Table 1. a) Development of binomial GAMM models ranked by increasing AIC. b) GAM summary table for the final model*. c) Output from gam.check evaluating the basis dimensions of smoothing splines.

a) Model	Residual deviance	% deviance explained	Dispersion	AIC	logLik	deltaAIC
s(Survey, bs="re", by=dum)+offset(logAreasw)+ s(solar altitude, by=Survey, bs="cc")+ te(x.utm, y.utm,yr, by=season, bs="cs")*	10203	40	0.912	10403	-5102	0
s(Survey, bs="re", by=dum)+offset(logAreasw)+ s(solar altitude, by=Survey, bs="cc")+ te(x.utm, y.utm, year, bs="cs")	11590	32	1.022	11806	-5795	1402
s(Survey, bs="re", by=dum)+offset(logAreasw)+ s(solar altitude, by=Survey, bs="cc")+ te(x.utm, y.utm, bs="cs")	12395	27	1.134	12474	-6198	2071
s(Survey, bs="re", by=dum)+offset(logAreasw)+ s(solar altitude, by=Survey, bs="cc")	14561	14.	0.993	14618	-7280	4215
s(Survey, bs="re", by=dum)+offset(logAreasw)+ s(solar altitude,bs="cc")	14969	12	1.020	14992	-7485	4589
s(Survey, bs="re", by=dum)+offset(logAreasw)	15095	11	1.008	15103	-7548	4700
s(Survey, bs="re", by=dum)	15128	14	0.998	15136	-7564	4732
~1	17631	0.000	1.000	17633	-8815	7229

Table 1b) Summary table for the final binomial GAMM model.

```
Family: binomial
Link function: logit
Formula:
Total.Count > 0 ~ s(Survey, bs = "re", by = dum) + offset(logAreasw) +
    s(altitude, by = Survey, bs = "cc") + te(x.utm, y.utm, yr,
    by = seas, bs = "cs")
Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -7.6413     0.3943  -19.38   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                             edf Ref.df    Chi.sq  p-value
s(Survey):dum            2.48903      3    97.854  < 2e-16 ***
s(altitude):SurveyCAN    0.06538      8     0.062    0.378
s(altitude):SurveyMENH   3.57539      8   103.149 1.02e-06 ***
s(altitude):SurveyNEAMAP 5.30534      8   176.406 2.45e-05 ***
s(altitude):SurveyNEFSC  5.76999      8    60.908 1.33e-12 ***
te(x.utm,y.utm,yr):seas 87.46750    125 12840.763  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.494   Deviance explained = 44.4%
-REML = 6982.6  Scale est. = 1         n = 20877
```

Table 1c) Evaluation of adequacy of basis dimensions of the final binomial GAMM

```
Method: REML   Optimizer: outer newton
full convergence after 9 iterations.
Gradient range [-0.002734402,0.0002251932]
(score 6982.594 & scale 1).
Hessian positive definite, eigenvalue range [0.003774754,12.20726].
Model rank =  162 / 162
Basis dimension (k) checking results. Low p-value (k-index<1) may
indicate that k is too low, especially if edf is close to k'.
                               k'      edf k-index p-value
s(Survey):dum              4.0000   2.4890      NA      NA
s(altitude):SurveyCAN      8.0000   0.0654    1.01    0.82
s(altitude):SurveyMENH     8.0000   3.5754    1.01    0.84
s(altitude):SurveyNEAMAP   8.0000   5.3053    1.01    0.84
s(altitude):SurveyNEFSC    8.0000   5.7700    1.01    0.86
te(x.utm,y.utm,yr):seas  125.0000  87.4675    0.88  <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 2. Availability estimates for the fishery ($v_{fishery}$) and NEFSC survey (v_{survey}) strata used to develop abundance indices for Illex. Area (km^2) calculations were developed using the species distribution model predictions (+/-SE) classified with the sensitivity-specificity threshold (0.29; sens-spec) and the negative and positive predicted value threshold (0.7; Pred.value) for probability of occupancy. Availability estimates are ratios of the area of overlap of the fishery or survey with the species distribution divided by the species distribution area. $V_{fishery}$ was evaluated using only summer/fall projections of the SDM. The survey area included offshore strata 1-30, 350, 351, 36-40 and 61-76 and was estimated to be 209,670km^2 when rasterized onto the analysis grid.

			Species distribution Area at threshold			$v_{fishery}$ at threshold		v_{survey} at threshold	
Year	Season	Grid used	sens-spec	pred. value	Fishery Area	sens-spec	pred. value	sens-spec	Pred. val
2008	fall	prediction	399587	179461	671	0.002	0.003	0.378	0.320
2008	fall	prediction-SE	374522	130085	671	0.002	0.004	0.383	0.309
2008	fall	prediction+SE	415643	221088	671	0.002	0.003	0.376	0.331
2009	fall	prediction	421661	248982	807	0.002	0.003	0.366	0.331
2009	fall	prediction-SE	409793	214078	807	0.002	0.003	0.366	0.328
2009	fall	prediction+SE	433033	289335	807	0.002	0.002	0.363	0.327
2010	fall	prediction	445781	336396	1077	0.003	0.003	0.351	0.315
2010	fall	prediction-SE	433469	293697	1077	0.003	0.004	0.353	0.327
2010	fall	prediction+SE	456394	373357	1077	0.002	0.003	0.349	0.309
2011	fall	prediction	447147	324606	1681	0.004	0.005	0.352	0.351
2011	fall	prediction-SE	423960	296407	1681	0.004	0.006	0.364	0.358
2011	fall	prediction+SE	466261	355279	1681	0.004	0.005	0.345	0.343
2012	fall	prediction	420497	287890	941	0.002	0.003	0.377	0.400
2012	fall	prediction-SE	401754	251965	941	0.002	0.004	0.387	0.427
2012	fall	prediction+SE	438420	316806	941	0.002	0.003	0.367	0.386
2013	fall	prediction	387264	217287	1273	0.003	0.005	0.409	0.488
2013	fall	prediction-SE	355717	148844	1273	0.004	0.006	0.436	0.621
2013	fall	prediction+SE	409291	257392	1273	0.003	0.005	0.394	0.467
2014	fall	prediction	351749	165228	1344	0.004	0.006	0.452	0.576
2014	fall	prediction-SE	334468	115957	1344	0.004	0.008	0.464	0.732
2014	fall	prediction+SE	379306	213609	1344	0.004	0.005	0.427	0.508
2015	fall	prediction	356950	187719	1133	0.003	0.005	0.448	0.505
2015	fall	prediction-SE	342476	152666	1133	0.003	0.006	0.455	0.553
2015	fall	prediction+SE	373049	216506	1133	0.003	0.005	0.438	0.499

Table 2 continued

			Species distribution Area at threshold			$v_{fishery}$ at threshold		v_{survey} at threshold	
Year	Season	Grid used	sens-spec	pred. value	Fishery Area	sens-spec	pred. value	sens-spec	pred. val
2016	fall	prediction	392977	228367	1609	0.004	0.007	0.412	0.454
2016	fall	prediction-SE	366041	204391	1609	0.005	0.008	0.428	0.455
2016	fall	prediction+SE	435218	255273	1609	0.004	0.006	0.383	0.446
2017	fall	prediction	446634	301059	3065	0.007	0.010	0.369	0.367
2017	fall	prediction-SE	420387	271433	3065	0.008	0.011	0.379	0.376
2017	fall	prediction+SE	467649	344111	3065	0.007	0.009	0.362	0.347
2018	fall	prediction	468022	372255	3656	0.008	0.010	0.358	0.319
2018	fall	prediction-SE	451118	354294	3656	0.008	0.011	0.361	0.313
2018	fall	prediction+SE	479915	393899	3656	0.008	0.009	0.356	0.323
2019	fall	prediction	471067	396878	2795	0.006	0.007	0.360	0.321
2019	fall	prediction-SE	455468	377763	2795	0.006	0.007	0.359	0.309
2019	fall	prediction+SE	483185	418723	2795	0.006	0.006	0.360	0.328
2008	spring	prediction	54794	11368				0.205	0.141
2008	spring	prediction-SE	36130	6781				0.210	0.118
2008	spring	prediction+SE	73442	18435				0.230	0.145
2009	spring	prediction	53867	4406				0.298	0.121
2009	spring	prediction-SE	36393	3071				0.313	0.022
2009	spring	prediction+SE	68868	7716				0.291	0.147
2010	spring	prediction	42042	3669				0.530	0.018
2010	spring	prediction-SE	35802	2468				0.475	0.027
2010	spring	prediction+SE	54849	5990				0.492	0.089
2011	spring	prediction	47700	6123				0.576	0.109
2011	spring	prediction-SE	41451	4331				0.528	0.046
2011	spring	prediction+SE	54261	8576				0.604	0.148
2012	spring	prediction	50385	10250				0.599	0.254
2012	spring	prediction-SE	45579	8329				0.564	0.256
2012	spring	prediction+SE	54787	12432				0.625	0.263
2013	spring	prediction	51499	14177				0.608	0.348
2013	spring	prediction-SE	46237	11728				0.573	0.358

Table 2 continued

			Species distribution Area at threshold			$v_{fishery}$ at threshold		v_{survey} at threshold	
Year	Season	Grid used	sens-spec	pred. value	Fishery Area	sens-spec	pred. value	sens-spec	pred. val
2013	spring	prediction+SE	56037	16487				0.635	0.360
2014	spring	prediction	52748	15641				0.613	0.362
2014	spring	prediction-SE	47807	13112				0.581	0.381
2014	spring	prediction+SE	57484	18548				0.635	0.384
2015	spring	prediction	54853	15574				0.614	0.304
2015	spring	prediction-SE	50309	13844				0.586	0.303
2015	spring	prediction+SE	58931	19080				0.633	0.324
2016	spring	prediction	57878	16107				0.616	0.240
2016	spring	prediction-SE	52288	13061				0.588	0.220
2016	spring	prediction+SE	69614	20983				0.583	0.273
2017	spring	prediction	112045	17561				0.373	0.220
2017	spring	prediction-SE	92158	13543				0.391	0.212
2017	spring	prediction+SE	132204	22682				0.357	0.287
2018	spring	prediction	238499	28216				0.220	0.212
2018	spring	prediction-SE	188827	18072				0.244	0.225
2018	spring	prediction+SE	269220	42987				0.213	0.213
2019	spring	prediction	299191	103145				0.206	0.110
2019	spring	prediction-SE	273357	72126				0.195	0.104
2019	spring	prediction+SE	318845	140356				0.220	0.118

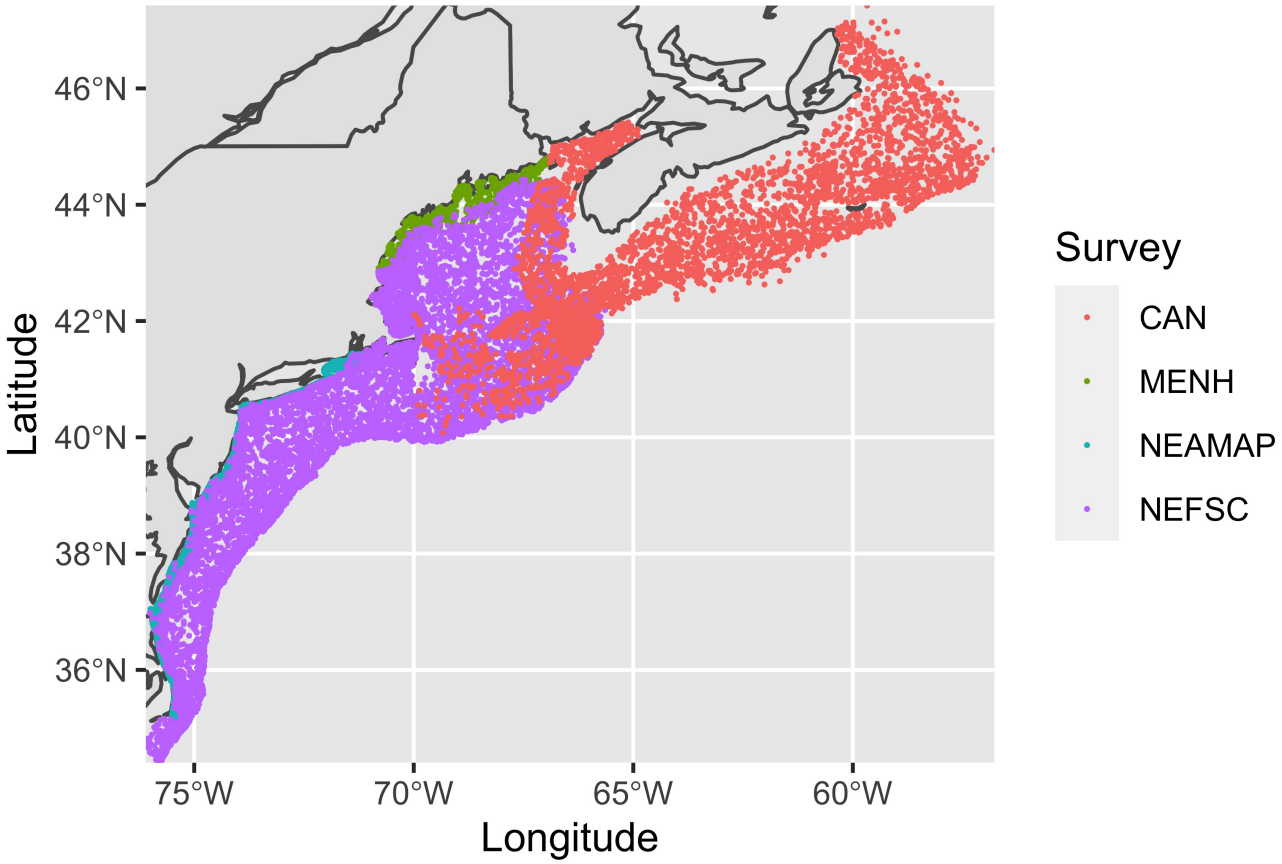


Figure 1. Map of stations sampled in the surveys of the continental shelf used to train and test the binomial GAM used to project *Illex* species distributions

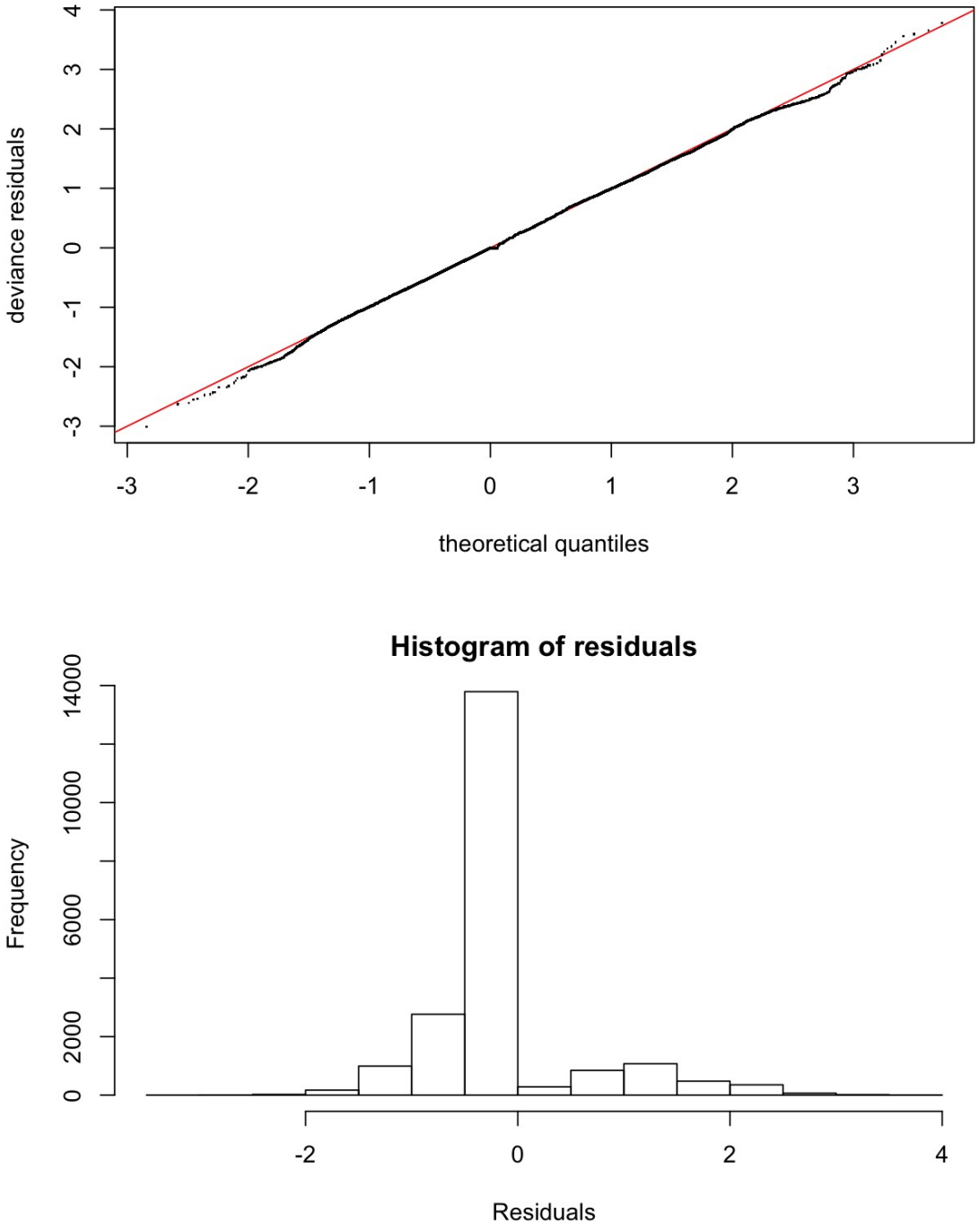
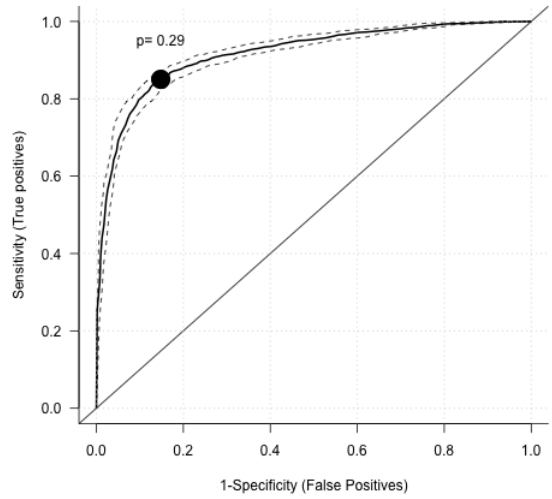
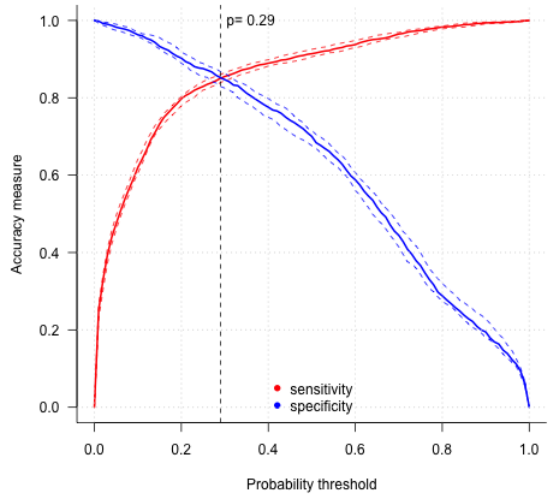


Figure 2. Distribution of residuals of the final binomial GAMM model. See table 1.





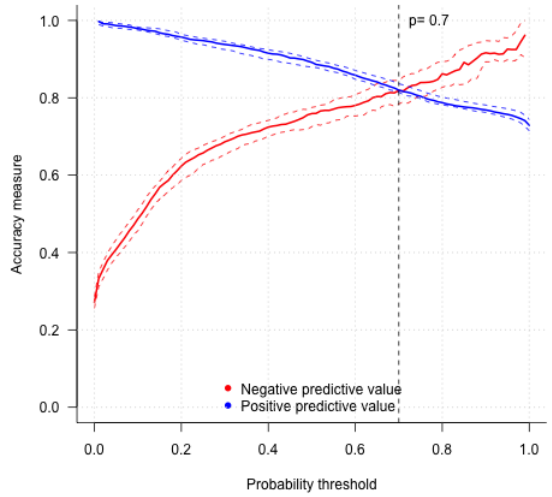


Figure 3. Top) Reciever Operator Characteristic (ROC) curves derived from 10 cross validated tests of the model. The point in the panel indicates the location on the ROC curve where sensitivity and specificity values were minimized. The diagonal line indicates the region where true and false positives are equally likely by chance. Middle) Sensitivity (the true positive predictions i.e. presences) and specificity (the true negative predictions i.e. absences) as a function of probability threshold for predicted presence from 10-fold cross validation of the GAMM species distribution model. The vertical line indicates the probability threshold where the difference between sensitivity and specificity was minimized (0.29). Bottom) Negative predictive value (proportion of negative predictions that are actually negative) and positive predictive value (proportion of positives predictions that are actually positive) were minimized at a probability threshold of 0.7. Dotted lines are 95% confidence limits developed from the 10 fold cross validation. The sensitivity-specificity and predictive value thresholds were used to classify projections of the species distributions (see Figure 4)

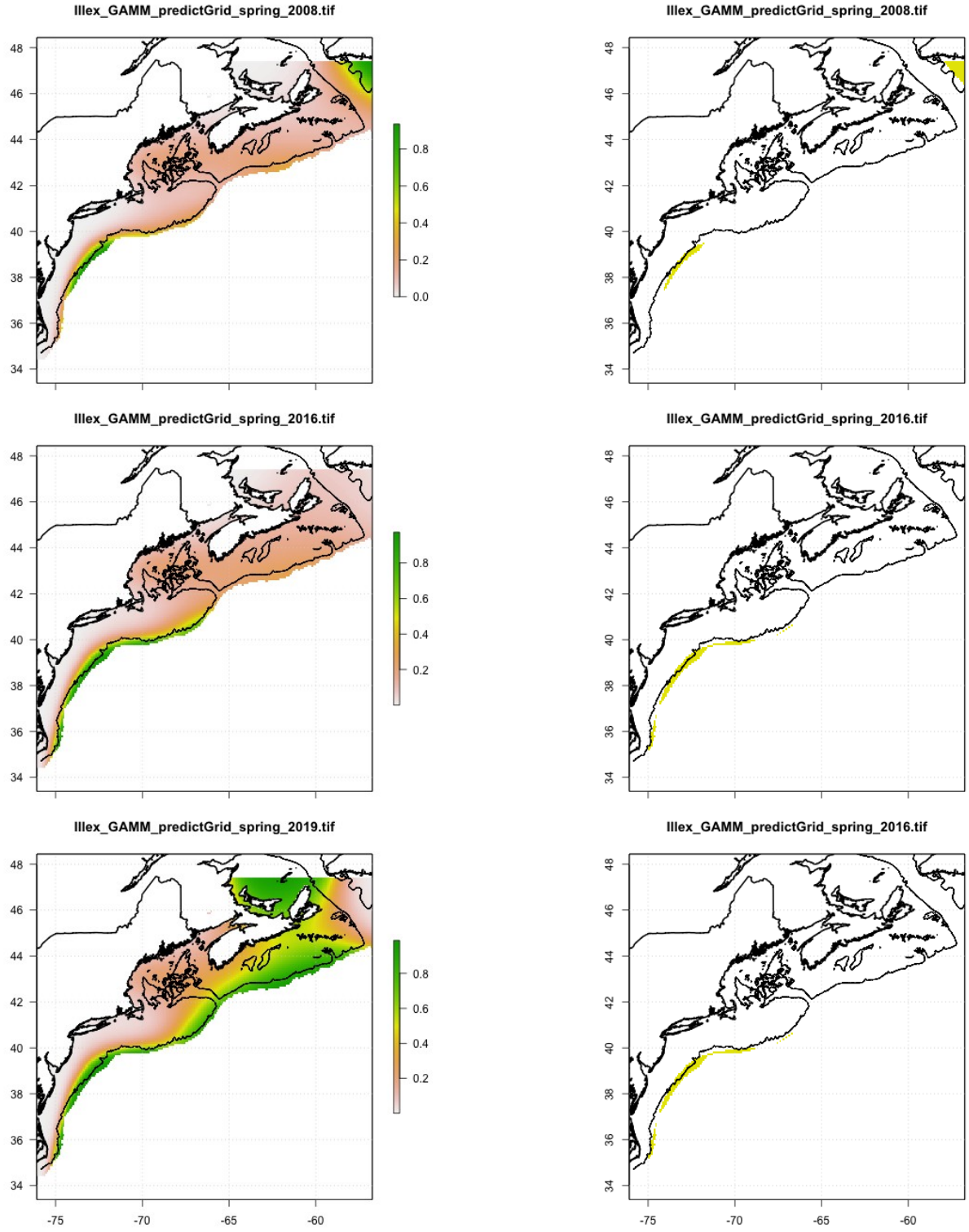


Figure 4a. Left) Projections of probability of occupancy for Illex from the GAMMSDM during the spring of 2008 (top), 2016 (middle), and 2019 (Bottom). Right) Species distribution maps (yellow) developed by classifying probabilities of occupancy depicted in the left panels using the predictive value threshold (0.7).

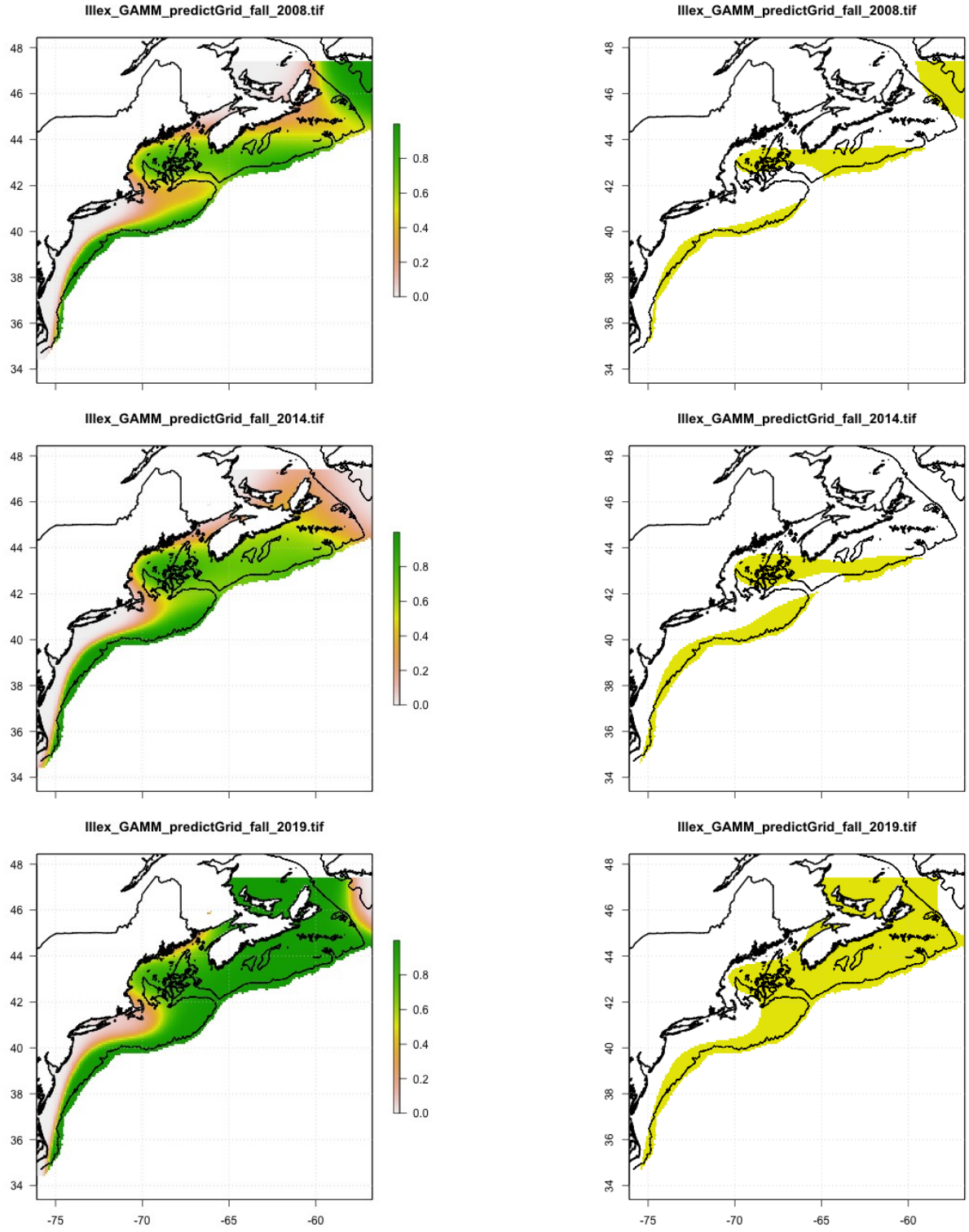


Figure 4b. Left) Projections of probability of occupancy for Illex from the GAMM during the fall of 2008 (top), 2014 (middle), and 2019 (Bottom). Right) Species distribution maps (yellow) developed by classifying probabilities of occupancy depicted in the left panels using the predictive value threshold (0.7).

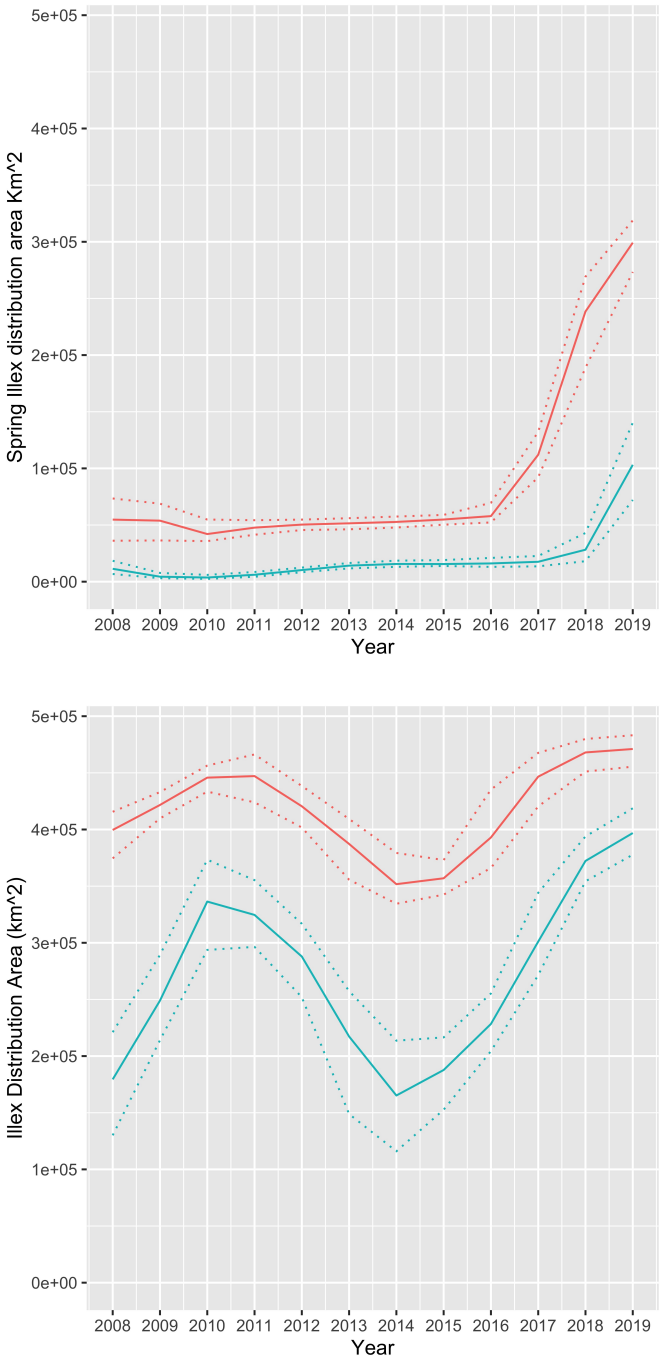


Figure 5. Species distribution areas (SDA) computed from projections of the species distribution model for Illex on the analysis grid classified on the basis of the sensitivity-specificity threshold (red) and the positive and negative predictive value threshold (blue). Top) SDA during the spring. Bottom) SDA in the fall. Dotted lines are areas calculated from predicted probabilities of occupancy +/- 1SE. SDAs including those associated with standard errors were used in the denominator in calculations of availability to the fishery (v_f) and the survey (v_s) in Table 2

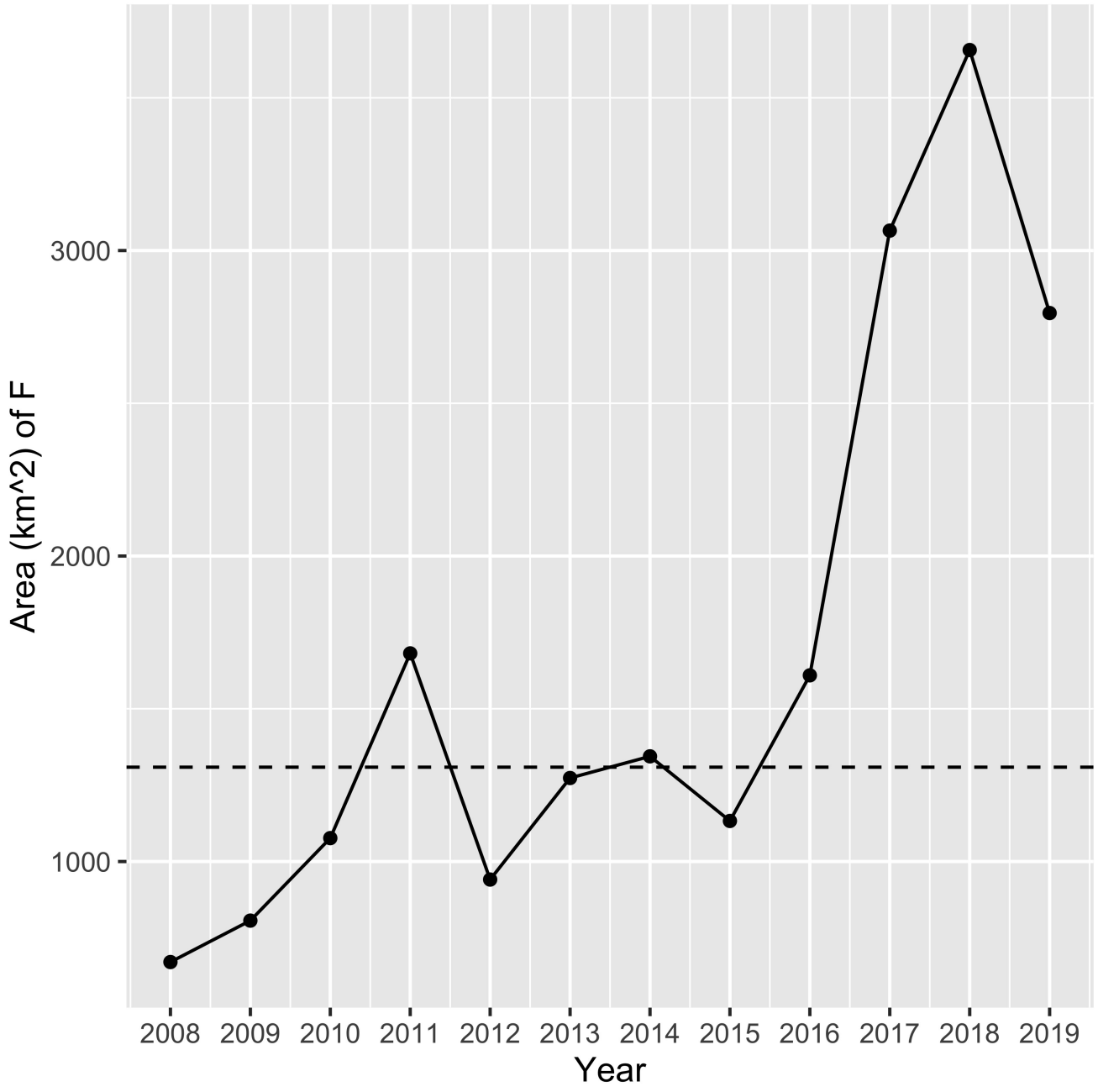


Figure 6. Fishing area calculated from gridded Vessel Trip Reports of both directed fishing and incidental catches of Illex in US waters.

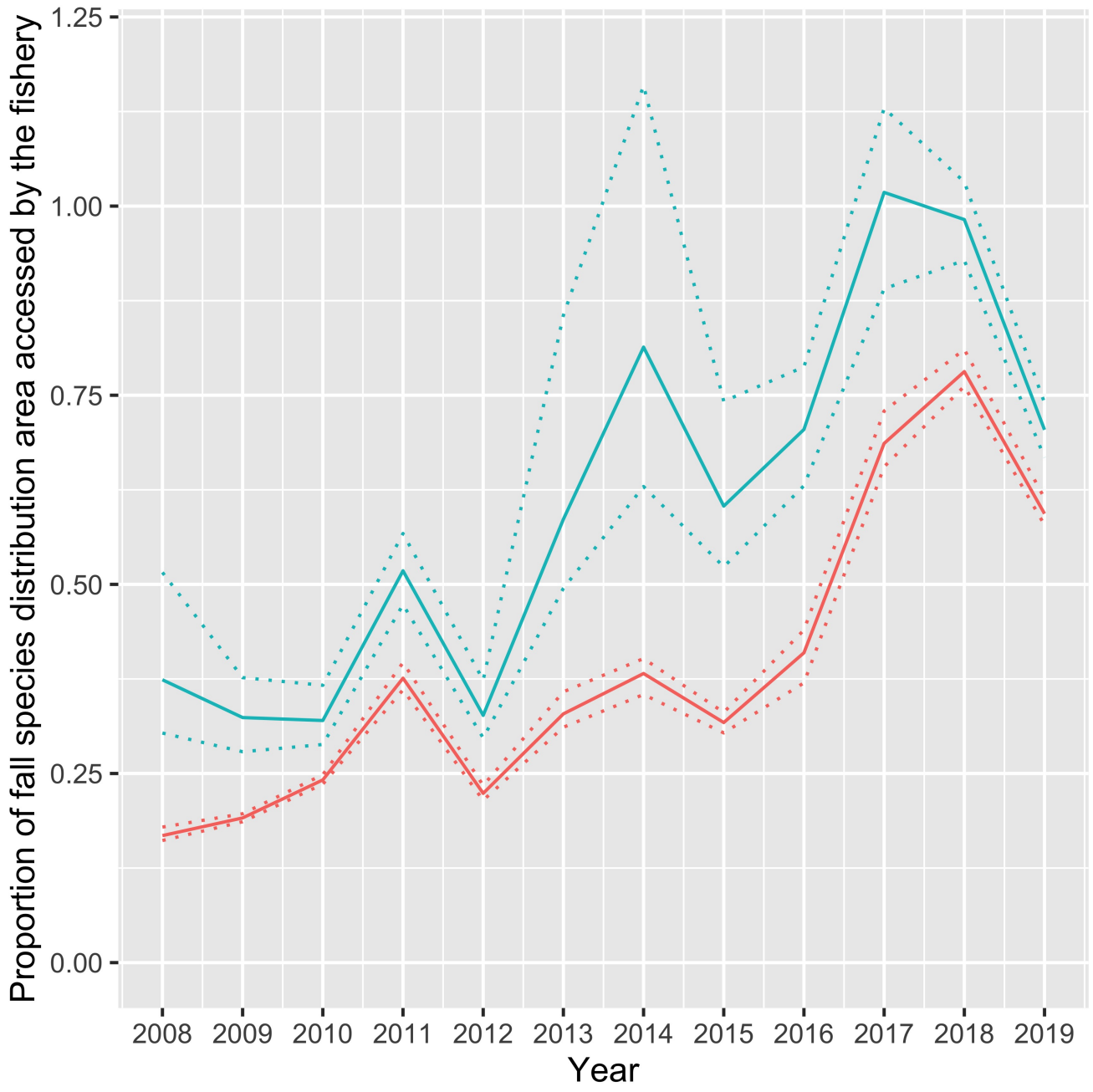


Figure 7. Availability of Illex to the fishery (v_f) calculated from the overlap of the fishing area and projected species distribution during the fall of each year. Availability is the ratio of the overlapped fishing area and the species distribution area classified on the basis of the sensitivity-specificity threshold (red) and the predictive value threshold (blue). Dotted lines depict areas calculated using predictions +/- 1SE

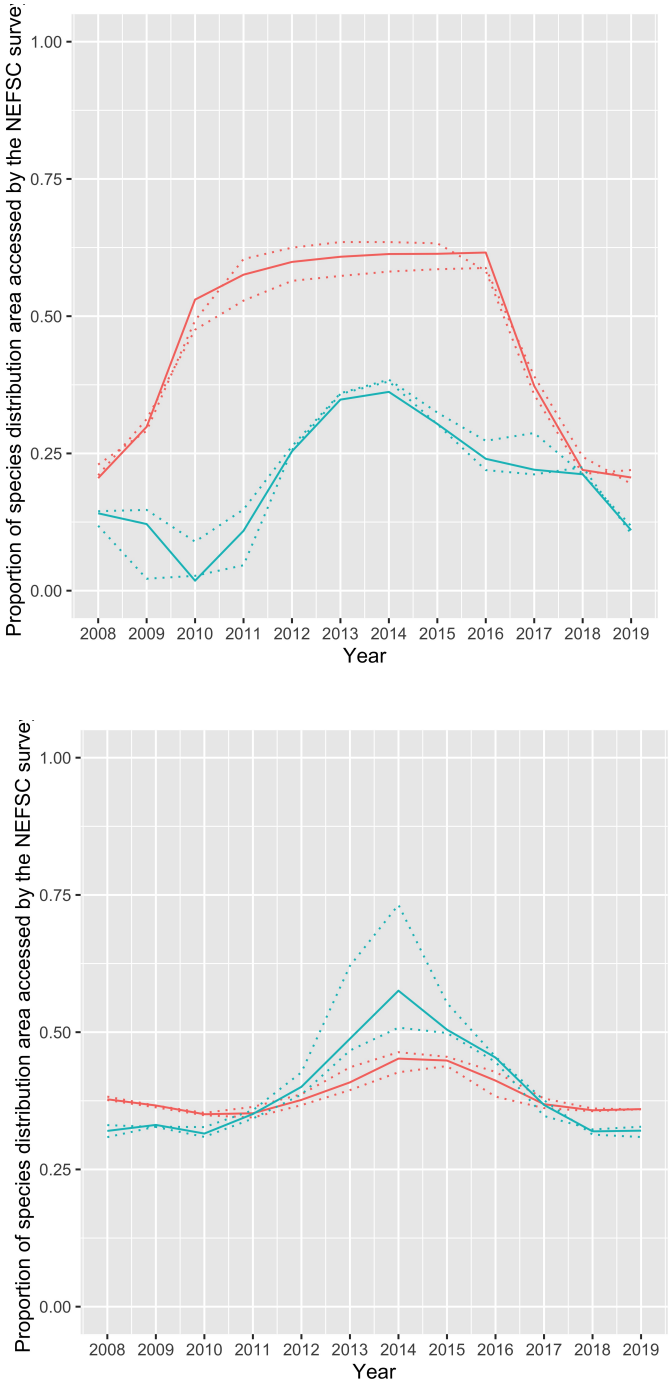


Figure 8. Availability of Illex to the NEFSC survey (v_s) calculated using overlap area of survey strata used to calculate Indices of Illex abundance and projected species distribution during the spring (top) and fall fall (bottom) of each year. Availability is the ratio of the area of overlap of the survey and species distribution divided by the species distribution area classified on the basis of the sensitivity-specificity threshold (red) and the predictive value threshold (blue). Dotted lines depict areas calculated using predictions +/- 1SE.