	3.33	0.06	0.21	0.74	2.52
2007	0.76	0.90	4.01	0.07	0.09	0.32	3.74
2008	1.11	1.23	6.29	0.03	0.10	0.20	9.62
2009	1.13	0.89	6.62	0.06	0.21	0.25	11.33
2010	1.10	0.68	10.63	0.03	0.18	0.28	8.09
2005-2007	0.994	0.622	3.489	0.064	0.147	0.421	2.969
2006-2008	1.013	0.871	4.541	0.052	0.135	0.420	5.294
2007-2009	0.999	1.009	5.639	0.053	0.133	0.258	8.232
2008-2010	1.114	0.933	7.848	0.040	0.161	0.245	9.684

6.2 Model 2 - Aggregate species size based catch efficiency

The general biomass trends using Model 2 calibrations are similar to Model 1, but the increase in the three year average biomass indices are less than Model 1, particularly for little and winter skate which have the greatest effect on the ABC calculation (because they comprise the greatest proportion of commercial catch which is used to weight the biomass indices).

The calculation of ABC for the surveys ending in 2009 and 2010 using the Model 2 calibration to adjust the FSV Bigelow data are shown in Table 22. The catch/biomass median includes the time series through 2007, is consistent with the FSV Bigelow sampled strata, and does not change with time.

The three year survey biomass moving average (Table 23), including the Model 2 calibrated survey for 2009 increased by 1% for little skate and 40% for winter skate, but declined by 35% for thorny skate. The three year biomass average for other skates changed by smaller amounts, except the noisy rosette skate biomass index (which does not influence the ABC much) increased by 26%. Although for little skate the 2009 biomass index decreased from 6.29 kg/tow on the FSV Albatross in 2008 to 3.42 kg/tow (Model 2 calibrated) on the FSV Bigelow in 2009 and for winter skate decreased from 9.62 kg/tow in 2008 to 8.92 kg/tow in 2009, therefore all of the increase in the three year biomass averages comes from dropping the 2006 biomass index, 3.33 and 2.52 kg/tow, respectively (Table 23).

As a result, the calculated ABC using the Model 2 calibrations would increase by 26% to 51,748 mt (Table 22). Similarly the TAL, assuming that the discard rate is 52% of total catch, increases by the same fraction from 14,780 to 18,618 mt and the wing TAL increases from 9,214 to 11,767 mt.

These survey trends and effects on the ABC were similar when the three year average survey biomass is updated for 2010 data, calibrated with Model 2 methods, increasing by another 10% for little skate and by 12% for winter skate (Table 23). The three year average increased for thorny skate (by 2%). Smooth skate biomass increased by 20% but at low overfished values (so the denominator is small) and the relatively noisy rosette skate three year average declined by 14% (after a 26% increase in 2009).

Updating for 2010 data (and dropping 2007 from the three year moving average) would increase the ABC to 57,974 mt (+41%), increasing the total TAL by the same fraction to 20,858 mt while the wing TAL would increase to 13,256 mt (Table 22). Again, much of the ABC increase is attributable to the relatively higher little and winter skate biomass indices, but also due to dropping the low 2007 values (4.01 and 3.74 kg/tow, respectively) from the average.

Table 22. Comparative calculation of ABC and other skate specifications (mt) using stratified mean biomass indices from FSV Bigelow survey strata, calibrated to FSV Albatross units via Model 2 methods. The survey biomass index is a three year average, kg/two, while the catch/biomass median is in mt/kg, including landings and discards through 2007.

		Catch		C/B derived catch limits		Catch/biomass		Survey biomass index	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
Surveys 2007 - 2009	Barndoor	400	320	3,767	2,826	3.222	2.417	1.169	
	Clearnose	1,110	888	3,322	2,491	2.695	2.021	1.233	
	Little	10,189	8,151	13,246	9,935	2.898	2.174	4.571	
	Rosette	47	38	136	102	2.090	1.567	0.065	
	Smooth	303	242	212	159	1.669	1.251	0.127	
	Thorny	5,209	4,167	851	638	3.117	2.337	0.273	
	Winter	16,586	13,269	30,214	22,660	4.067	3.051	7.428	
	Total	33,846	27,076	51,748	38,811				
	ABC (mt)	51,748							
	ACT (mt)	38,811	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Season 3
	TAL (mt)	18,618	17,694	11,767	-7.4%	5,928	1,826	2,199	1,903
		Catch		C/B derived catch limits		Catch/biomass		Survey biomass index	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
Surveys 2008 - 2010	Barndoor	400	320	4,655	3,491	3.222	2.417	1.445	
	Clearnose	1,110	888	3,558	2,669	2.695	2.021	1.320	
	Little	10,189	8,151	14,569	10,927	2.898	2.174	5.027	
	Rosette	47	38	117	88	2.090	1.567	0.056	
	Smooth	303	242	253	190	1.669	1.251	0.151	
	Thorny	5,209	4,167	867	650	3.117	2.337	0.278	
	Winter	16,586	13,269	33,955	25,466	4.067	3.051	8.348	
	Total	33,846	27,076	57,974	43,480				
	ABC (mt)	57,974							
	ACT (mt)	43,480	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Season 3
	TAL (mt)	20,858	19,934	13,256	4.3%	6,678	2,057	2,478	2,144

Table 23. Annual fall and spring (for little skate) stratified mean biomass using consistent FSV Bigelow strata with 2009 and 2010 values calibrated to FSV Albatross equivalents using Model 2, and three year moving averages.

Year	Barndoor	Clearnose	Little	Rosette	Smooth	Thorny	Winter
1964	1.16				0.24		
1965	1.88				0.49		
1966	0.82				0.36		
1967	0.34			0.02	0.18		2.23
1968	0.29			0.00	0.40	4.51	1.86
1969	0.06			0.00	0.27	5.75	1.44
1970	0.01			0.01	0.24	7.43	3.00
1971	0.10			0.00	0.16	5.33	1.10
1972	0.10			0.02	0.34	4.13	2.98
1973	0.00			0.01	0.31	4.63	4.75
1974	-			0.02	0.13	3.00	2.12
1975	0.02	0.15		0.01	0.08	2.45	1.33
1976	0.05	0.10		0.02	0.04	1.75	2.65
1977	-	0.66	1.20	0.02	0.38	3.16	4.15
1978	-	0.10	1.24	0.01	0.46	4.19	5.06
1979	0.01	0.33	0.58	0.01	0.19	3.66	5.19
1980	-	0.63	1.97	0.09	0.35	4.58	6.30
1981	-	0.12	1.34	0.08	0.12	3.28	5.73
1982	-	0.14	3.39	0.01	0.04	0.66	8.42
1983	-	0.13	5.01	0.00	0.15	2.42	13.03
1984	0.01	0.16	3.59	0.03	0.20	2.85	13.47
1985	0.00	0.19	6.08	0.01	0.21	2.89	9.31
1986	0.03	0.53	2.56	0.00	0.21	1.60	16.01
1987	0.01	0.27	3.99	0.03	0.10	0.95	11.20
1988	0.01	0.07	4.97	0.02	0.29	1.49	7.67
1989	0.00	0.25	6.38	0.02	0.13	1.81	5.14
1990	0.03	0.36	4.92	0.02	0.20	1.72	7.23
1991	0.03	0.77	4.79	0.01	0.17	1.64	4.79
1992	0.00	0.28	5.01	0.03	0.13	0.93	3.63
1993	0.09	0.18	7.16	0.02	0.23	1.69	1.93
1994	0.04	0.53	3.28	0.07	0.10	1.53	2.15
1995	0.11	0.26	2.66	0.04	0.19	0.78	2.01
1996	0.04	0.40	6.63	0.04	0.18	0.80	2.31
1997	0.11	0.60	2.40	0.01	0.24	0.84	2.49
1998	0.09	1.14	5.09	0.05	0.03	0.66	3.80
1999	0.31	1.05	8.90	0.07	0.07	0.46	5.13
2000	0.27	1.10	6.15	0.03	0.16	0.83	4.44
2001	0.55	0.98	6.73	0.12	0.29	0.32	3.89
2002	0.72	0.93	5.97	0.05	0.11	0.41	5.66
2003	0.56	0.60	6.15	0.03	0.19	0.75	3.43
2004	1.33	0.80	5.95	0.05	0.22	0.72	4.08
2005	1.05	0.49	3.13	0.06	0.13	0.20	2.65
2006	1.17	0.48	3.33	0.06	0.21	0.74	2.52
2007	0.76	0.90	4.01	0.07	0.09	0.32	3.74
2008	1.11	1.23	6.29	0.03	0.10	0.20	9.62
2009	1.64	1.56	3.42	0.10	0.19	0.30	8.92
2010	1.59	1.17	5.38	0.04	0.17	0.34	6.50
2005-2007	0.994	0.622	3.489	0.064	0.147	0.421	2.969
2006-2008	1.013	0.871	4.541	0.052	0.135	0.420	5.294
2007-2009	1.169	1.233	4.571	0.065	0.127	0.273	7.428
2008-2010	1.445	1.320	5.027	0.056	0.151	0.278	8.348

6.3 Model 3S - Aggregate catch efficiency by length and season

The general biomass trends using Model 3S calibrations are similar to Model 2, but the increase in the three year average biomass indices are less than Model 1 and greater than Model 2, particularly influenced by the little and winter skate calibrated indices which have the greatest effect on the ABC calculation (because they comprise the greatest proportion of commercial catch which is used to weight the biomass indices).

The calculation of ABC for the surveys ending in 2009 and 2010 using the Model 3S calibration to adjust the FSV Bigelow data are shown in Table 24. The catch/biomass median includes the time series through 2007, is consistent with the FSV Bigelow sampled strata, and does not change with time.

The three year survey biomass moving average (Table 25), including the Model 3S calibrated survey for 2009 increased by 7% for little skate and 45% for winter skate, but declined by 35% for thorny skate. The three year biomass average for other skates changed by smaller amounts, except the noisy rosette skate biomass index (which does not influence the ABC much) decreased by 7%. Although for little skate, the 2009 biomass index decreased from 6.29 kg/tow on the FSV Albatross in 2008 to 4.33 kg/tow (Model 3S calibrated) on the FSV Bigelow in 2009 and for winter skate increased from 9.62 kg/tow in 2008 to 9.71 kg/tow in 2009, therefore most of the increase in the three year biomass averages comes from dropping the 2006 biomass index, 3.33 and 2.52 kg/tow, respectively (Table 25).

As a result, the calculated ABC using the Model 3S calibrations would increase by 31% to 53,611 mt (Table 24). Similarly the TAL, assuming that the discard rate is 52% of total catch, increases by the same fraction from 14,780 to 19,289 mt and the wing TAL increases from 9,214 to 12,213 mt.

These survey trends and effects on the ABC were similar when the three year average survey biomass is updated for 2010 data, calibrated with Model 3S methods, increasing by another 19% for little skate and by 14% for winter skate (Table 25). The three year average increased slightly for thorny skate (by 1%). Smooth skate biomass increased by 18% but at low overfished values (so the denominator is small) and the relatively noisy rosette skate three year average declined by 33% (after a 7% decrease in 2009).

Updating for 2010 data (and dropping 2007 from the three year moving average) would increase the ABC to 61,871 mt (+51%), increasing the total TAL by the same fraction to 22,261 mt while the wing TAL would increase to 14,189 mt (Table 24). Again, much of the ABC increase is attributable to the relatively higher little and winter skate biomass indices, but also due to dropping the low 2007 values (4.01 and 3.74 kg/tow, respectively) from the average.

Table 24. Comparative calculation of ABC and other skate specifications (mt) using stratified mean biomass indices from FSV Bigelow survey strata, calibrated to FSV Albatross units via Model 3S methods. The survey biomass index is a three year average, kg/two, while the catch/biomass median is in mt/kg, including landings and discards through 2007.

		Catch		C/B derived catch limits		Catch/biomass		Survey biomass index	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
	Barndoor	400	320	3,641	2,731	3.222	2.417	1.130	
	Clearnose	1,110	888	3,396	2,547	2.695	2.021	1.260	
	Little	10,189	8,151	14,131	10,598	2.898	2.174	4.876	
Surveys 2007 - 2009	Rosette	47	38	101	75	2.090	1.567	0.048	
	Smooth	303	242	209	157	1.669	1.251	0.125	
	Thorny	5,209	4,167	856	642	3.117	2.337	0.275	
	Winter	16,586	13,269	31,277	23,458	4.067	3.051	7.690	
	Total	33,846	27,076	53,611	40,208				
	ABC (mt)	53,611							
	ACT (mt)	40,208	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Season 3
	TAL (mt)	19,289	18,365	12,213	-3.9%	6,152	1,895	2,282	1,975
		Catch		C/B derived catch limits		Catch/biomass		Survey biomass index	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
	Barndoor	400	320	4,409	3,307	3.222	2.417	1.368	
	Clearnose	1,110	888	3,682	2,762	2.695	2.021	1.366	
	Little	10,189	8,151	16,871	12,653	2.898	2.174	5.821	
Surveys 2008 - 2010	Rosette	47	38	67	50	2.090	1.567	0.032	
	Smooth	303	242	248	186	1.669	1.251	0.148	
	Thorny	5,209	4,167	869	652	3.117	2.337	0.279	
	Winter	16,586	13,269	35,724	26,793	4.067	3.051	8.783	
	Total	33,846	27,076	61,871	46,403				
	ABC (mt)	61,871							
	ACT (mt)	46,403	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Season 3
	TAL (mt)	22,261	21,337	14,189	11.7%	7,148	2,202	2,652	2,294

Table 25. Annual fall and spring (for little skate) stratified mean biomass using consistent FSV Bigelow strata with 2009 and 2010 values calibrated to FSV Albatross equivalents using Model 3S, and three year moving averages.

Year	Barndoor	Clearnose	Little	Rosette	Smooth	Thorny	Winter
1964	1.16				0.24		
1965	1.88				0.49		
1966	0.82				0.36		
1967	0.34			0.02	0.18		2.23
1968	0.29			0.00	0.40	4.51	1.86
1969	0.06			0.00	0.27	5.75	1.44
1970	0.01			0.01	0.24	7.43	3.00
1971	0.10			0.00	0.16	5.33	1.10
1972	0.10			0.02	0.34	4.13	2.98
1973	0.00			0.01	0.31	4.63	4.75
1974	-			0.02	0.13	3.00	2.12
1975	0.02	0.15		0.01	0.08	2.45	1.33
1976	0.05	0.10		0.02	0.04	1.75	2.65
1977	-	0.66	1.20	0.02	0.38	3.16	4.15
1978	-	0.10	1.24	0.01	0.46	4.19	5.06
1979	0.01	0.33	0.58	0.01	0.19	3.66	5.19
1980	-	0.63	1.97	0.09	0.35	4.58	6.30
1981	-	0.12	1.34	0.08	0.12	3.28	5.73
1982	-	0.14	3.39	0.01	0.04	0.66	8.42
1983	-	0.13	5.01	0.00	0.15	2.42	13.03
1984	0.01	0.16	3.59	0.03	0.20	2.85	13.47
1985	0.00	0.19	6.08	0.01	0.21	2.89	9.31
1986	0.03	0.53	2.56	0.00	0.21	1.60	16.01
1987	0.01	0.27	3.99	0.03	0.10	0.95	11.20
1988	0.01	0.07	4.97	0.02	0.29	1.49	7.67
1989	0.00	0.25	6.38	0.02	0.13	1.81	5.14
1990	0.03	0.36	4.92	0.02	0.20	1.72	7.23
1991	0.03	0.77	4.79	0.01	0.17	1.64	4.79
1992	0.00	0.28	5.01	0.03	0.13	0.93	3.63
1993	0.09	0.18	7.16	0.02	0.23	1.69	1.93
1994	0.04	0.53	3.28	0.07	0.10	1.53	2.15
1995	0.11	0.26	2.66	0.04	0.19	0.78	2.01
1996	0.04	0.40	6.63	0.04	0.18	0.80	2.31
1997	0.11	0.60	2.40	0.01	0.24	0.84	2.49
1998	0.09	1.14	5.09	0.05	0.03	0.66	3.80
1999	0.31	1.05	8.90	0.07	0.07	0.46	5.13
2000	0.27	1.10	6.15	0.03	0.16	0.83	4.44
2001	0.55	0.98	6.73	0.12	0.29	0.32	3.89
2002	0.72	0.93	5.97	0.05	0.11	0.41	5.66
2003	0.56	0.60	6.15	0.03	0.19	0.75	3.43
2004	1.33	0.80	5.95	0.05	0.22	0.72	4.08
2005	1.05	0.49	3.13	0.06	0.13	0.20	2.65
2006	1.17	0.48	3.33	0.06	0.21	0.74	2.52
2007	0.76	0.90	4.01	0.07	0.09	0.32	3.74
2008	1.11	1.23	6.29	0.03	0.10	0.20	9.62
2009	1.52	1.64	4.33	0.05	0.18	0.30	9.71
2010	1.47	1.22	6.84	0.02	0.16	0.33	7.02
2005-2007	0.994	0.622	3.489	0.064	0.147	0.421	2.969
2006-2008	1.013	0.871	4.541	0.052	0.135	0.420	5.294
2007-2009	1.130	1.260	4.876	0.048	0.125	0.275	7.690
2008-2010	1.368	1.366	5.821	0.032	0.148	0.279	8.783

6.4 Model 3SR - Aggregate catch efficiency by length, season, and region

The general biomass trends using Model 3SR calibrations are similar to Model 2, but the increase in the three year average biomass indices are less than Model 1 and greater than Model 2 and Model 3S, particularly influenced by the little and winter skate calibrated indices which have the greatest effect on the ABC calculation (because they comprise the greatest proportion of commercial catch which is used to weight the biomass indices).

The calculation of ABC for the surveys ending in 2009 and 2010 using the Model 3SR calibration to adjust the FSV Bigelow data are shown in Table 26. The catch/biomass median includes the time series through 2007, is consistent with the FSV Bigelow sampled strata, and does not change with time.

The three year survey biomass moving average (Table 27), including the Model 3SR calibrated survey for 2009 increased by 8% for little skate and 50% for winter skate, but declined by 30% for thorny skate. The three year biomass average for other skates changed by smaller amounts, except the noisy rosette skate biomass index (which does not influence the ABC much) decreased by 4%. Although for little skate, the 2009 biomass index decreased from 6.29 kg/tow on the FSV Albatross in 2008 to 4.37 kg/tow (Model 3SR calibrated) on the FSV Bigelow in 2009 and for winter skate increased from 9.62 kg/tow in 2008 to 10.45 kg/tow in 2009, therefore most of the increase in the three year biomass averages comes from dropping the 2006 biomass index, 3.33 and 2.52 kg/tow, respectively (Table 27).

As a result, the calculated ABC using the Model 3SR calibrations would increase by 33% to 54,784 mt (Table 26). Similarly the TAL, assuming that the discard rate is 52% of total catch, increases by the same fraction from 14,780 to 19,711 mt and the wing TAL increases from 9,214 to 12,493 mt.

These survey trends and effects on the ABC were similar when the three year average survey biomass is updated for 2010 data, calibrated with Model 3SR methods, increasing by another 20% for little skate and by 15% for winter skate (Table 27). The three year average for thorny skate increased by 7%. Smooth skate biomass increased by 23% but at low overfished values (so the denominator is small) and the relatively noisy rosette skate three year average declined by 31% (after a 4% decrease in 2009).

Updating for 2010 data (and dropping 2007 from the three year moving average) would increase the ABC to 63,478 mt (+55%), increasing the total TAL by the same fraction to 22,839 mt while the wing TAL would increase to 14,573 mt (Table 26). Again, much of the ABC increase is attributable to the relatively higher little and winter skate biomass indices, but also due to dropping the low 2007 values (4.01 and 3.74 kg/tow, respectively) from the average.

Table 26. Comparative calculation of ABC and other skate specifications (mt) using stratified mean biomass indices from FSV Bigelow survey strata, calibrated to FSV Albatross units via Model 3SR methods. The survey biomass index is a three year average, kg/two, while the catch/biomass median is in mt/kg, including landings and discards through 2007.

		Catch		C/B derived catch limits		Catch/biomass		Survey biomass index	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
Surveys 2007 - 2009	Barndoor	400	320	3,878	2,908	3.222	2.417	1.203	
	Clearnose	1,110	888	3,193	2,395	2.695	2.021	1.185	
	Little	10,189	8,151	14,172	10,629	2.898	2.174	4.890	
	Rosette	47	38	104	78	2.090	1.567	0.050	
	Smooth	303	242	229	172	1.669	1.251	0.137	
	Thorny	5,209	4,167	918	689	3.117	2.337	0.295	
	Winter	16,586	13,269	32,291	24,218	4.067	3.051	7.939	
	Total	33,846	27,076	54,784	41,088				
	ABC (mt)	54,784							
	ACT (mt)	41,088	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Season 3
	TAL (mt)	19,711	18,787	12,493	-1.7%	6,294	1,938	2,335	2,020
		Catch		C/B derived catch limits		Catch/biomass		Survey biomass index	
	Species	Median	80% of medi	Median	75% of medi	Median	75% of median		
Surveys 2008 - 2010	Barndoor	400	320	4,881	3,661	3.222	2.417	1.515	
	Clearnose	1,110	888	3,329	2,496	2.695	2.021	1.235	
	Little	10,189	8,151	16,928	12,696	2.898	2.174	5.841	
	Rosette	47	38	71	54	2.090	1.567	0.034	
	Smooth	303	242	283	212	1.669	1.251	0.170	
	Thorny	5,209	4,167	987	740	3.117	2.337	0.317	
	Winter	16,586	13,269	36,999	27,750	4.067	3.051	9.096	
	Total	33,846	27,076	63,478	47,609				
	ABC (mt)	63,478							
	ACT (mt)	47,609	Federal TAL	Wing TAL	Mortality red	Bait TAL	Season 1	Season 2	Season 3
	TAL (mt)	22,839	21,915	14,573	14.7%	7,341	2,261	2,724	2,357

Table 27. Annual fall and spring (for little skate) stratified mean biomass using consistent FSV Bigelow strata with 2009 and 2010 values calibrated to FSV Albatross equivalents using Model 3SR, and three year moving averages.

Year	Barndoor	Clearnose	Little	Rosette	Smooth	Thorny	Winter
1964	1.16				0.24		
1965	1.88				0.49		
1966	0.82				0.36		
1967	0.34			0.02	0.18		2.23
1968	0.29			0.00	0.40	4.51	1.86
1969	0.06			0.00	0.27	5.75	1.44
1970	0.01			0.01	0.24	7.43	3.00
1971	0.10			0.00	0.16	5.33	1.10
1972	0.10			0.02	0.34	4.13	2.98
1973	0.00			0.01	0.31	4.63	4.75
1974	-			0.02	0.13	3.00	2.12
1975	0.02	0.15		0.01	0.08	2.45	1.33
1976	0.05	0.10		0.02	0.04	1.75	2.65
1977	-	0.66	1.20	0.02	0.38	3.16	4.15
1978	-	0.10	1.24	0.01	0.46	4.19	5.06
1979	0.01	0.33	0.58	0.01	0.19	3.66	5.19
1980	-	0.63	1.97	0.09	0.35	4.58	6.30
1981	-	0.12	1.34	0.08	0.12	3.28	5.73
1982	-	0.14	3.39	0.01	0.04	0.66	8.42
1983	-	0.13	5.01	0.00	0.15	2.42	13.03
1984	0.01	0.16	3.59	0.03	0.20	2.85	13.47
1985	0.00	0.19	6.08	0.01	0.21	2.89	9.31
1986	0.03	0.53	2.56	0.00	0.21	1.60	16.01
1987	0.01	0.27	3.99	0.03	0.10	0.95	11.20
1988	0.01	0.07	4.97	0.02	0.29	1.49	7.67
1989	0.00	0.25	6.38	0.02	0.13	1.81	5.14
1990	0.03	0.36	4.92	0.02	0.20	1.72	7.23
1991	0.03	0.77	4.79	0.01	0.17	1.64	4.79
1992	0.00	0.28	5.01	0.03	0.13	0.93	3.63
1993	0.09	0.18	7.16	0.02	0.23	1.69	1.93
1994	0.04	0.53	3.28	0.07	0.10	1.53	2.15
1995	0.11	0.26	2.66	0.04	0.19	0.78	2.01
1996	0.04	0.40	6.63	0.04	0.18	0.80	2.31
1997	0.11	0.60	2.40	0.01	0.24	0.84	2.49
1998	0.09	1.14	5.09	0.05	0.03	0.66	3.80
1999	0.31	1.05	8.90	0.07	0.07	0.46	5.13
2000	0.27	1.10	6.15	0.03	0.16	0.83	4.44
2001	0.55	0.98	6.73	0.12	0.29	0.32	3.89
2002	0.72	0.93	5.97	0.05	0.11	0.41	5.66
2003	0.56	0.60	6.15	0.03	0.19	0.75	3.43
2004	1.33	0.80	5.95	0.05	0.22	0.72	4.08
2005	1.05	0.49	3.13	0.06	0.13	0.20	2.65
2006	1.17	0.48	3.33	0.06	0.21	0.74	2.52
2007	0.76	0.90	4.01	0.07	0.09	0.32	3.74
2008	1.11	1.23	6.29	0.03	0.10	0.20	9.62
2009	1.74	1.42	4.37	0.05	0.22	0.36	10.45
2010	1.69	1.05	6.86	0.02	0.19	0.39	7.21
2005-2007	0.994	0.622	3.489	0.064	0.147	0.421	2.969
2006-2008	1.013	0.871	4.541	0.052	0.135	0.420	5.294
2007-2009	1.203	1.185	4.890	0.050	0.137	0.295	7.939
2008-2010	1.515	1.235	5.841	0.034	0.170	0.317	9.096

6.5 Summary

Most of the increase from the Amendment 3 ABC of 41,080 mt using 2006-2008 FSV Albatross weight per tow data would occur because of generally increasing biomass in 2009 and 2010 (especially compared with 2006-2007), particularly for little and winter skates regardless of the applied calibration model. Without accounting for the effect that using FSV Bigelow strata would have and using Model 1 to calibrate 2009 and 2010 data, the ABC would increase to 68,380 mt (+66%, Table 30 column 3). If the effect of using consistent FSV Bigelow strata is taken into account and the catch/biomass medians are recalculated on that basis, the aggregate ABC would increase to 72,651 mt (Table 30 column 5), mostly from the increase in the catch/biomass median for little skate. This result is only illustrative of the effect that the FSV Bigelow consistent strata would have on the ABC, calculated using the same mean biomass data as that applied to the FSV Albatross strata results.

Using the consistent FSV Bigelow strata and applying the Model 1 calibration to 2009 and 2010 FSV Bigelow data would increase the ABC to 69,353 mt (+69%, Table 30 column 6), most of the difference coming from little skate which was less abundant during 2007 in the more offshore FSV Bigelow strata. Model 2 (Table 30 column 7) gives the most conservative (i.e. lowest) ABC results, the biggest reductions compared to Model 1 in little and winter skates. Although the calibrated three year average is higher for some skates (i.e. barndoor, clearnose, rosette, smooth, and thorny), the largest reduction compared to Model 1 calibration is for little and winter skates which when taken together the effect is to reduce the total ABC to 57,556 mt (still a 40% increase over current specifications). Model 3S and Model 3SR produce intermediate ABCs of 61,452 mt (+50%) and 62,985 mt (+53%), primarily because the calibration coefficient for winter skate is lower than it is for Model 2 (Table 28).

The general trend in the potential ABC specifications using calibrated data is the same, driven primarily by the increase in the mean weight per tow for little and winter skates (and by omitting 2006 and 2007 surveys when mean weight per tow was relatively low). There are however differences between the three model types (four results depending on whether Model 3 is stratified by season only or season and region). Models 2, 3S and 3SR are more conservative than Model 1, presumably because the calibration coefficients by length are higher for smaller size skates than they are in the aggregate for Model 1.

These differences caused by changes in length frequency (Models 2, 3S, and 3SR), availability to the survey (Models 3S and 3SR), and geographical distribution (Model 3R) will cause the ABC to vary by year. For example, the ABC increase caused by updating the three year average from 2007-2009 to 2008 to 2010 (Table 29) is 21.9% for Model 1, 12.0% for Model 2, 15.4% for Model 3S, and 16.4% for Model 3SR.

Table 28. Three year (2008-2010) catch per tow for three models to calibrate 2009-2010 FSV Bigelow data into FSV Albatross equivalents, using consistent FSV Bigelow strata.

Species	Model 1	Model 2	Model 3S	Model 3SR
Barndoor	1.114	1.445	1.368	1.515
Clearnose	0.933	1.320	1.366	1.235
Little	7.848	5.027	5.821	5.841
Rosette	0.040	0.056	0.032	0.034
Smooth	0.161	0.151	0.148	0.170
Thorny	0.245	0.278	0.145	0.158
Winter	9.684	8.348	8.783	9.096

Table 29. Summary of ABC specifications by calibration model and three year average biomass, percent increase from current specifications is parenthesized.

Model	2007-2009 survey	2008-2010 survey
Model 1 (by species)	56,900 (+39%)	69,353 (+68%)
Model 2 (aggregate species by length)	51,748 (+26%)	57,974 (+41%)
Model 3S (fitted to length by season)	53,611 (+31%)	61,871 (+51%)
Model 3SR (fitted to length by season and region)	54,784 (+33%)	63,748 (+55%)

Table 30. Partial effects of stratification and calibration of 2009 and 2010 FSV Bigelow biomass catches with four models. Model 1 uses constant calibration at length by species. Model 2 uses a calibration coefficient fitted at length for all species combined. Model 3S calibrations are fitted to length by season, and Model 3SR calibrations are fitted to length by season and region.

Species	FSV Albatross strata		Consistent FSV Bigelow strata					
	C/B median (kg/tow)	ABC[3] (mt)	C/B median (kg/tow)	ABC[1] (mt)	Model 1 ABC (mt)	Model 2 ABC (mt)	Model 3S ABC (mt)	Model 3SR ABC (mt)
Barndoor	3.23	68,380	3.22	68,371	68,398	70,417	70,171	70,643
Clearnose	2.44	68,380	2.69	68,661	68,208	70,396	70,520	70,166
Little	2.39	68,380	2.90	72,899	69,868	61,179	63,480	63,538
Rosette	2.19	68,380	2.09	68,376	68,373	69,386	69,337	69,341
Smooth	1.69	68,380	1.67	68,376	68,374	69,338	69,333	69,368
Thorny	3.14	68,380	3.12	68,374	68,364	69,040	69,041	69,084
Winter	4.12	68,380	4.07	67,873	68,047	63,919	65,688	66,964
All		68,380		72,651	69,353	57,556	61,452	62,985

[3] Model 1 calibration applied to 2009 and 2010 FSV Bigelow catches.

7.0 Effects on setting ABC using calibrated 2008 FSV Albatross and uncalibrated 2009-2010 FSV Bigelow survey data

The effects on skate ABCs from converting the FSV Albatross to FSV Bigelow units is theoretically the same as that described in Section 6.0. But the conversion process itself introduces error arising from uncertainty in the calibration coefficients, particularly if the conversion is applied to individual lengths or tows (see working document titled, "Conversion of Skate Abundance Indices from Albatross to Bigelow Units") as required for calibration Models 2 and 3. Applying the calibration coefficients to a longer FSV Albatross time series would infuse more error into the time series and the biological reference points, but the effects on the catch/biomass median and other reference points needs further research. In addition, because the FSV Bigelow catches several times the amount of skates that were observed in the comparable FSV Albatross tows, there are times and places where the FSV Bigelow would catch skates where the FSV Albatross did not, creating special challenges for converting zero values (whether by tow, or in the case of barndoor skate for the annual mean biomass) to an FSV Bigelow equivalent. This special problem has not yet been adequately analyzed or vetted.

Finally, there is a matter of workload. At the present time, there are several choices about which calibration model and analytical method to use. Until that decision is made, it would take substantial work to adjust the longer FSV Albatross time series for all choices. If the SSC approves one method and decides on how to treat the additional error and zero values, then the Skate PDT can covert the FSV Albatross time series into FSV Bigelow units, estimate new biological reference points in FSV Bigelow units, and set the ABC based on unconverted FSV Bigelow mean biomass.

8.0 Conclusions

Based on the above thorough analysis, the Skate PDT drew the following conclusions about the four calibration approaches presented in this report. In general, there are some tradeoffs to be considered in choosing which model is the best to use. Model 1 accounts for differences in behavior by skate species, but may not account for differences in length-based processes and requires an assumption for rosette skate, due to insufficient observations during the calibration surveys. Model 2 accounts for length based processes, but these may be reflective of differences in the proportions of skates at each length. Models 3R and especially 3SR may capture the length based processes while the regional difference helps to separate the influence of differential size frequencies (particularly little skate in the northern region).

- Consistent FSV Bigelow strata should be used with recalculated catch/biomass medians to set ABC. Adjustments to biological reference points are needed to properly compare the FSV Bigelow calibrated results with mortality thresholds and biomass thresholds and targets to determine status.

- Conversion of FSV Albatross catch per tow data into FSV Bigelow equivalents introduces error into the 45 year time series and introduces additional complications. Until these issues can be resolved, the PDT recommends converting FSV Bigelow data into FSV Albatross equivalents for the purposes of setting ABC and making status determinations.

- All three Model types follow the same principals and apply the same assumed error distribution as reviewed in the 2009 SAW review. The Model 2 approach has been applied for several other species due to differences in relative catch efficiency at size, particularly for flatfish which are less prone to capture by the FSV Albatross trawl which employs rollers.

- Model 1 is the least complex and easiest to apply to future survey results and addresses species specific differences in relative catch efficiency which appear to be important particularly for little and winter skate. This model would be easier to apply if we were to re-calibrate FSVA catches in FSVB equivalents.

- Models 2 and 3 will respond better to changes in length frequency by season (3S) and region (3SR) and be less sensitive to new recruitment (which is a desirable result because the calibration coefficient appears to be considerably higher for small skates that are captured more efficiently by the FSV Bigelow). Length based calibrations would complicate a conversion of FSVA catches into FSVB equivalents.

- Model 3SR incorporates regional differences in relative catch efficiency and could be more consistent with potentially establishing regionally based ABCs if the management unit is split to protect overfished skates in the north. The consequences of a regional based ABC are however unknown and may not be intuitive. Indirectly, it also addresses a species specific length based calibration model because of the differential geographical distribution of various skate species.

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