Supplement to

Atlantic Marine Assessment Program for Protected Species: 2019-2025

Appendix B

Whale
Generalize Additive Density-Habitat Models and Maps, by Species

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B.1 Study Area

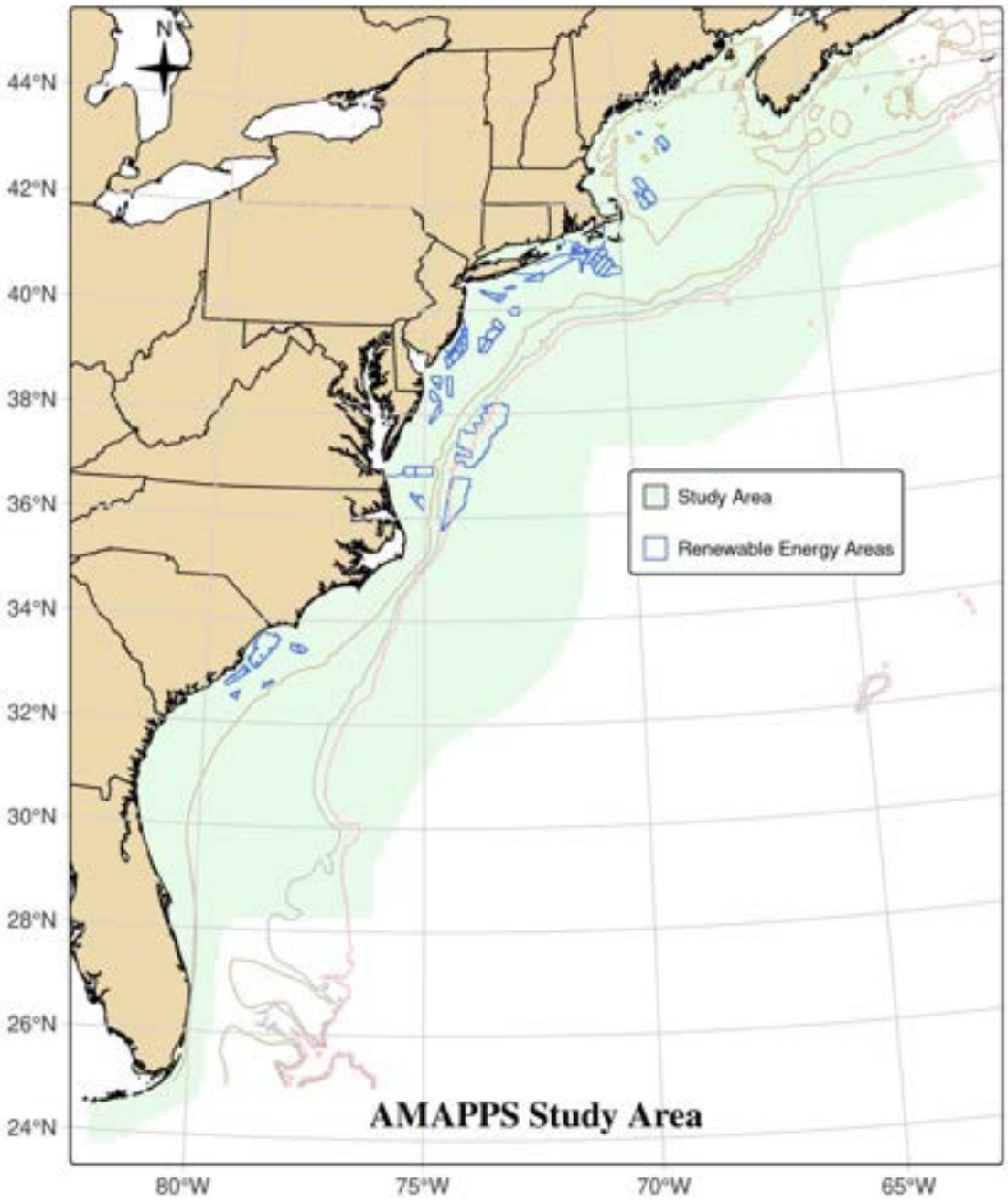

Figure 1-1 AMAPPS study area and Massachusetts to North Carolina wind-energy study areas

We identified the locations of the offshore wind energy areas (blue line) in relationship to the AMAPPS study area (green shaded). Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

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B.2 Humpback Whale (*Megaptera novaeangliae*)

Figure B.2-1. Humpback Whale
Image collected under MMPA Research permit #17355. Credit: NOAA/NEFSC/Tim Cole

B.2.1 Data Collection

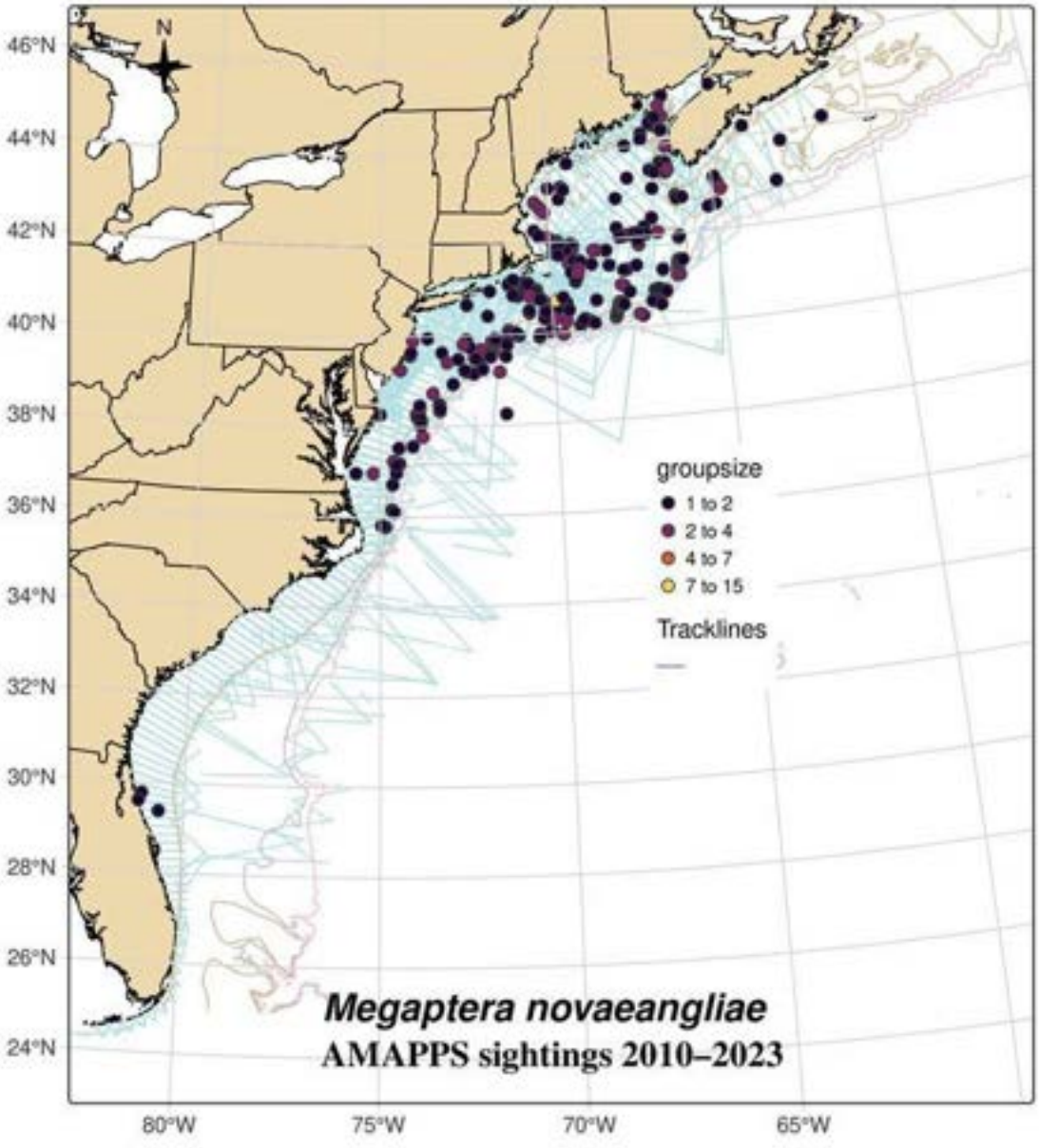

Figure B.2-2. Distribution of track lines and humpback whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.2-1. AMAPPS research effort 2010 to 2023 and humpback whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	45	76
NE Shipboard	Summer	49,064	197	297
NE Aerial	Spring	38,839	59	88
NE Aerial	Summer	52,003	84	106
NE Aerial	Fall	87,311	85	119
NE Aerial	Winter	24,747	5	5
SE Shipboard	Spring	2,604	6	7
SE Shipboard	Summer	18,331	2	3
SE Shipboard	Fall	2,673	-	-
SE Shipboard	Winter	302	-	-
SE Aerial	Spring	48,634	13	16
SE Aerial	Summer	43,285	-	-
SE Aerial	Fall	21,153	4	7
SE Aerial	Winter	19,151	4	4

B.2.2 Mark-Recapture Distance Sampling Analysis

Table B.2-2. Intermediate parameters in humpback whale mark-recapture distance sampling models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15	0.89
NE–aerial group 3	distance + sea state	900	distance + sea state + glare	900	HR	0.66	0.07	0.03	0.96
NE–shipboard group 8	distance * observer + time of day	10,000	distance + sea state + swell height	10,000	HR	0.39	0.17	0.06	0.92
SE–shipboard group 5	distance + log(group size)	9000	distance + glare	9000	HR	0.58	0.11	0.70	0.61

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

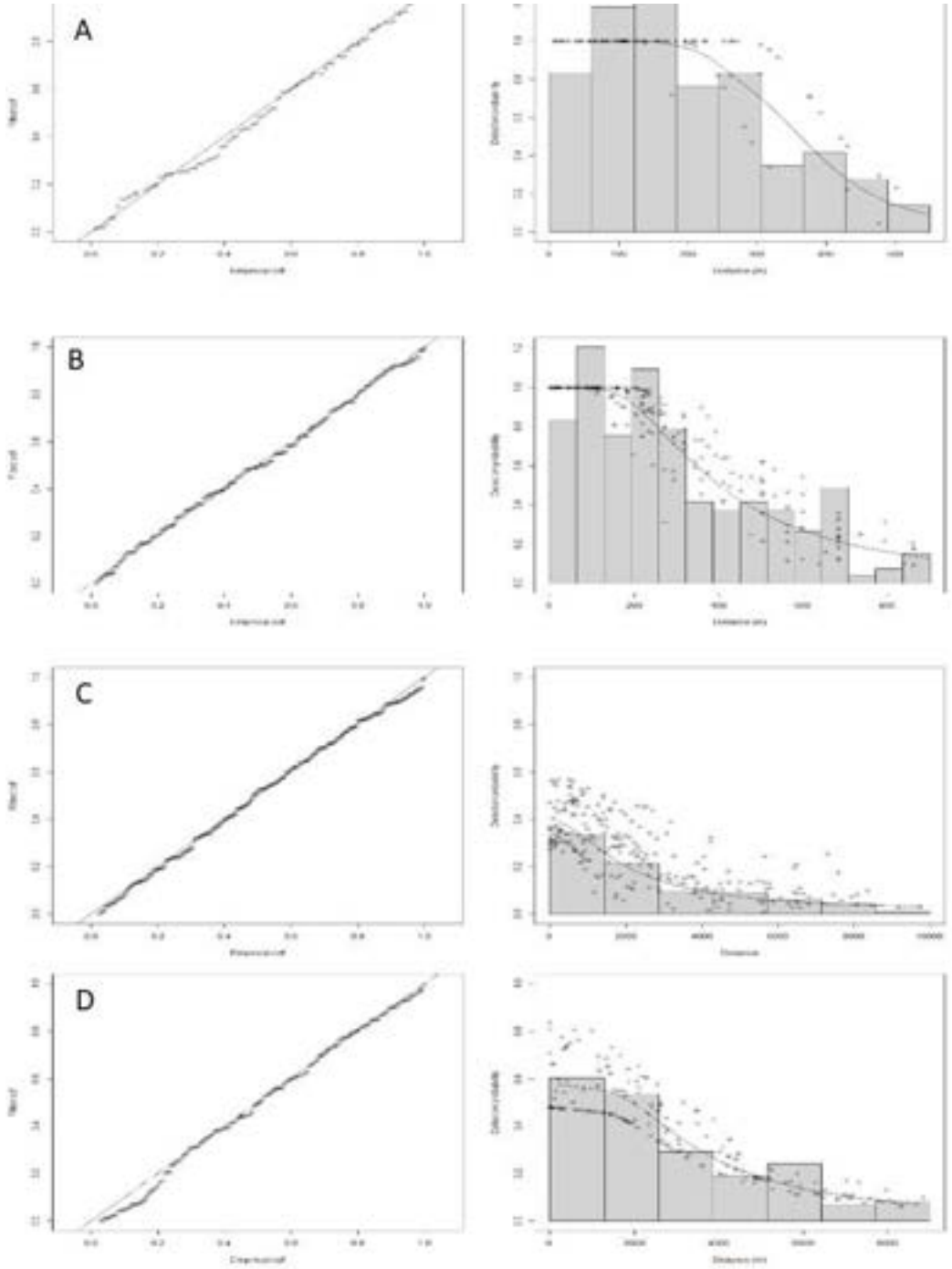

Figure B.2-3. Q-Q plots and detection functions from the humpback whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 3; C) NE-shipboard analysis set 8; D) SE-shipboard analysis set 5.

B.2.3 Generalized Additive Model Analysis

Table B.2-3. 2010 to 2023 density-habitat model output for humpback whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(salinity)	2.15	5	4.75	5.02	<0.0001
s(btemp)	3.29	5	7.58	2.94	<0.0001
s(pic)	0.83	5	0.86	0.08	0.0218
s(pp)	0.93	5	2.70	0.95	0.0001
s(slope)	0.82	5	0.93	1.21	0.0126
s(dist125)	2.70	5	11.43	13.14	<0.0001
s(dist1000)	2.37	5	2.32	2.99	0.0020
s(latdd)	4.51	5	16.97	15.91	<0.0001

R-sq.(adj) = 0.0196. Deviance explained = 42.2%
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

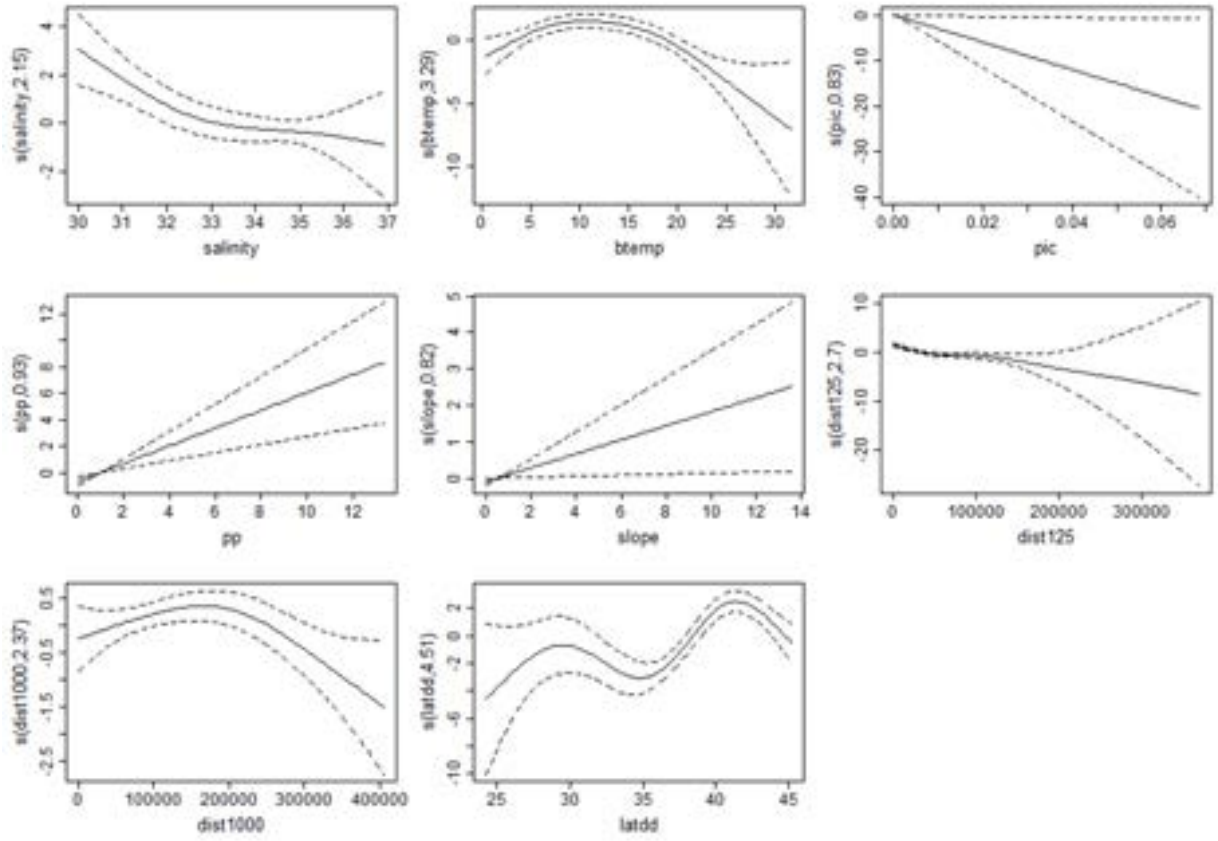

Figure B.2-4. Humpback whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.2.4 Model Cross-Validation

Table B.2-4. Diagnostic statistics from the humpback whale density-density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
RHO	Spearman rank correlation	Non-zero density	0.451	Excellent
MAPE	Mean absolute percentage error	Non-zero density	92.704	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.088	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.006	Excellent
MAPE	Mean absolute percentage error	All data divided in 25 random samples	93.894	Fair to good

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.2.5 Abundance Estimates for AMAPPS Study Area

Table B.2-5. Humpback whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	1,570	0.32	851 – 2,895
Summer (June–August)	2,987	0.32	1,620 – 5,508
Fall (September–November)	2,104	0.31	1,162 – 3,810
Winter (December–February)	1,312	0.32	711 – 2,419
Summer 2011 U.S. surveys[1]	335	0.42	199 − 564
Summer 2016 U.S. surveys[1]	2,368	0.48	1,315 − 4,264
Summer 2021 U.S. surveys[1]	870	0.36	439 – 1,724

[1]Hayes et al. 2024

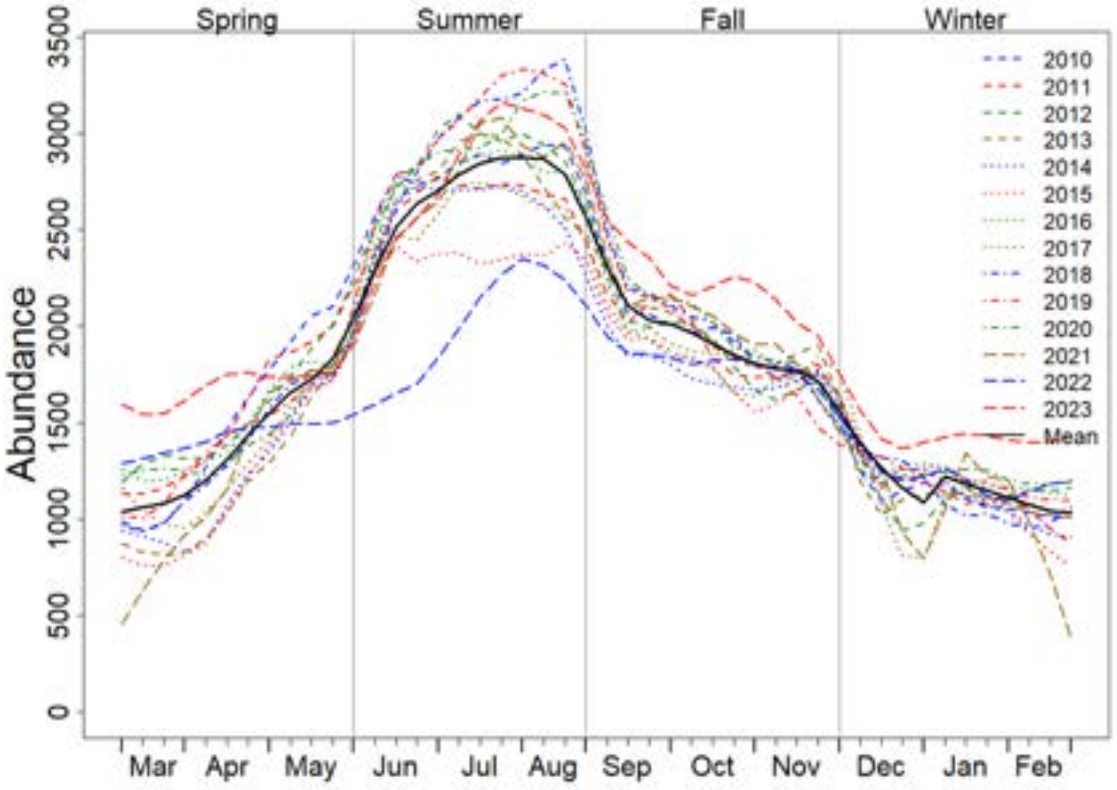

Figure B.2-5. Annual abundance trends for humpback whales in the AMAPPS study area

B.2.6 Seasonal Prediction Maps

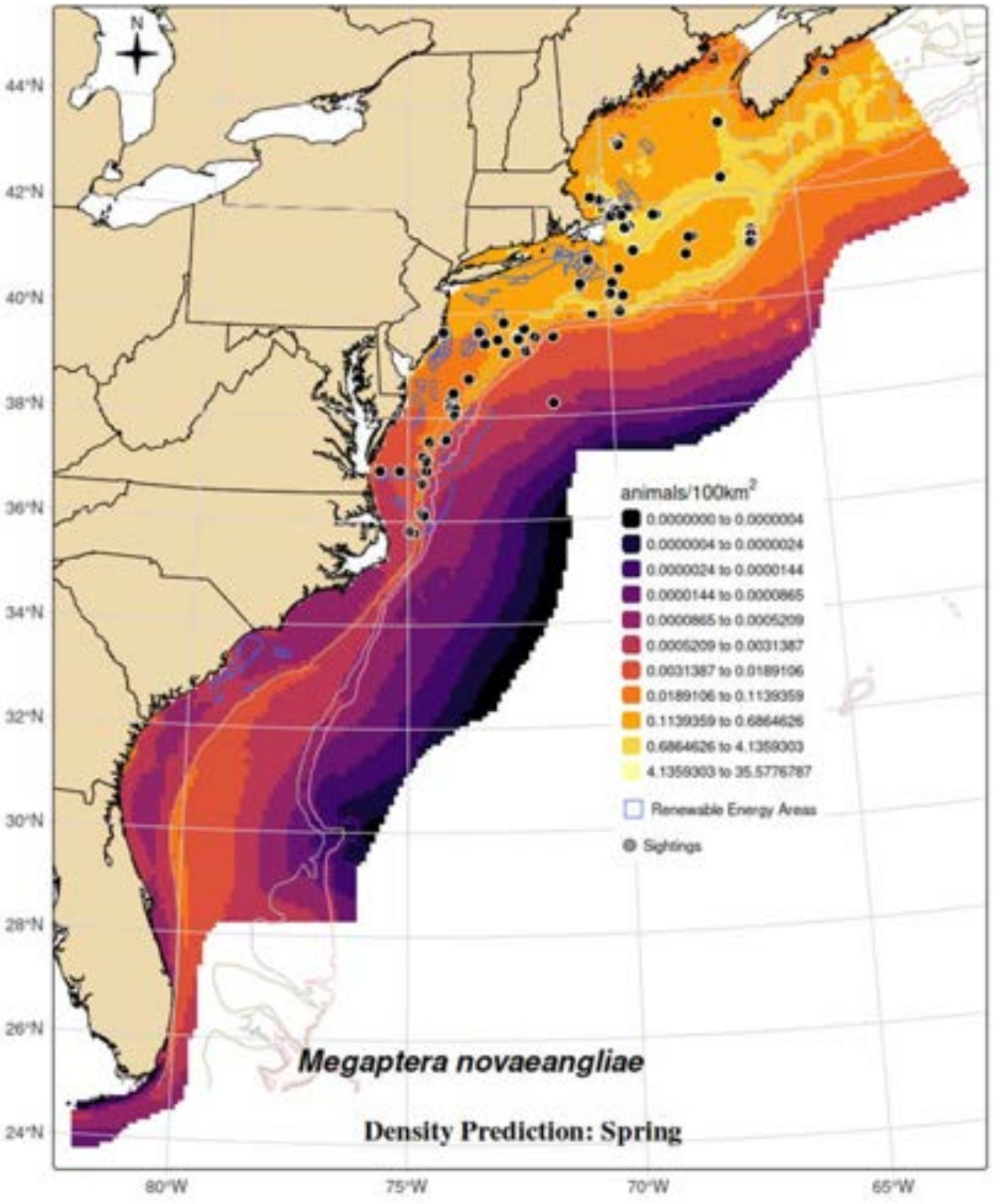

Figure B.2-6. Humpback whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

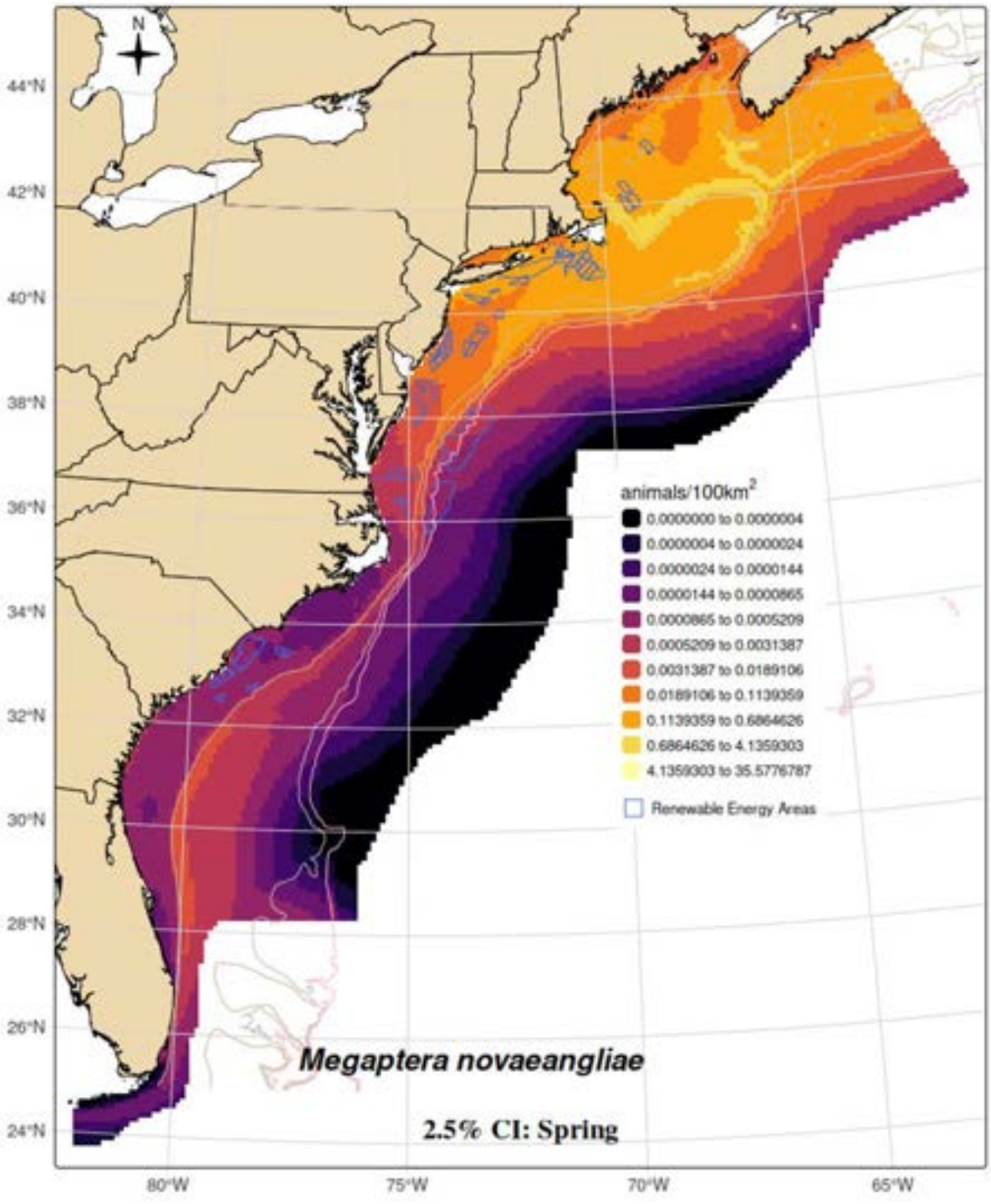

Figure B.2-7. Lower 2.5% confidence interval of the spring humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

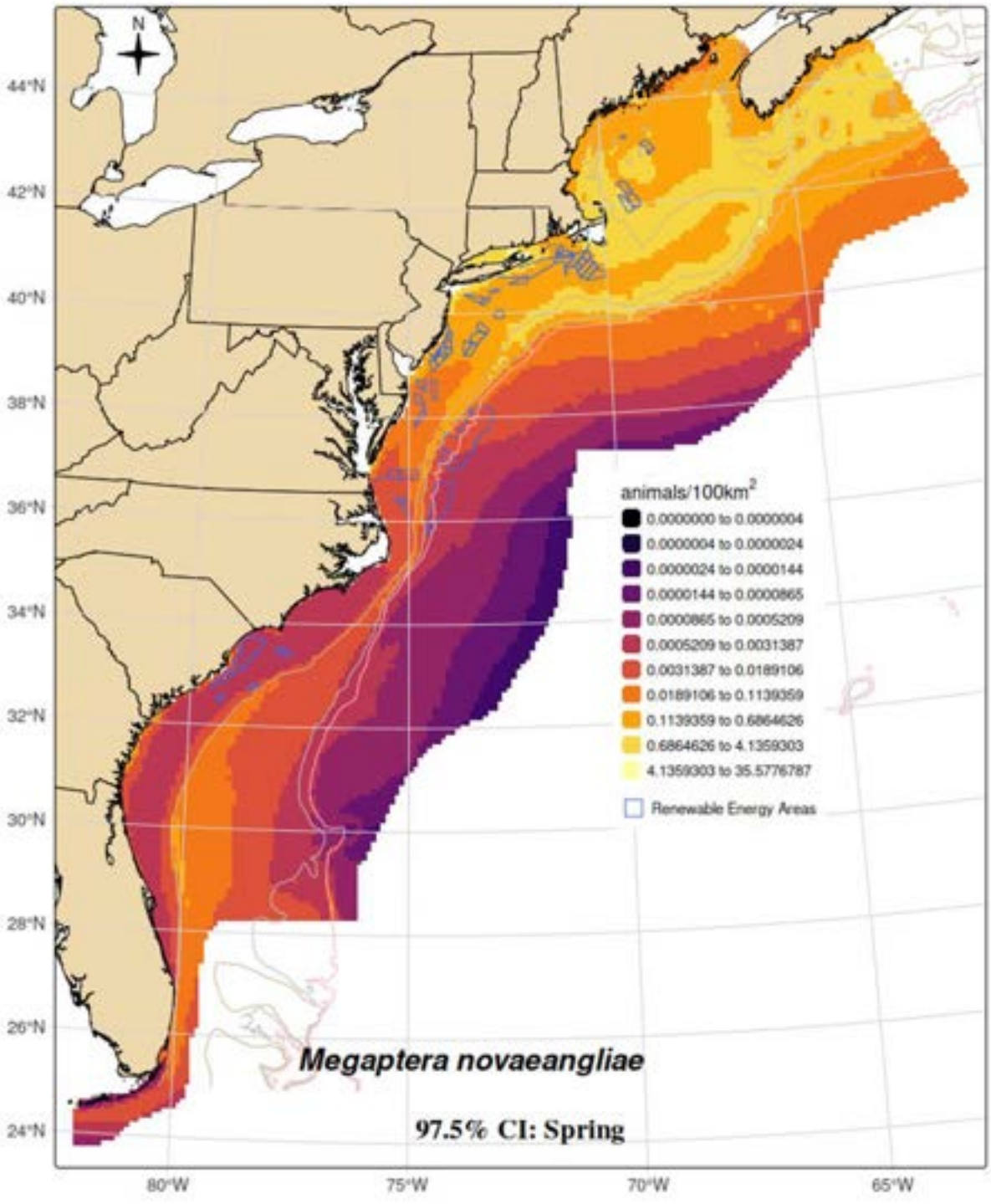

Figure B.2-8. Upper 97.5% confidence interval of the spring humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.
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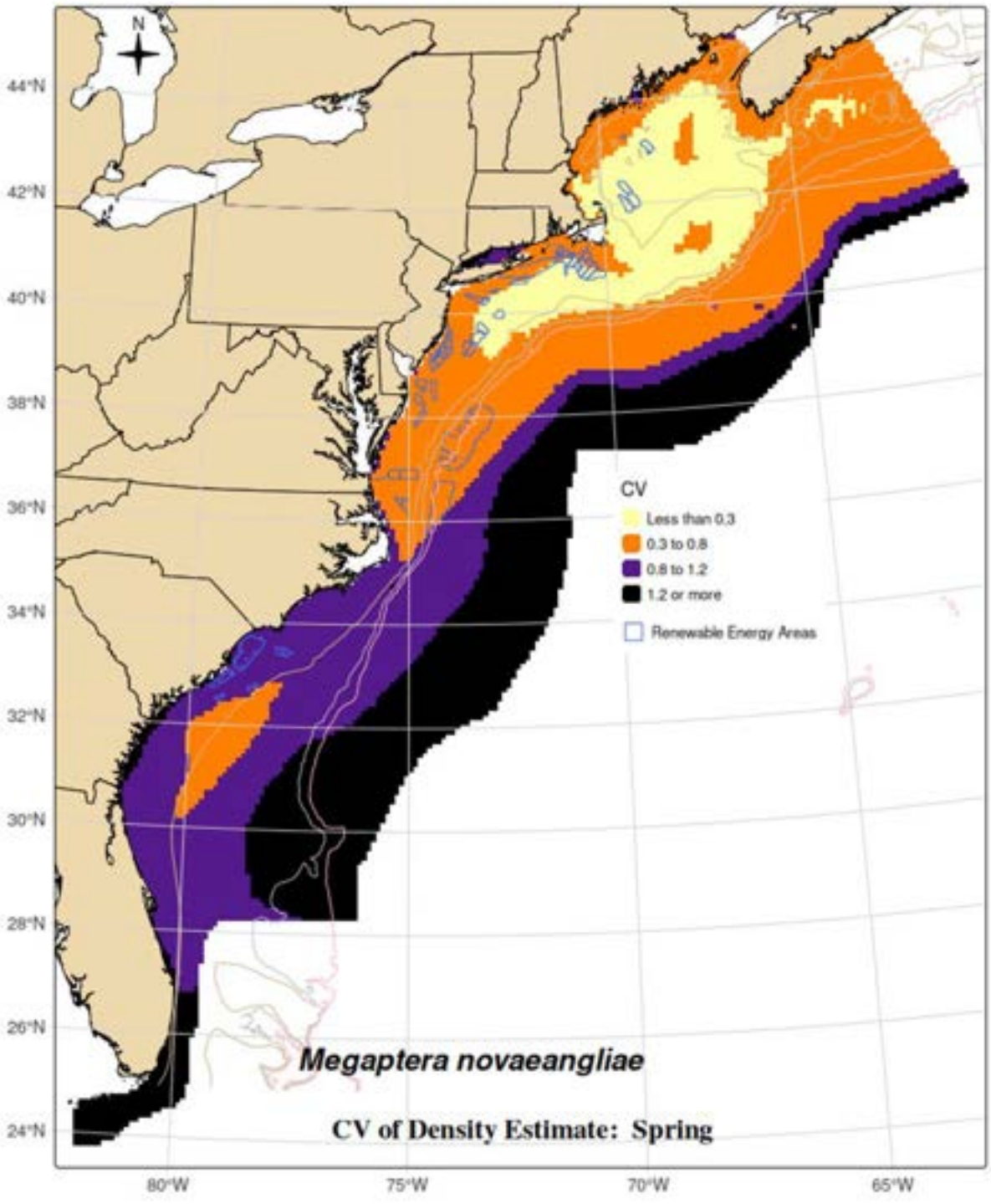

Figure B.2-9. CV of spring humpback whale density estimates

CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

Map showing predicted summer density of humpback whales along the U.S. East Coast, with colors ranging from dark purple (lowest density) to yellow (highest density) representing

animals per 100 km². Map includes labeled renewable energy areas outlined in green and black dots indicating whale sightings, highlighting highest densities in the Gulf of Main and around. the Georges Bank region

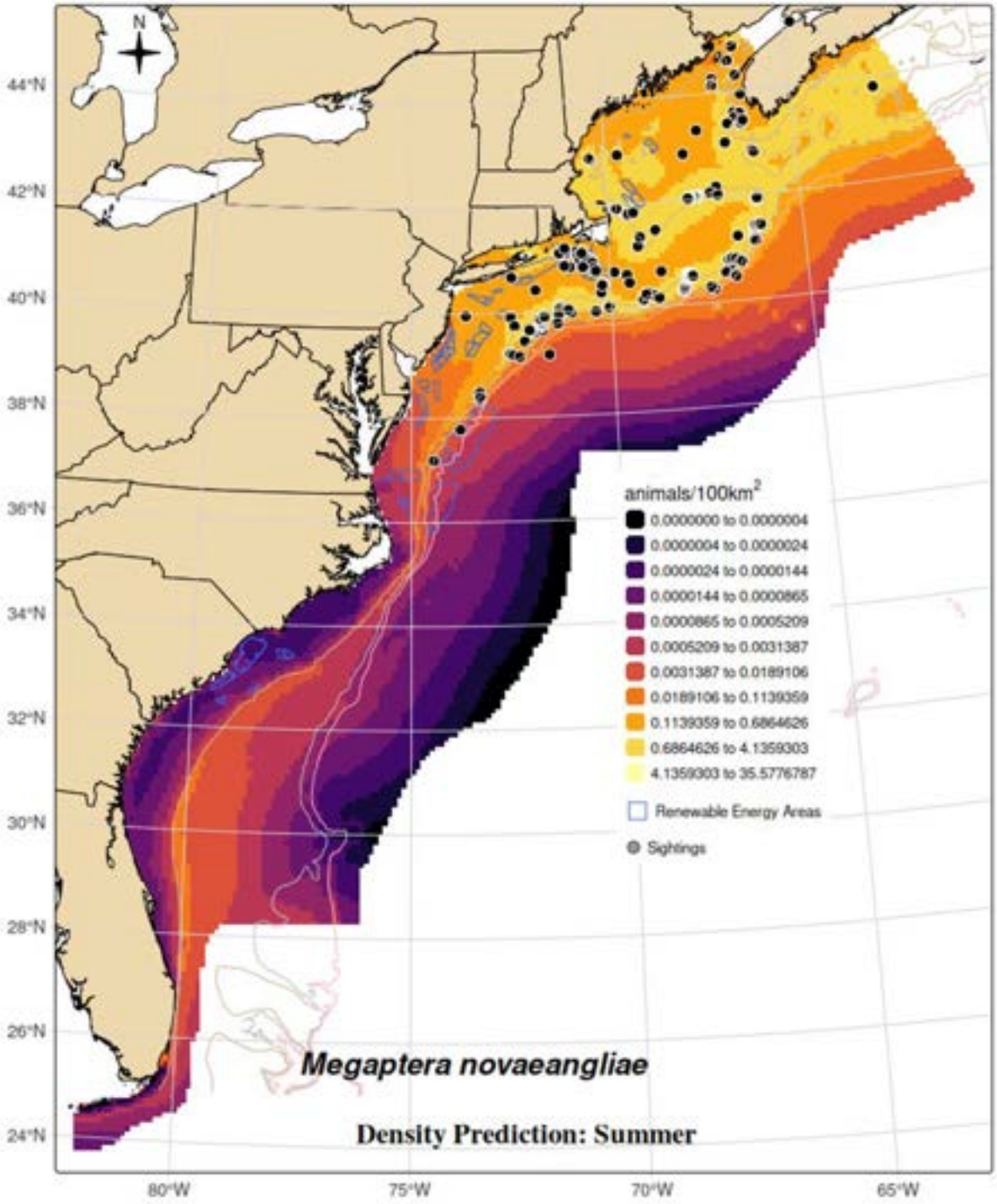

Figure B.2-10. Humpback whale summer average density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

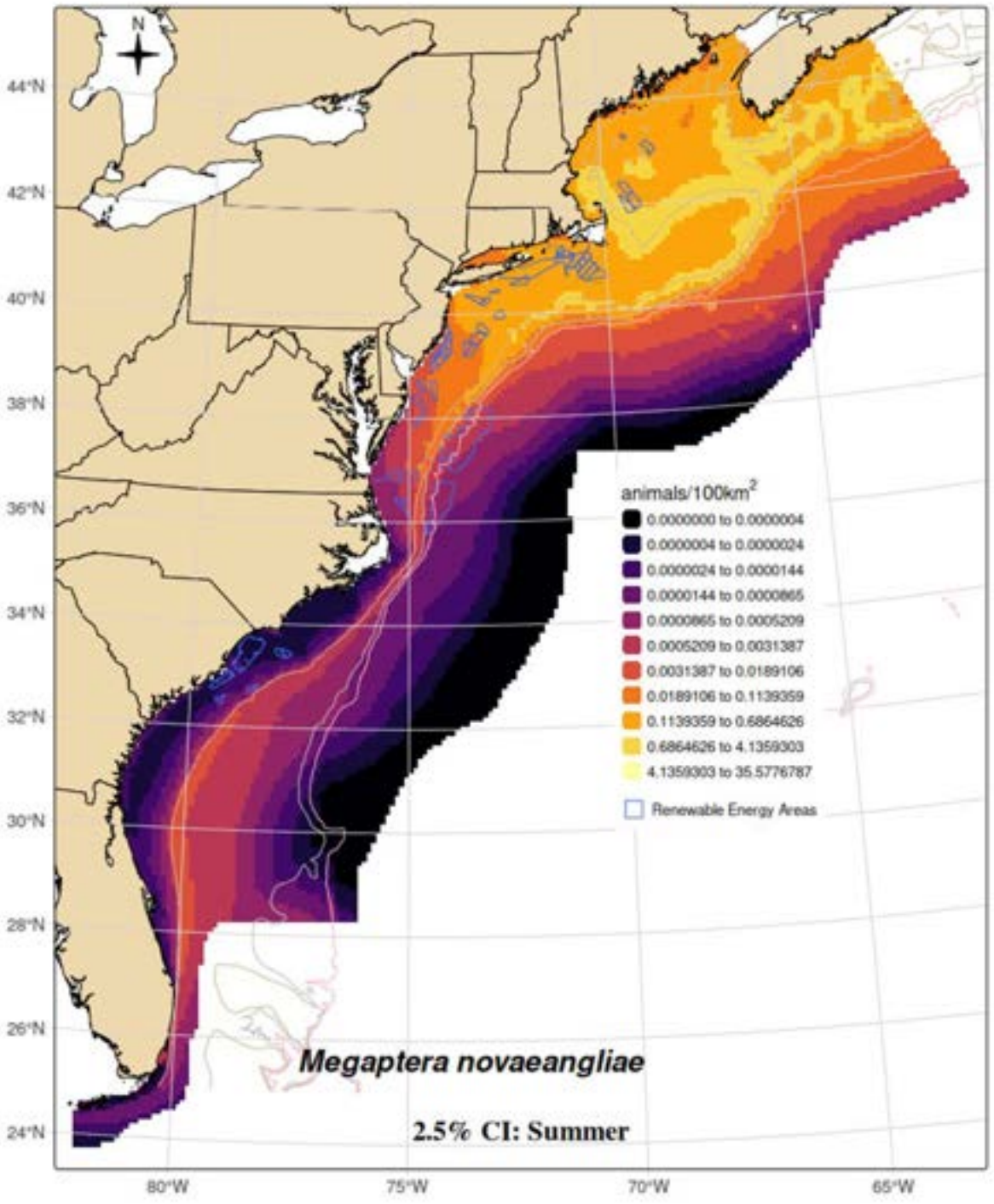

Figure B.2-11. Lower 2.5% confidence interval of the summer humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

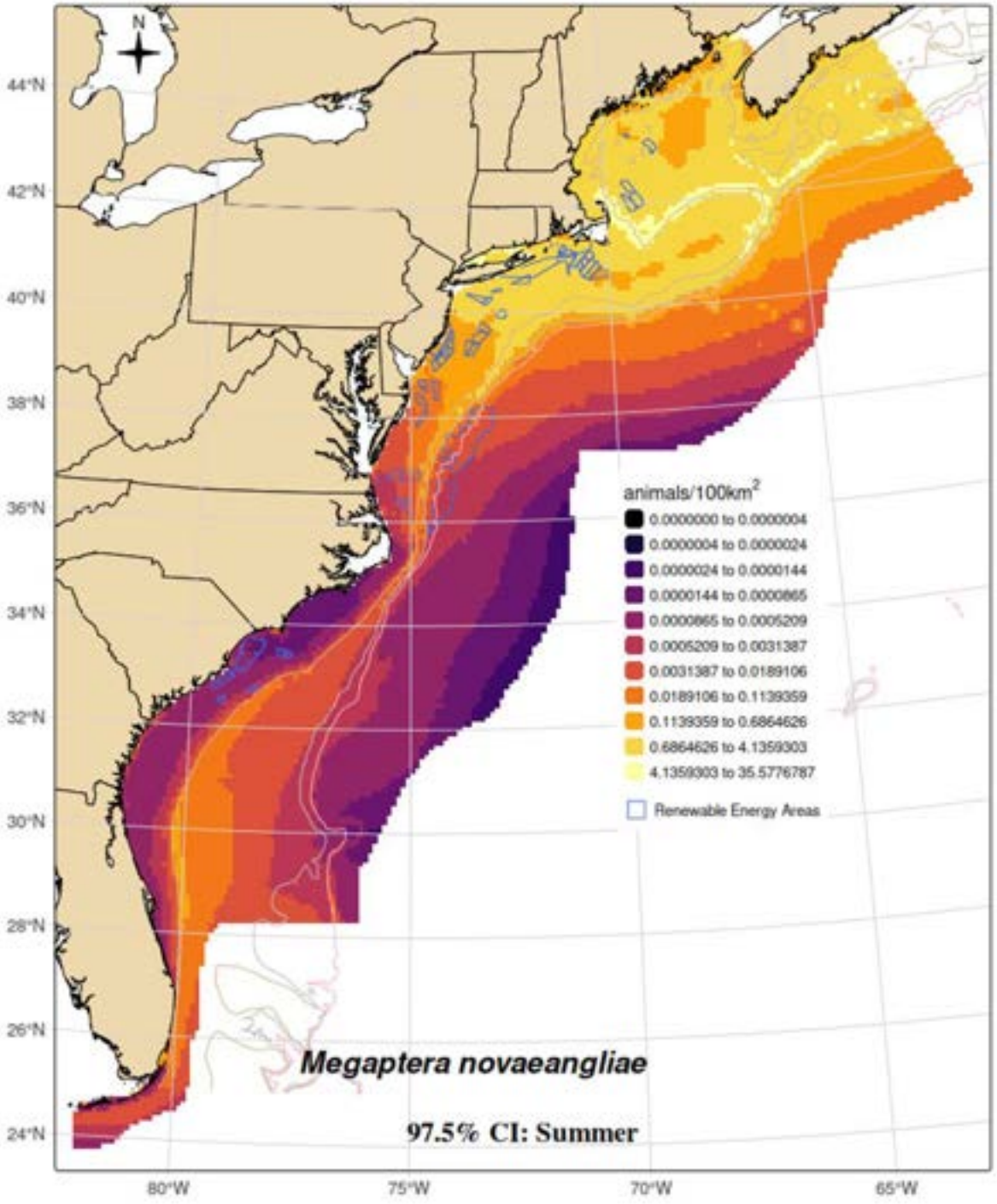

Figure B.2-12. Upper 97.5% confidence interval of the summer humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

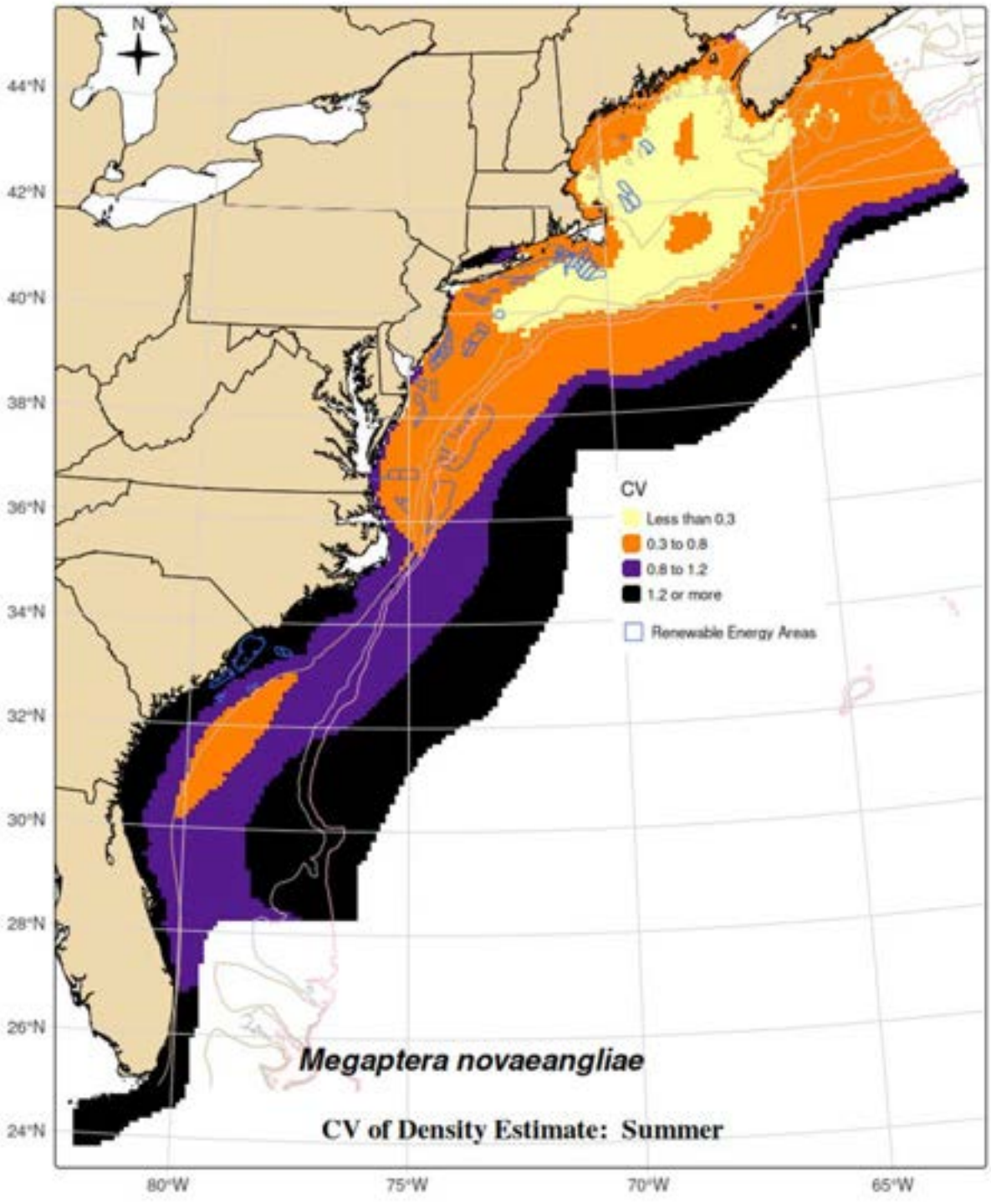

Figure B.2-13. CV of summer humpback whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

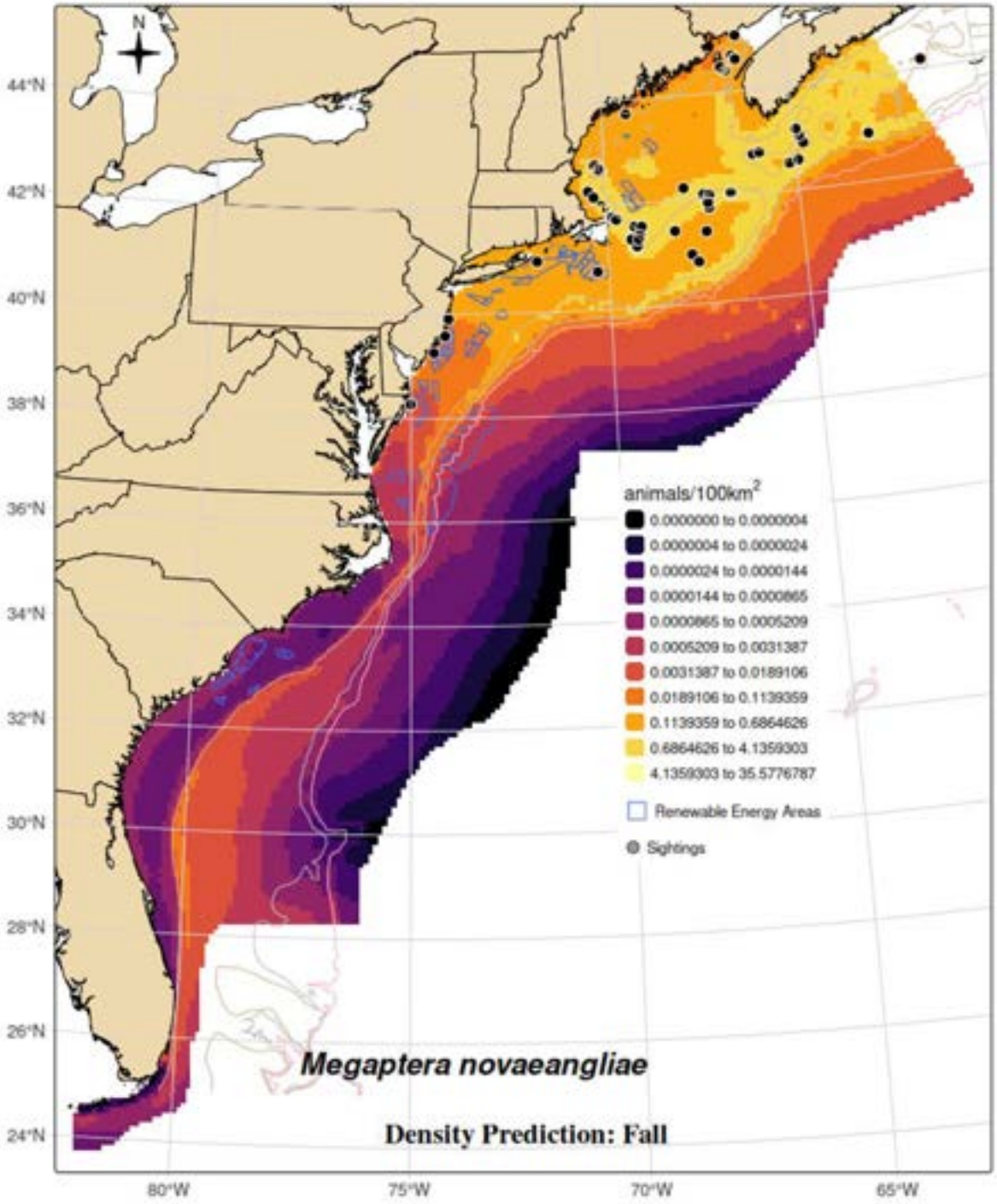

Figure B.2-14. Humpback whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

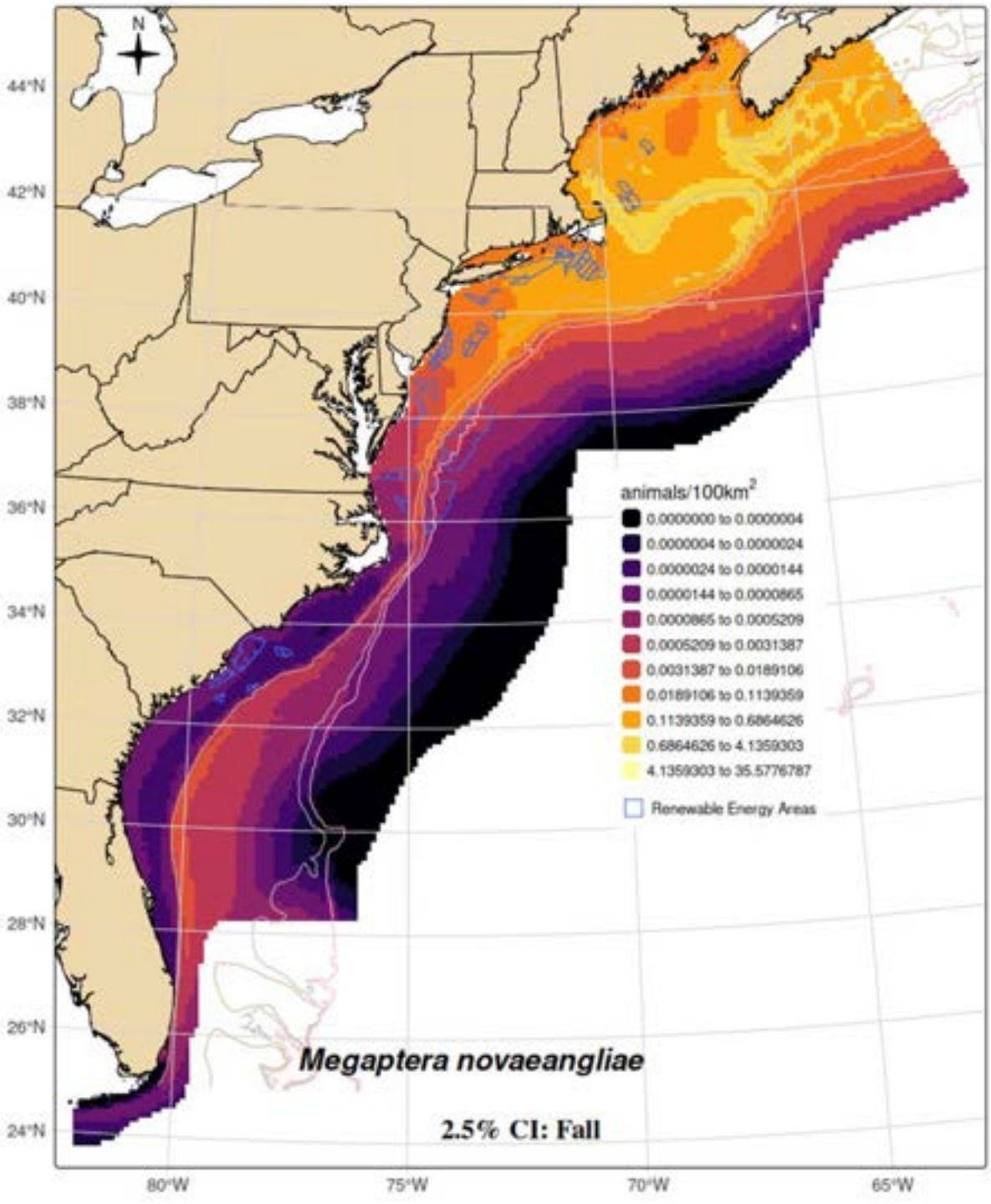

Figure B.2-15. Lower 2.5% confidence interval of the fall humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

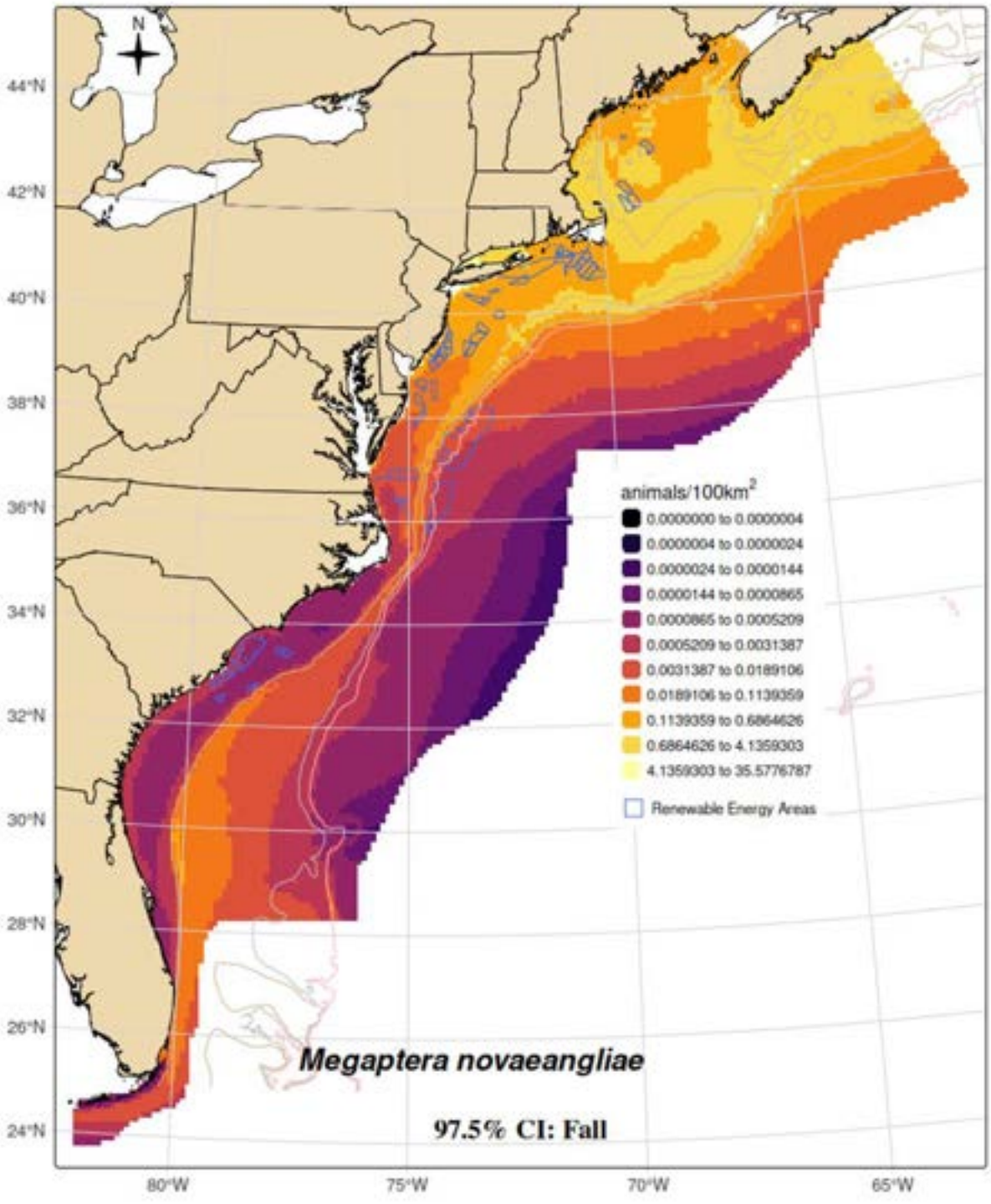

Figure B.2-16. Upper 97.5% confidence interval of the fall humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

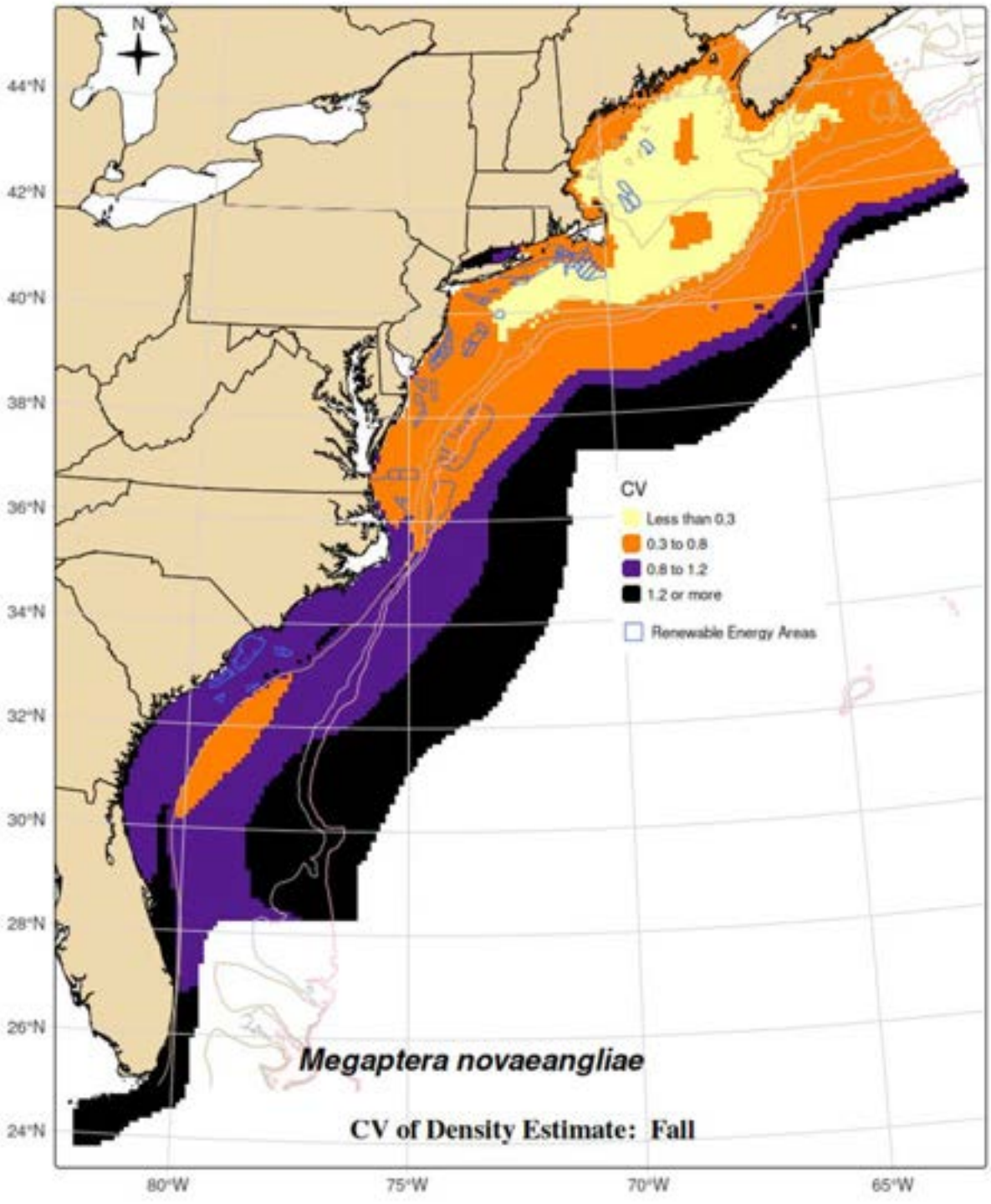

Figure B.2-17. CV of fall humpback whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

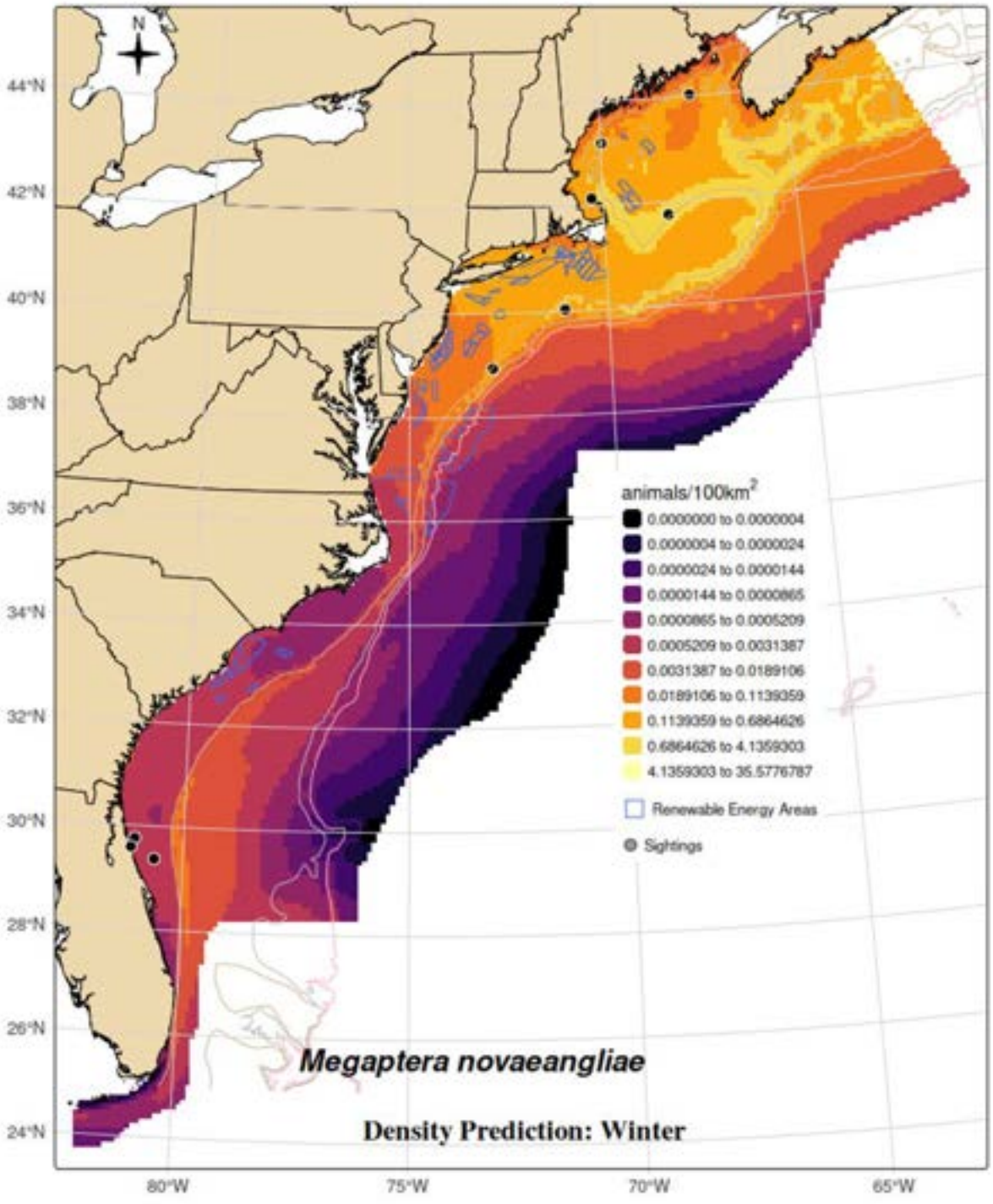

Figure B.2-18. Humpback whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

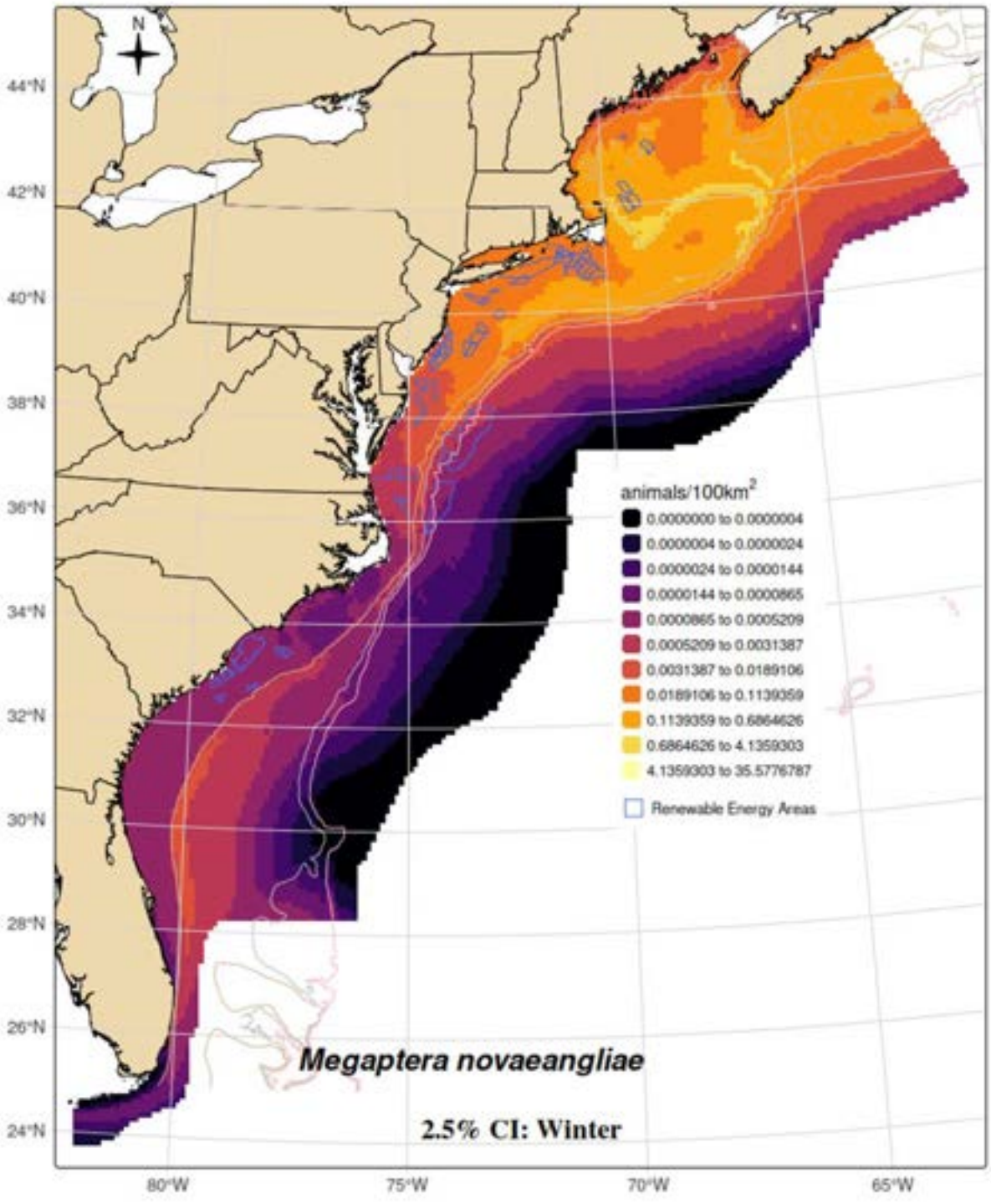

Figure B.2-19. Lower 2.5% confidence interval of the winter humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

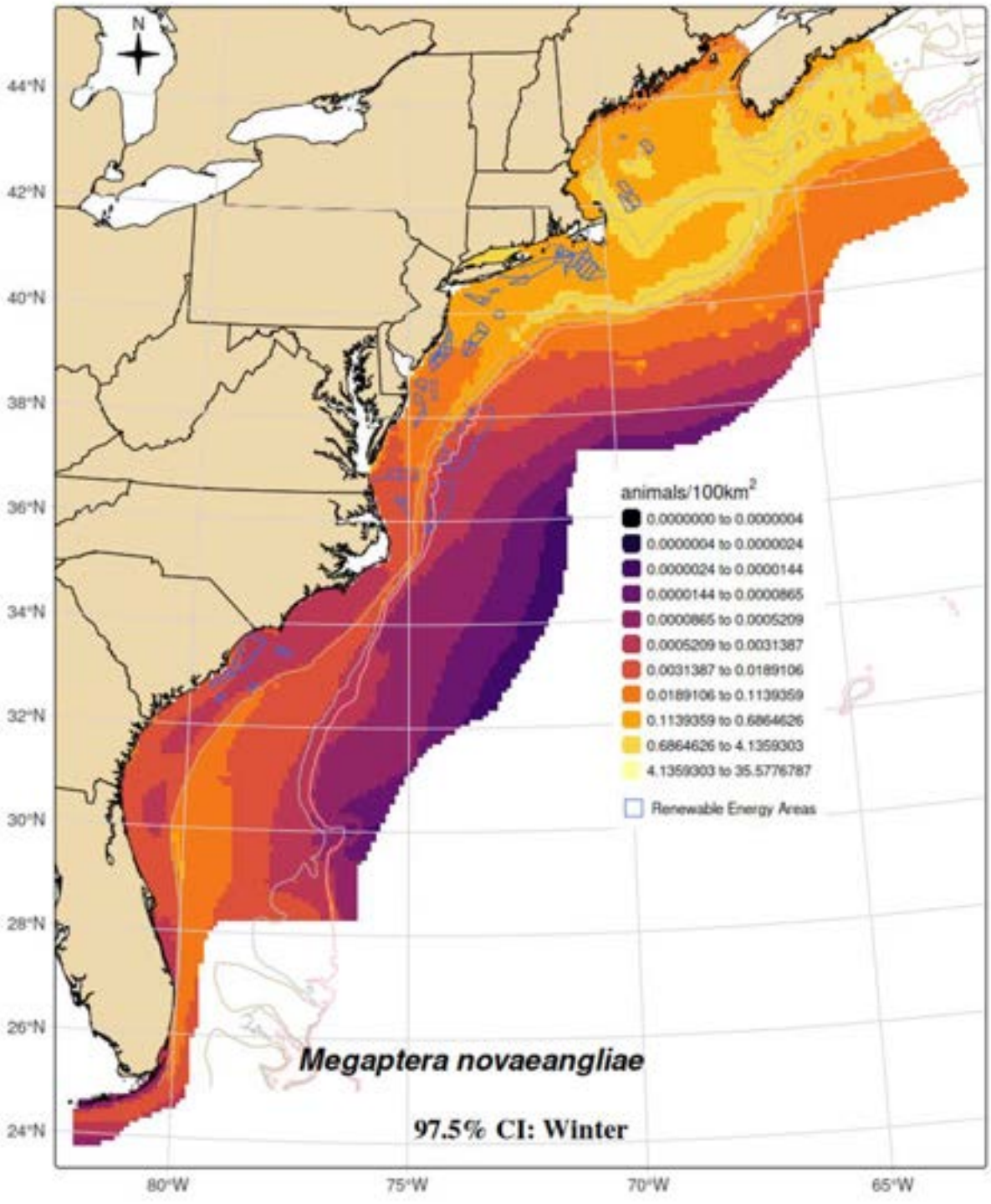

Figure B.2-20. Upper 97.5% confidence interval of the winter humpback whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

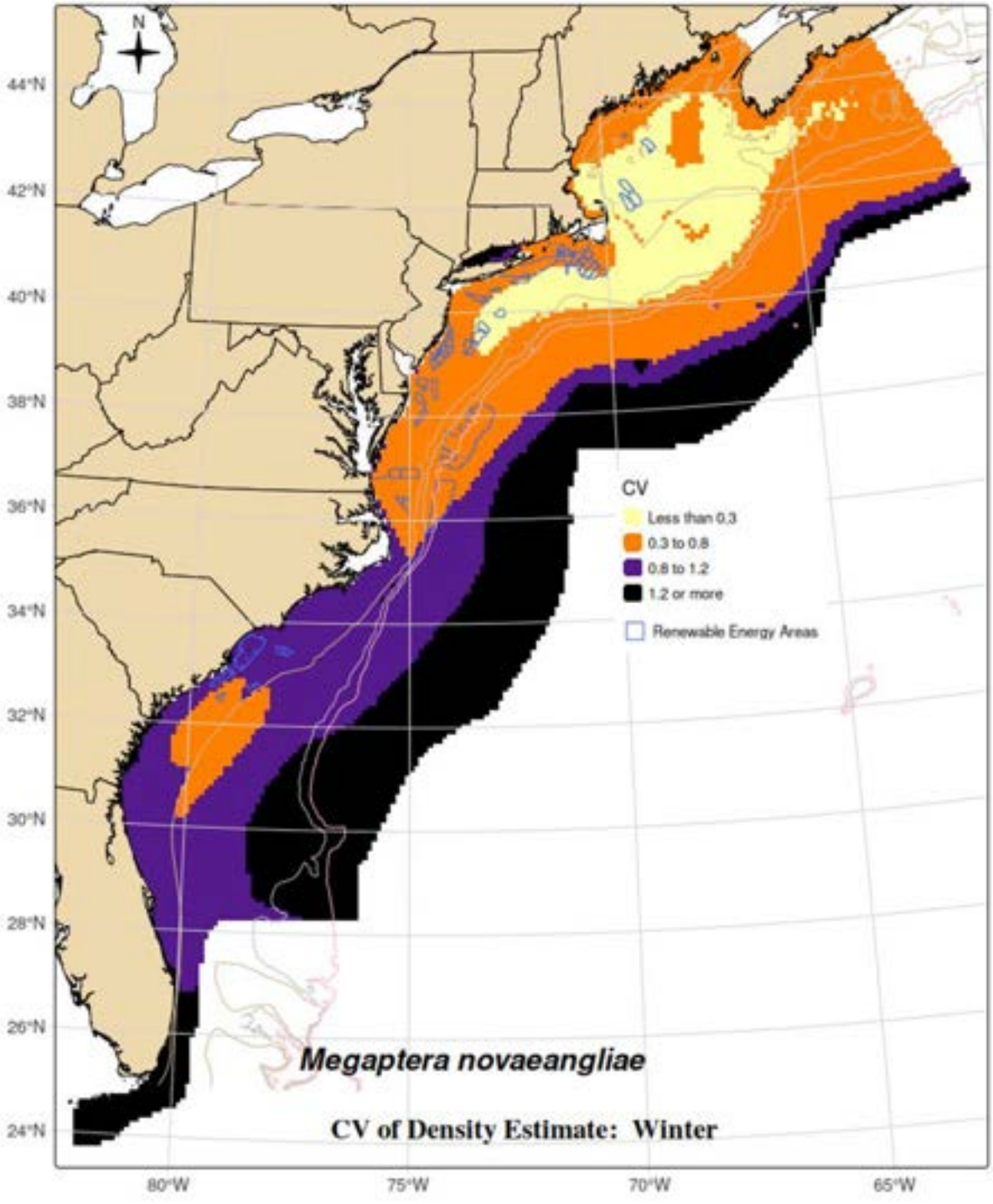

Figure B.2-21. CV of winter humpback whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.2.7 Offshore Energy Development Areas

Table B.2-6. Humpback whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	29.1	0.31	15.9 - 53.2
	NY	8.1	0.41	3.8 - 17.5
	NJ	5.3	0.42	2.4 - 11.6
	DE/MD	1.4	0.47	0.6 - 3.2
	VA	0.1	0.56	0 - 0.4
	NC	0.2	0.61	0.1 - 0.5
	NC/SC	0.2	1.17	0 – 1
	GA	0.0	1.62	0 - 0.2
	FL	0.0	1.56	0 - 0.3
Summer (Jun-Aug)	RI/MA	53.1	0.31	29.3 - 96.2
	NY	15.2	0.45	6.6 – 35
	NJ	5.5	0.51	2.1 - 14.1
	DE/MD	1.2	0.57	0.4 - 3.3
	VA	0.1	0.58	0 - 0.2
	NC	0.1	0.64	0 - 0.4
	NC/SC	0.0	0.95	0 - 0.2
	GA	0.0	1.92	0 – 0
	FL	0.0	1.56	0 - 0.4
Fall (Sep-Nov)	RI/MA	25.0	0.32	13.7 - 45.8
	NY	5.6	0.43	2.5 - 12.5
	NJ	3.1	0.49	1.2 - 7.6
	DE/MD	0.7	0.54	0.3 - 1.9
	VA	0.1	0.62	0 - 0.2
	NC	0.1	0.68	0 - 0.3
	NC/SC	0.0	0.88	0 - 0.1
	GA	0.0	1.05	0 – 0
	FL	0.0	1.56	0 - 0.3
Winter (Dec-Feb)	RI/MA	15.7	0.33	8.3 - 29.5
	NY	4.1	0.39	2 - 8.6
	NJ	2.7	0.43	1.2 - 6.1
	DE/MD	0.8	0.47	0.3 – 2
	VA	0.1	0.56	0 - 0.3
	NC	0.1	0.61	0 - 0.4
	NC/SC	0.1	0.89	0 - 0.6
	GA	0.0	1.05	0 - 0.1
	FL	0.0	1.56	0 - 0.3

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

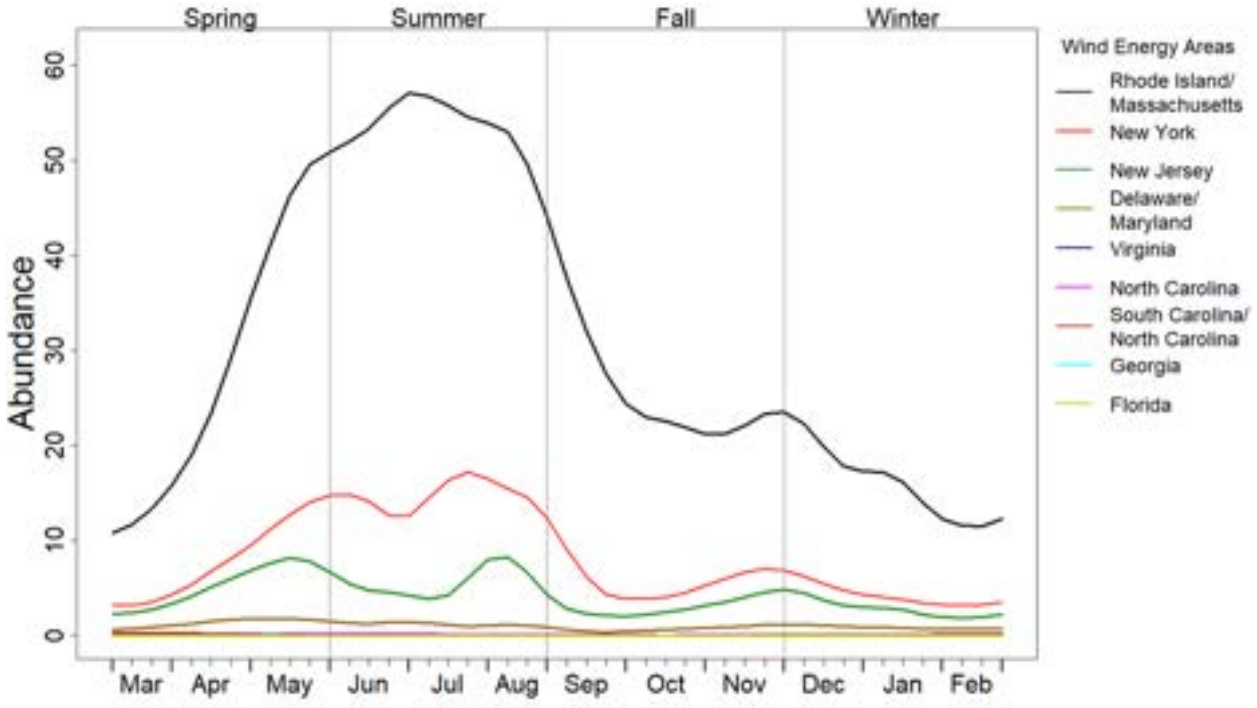

Figure B.2-22. Average seasonal abundance of humpback whales in the wind-energy study areas

B.3 Fin Whale (*Balaenoptera physalus*)

Figure B.3-1. Fin whale
Image collected under MMPA Research permit #17355. Credit: NOAA/NEFSC/Brenda Rhone.

B.3.1 Data Collection

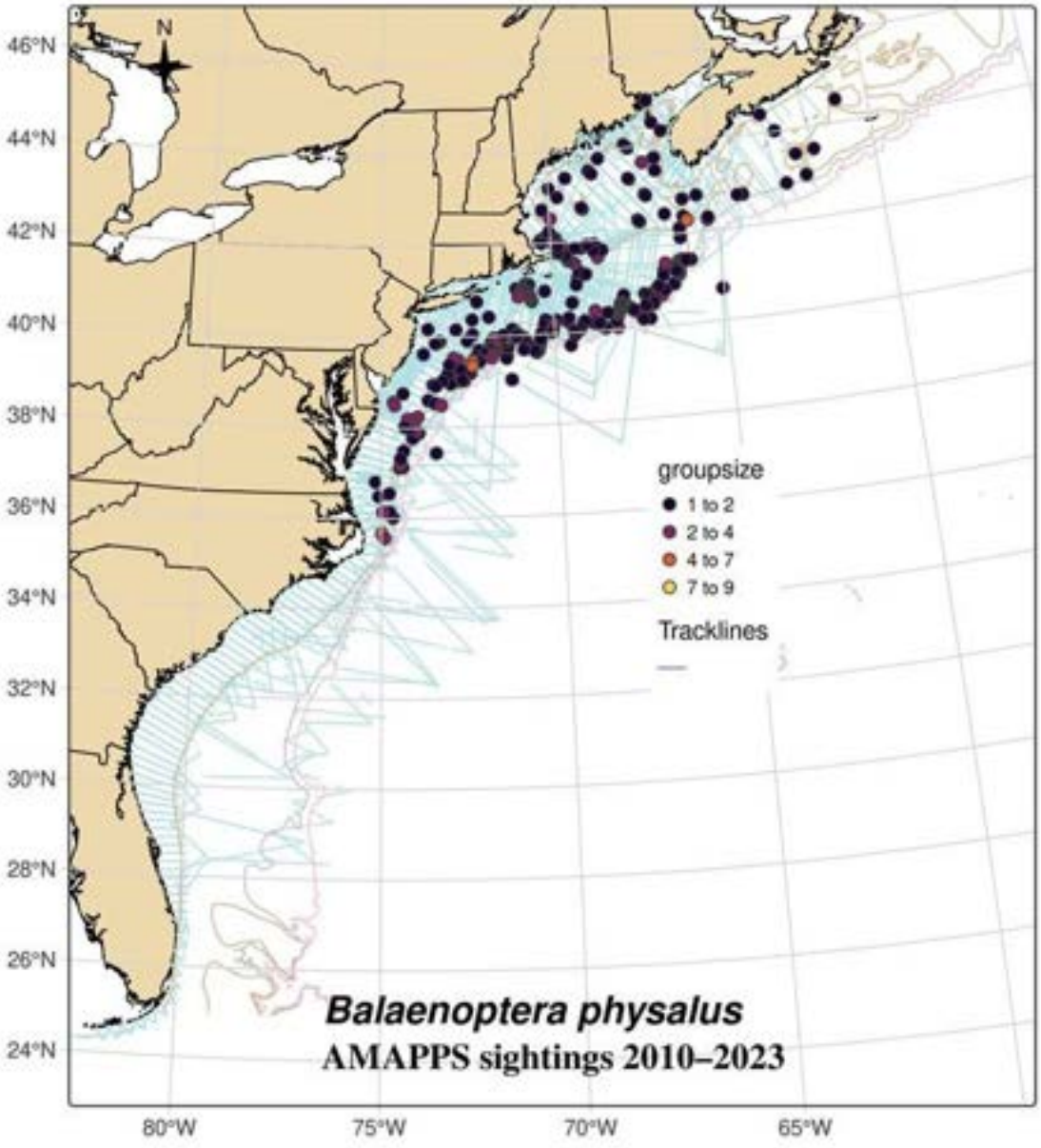

Figure B.3-2. Distribution of track lines and fin whale sightings 2010–2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.3-1. AMAPPS research effort 2010–2023 and fin whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	34	48
NE Shipboard	Summer	49,064	485	720
NE Aerial	Spring	38,839	53	72
NE Aerial	Summer	52,003	40	43
NE Aerial	Fall	87,311	84	103
NE Aerial	Winter	24,747	7	7
SE Shipboard	Spring	2,604	0	0
SE Shipboard	Summer	18,331	6	10
SE Shipboard	Fall	2,673	3	9
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	17	23
SE Aerial	Summer	43,285	5	7
SE Aerial	Fall	21,153	7	12
SE Aerial	Winter	19,152	2	2

B.3.2 Mark-Recapture Distance Sampling Analysis

Table B.3-2. Intermediate parameters in fin whale mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15	0.89
NE–aerial group 1	distance + quality	500	distance + quality	1000	HR	0.54	0.12	0.90	0.97
NE–shipboard group 10	distance * observer + log(group size)	4500	Distance + glare + swell height + time of day	4500	HR	0.54	0.08	0.01	0.95
SE–shipboard group 5	distance + log(group size)	9000	distance + glare	9000	HR	0.58	0.11	0.70	0.61

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

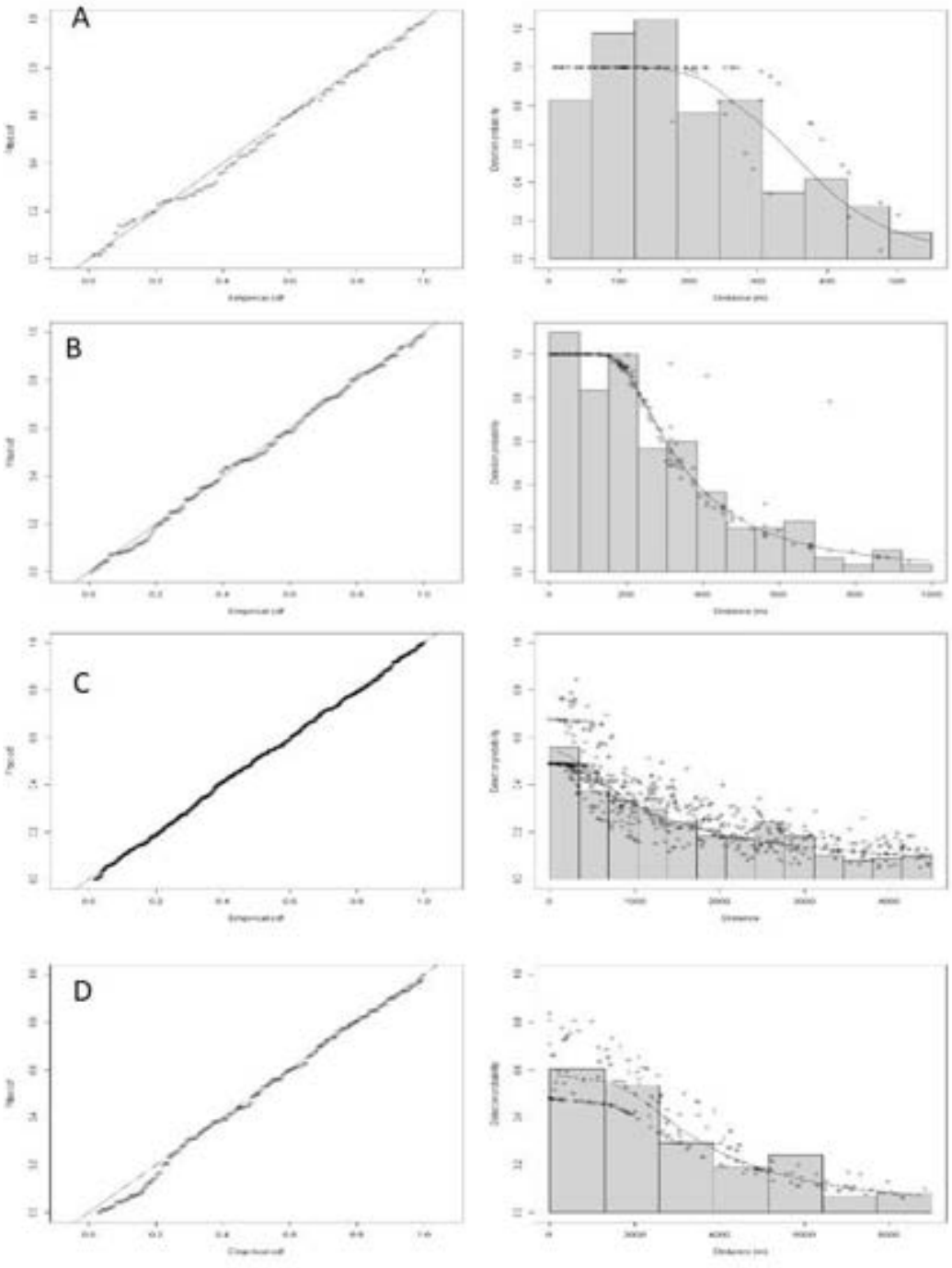

Figure B.3-3. Q-Q plots and detection functions from the fin whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 1; C) NE-shipboard analysis set 10; D) SE-shipboard analysis set 5.

B.3.3 Generalized Additive Model Analysis

Table B.3-3. 2010 to 2023 density-habitat model output for fin whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(dist125)	2.9981	5	14.492	7.4	<2e-16
s(latdd)	3.0737	5	30.532	18.92	<2e-16
s(dist2GSNw)	4.4804	5	15.357	9.83	<2e-16
s(sstmur)	4.4535	5	17.46	11.37	<2e-16
s(dist1000)	4.4545	5	15.05	9.09	<2e-16
s(depth)	0.7697	5	0.676	1.1	0.0352
s(mlp)	0.682	5	0.404	0.51	0.0837

Adjusted R^2 =0.0565. Deviance explained = 58.2%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

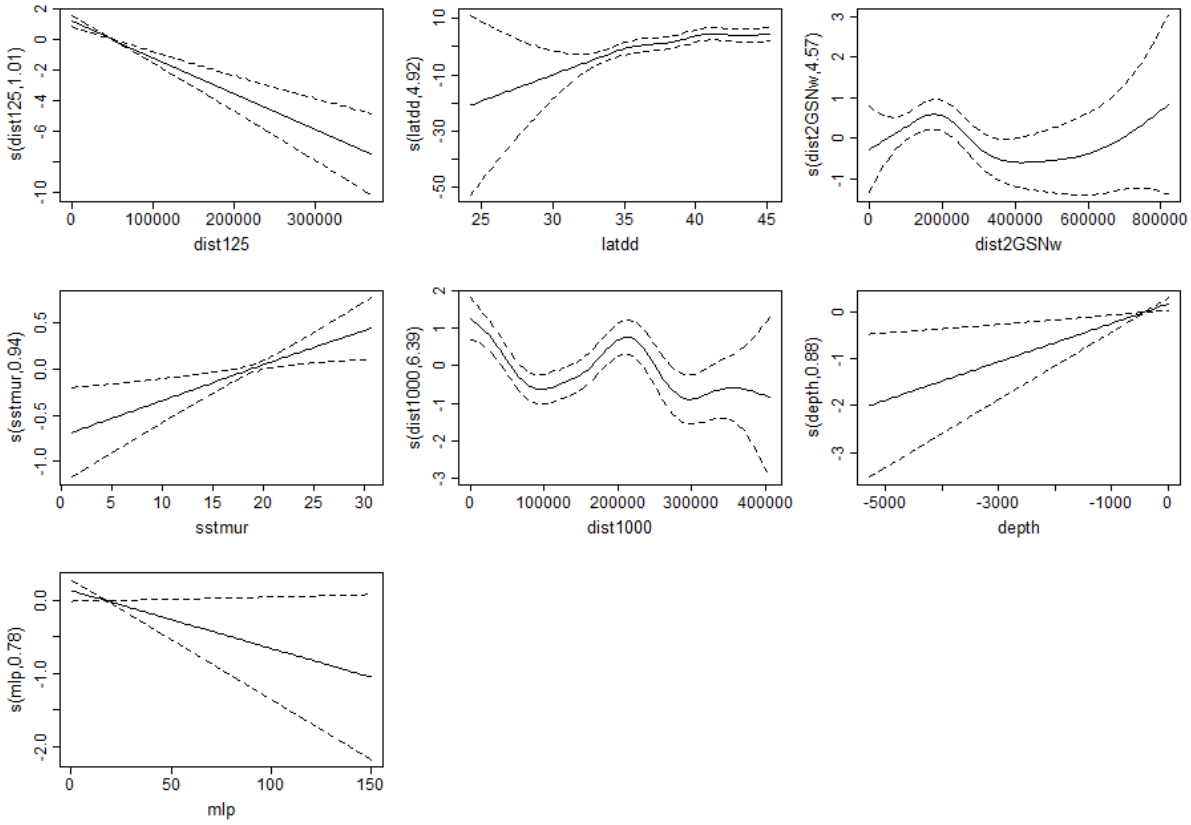

Figure B.3-4. Fin whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.3.4 Model Cross-Validation

Table B.3-4. Diagnostic statistics from the fin whale density-density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
RHO	Spearman rank correlation	Non-zero density	0.552	Excellent
MAPE	Mean absolute percentage error	Non-zero density	86.930	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.319	Excellent
MAE	Mean absolute error	All data divided in 25 random samples	0.118	Excellent
MAPE	Mean absolute percentage error	All data divided in 25 random samples	79.984	Fair to good

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.3.5 Abundance Estimates for AMAPPS Study Area

Table B.3-5. Fin whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	5,833	0.31	3,221 – 10,562
Summer (June–August)	9,414	0.30	5,295 – 16,736
Fall (September–November)	8,550	0.29	4,899 – 14,923
Winter (December–February)	4,863	0.31	2,686 – 8,805
Summer 2011 U.S. surveys[1]	1,618	0.33	1,068 − 2,451
Summer 2016 U.S. surveys[1]	2,390	0.38	1,487 − 3,841
Summer 2021 U.S. surveys[1]	2,252	0.39	1,077 – 4,708

[1]Hayes et al. 2024

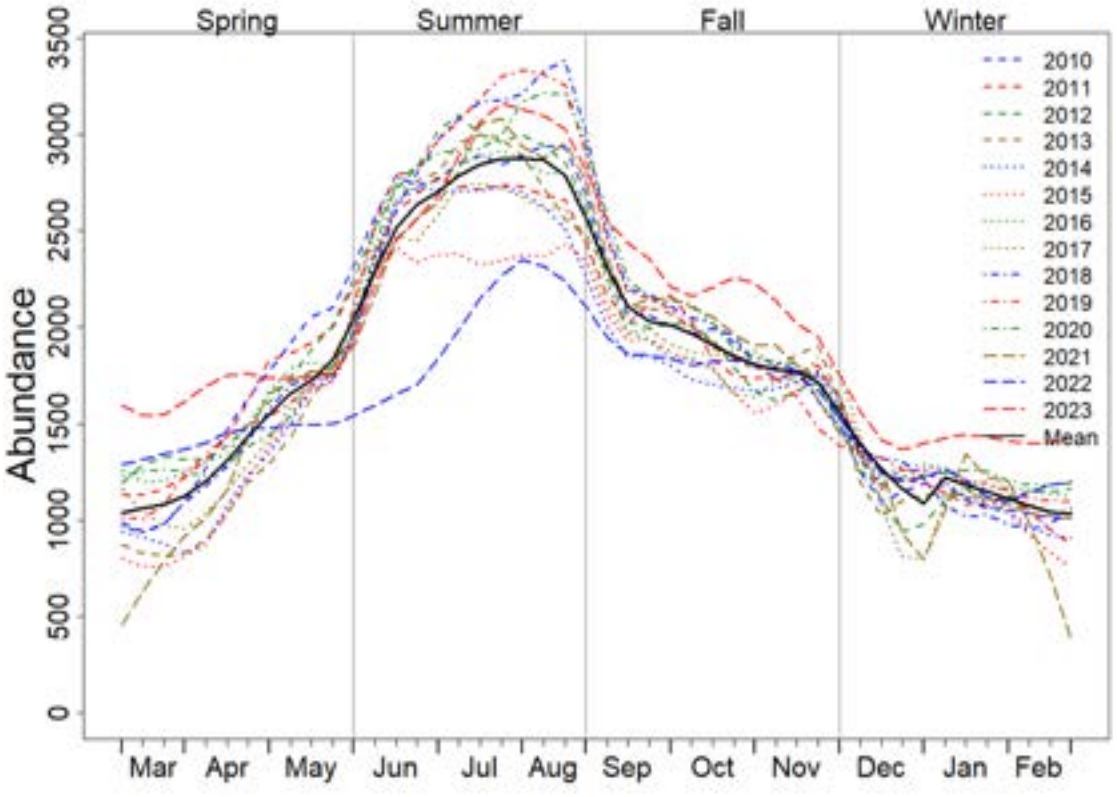

Figure B.3-5. Annual abundance trends for fin whales in the AMAPPS study area

B.3.6 Seasonal Prediction Maps

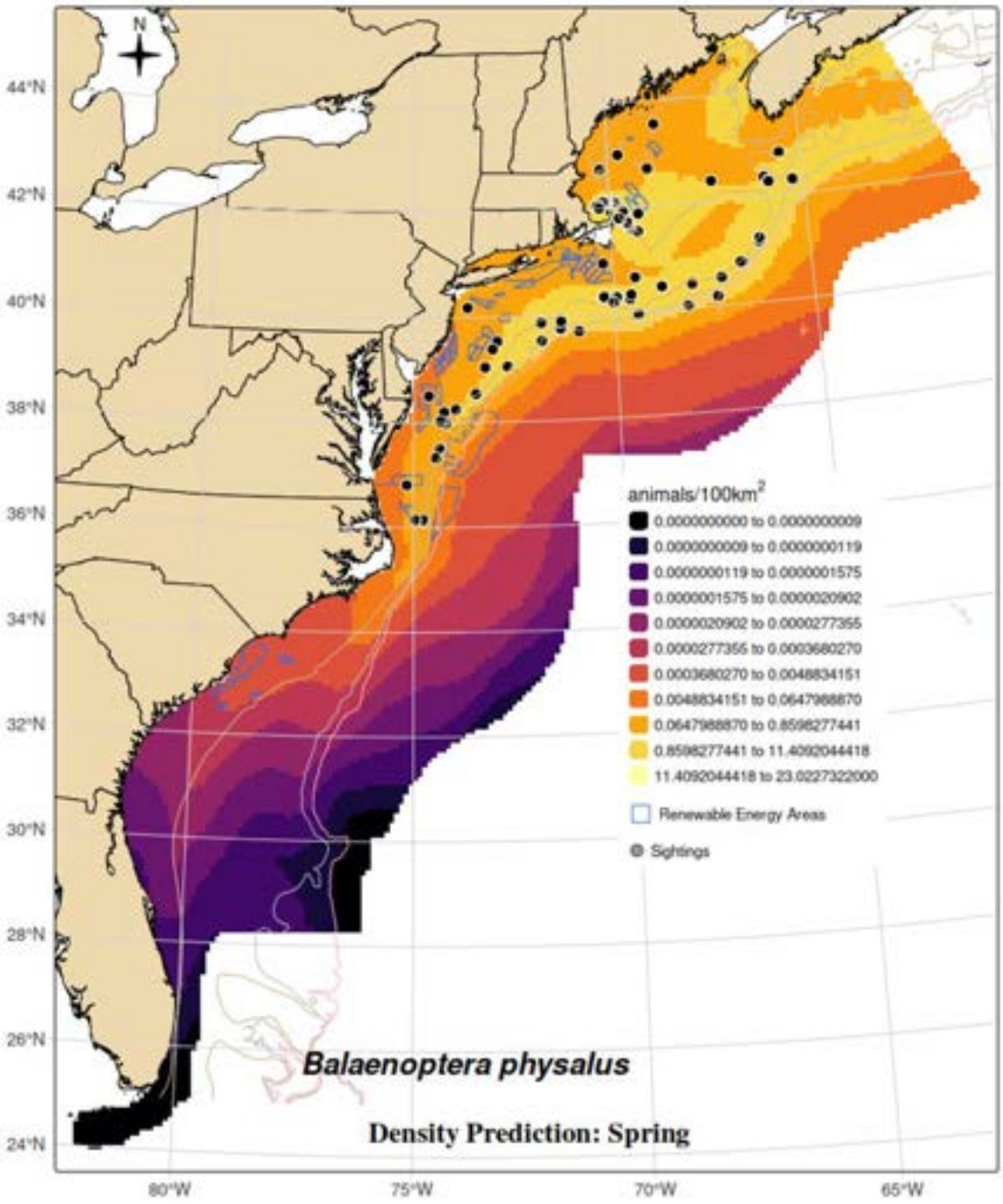

Figure B.3-6. Fin whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

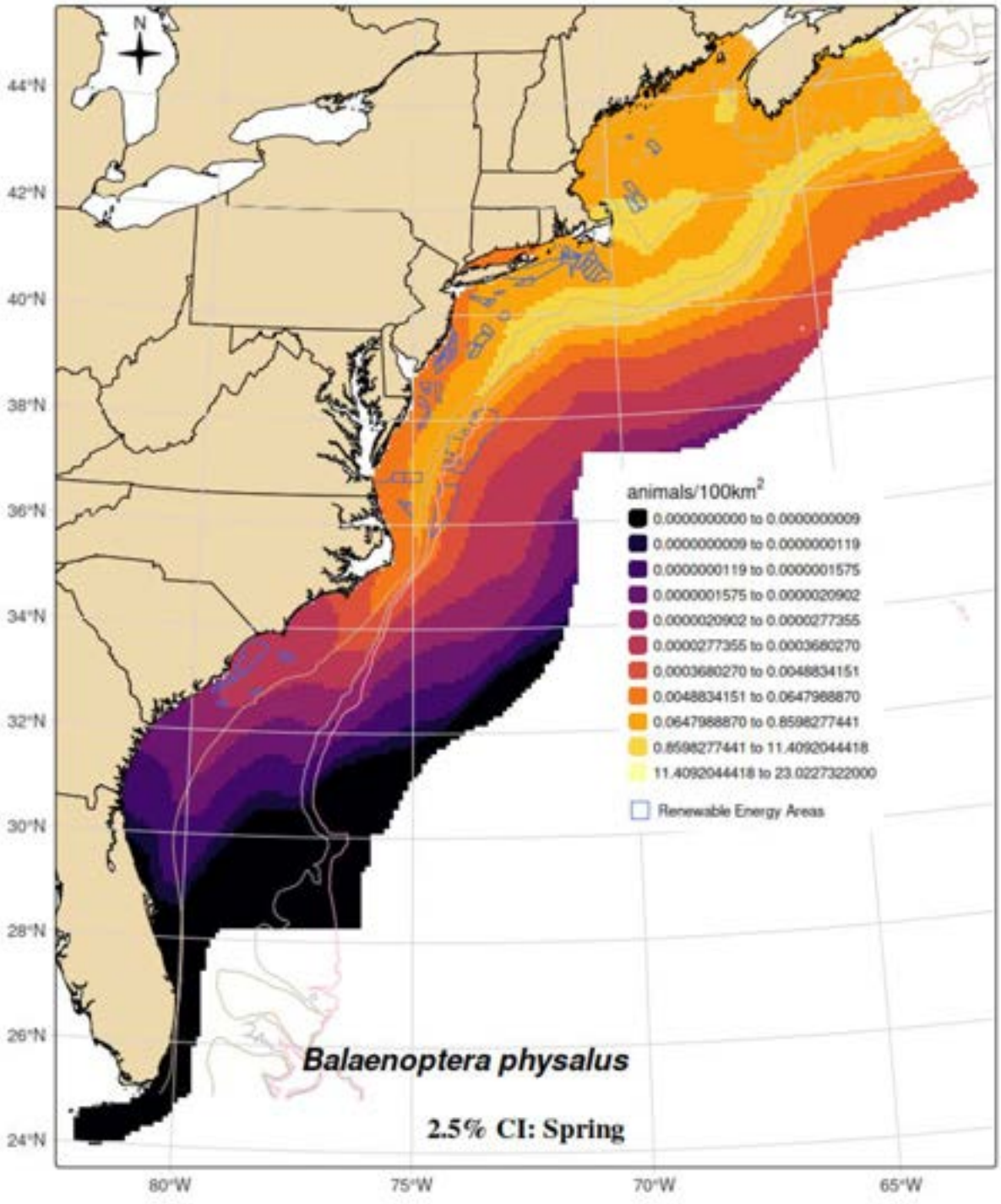

Figure B.3-7. Lower 2.5% confidence interval of the spring fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

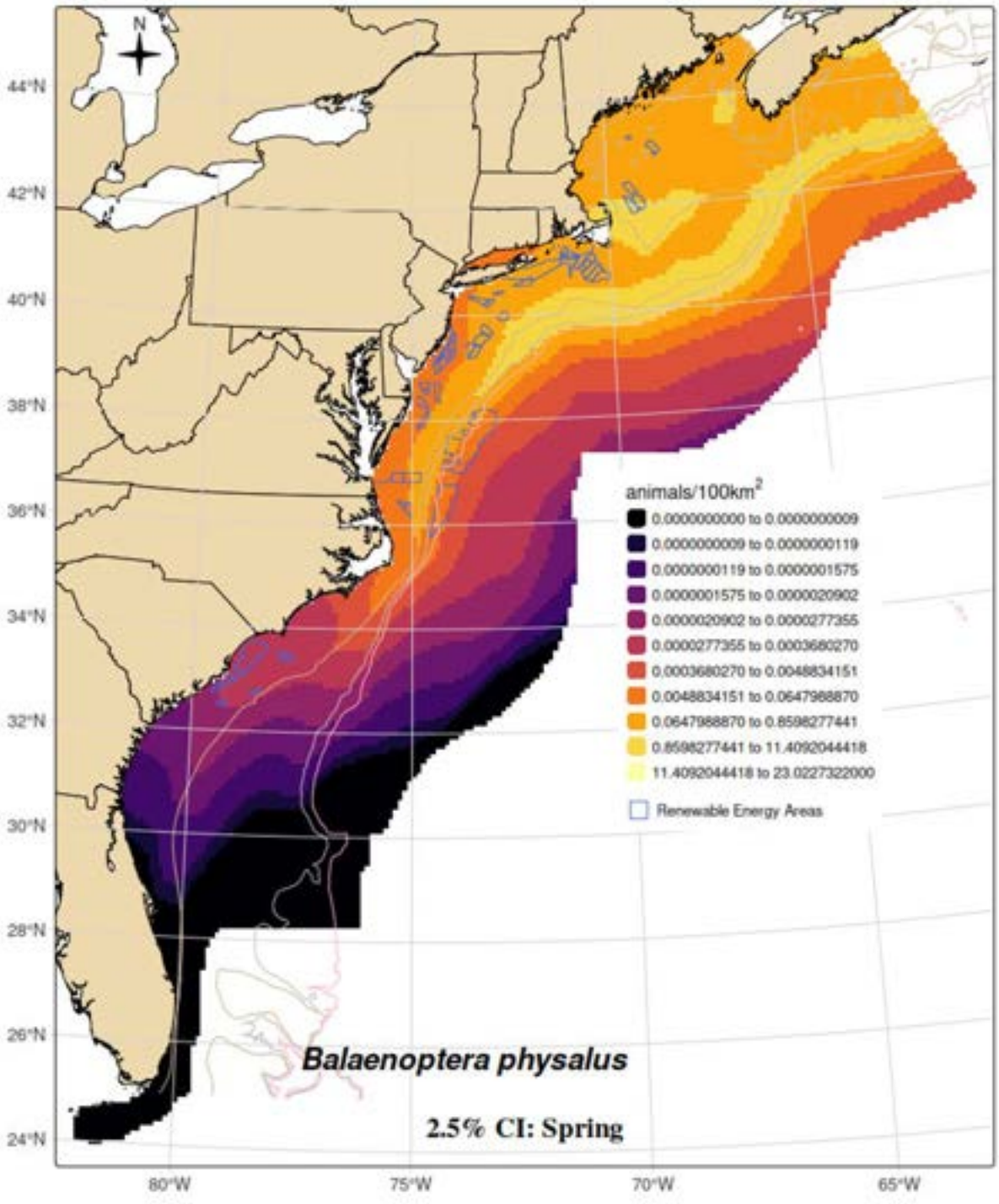

Figure B.3-8. Upper 97.5% confidence interval of the spring fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

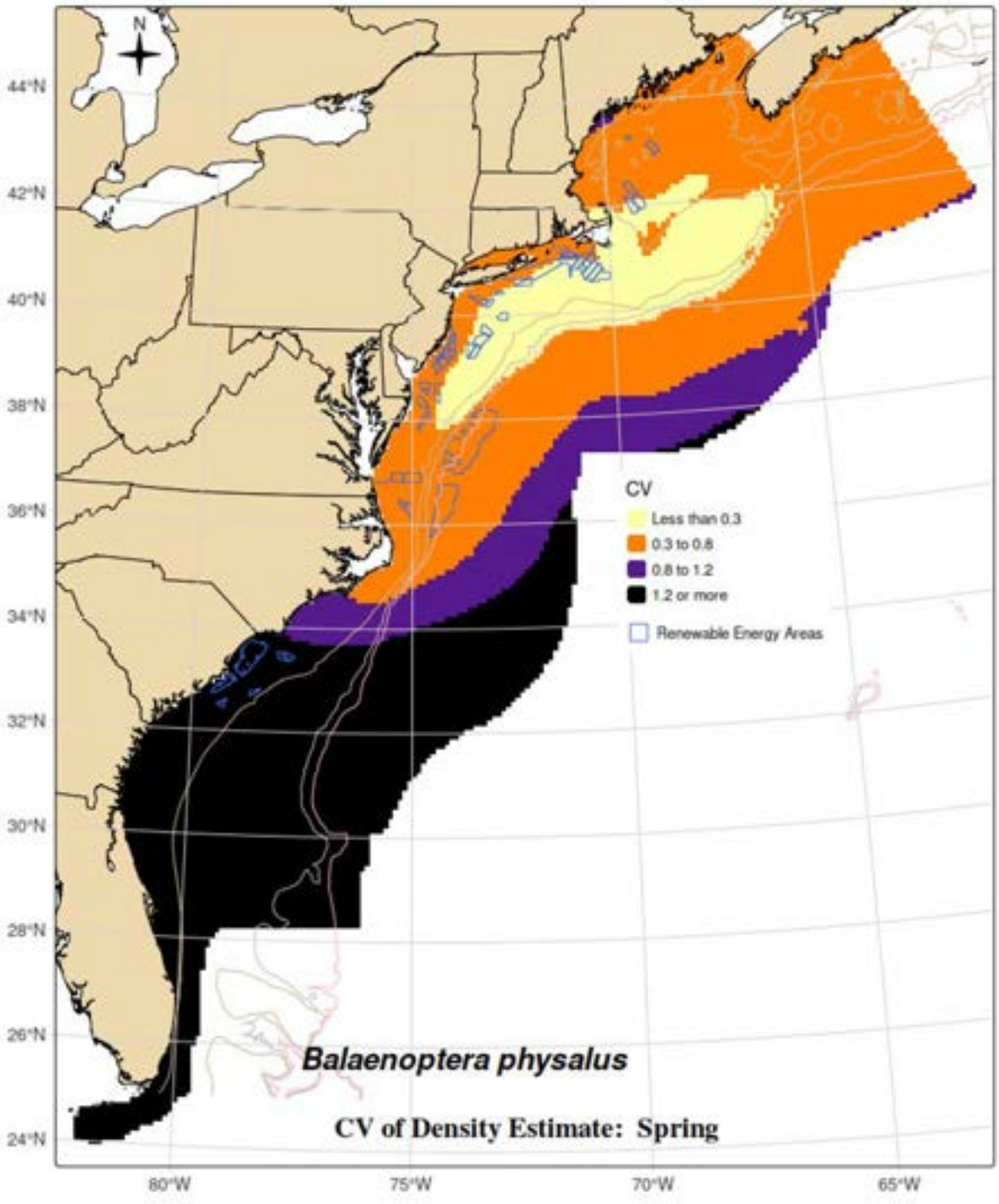

Figure B.3-9. CV of spring fin whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

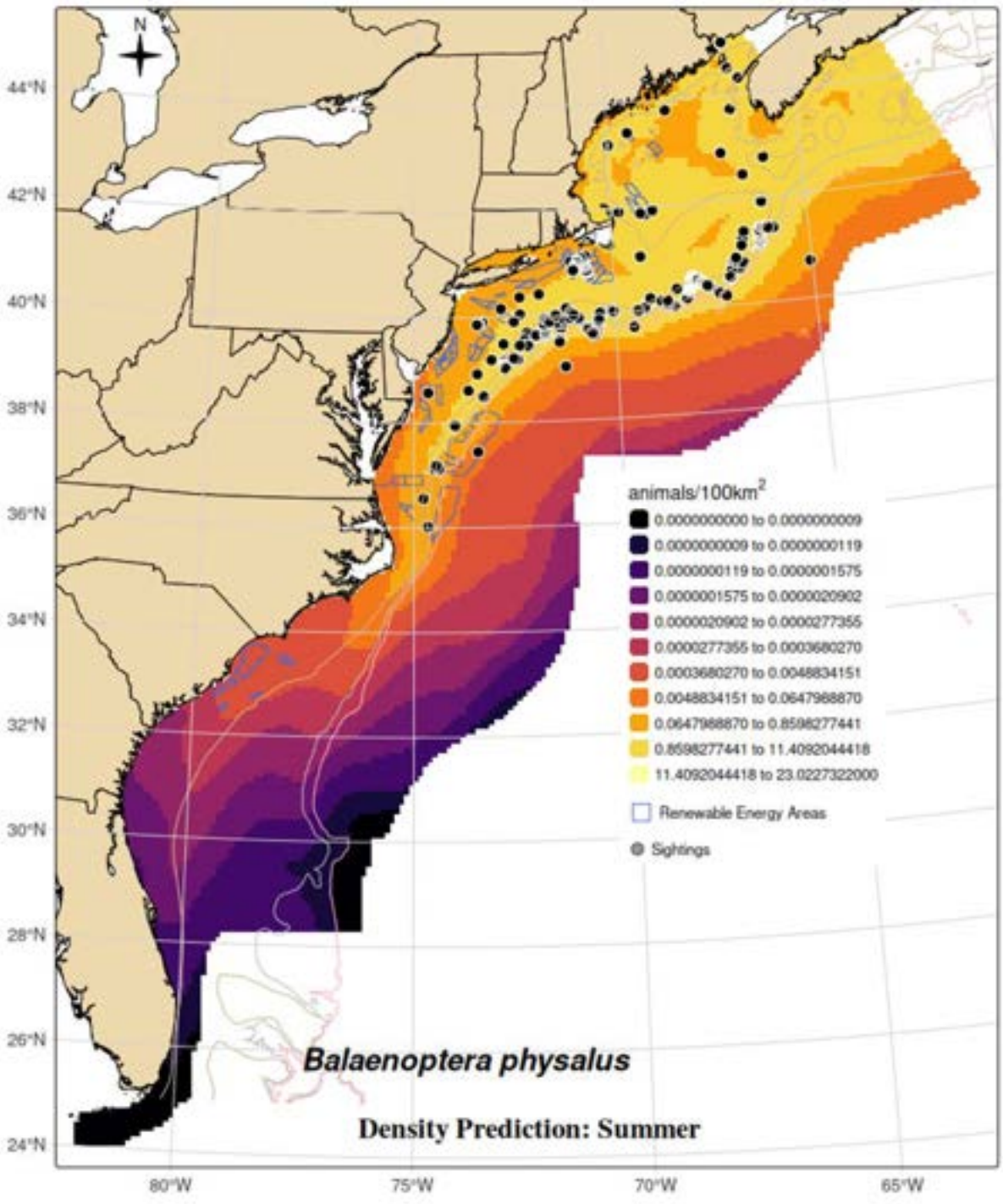

Figure B.3-10. Fin whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

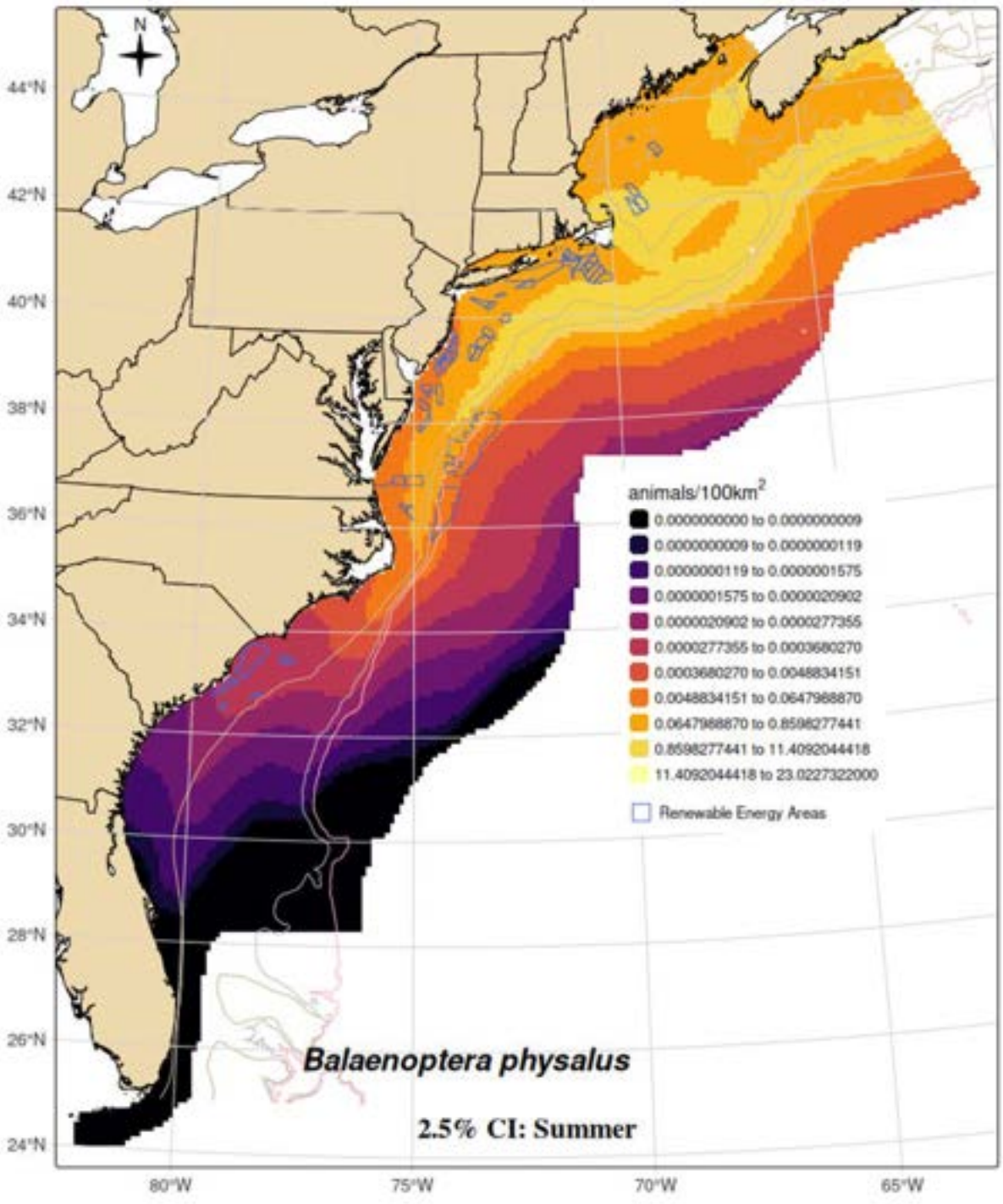

Figure B.3-11. Lower 2.5% confidence interval of the summer fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

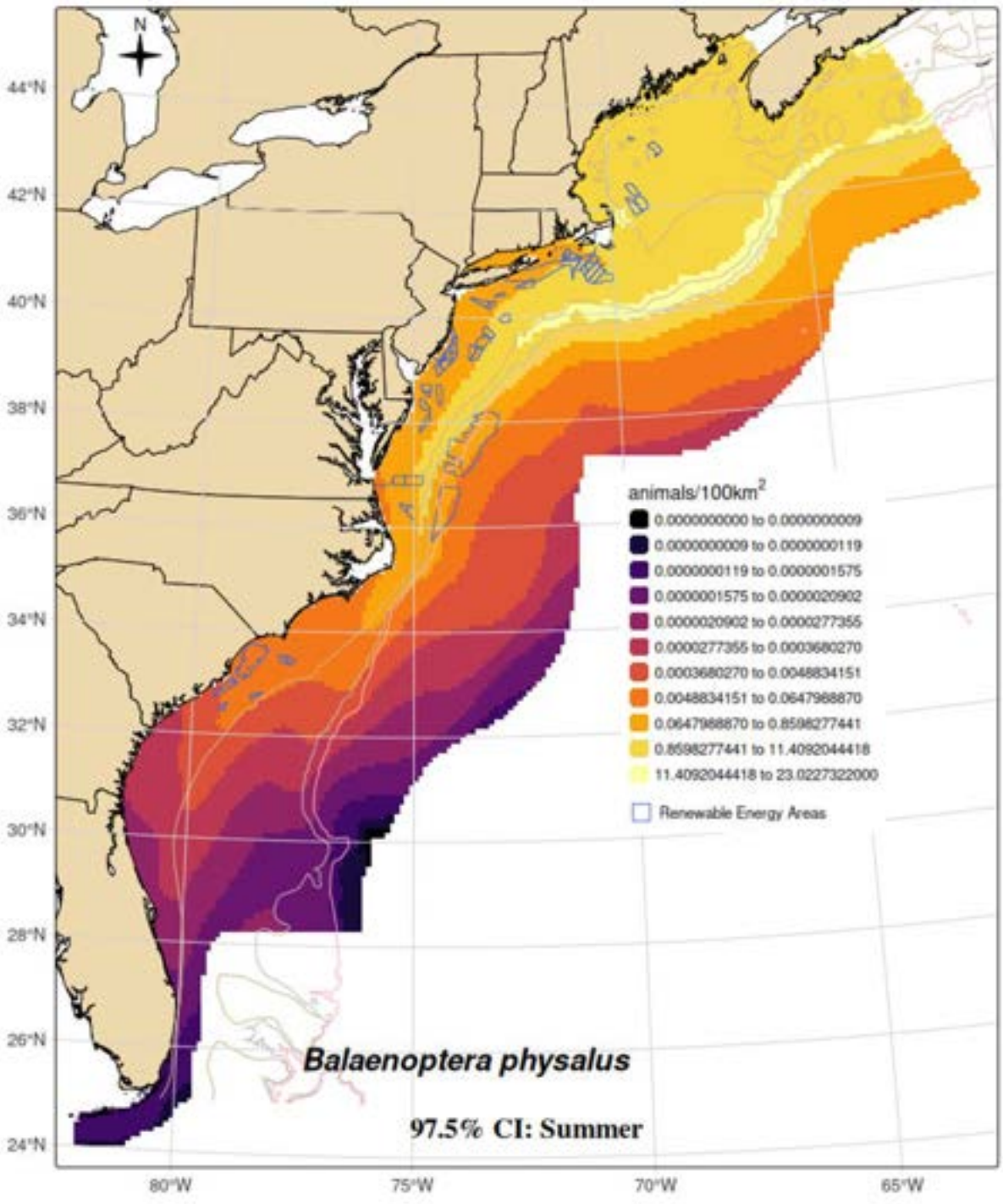

Figure B.3-12. Upper 97.5% confidence interval of the summer fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

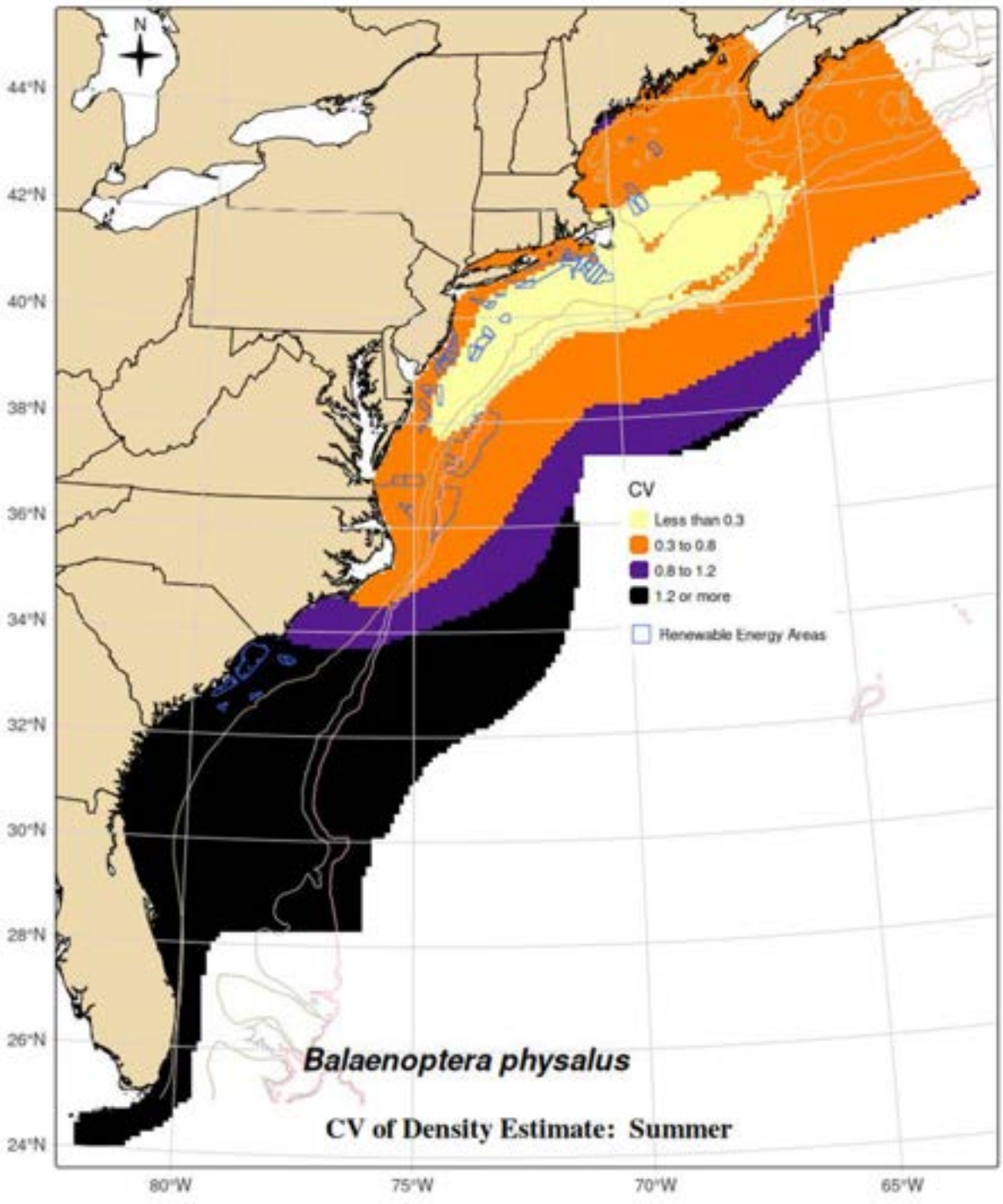

Figure B.3-13. CV of summer fin whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

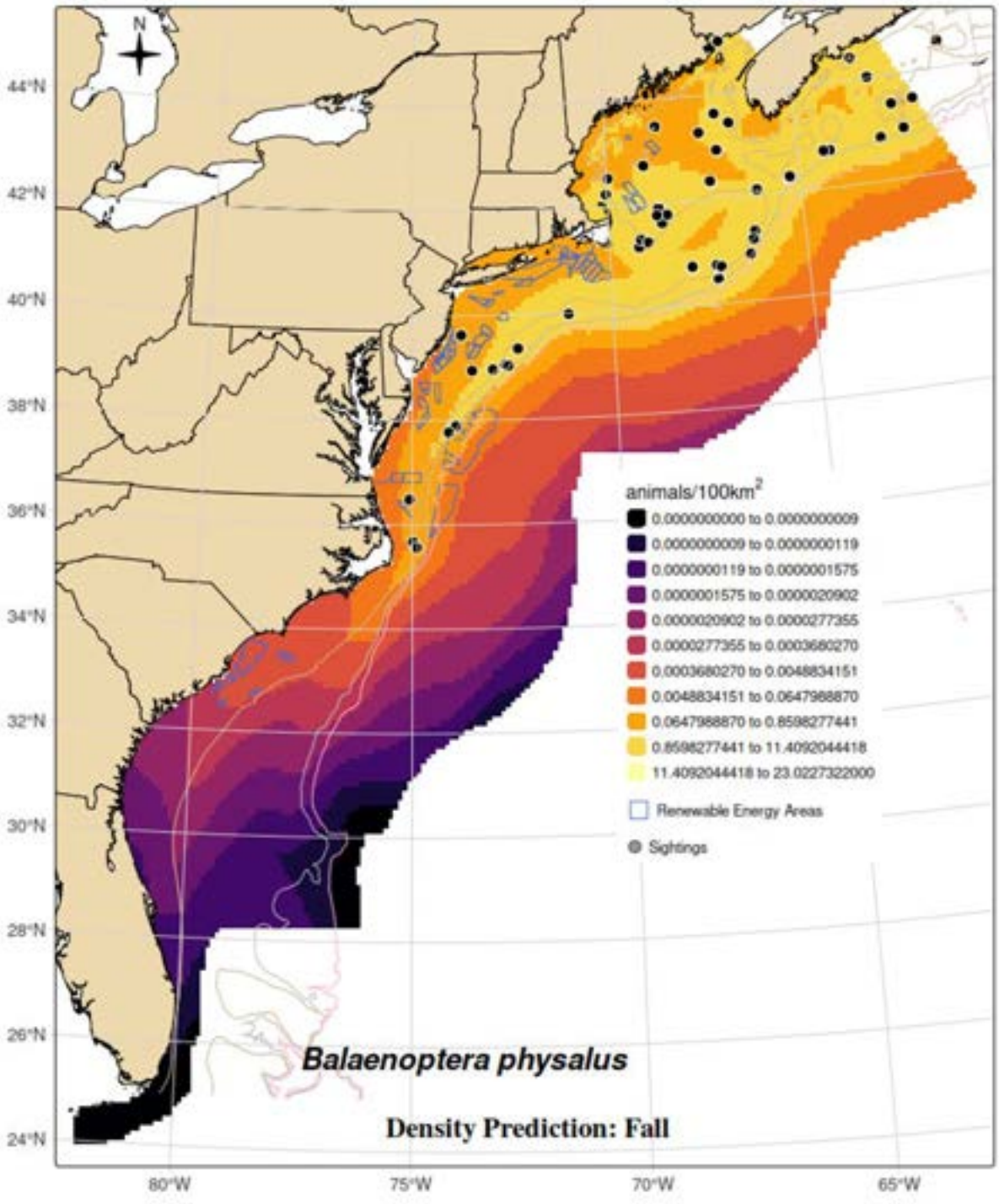

Figure B.3-14. Fin whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

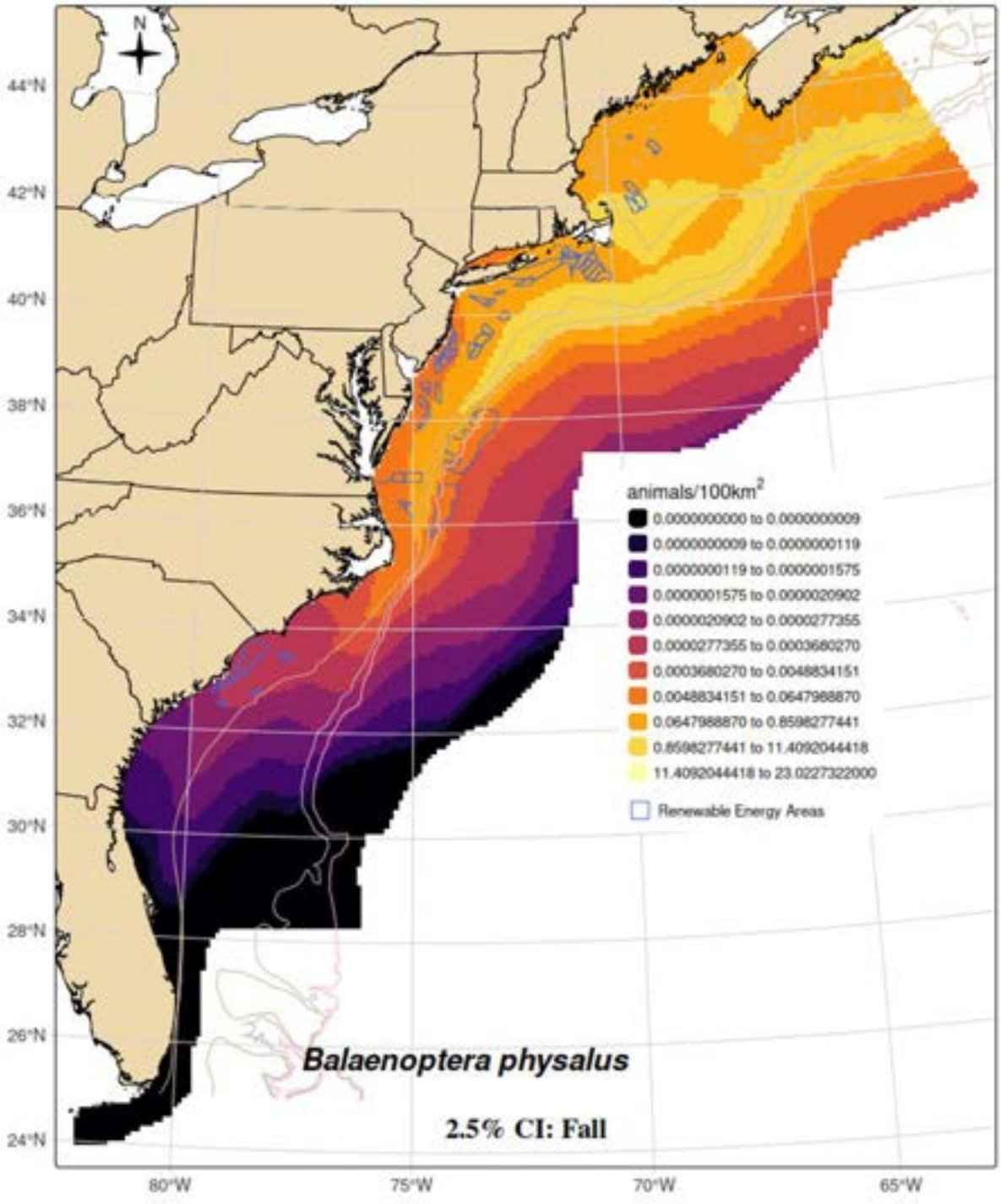

Figure B.3-15. Lower 2.5% confidence interval of the fall fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

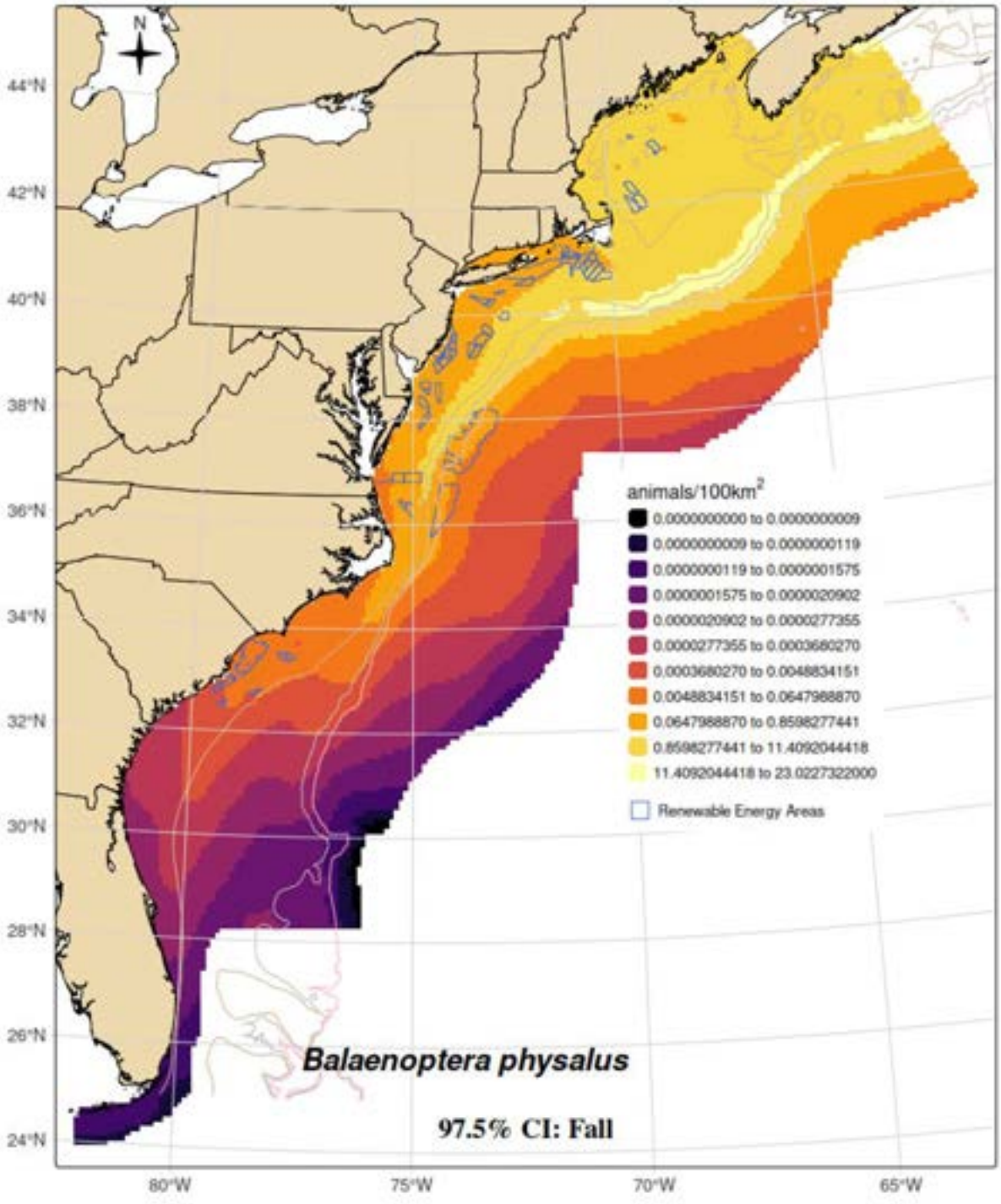

Figure B.3-16. Upper 97.5% confidence interval of the fall fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

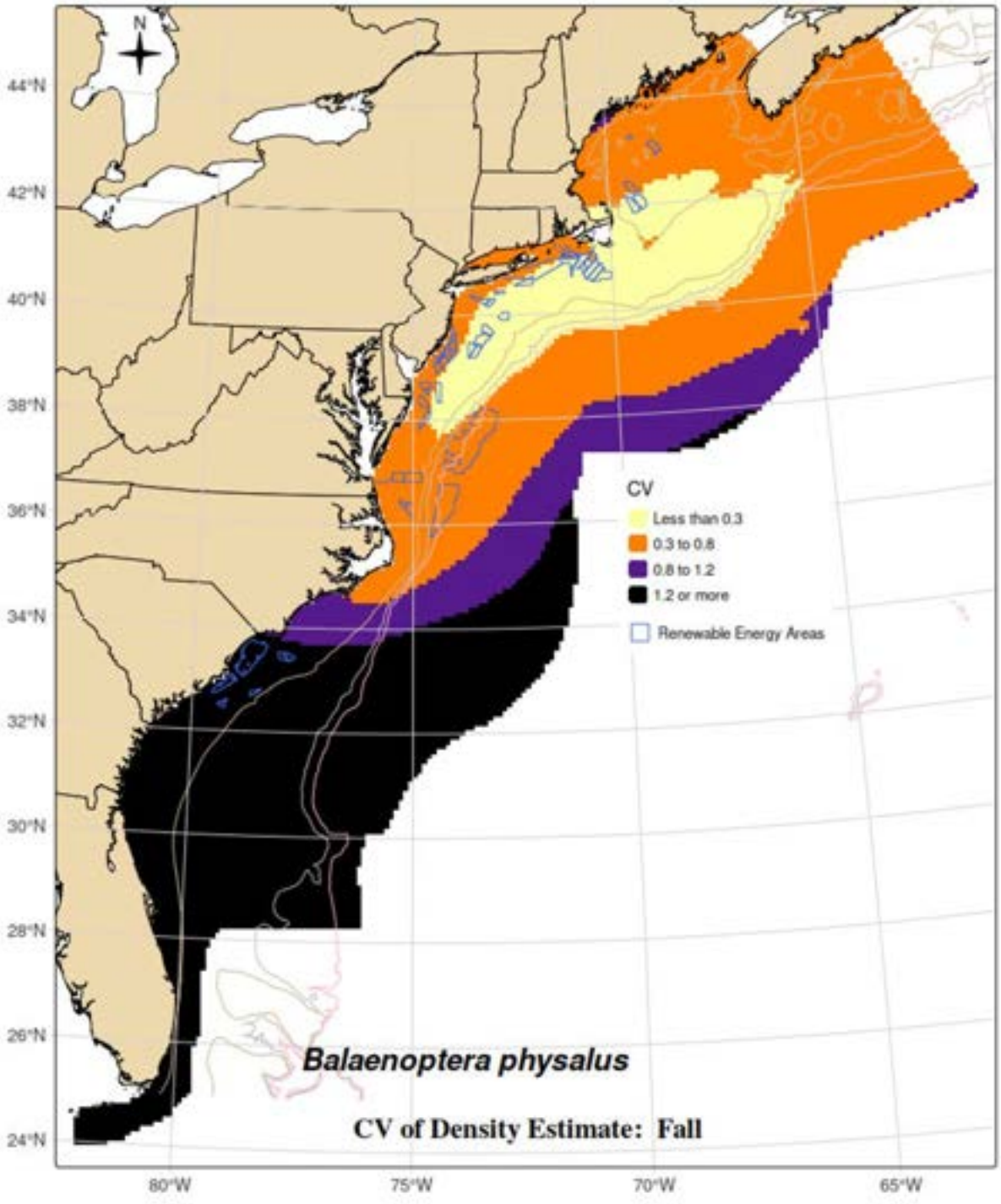

Figure B.3-17. CV of fall fin whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

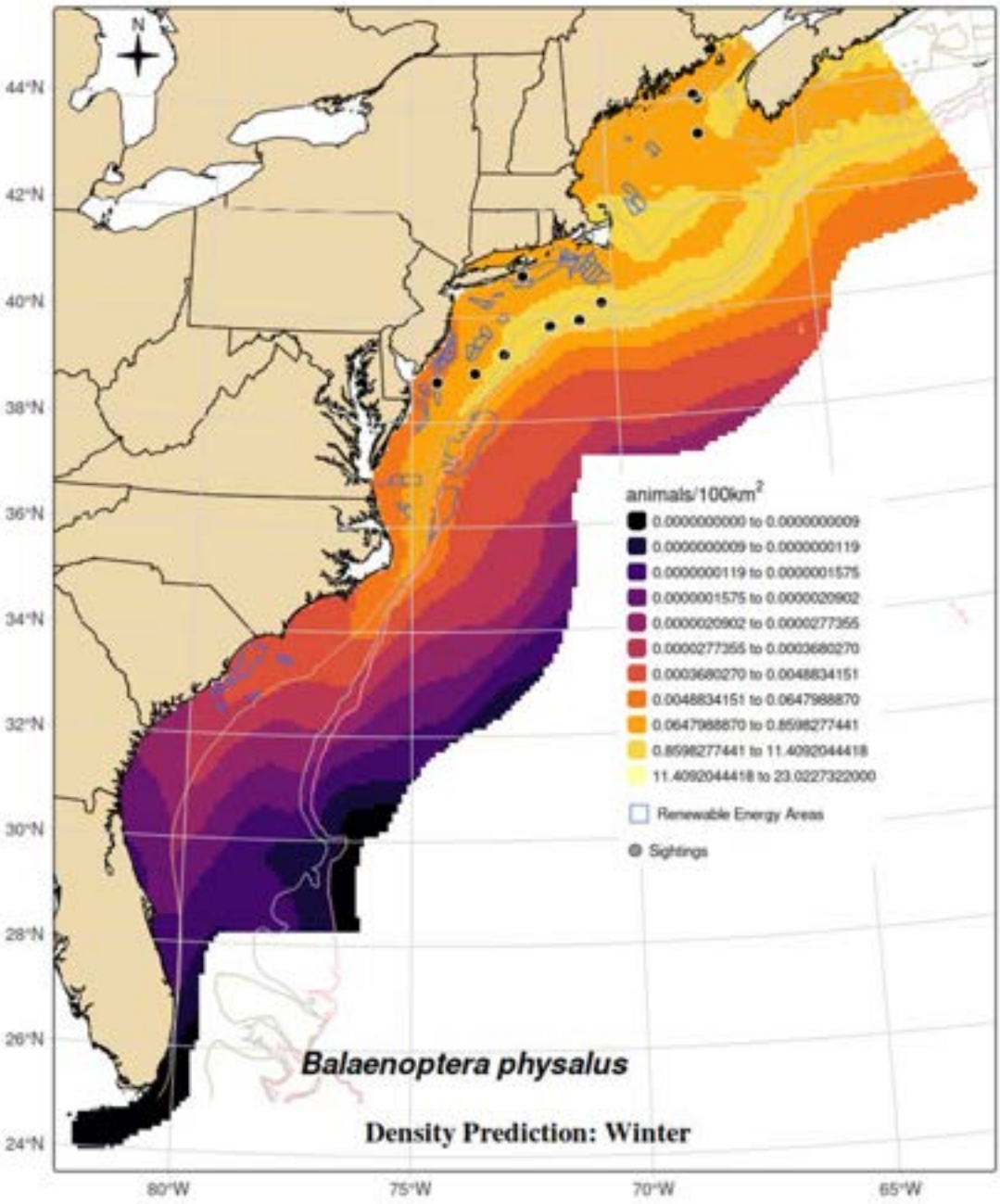

Figure B.3-18. Fin whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

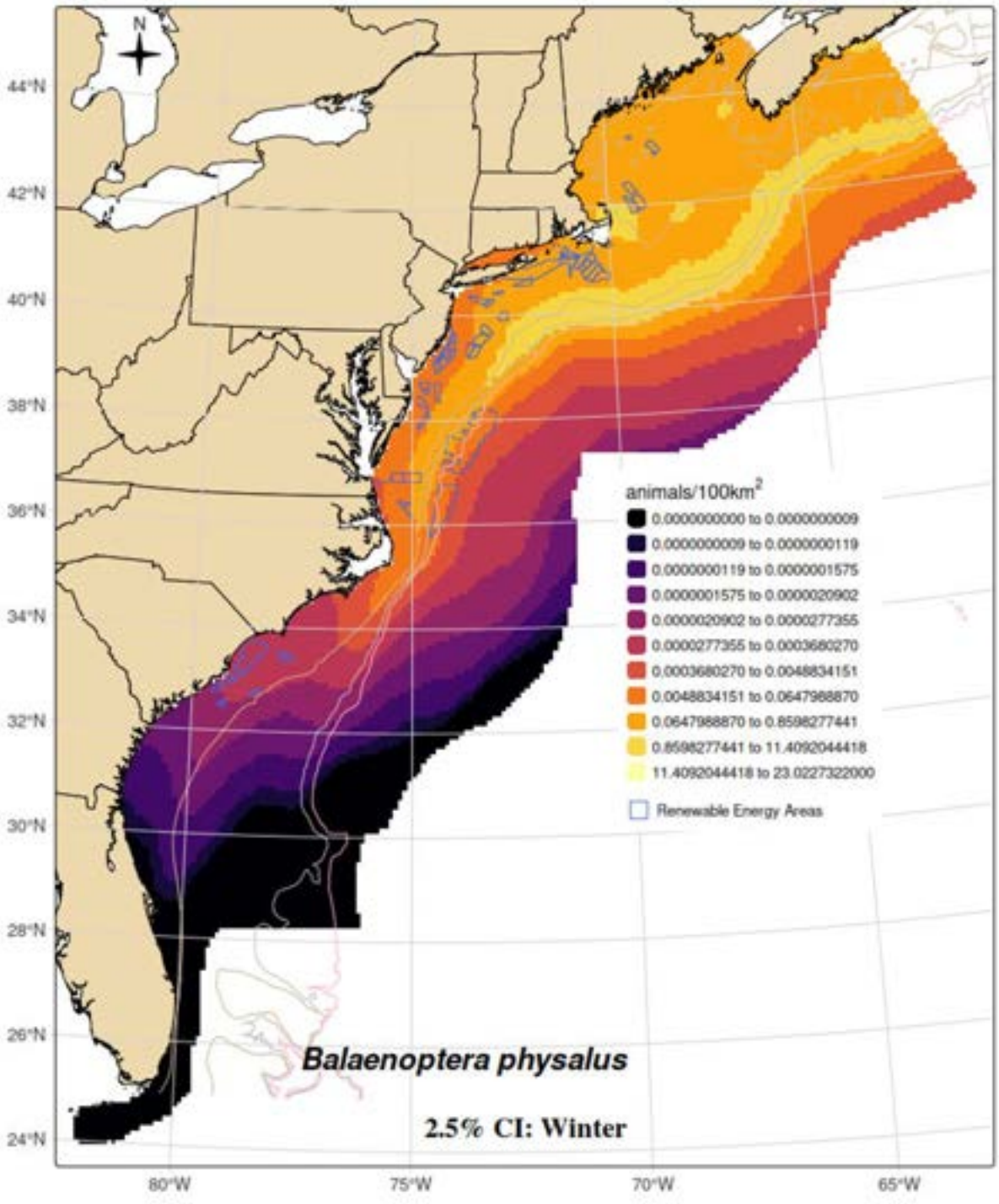

Figure B.3-19. Lower 2.5% confidence interval of the winter fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

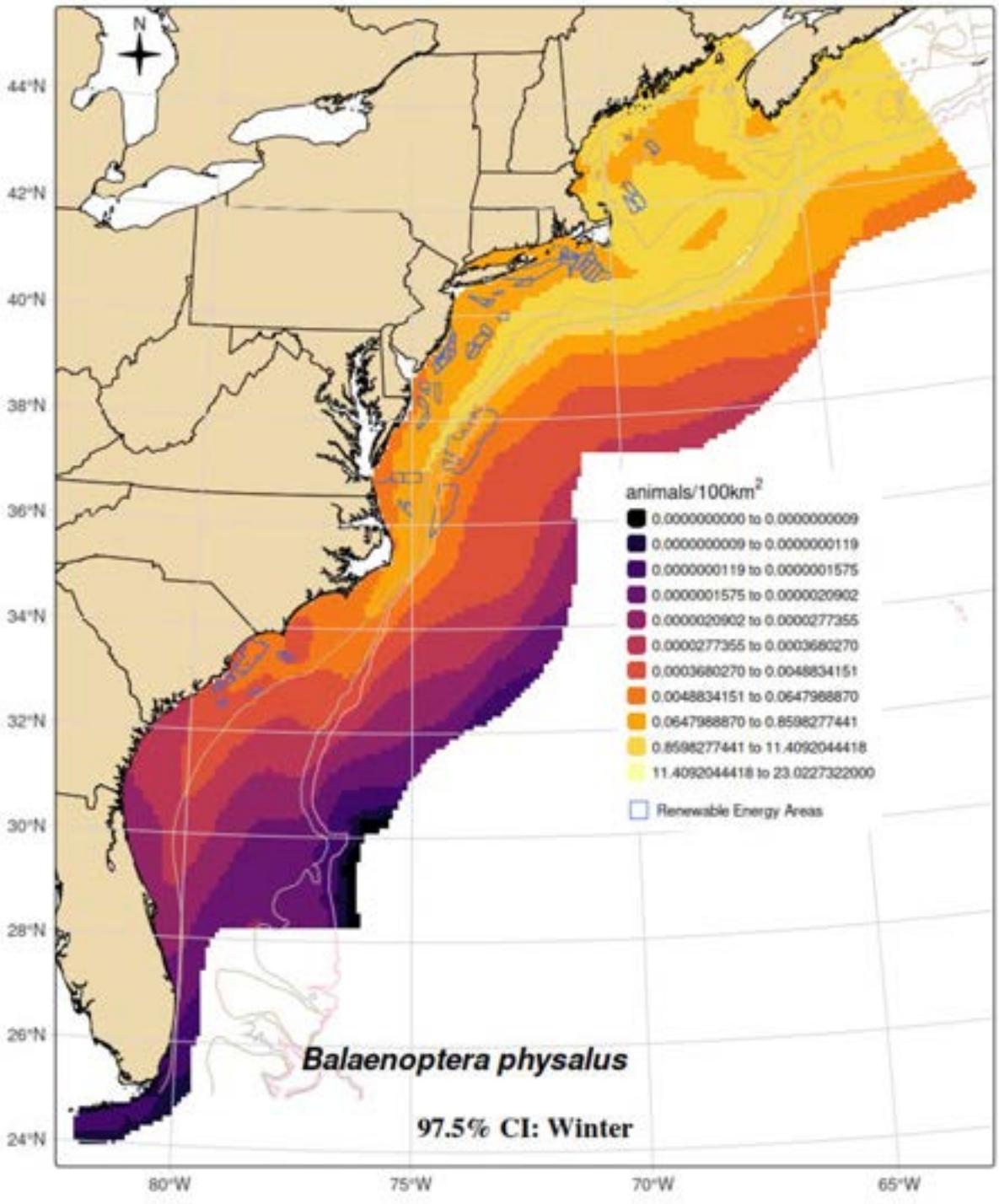

Figure B.3-20. Upper 97.5% confidence interval of the winter fin whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

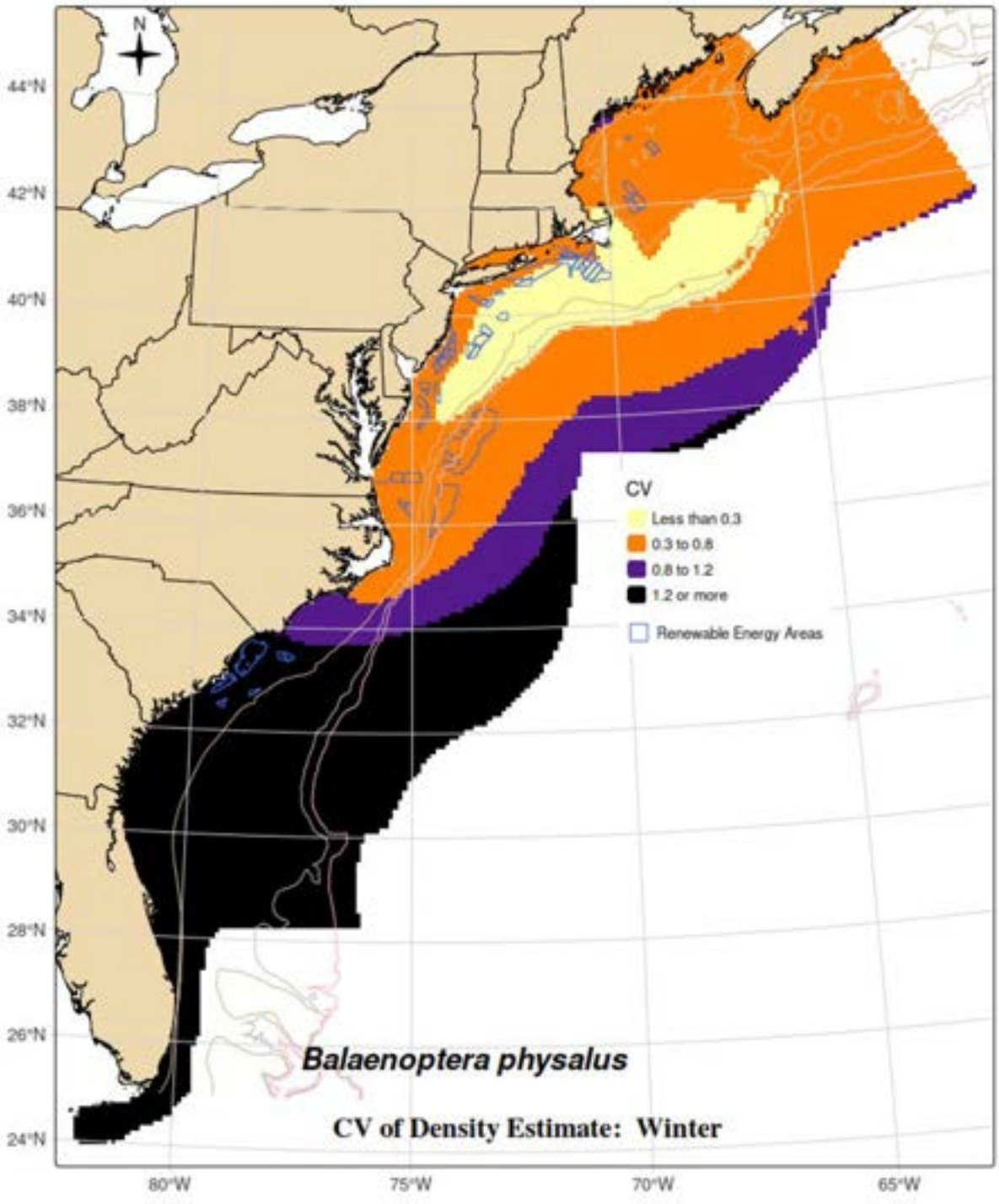

Figure B.3-21. CV of winter fin whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.3.7 Offshore Energy Development Areas

Table B.3-6. Fin whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	49.1	0.27	29.4 – 82
	NY	5.1	0.33	2.7 - 9.6
	NJ	3.3	0.34	1.7 - 6.3
	DE/MD	2.0	0.33	1.1 - 3.8
	VA	1.7	0.40	0.8 - 3.5
	NC	4.5	0.43	2 - 10.2
	NC/SC	0.1	1.52	0 - 0.9
	GA	0.0	2.87	0 – 0
	FL	0.0	12.69	0 – 0
Summer (Jun-Aug)	RI/MA	84.8	0.26	51.6 - 139.3
	NY	8.9	0.32	4.8 - 16.4
	NJ	5.8	0.33	3.1 - 10.9
	DE/MD	3.6	0.32	2 - 6.6
	VA	2.8	0.39	1.3 - 5.8
	NC	7.1	0.42	3.2 - 15.7
	NC/SC	0.1	1.51	0 - 1.3
	GA	0.0	2.86	0 – 0
	FL	0.0	12.69	0 – 0
Fall (Sep-Nov)	RI/MA	67.8	0.26	41.3 - 111.3
	NY	6.9	0.32	3.7 - 12.8
	NJ	4.6	0.33	2.5 - 8.6
	DE/MD	2.7	0.32	1.5 – 5.0
	VA	2.1	0.39	1 - 4.3
	NC	5.4	0.43	2.4 - 12.1
	NC/SC	0.1	1.50	0 - 0.9
	GA	0.0	2.86	0 – 0
	FL	0.0	12.69	0 – 0
Winter (Dec-Feb)	RI/MA	37.6	0.27	22.1 - 63.7
	NY	4.0	0.33	2.1 - 7.5
	NJ	2.8	0.35	1.4 - 5.3
	DE/MD	1.7	0.33	0.9 - 3.2
	VA	1.4	0.40	0.6 - 2.9
	NC	3.6	0.44	1.6 - 8.3
	NC/SC	0.1	1.52	0 - 0.8
	GA	0.0	2.87	0 – 0
	FL	0.0	12.69	0 – 0

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

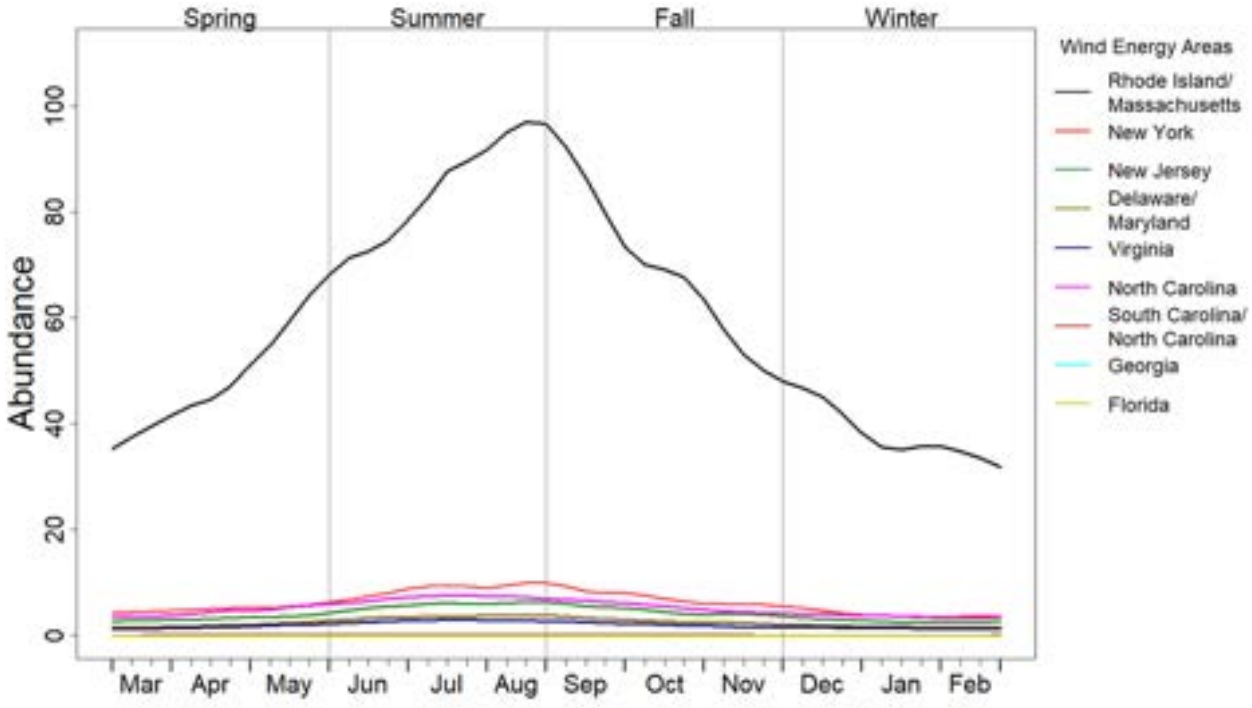

Figure B.3-22. Average seasonal abundance of fin whales in the wind-energy study areas

B.4 Sei Whale (*Balaenoptera borealis*)

Figure B.4-1. Sei whale
Image collected under MMPA Research permit #775-1875 Credit: NOAA/NEFSC/Genevieve Davis.

B.4.1 Data Collection

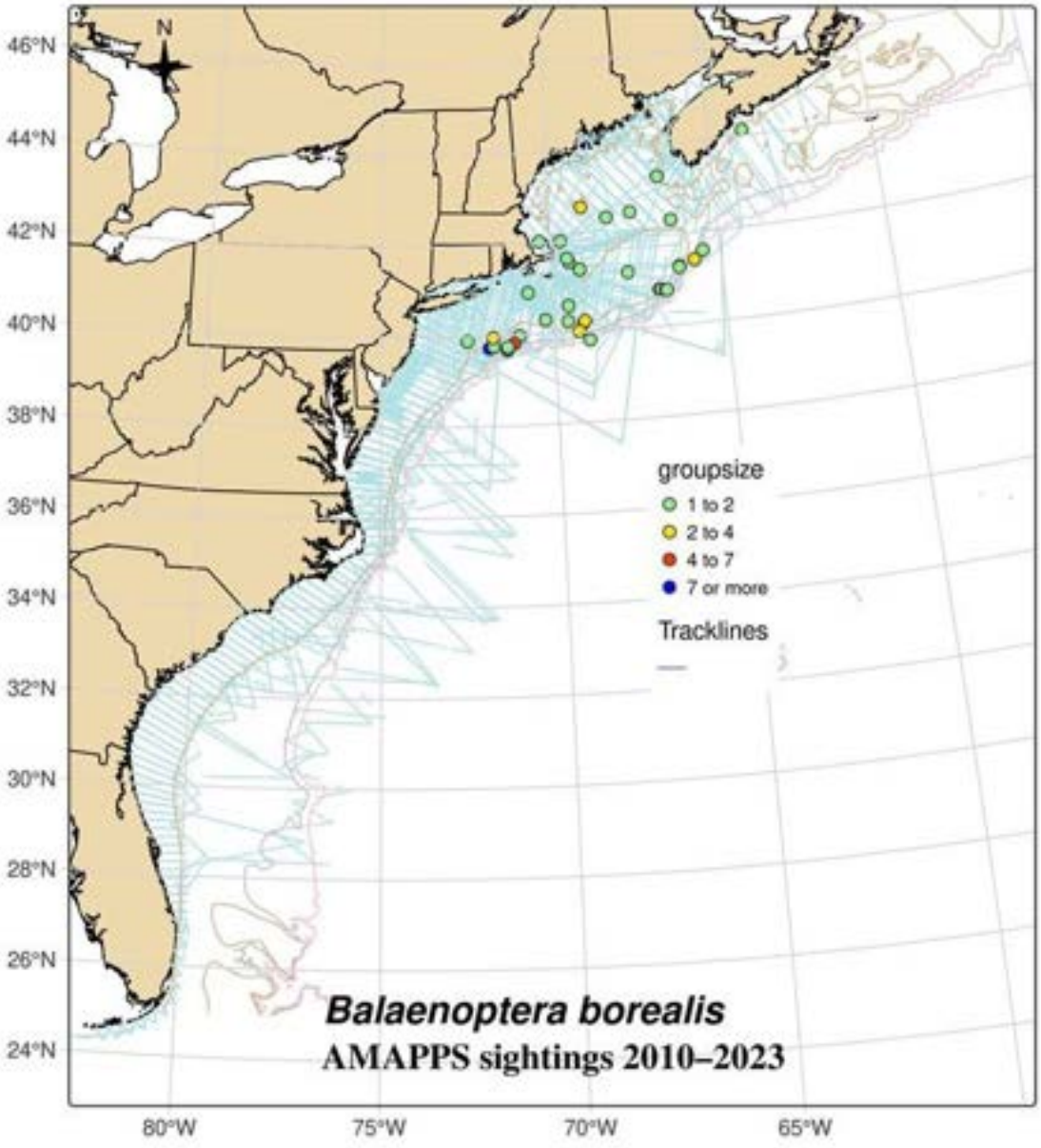

Figure B.4-2. Distribution of track lines and sei whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.4-1. AMAPPS research effort 2010 to 2023 and sei whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	28	33
NE Shipboard	Summer	49,064	23	32
NE Aerial	Spring	38,839	15	35
NE Aerial	Summer	52,003	5	6
NE Aerial	Fall	87,311	5	11
NE Aerial	Winter	24,747	2	5
SE Shipboard	Spring	2,604	0	0
SE Shipboard	Summer	18,331	0	0
SE Shipboard	Fall	2,673	0	0
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	0	0
SE Aerial	Summer	43,285	0	0
SE Aerial	Fall	21,153	0	0
SE Aerial	Winter	19,152	0	0

B.4.2 Mark-Recapture Distance Sampling Analysis

Table B.4-2. Intermediate parameters in sei whale mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
NE–aerial group 1	distance + quality	500	distance + quality	1000	HR	0.54	0.12	0.90	0.97
NE–shipboard group 10	distance * observer + log(group size)	4500	Distance + glare + swell height + time of day	4500	HR	0.54	0.08	0.01	0.95
SE–shipboard group 5	distance + log(group size)	9000	distance + glare	9000	HR	0.58	0.11	0.70	0.61

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables B.4-20 and 4-21.

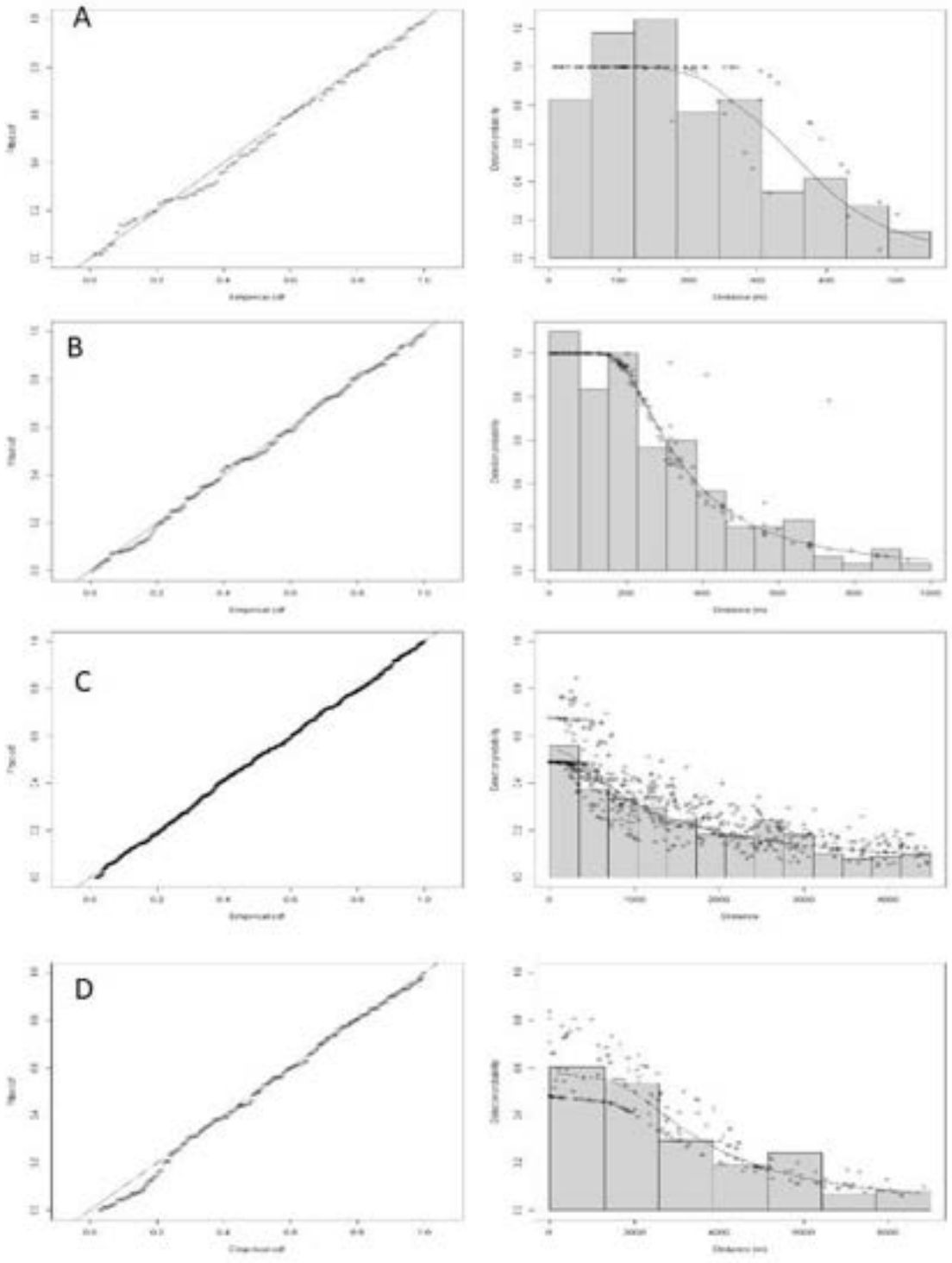

Figure B.4-3. Q-Q plots and detection functions from the sei whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 1; C) NE-shipboard analysis set 10; D) SE-shipboard analysis set 5.

B.4.3 Generalized Additive Model Analysis

Table B.4-3. 2010 to 2023 density-habitat model output for sei whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(sstmur)	0.96	5	1.90	6.42	0.0012
s(dist2shore)	2.15	5	4.11	16.87	<0.0001
s(slope)	0.56	5	0.24	1.57	0.1414
s(latdd)	2.55	5	2.39	11.32	0.0033

Adjusted R^2 = 0.00237. Deviance explained = 36.2%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

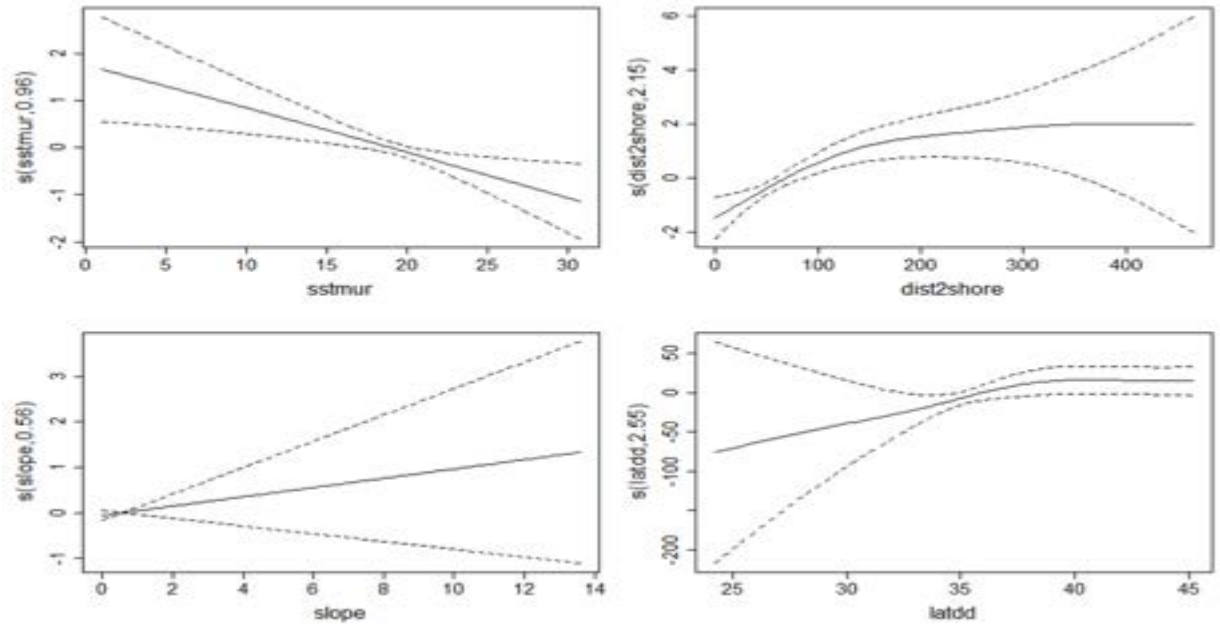

Figure B.4-4. Sei whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.4.4 Model Cross-Validation

Table B.4-4. Diagnostic statistics from the sei whale density-density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
MAPE	Mean absolute percentage error	Non-zero density	98.729	Fair to good
RHO	Spearman rank correlation	Non-zero density	0.100	Fair to good
MAPE	Mean absolute percentage error	All data divided in 25 random samples	98.846	Excellent
RHO	Spearman rank correlation	All data divided in 25 random samples	0.057	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.0002	Excellent

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.4.5 Abundance Estimates for AMAPPS Study Area

Table B.4-5. Sei whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	304	0.55	111 – 833
Summer (June–August)	125	0.56	45 – 384
Fall (September–November)	147	0.55	54 – 403
Winter (December–February)	284	0.55	104 – 778
Summer 2011 U.S. surveys[1]	357	0.52	190 − 672
Summer 2016 U.S. surveys[1]	52	0.53	27 − 99
Summer 2021 U.S. surveys[1]	34	0.99	7 – 172

[1]Hayes et al. 2024

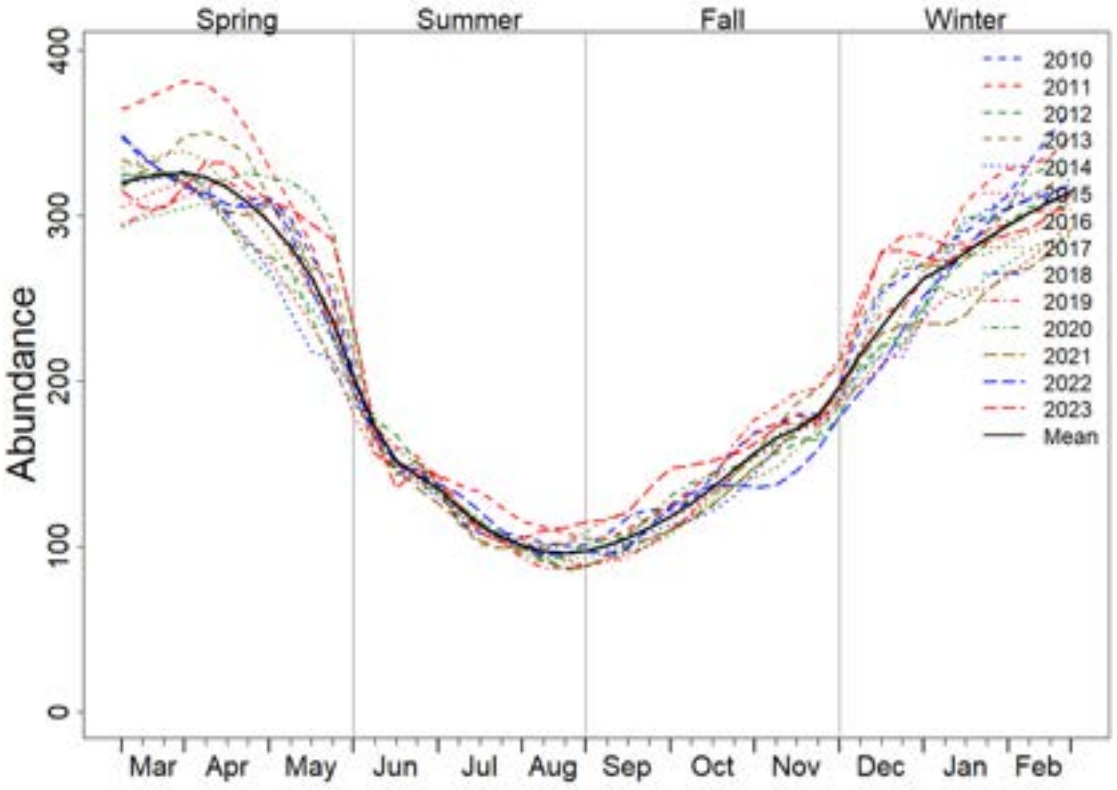

Figure B.4-5. Annual abundance trends for sei whales in the AMAPPS study area

B.4.6 Seasonal Prediction Maps

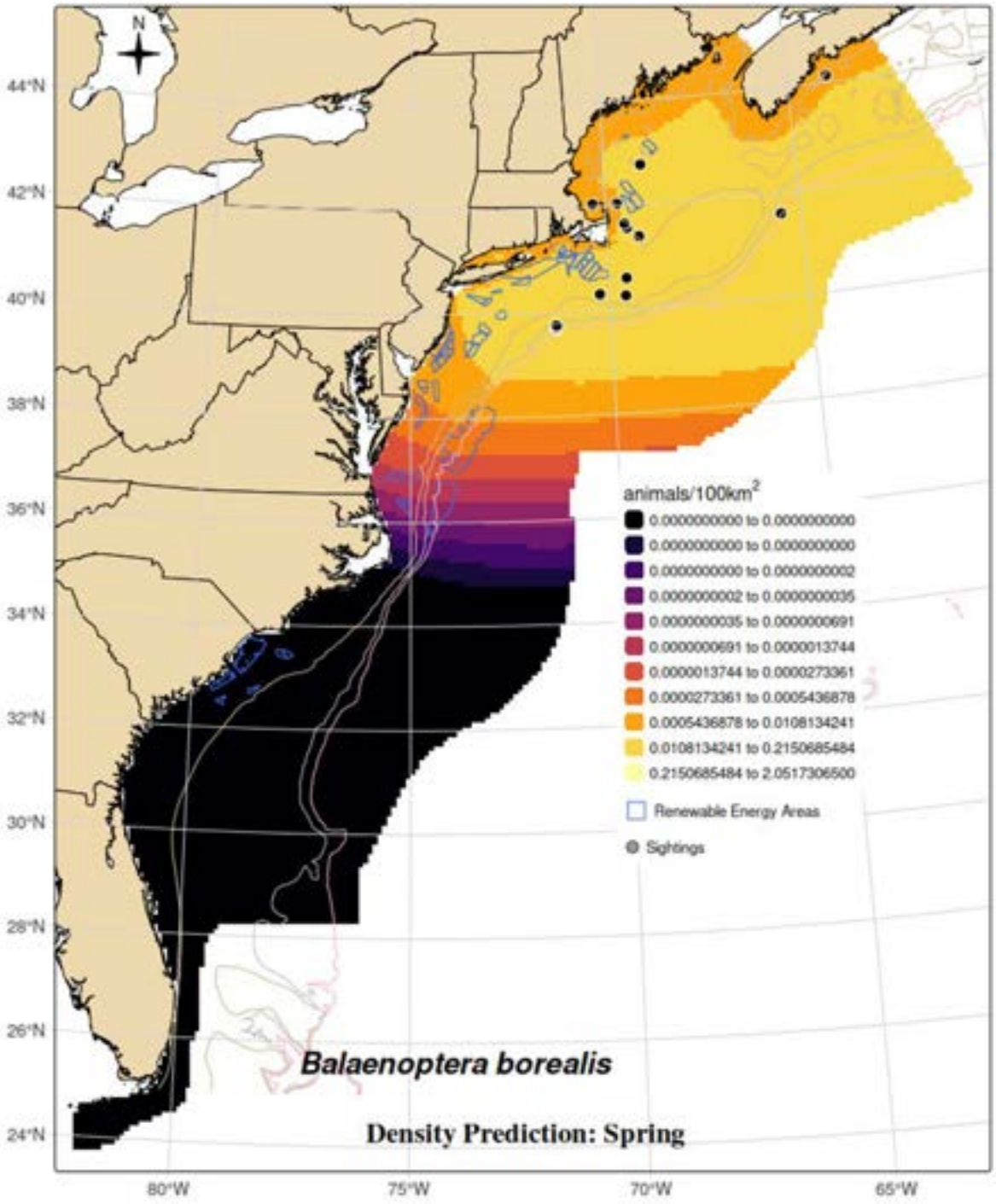

Figure B.4-6. Sei whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas

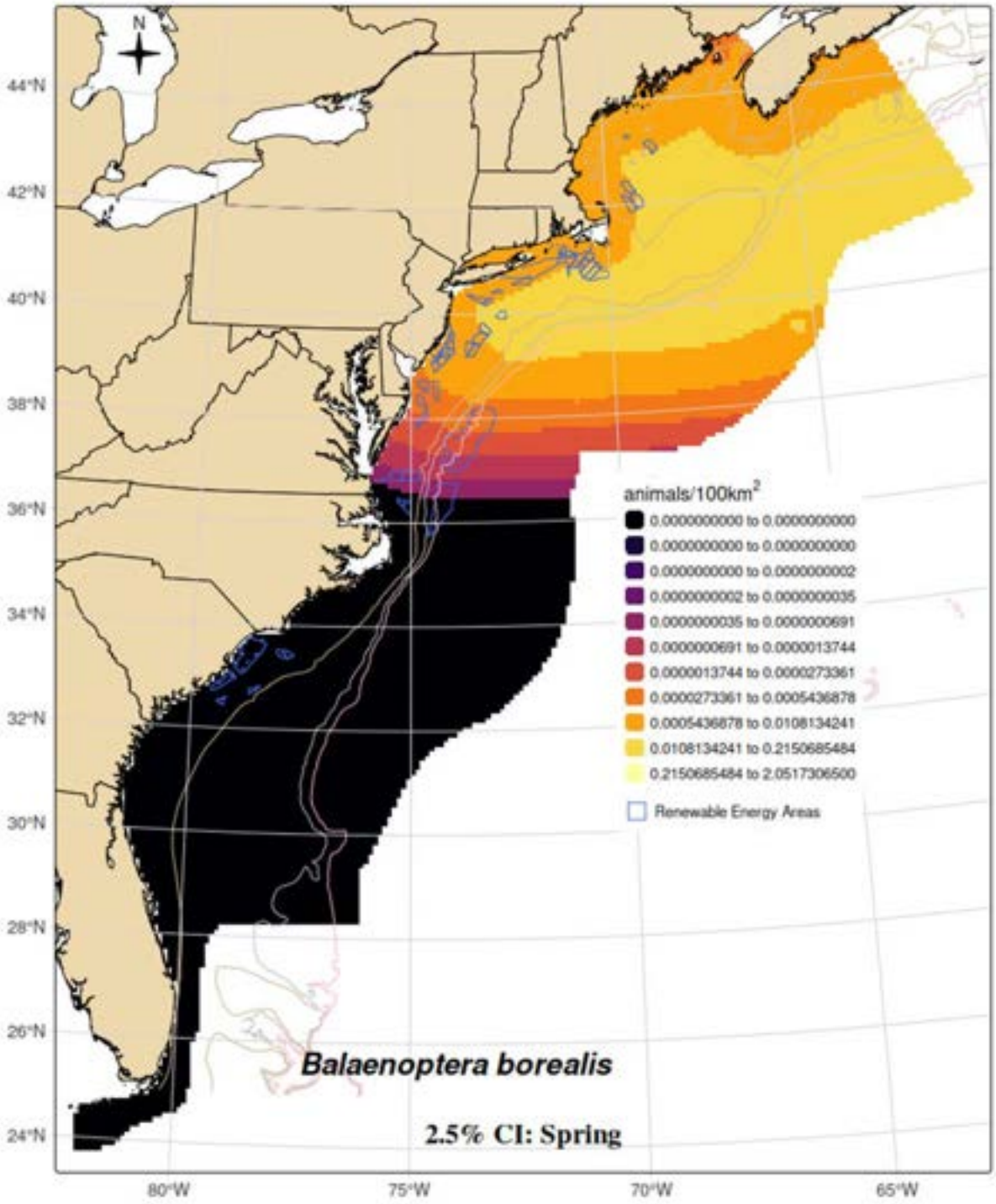

Figure B.4-7. Lower 2.5% confidence interval of the spring sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

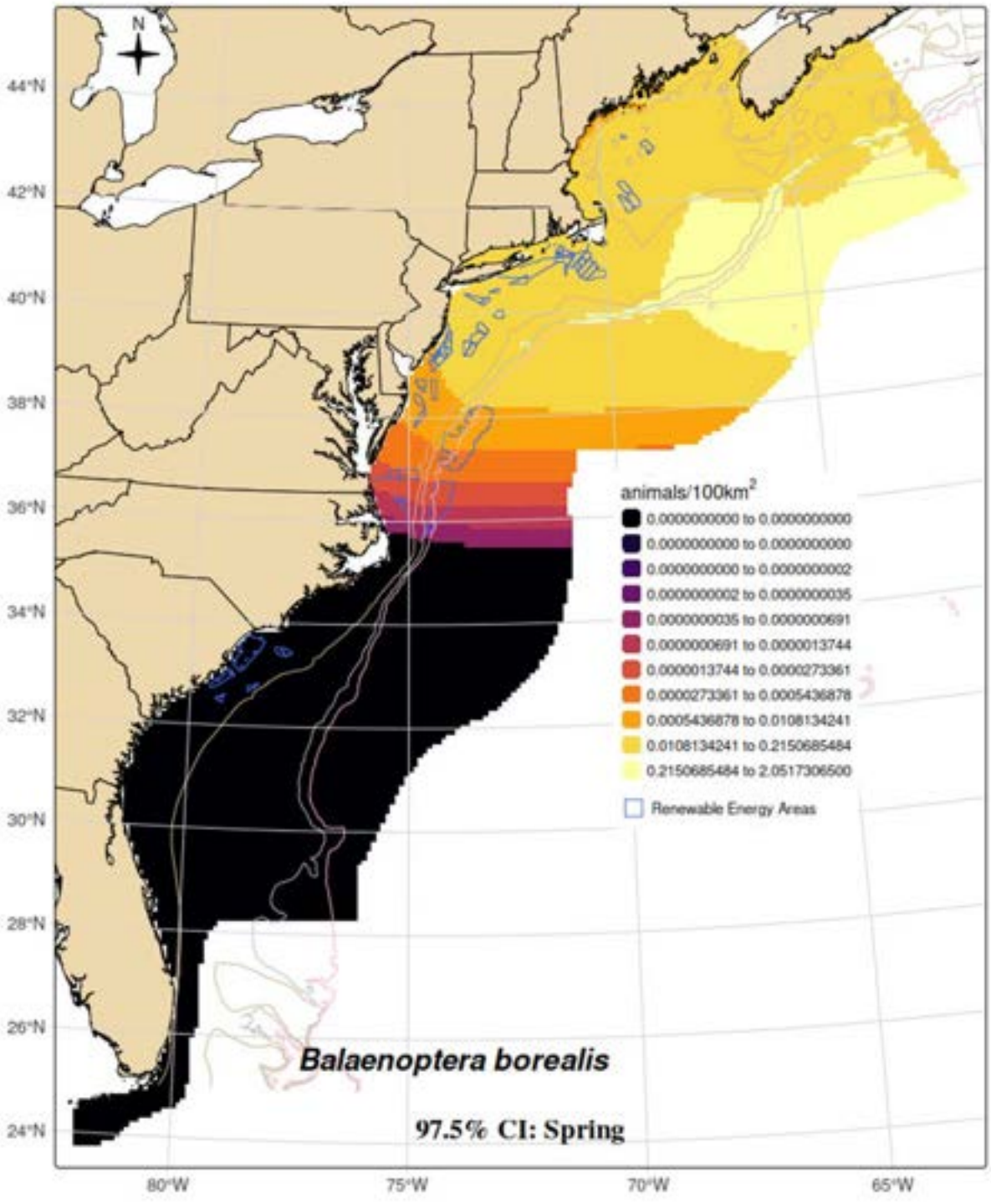

Figure B.4-8. Upper 97.5% confidence interval of the spring sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

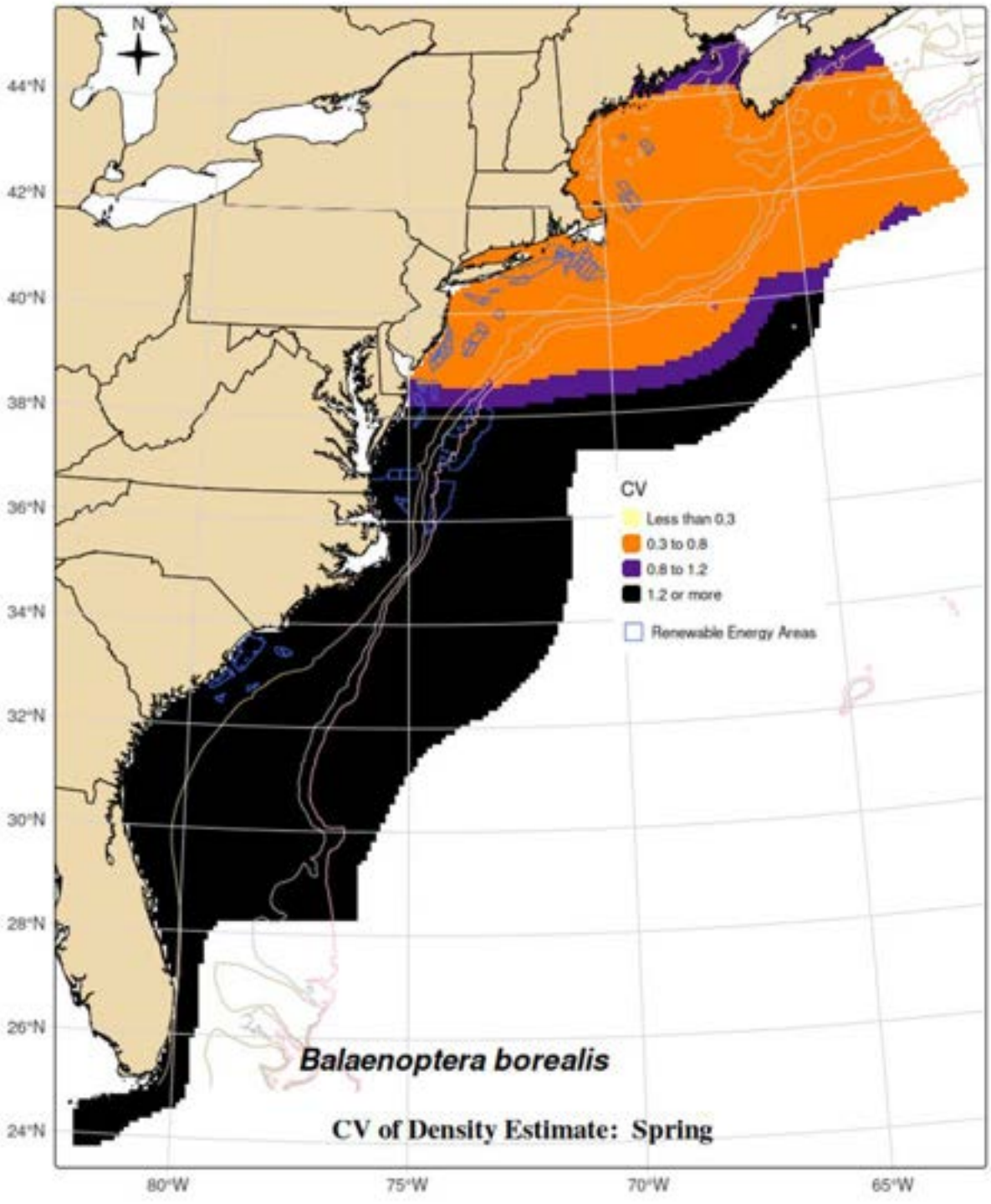

Figure B.4-9. CV of spring sei whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

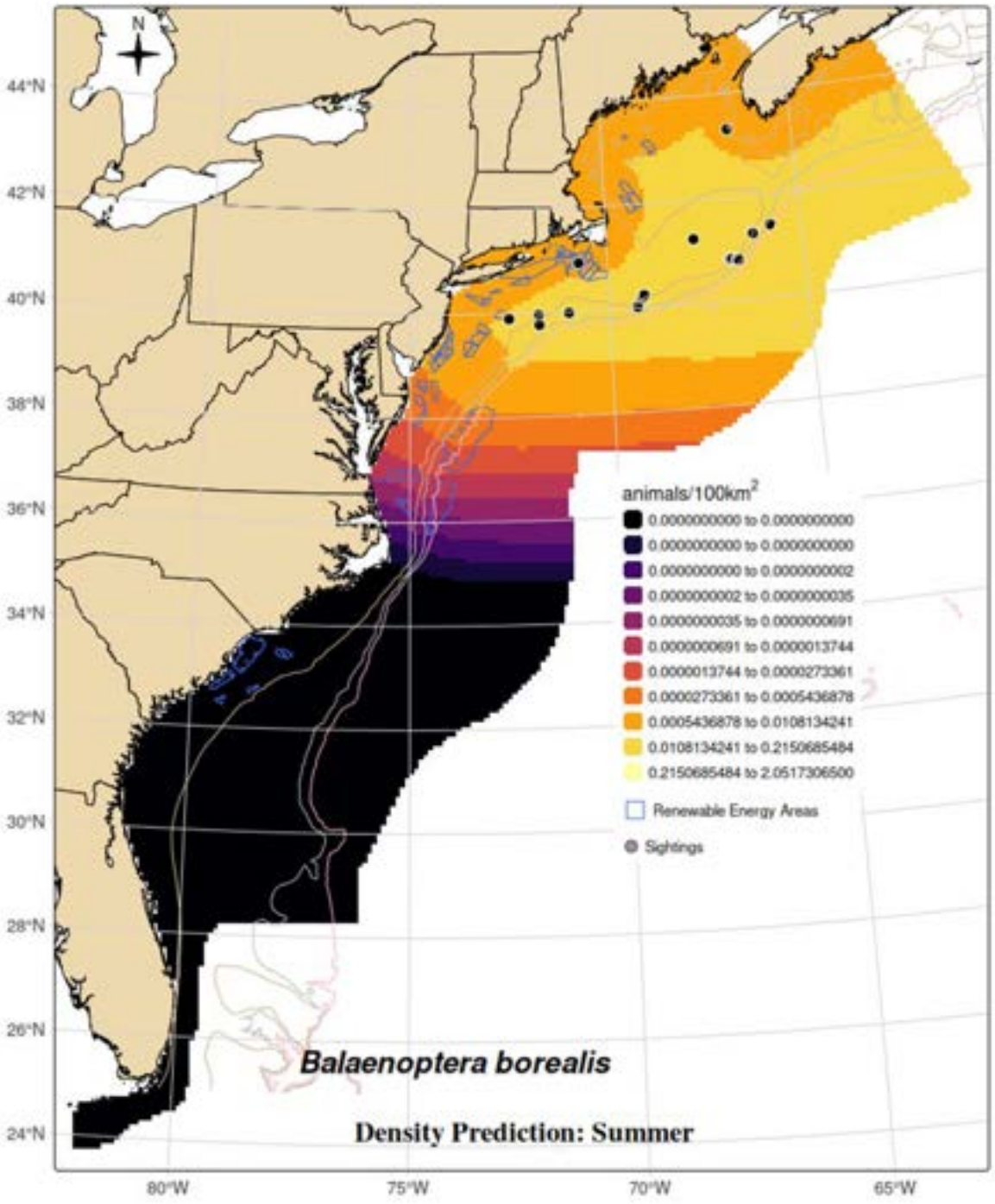

Figure B.4-10. Sei whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas

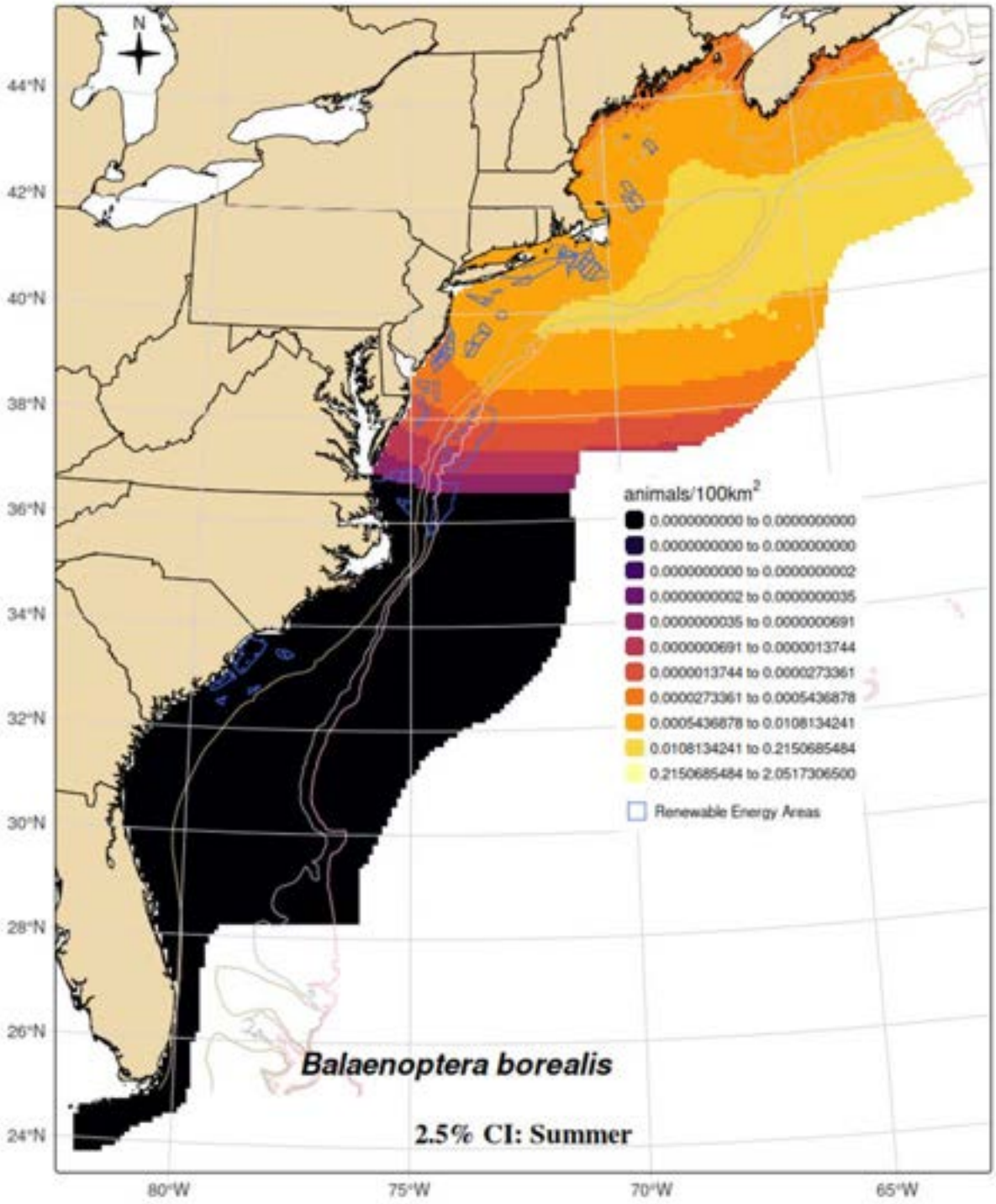

Figure B.4-11. Lower 2.5% confidence interval of the summer sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

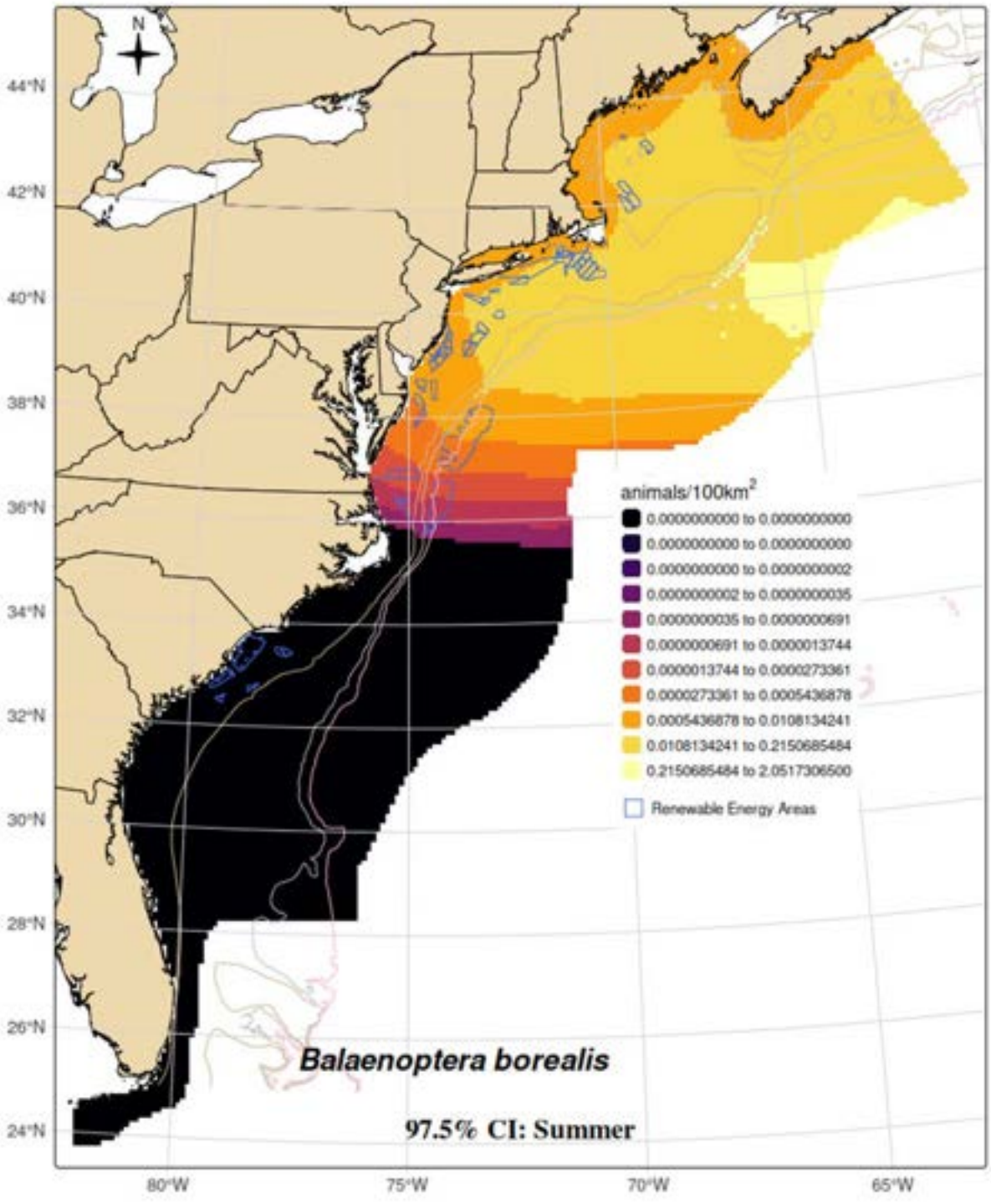

Figure B.4-12. Upper 97.5% confidence interval of the summer sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

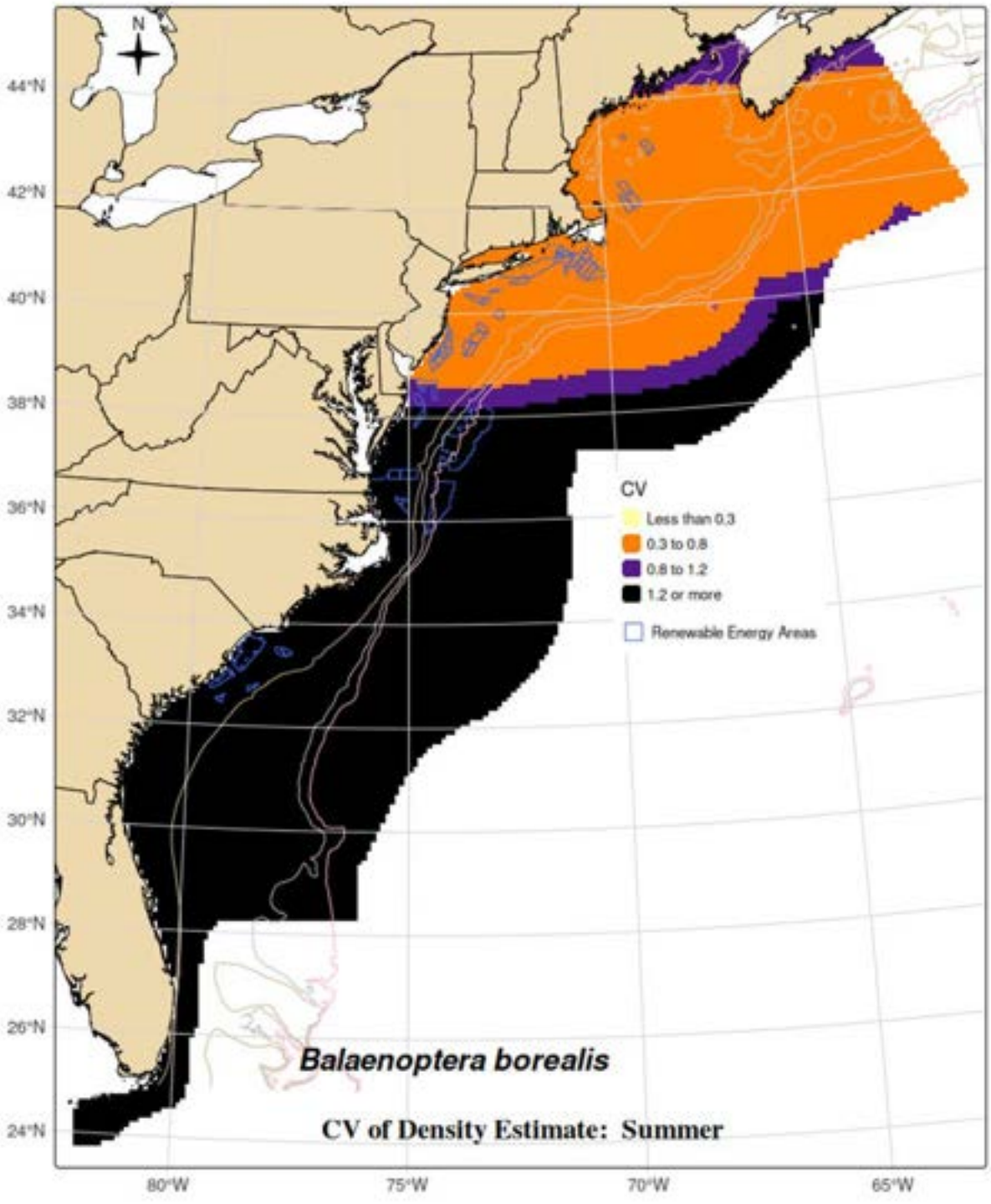

Figure B.4-13. CV of summer sei whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

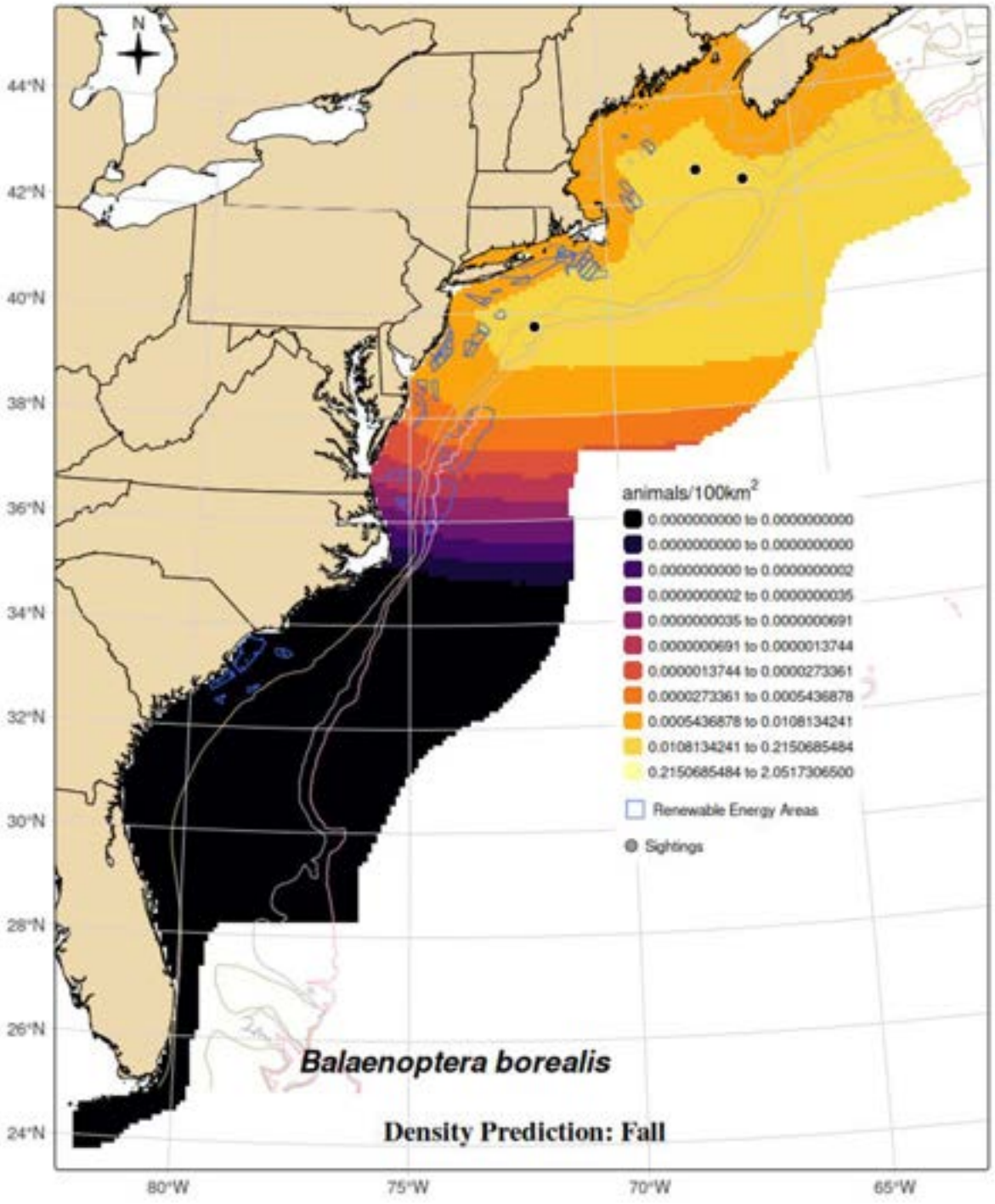

Figure B.4-14. Sei whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

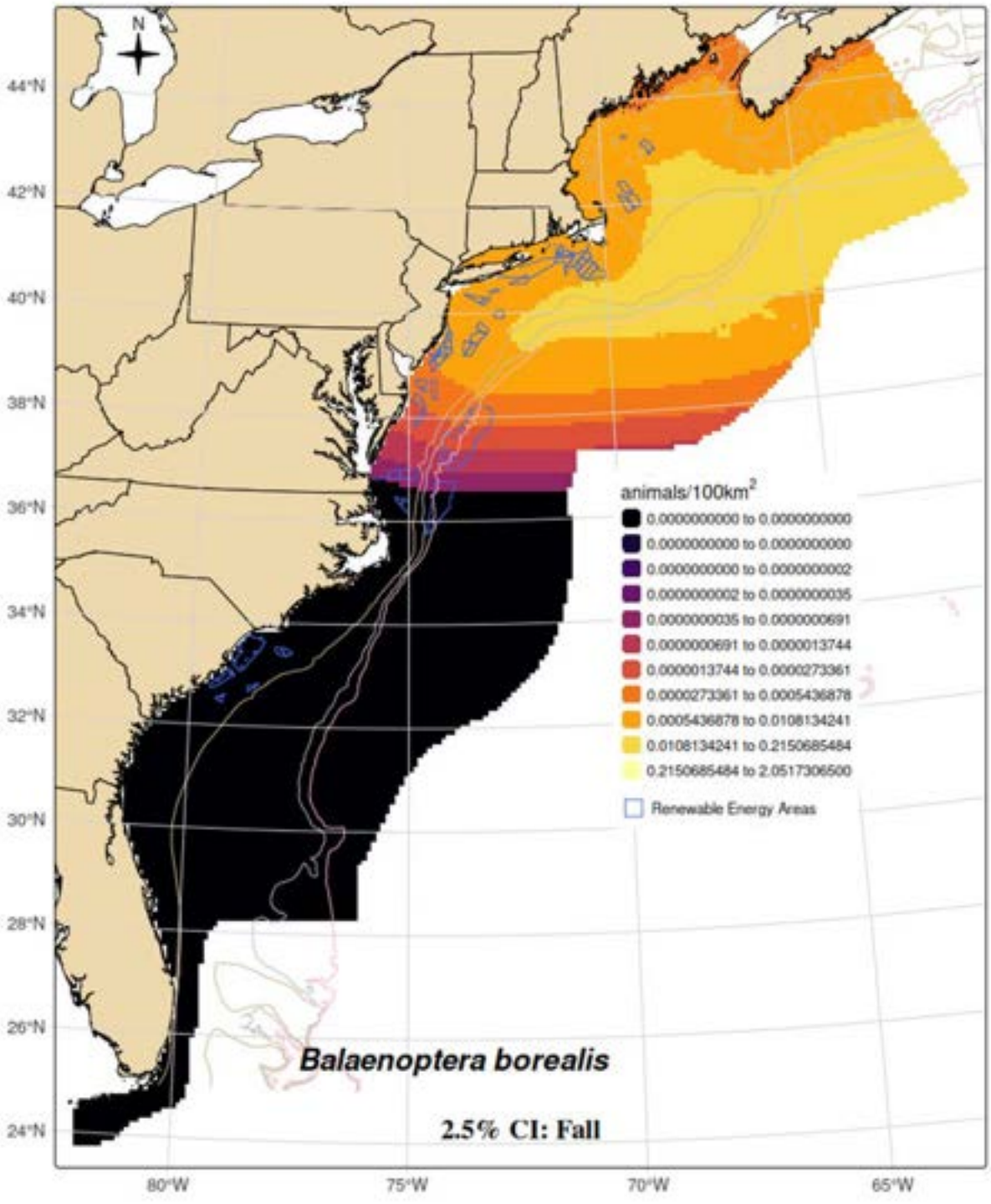

Figure B.4-15. Lower 2.5% confidence interval of the fall sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

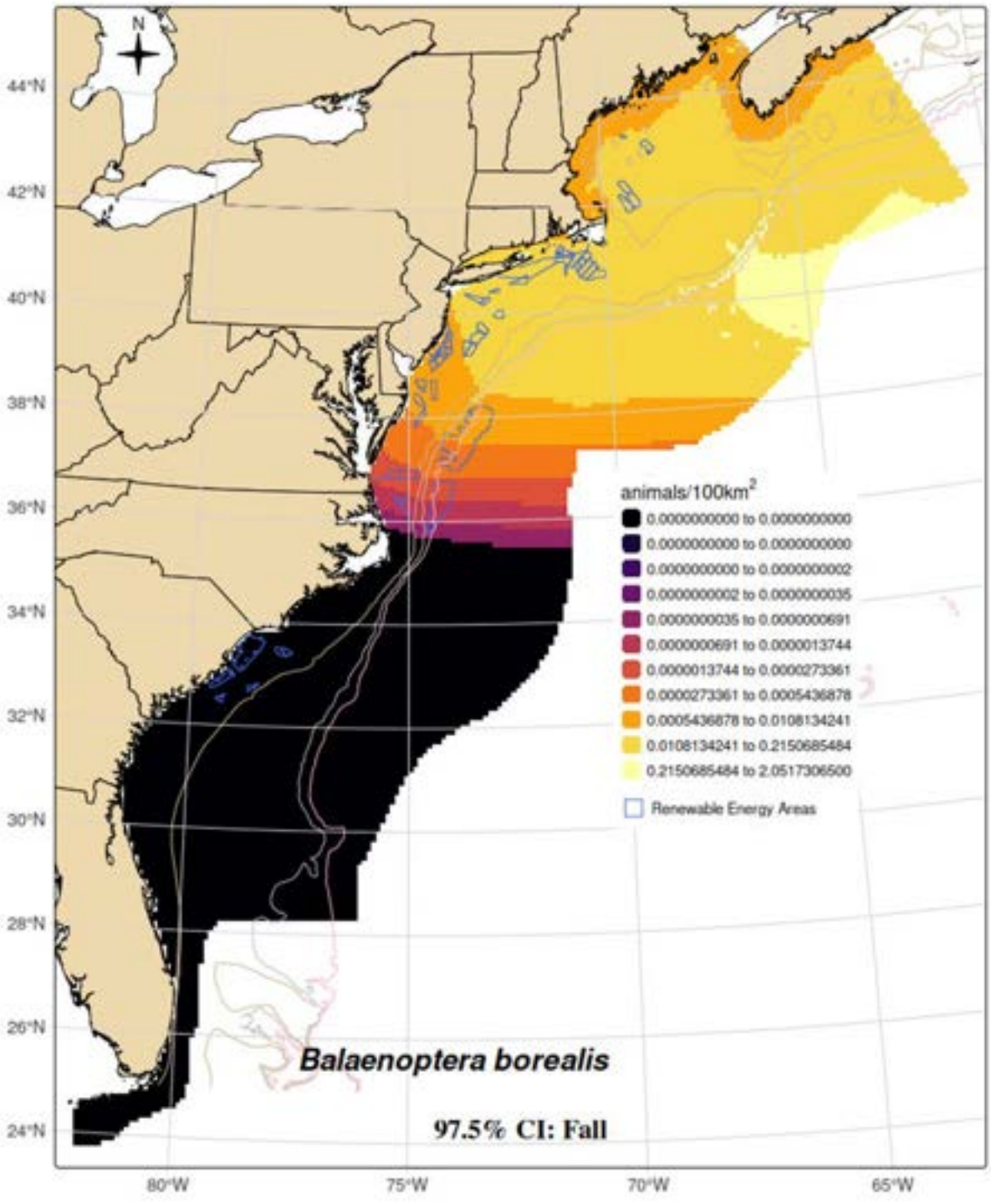

Figure B.4-16. Upper 97.5% confidence interval of the fall sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

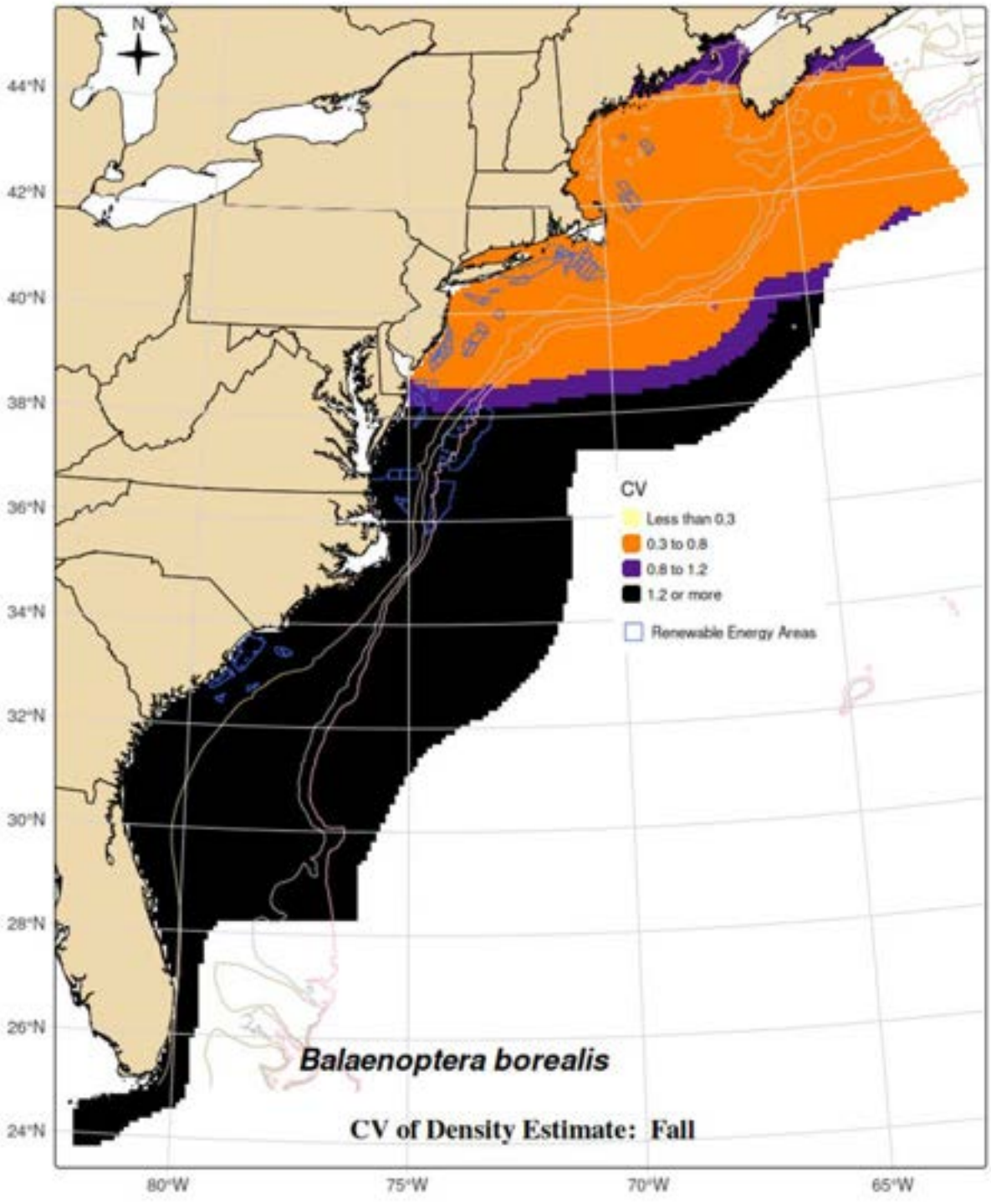

Figure B.4-17. CV of fall sei whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

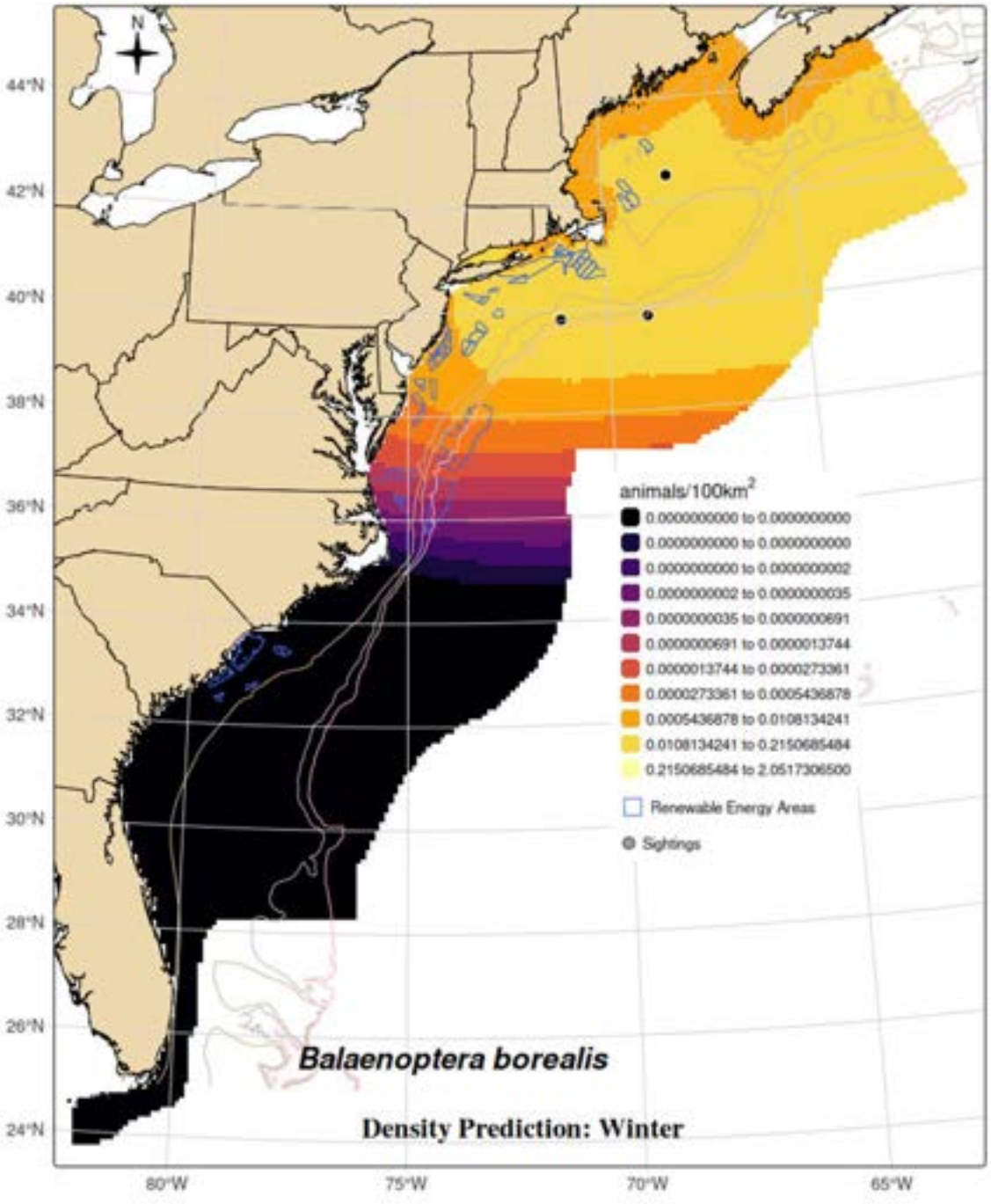

Figure B.4-18. Sei whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

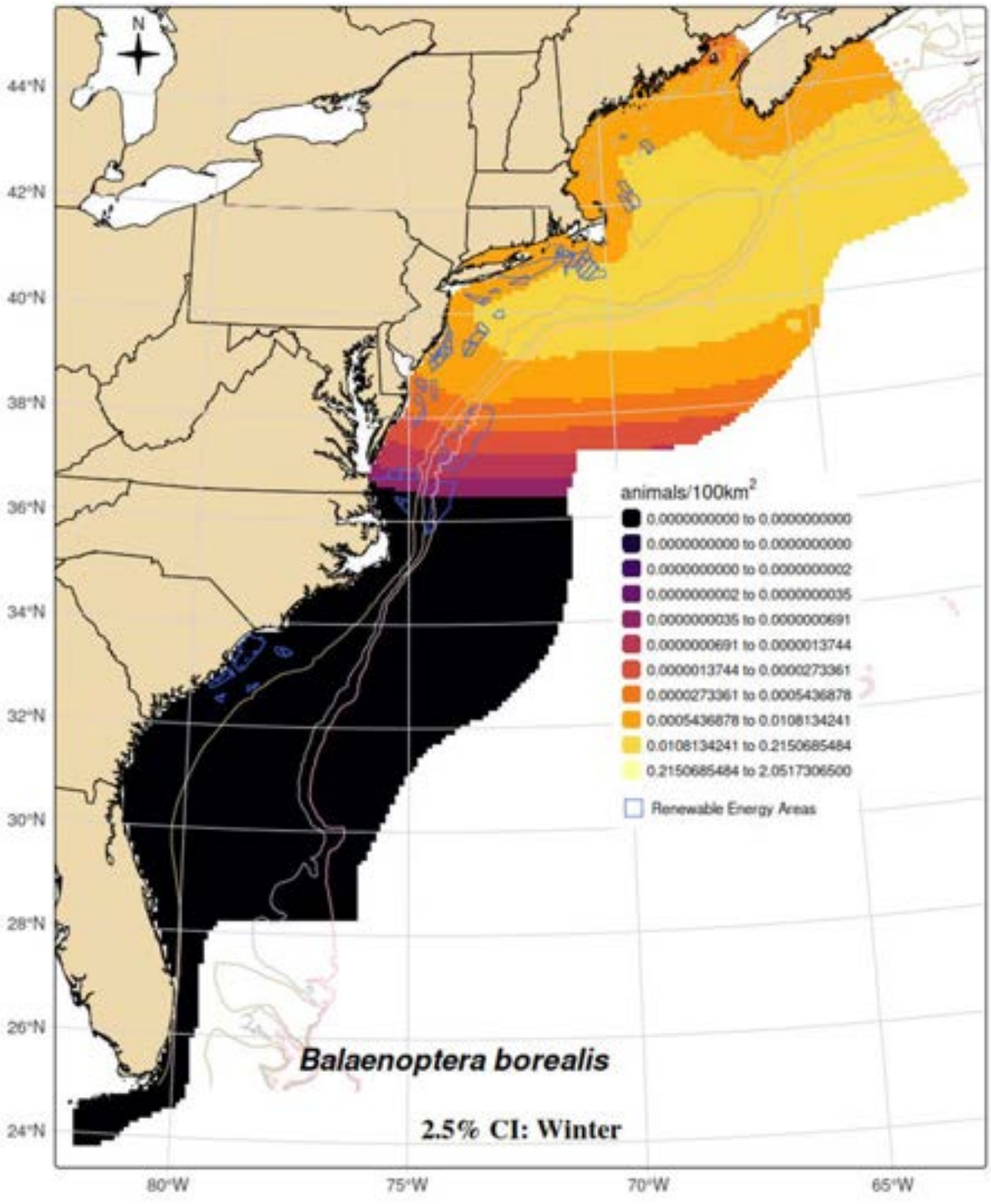

Figure B.4-19. Lower 2.5% confidence interval of the winter sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

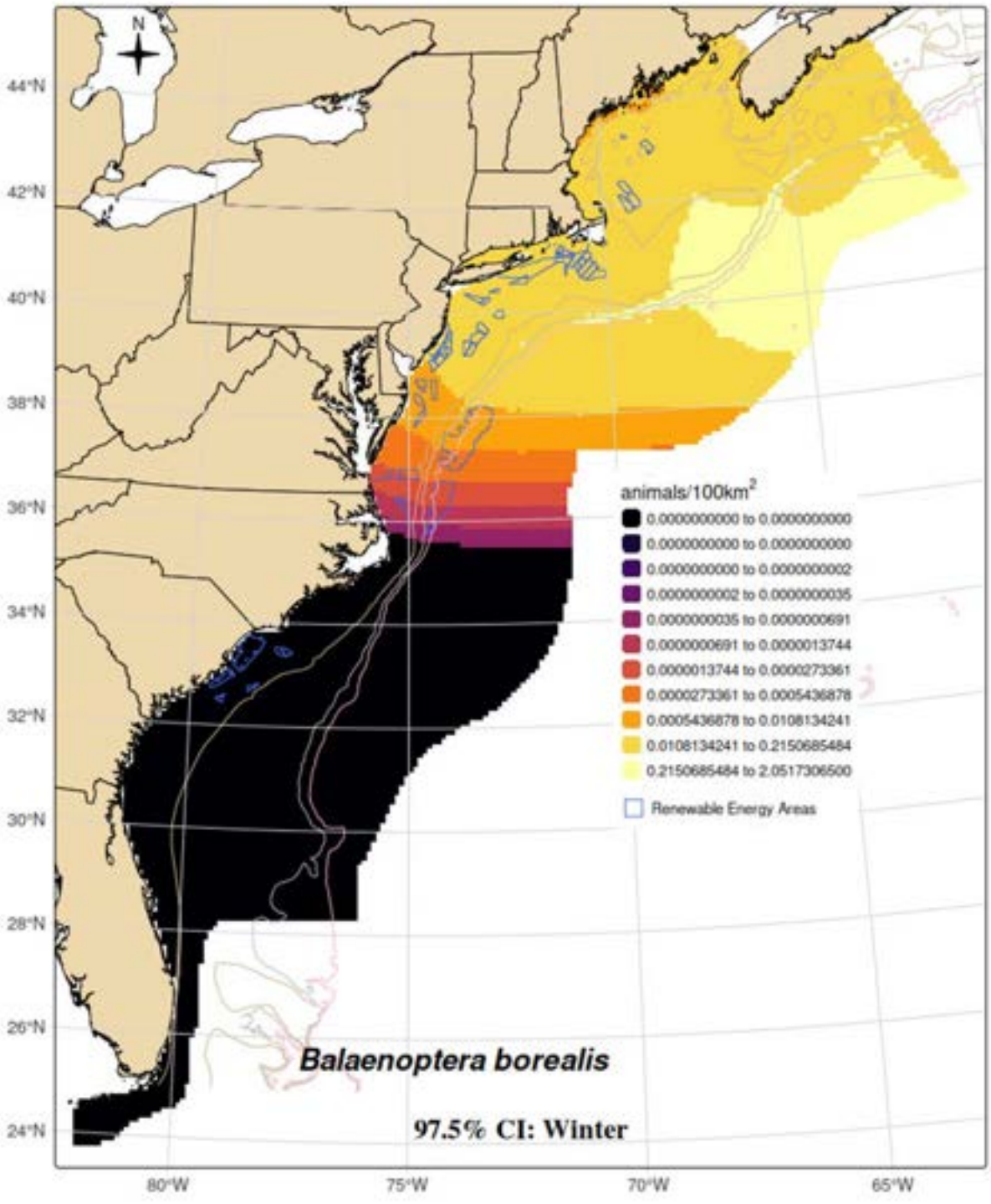

Figure B.4-20. Upper 97.5% confidence interval of the winter sei whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

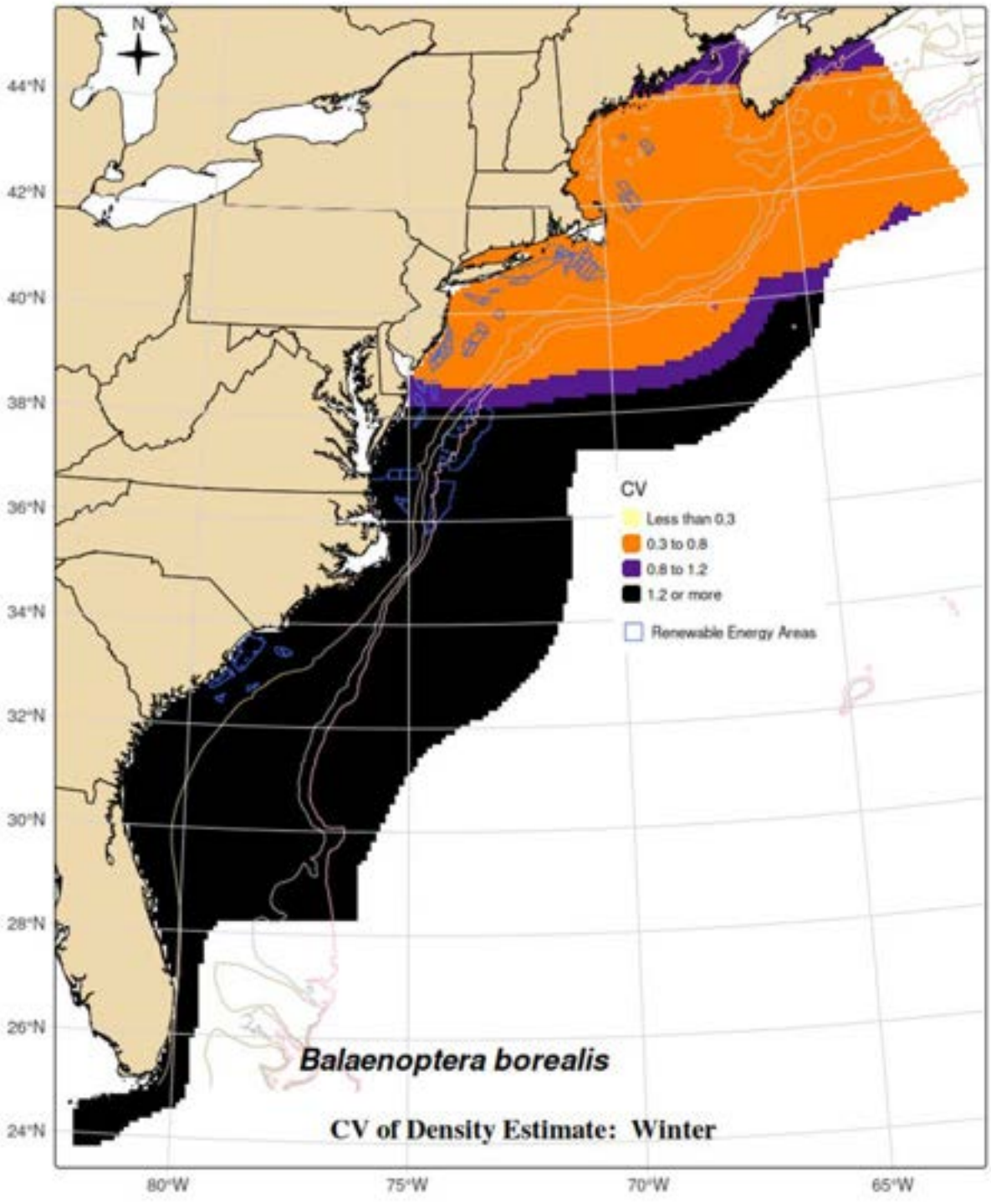

Figure B.4-21. CV of winter sei whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.4.7 Offshore Energy Development Areas

Table B.4-6. Sei whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	2.5	0.41	1.2 - 5.4
	NY	0.5	0.44	0.2 - 1.1
	NJ	0.3	0.57	0.1 - 0.8
	DE/MD	0.0	0.88	0 - 0.2
	VA	0.0	3.22	0 - 0
	NC	0.0	4.55	0 - 0
	NC/SC	0.0	17.81	0 - 0
	GA	0.0	24.90	0 - 0
	FL	0.0	64.33	0 - 0
Summer (Jun-Aug)	RI/MA	0.8	0.44	0.4 - 1.9
	NY	0.1	0.50	0.1 - 0.4
	NJ	0.1	0.59	0 - 0.2
	DE/MD	0.0	0.87	0 - 0
	VA	0.0	3.22	0 - 0
	NC	0.0	4.56	0 - 0
	NC/SC	0.0	17.82	0 - 0
	GA	0.0	24.90	0 - 0
	FL	0.0	64.34	0 - 0
Fall (Sep-Nov)	RI/MA	1.1	0.41	0.5 - 2.3
	NY	0.2	0.44	0.1 - 0.5
	NJ	0.1	0.55	0 - 0.3
	DE/MD	0.0	0.86	0 - 0.1
	VA	0.0	3.22	0 - 0
	NC	0.0	4.56	0 - 0
	NC/SC	0.0	17.81	0 - 0
	GA	0.0	24.90	0 - 0
	FL	0.0	64.34	0 - 0
Winter (Dec-Feb)	RI/MA	2.5	0.41	1.2 - 5.4
	NY	0.5	0.44	0.2 - 1.2
	NJ	0.3	0.58	0.1 - 0.9
	DE/MD	0.0	0.89	0 - 0.2
	VA	0.0	3.22	0 - 0
	NC	0.0	4.55	0 - 0
	NC/SC	0.0	17.81	0 - 0
	GA	0.0	24.90	0 - 0
	FL	0.0	64.33	0 - 0

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

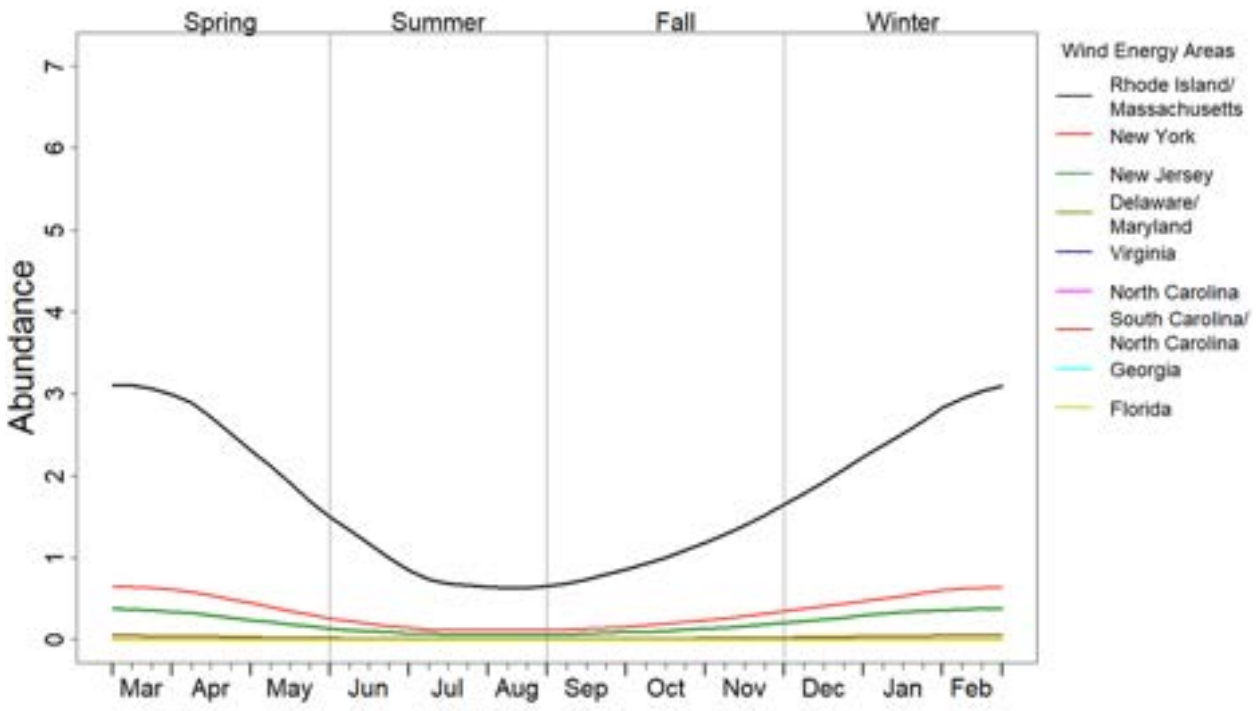

Figure B.4-22. Average seasonal abundance of sei whales in the wind-energy study areas

B.5 Minke Whale (*Balaenoptera acutorostrata*)

Figure B.5-1. Minke whale
Image collected under MMPA Research permit #17355. Credit: NOAA/NEFSC/Leah Crowe

B.5.1 Data Collection

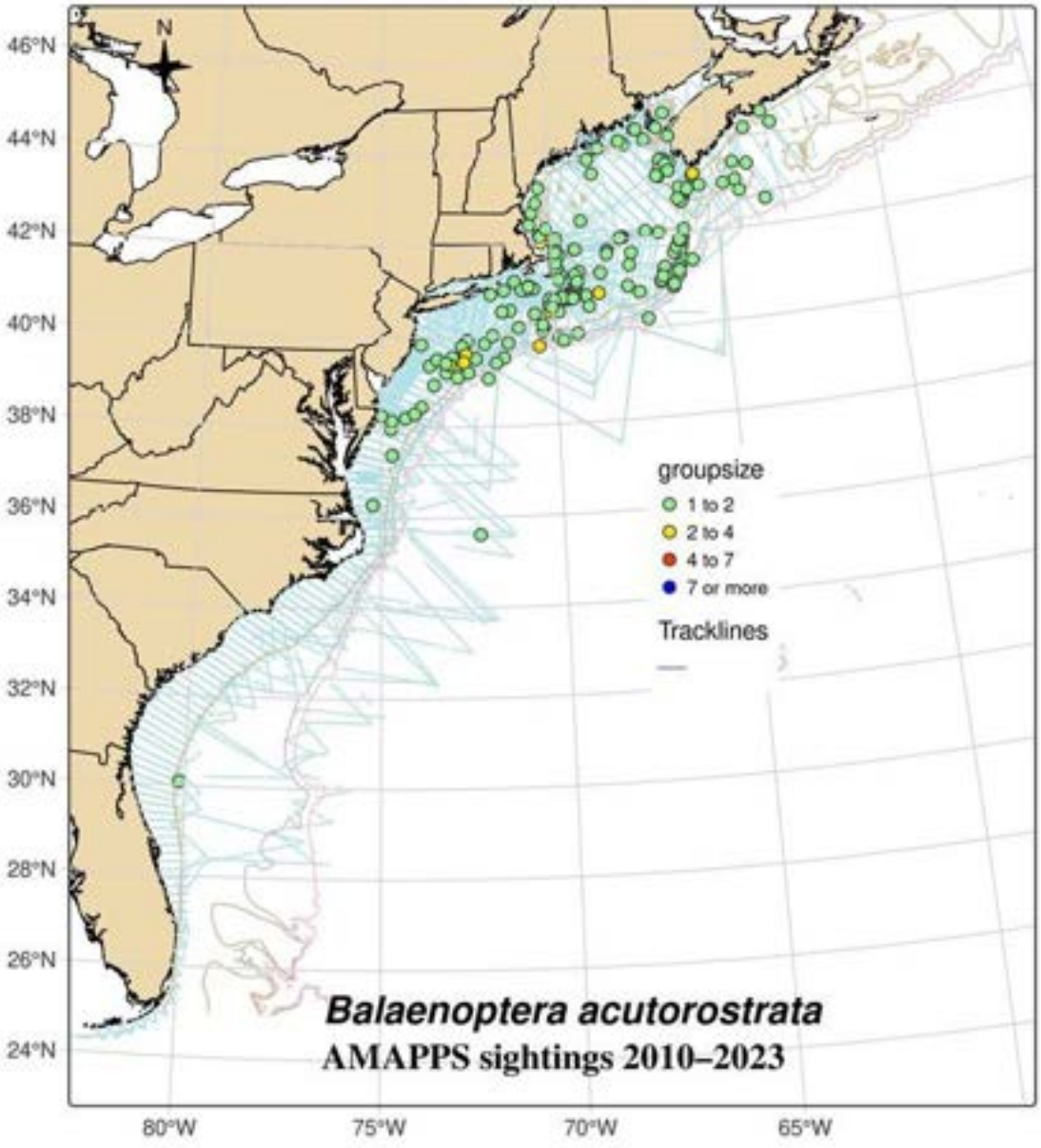

Figure B.5-2. Distribution of track lines and minke whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.5-1. AMAPPS research effort 2010 to 2023 and minke whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	8	11
NE Shipboard	Summer	49,064	35	35
NE Aerial	Spring	38,839	54	55
NE Aerial	Summer	52,003	106	111
NE Aerial	Fall	87,311	56	73
NE Aerial	Winter	24,747	1	1
SE Shipboard	Spring	2,604	0	0
SE Shipboard	Summer	18,331	1	1
SE Shipboard	Fall	2,673	0	0
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	15	19
SE Aerial	Summer	43,285	0	0
SE Aerial	Fall	21,153	3	3
SE Aerial	Winter	19,152	2	2

B.5.2 Mark-Recapture Distance Sampling Analysis

Table B.5-2. Intermediate parameters in minke whale mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15	0.89
NE–aerial group 2	distance * observer + log(group size) + sea state	380	distance + sea state + glare	600	HR	0.75	0.07	0.06	0.70
NE–shipboard group 10	distance * observer + log(group size)	4500	Distance + glare + swell height + time of day	4500	HR	0.54	0.08	0.01	0.95
SE–shipboard group 5	distance + log(group size)	9000	distance + glare	9000	HR	0.58	0.11	0.70	0.61

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

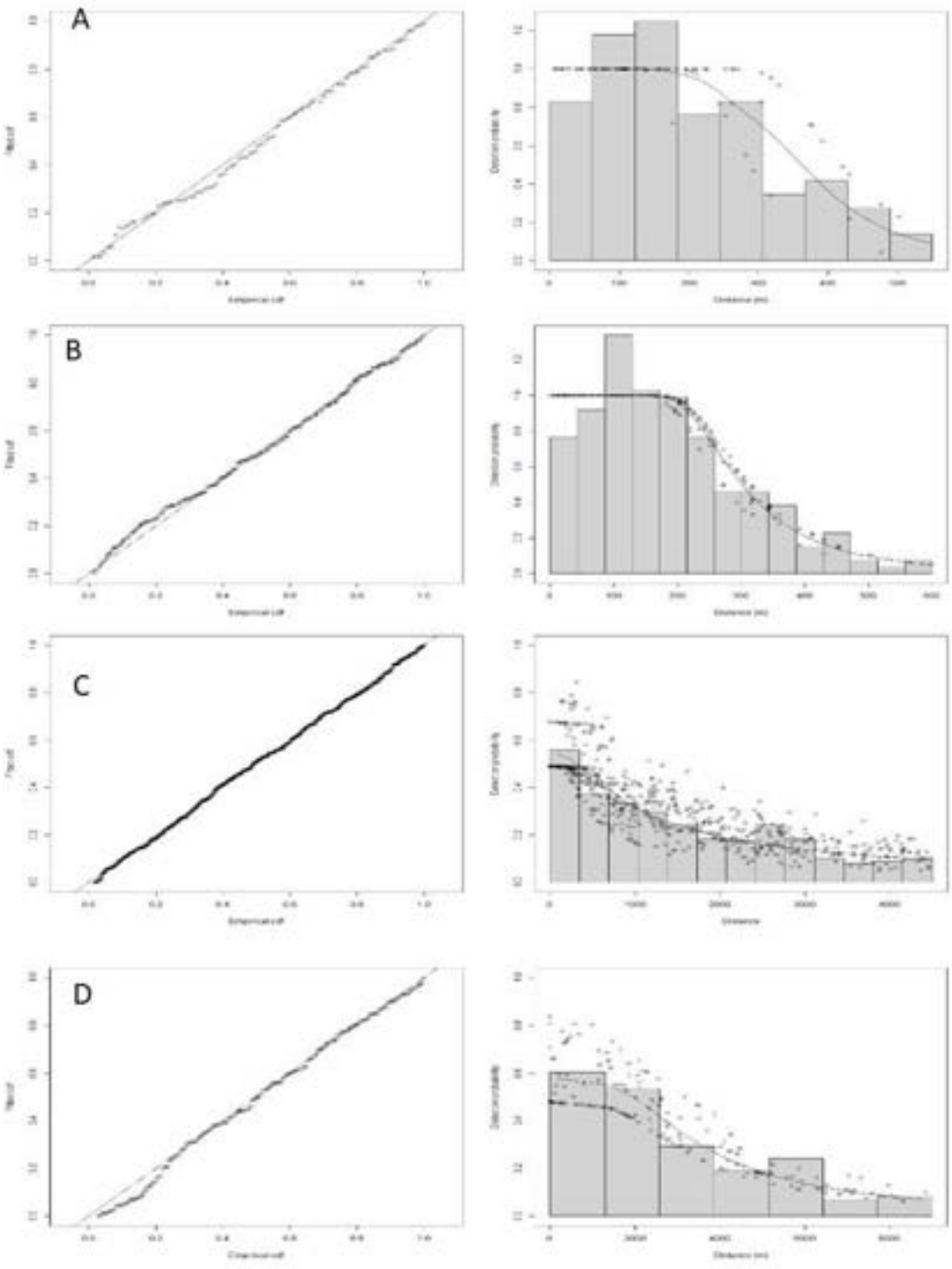

Figure B.5-3. Q-Q plots and detection functions from the minke whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 2; C) NE-shipboard analysis set 10; D) SE-shipboard analysis set 5.

B.5.3 Generalized Additive Model Analysis

Table B.5-3. 2010 to 2023 density-habitat model output for minke whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(mlp)	0.52	5	0.20	0.26	0.1539
s(btemp)	0.86	5	0.96	0.24	0.0154
s(pp)	2.31	5	4.73	7.34	<0.0001
s(dist2GSSw)	3.28	5	4.63	1.02	<0.0001
s(dist125)	1.01	5	8.34	11.39	<0.0001
s(dist1000)	3.68	5	7.32	9.21	<0.0001
s(latdd)	4.05	5	15.60	9.07	<0.0001

Adjusted R^2 = 0.0154. Deviance explained = 38.5%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

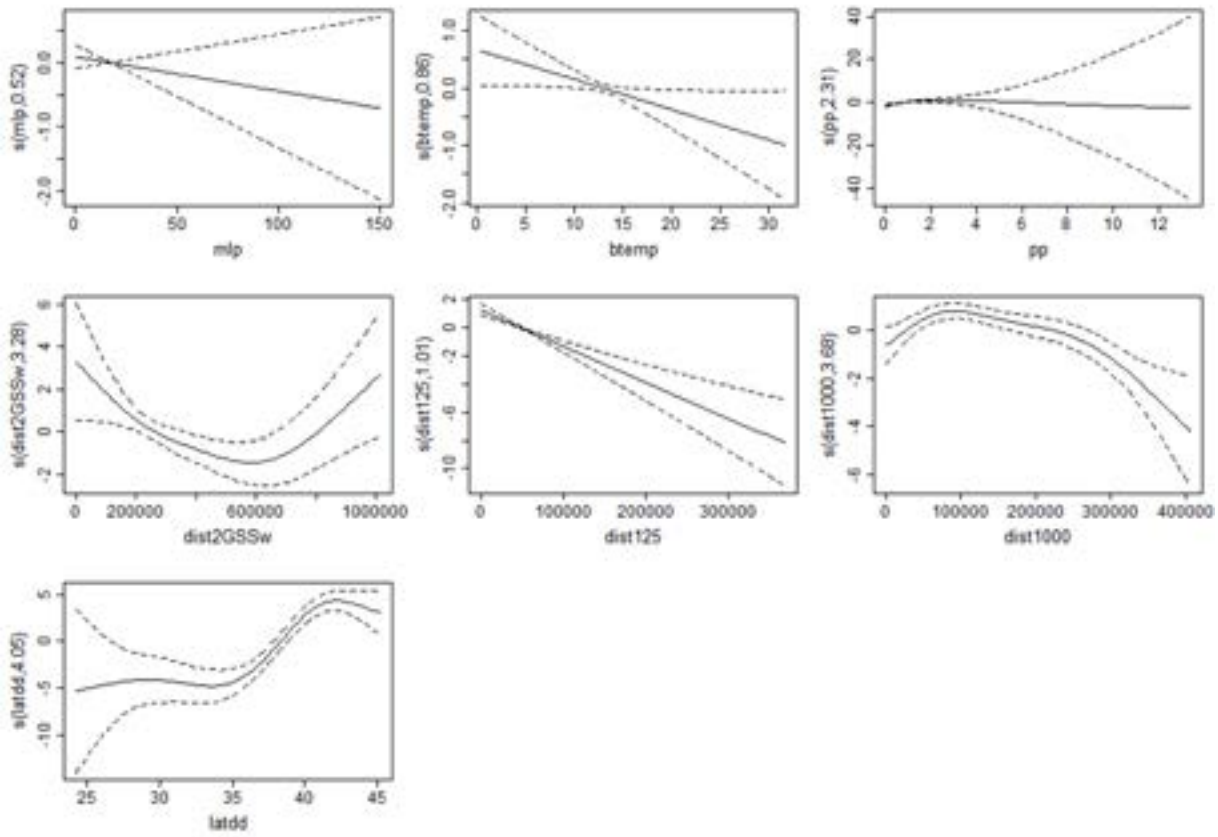

Figure B.5-4. Minke whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.5.4 Model Cross-Validation

Table B.5-4. Diagnostic statistics from the minke whale density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
RHO	Spearman rank correlation	Non-zero density	0.311	Excellent
MAPE	Mean absolute percentage error	Non-zero density	76.586	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.109	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.008	Excellent
MAPE	Mean absolute percentage error	All data divided in 25 random samples	93.539	Fair to good

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.5.5 Abundance Estimates for AMAPPS Study Area

Table B.5-5. Minke whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	2,793	0.38	1,360 – 5,737
Summer (June–August)	5,259	0.37	2,606 – 10,612
Fall (September–November)	2,694	0.36	1,359 – 5,340
Winter (December–February)	1,422	0.39	680 – 2,973
Summer 2011 U.S. surveys[1]	2,591	0.81	1,035 − 6,485
Summer 2016 U.S. surveys[1]	2,802	0.81	1,120 − 7,013
Summer 2021 U.S. surveys[1]	5,630	0.58	1,959 – 16,177

[1]Hayes et al. 2024

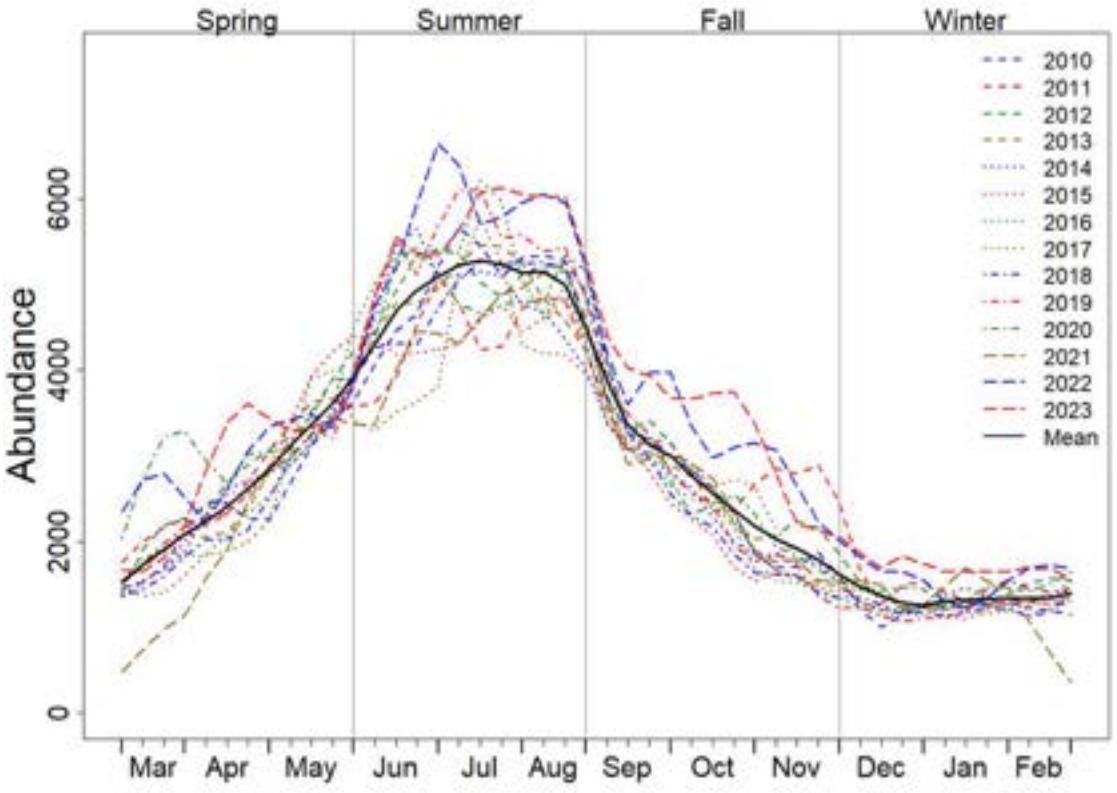

Figure B.5-5. Annual abundance trends for minke whales in the AMAPPS study area

B.5.6 Seasonal Prediction Maps

Map showing predicted spring density of minke whales along the U.S. East Coast, with colors ranging from dark purple (lowest density) to yellow (highest density) representing animals per 100 km². Map includes labeled renewable energy areas outlined in green and black dots indicating whale sightings, highlighting highest densities in the Gulf of Maine and around. the

Georges Bank region

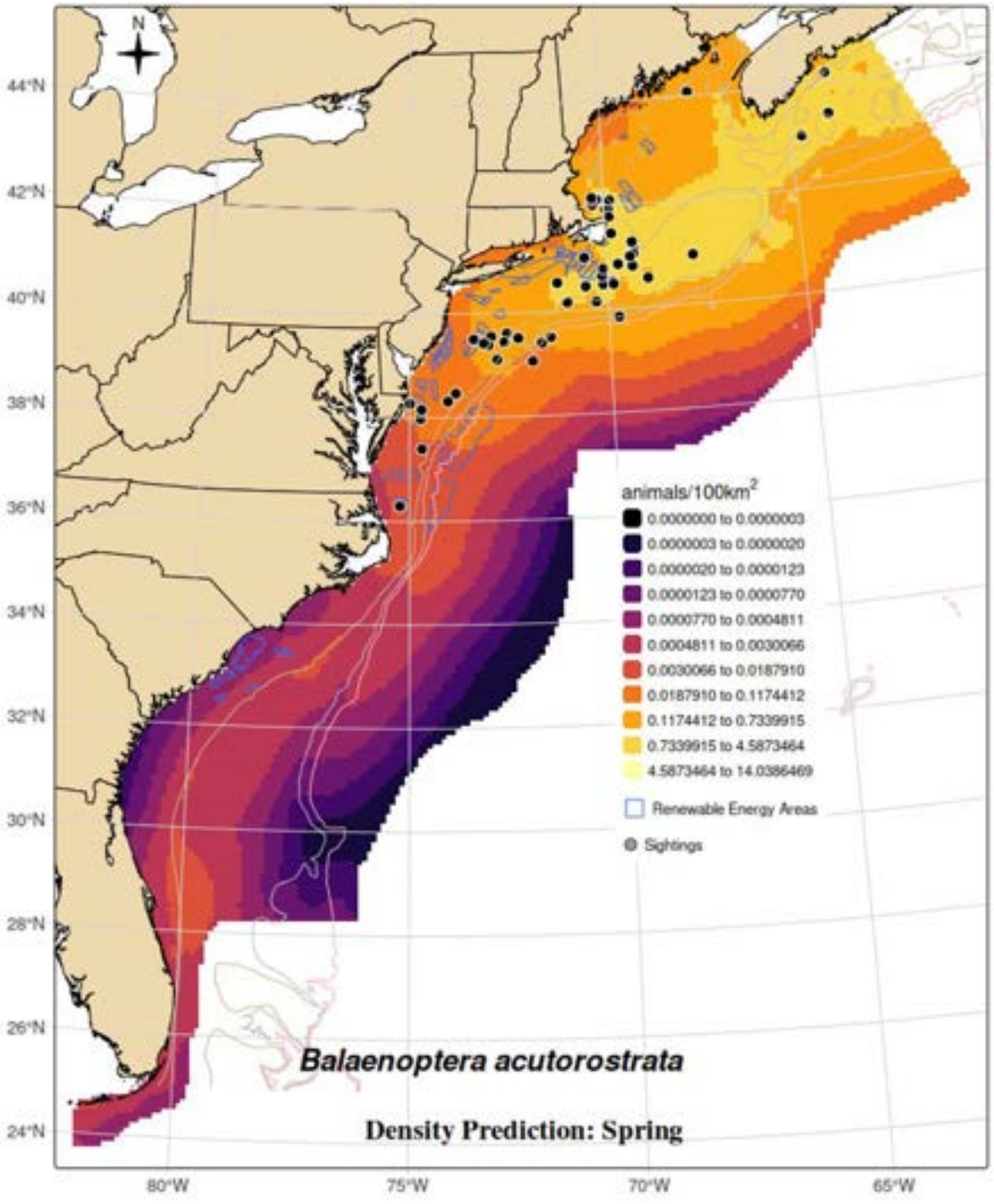

Figure B.5-6. Minke whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

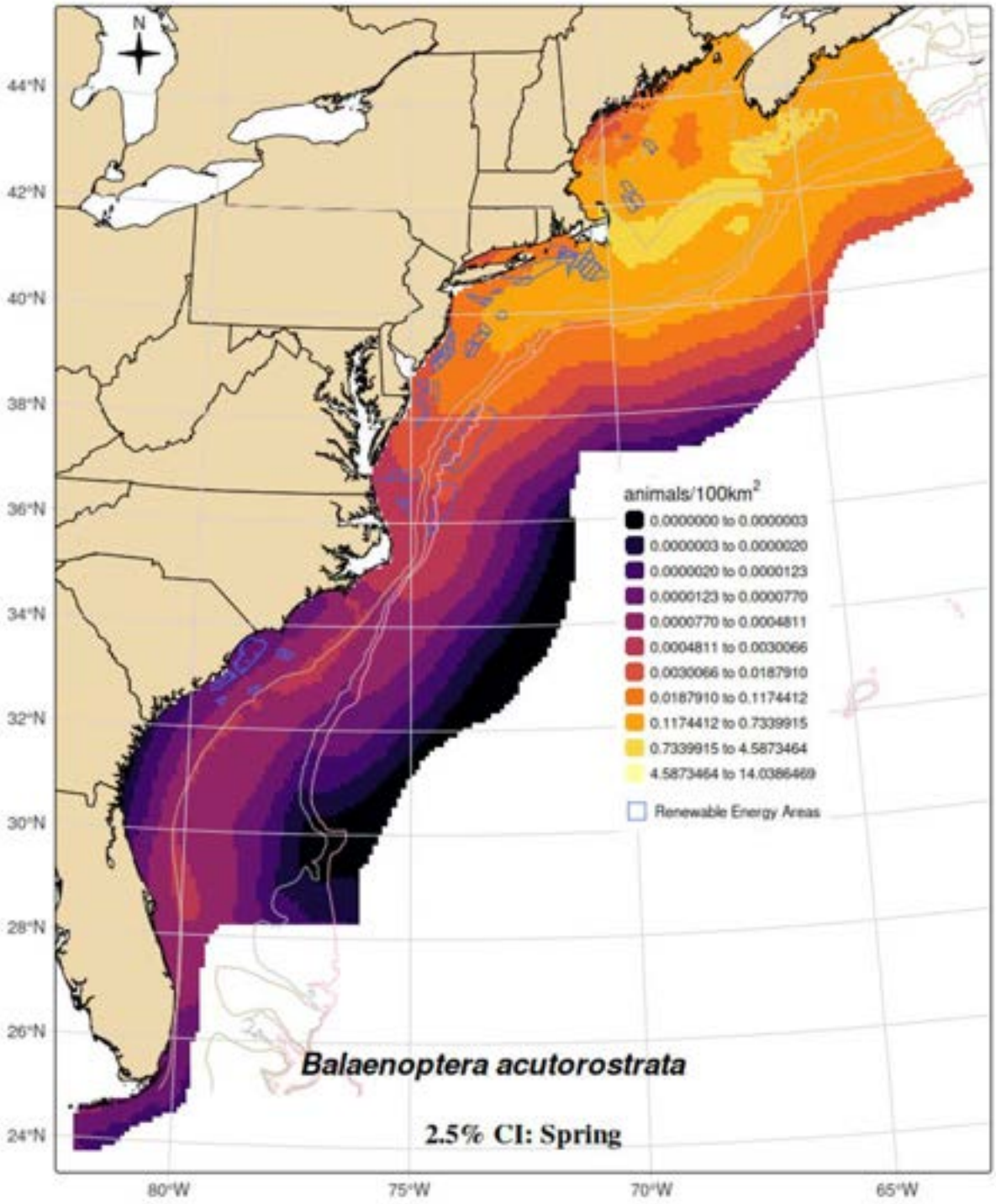

Figure B.5-7. Lower 2.5% confidence interval of the spring minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

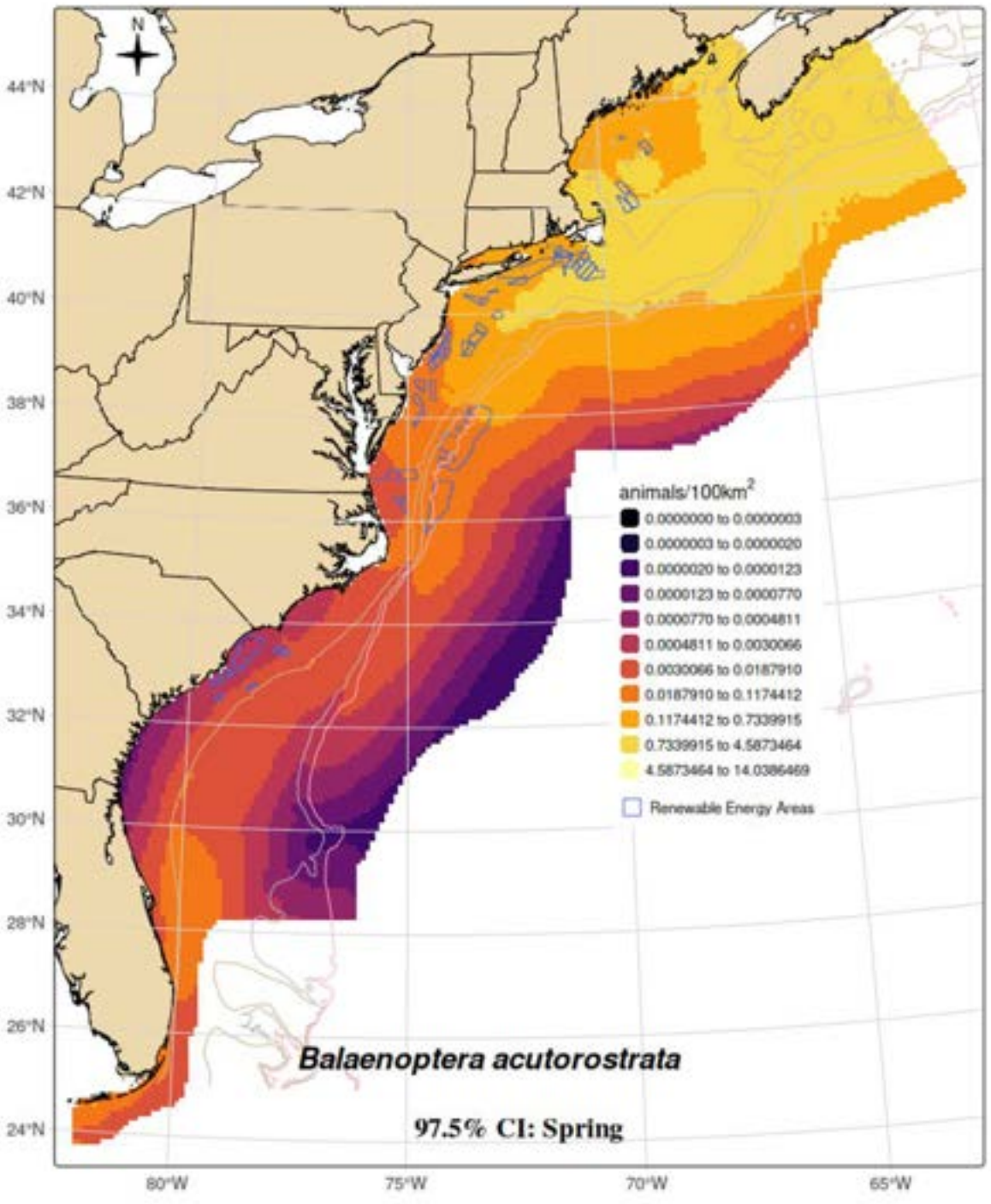

Figure B.5-8. Upper 97.5% confidence interval of the spring minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

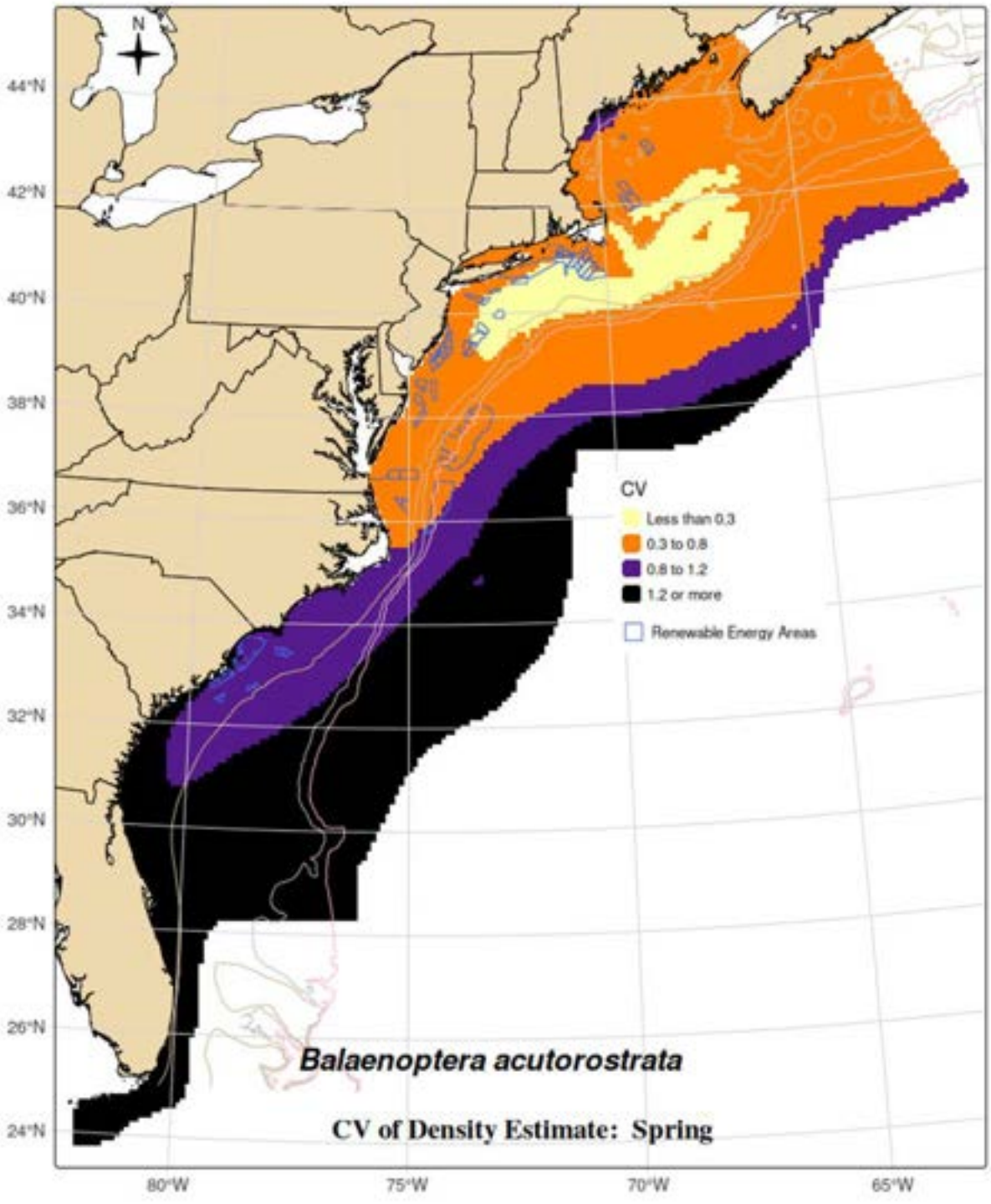

Figure B.5-9. CV of spring minke whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

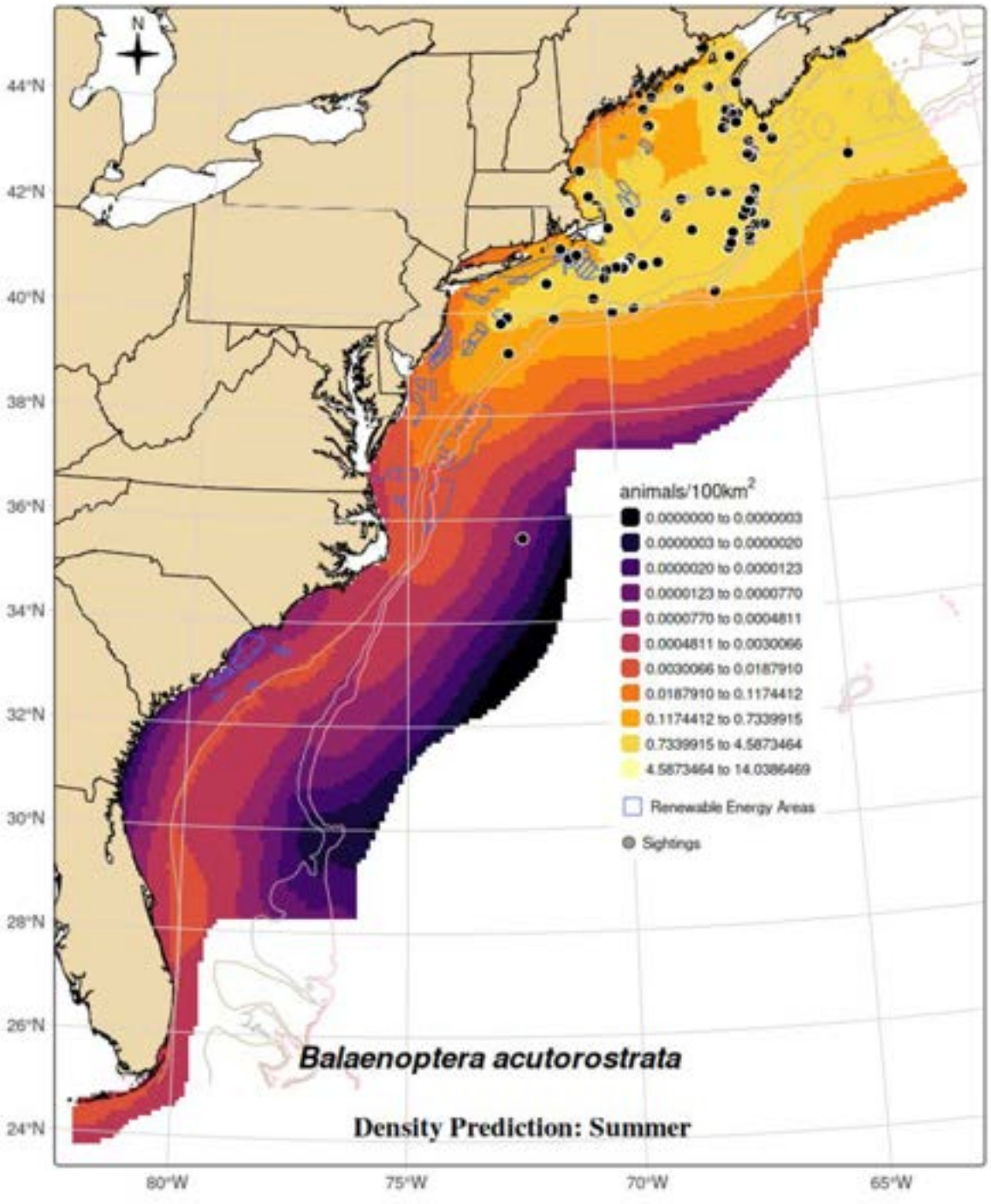

Figure B.5-10. Minke whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

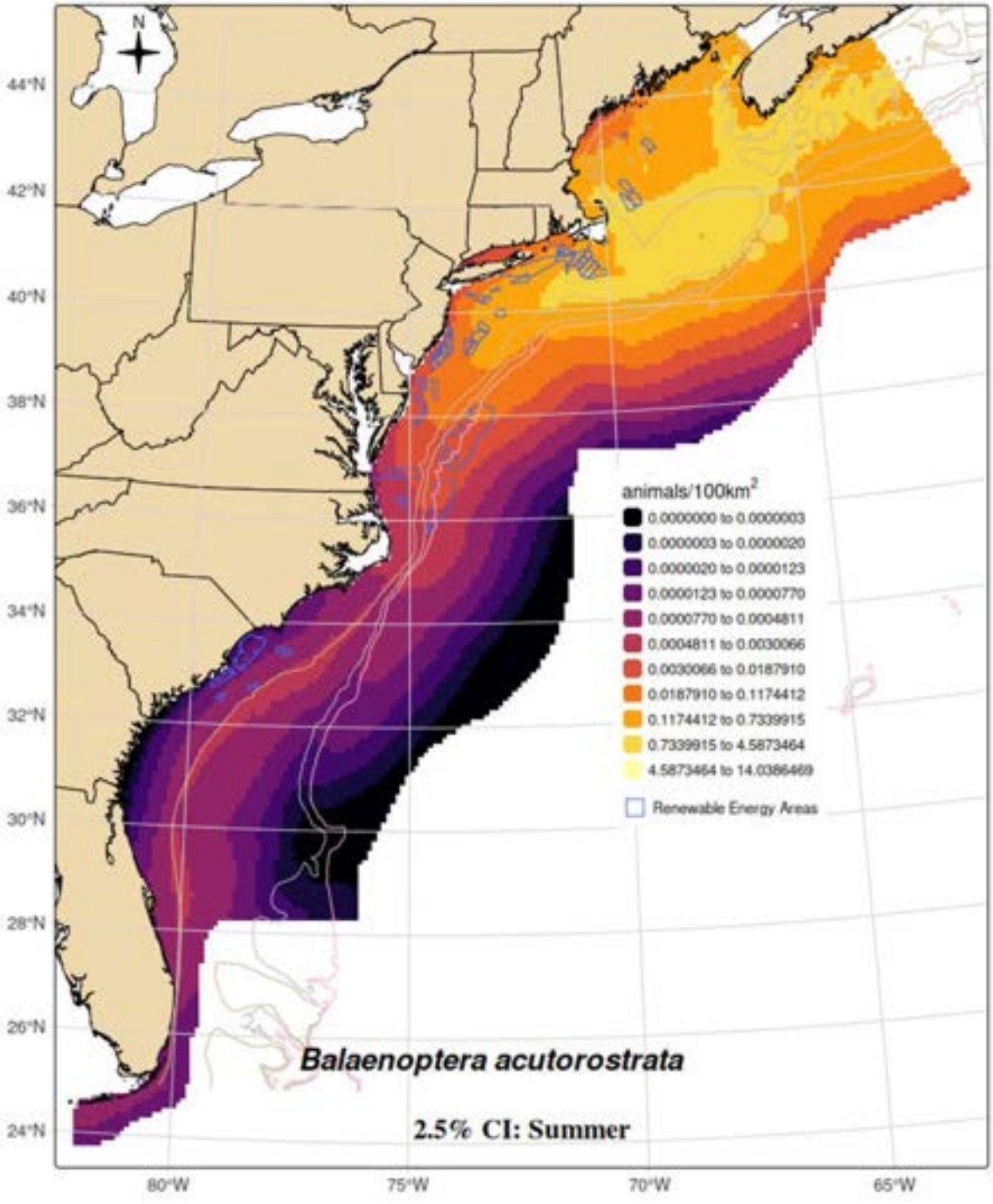

Figure B.5-11. Lower 2.5% confidence interval of the summer minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

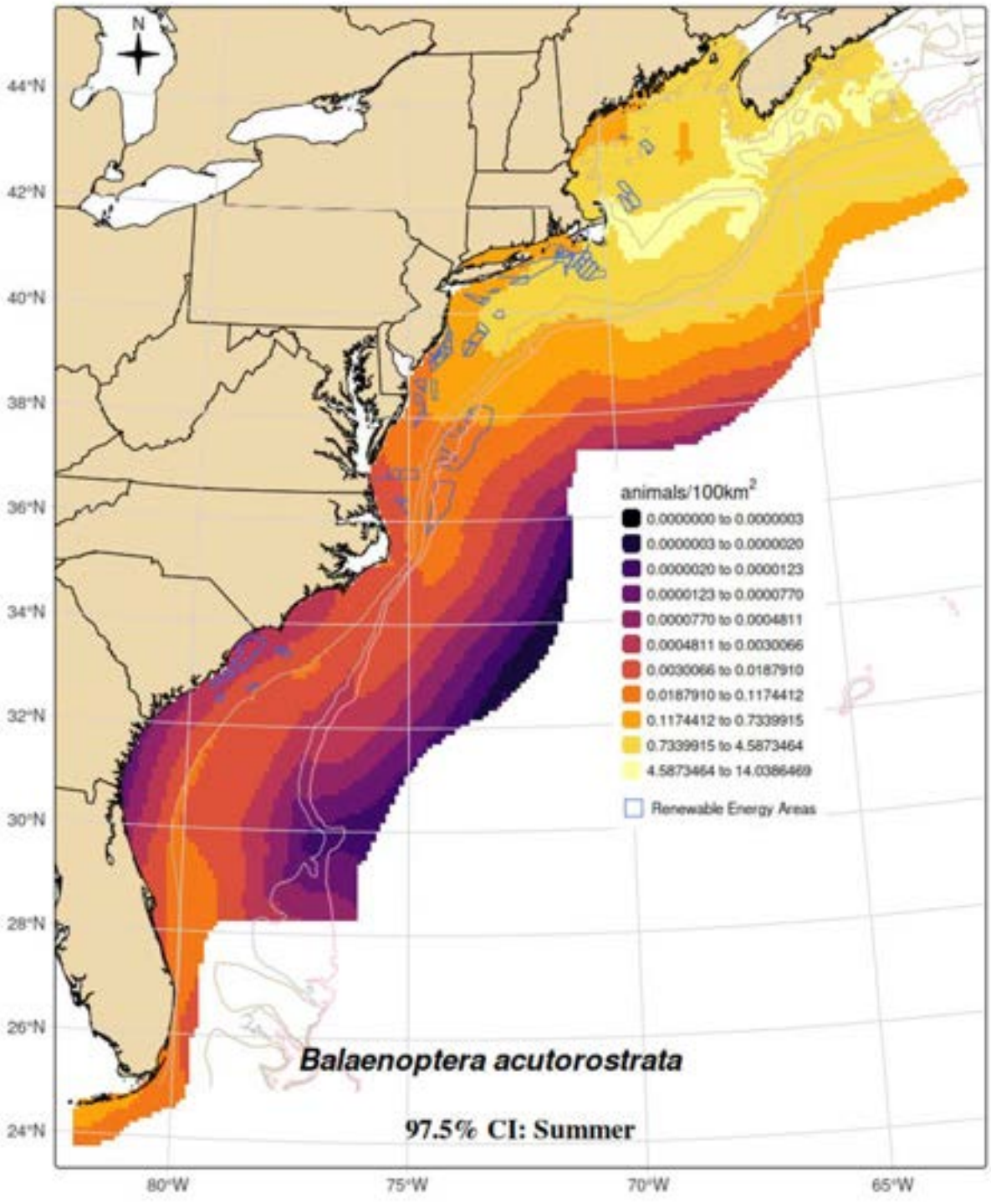

Figure B.5-12. Upper 97.5% confidence interval of the summer minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

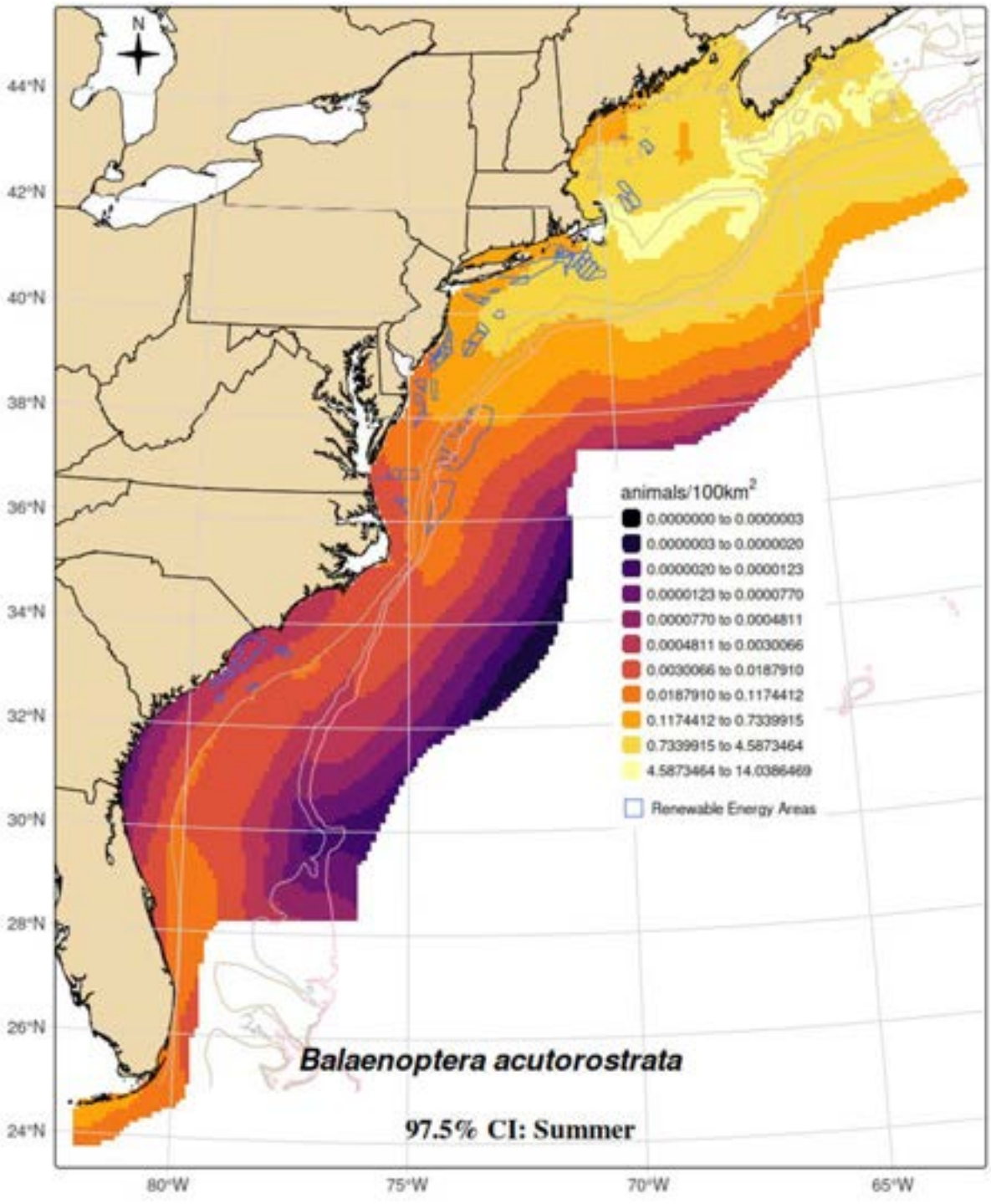

Figure B.5-13. CV of summer minke whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

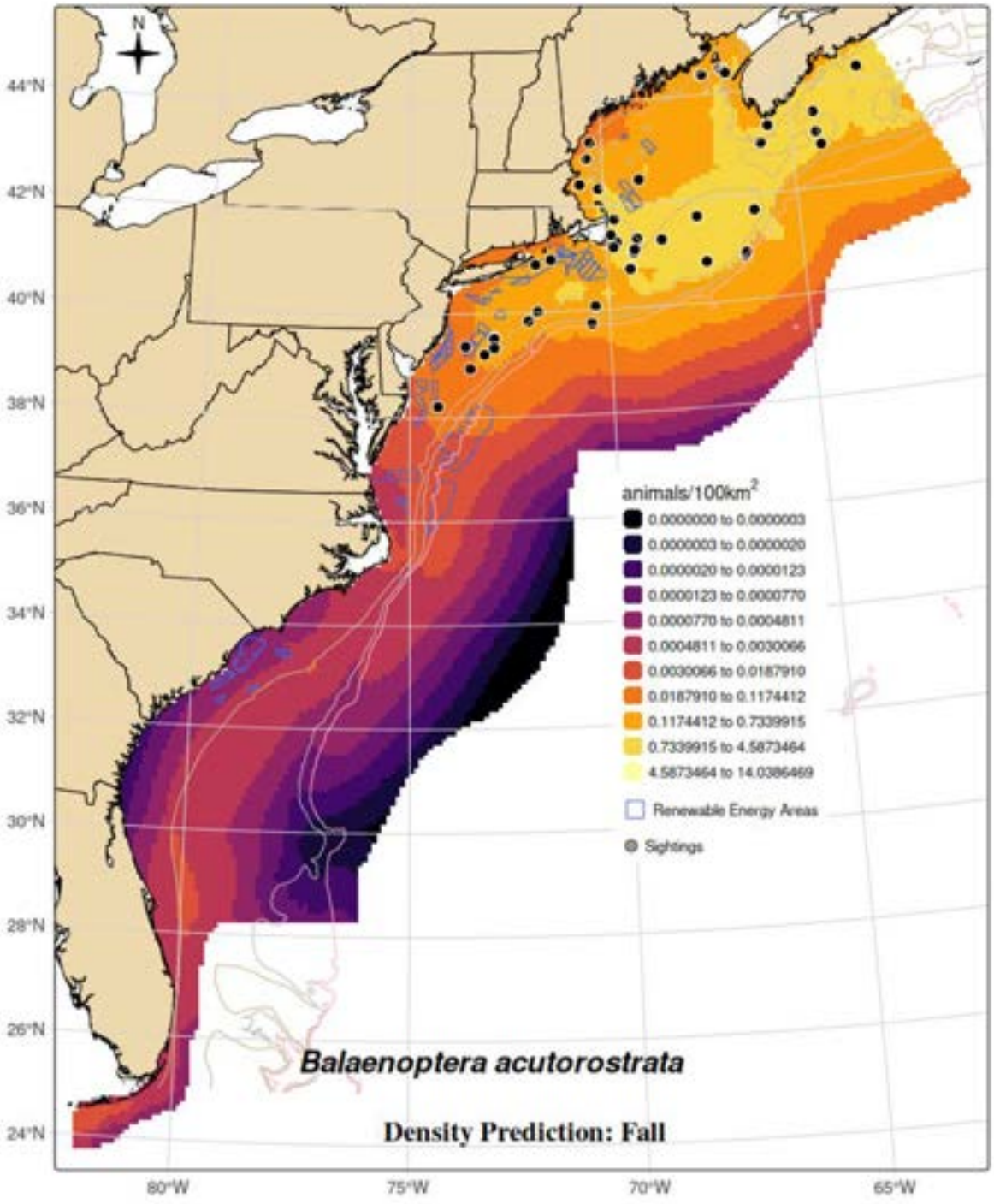

Figure B.5-14. Minke whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

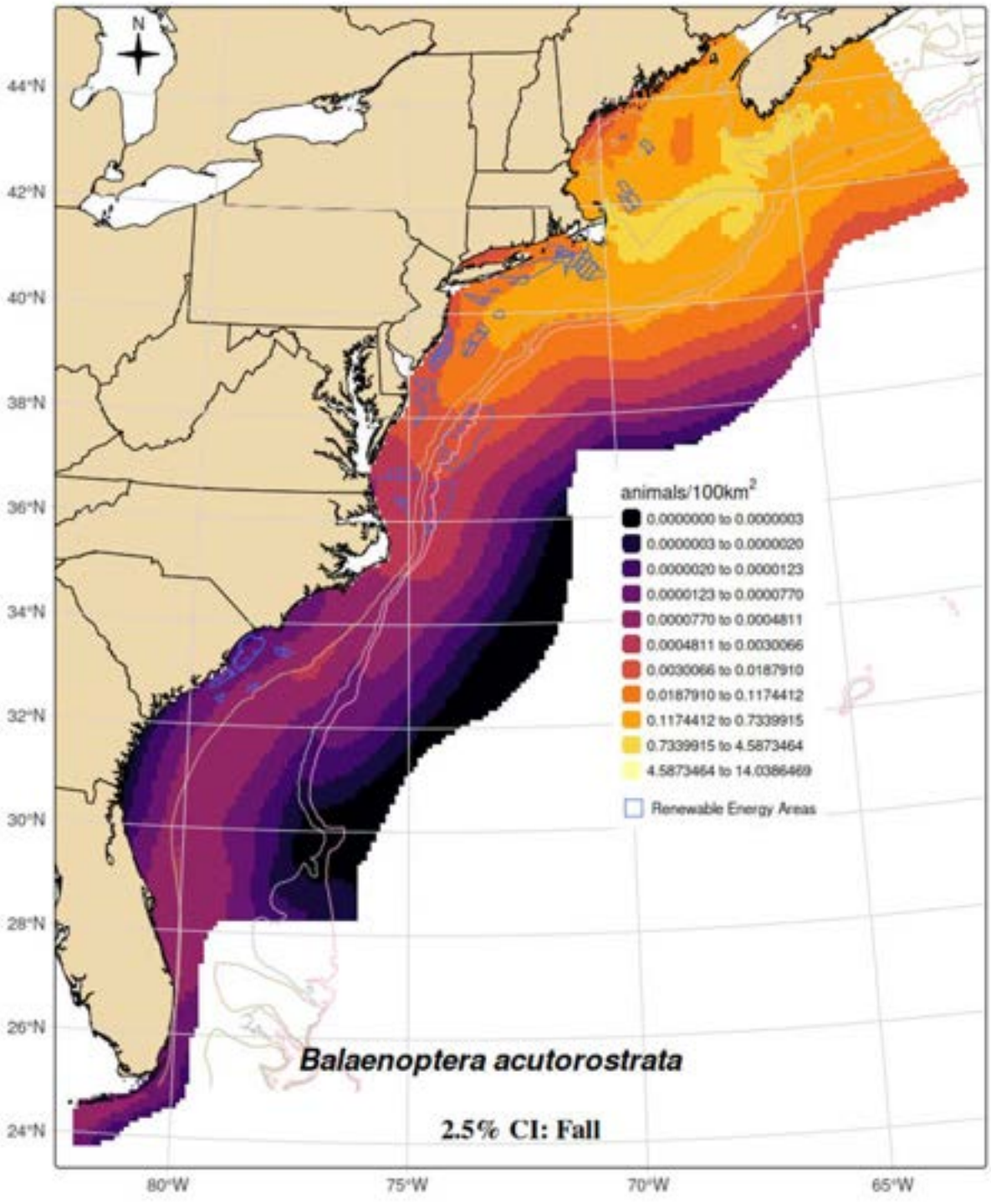

Figure B.5-15. Lower 2.5% confidence interval of the fall minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

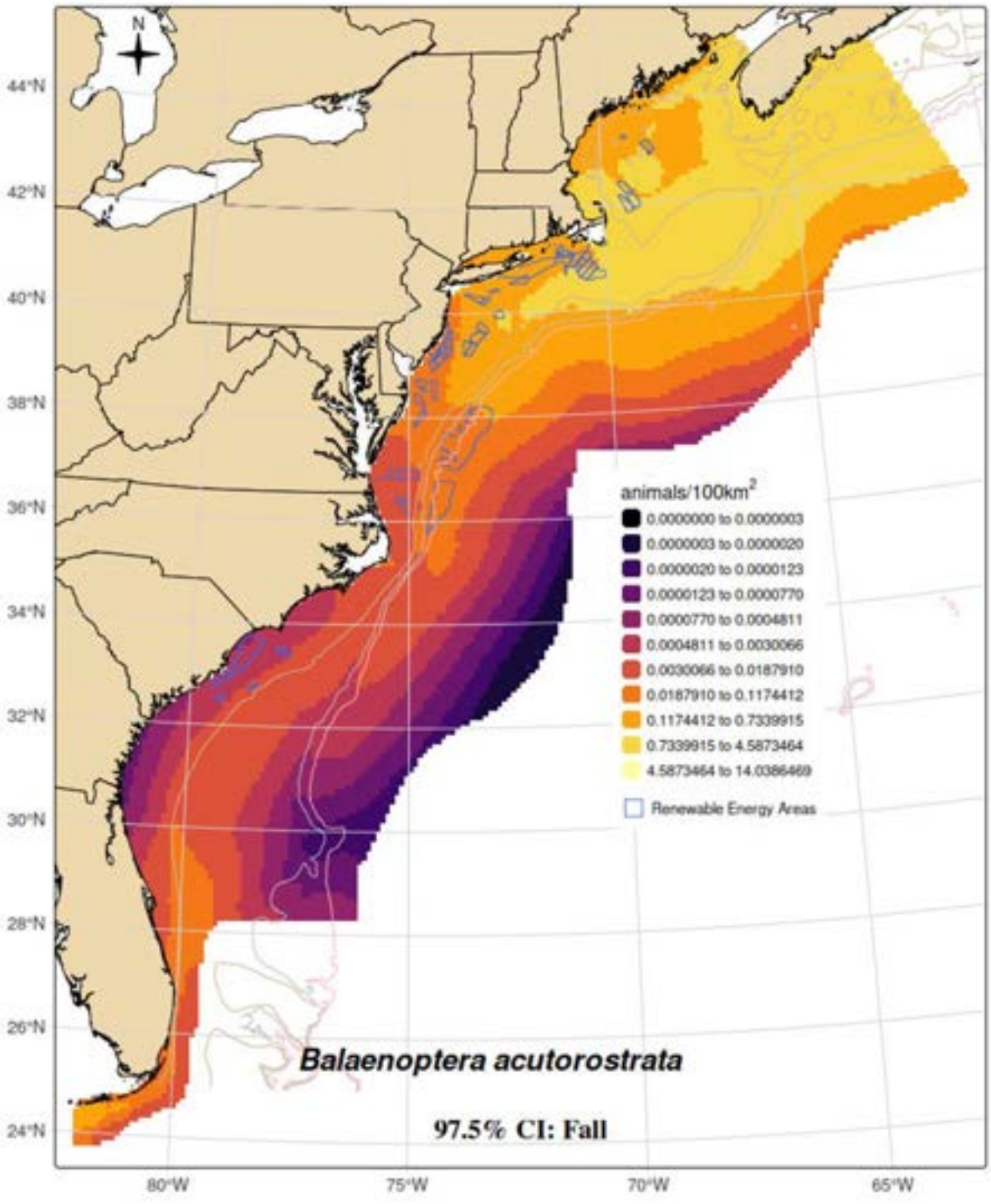

Figure B.5-16. Upper 97.5% confidence interval of the fall minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

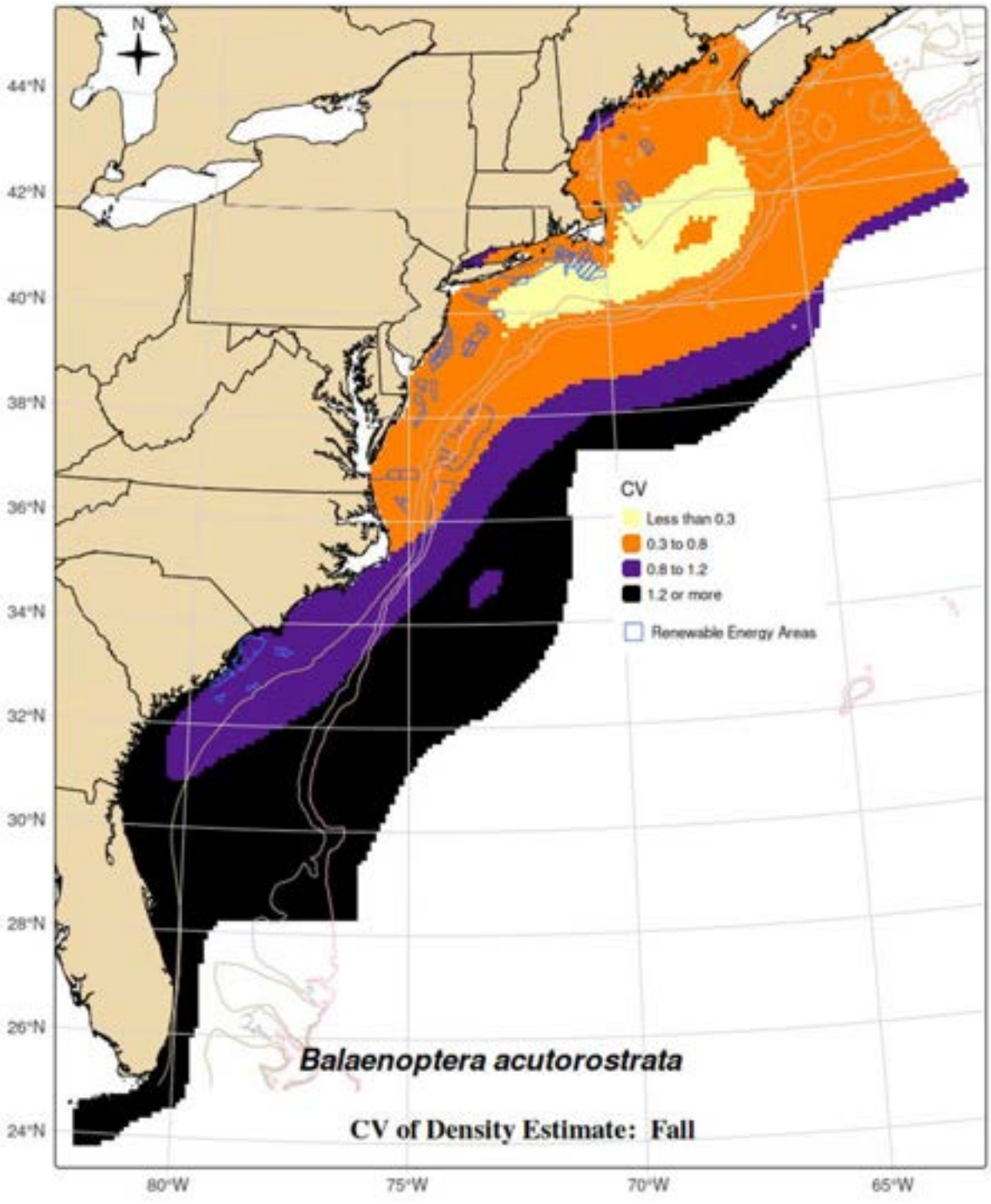

Figure B.5-17. CV of fall minke whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

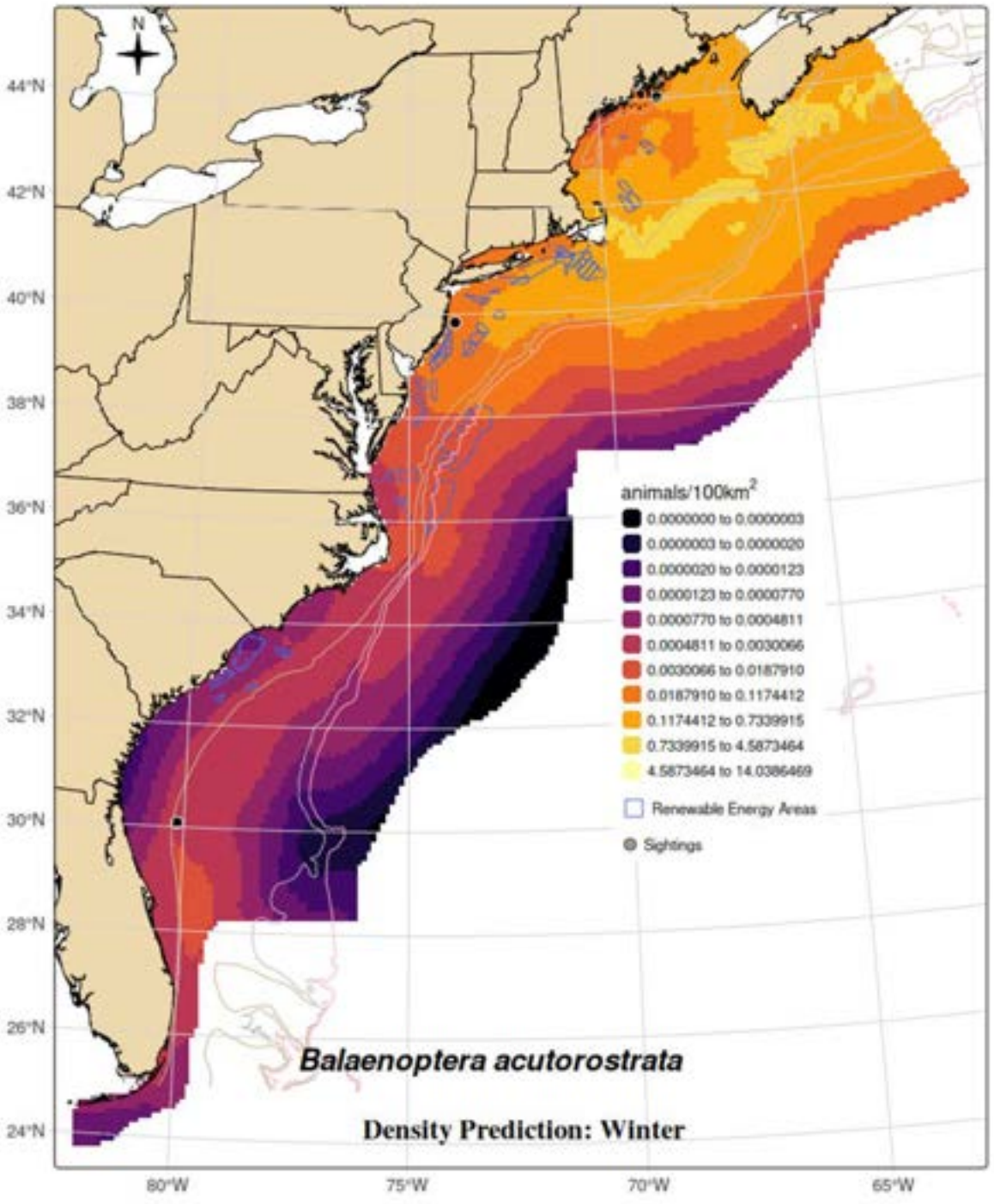

Figure B.5-18. Minke whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

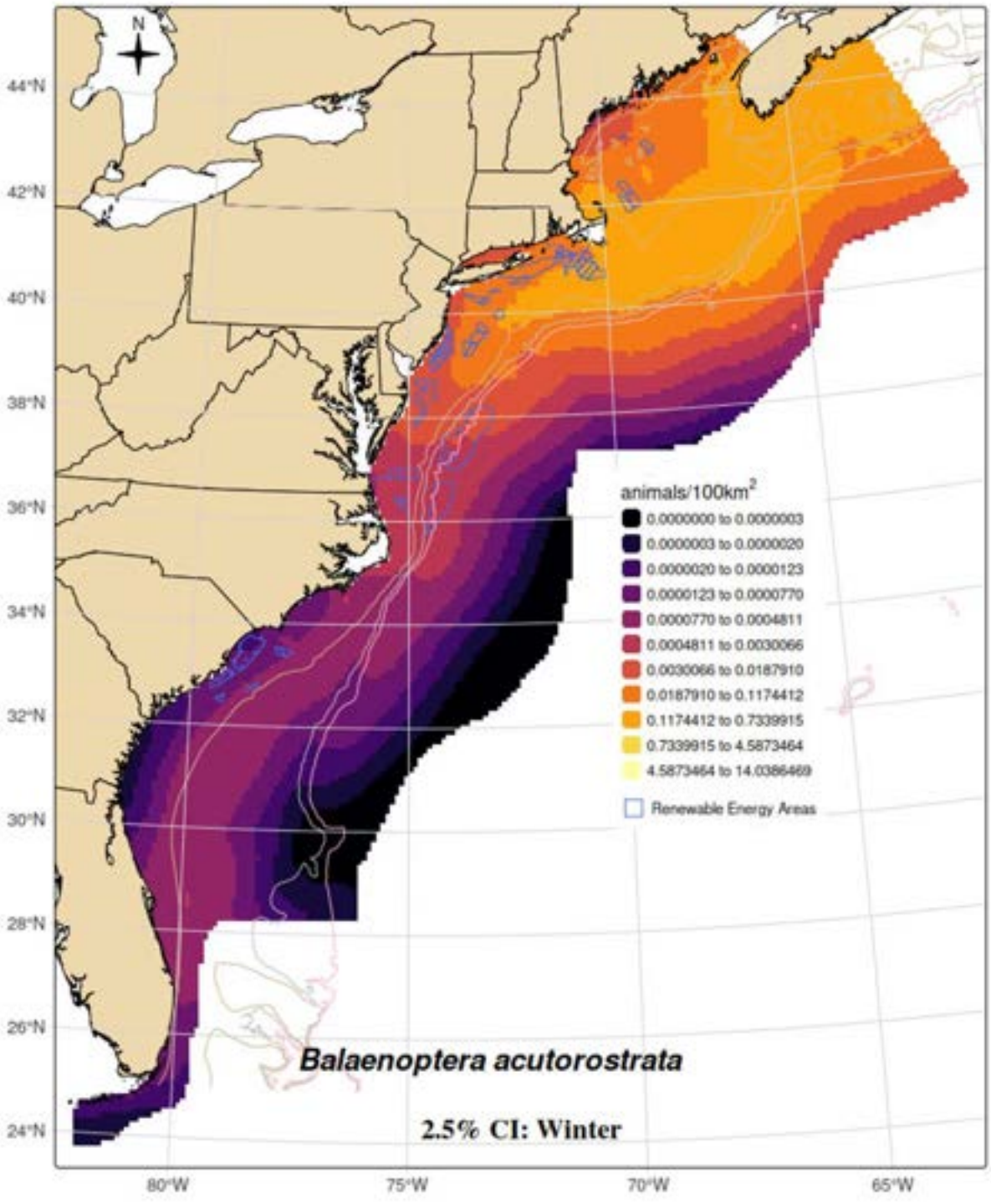

Figure B.5-19. Lower 2.5% confidence interval of the winter minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

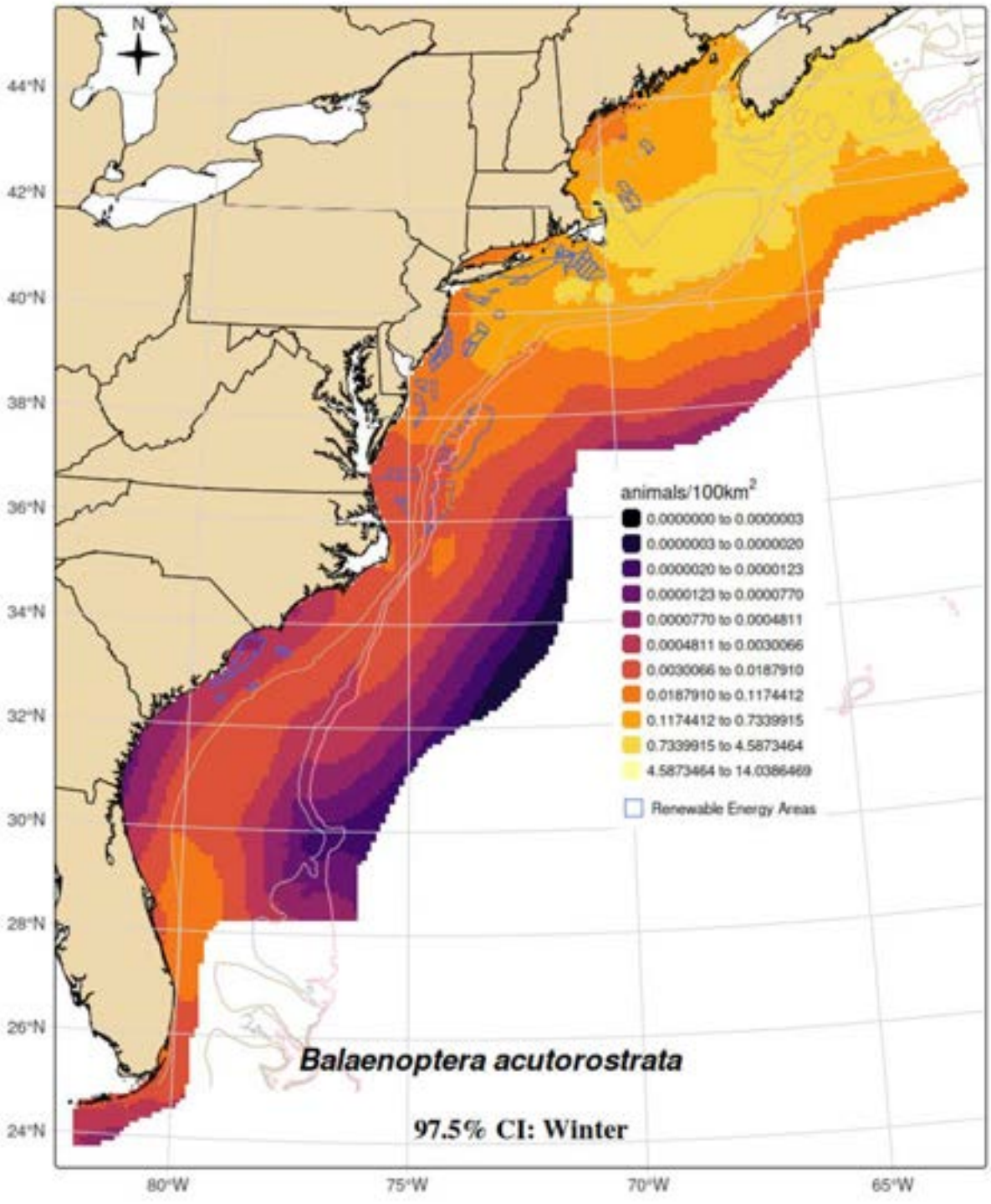

Figure B.5-20. Upper 97.5% confidence interval of the winter minke whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

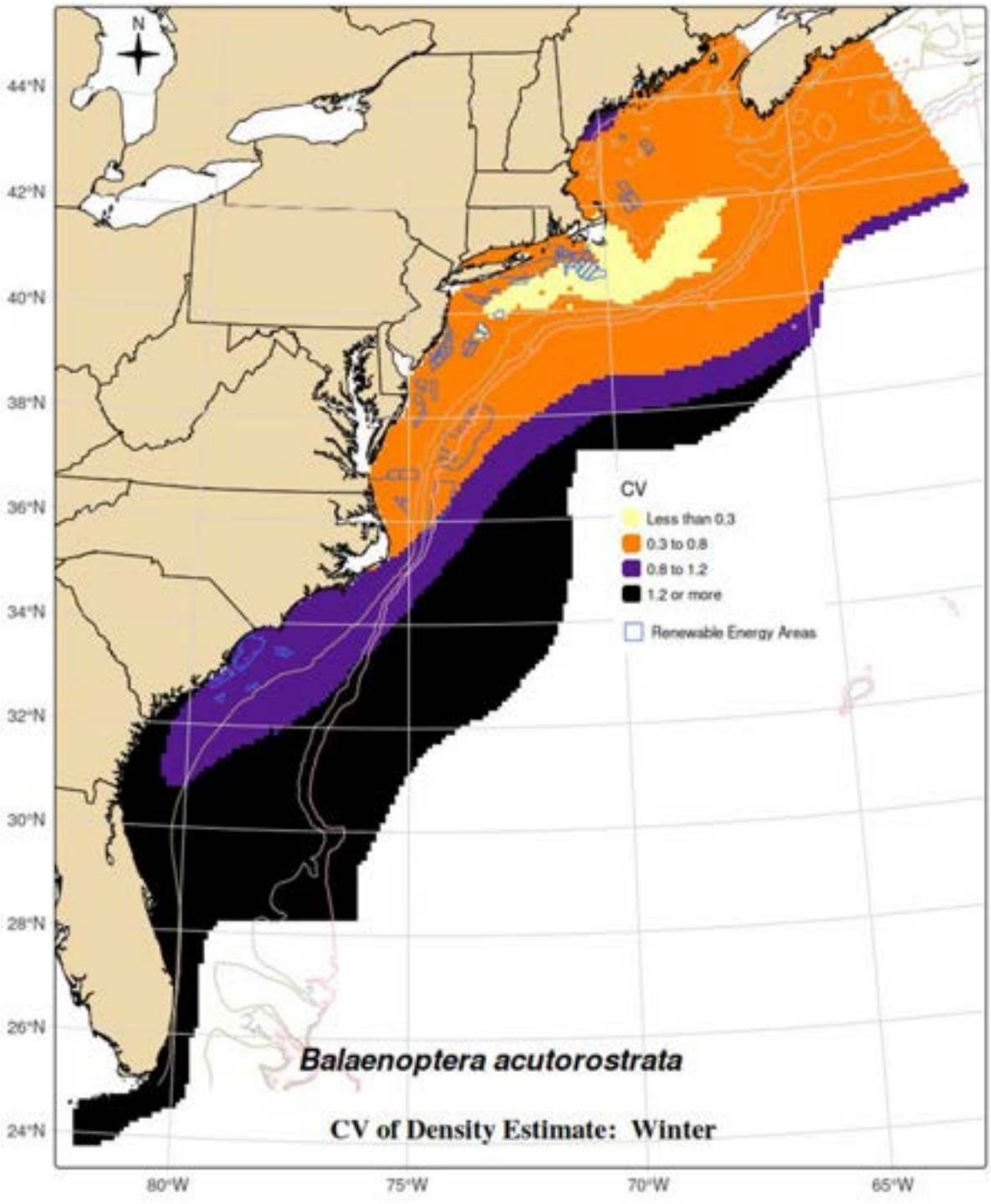

Figure B.5-21. CV of winter minke whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.5.7 Offshore Energy Development Areas

Table B.5-6. Minke whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	57.8	0.29	33 - 101.3
	NY	4.0	0.33	2.1 - 7.6
	NJ	2.8	0.37	1.4 - 5.6
	DE/MD	1.2	0.41	0.5 - 2.5
	VA	0.2	0.53	0.1 - 0.4
	NC	0.2	0.61	0.1 - 0.5
	NC/SC	0.1	1.06	0 - 0.4
	GA	0.0	1.35	0 – 0
	FL	0.0	2.85	0 - 0.1
Summer (Jun-Aug)	RI/MA	87.5	0.28	51.2 - 149.5
	NY	6.2	0.41	2.9 - 13.4
	NJ	3.3	0.47	1.4 - 7.9
	DE/MD	1.4	0.52	0.5 - 3.5
	VA	0.2	0.58	0.1 - 0.5
	NC	0.2	0.64	0.1 - 0.6
	NC/SC	0.1	1.09	0 - 0.5
	GA	0.0	1.70	0 – 0
	FL	0.0	2.99	0 - 0.2
Fall (Sep-Nov)	RI/MA	40.1	0.29	23.1 - 69.7
	NY	3.1	0.38	1.5 - 6.3
	NJ	2.0	0.48	0.8 - 4.9
	DE/MD	0.8	0.46	0.4 – 2
	VA	0.1	0.55	0 - 0.3
	NC	0.1	0.63	0 - 0.3
	NC/SC	0.1	1.08	0 - 0.3
	GA	0.0	1.37	0 – 0
	FL	0.0	2.96	0 - 0.2
Winter (Dec-Feb)	RI/MA	27.5	0.29	15.7 - 48.4
	NY	2.2	0.35	1.1 - 4.2
	NJ	1.6	0.40	0.8 - 3.4
	DE/MD	0.7	0.43	0.3 - 1.5
	VA	0.1	0.54	0 - 0.3
	NC	0.1	0.61	0 - 0.3
	NC/SC	0.0	1.06	0 - 0.3
	GA	0.0	1.29	0 – 0
	FL	0.0	2.80	0 - 0.1

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

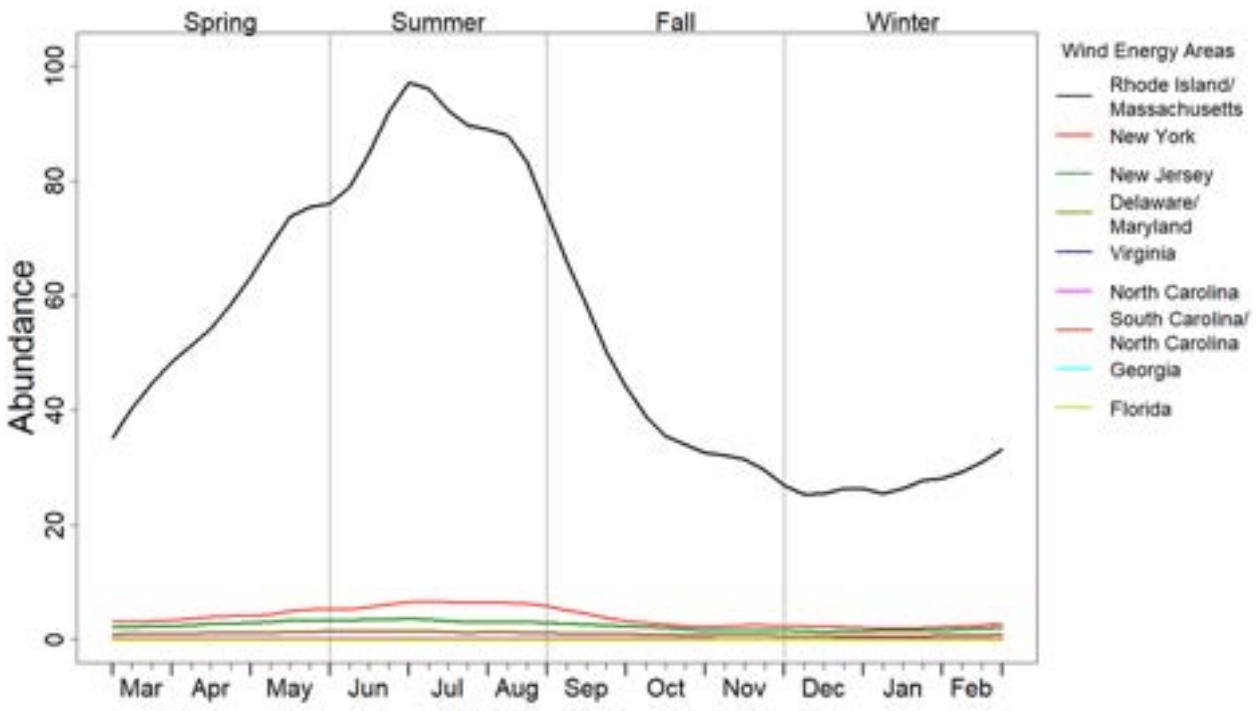

Figure B.5-22. Average seasonal abundance of minke whales in the wind-energy study areas

B.6 Sperm Whale (*Physeter macrocephalus*)

Figure B.6-1. Sperm whales
Image collected under MMPA Research permit #775-1875. Credit: NOAA/NEFSC

B.6.1 Data Collection

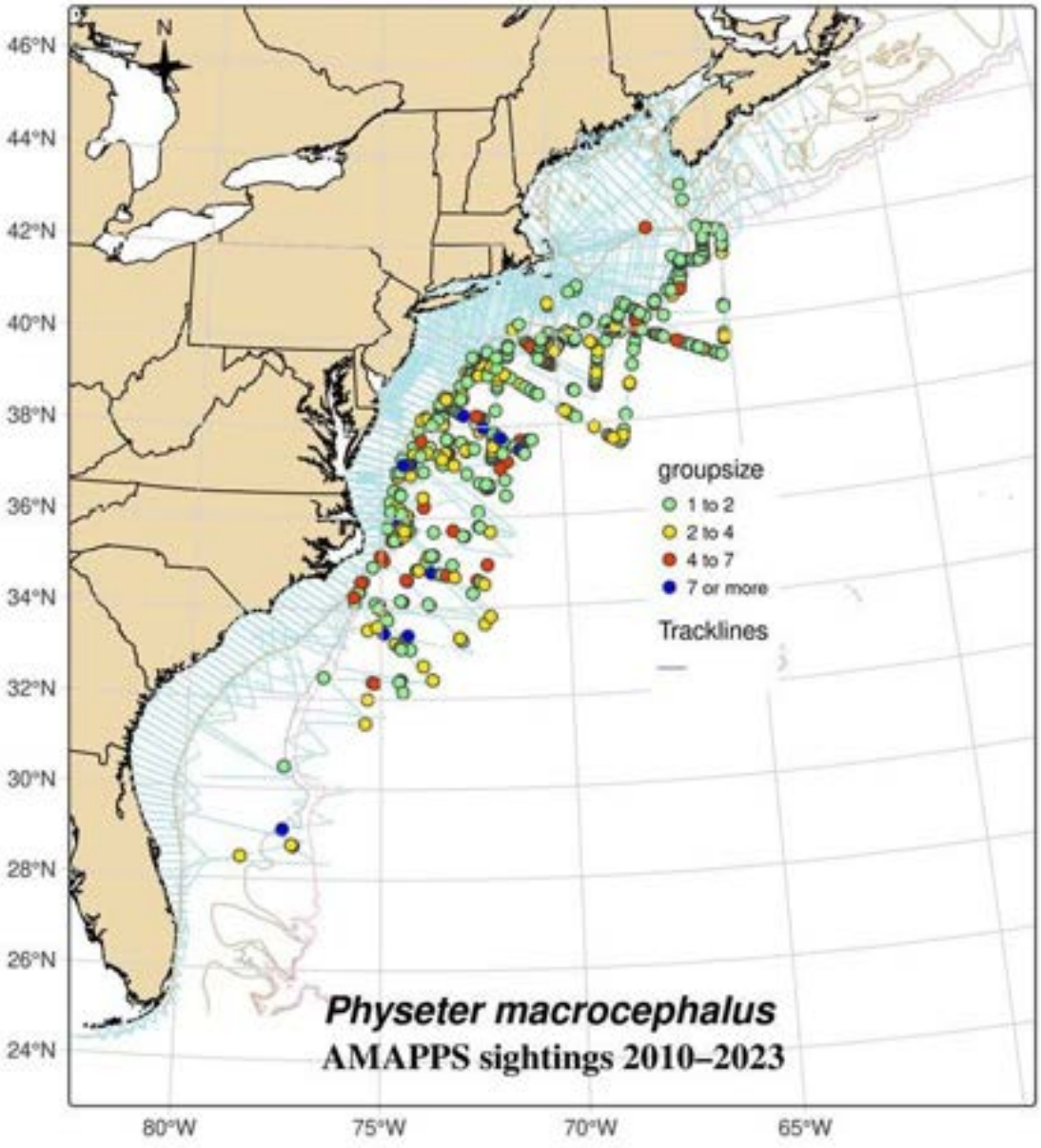

Figure B.6-2. Distribution of track lines and sperm whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.6-1. AMAPPS research effort 2010 to 2023 and sperm whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	38	44
NE Shipboard	Summer	49,064	467	723
NE Aerial	Spring	38,839	3	3
NE Aerial	Summer	52,003	6	11
NE Aerial	Fall	87,311	8	12
NE Aerial	Winter	24,747	0	0
SE Shipboard	Spring	2,604	26	93
SE Shipboard	Summer	18,331	115	296
SE Shipboard	Fall	2,673	12	38
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	9	10
SE Aerial	Summer	43,285	3	3
SE Aerial	Fall	21,153	0	0
SE Aerial	Winter	19,152	0	0

B.6.2 Mark-Recapture Distance Sampling Analysis

Table B.6-2. Intermediate parameters in sperm whale mark-recapture distance sampling models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15	0.89
NE–aerial group 3	distance + sea state	900	distance + sea state + glare	900	HR	0.66	0.07	0.03	0.96
NE–shipboard group 9	distance + log(group size) + sea state	6000	distance + glare + time of day	6000	HR	0.55	0.08	0.31	0.93
SE–shipboard group 5	distance + log(group size)	9000	distance + glare	9000	HR	0.58	0.11	0.70	0.61

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

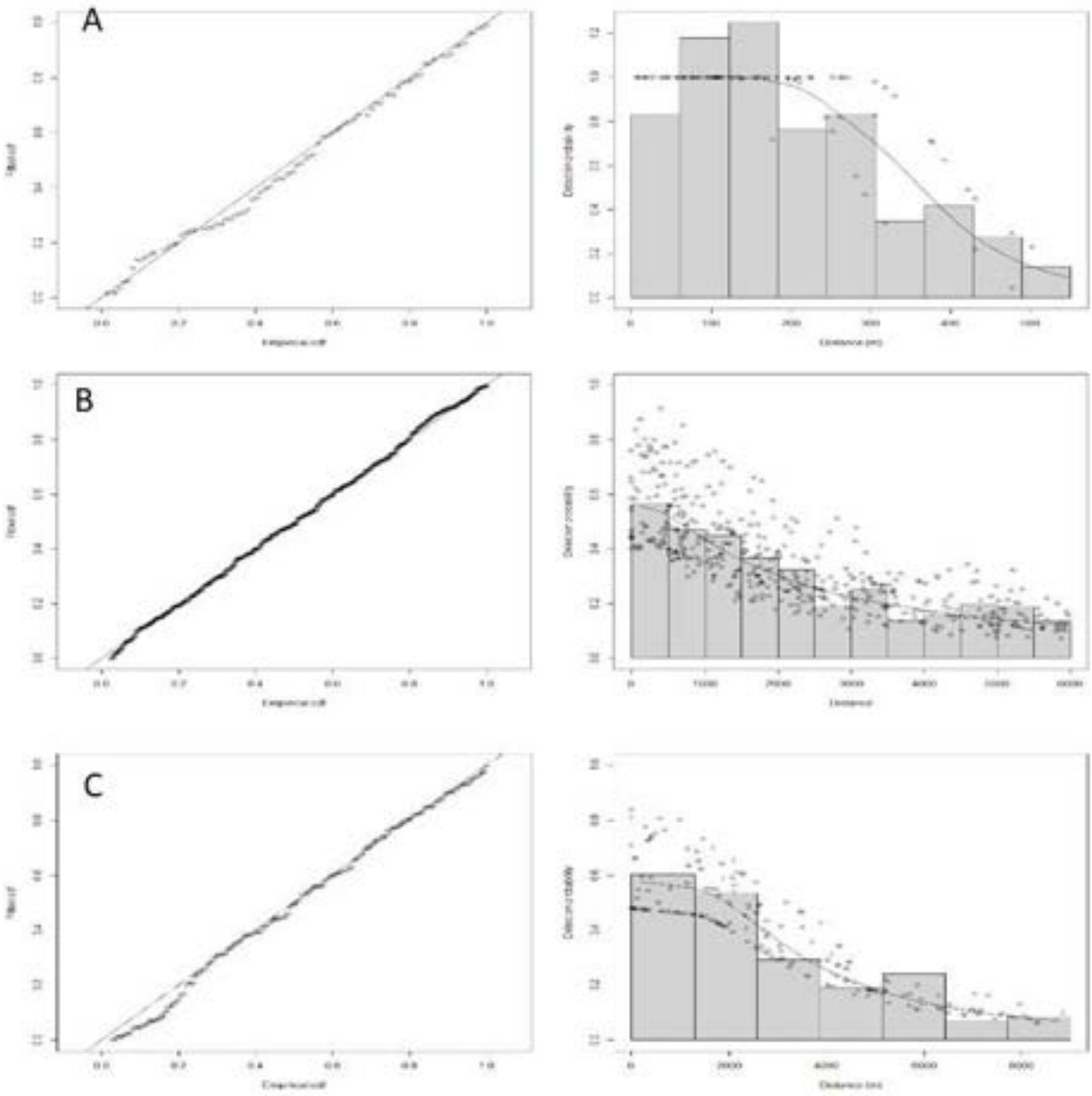

Figure B.6-3. Q-Q plots and detection functions from the sperm whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 3; C) NE-shipboard analysis set 9; D) SE-shipboard analysis set 5.

B.6.3 Generalized Additive Model Analysis

Table B.6-3. 2010 to 2023 density-habitat model output for sperm whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(depth)	4.37	5	32.50	21.88	<0.0001
s(btemp)	3.29	5	8.57	5.28	<0.0001
s(mlp)	0.82	5	0.83	1.42	0.0235
s(dist2GSSw)	1.16	5	2.98	3.01	<0.0001
s(dist1000)	3.16	5	19.85	7.29	<0.0001
s(pp)	0.99	5	8.50	5.26	<0.0001
s(latdd)	1.28	5	7.34	6.16	<0.0001

Adjusted R^2 = 0.0441. Deviance explained = 50.3%
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

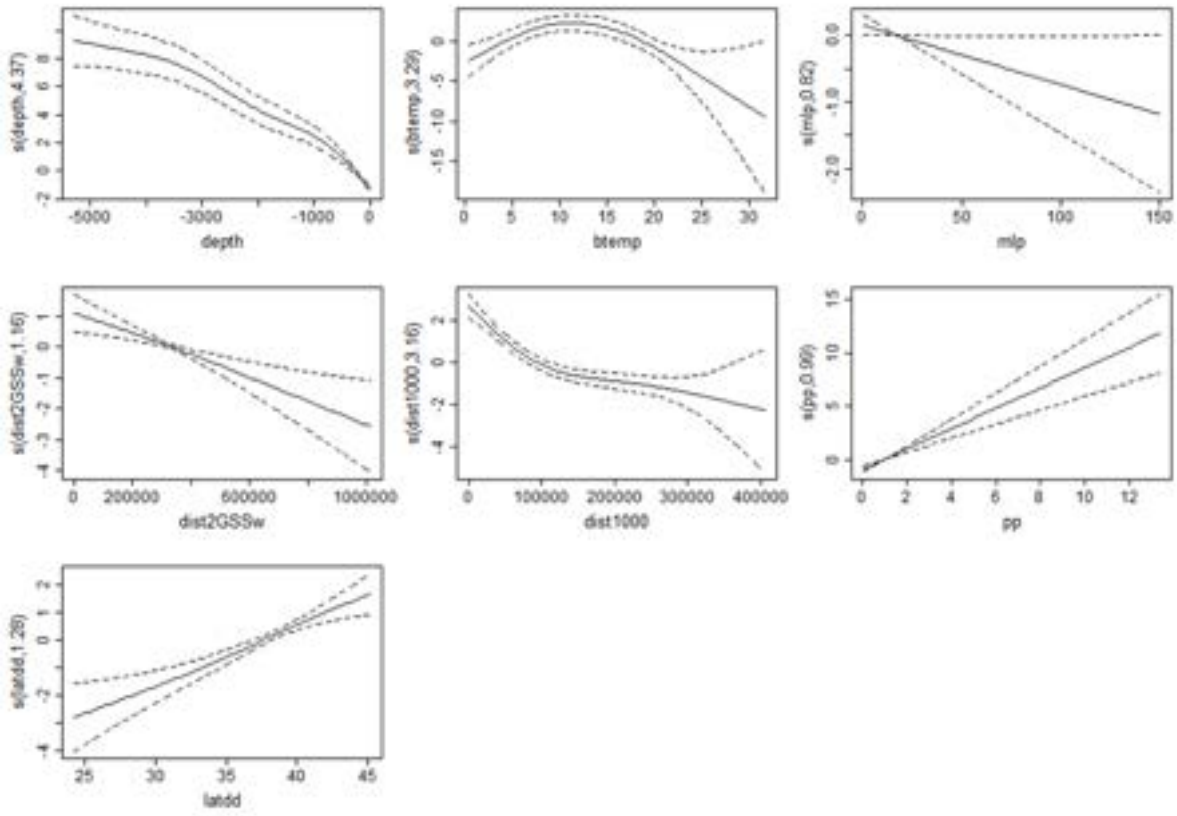

Figure B.6-4. Sperm whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.6.4 Model Cross-Validation

Table B.6-4. Diagnostic statistics from the sperm whale density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
MAPE	Mean absolute percentage error	Non-zero density	85.894	Fair to good
RHO	Spearman rank correlation	Non-zero density	0.271	Fair to good
MAPE	Mean absolute percentage error	All data divided in 25 random samples	85.342	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.160	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.002	Excellent

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.6.5 Abundance Estimates for AMAPPS Study Area

Table B.6-5. Sperm whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	4,435	0.25	2,737 – 7,186
Summer (June–August)	5,713	0.22	3,731 – 8,748
Fall (September–November)	3,957	0.23	2,536 – 6,175
Winter (December–February)	2,760	0.30	1,552 – 4,907
Summer 2011 U.S. surveys[1]	39	0.64	18 − 83
Summer 2016 U.S. surveys[1]	4,349	0.28	3,051 − 6,200
Summer 2021 U.S. surveys[1]	5,895	0.29	3,377 – 10,289

[1]Hayes et al. 2024

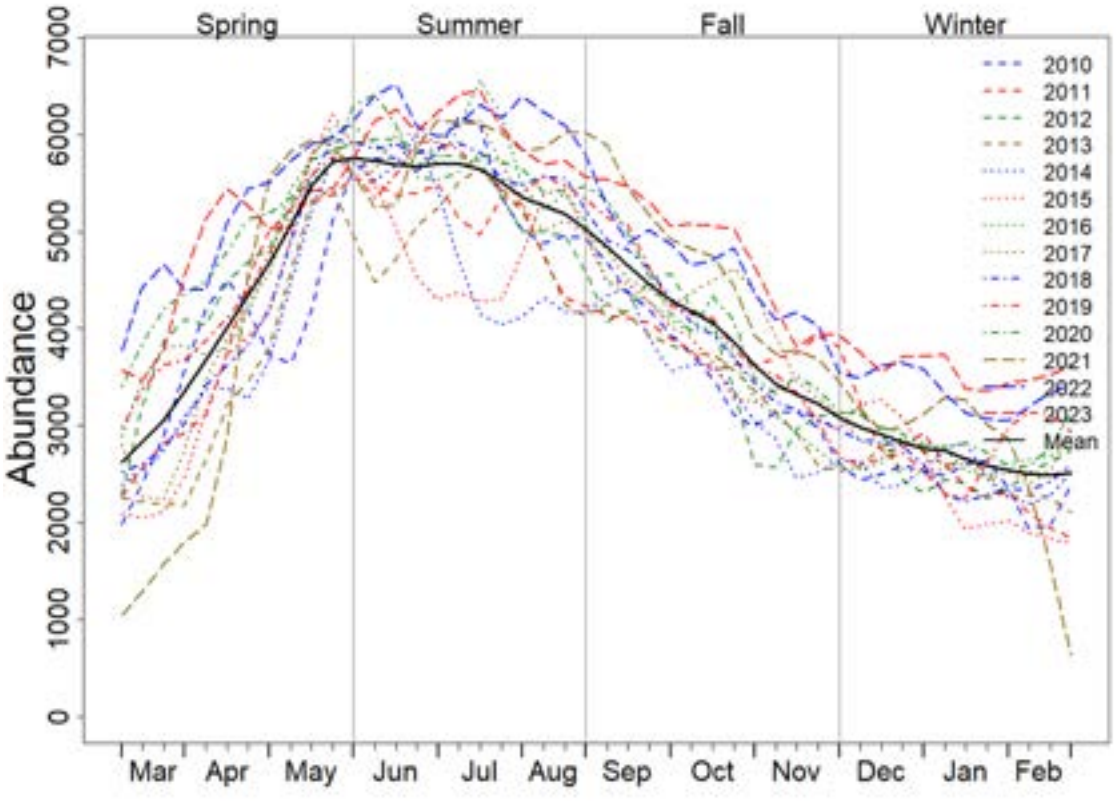

Figure B.6-5. Annual abundance trends for sperm whales in the AMAPPS study area

B.6.6 Seasonal Prediction Maps

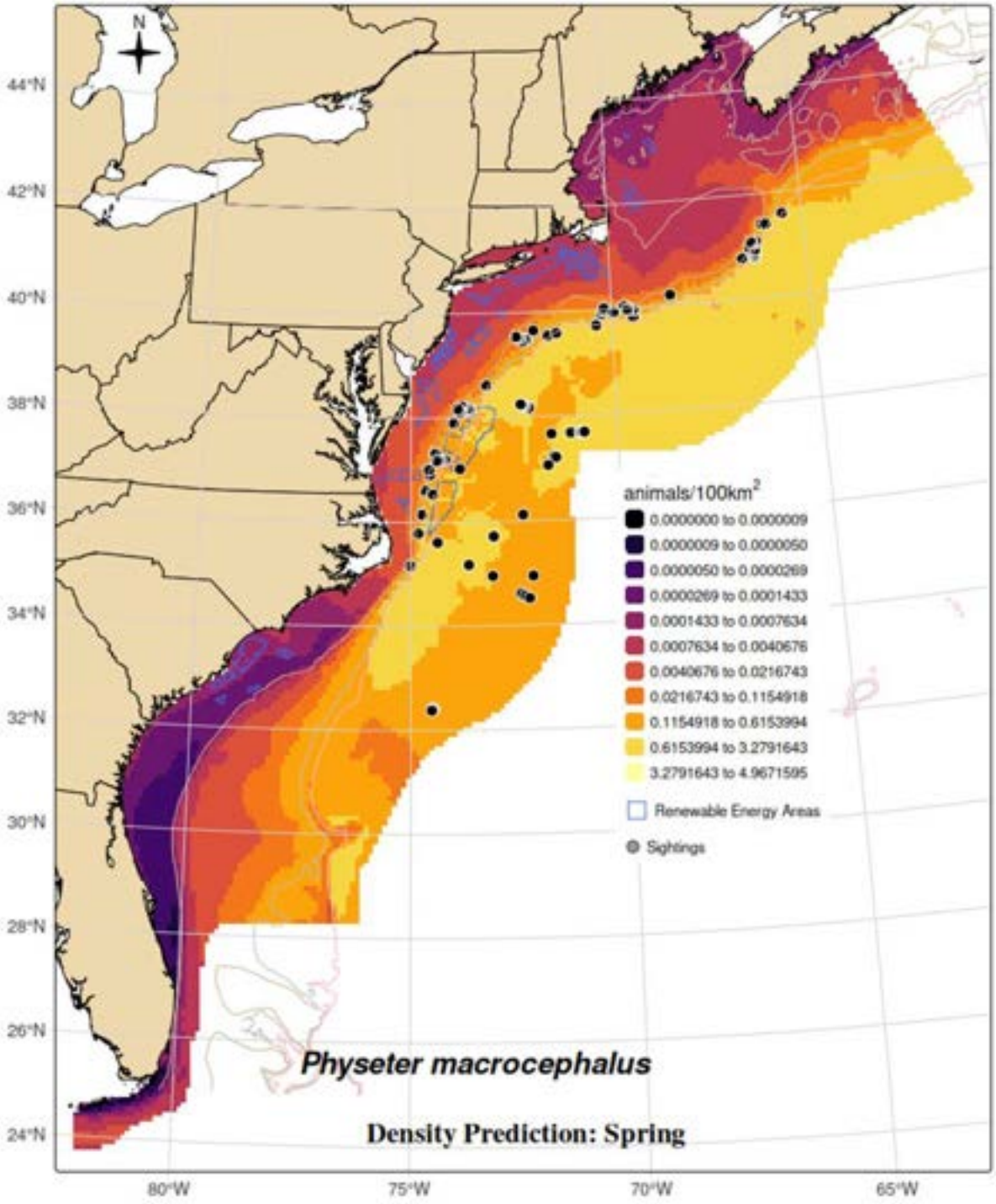

Figure B.6-6. Sperm whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

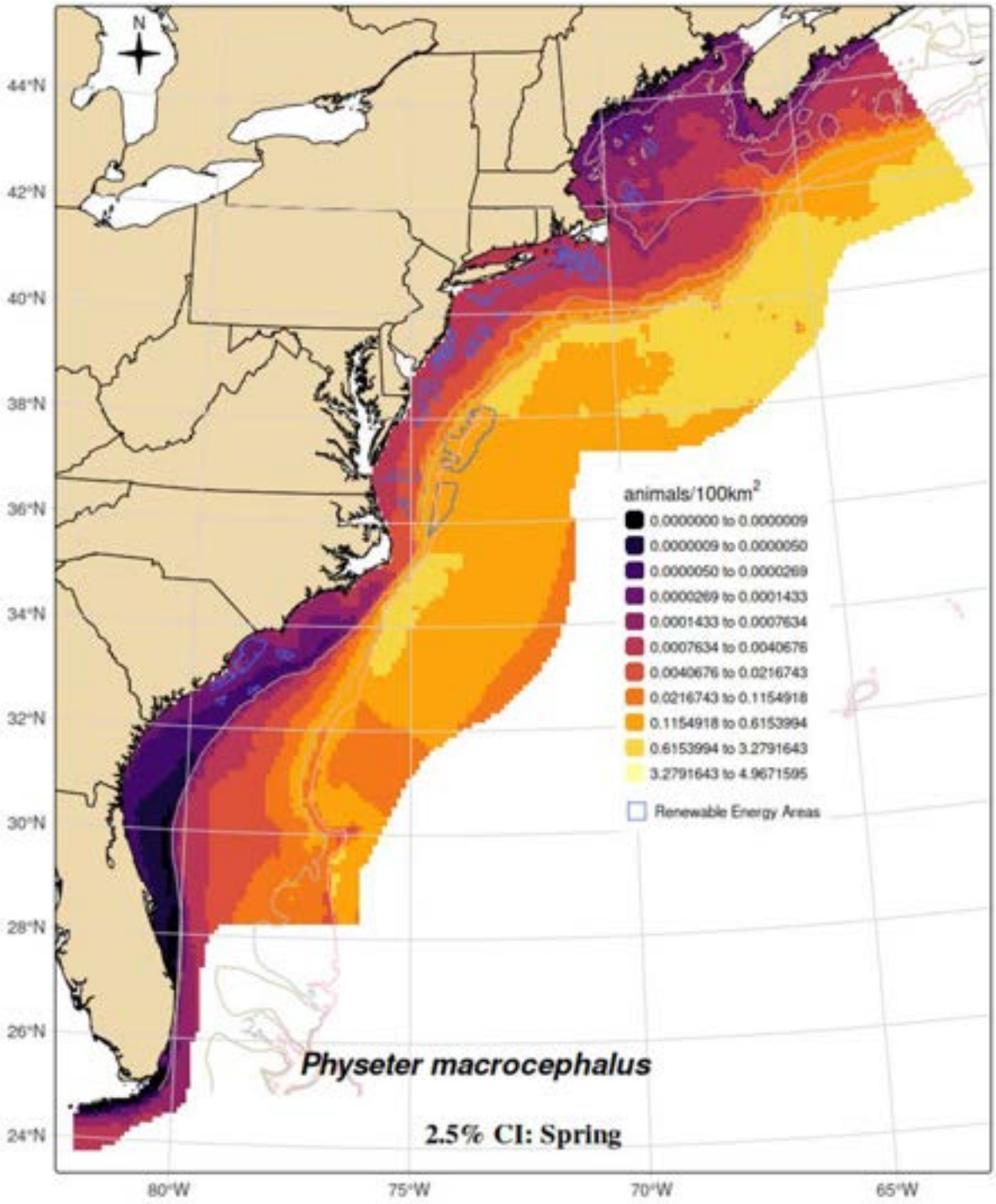

Figure B.6-7. Lower 2.5% confidence interval of the spring sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

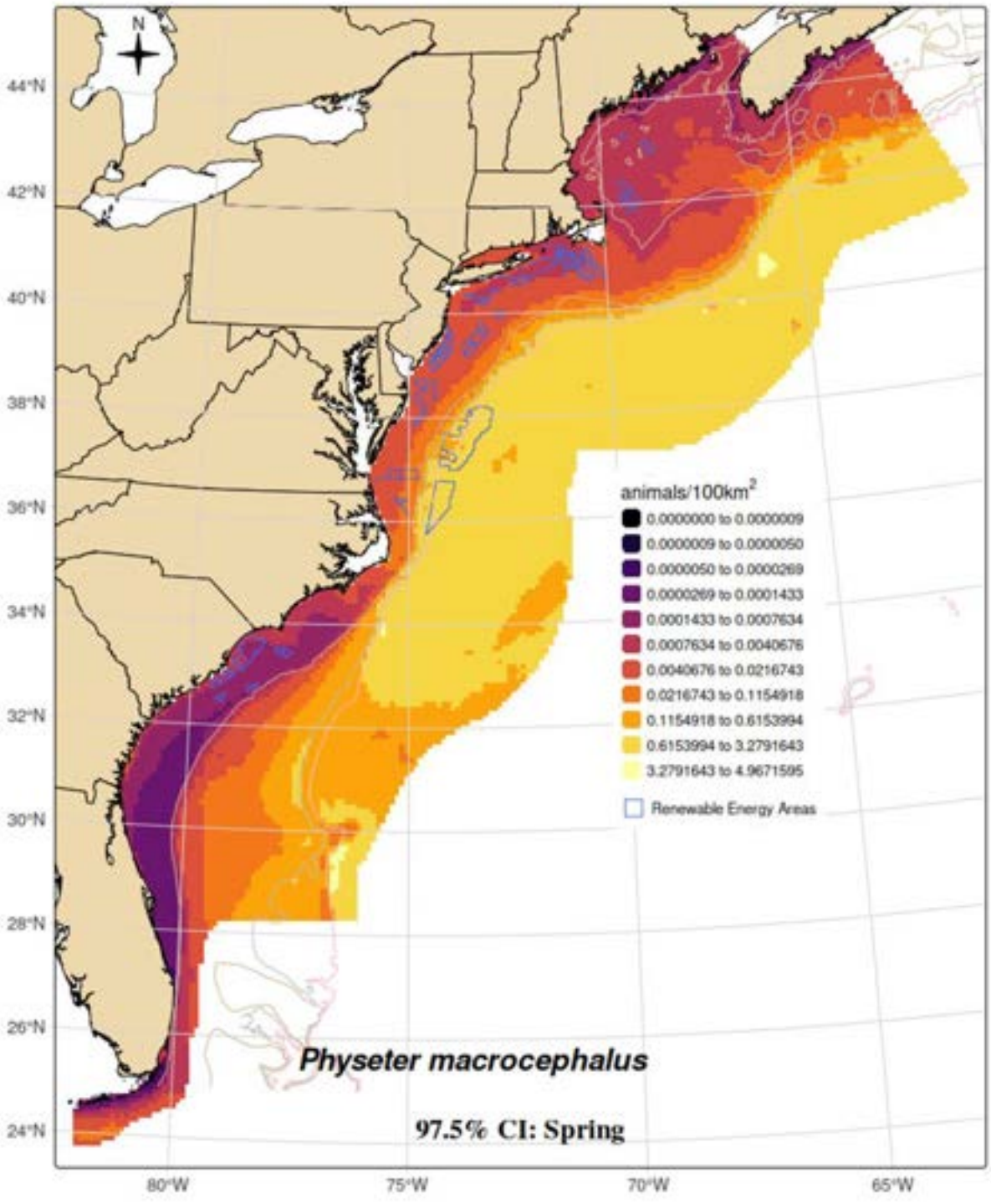

Figure B.6-8. Upper 97.5% confidence interval of the spring sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

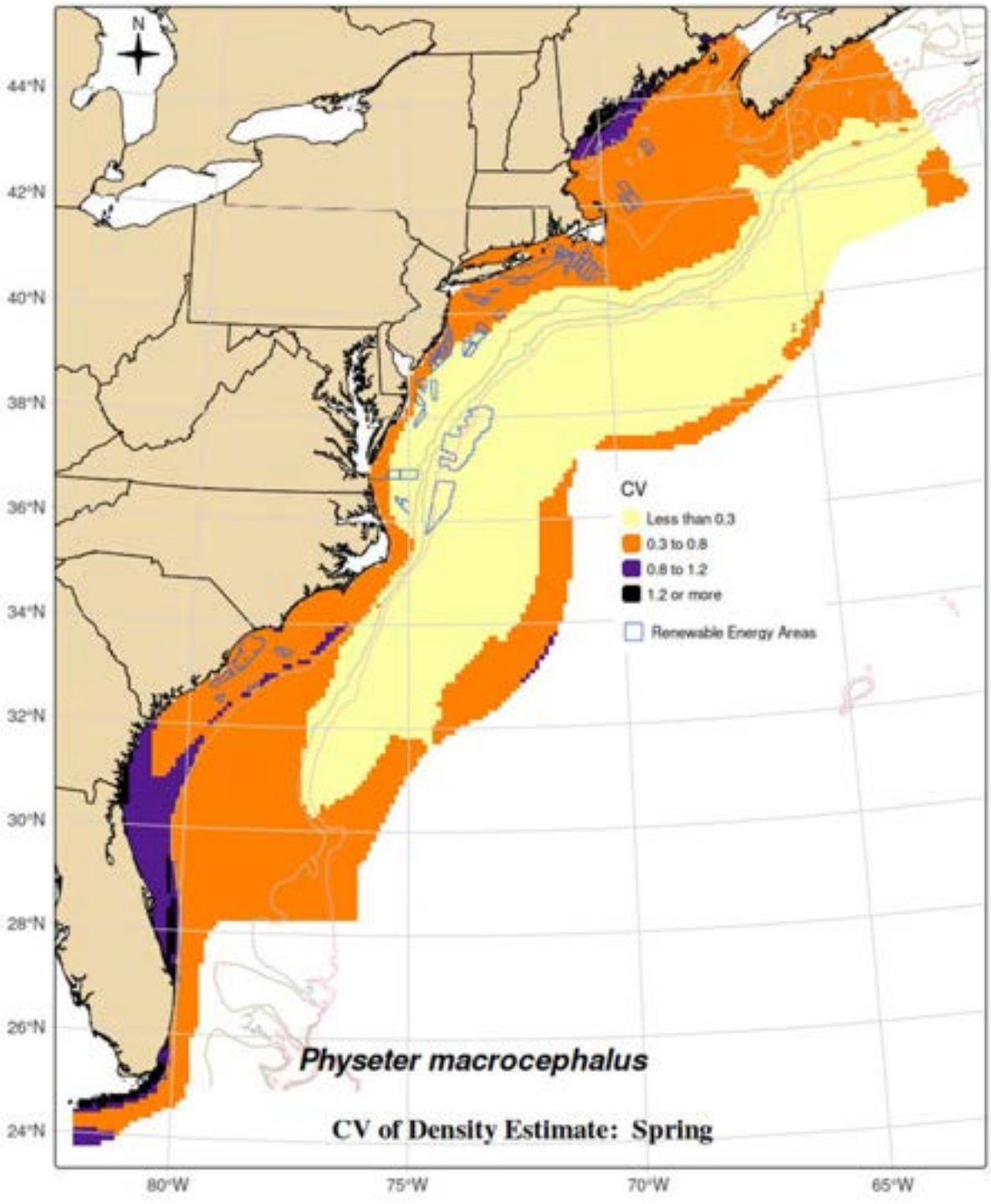

Figure B.6-9. CV of spring sperm whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

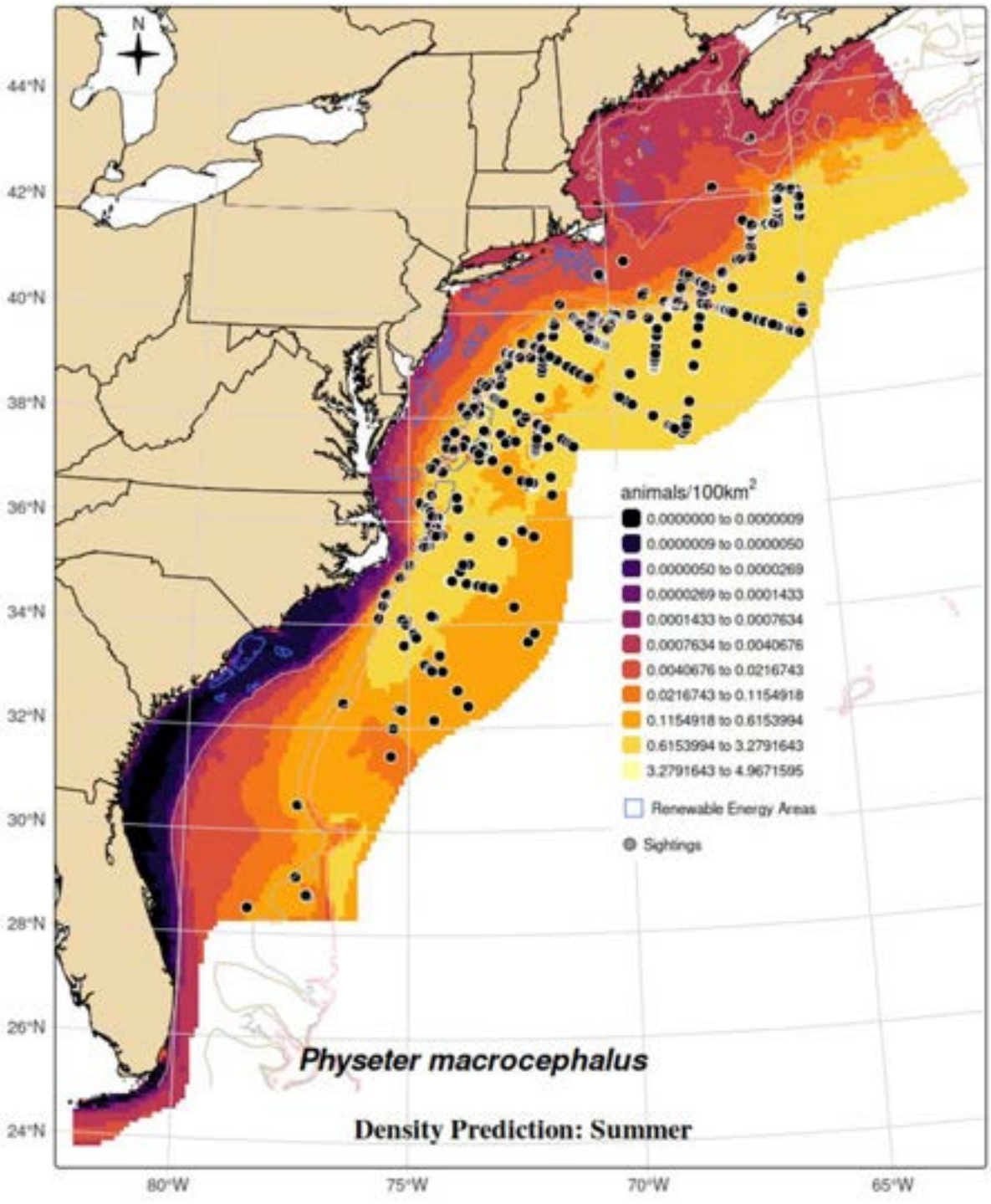

Figure B.6-10. Sperm whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

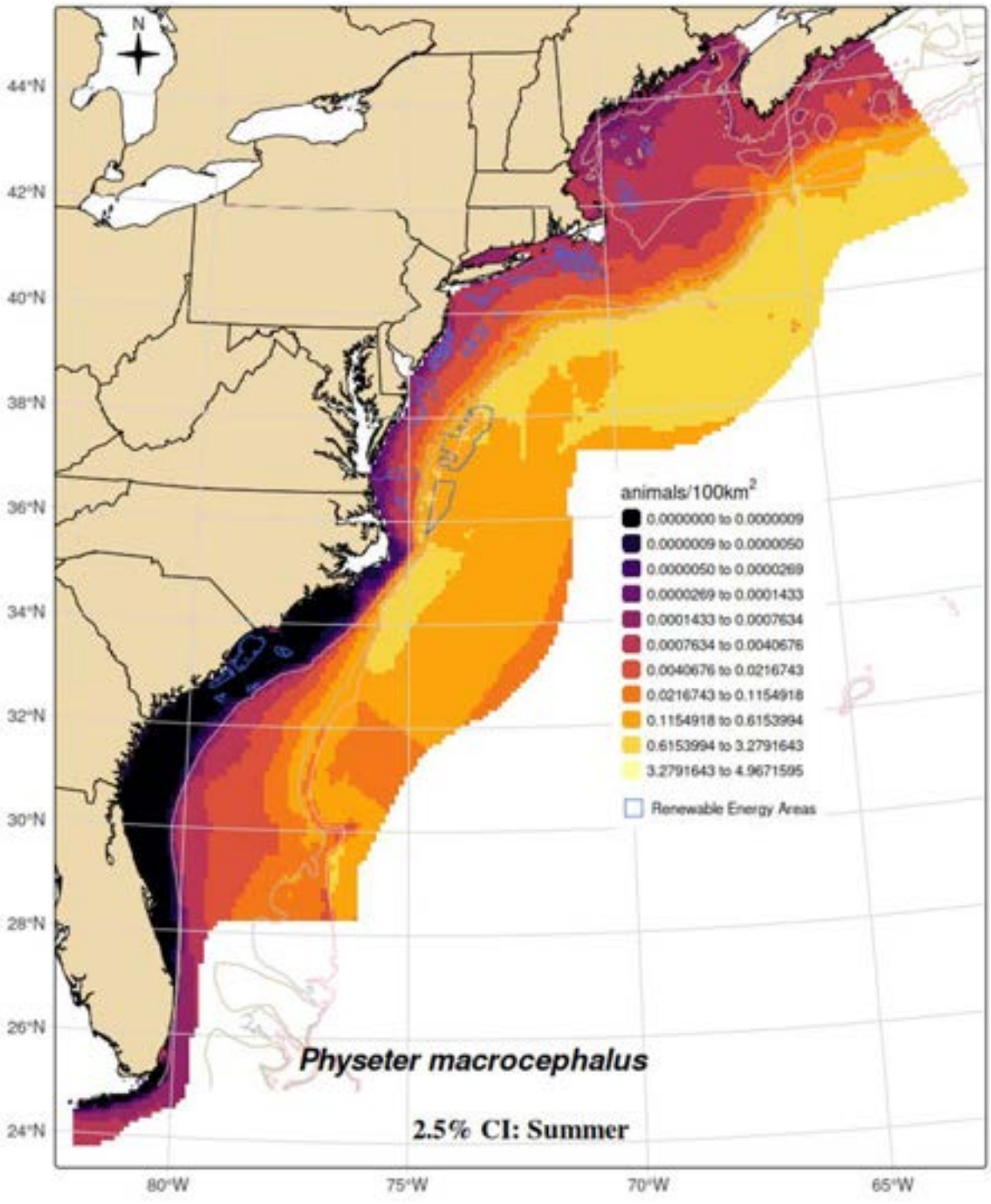

Figure B.6-11. Lower 2.5% confidence interval of the summer sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

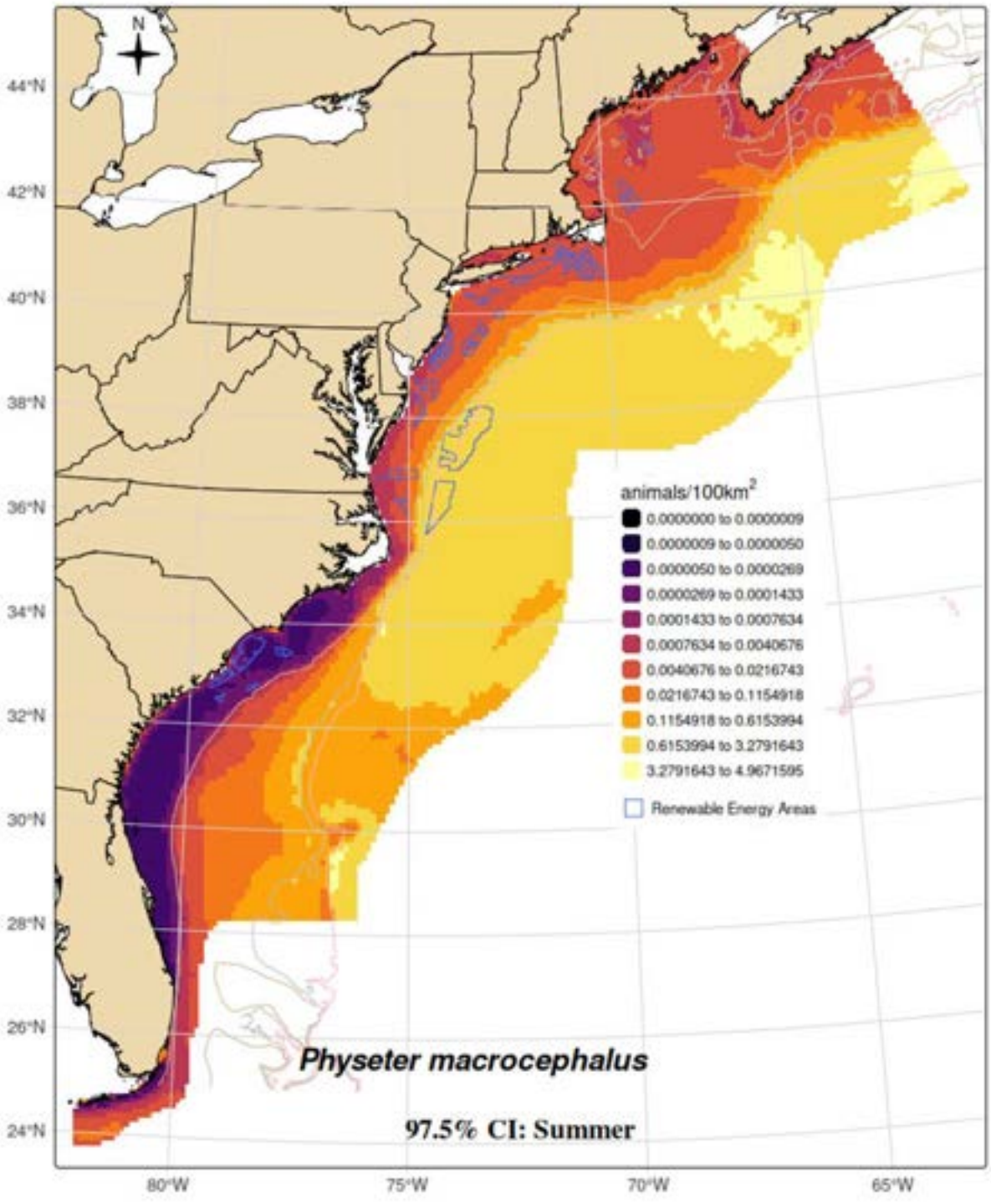

Figure B.6-12. Upper 97.5% confidence interval of the summer sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

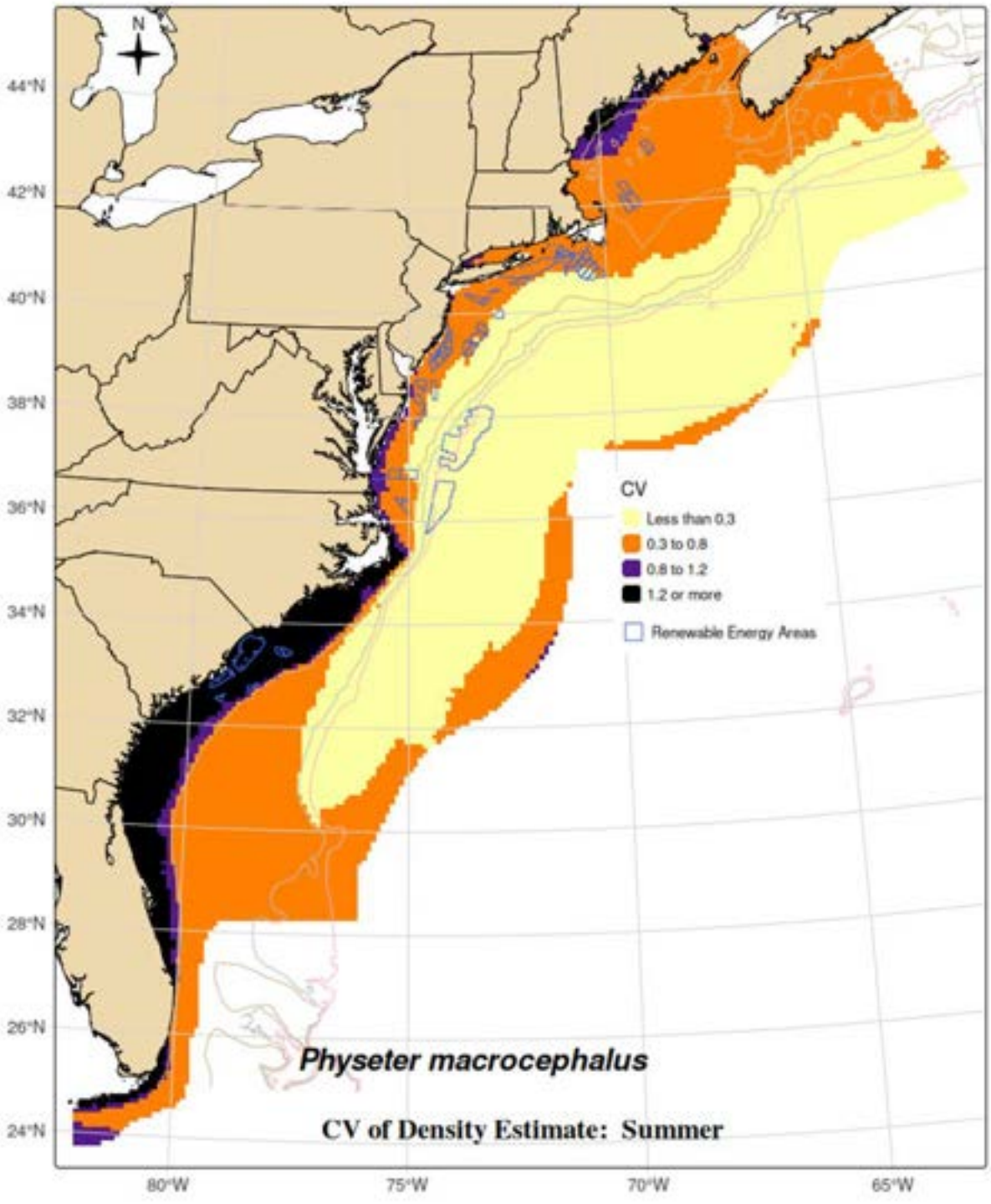

Figure B.6-13. CV of summer sperm whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

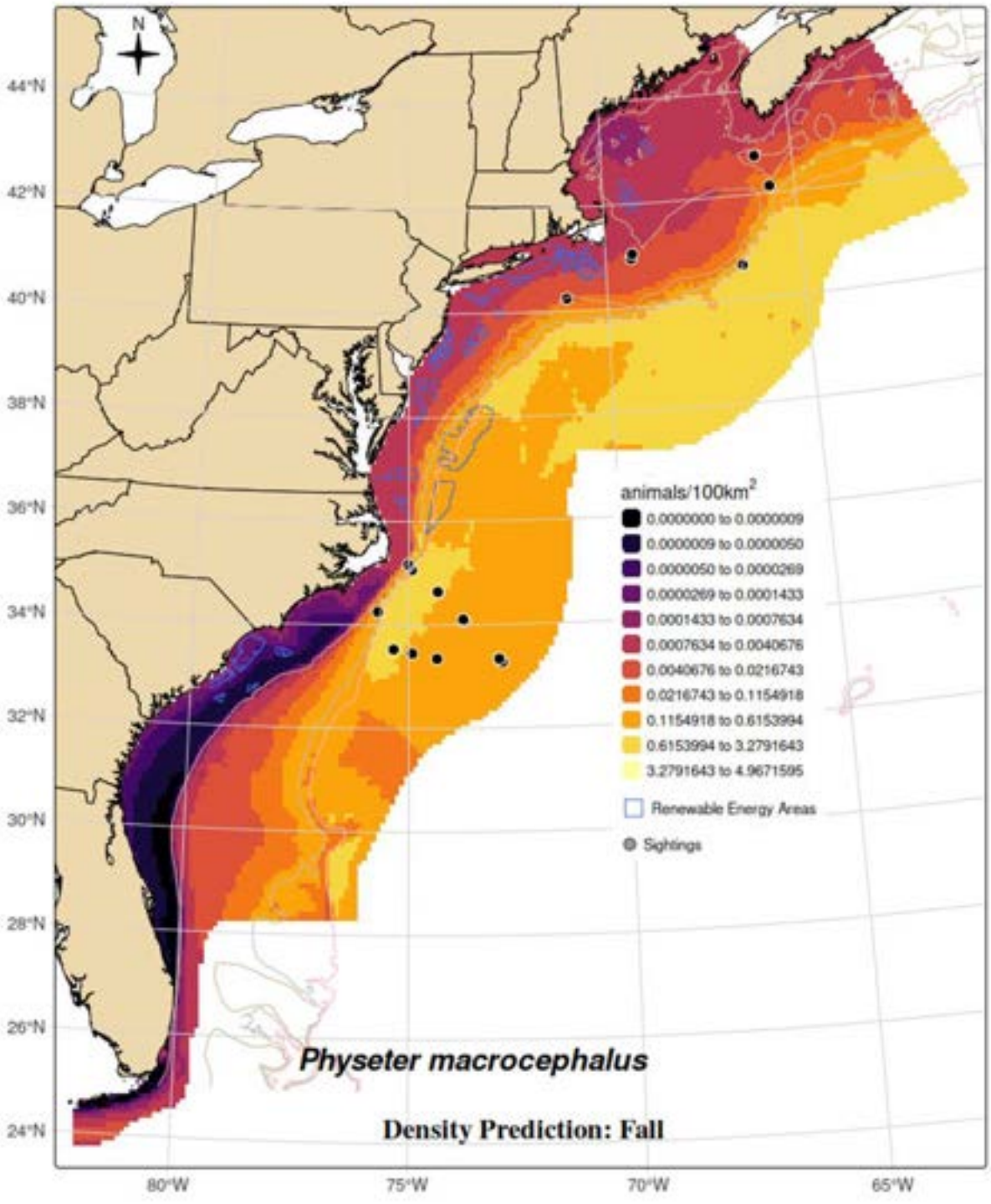

Figure B.6-14. Sperm whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

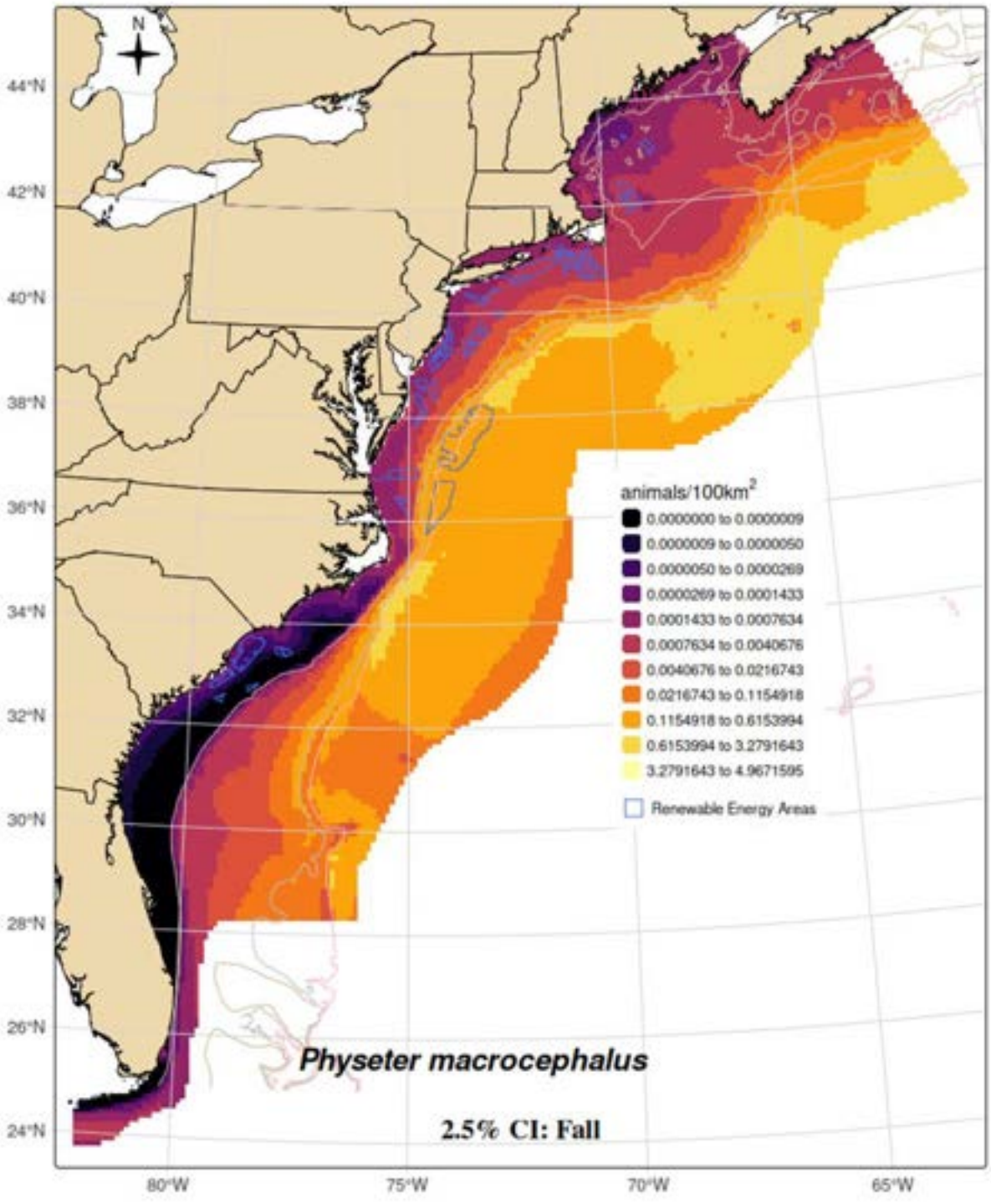

Figure B.6-15. Lower 2.5% confidence interval of the fall sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

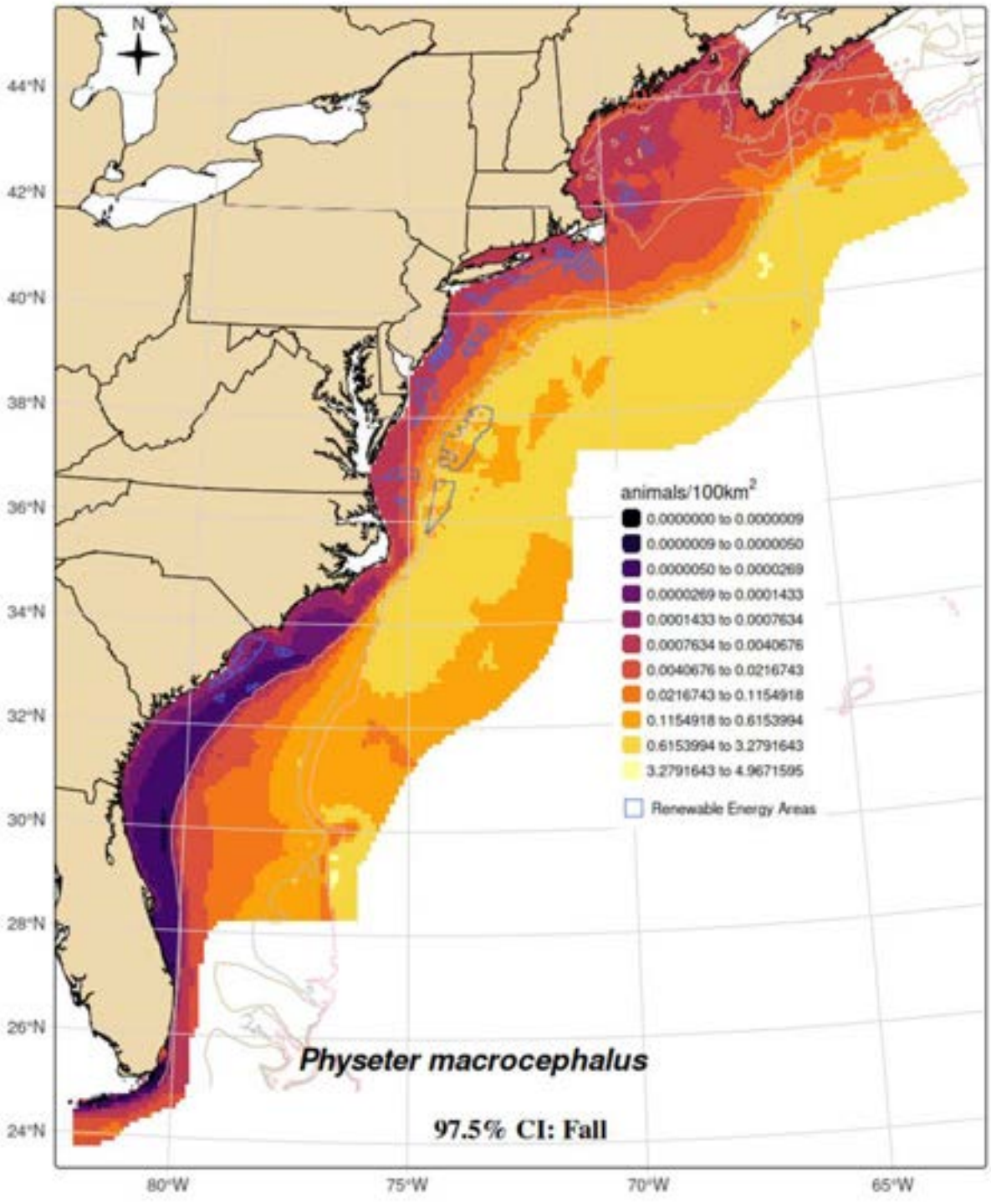

Figure B.6-16. Upper 97.5% confidence interval of the fall sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

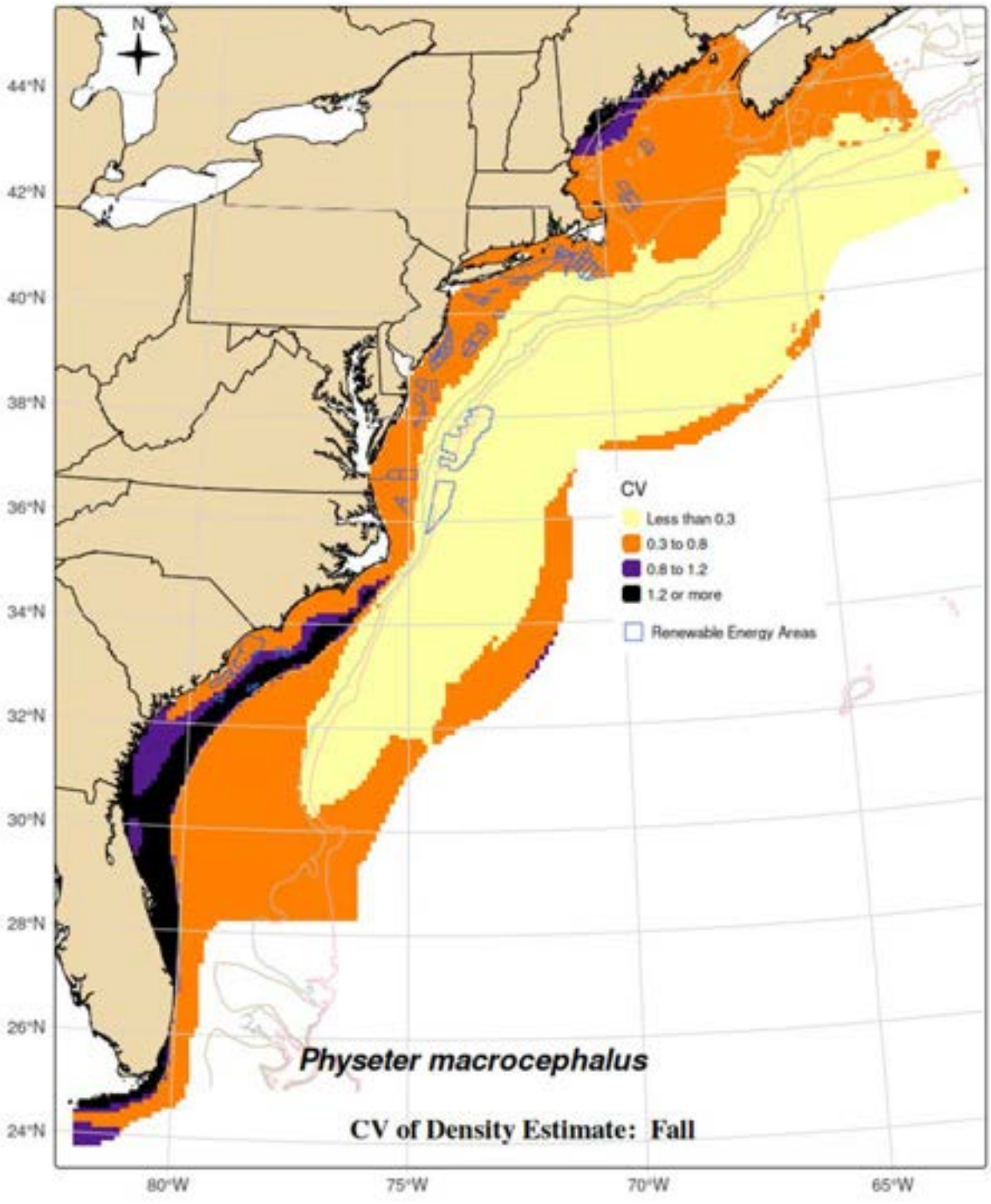

Figure B.6-17. CV of fall sperm whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

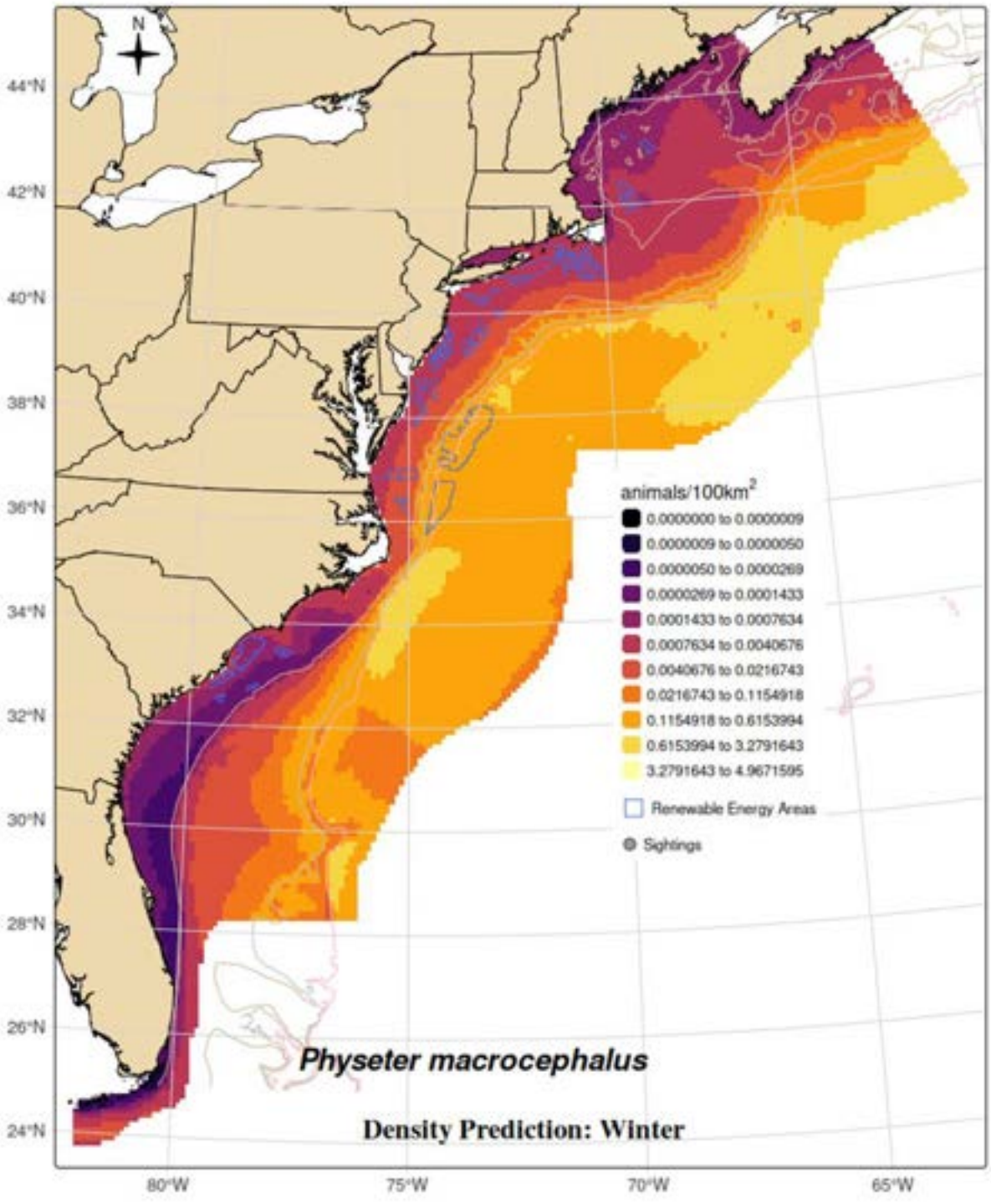

Figure B.6-18. Sperm whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

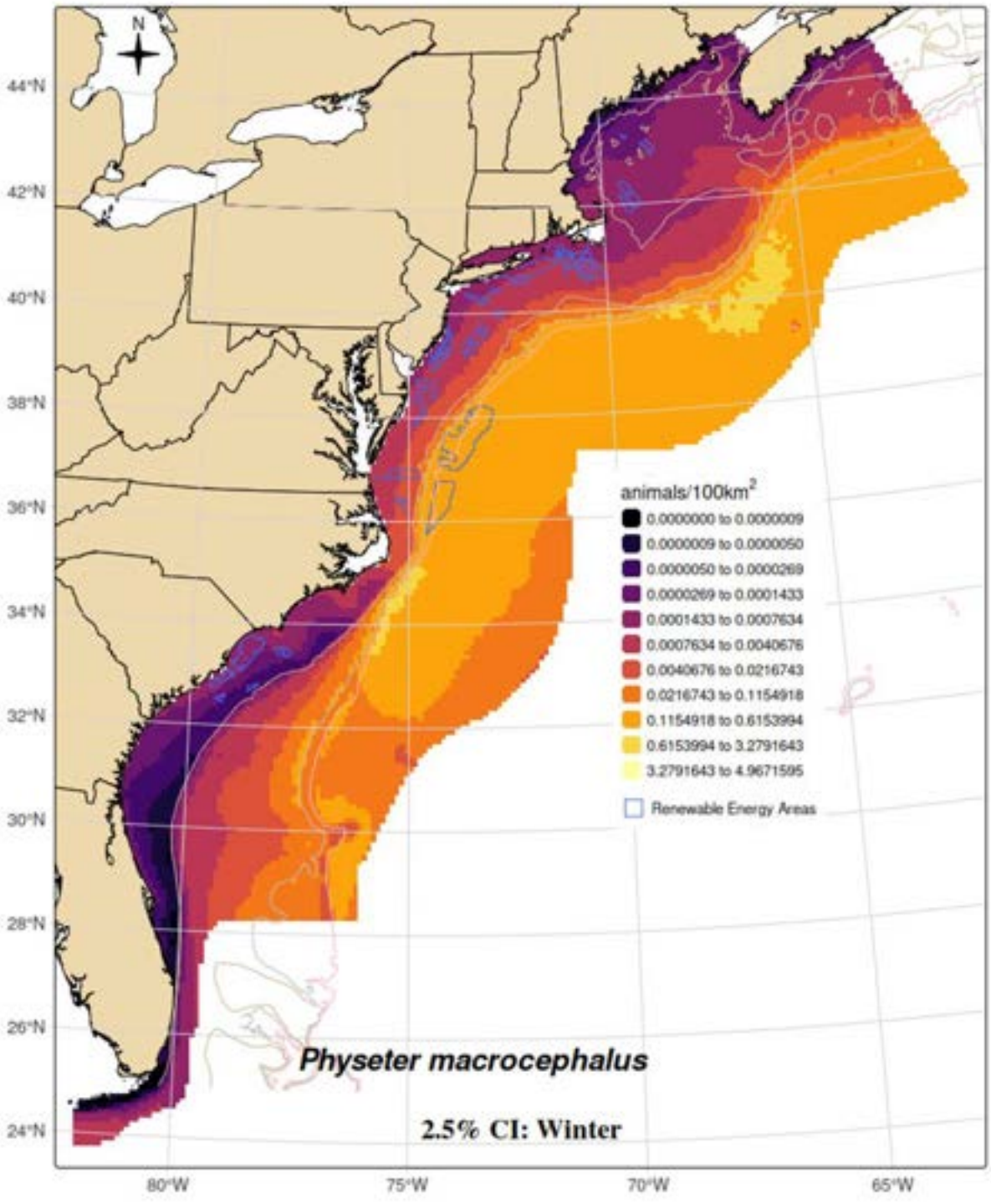

Figure B.6-19. Lower 2.5% confidence interval of the winter sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

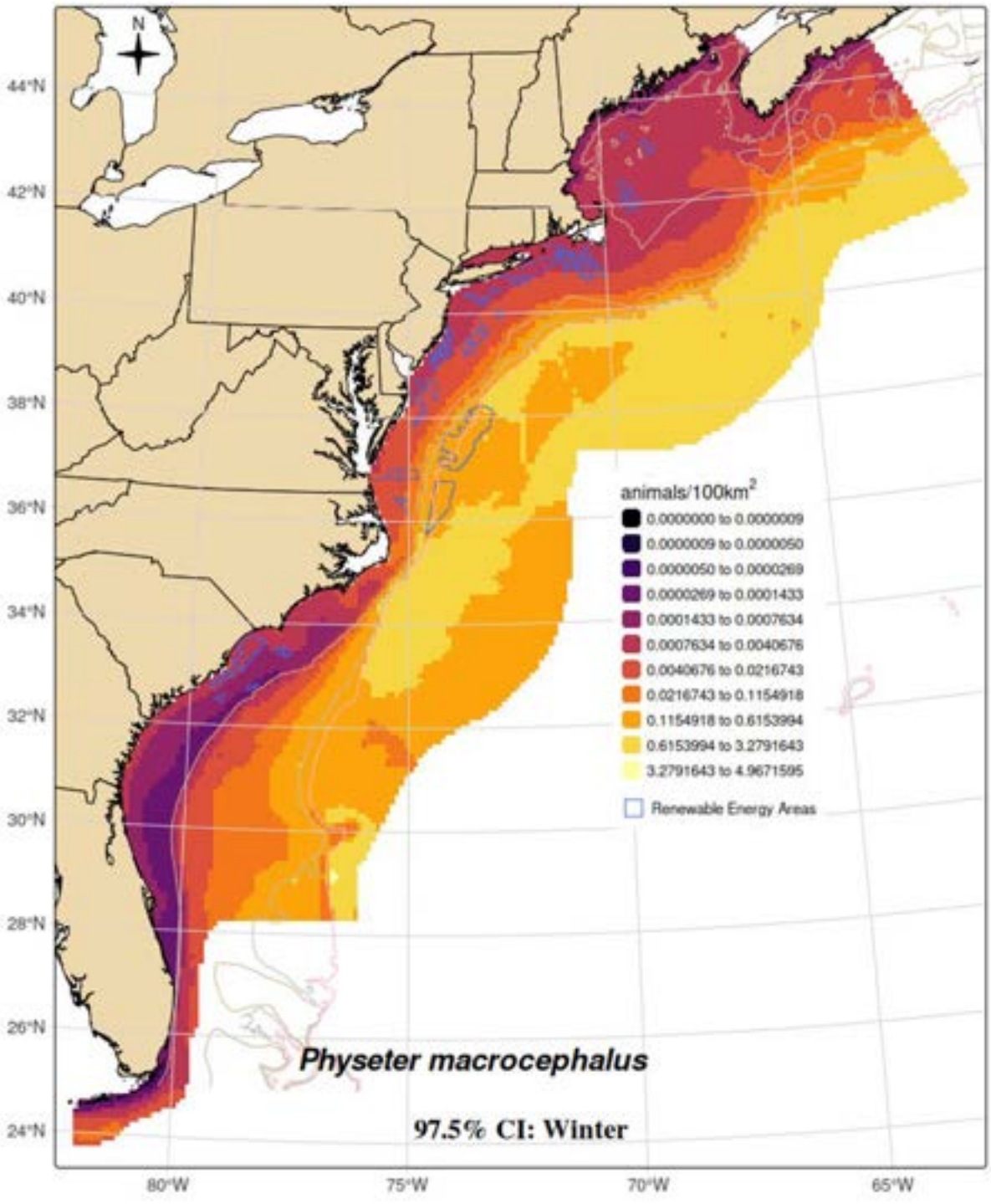

Figure B.6-20. Upper 97.5% confidence interval of the winter sperm whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

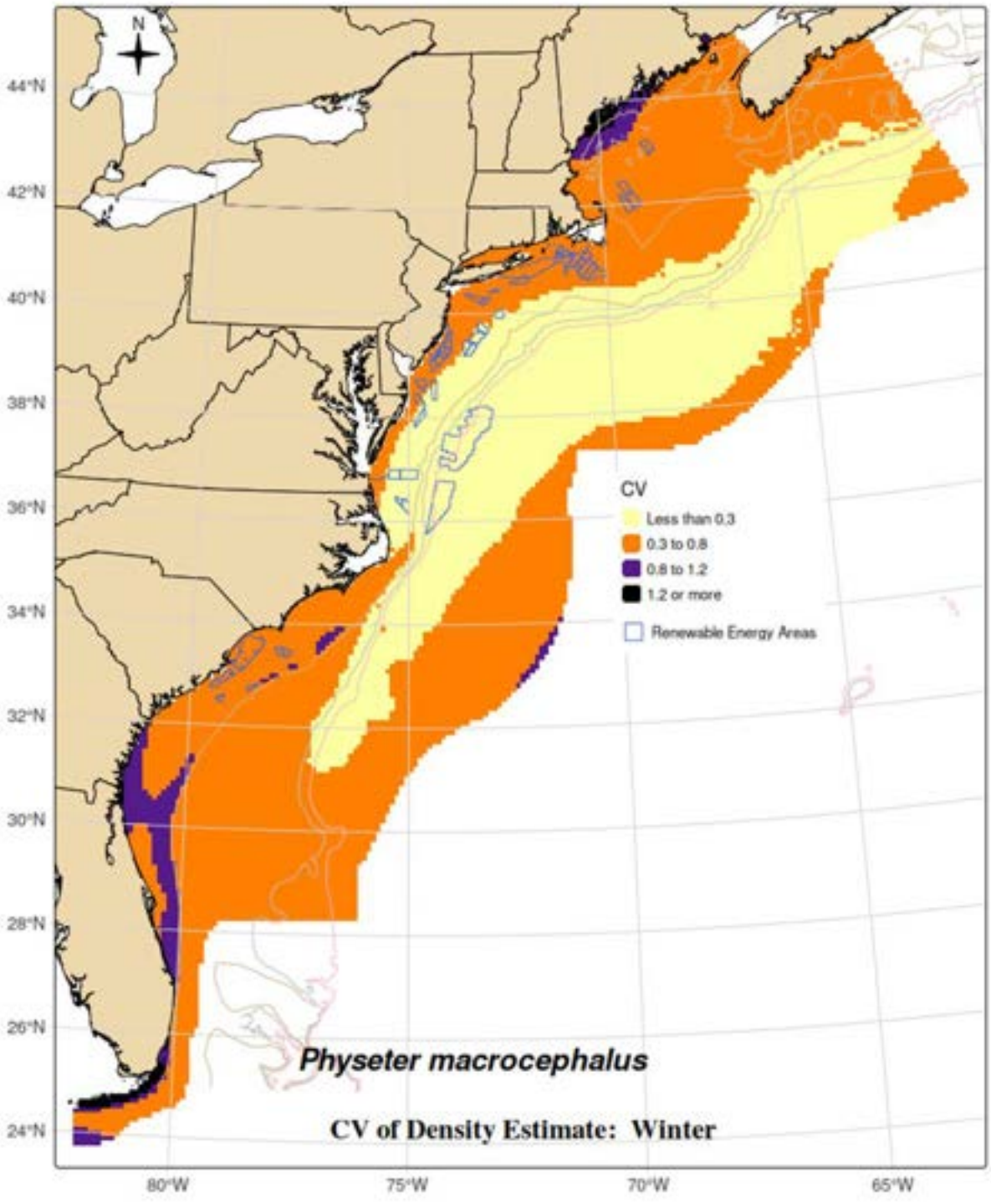

Figure B.6-21. CV of winter sperm whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.6.7 Offshore Energy Development Areas

Table B.6-6. Sperm whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	29.1	0.31	15.9 - 53.2
	NY	8.1	0.41	3.8 - 17.5
	NJ	5.3	0.42	2.4 - 11.6
	DE/MD	1.4	0.47	0.6 - 3.2
	VA	0.1	0.56	0 - 0.4
	NC	0.2	0.61	0.1 - 0.5
	NC/SC	0.2	1.17	0 – 1
	GA	0.0	1.62	0 - 0.2
	FL	0.0	1.56	0 - 0.3
Summer (Jun-Aug)	RI/MA	53.1	0.31	29.3 - 96.2
	NY	15.2	0.45	6.6 – 35
	NJ	5.5	0.51	2.1 - 14.1
	DE/MD	1.2	0.57	0.4 - 3.3
	VA	0.1	0.58	0 - 0.2
	NC	0.1	0.64	0 - 0.4
	NC/SC	0.0	0.95	0 - 0.2
	GA	0.0	1.92	0 – 0
	FL	0.0	1.56	0 - 0.4
Fall (Sep-Nov)	RI/MA	25.0	0.32	13.7 - 45.8
	NY	5.6	0.43	2.5 - 12.5
	NJ	3.1	0.49	1.2 - 7.6
	DE/MD	0.7	0.54	0.3 - 1.9
	VA	0.1	0.62	0 - 0.2
	NC	0.1	0.68	0 - 0.3
	NC/SC	0.0	0.88	0 - 0.1
	GA	0.0	1.05	0 – 0
	FL	0.0	1.56	0 - 0.3
Winter (Dec-Feb)	RI/MA	15.7	0.33	8.3 - 29.5
	NY	4.1	0.39	2 - 8.6
	NJ	2.7	0.43	1.2 - 6.1
	DE/MD	0.8	0.47	0.3 – 2
	VA	0.1	0.56	0 - 0.3
	NC	0.1	0.61	0 - 0.4
	NC/SC	0.1	0.89	0 - 0.6
	GA	0.0	1.05	0 - 0.1
	FL	0.0	1.56	0 - 0.3

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

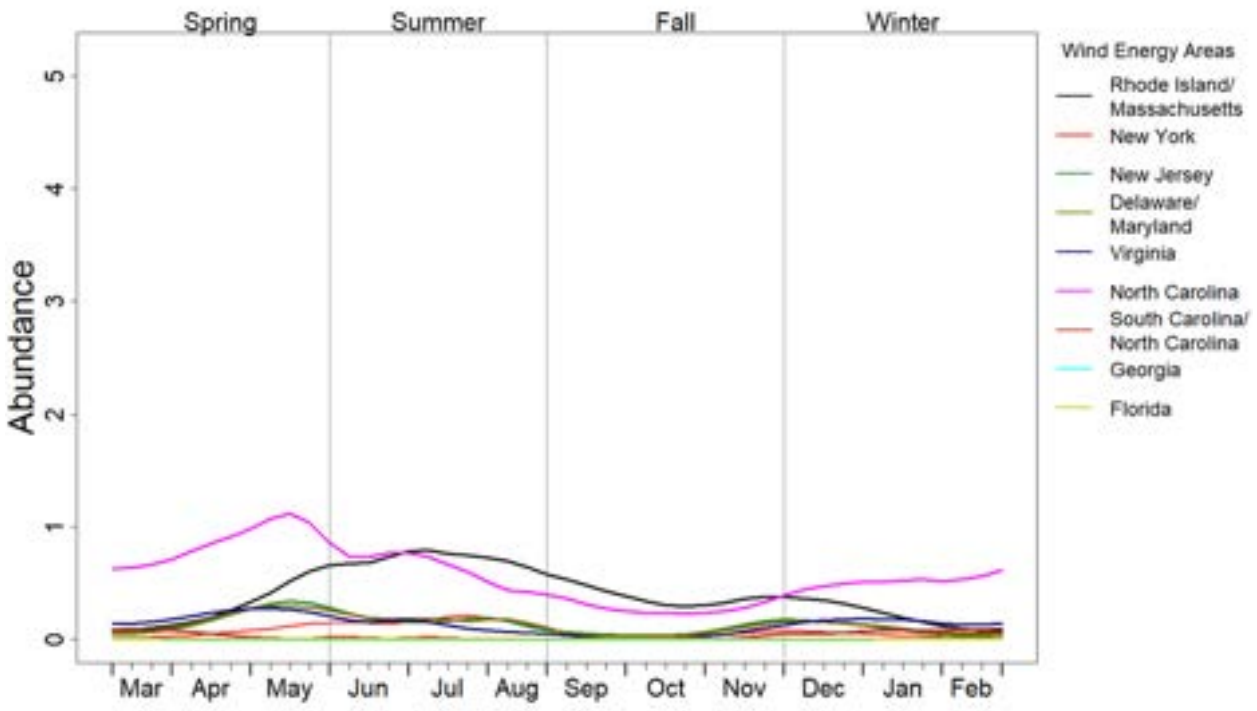

Figure B.6-22. Average seasonal abundance of sperm whales in the wind-energy study areas

B.7 Goose-beaked Whale (*Ziphius cavirostris*)

Figure B.7-1. Goose-beaked whale
Image collected under MMPA research permit #779-1633. Credit:NOAA/SEFSC.

B.7.1 Data Collection

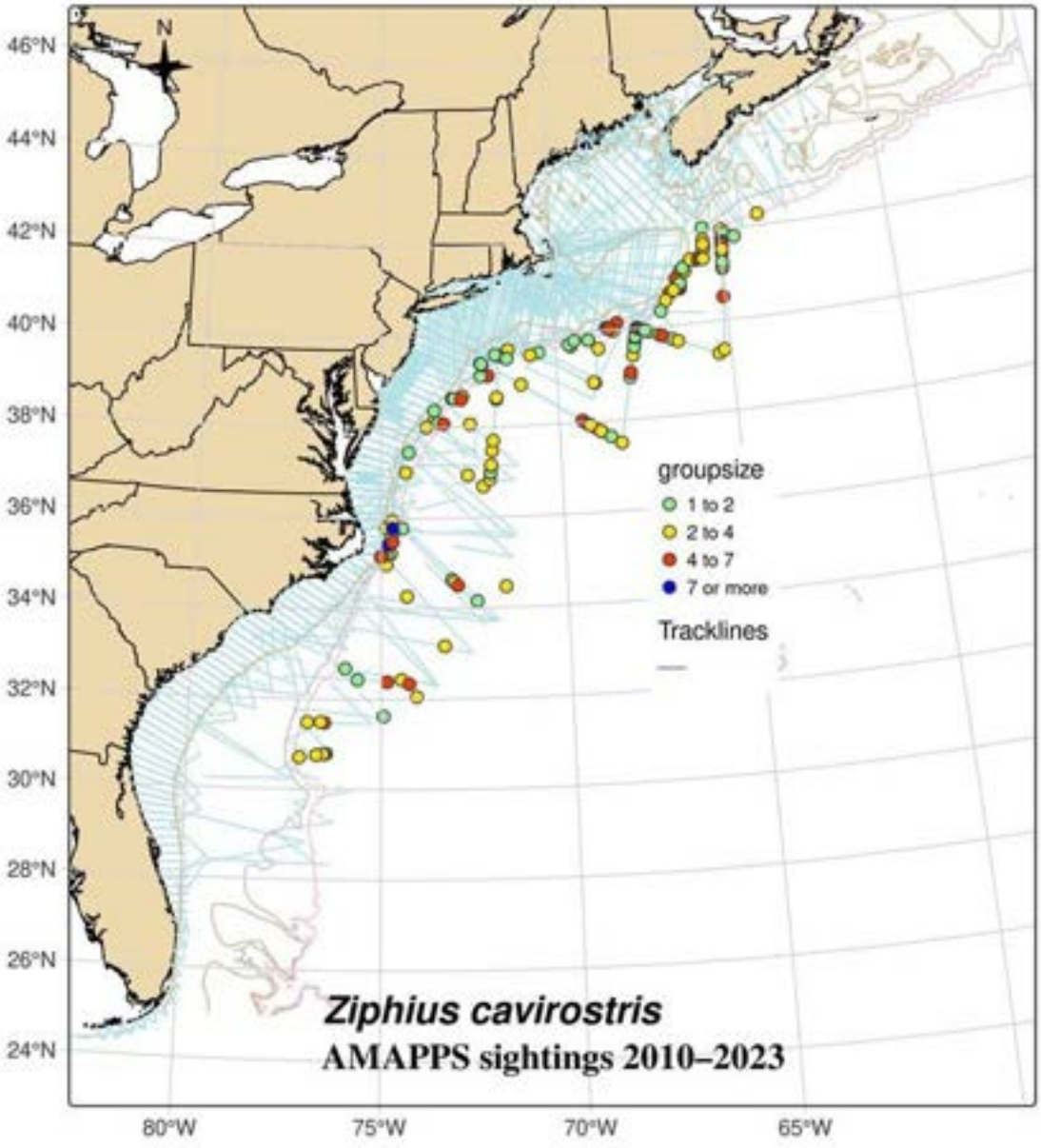

Figure B.7-2. Distribution of track lines and goose-beaked whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.7-1. AMAPPS research effort 2010 to 2017 and goose-beaked whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	16	21
NE Shipboard	Summer	49,064	288	789
NE Aerial	Spring	38,839	5	11
NE Aerial	Summer	52,003	4	8
NE Aerial	Fall	87,311	2	6
NE Aerial	Winter	24,747	0	0
SE Shipboard	Spring	2,604	2	4
SE Shipboard	Summer	18,331	52	131
SE Shipboard	Fall	2,673	7	12
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	6	22
SE Aerial	Summer	43,285	1	2
SE Aerial	Fall	21,153	0	0
SE Aerial	Winter	19,152	0	0

B.7.2 Mark-Recapture Distance Sampling Analysis

Table B.7-2. Intermediate parameters in goose-beaked whale mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15	0.89
NE–aerial group 2	distance * observer + log(group size) + sea state	380	distance + sea state + glare	600	HR	0.75	0.07	0.06	0.70
NE–shipboard group 6	distance * observer + log(group size) + sea state	3900	distance + glare + time of day	3900	HR	0.37	0.13	0.14	0.81
SE–shipboard group 4	distance * observer + log(group size)	5000	Distance + log(group size)	5000	HR	0.35	0.29	0.28	0.91

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

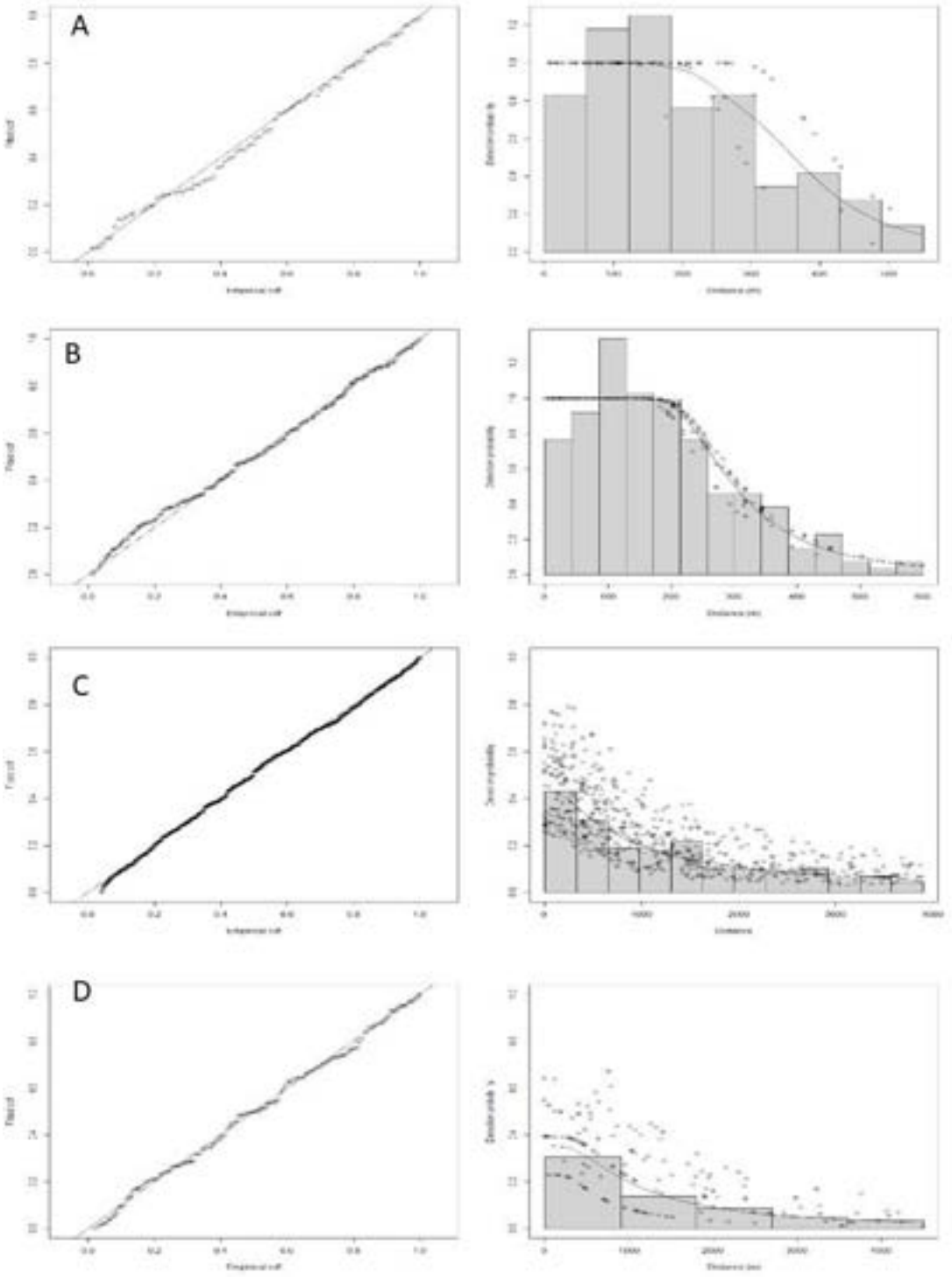

Figure B.7-3. Q-Q plots and detection functions from the goose-beaked whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 2; C) NE-shipboard analysis set 6; D) SE-shipboard analysis set 4.

B.7.3 Generalized Additive Model Analysis

Table B.7-3. 2010 to 2023 density-habitat model output for goose-beaked whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(sstmur)	4.56	5	10.98	6.84	<0.0001
s(btemp)	0.00	5	0.00	0.01	0.3880
s(depth)	4.65	5	53.26	35.17	<0.0001
s(slope)	3.17	5	16.89	4.67	<0.0001
s(latdd)	1.30	5	7.65	7.11	<0.0001

Adjusted R^2 = 0.0511. Deviance explained = 53.8%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

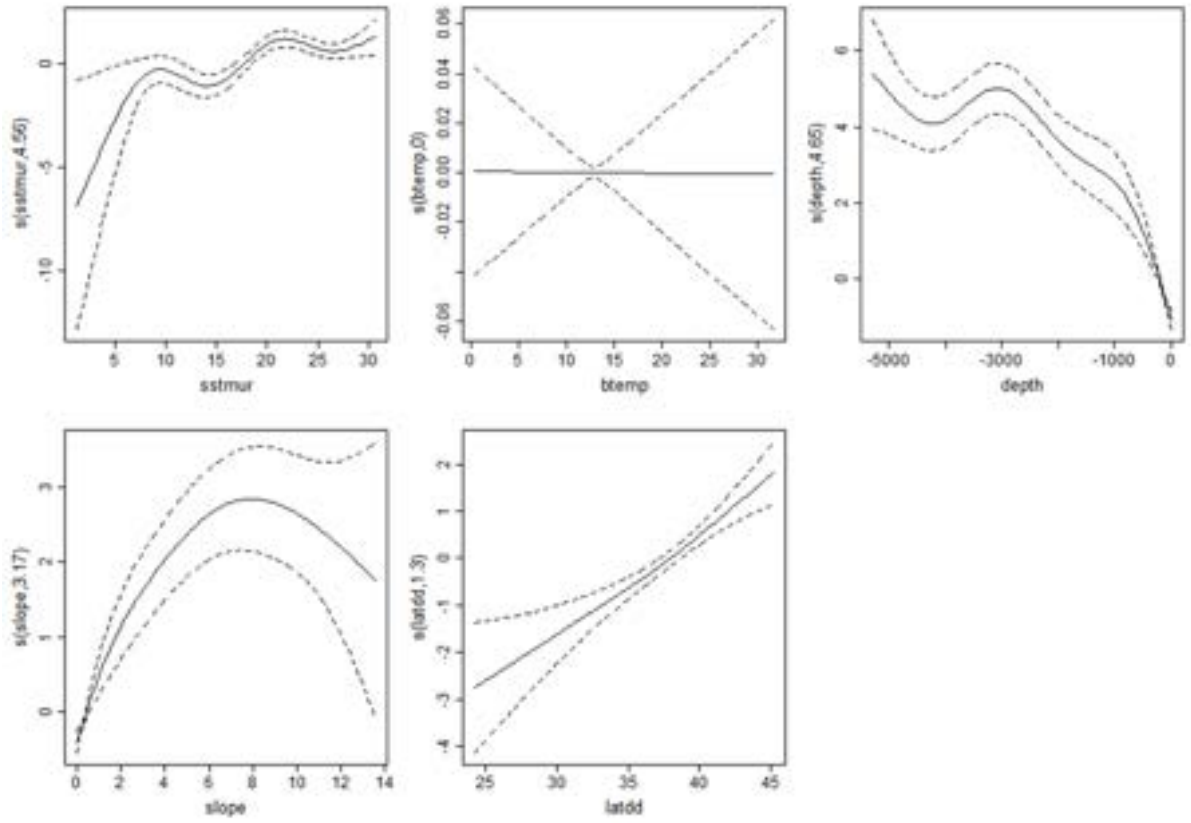

Figure B.7-4. Goose-beaked whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat mode. lCovariate abbreviations explained in main text in Table 4-2.

B.7.4 Model Cross-Validation

Table B.7-4. Diagnostic statistics from the goose-beaked whale density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
MAPE	Mean absolute percentage error	Non-zero density	90.6203	Fair to good
RHO	Spearman rank correlation	Non-zero density	0.291	Fair to good
MAPE	Mean absolute percentage error	All data divided in 25 random samples	88.416	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.129	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.002	Excellent

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.7.5 Abundance Estimates for AMAPPS Study Area

Table B.7-5. Goose-beaked whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	2,803	0.35	1,440 – 5,457
Summer (June–August)	5,177	0.25	3,195 – 8,388
Fall (September–November)	4,937	0.26	2,991 – 8,150
Winter (December–February)	2,742	0.35	1,408 – 5,339
Summer 2011 U.S. surveys[1]	6,532	0.32	4,364 − 9,777
Summer 2016 U.S. surveys[1]	5,744	0.36	3,678 − 8,971
Summer 2021 U.S. surveys[1]	4,670	0.24	2,937 – 7,426

[1]Hayes et al. 2024

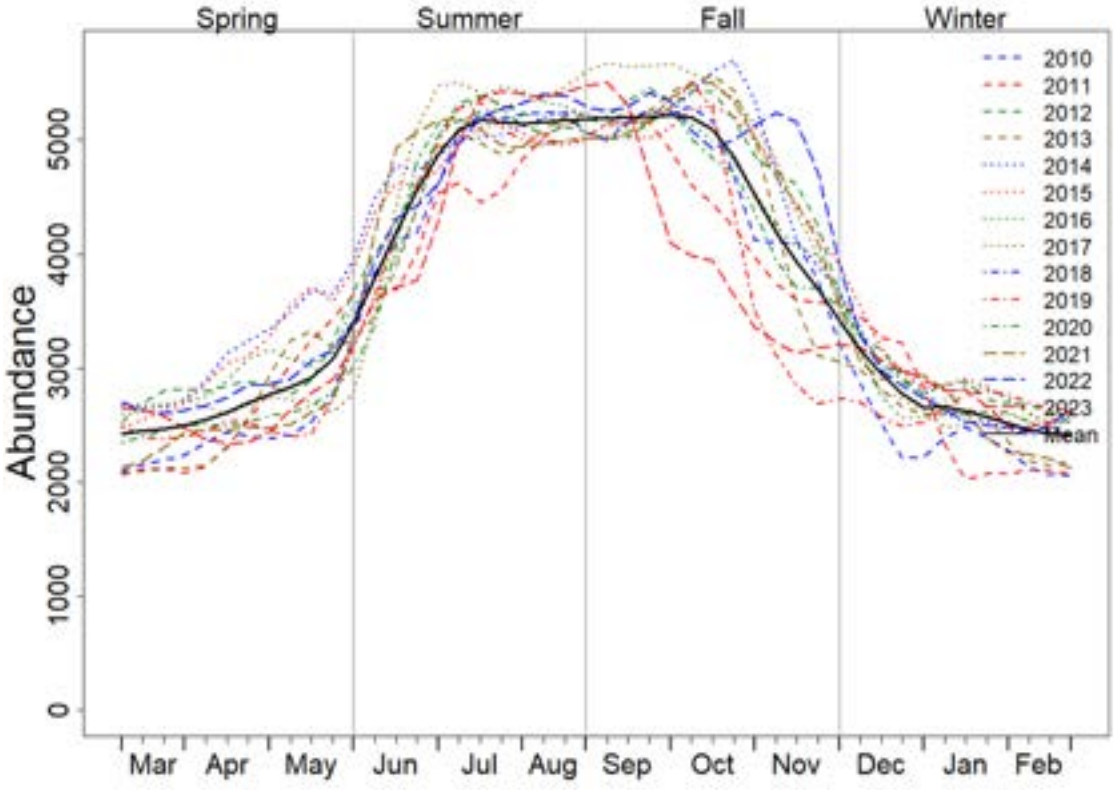

Figure B.7-5. Annual abundance trends for goose-beaked whales in the AMAPPS study area

B.7.6 Seasonal Prediction Maps

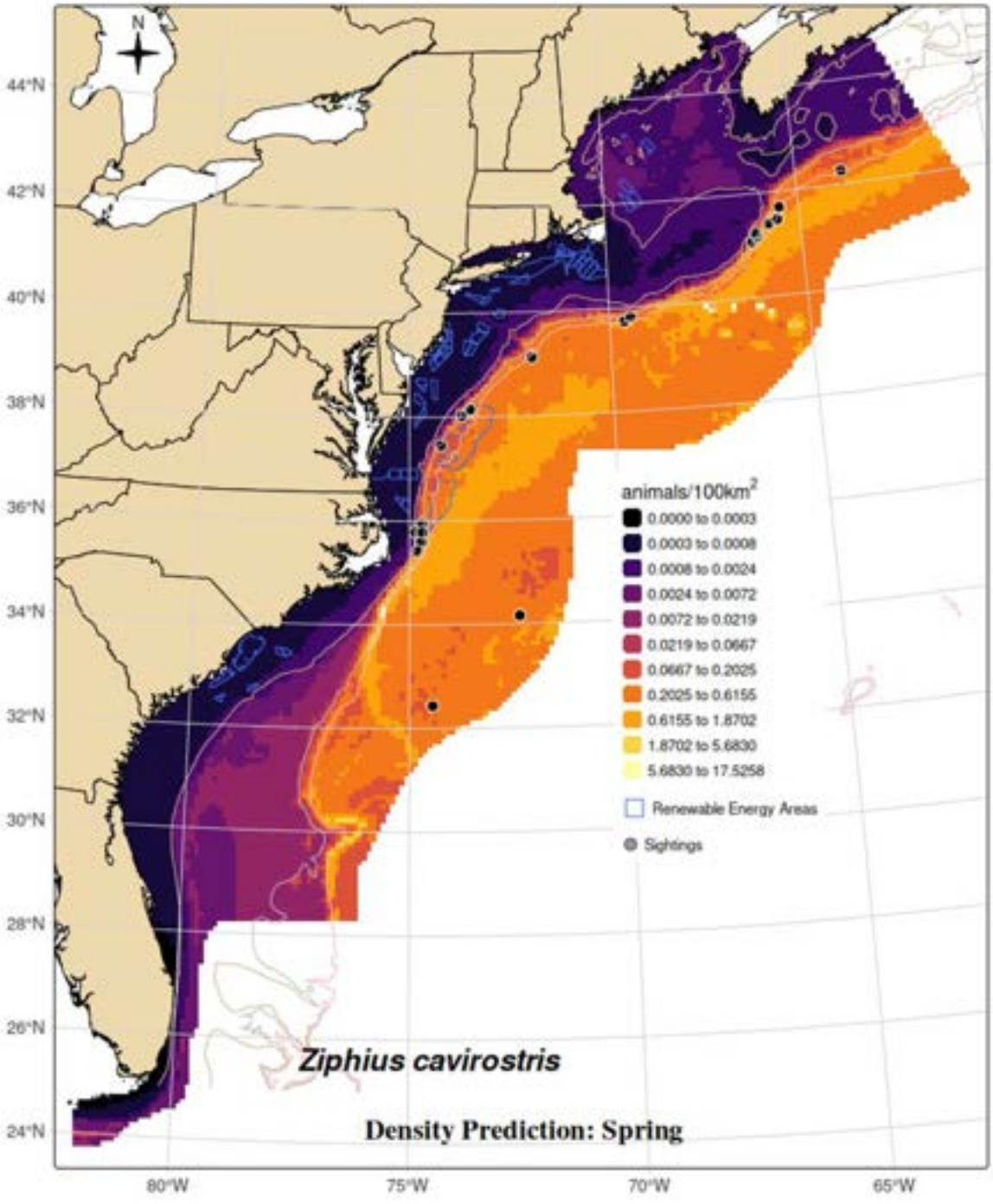

Figure B.7-6. Goose-beaked whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

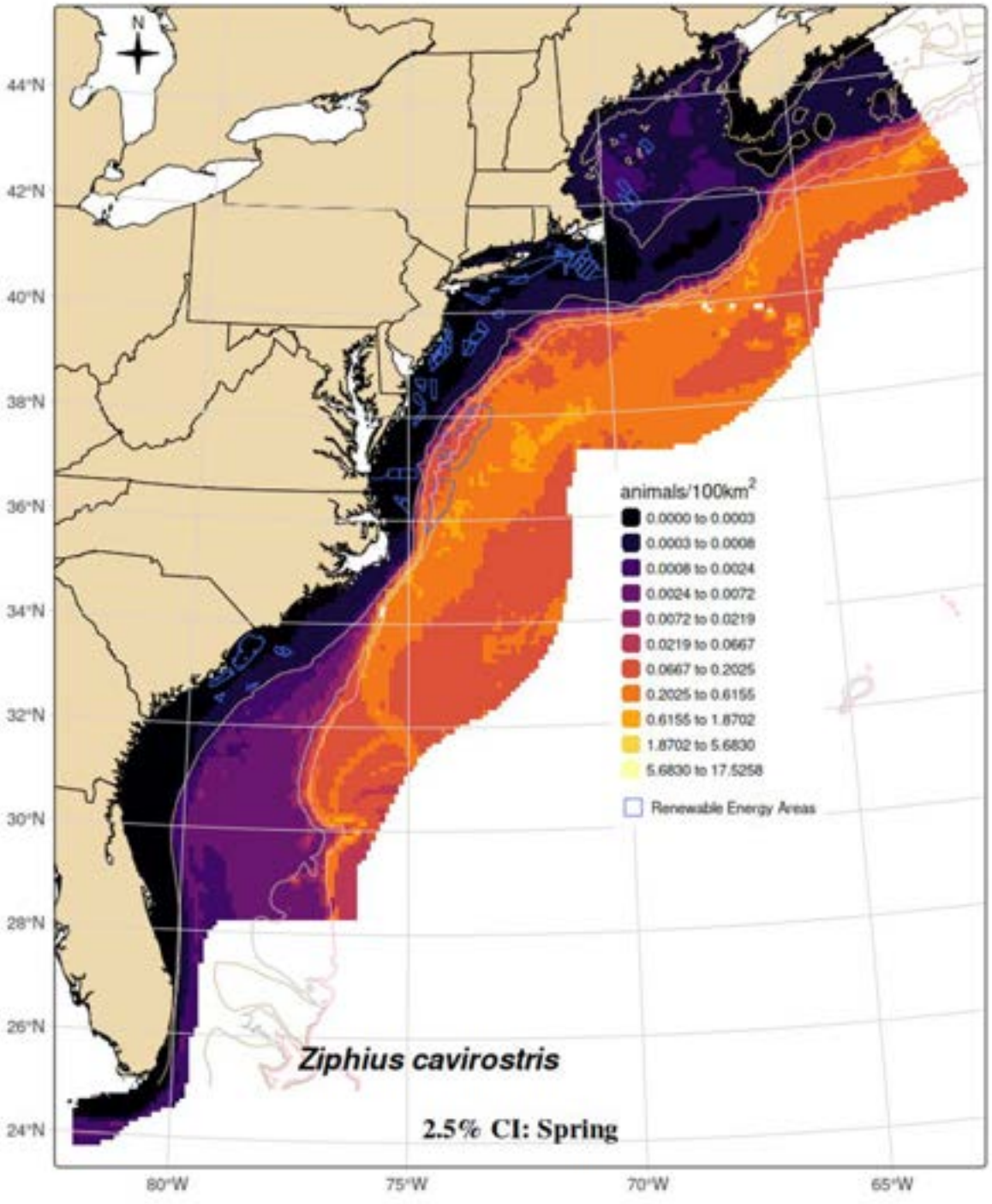

Figure B.7-7. Lower 2.5% confidence interval of the spring goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

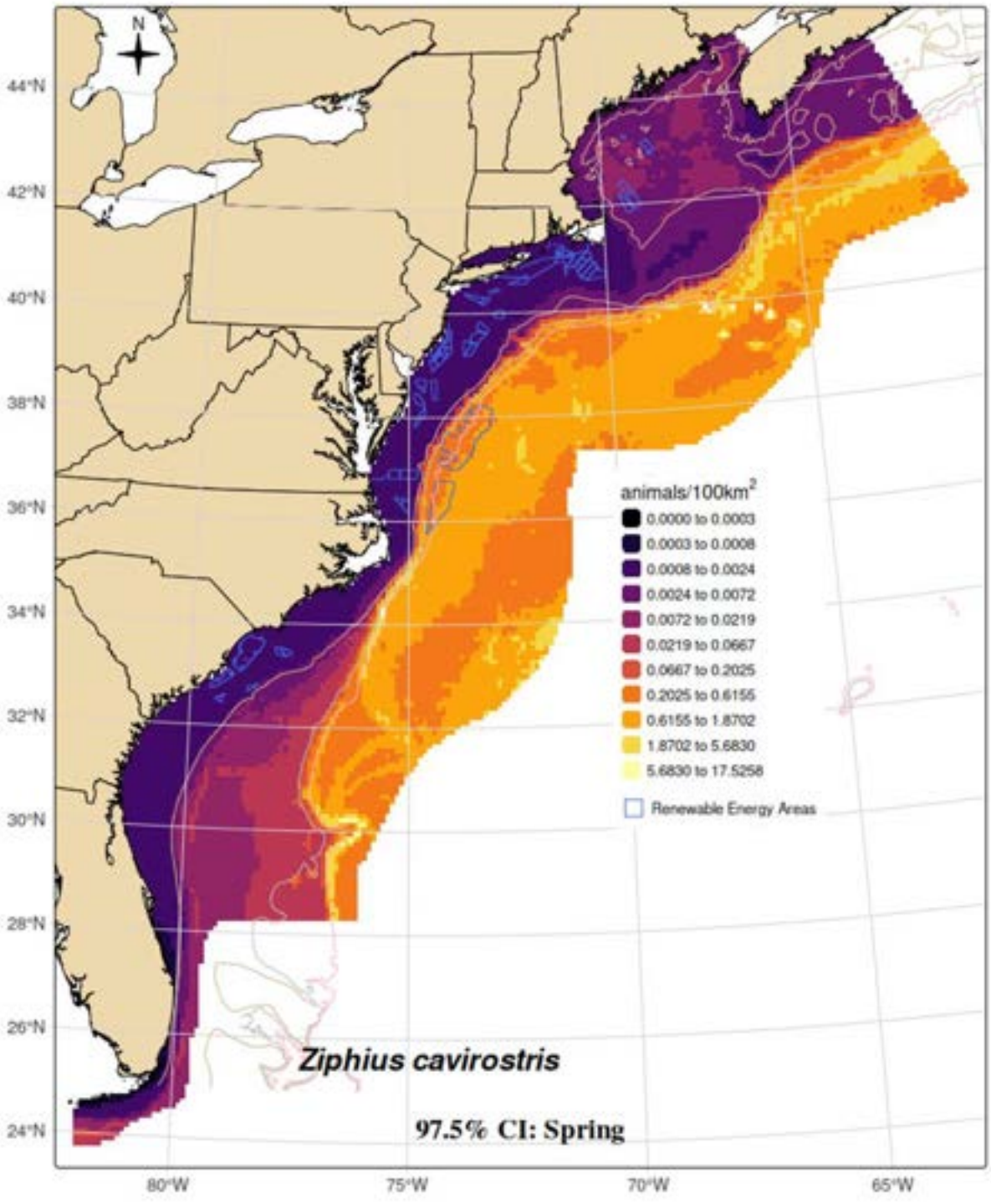

Figure B.7-8. Upper 97.5% confidence interval of the spring goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

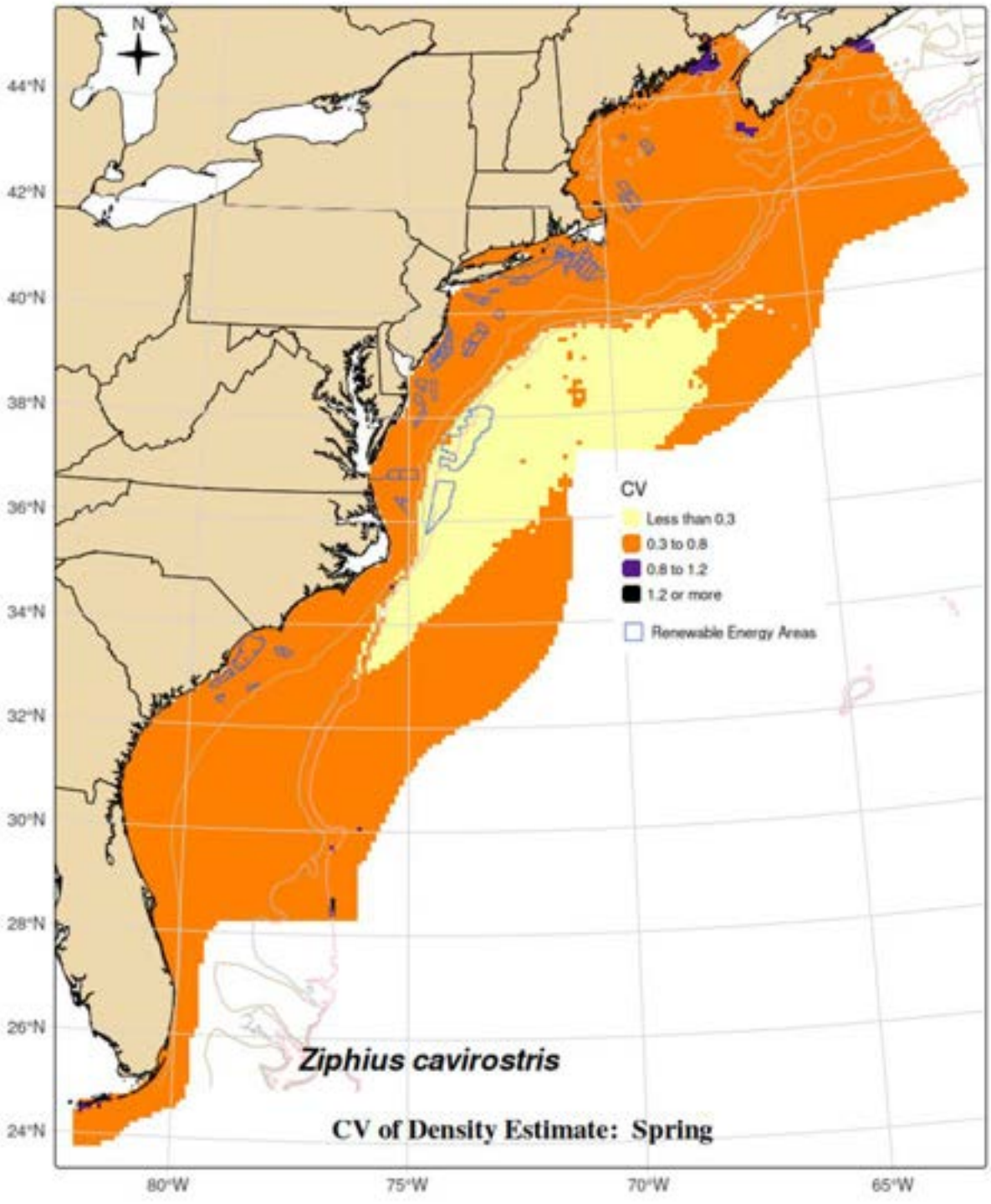

Figure B.7-9. CV of spring goose-beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

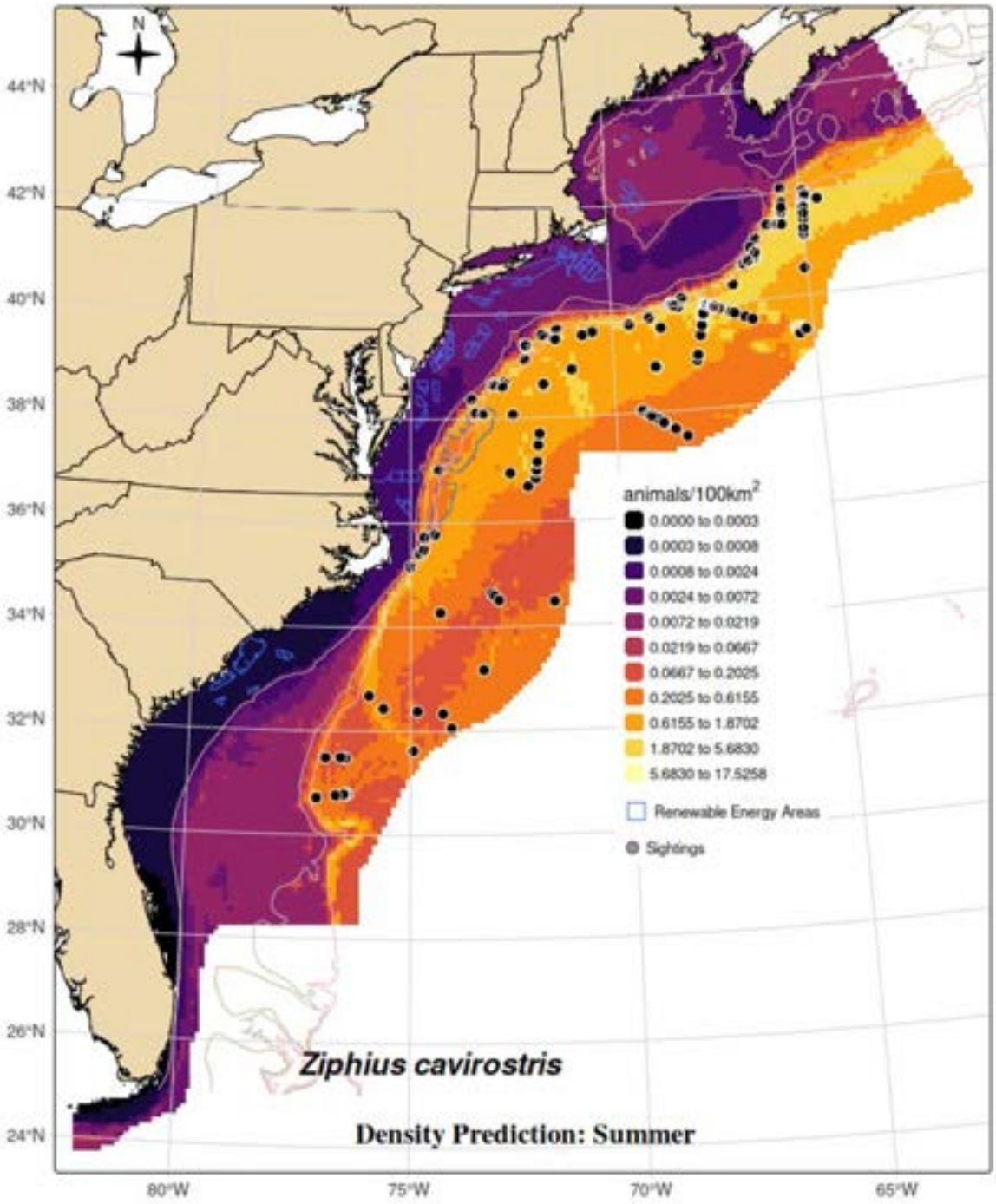

Figure B.7-10. Goose-beaked whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. White circles indicate locations of passive acoustic detections of Cuvier's beaked whales from the NEFSC and SEFSC 2013 and 2016 towed hydrophone arrays. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

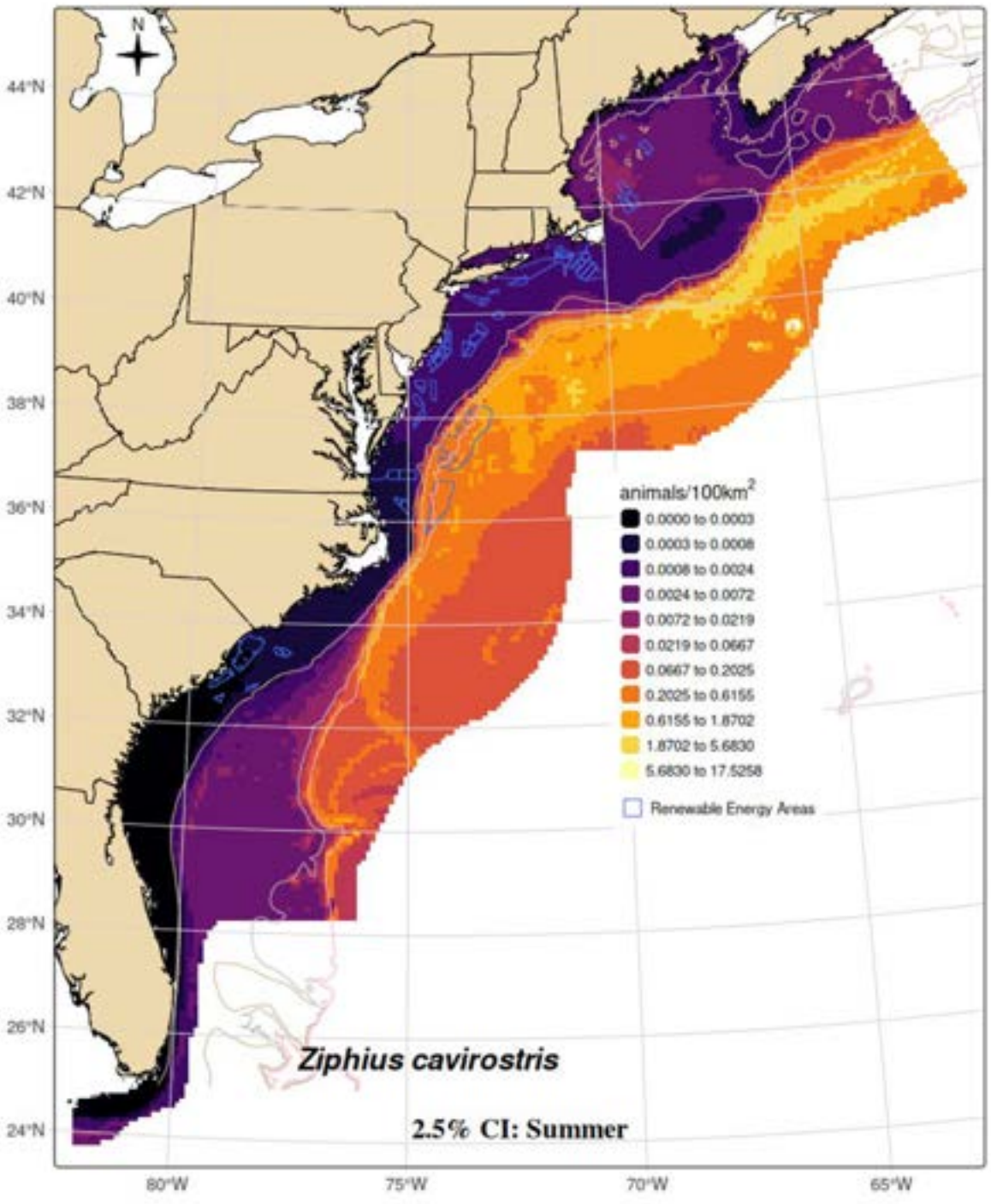

Figure B.7-11. Lower 2.5% confidence interval of summer goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

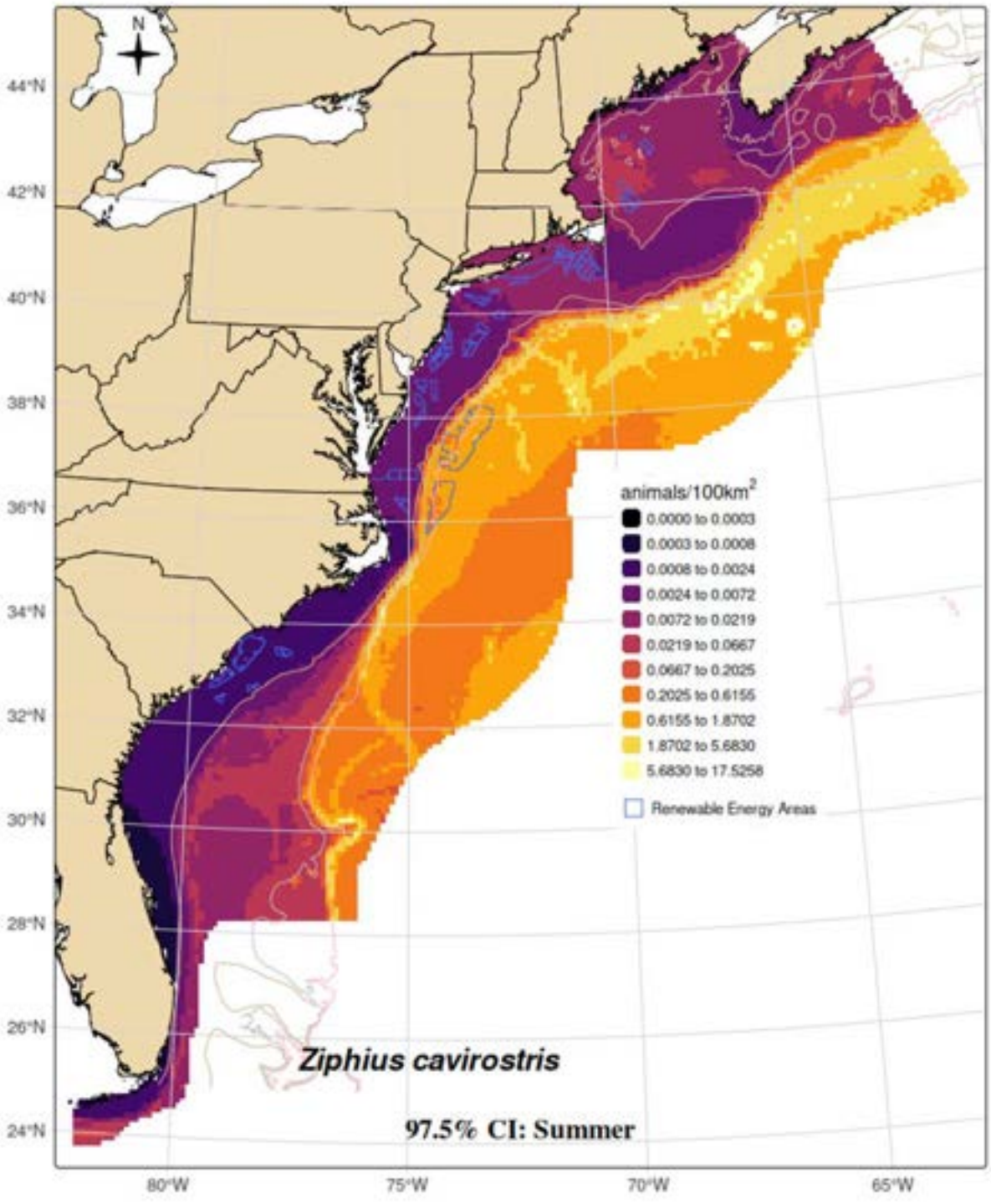

Figure B.7-12. Upper 97.5% confidence interval of summer goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

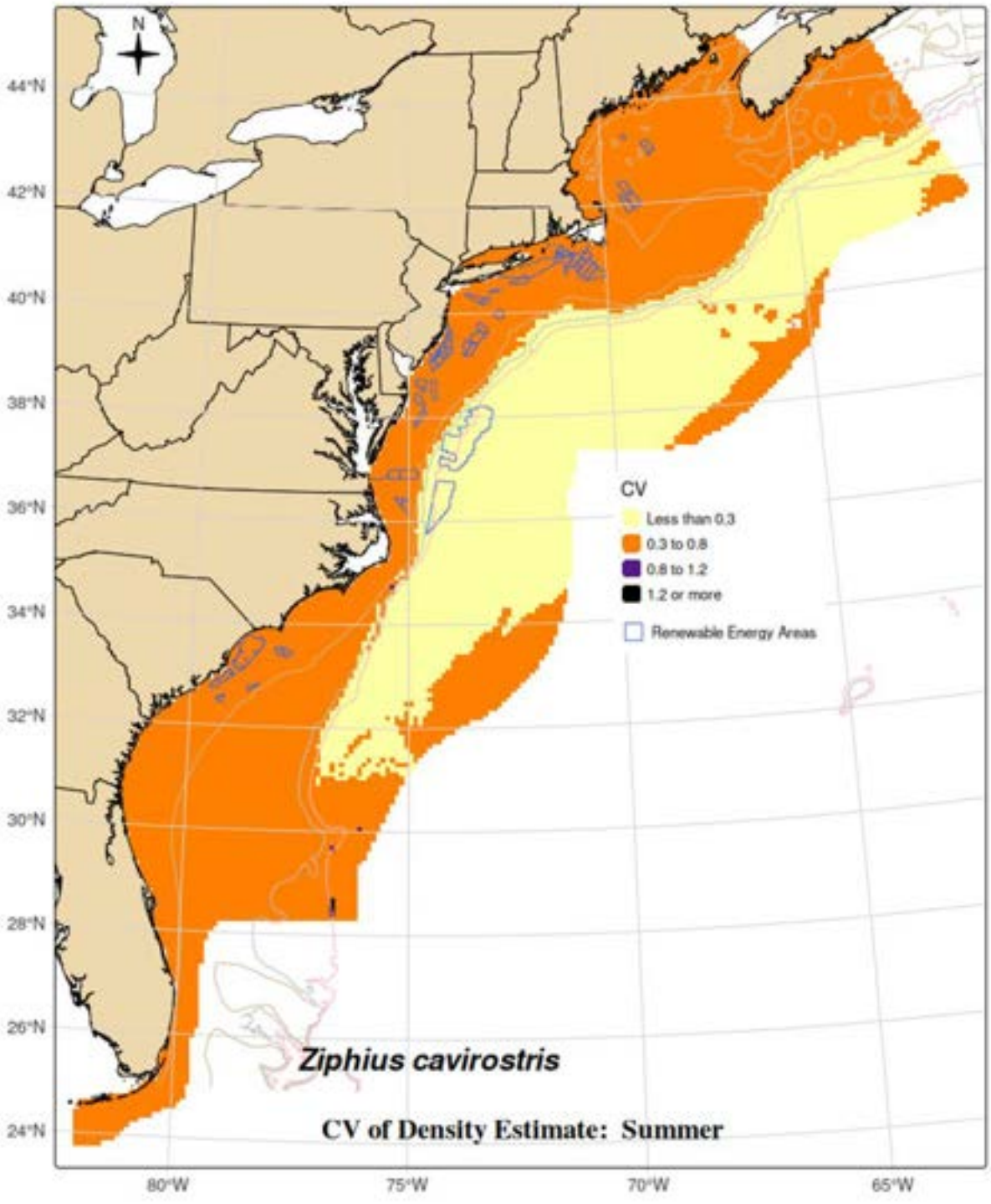

Figure B.7-13. CV of summer goose-beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

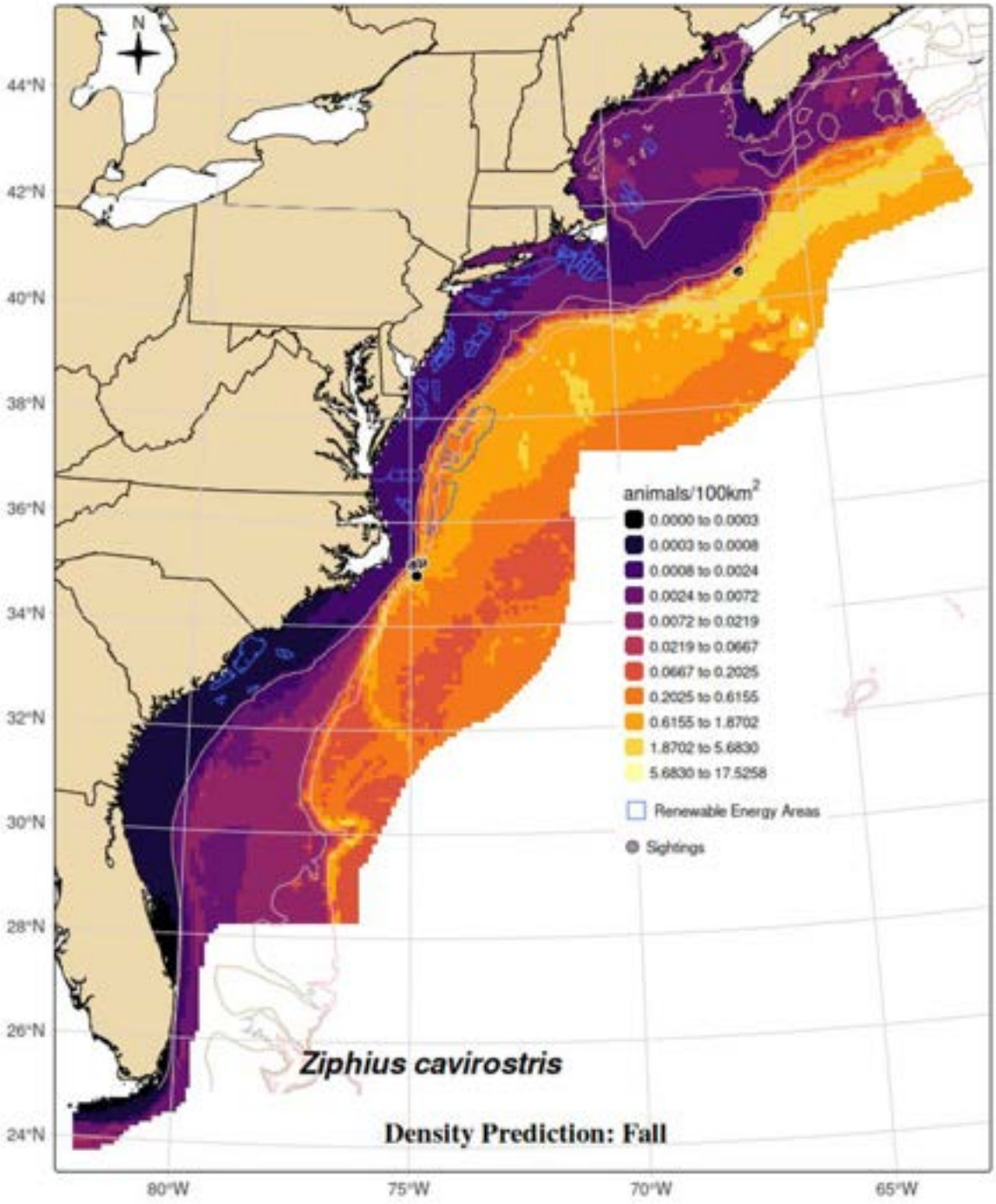

Figure B.7-14. Goose-beaked whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

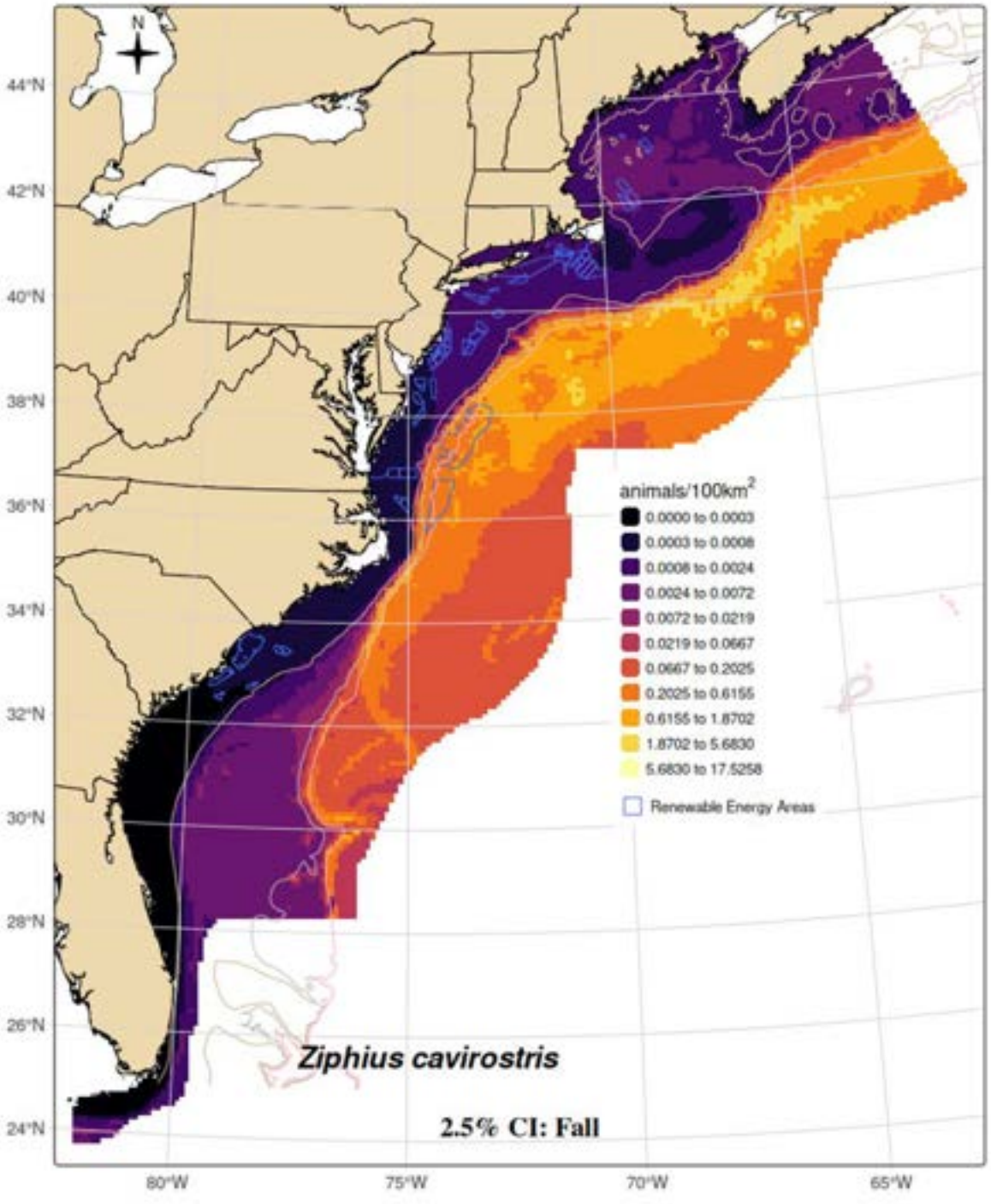

Figure B.7-15. Lower 2.5% confidence interval of the fall goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

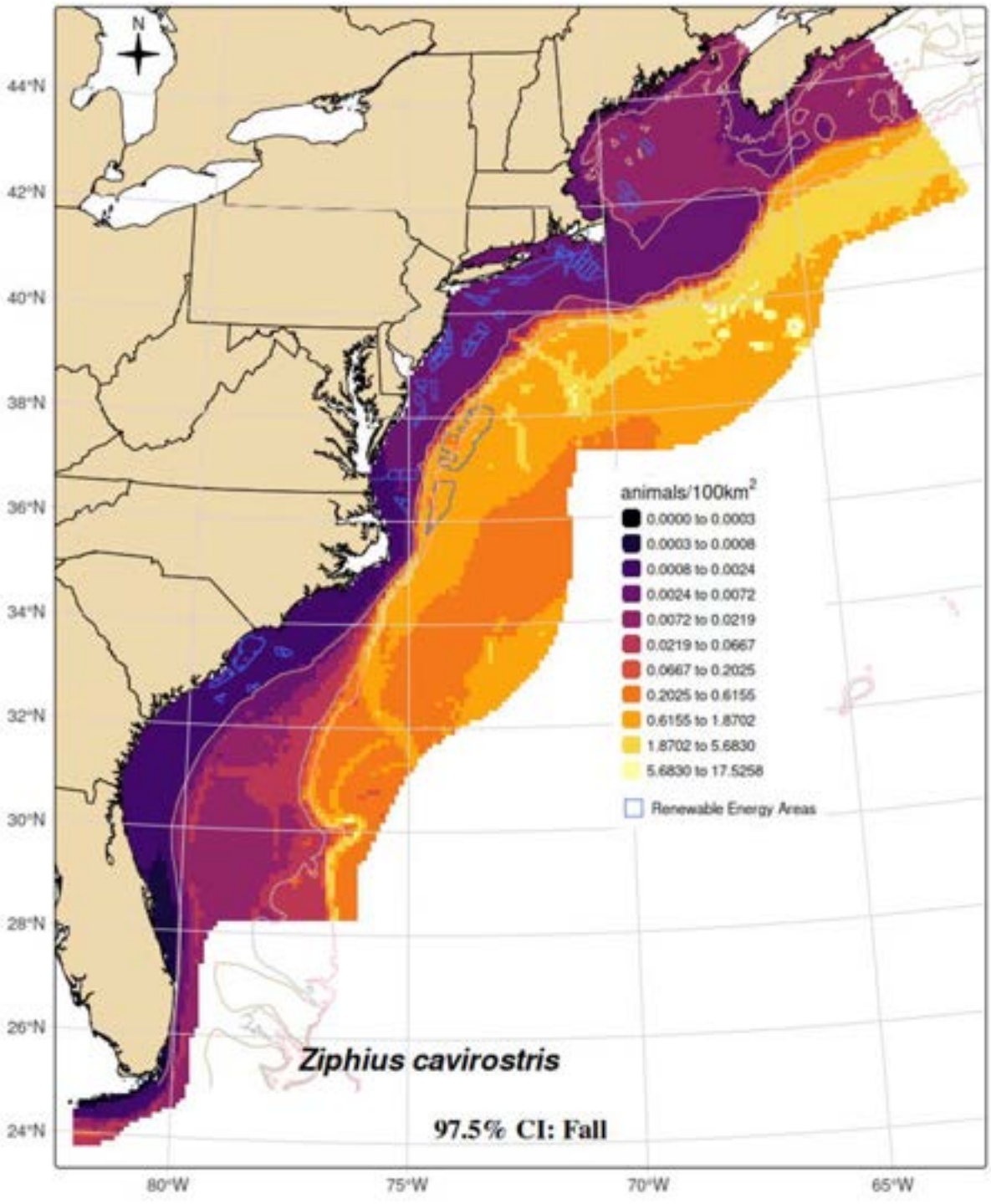

Figure B.7-16. Upper 97.5% confidence interval of the fall goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

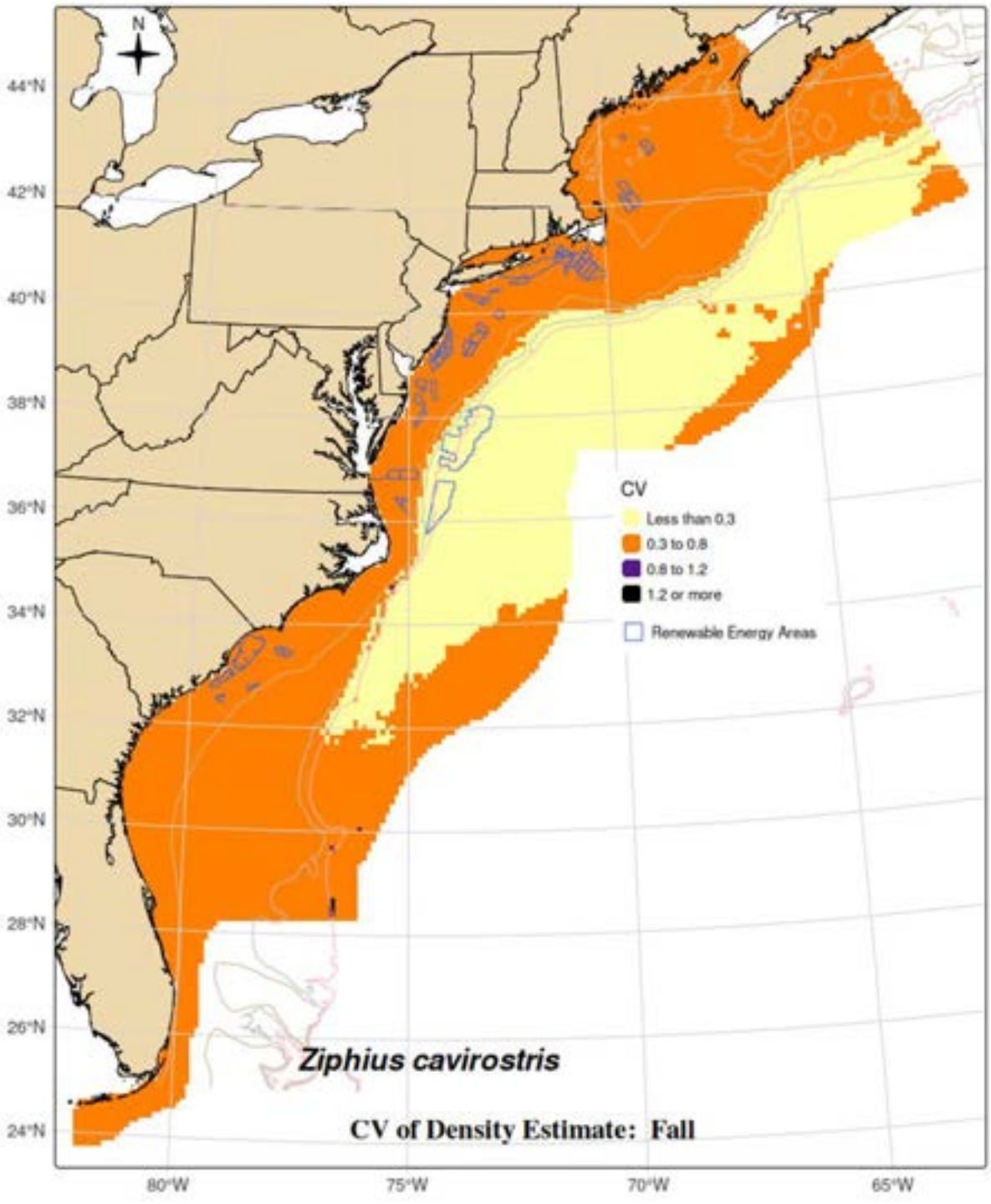

Figure B.7-17. CV of fall goose-beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

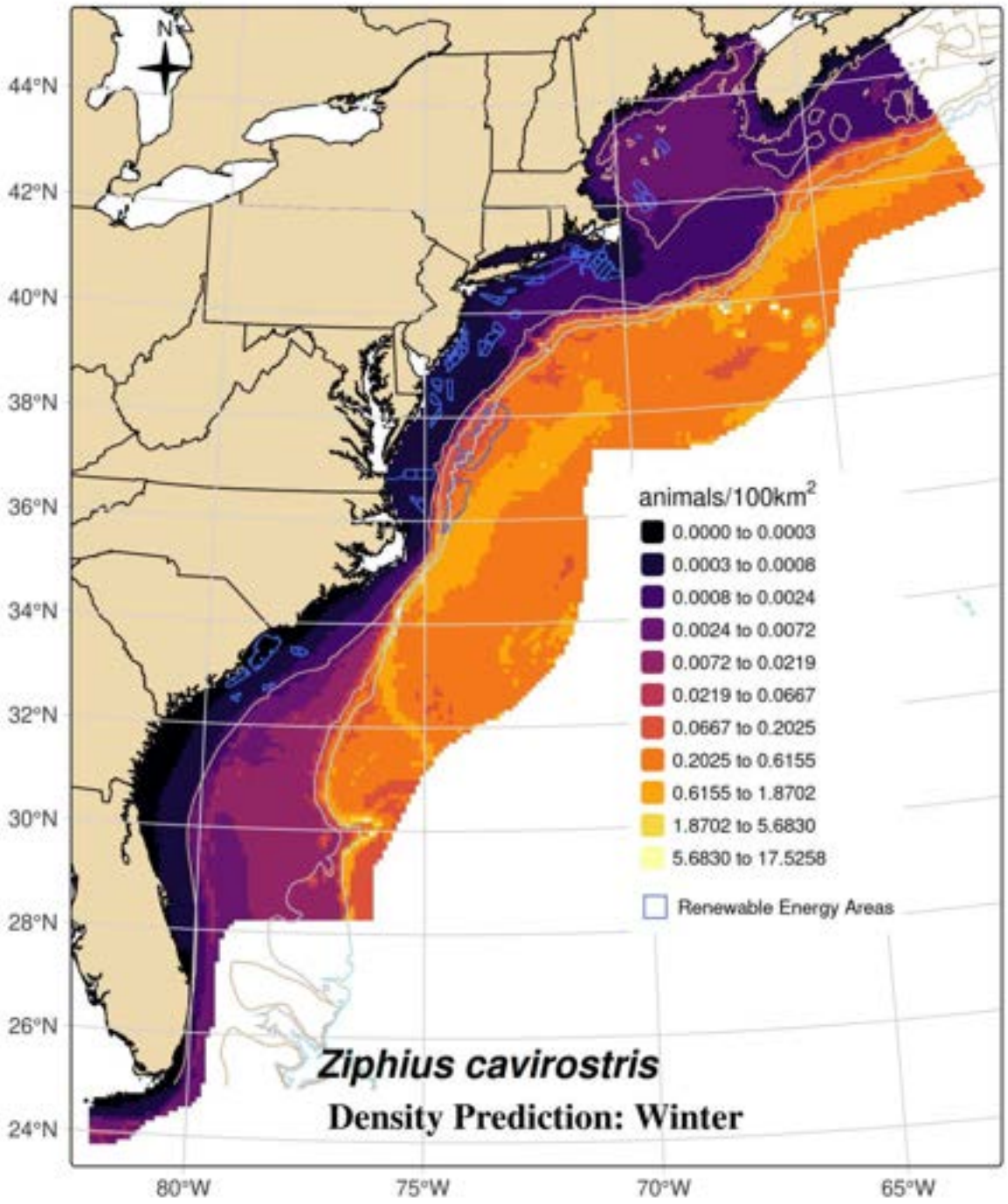

Figure B.7-18. Goose-beaked whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

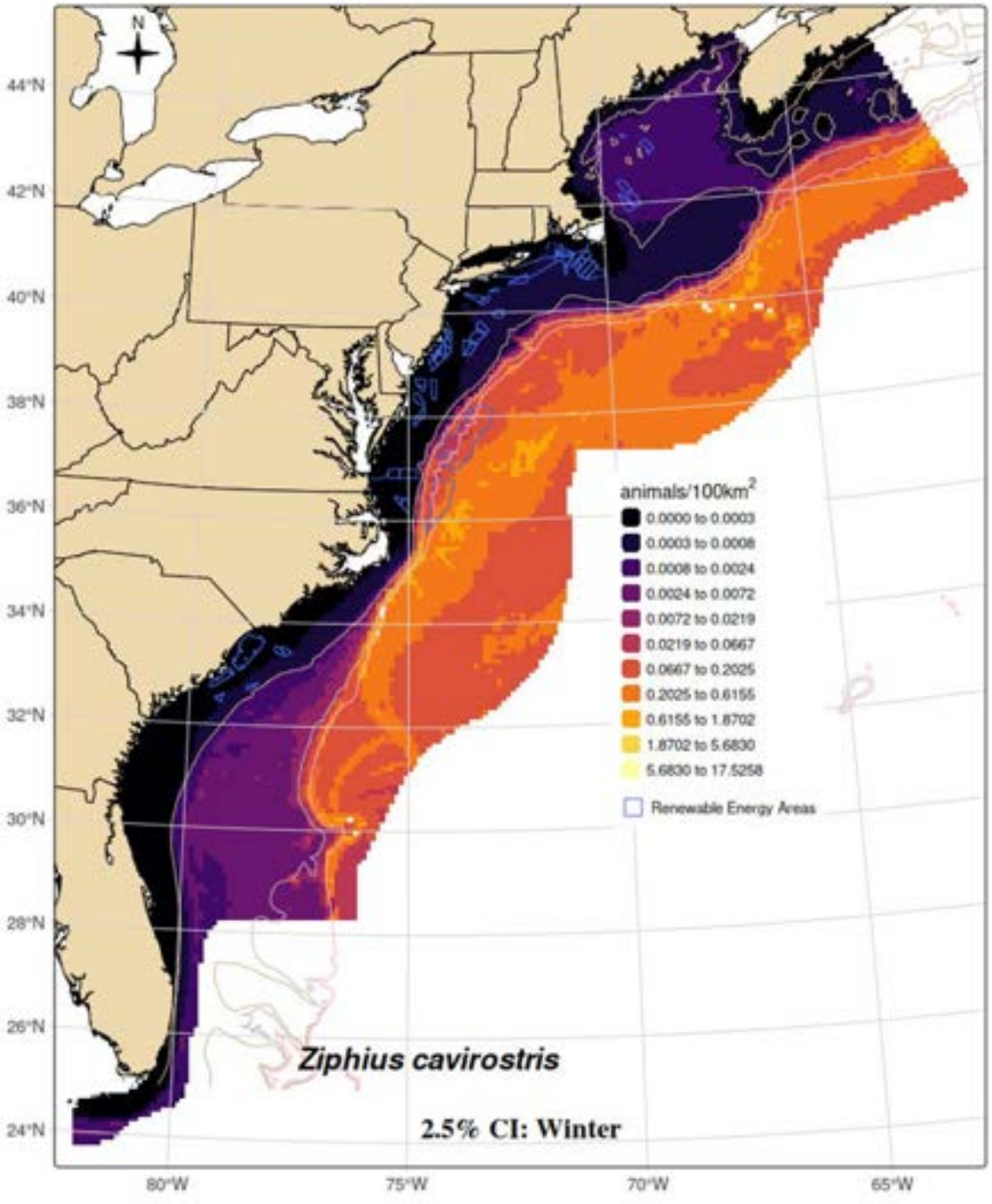

Figure B.7-19. Lower 2.5% confidence interval of the winter goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

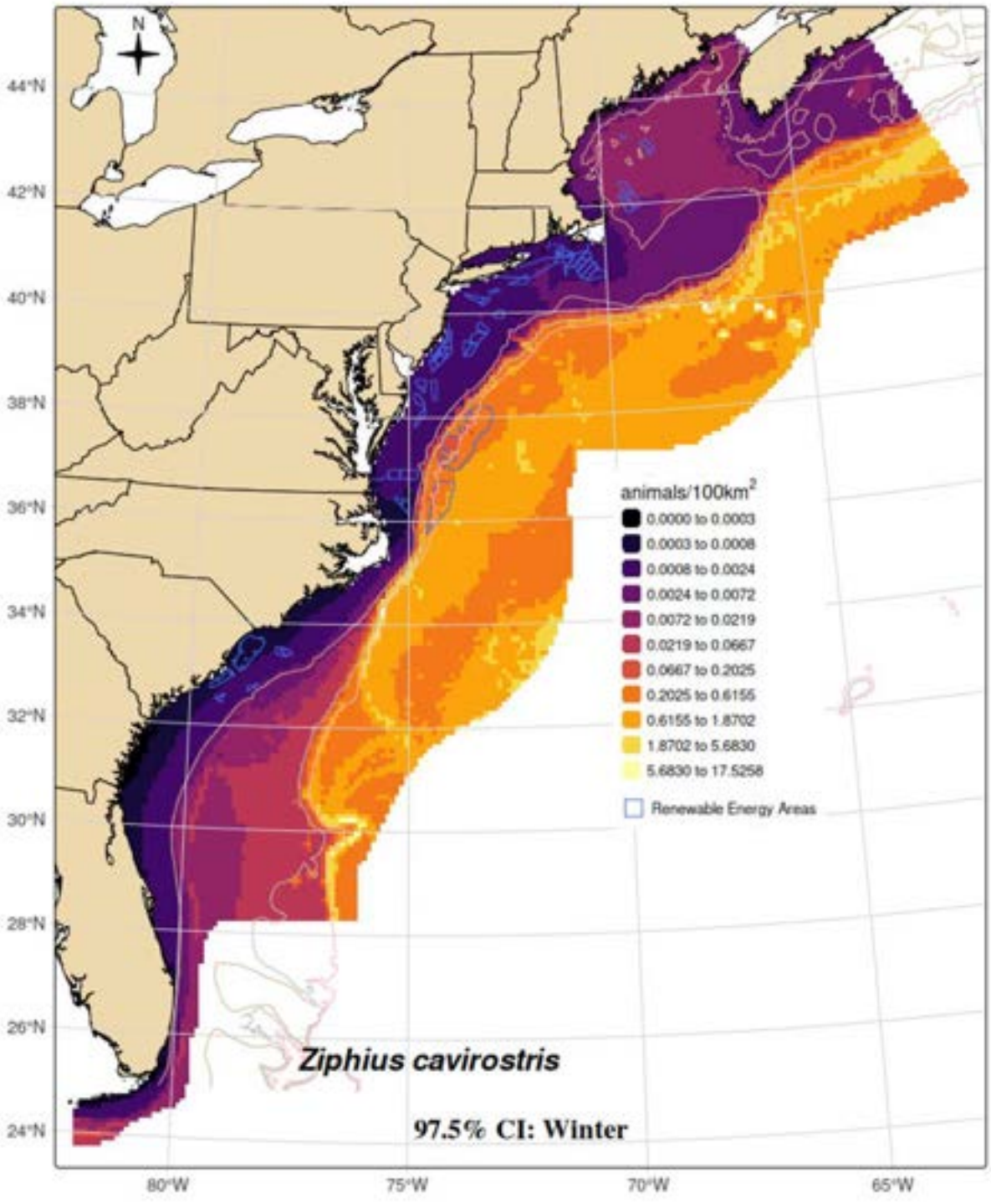

Figure B.7-20. Upper 97.5% confidence interval of winter goose-beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

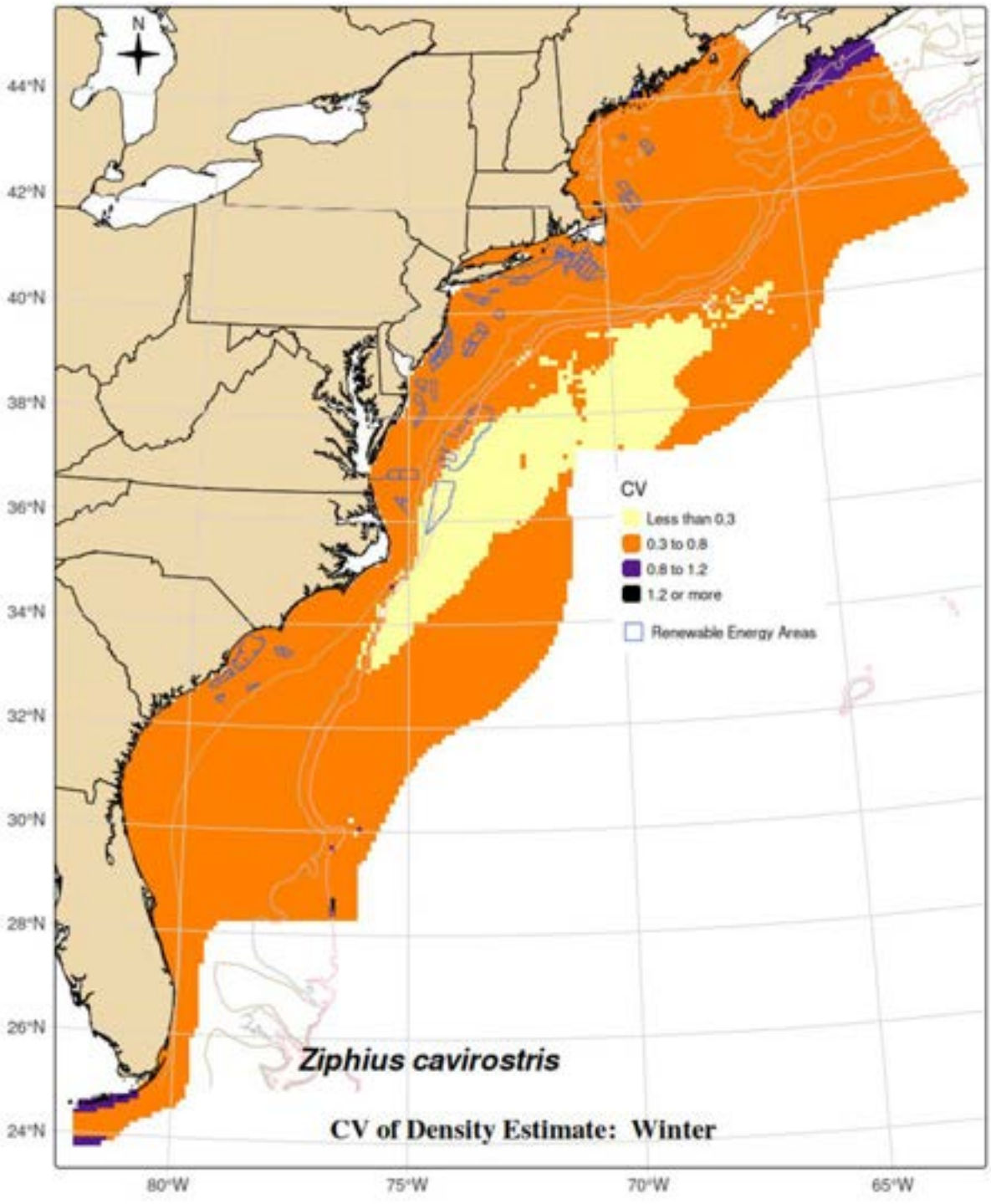

Figure B.7-21. CV of summer goose-beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.7.7 Offshore Energy Development Areas

Table B.7-6. Goose-beaked whale abundance estimates for wind energy areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	0.1	0.58	0 - 0.2
	NY	0.0	0.55	0 – 0
	NJ	0.0	0.53	0 - 0.1
	DE/MD	0.0	0.52	0 – 0
	VA	0.0	0.47	0 – 0
	NC	0.0	0.43	0 - 0.1
	NC/SC	0.1	0.45	0 - 0.2
	GA	0.0	0.49	0 – 0
	FL	0.0	0.64	0 - 0.1
Summer (Jun-Aug)	RI/MA	0.4	0.37	0.2 - 0.8
	NY	0.1	0.37	0.1 - 0.2
	NJ	0.1	0.38	0.1 - 0.3
	DE/MD	0.1	0.38	0 - 0.2
	VA	0.0	0.39	0 - 0.1
	NC	0.1	0.38	0 - 0.1
	NC/SC	0.1	0.42	0 - 0.2
	GA	0.0	0.45	0 – 0
	FL	0.0	0.60	0 - 0.1
Fall (Sep-Nov)	RI/MA	0.2	0.38	0.1 - 0.5
	NY	0.1	0.38	0 - 0.1
	NJ	0.1	0.39	0 - 0.2
	DE/MD	0.1	0.39	0 - 0.1
	VA	0.0	0.40	0 - 0.1
	NC	0.1	0.39	0 - 0.1
	NC/SC	0.1	0.43	0 - 0.2
	GA	0.0	0.47	0 – 0
	FL	0.0	0.60	0 - 0.1
Winter (Dec-Feb)	RI/MA	0.1	0.58	0 - 0.2
	NY	0.0	0.58	0 - 0.1
	NJ	0.0	0.60	0 - 0.1
	DE/MD	0.0	0.58	0 – 0
	VA	0.0	0.52	0 – 0
	NC	0.0	0.46	0 – 0
	NC/SC	0.1	0.46	0 - 0.2
	GA	0.0	0.53	0 – 0
	FL	0.0	0.66	0 - 0.1

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

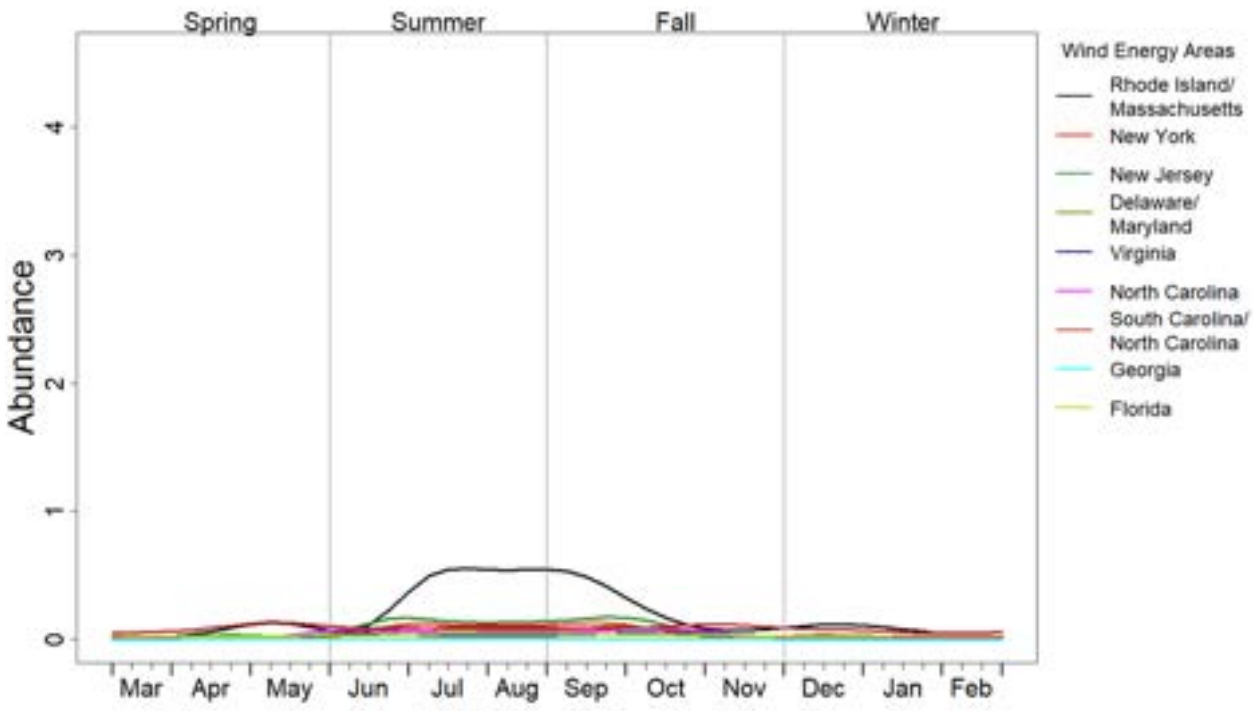

Figure B.7-22. Average seasonal abundance of goose-beaked whales in wind-energy study areas

B.8 Sowerby's Beaked Whale (*Mesoplodon bidens*)

Figure B.8-1. Sowerby's beaked whale
Image collected under MMPA Research permit #17355. Credit: NOAA/NEFSC/Desray Reeb

B.8.1 Data Collection

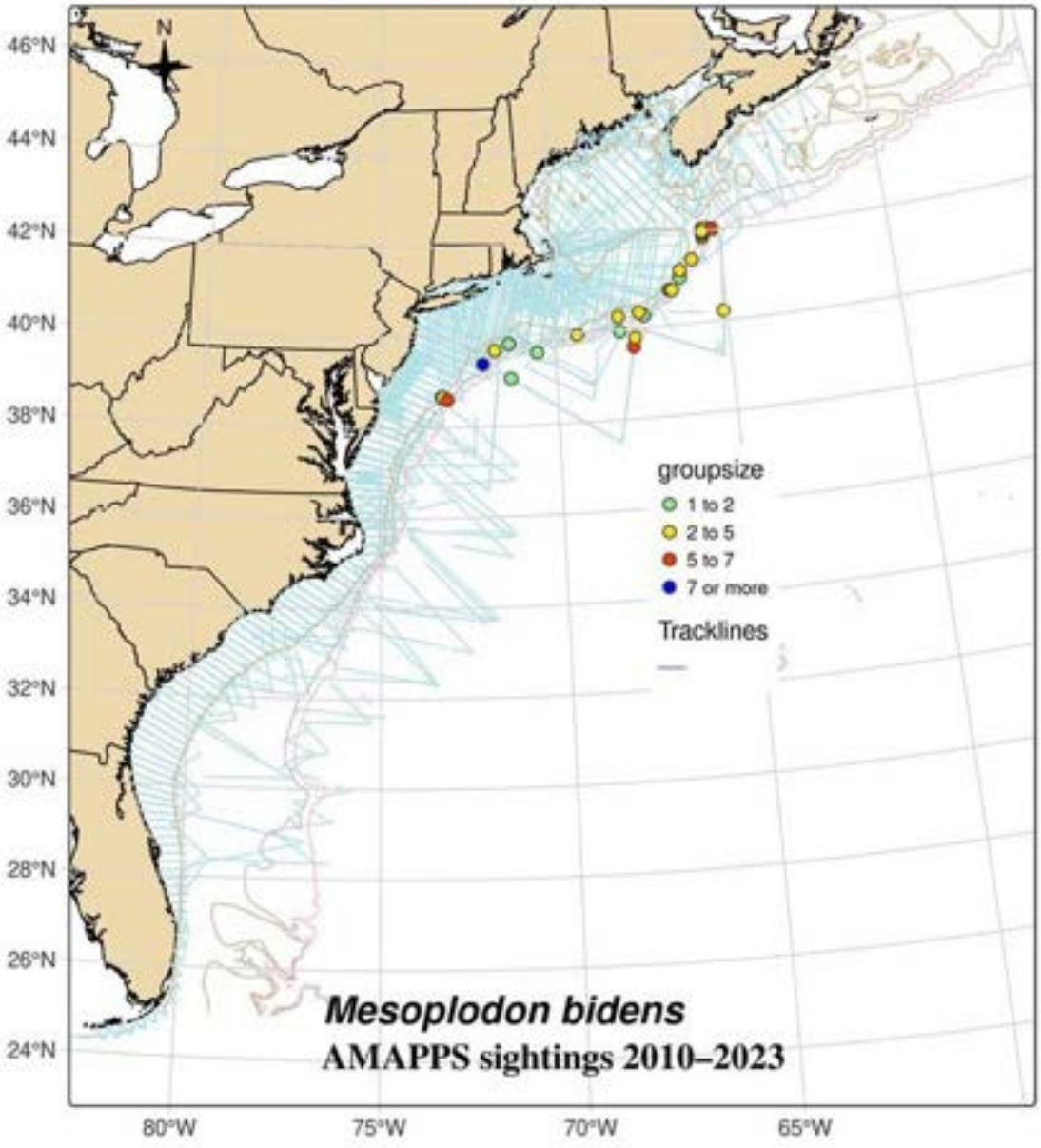

Figure B.8-2. Distribution of track lines and Sowerby's beaked whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.8-1. AMAPPS research effort 2010 to 2023 and Sowerby's beaked whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	4	7
NE Shipboard	Summer	49,064	57	175
NE Aerial	Spring	38,839	4	8
NE Aerial	Summer	52,003	3	11
NE Aerial	Fall	87,311	4	5
NE Aerial	Winter	24,747	0	0
SE Shipboard	Spring	2,604	0	0
SE Shipboard	Summer	18,331	1	3
SE Shipboard	Fall	2,673	0	0
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	0	0
SE Aerial	Summer	43,285	1	6
SE Aerial	Fall	21,153	0	0
SE Aerial	Winter	19,152	2	2

B.8.2 Mark-Recapture Distance Sampling Analysis

Table B.8-2. Intermediate parameters in Sowerby's beaked whale mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15	0.89
NE–aerial group 2	distance * observer + log(group size) + sea state	380	distance + sea state + glare	600	HR	0.75	0.07	0.06	0.70
NE–shipboard group 6	distance * observer + log(group size) + sea state	3900	distance + glare + time of day	3900	HR	0.37	0.13	0.14	0.81
SE–shipboard group 4	distance * observer + log(group size)	5000	Distance + log(group size)	5000	HR	0.35	0.29	0.28	0.91

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

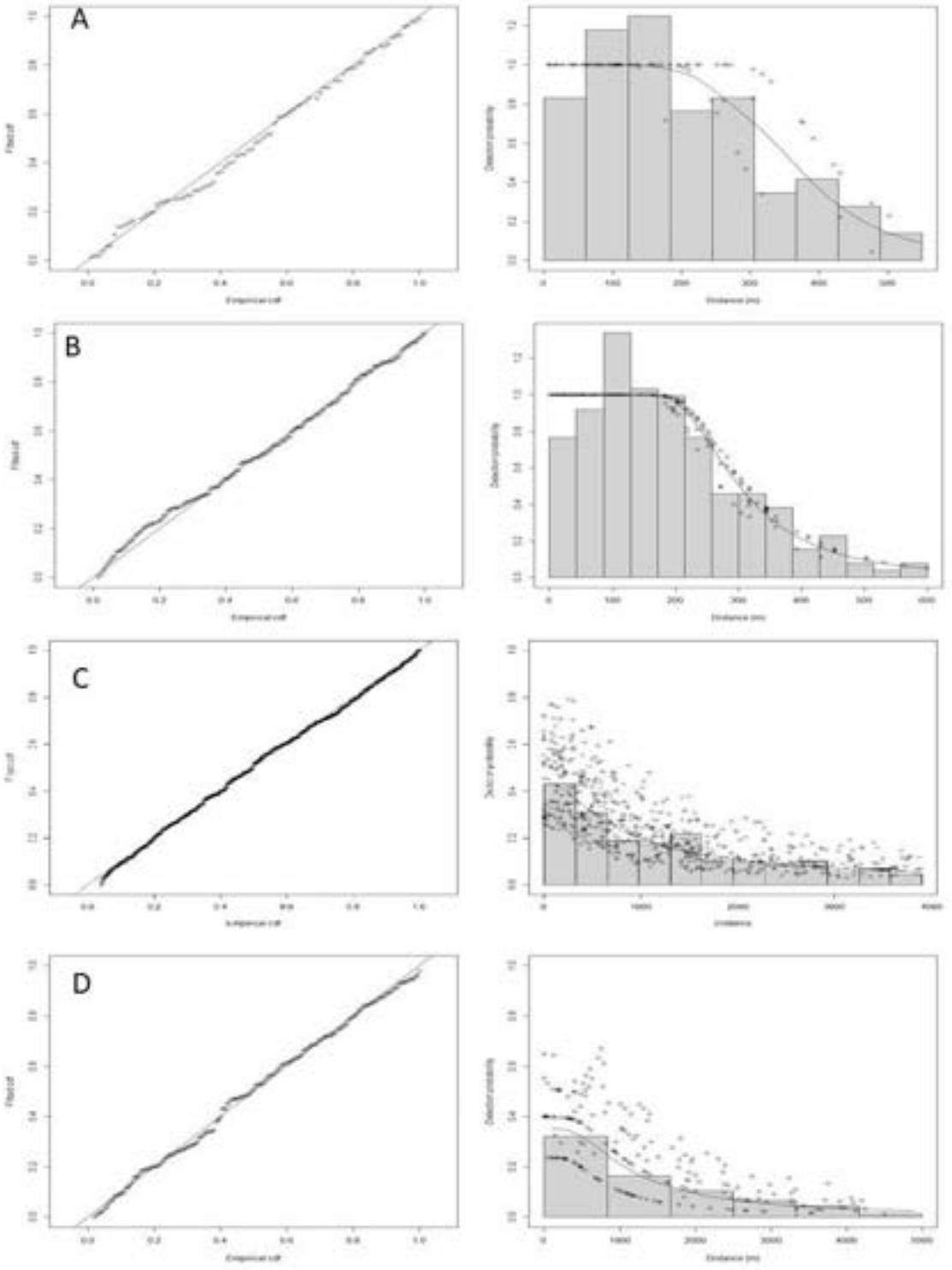

Figure B.8-3. Q-Q plots and detection functions from the Sowerby's beaked whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 2; C) NE-shipboard analysis set 6; D) SE-shipboard analysis set 4.

B.8.3 Generalized Additive Model Analysis

Table B.8-3. 2010 to 2023 density-habitat model output for Sowerby's beaked whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(mlp)	0.90	5	1.59	6.92	0.0029
s(btemp)	0.96	5	2.29	4.48	0.0004
s(dist2shore)	0.89	5	1.39	0.35	0.0045
s(dist1000)	1.09	5	7.72	27.76	<0.0001
s(latdd)	1.01	5	3.58	9.14	<0.0001

Adjusted R^2 = 0.0226. Deviance explained = 48.7%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

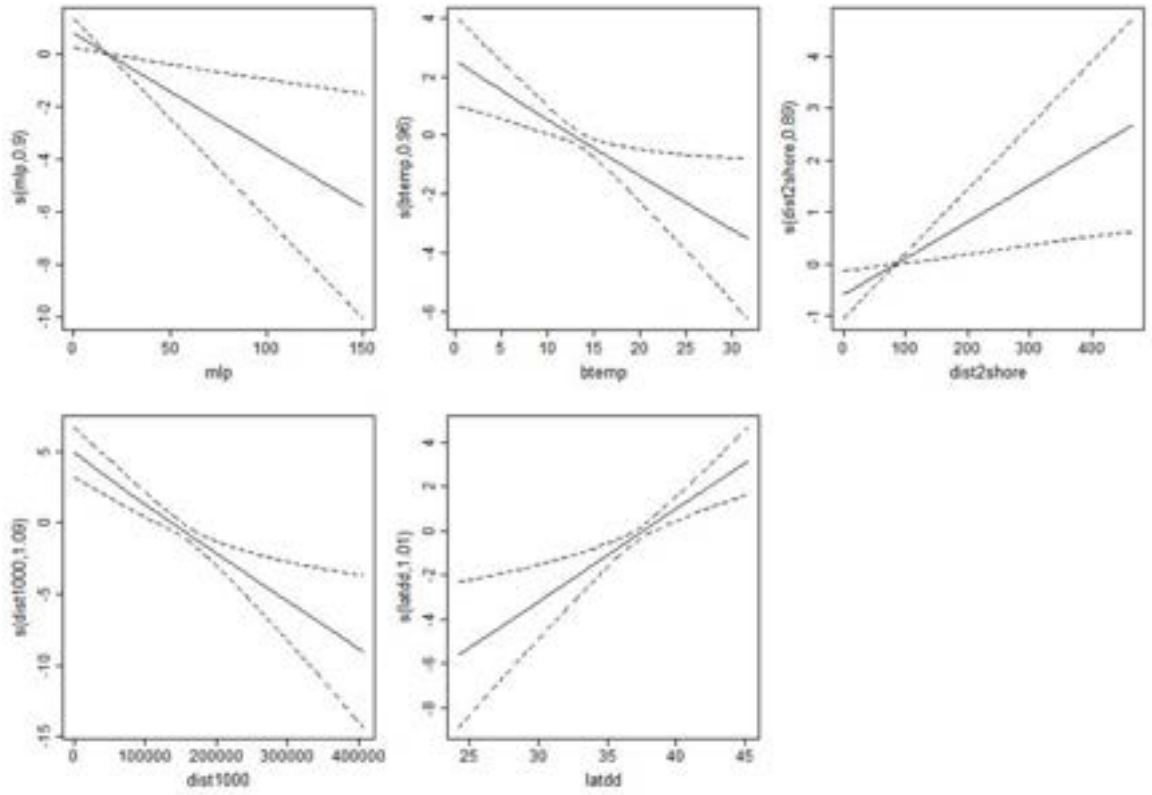

Figure B.8-4. Sowerby's beaked whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat models. Covariate abbreviations explained in main text in Table 4-2.

B.8.4 Model Cross-Validation

Table B.8-4. Diagnostic statistics from the Sowerby's beaked whale density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
MAPE	Mean absolute percentage error	Non-zero density	96.904	Fair to good
RHO	Spearman rank correlation	Non-zero density	0.399	Excellent
MAPE	Mean absolute percentage error	All data divided in 25 random samples	97.039	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.058	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.0004	Excellent

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.8.5 Abundance Estimates for AMAPPS Study Area

Table B.8-5. Sowerby's beaked whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	233	0.43	104 – 522
Summer (June–August)	502	0.36	253 – 995
Fall (September–November)	268	0.41	124 – 580
Winter (December–February)	93	0.62	30 – 284
Summer 2011 U.S. surveys[1]	3,653	0.69	1,632 – 8,179
Summer 2016 U.S. surveys[1]	209	0.56	106 – 410
Summer 2021 U.S. surveys[1]	492	0.50	195 – 1,242

Hayes *et al.* 2024

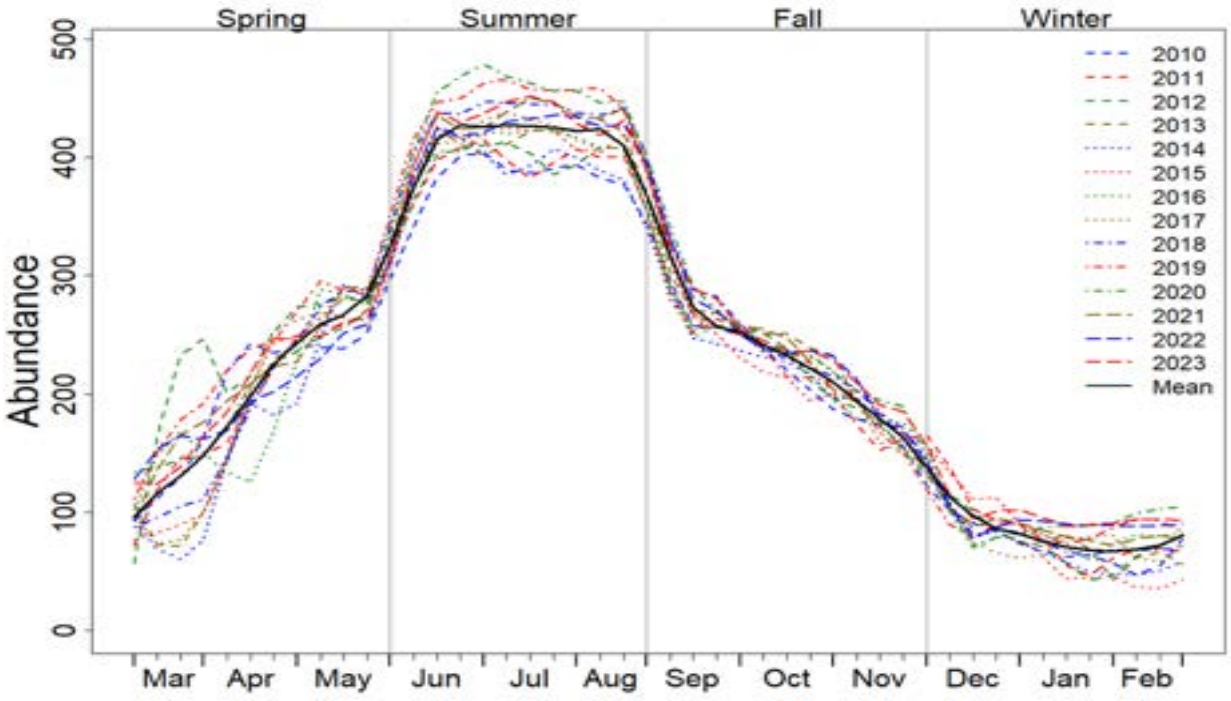

Figure B.8-5. Annual abundance trends for Sowerby's beaked whales in the AMAPPS study area

B.8.6 Seasonal Prediction Maps

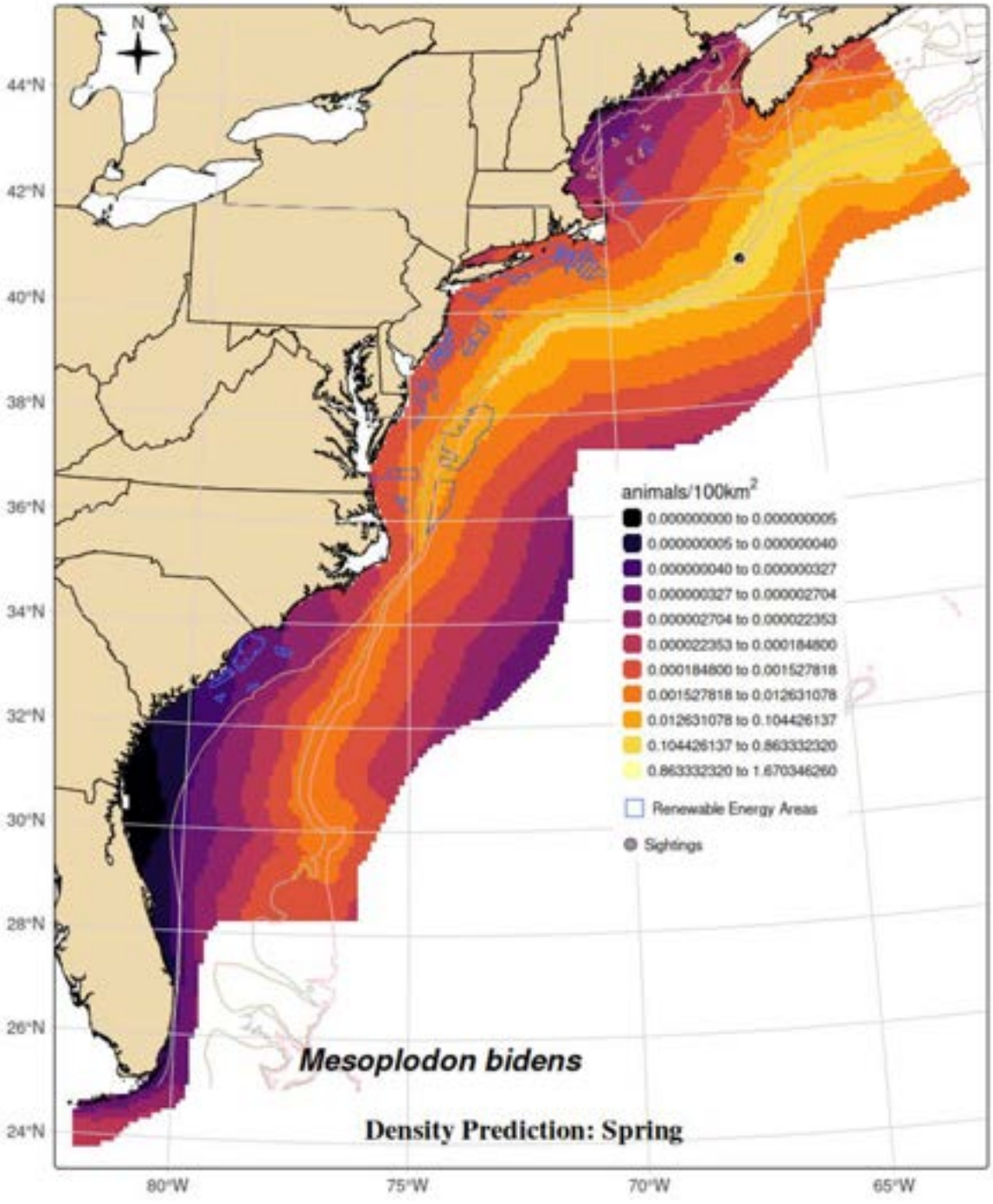

Figure B.8-6. Sowerby's beaked whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

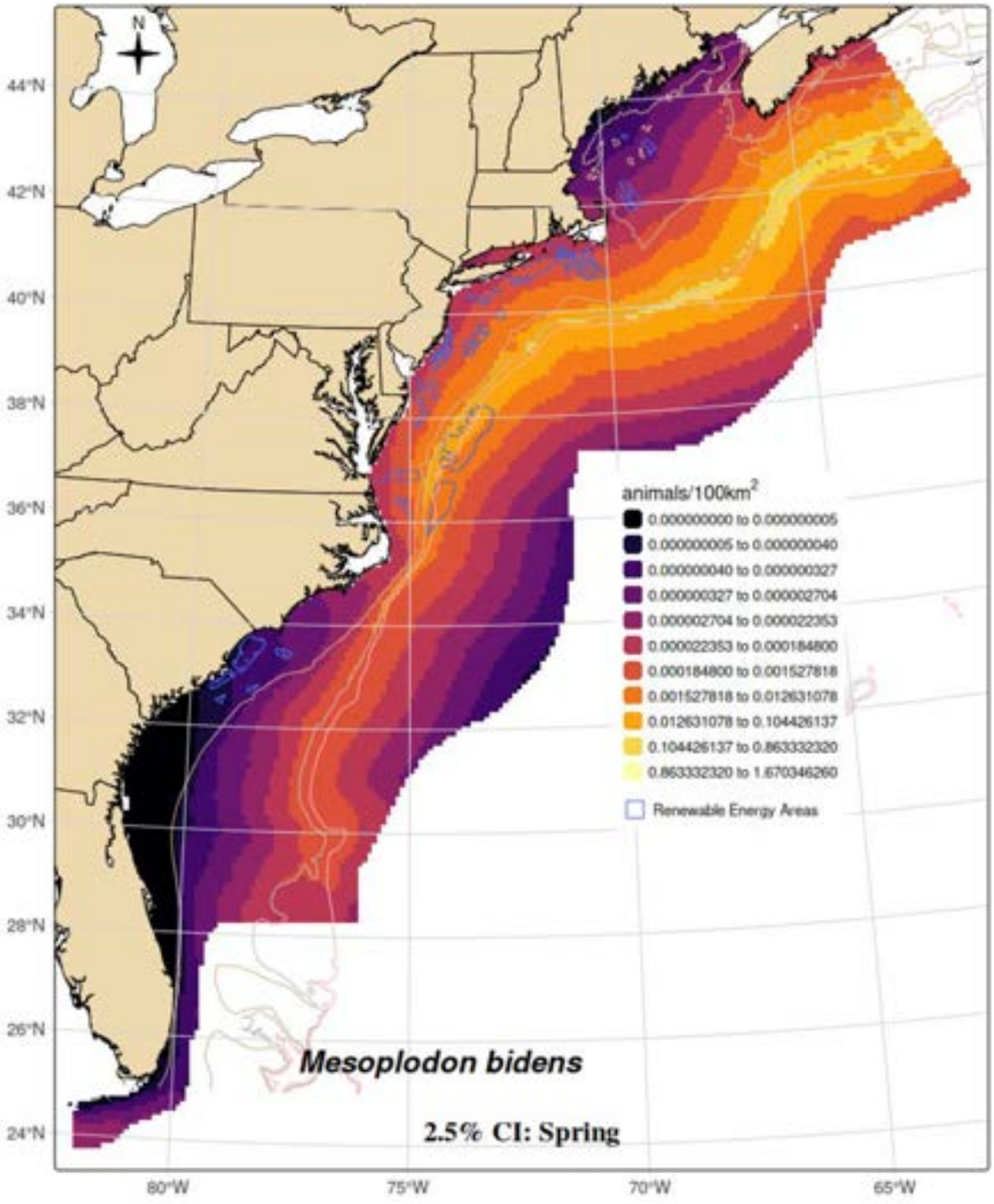

Figure B.8-7. Lower 2.5% confidence interval of spring Sowerby's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

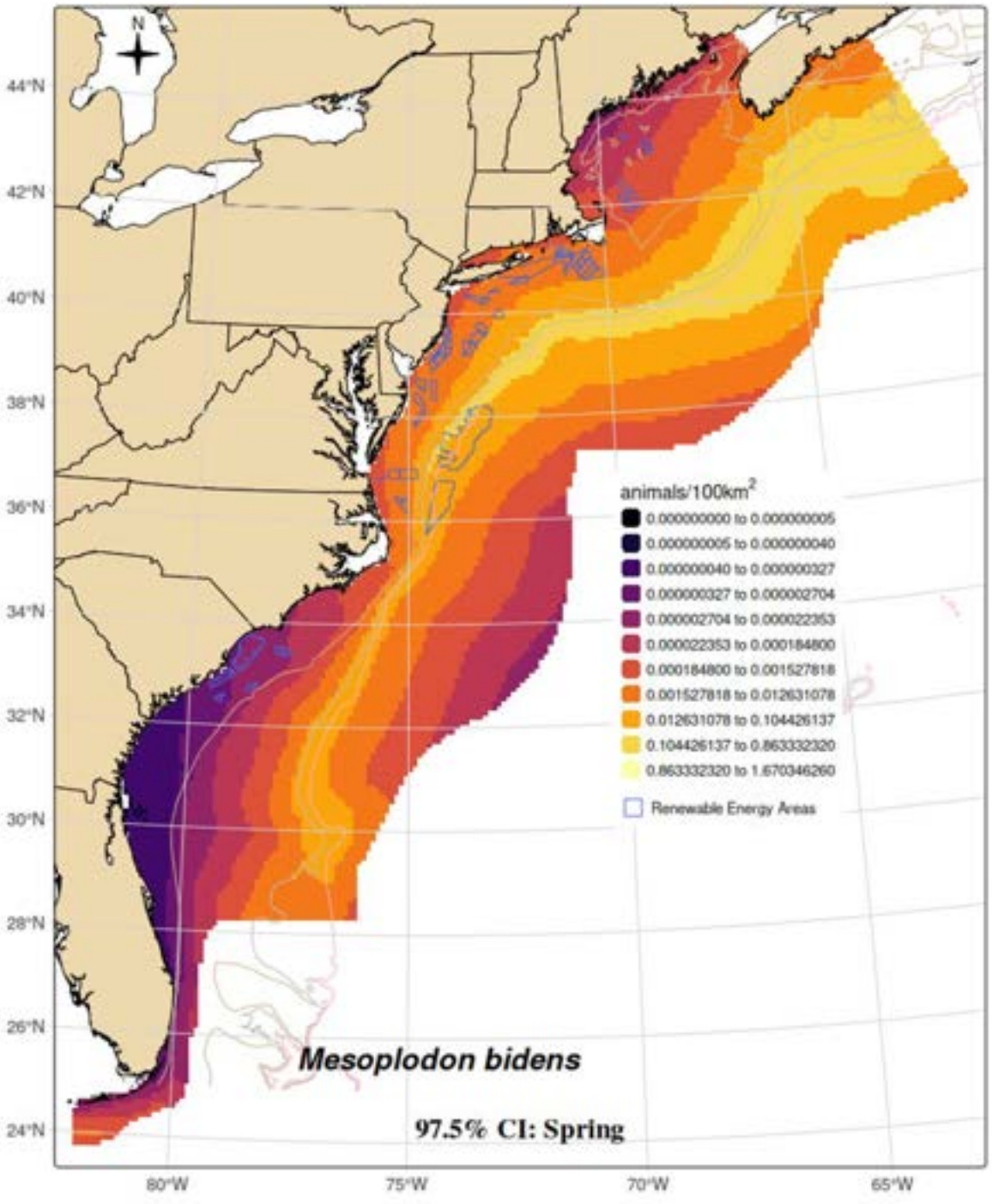

Figure B.8-8. Upper 97.5% confidence interval of spring Sowerby's beaked whale density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

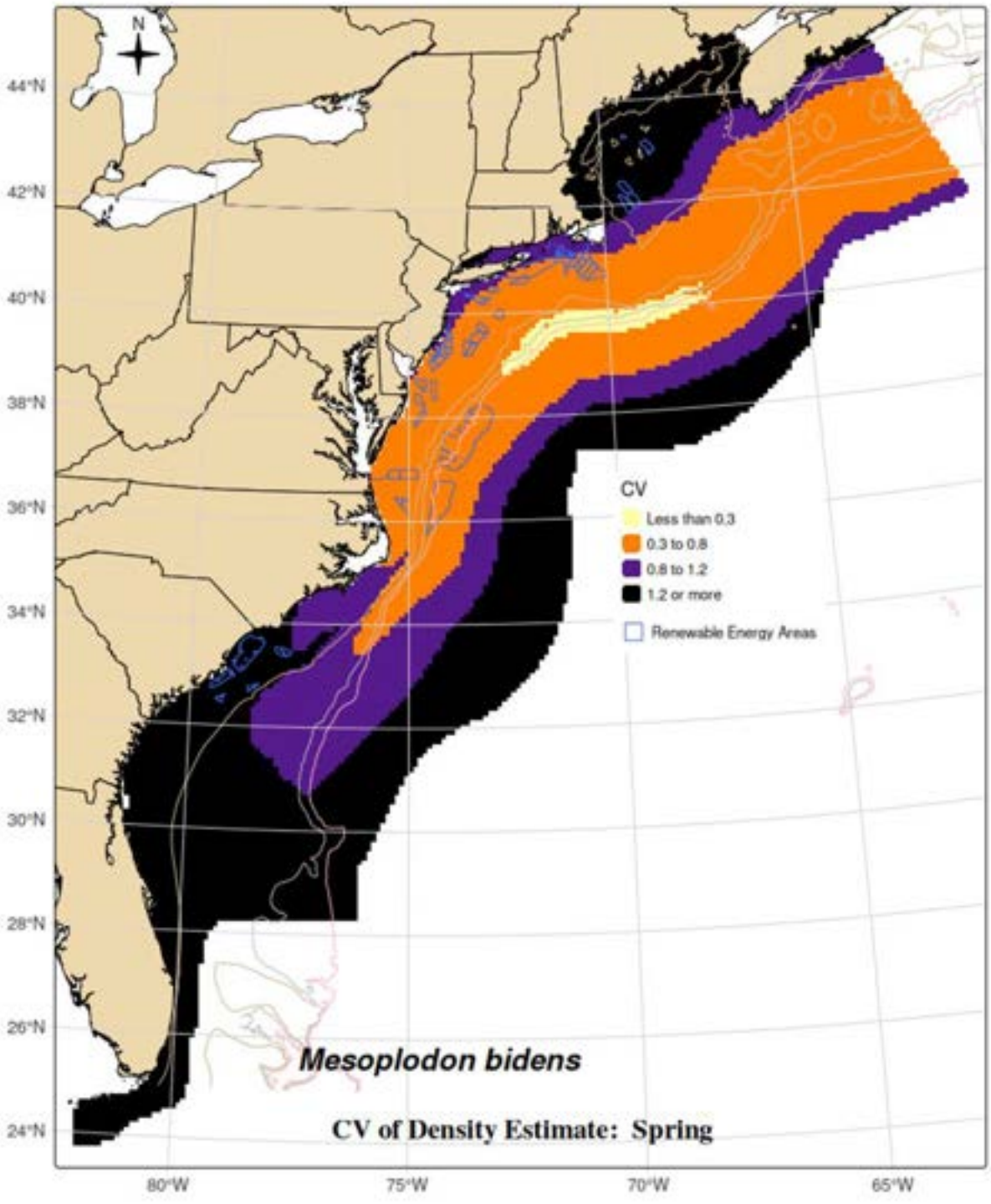

Figure B.8-9. CV of spring Sowerby's beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

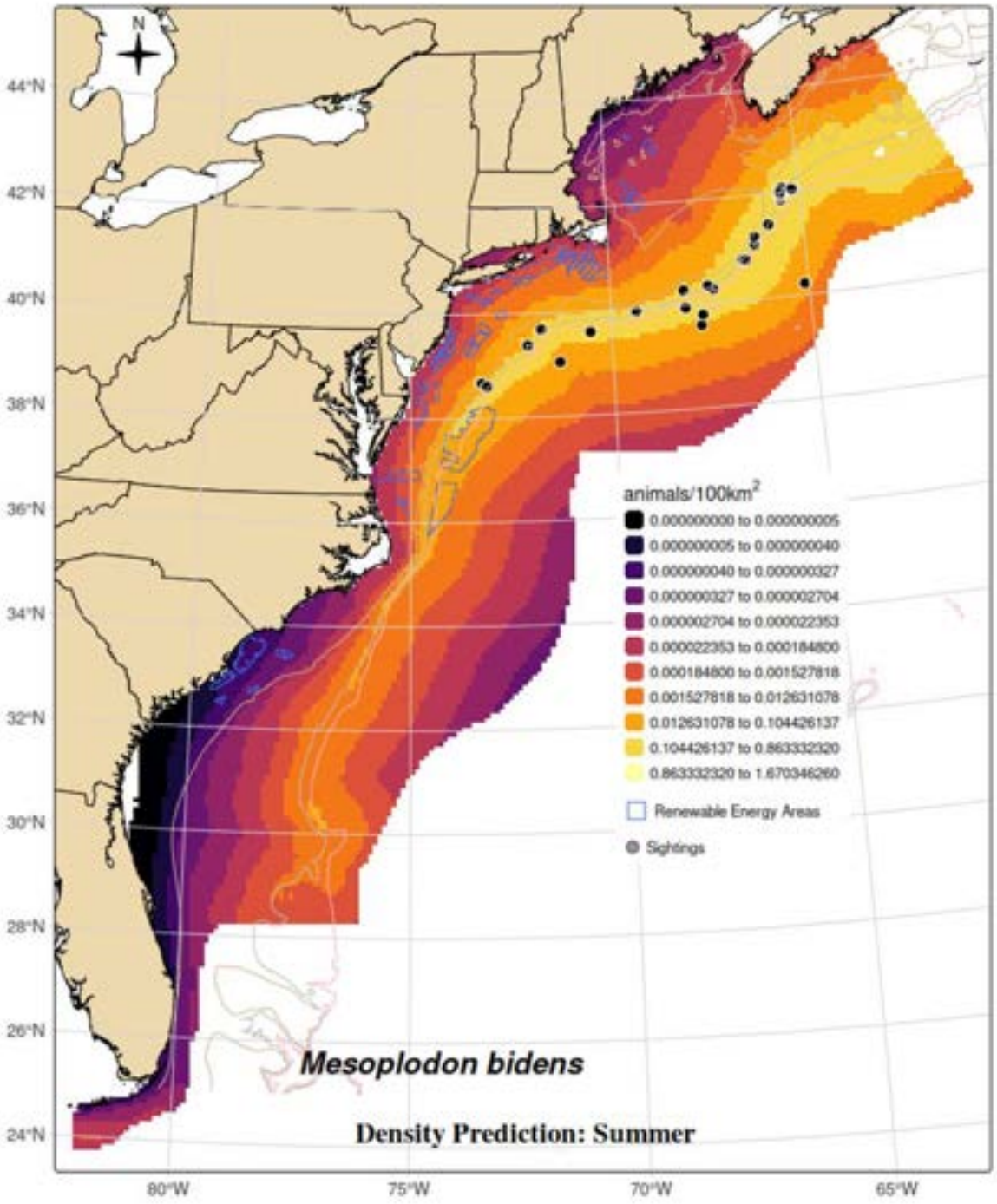

Figure B.8-10. Sowerby's beaked whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

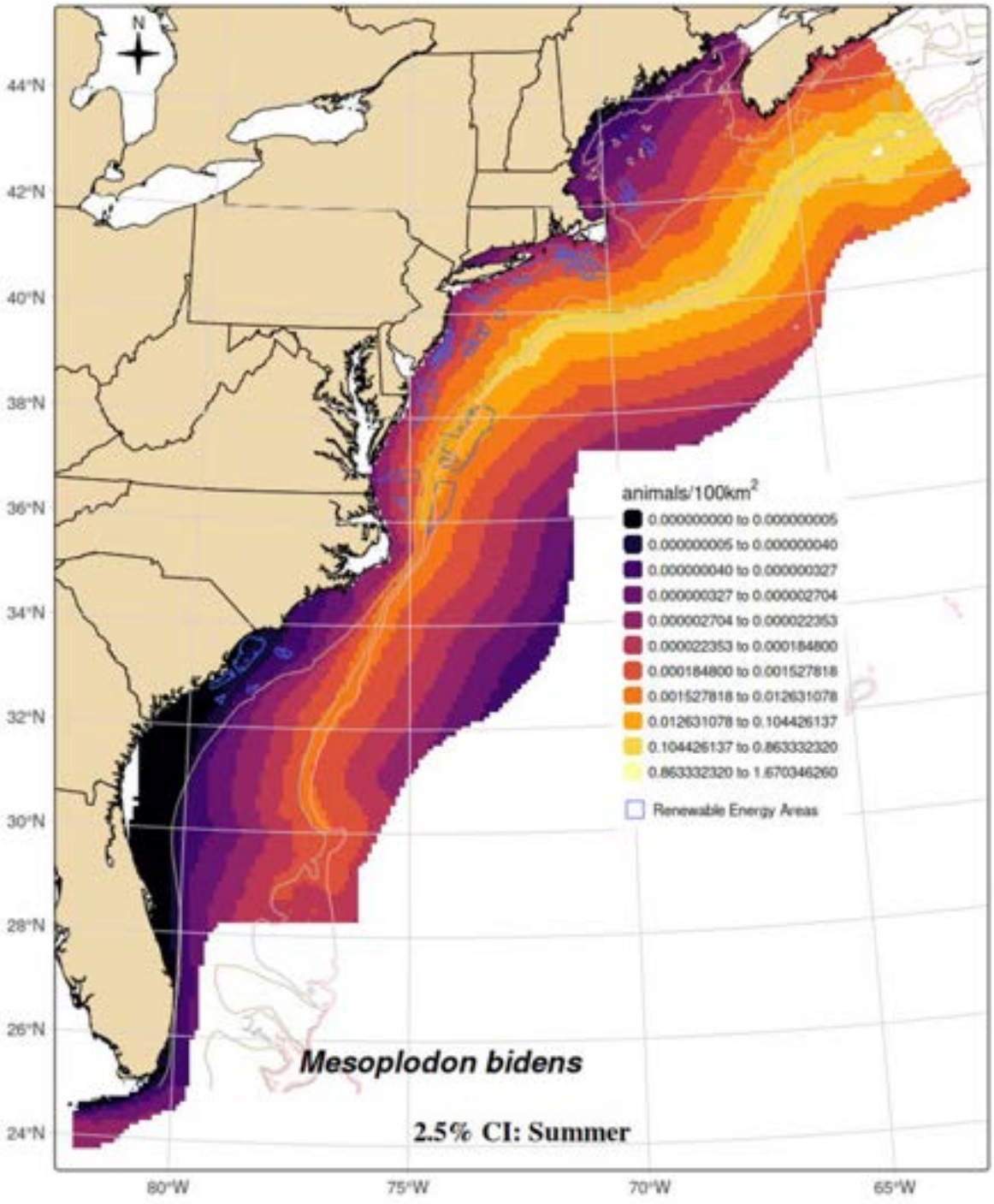

Figure B.8-11. Lower 2.5% confidence interval of summer Sowerby's beaked whale density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

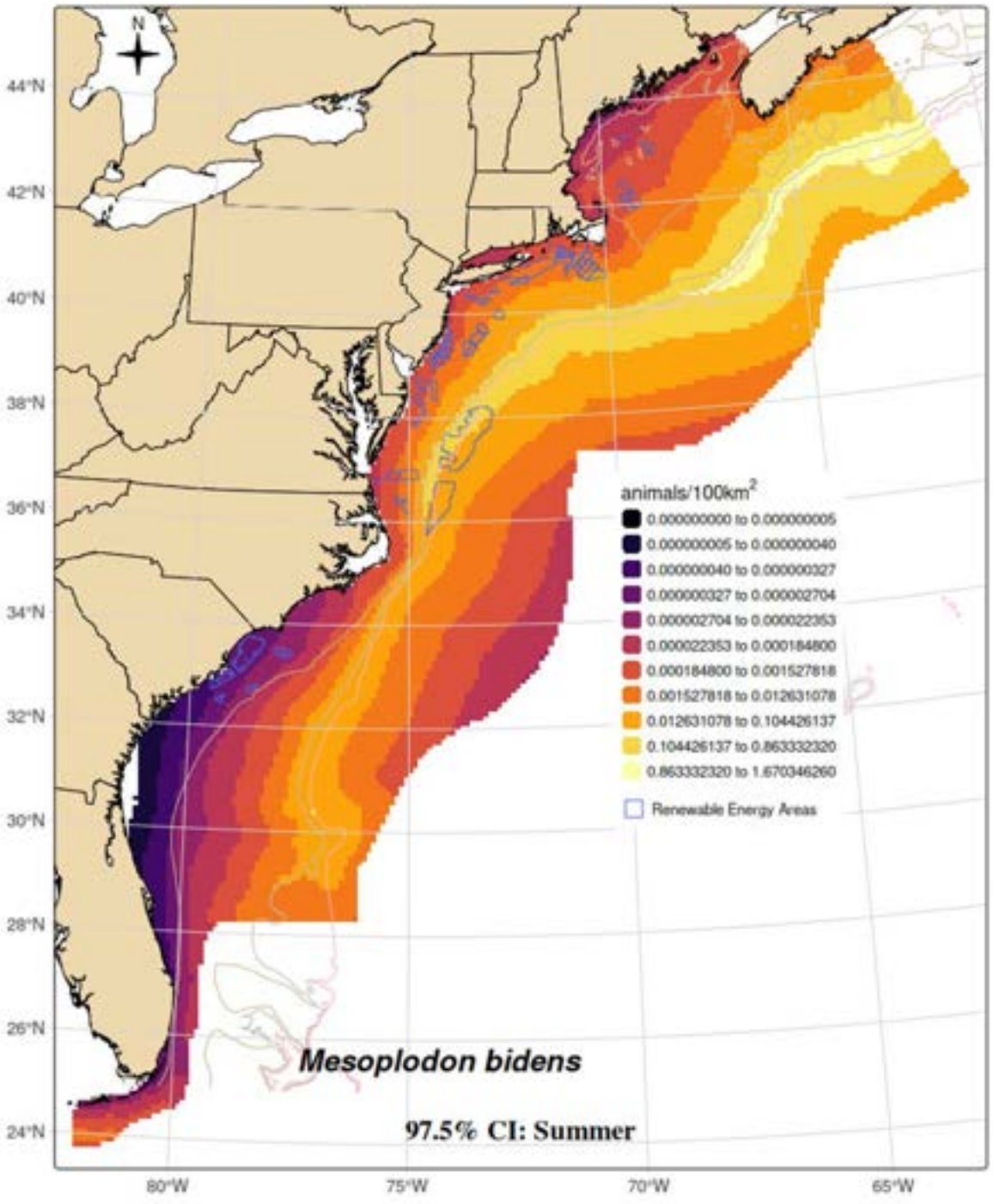

Figure B.8-12. Upper 97.5% confidence interval of summer Sowerby's beaked whale density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

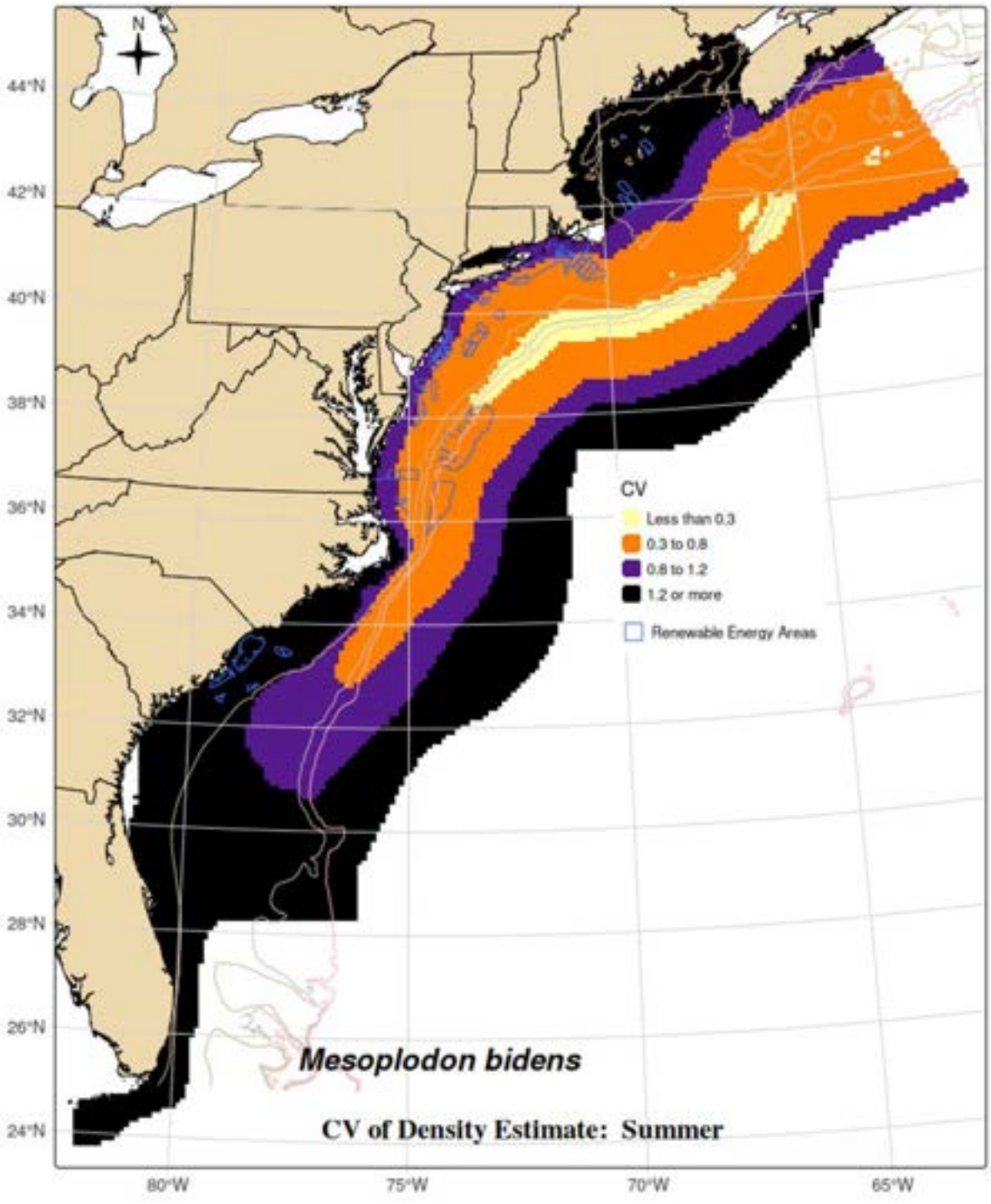

Figure B.8-13. CV of summer Sowerby's beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

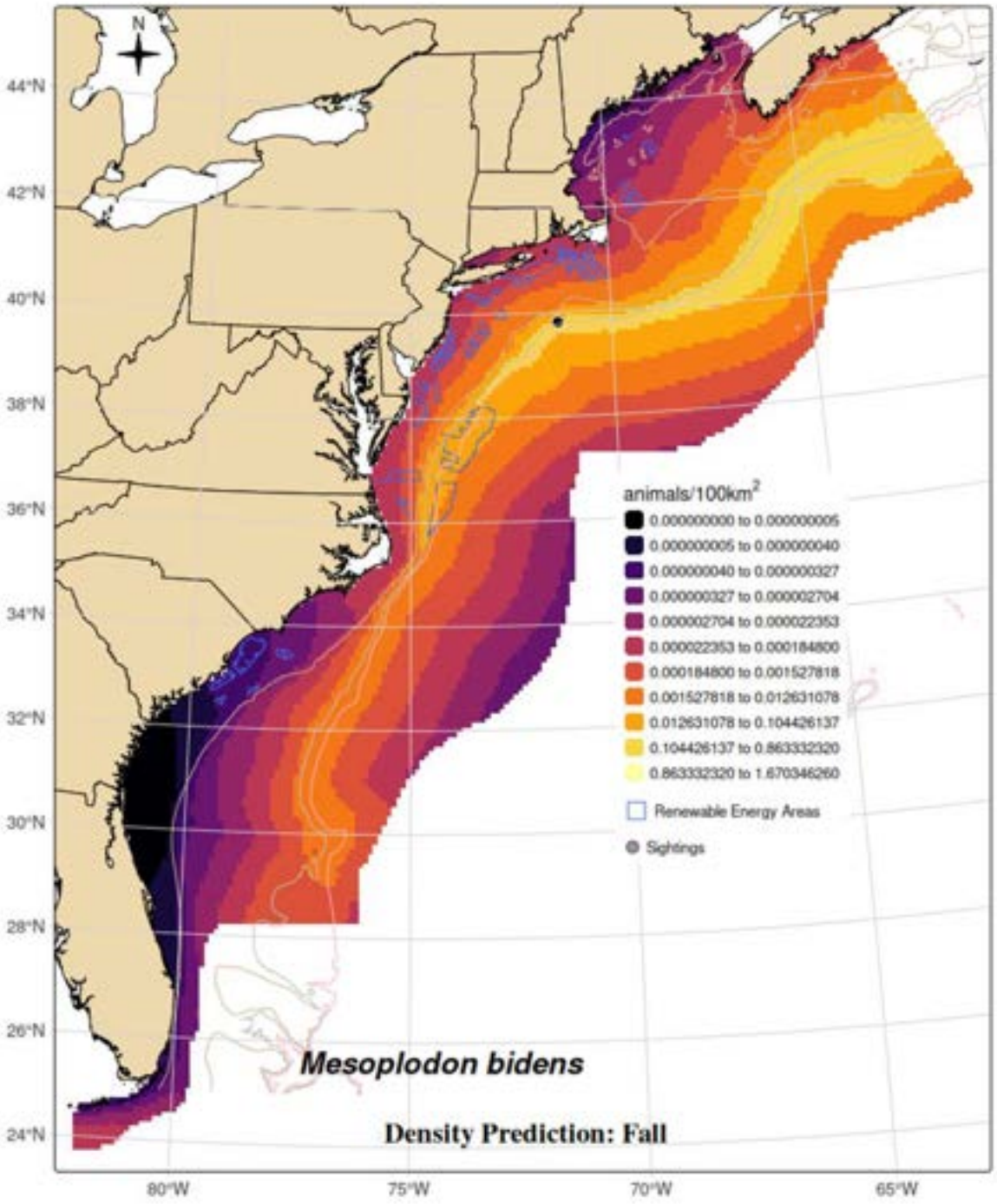

Figure B.8-14. Sowerby's beaked whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

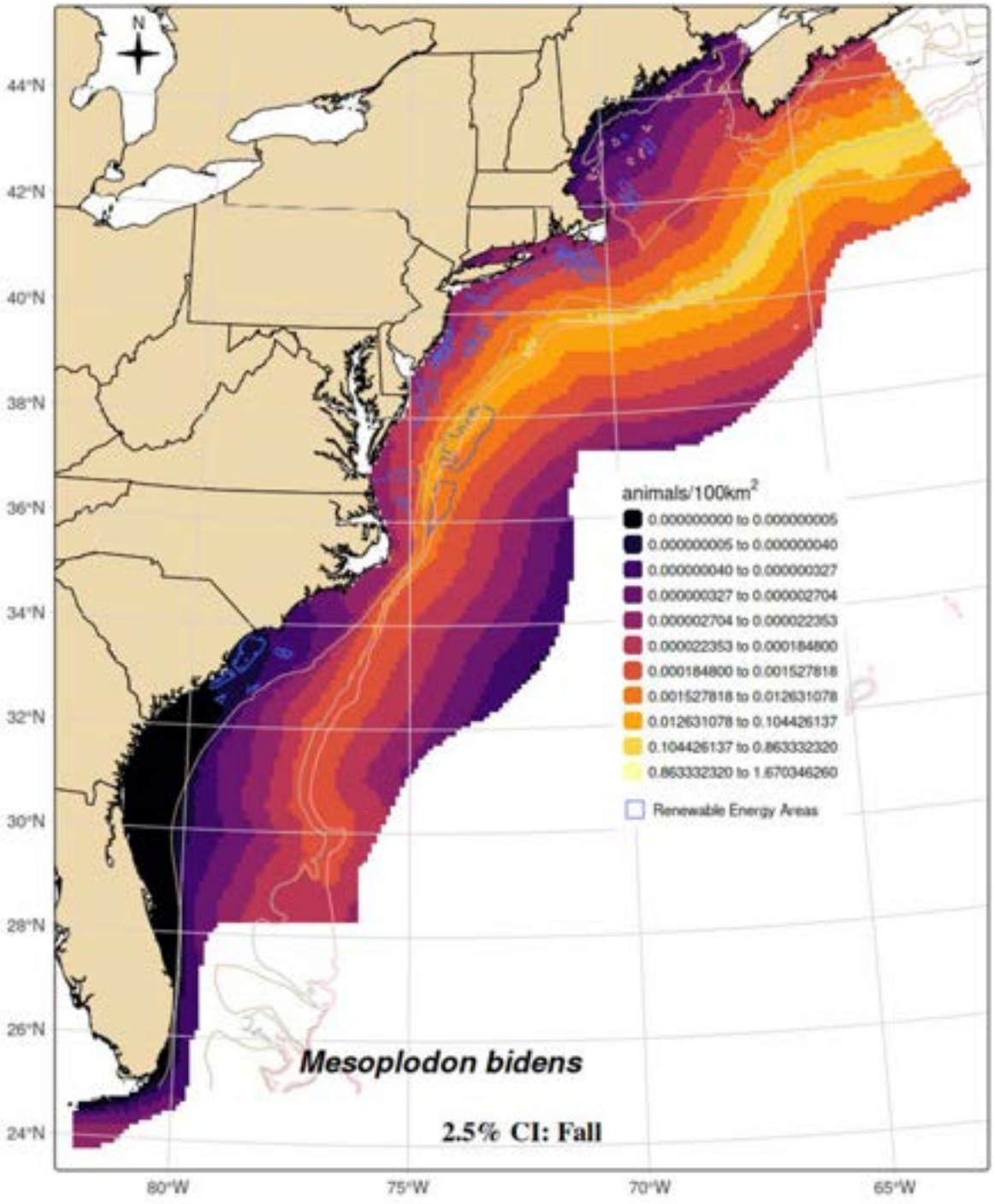

Figure B.8-15. Lower 2.5% confidence interval of fall Sowerby's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

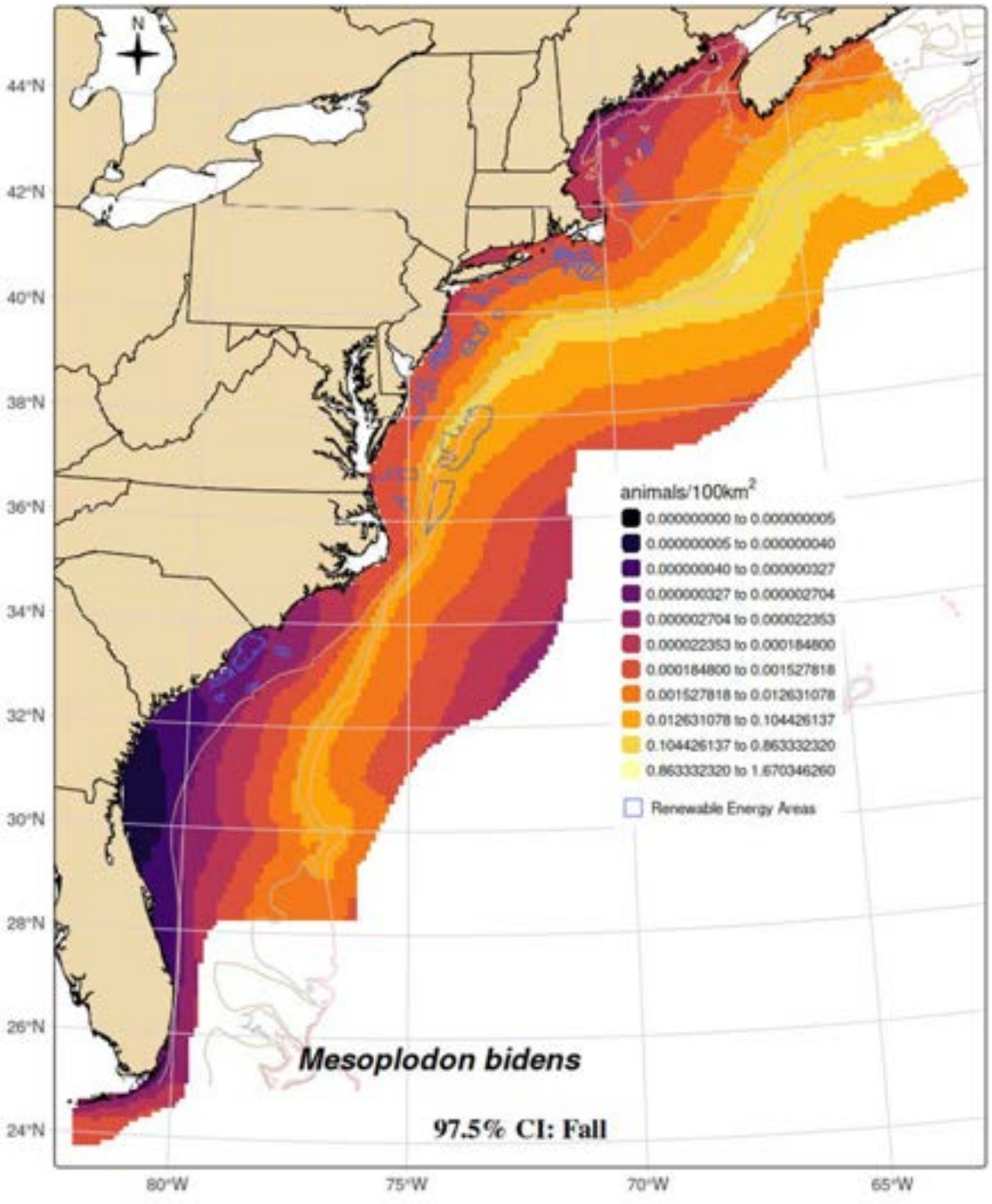

Figure B.8-16. Upper 97.5% confidence interval of fall Sowerby's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

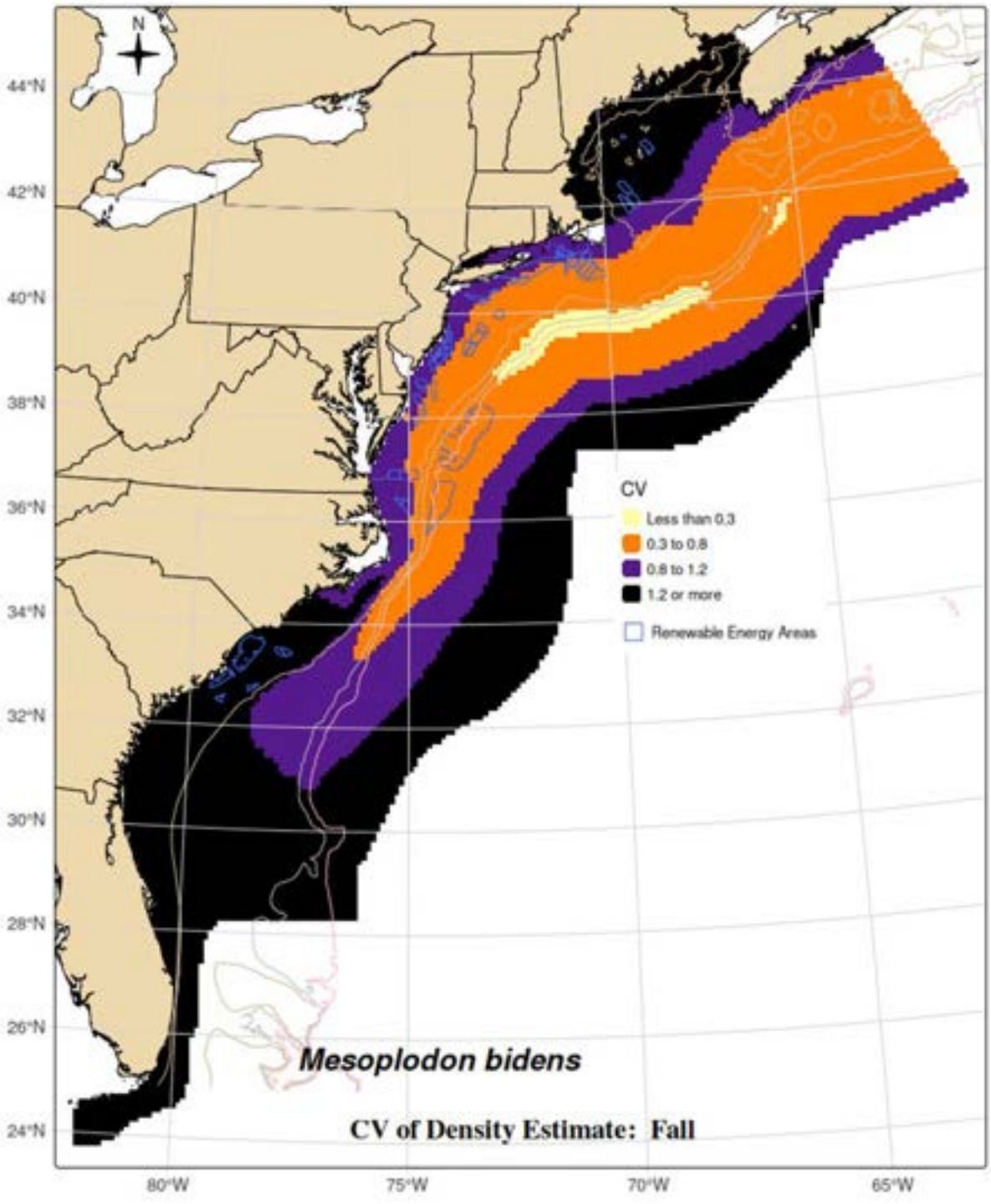

Figure B.8-17. CV of fall Sowerby's beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

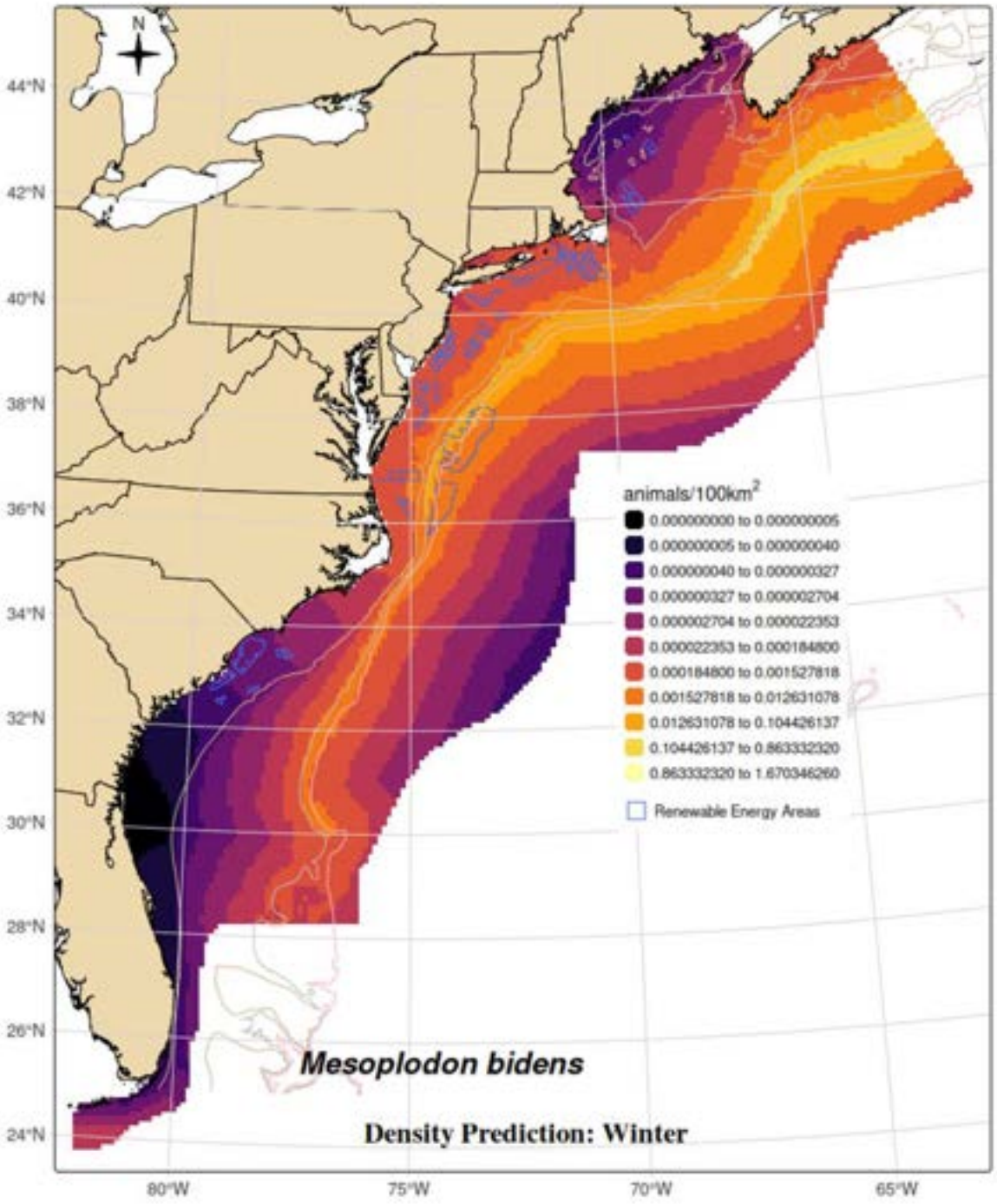

Figure B.8-18. Sowerby's beaked whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

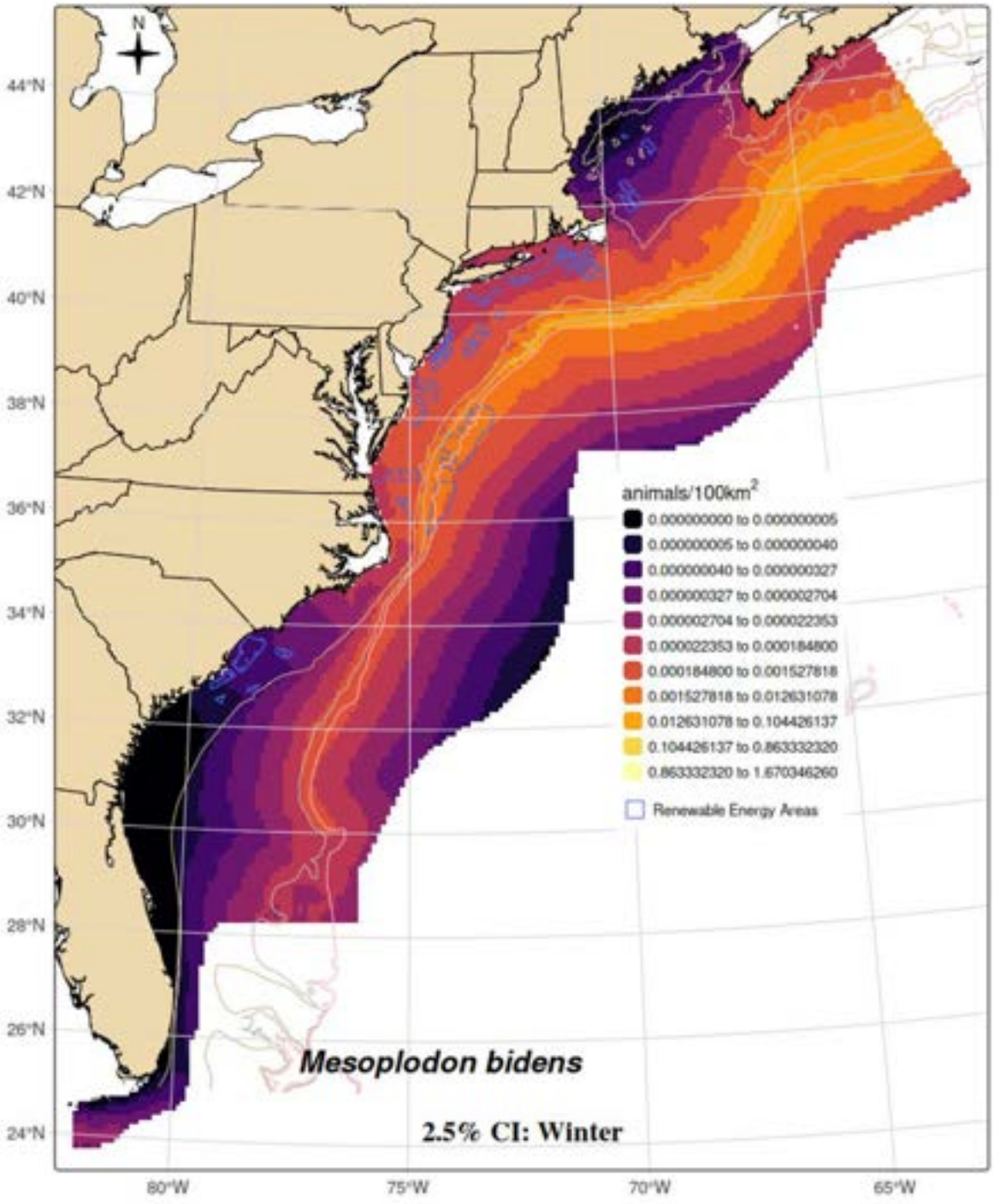

Figure B.8-19. Lower 2.5% confidence interval of summer Sowerby's beaked whale density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

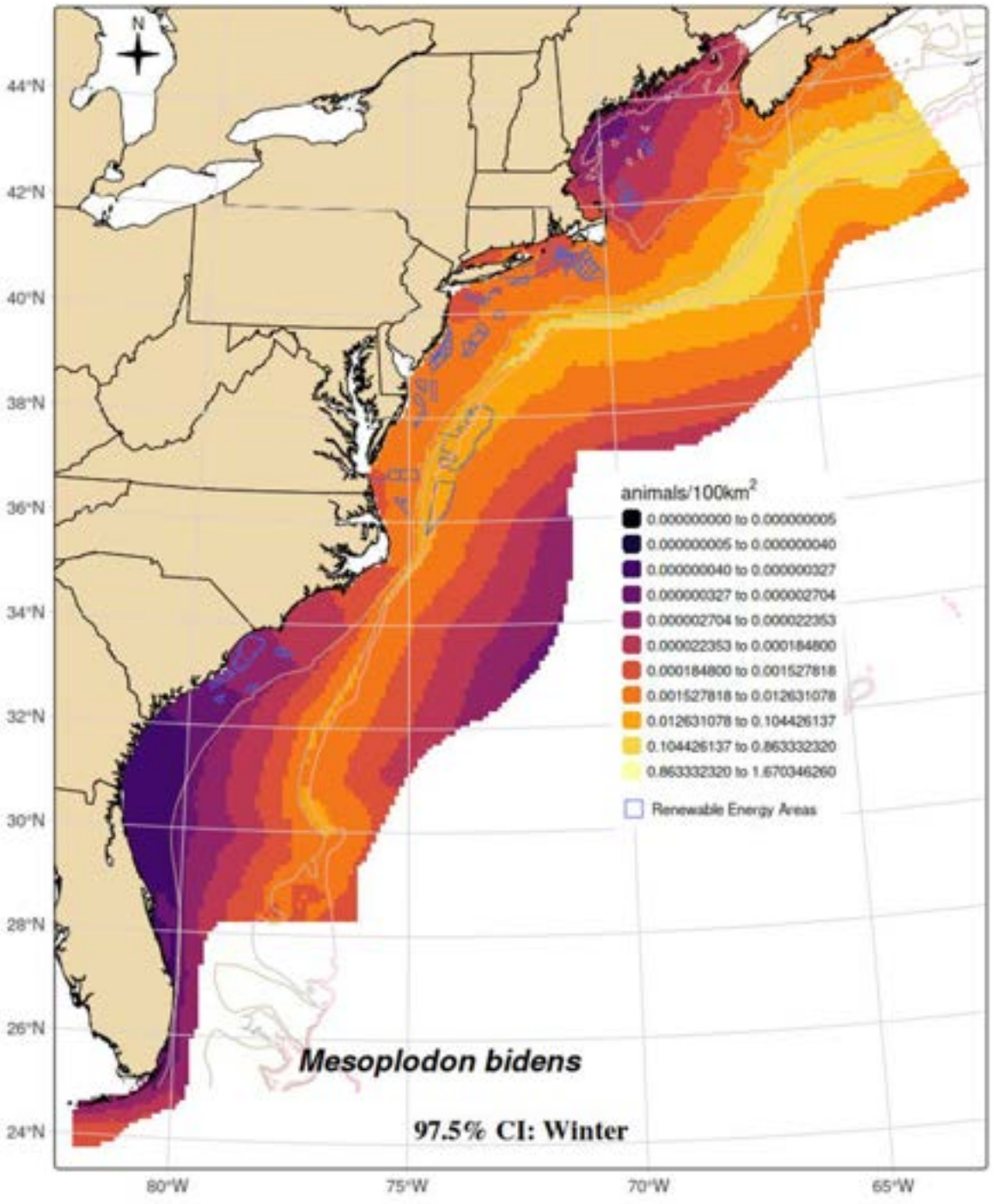

Figure B.8-20. Upper 97.5% confidence interval of summer Sowerby's beaked whale density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

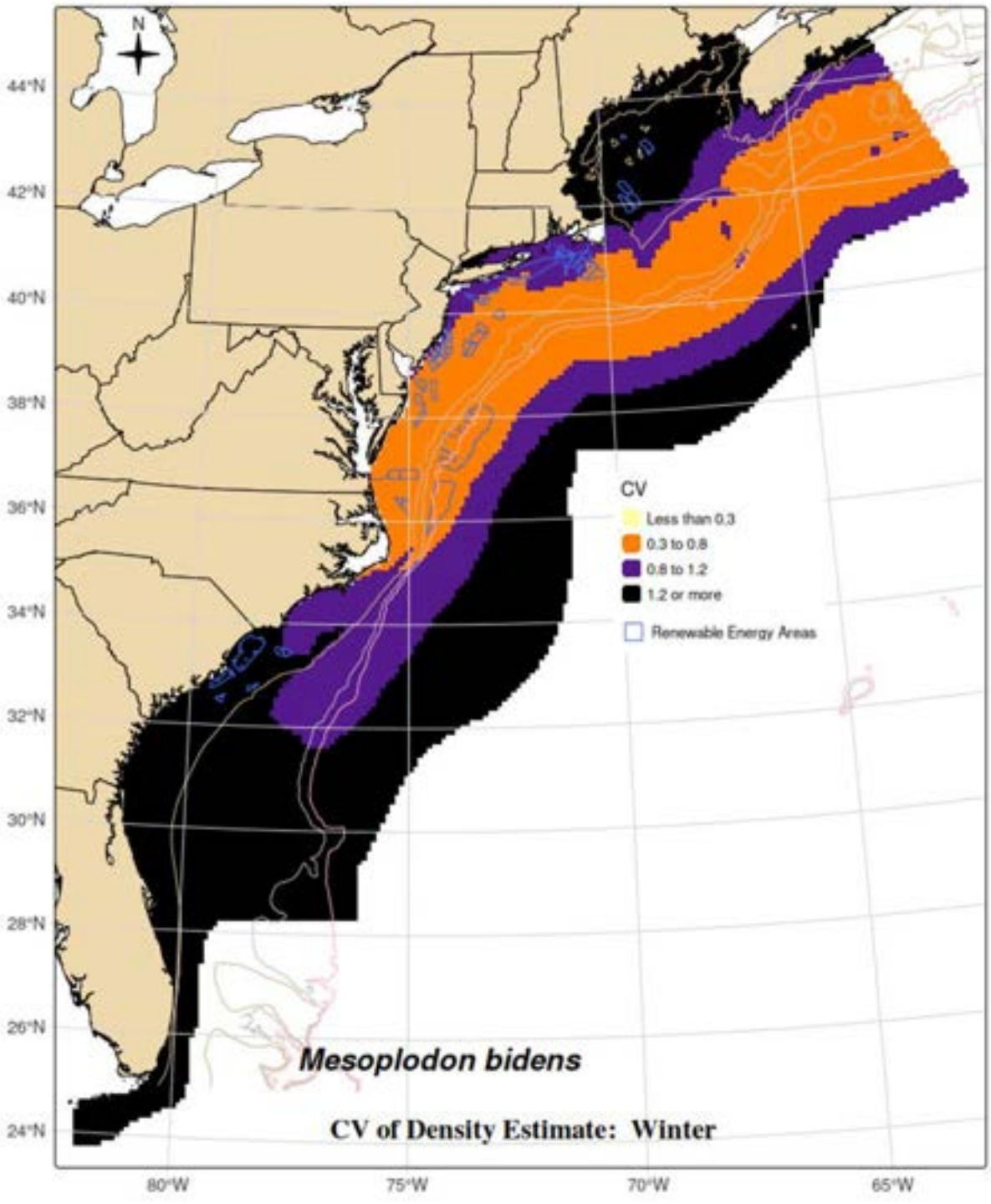

Figure B.8-21. CV of summer Sowerby's beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.8.7 Offshore Energy Development Areas

Table B.8-6. Sowerby's beaked whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	0.2	0.58	0.1 - 0.7
	NY	0.0	0.73	0 - 0.1
	NJ	0.0	0.65	0 - 0.1
	DE/MD	0.0	0.59	0 - 0.1
	VA	0.0	0.55	0 - 0.1
	NC	0.1	0.56	0 - 0.2
	NC/SC	0.0	1.37	0 - 0
	GA	0.0	2.55	0 - 0
	FL	0.0	1.83	0 - 0
Summer (Jun-Aug)	RI/MA	0.3	0.54	0.1 - 0.8
	NY	0.0	0.71	0 - 0
	NJ	0.0	0.72	0 - 0.1
	DE/MD	0.0	0.66	0 - 0
	VA	0.0	0.71	0 - 0
	NC	0.1	0.64	0 - 0.2
	NC/SC	0.0	1.52	0 - 0
	GA	0.0	2.78	0 - 0
	FL	0.0	1.81	0 - 0
Fall (Sep-Nov)	RI/MA	0.1	0.61	0 - 0.2
	NY	0.0	0.81	0 - 0
	NJ	0.0	0.81	0 - 0
	DE/MD	0.0	0.77	0 - 0
	VA	0.0	0.84	0 - 0
	NC	0.0	0.73	0 - 0.1
	NC/SC	0.0	1.53	0 - 0
	GA	0.0	2.63	0 - 0
	FL	0.0	1.83	0 - 0
Winter (Dec-Feb)	RI/MA	0.1	0.78	0 - 0.3
	NY	0.0	0.82	0 - 0
	NJ	0.0	0.71	0 - 0.1
	DE/MD	0.0	0.64	0 - 0.1
	VA	0.0	0.59	0 - 0.1
	NC	0.0	0.63	0 - 0.1
	NC/SC	0.0	1.34	0 - 0
	GA	0.0	2.51	0 - 0
	FL	0.0	1.89	0 - 0

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

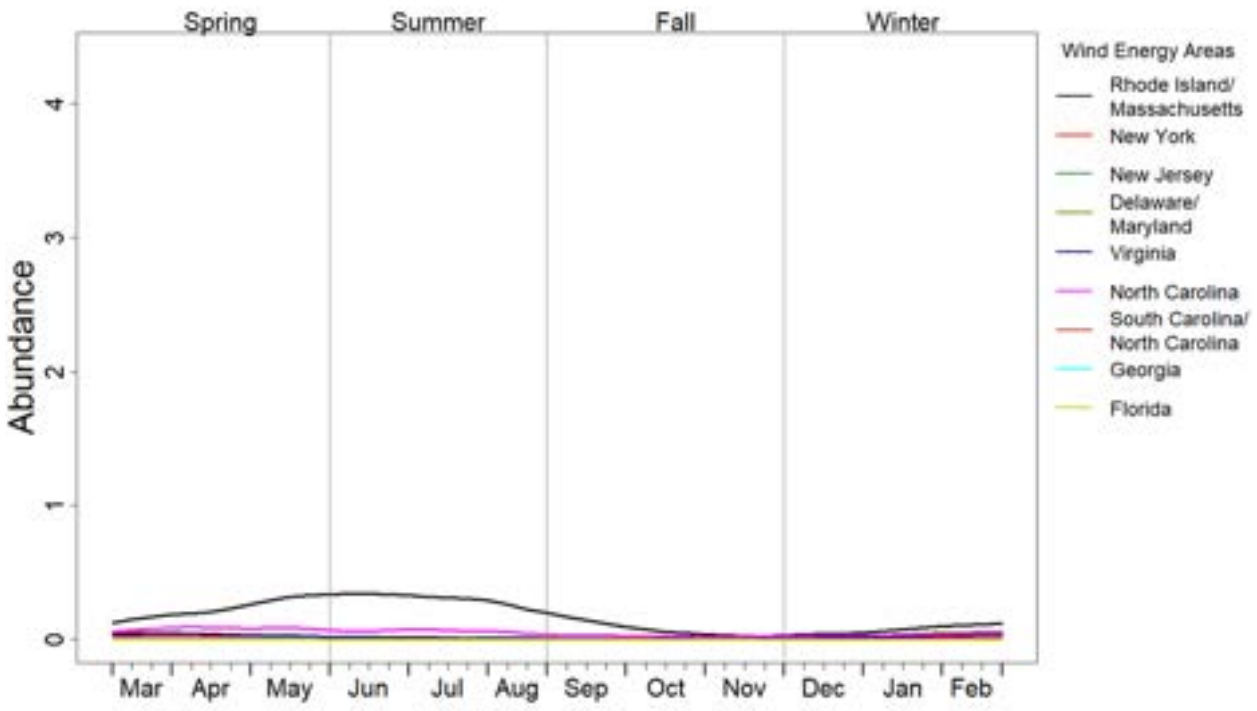

Figure B.8-22. Average seasonal abundance of Sowerby's beaked whales in wind-energy study areas

B.9 Gervais' Beaked Whales

Figure B.9-1. Gervais' beaked whales
Image Credit: NOAA/NEFSC/Keith Mullin

B.9.1 Data Collection

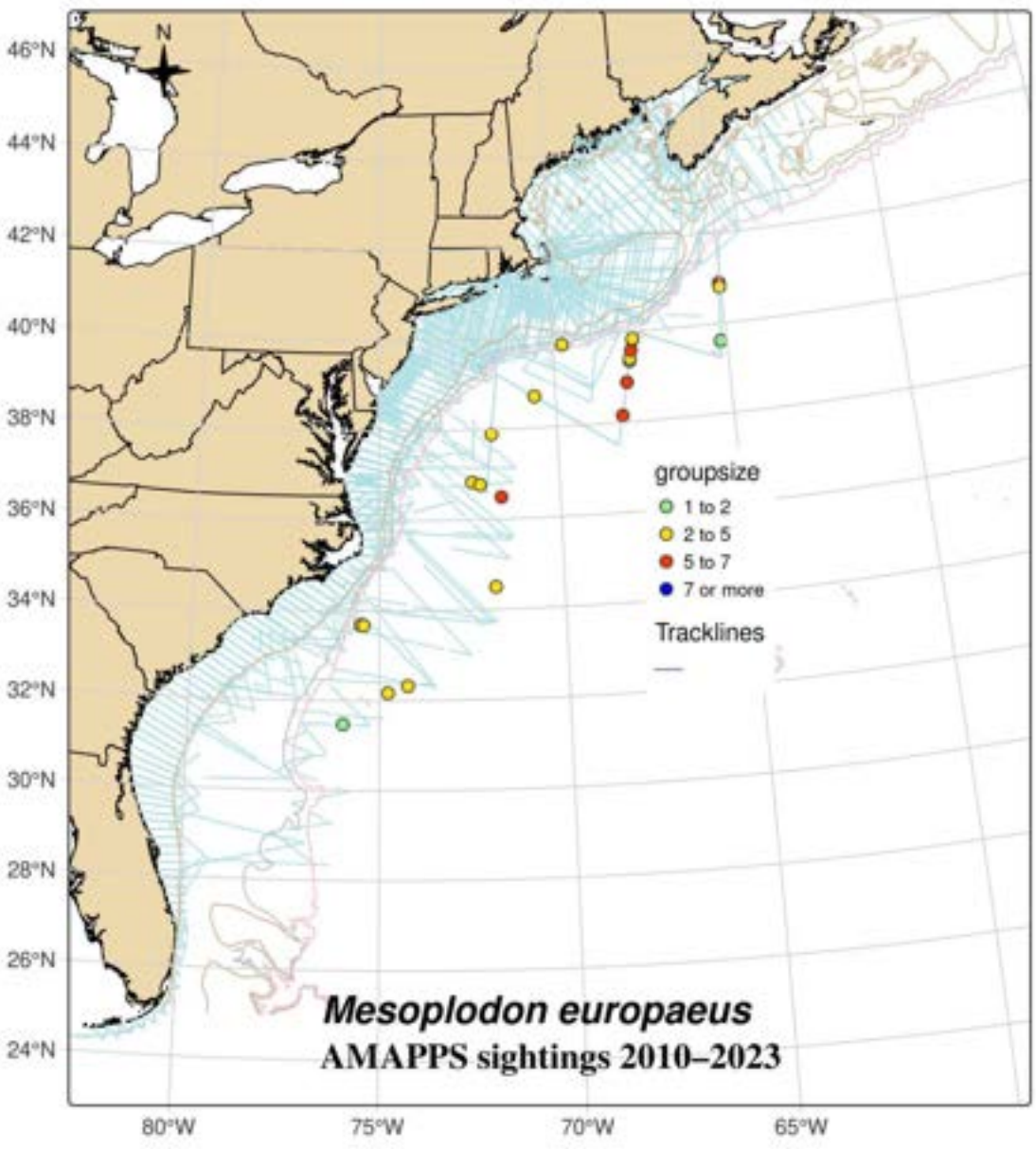

Figure B.9-2. Distribution of track lines and Gervais' beaked whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.9-1. AMAPPS research effort 2010 to 2023 and Gervais' beaked whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	0	0
NE Shipboard	Summer	49,064	29	79
NE Aerial	Spring	38,839	0	0
NE Aerial	Summer	52,003	0	0
NE Aerial	Fall	87,311	0	0
NE Aerial	Winter	24,747	0	0
SE Shipboard	Spring	2,604	1	4
SE Shipboard	Summer	18,331	101	244
SE Shipboard	Fall	2,673	4	6
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	0	0
SE Aerial	Summer	43,285	0	0
SE Aerial	Fall	21,153	0	0
SE Aerial	Winter	19,152	0	0

B.9.2 Mark-Recapture Distance Sampling Analysis

Table B.9-2. Intermediate parameters in Gervais' beaked whale mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15
NE–aerial group 2	distance * observer + log(group size) + sea state	380	distance + sea state + glare	600	HR	0.75	0.07	0.06
NE–shipboard group 6	distance * observer + log(group size) + sea state	3900	distance + glare + time of day	3900	HR	0.37	0.13	0.14
SE–shipboard group 4	distance * observer + log(group size)	5000	Distance + log(group size)	5000	HR	0.35	0.29	0.28

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

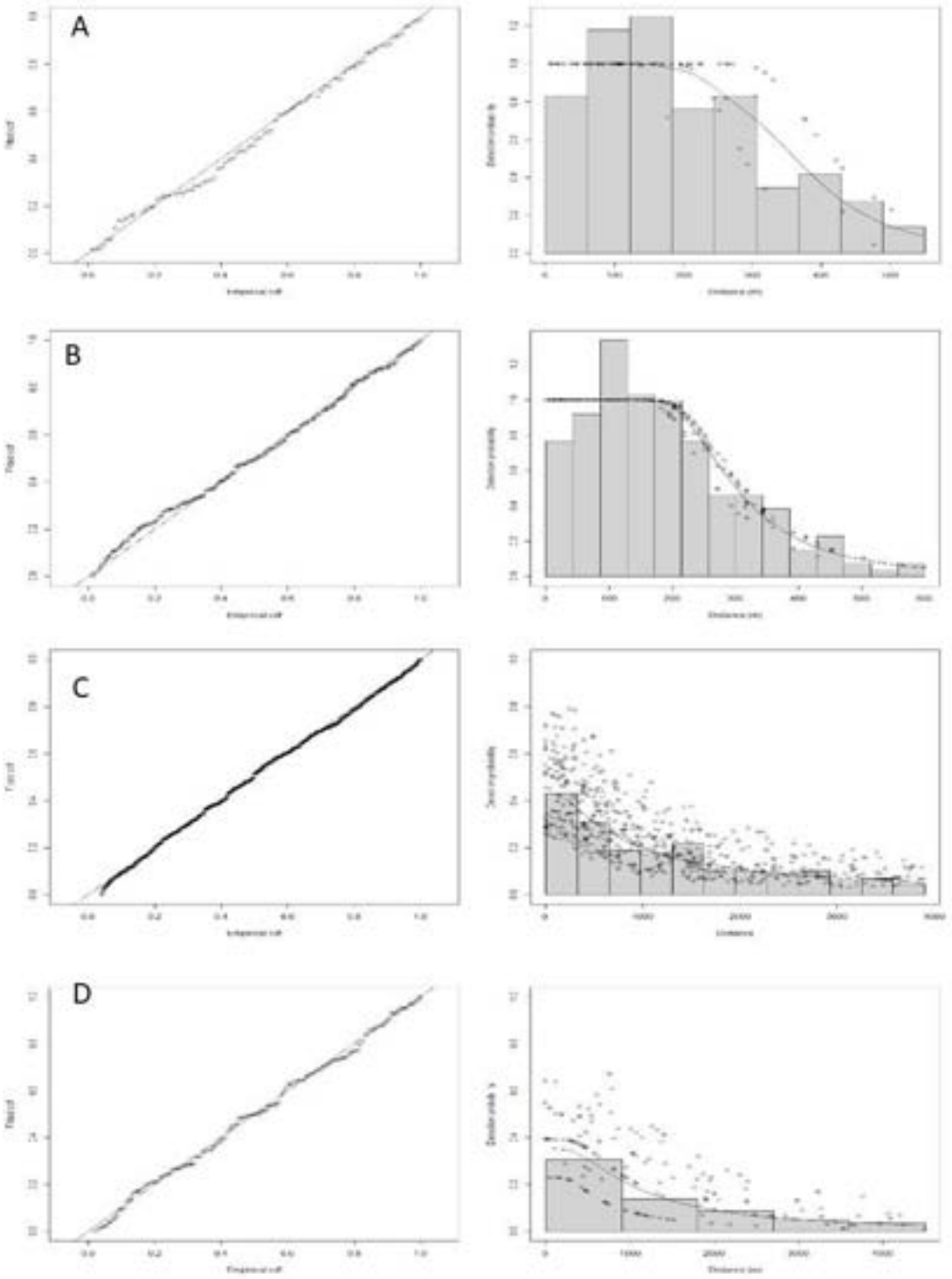

Figure B.9-3. Q-Q plots and detection functions from the Gervais' beaked whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 2; C) NE-shipboard analysis set 6; D) SE-shipboard analysis set 4.

B.9.3 Generalized Additive Model Analysis

Table B.9-3. 2010 to 2023 density-habitat model output for Gervais' beaked whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(depth)	2.26	5	12.67	33.57	<0.0001
s(poc)	0.96	4	5.82	8.80	<0.0001
s(dist2GSSw)	0.94	5	2.09	2.73	0.0005
s(dist1000)	1.13	5	4.98	6.35	<0.0001
s(dist2GSNw)	0.91	5	1.38	1.66	0.0042

Adjusted R^2 = 0.0781. Deviance explained = 53.1%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

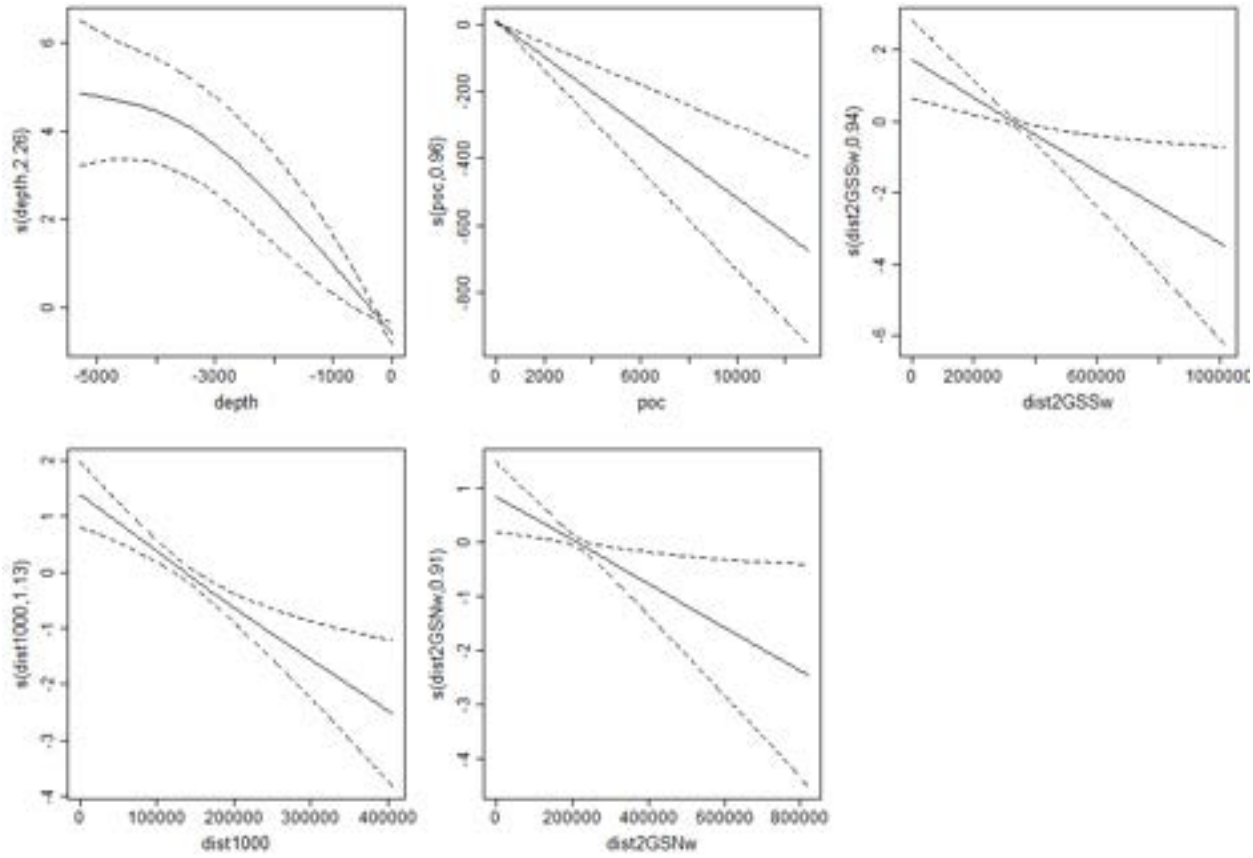

Figure B.9-4. Gervais beaked whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.9.4 Model Cross-Validation

Table B.9-4. Diagnostic statistics from the Gervais' beaked whale density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
MAPE	Mean absolute percentage error	Non-zero density	90.610	Fair to good
RHO	Spearman rank correlation	Non-zero density	0.1126	Fair to good
MAPE	Mean absolute percentage error	All data divided in 25 random samples	90.538	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.095	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.001	Excellent

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.9.5 Abundance Estimates for AMAPPS Study Area

Table B.9-5. Gervais' beaked whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	1,474	0.27	876 – 2,479
Summer (June–August)	2,815	0.23	1,804 – 4,393
Fall (September–November)	1,965	0.25	1,213 – 3,184
Winter (December–February)	1,001	0.33	533 – 1,880
Summer 2011 U.S. surveys[1]	7,092	0.54	3,690 – 13,631
Summer 2016 U.S. surveys[1]	10,107	0.27	7,215 – 14,158
Summer 2021 U.S. surveys[1]	8,595	0.24	5,405 – 13,667

[1]Hayes et al. 2024

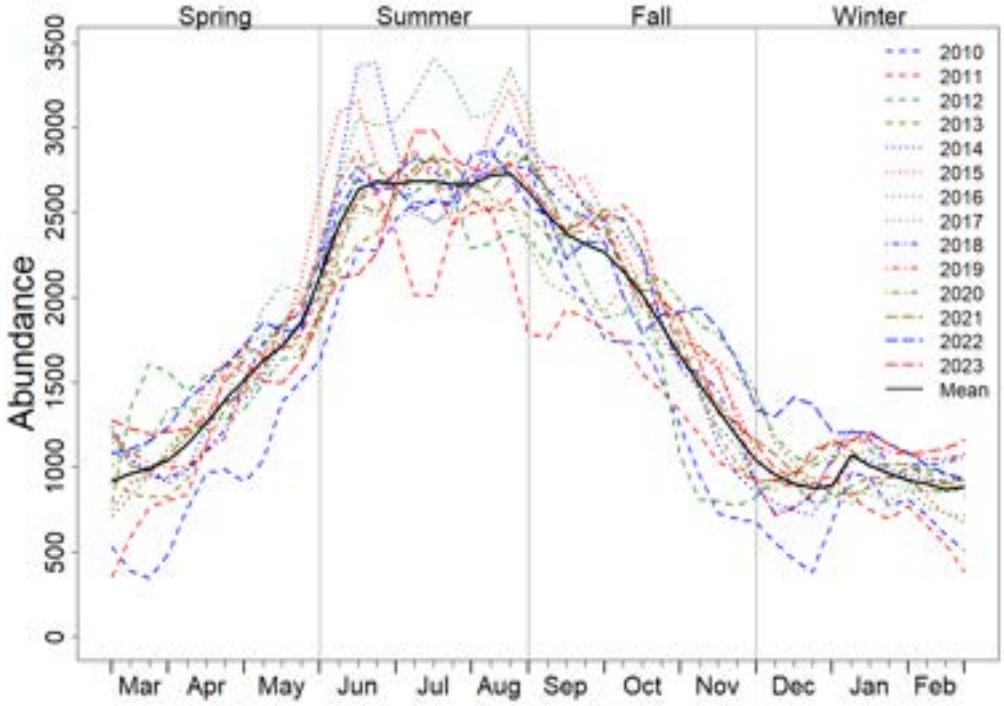

Figure B.9-5. Annual abundance trends for Gervais' beaked whales in the AMAPPS study area

B.9.6 Seasonal Prediction Maps

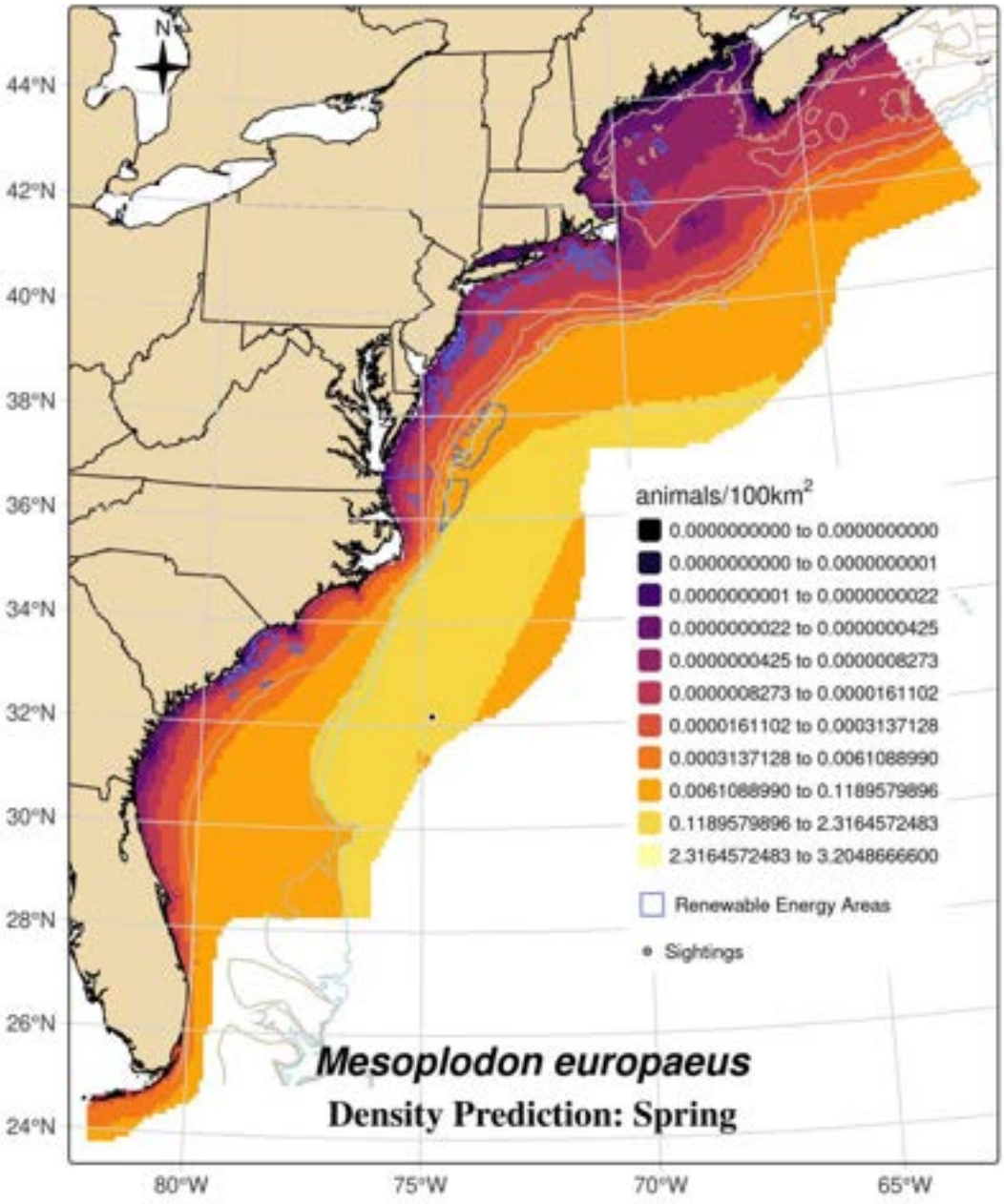

Figure B.9-6. Gervais' beaked whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas

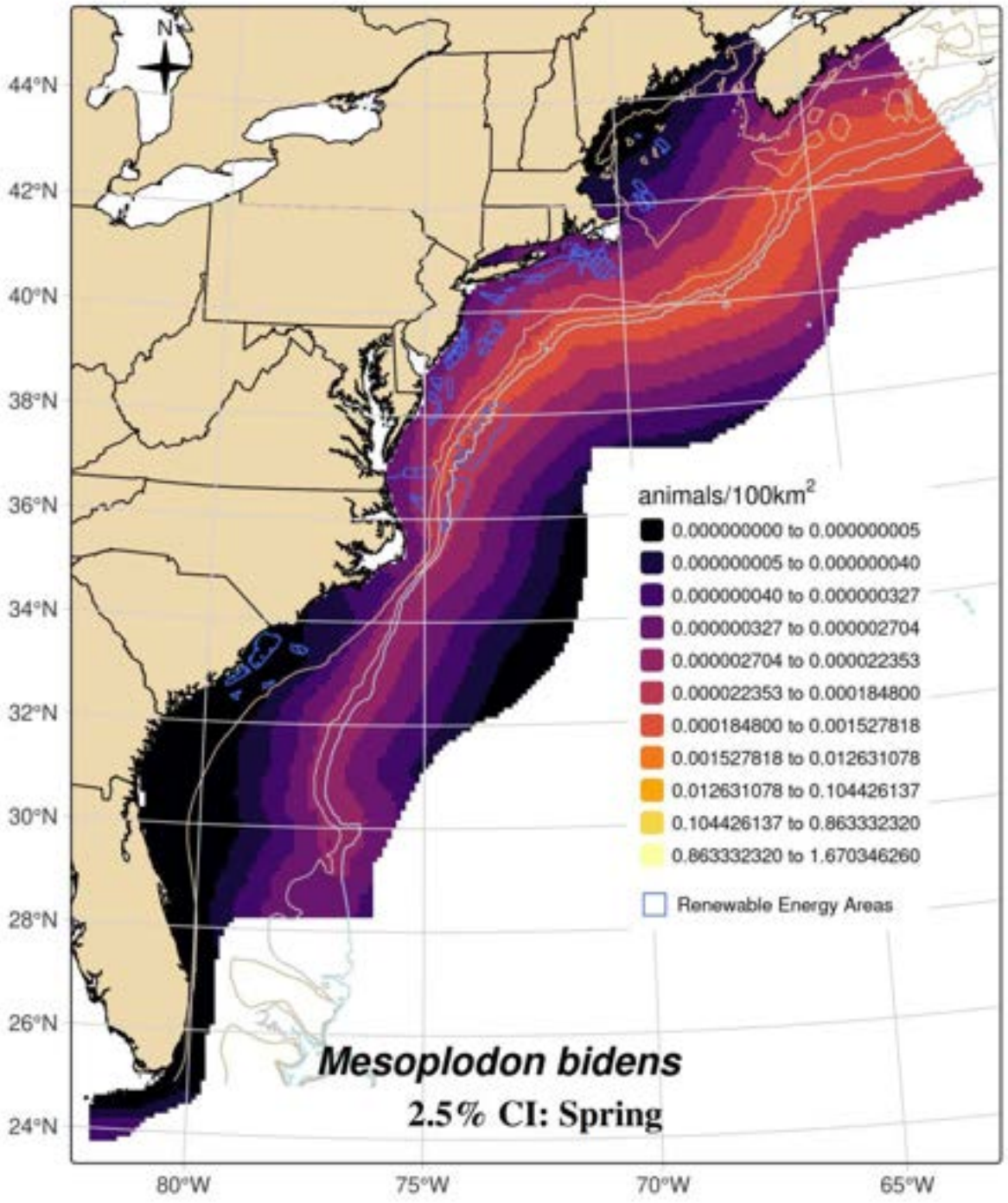

Figure B.9-7. Lower 2.5% confidence interval of spring Gervais' beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

Ervais’

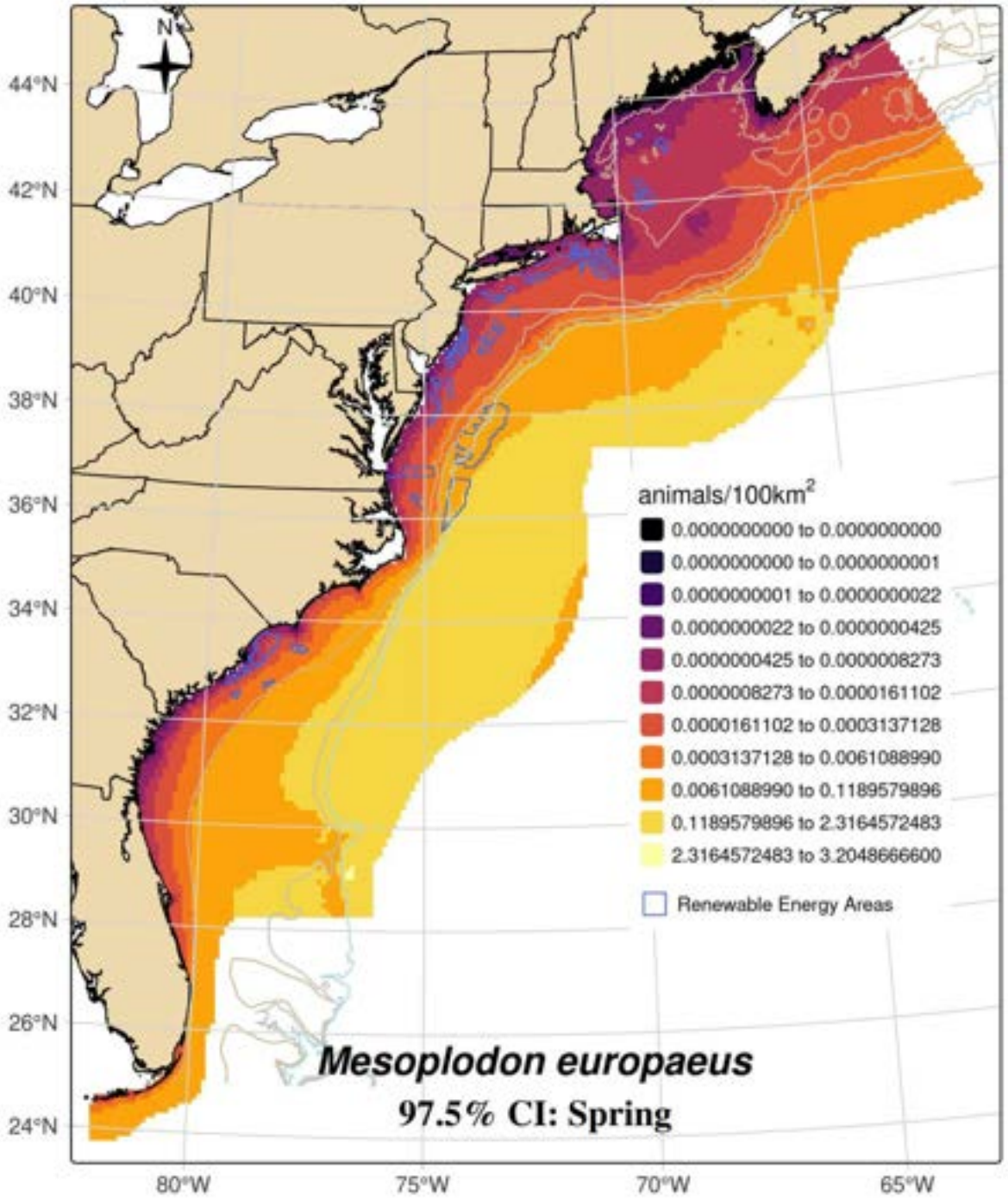

Figure B.9-8. Upper 97.5% confidence interval of spring Gervais’ beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

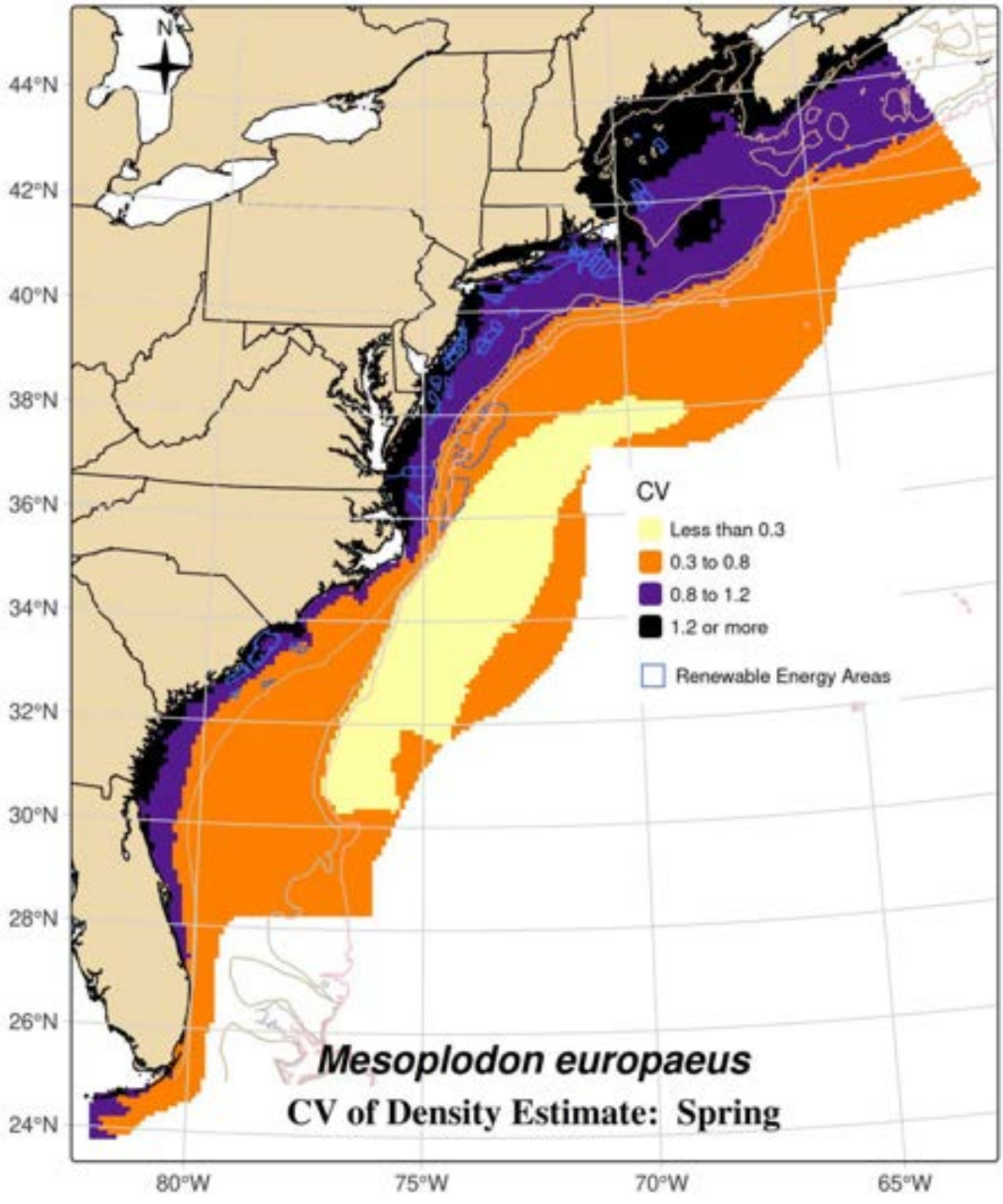

Figure B.9-9. CV of spring Gervais' whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

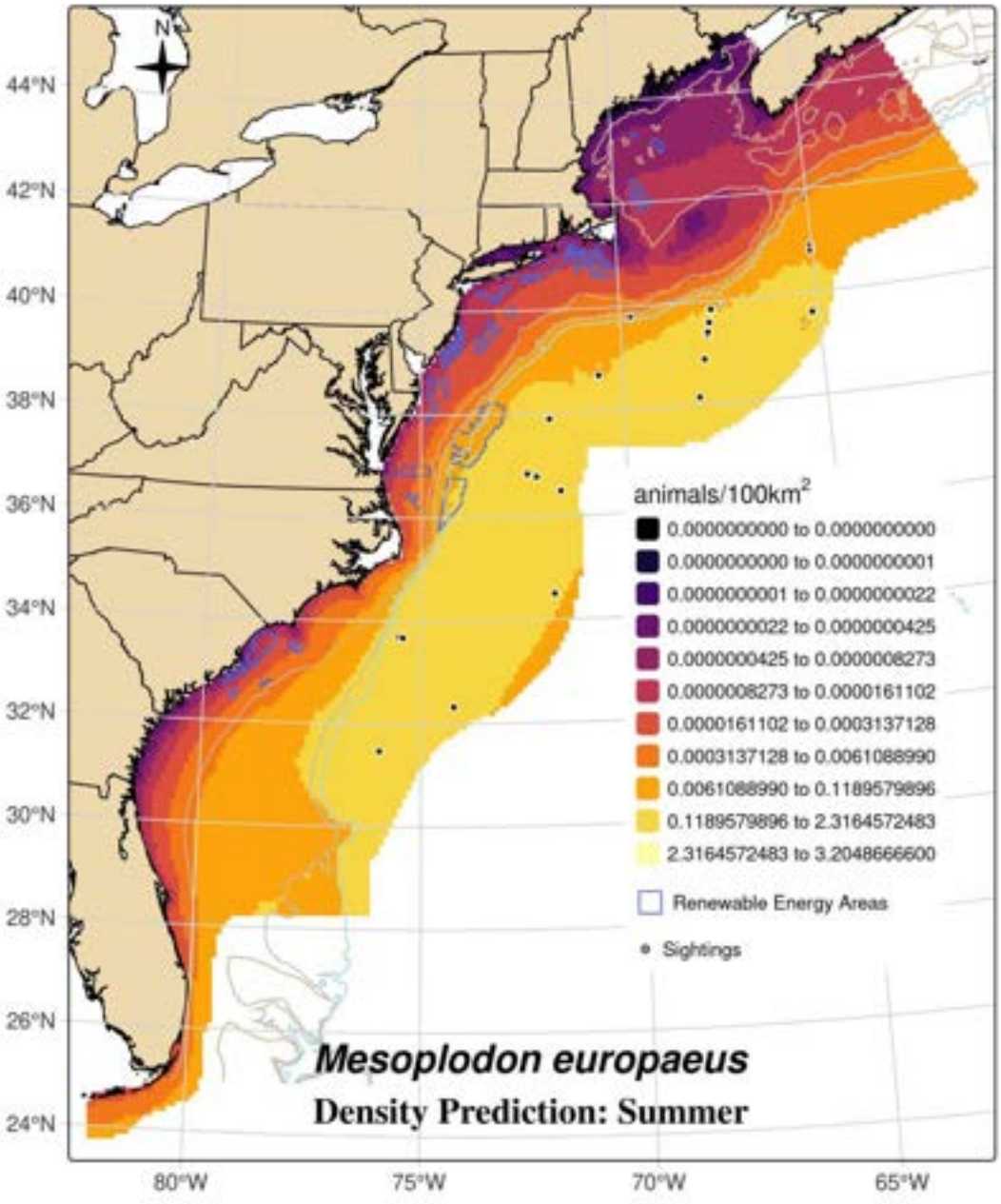

Figure B.9-10. Gervais' beaked whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas

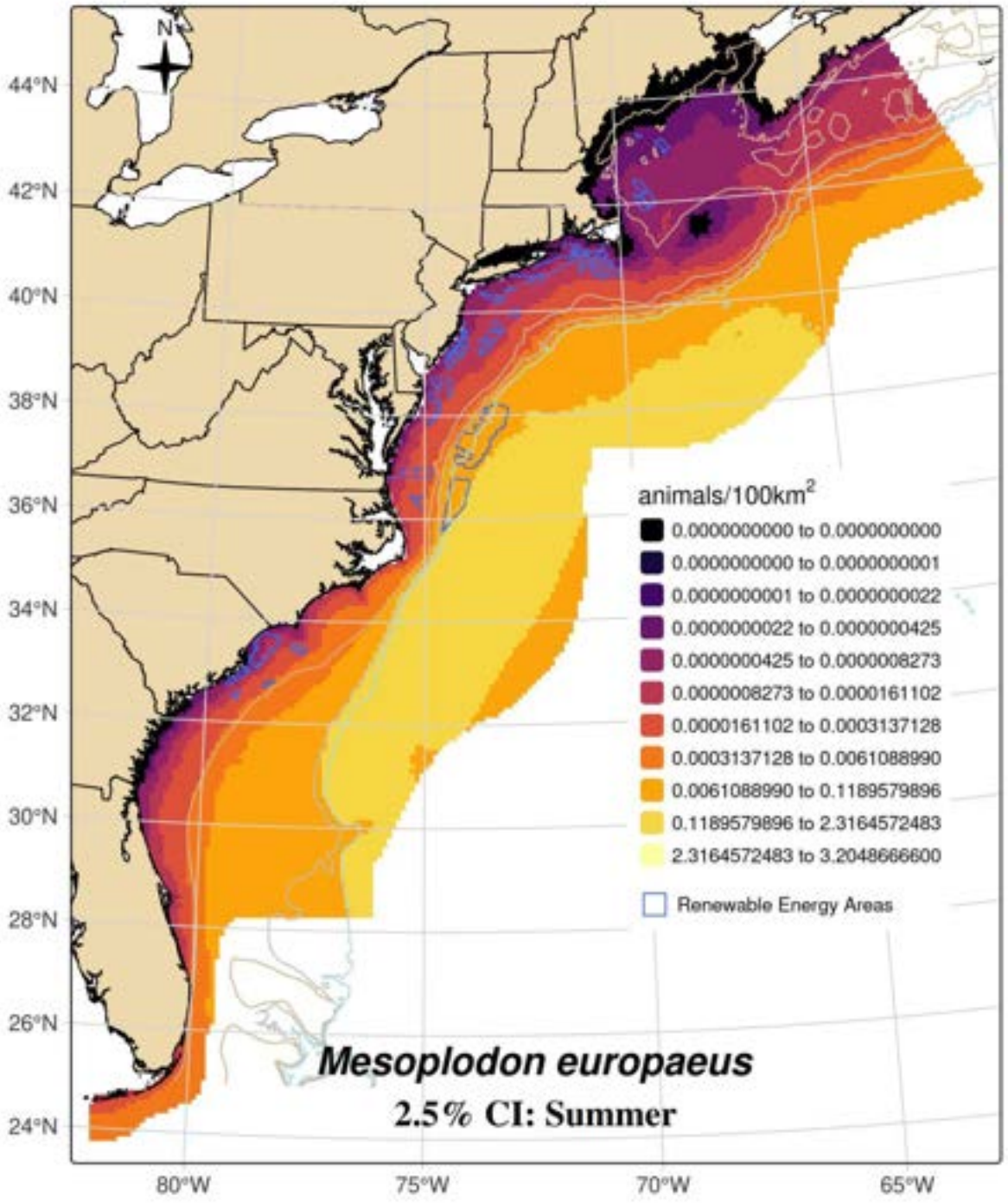

Figure B.9-11. Lower 2.5% confidence interval of summer Gervais' beaked whale density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

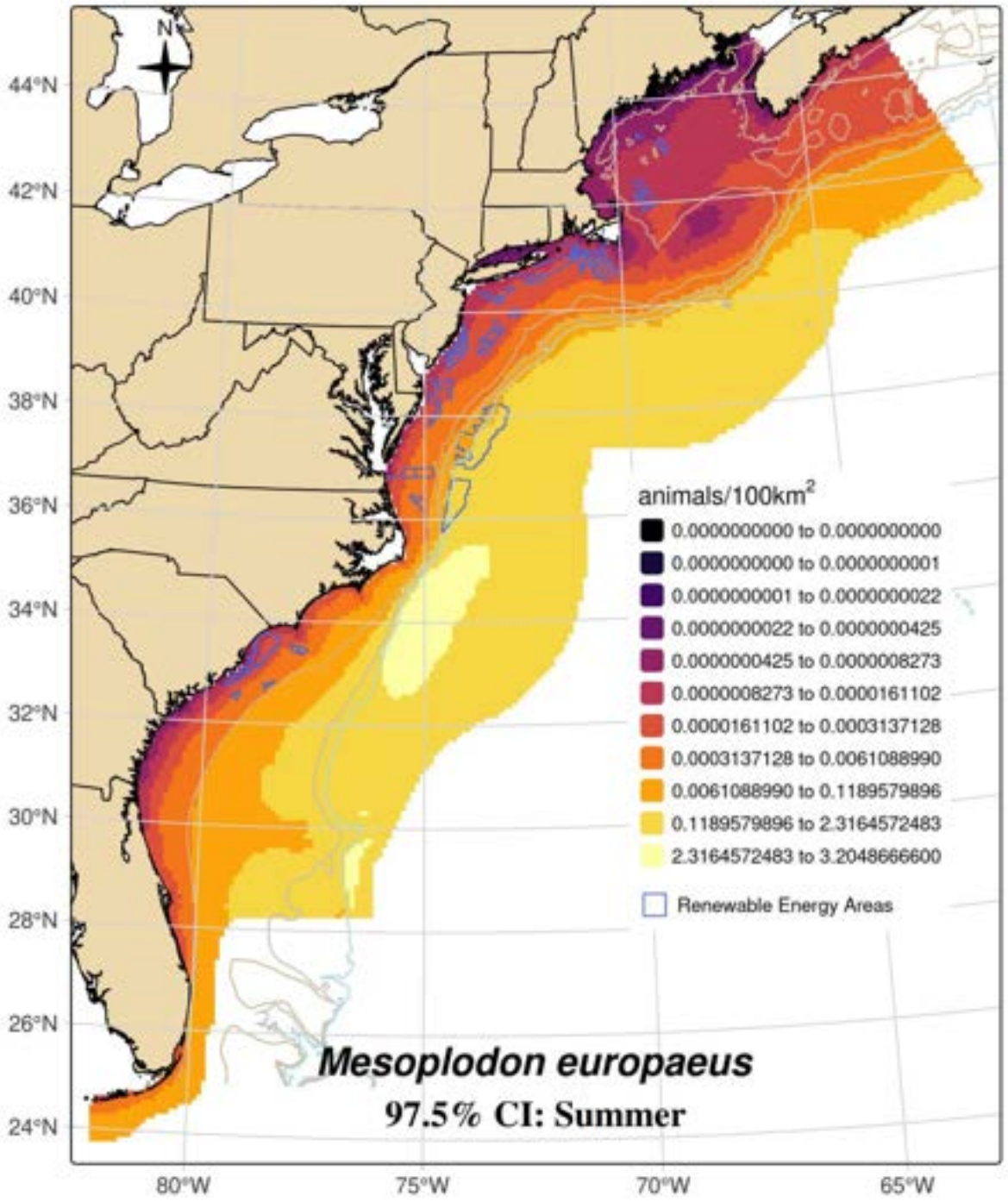

Figure B.9-12. Upper 97.5% confidence interval of summer Gervais' beaked whale density estimate
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

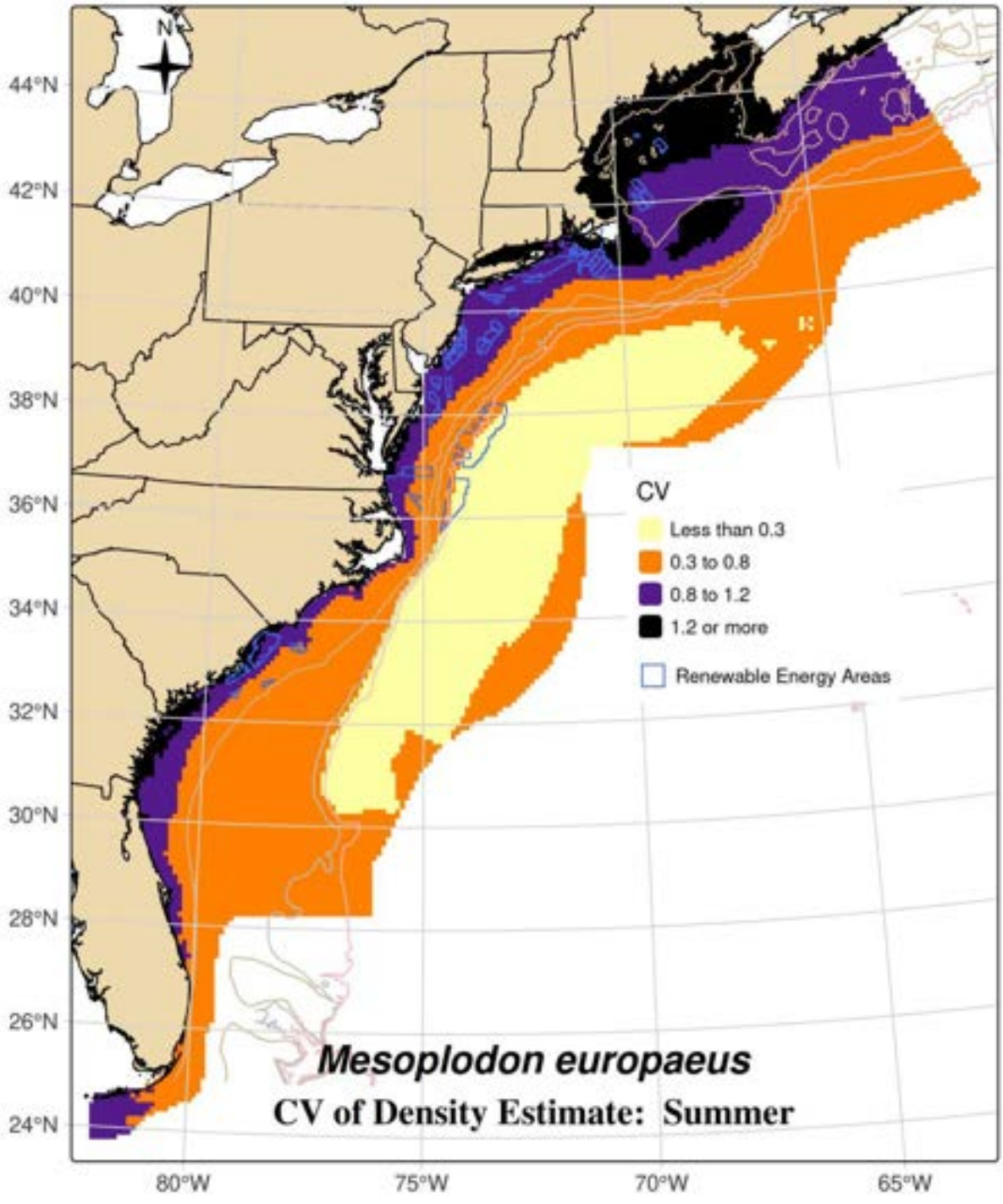

Figure B.9-13. CV of summer Gervais' beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

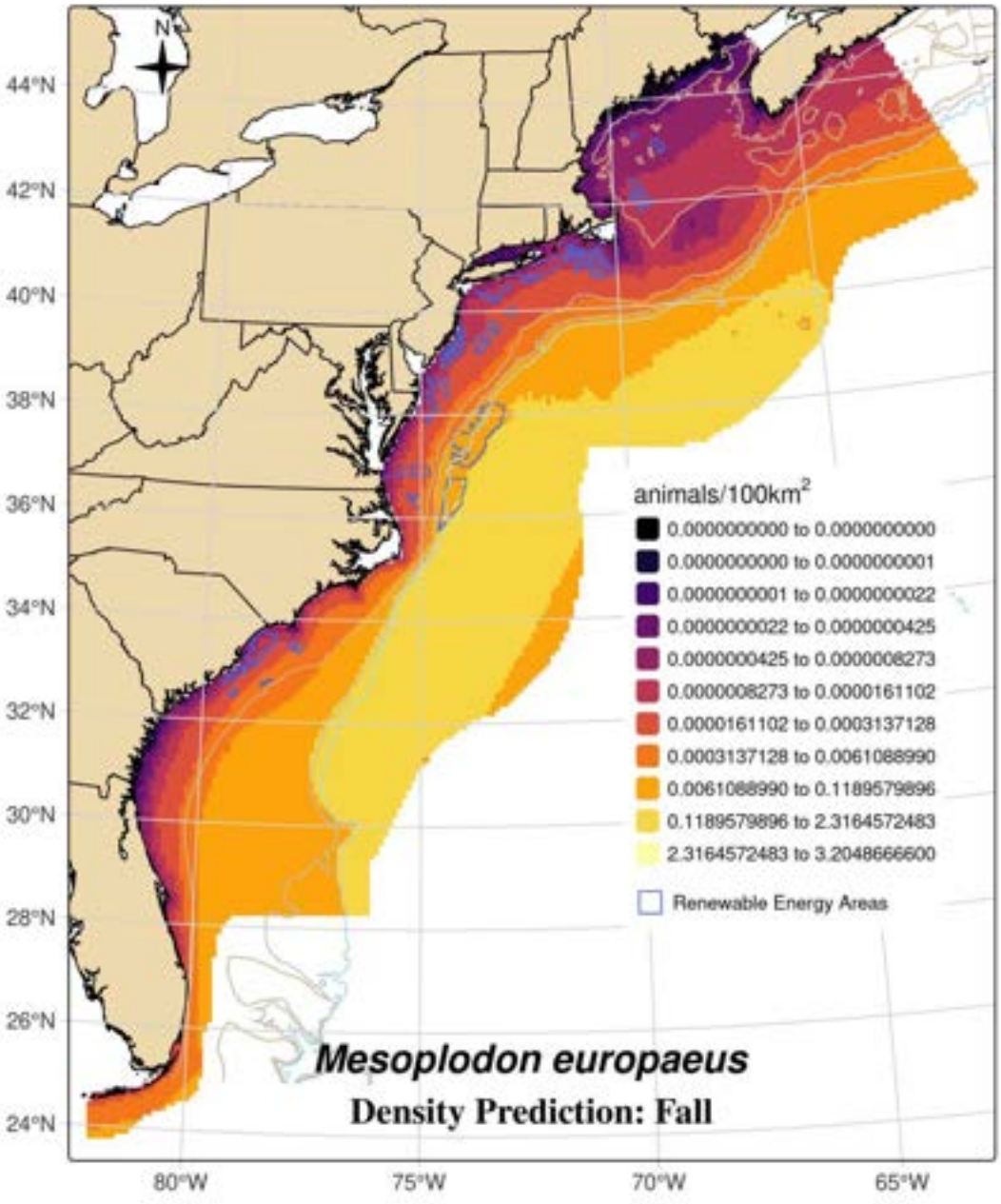

Figure B.9-14. Gervais' beaked whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas

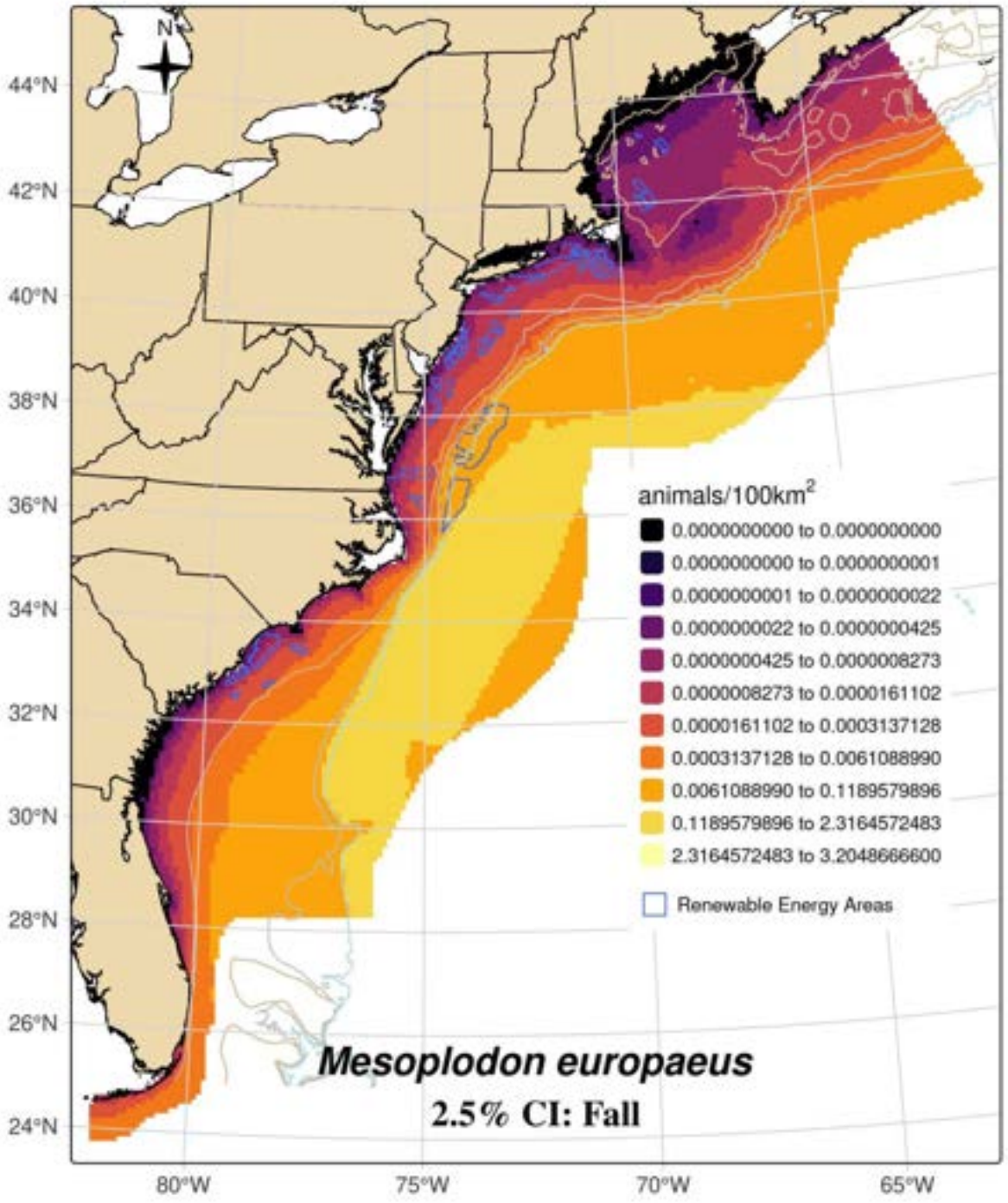

Figure B.9-15. Lower 2.5% confidence interval of the fall Gervais' beaked whale density estimates Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

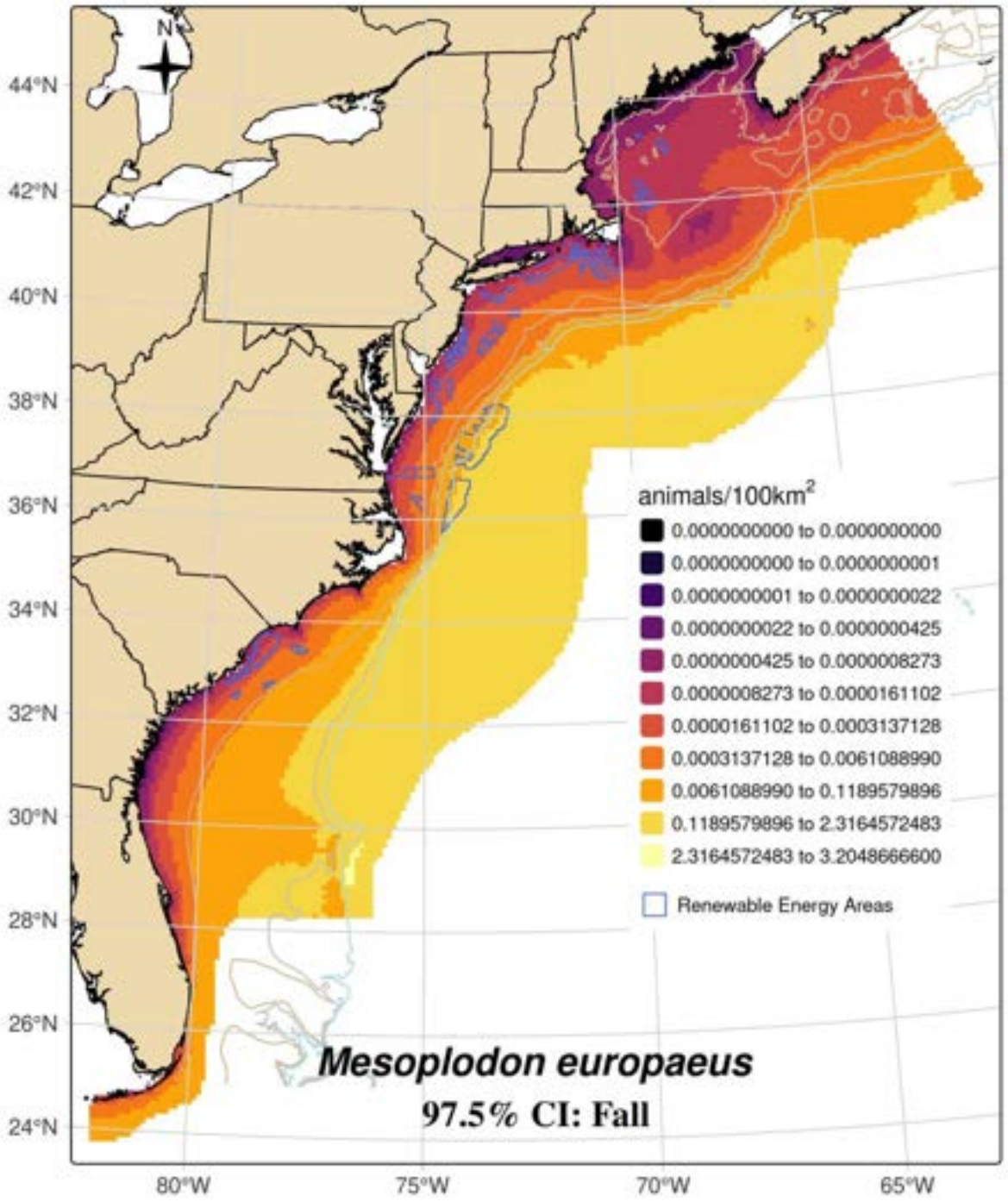

Figure B.9-16. Upper 97.5% confidence interval of the fall Gervais' beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

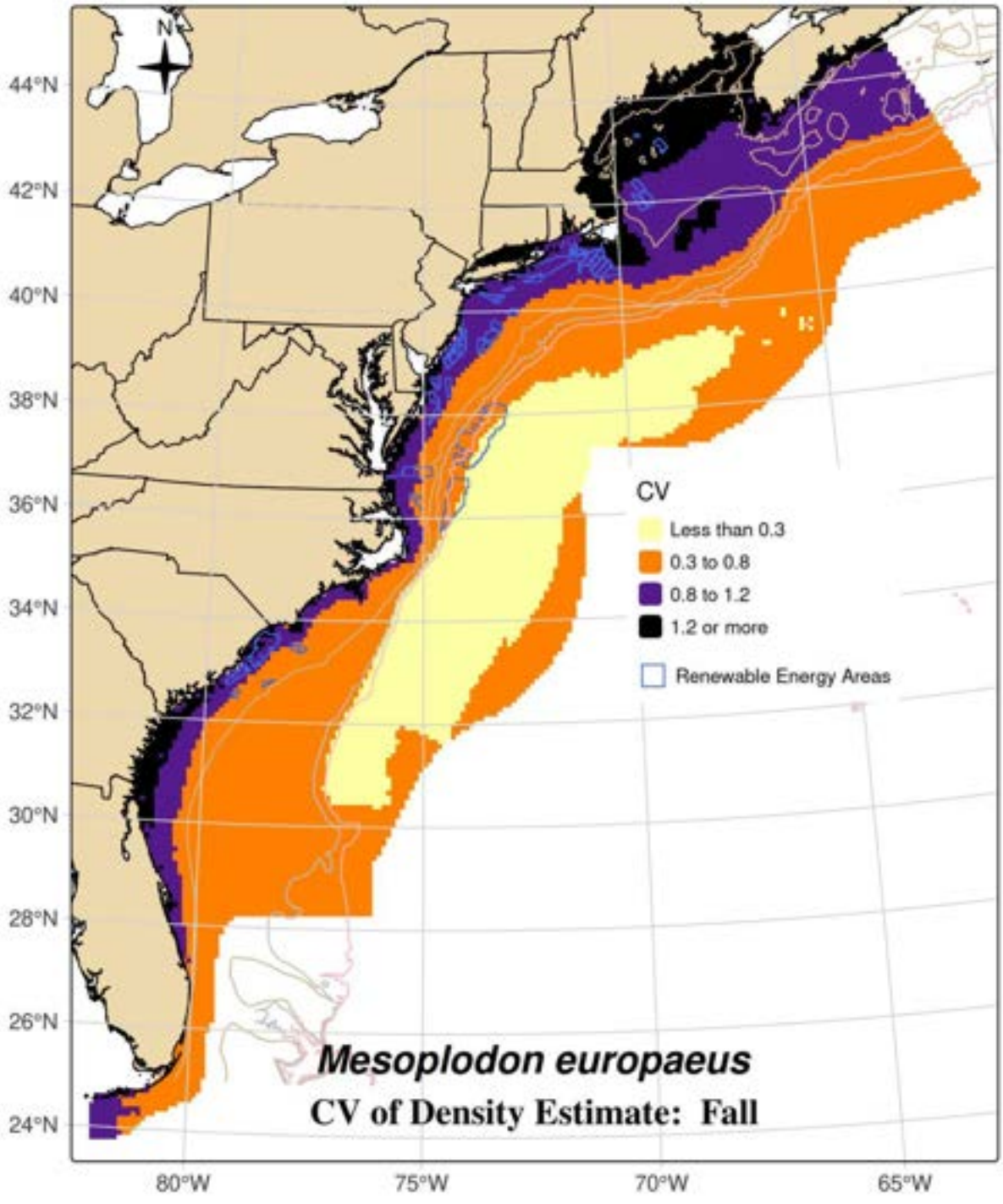

Figure B.9-17. CV of fall Gervais' beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

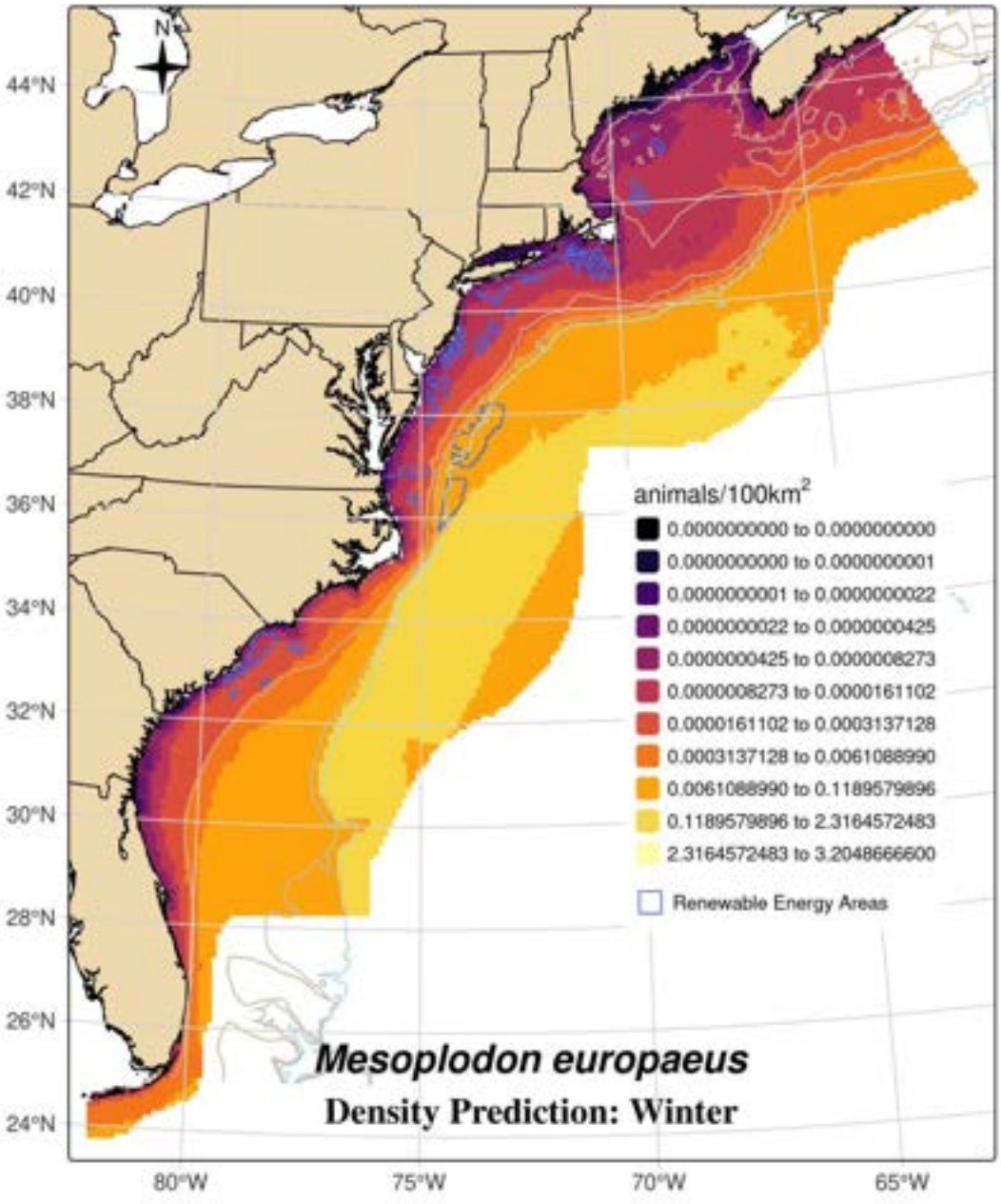

Figure B.9-18. Gervais' beaked whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas

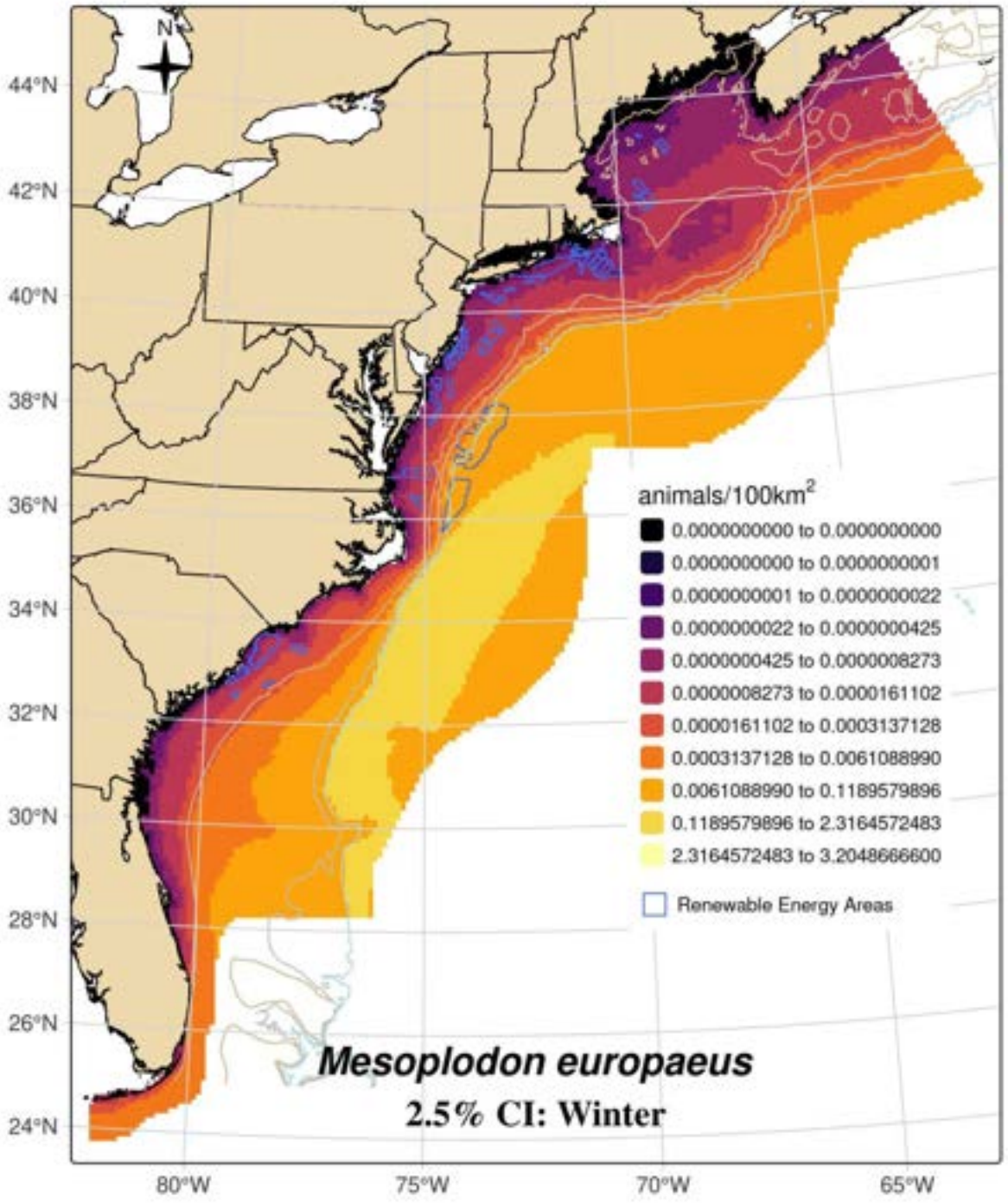

Figure B.9-19. Lower 2.5% confidence interval of winter Gervais' beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

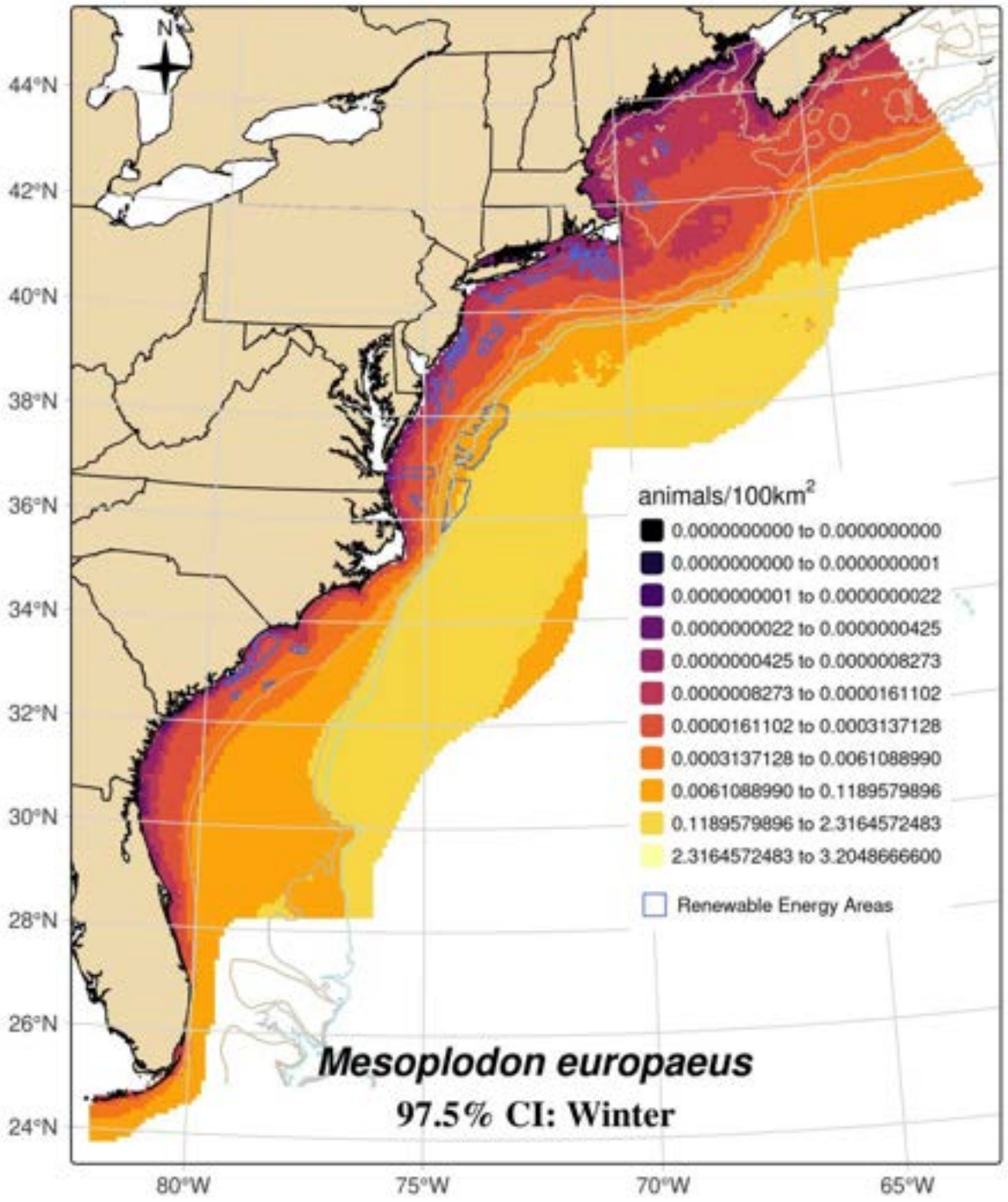

Figure B.9-20. Upper 97.5% confidence interval of winter Gervais' beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

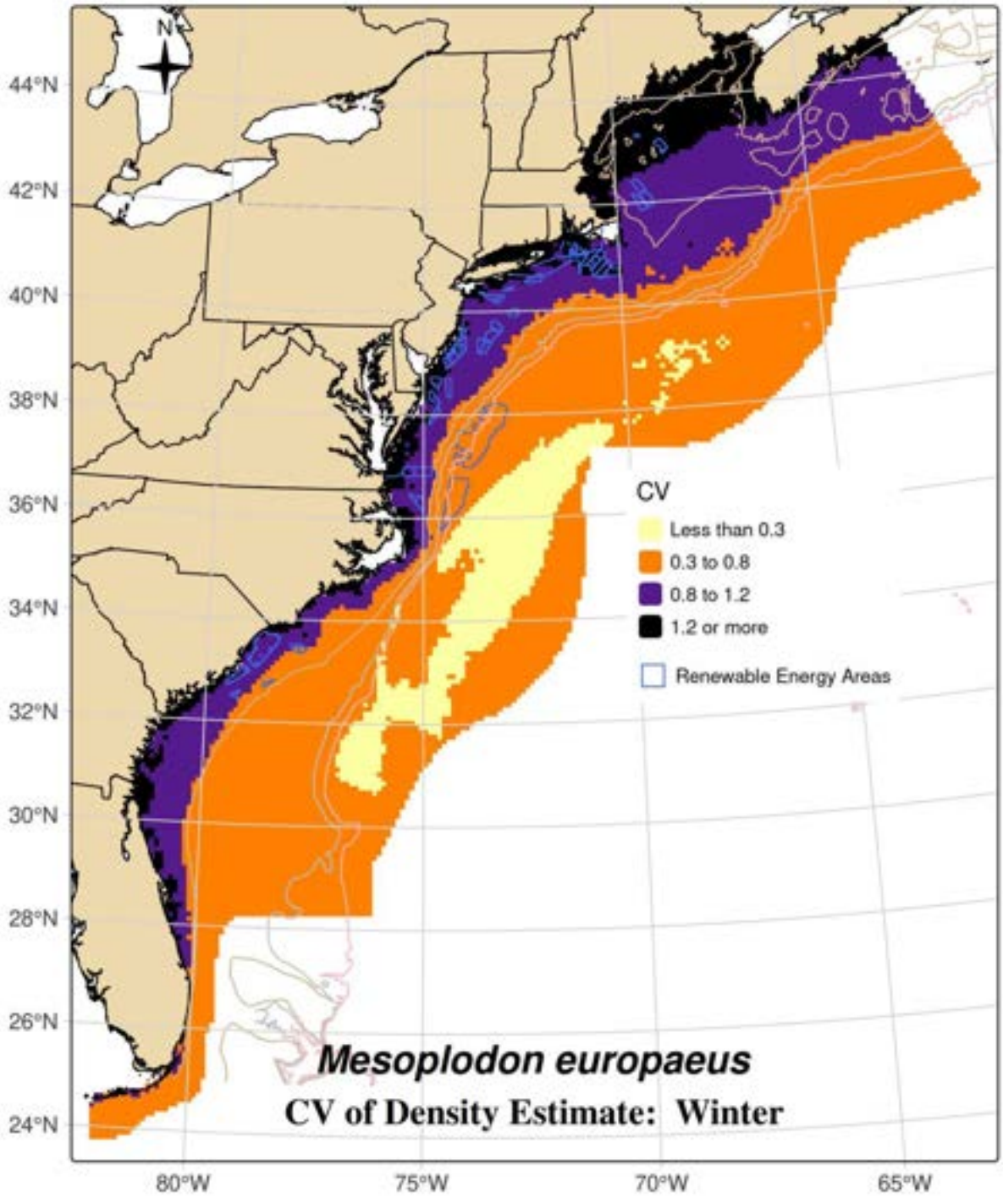

Figure B.9-21. CV of summer Gervais' beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.9.7 Offshore Energy Development Areas

Table B.9-6. Gervais' beaked whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	0	1.02	0 - 0
	NY	0	1.1	0 - 0
	NJ	0	1.25	0 - 0
	DE/MD	0	1.15	0 - 0
	VA	0	1.02	0 - 0
	NC	0	0.85	0 - 0
	NC/SC	0	0.68	0 - 0.1
	GA	0	1.24	0 - 0
	FL	0.1	0.61	0 - 0.2
Summer (Jun-Aug)	RI/MA	0	0.84	0 - 0
	NY	0	0.96	0 - 0
	NJ	0	0.93	0 - 0
	DE/MD	0	0.87	0 - 0
	VA	0	0.8	0 - 0
	NC	0	0.7	0 - 0.1
	NC/SC	0	0.68	0 - 0.1
	GA	0	1.26	0 - 0
	FL	0.1	0.62	0 - 0.2
Fall (Sep-Nov)	RI/MA	0	0.85	0 - 0
	NY	0	0.95	0 - 0
	NJ	0	0.93	0 - 0
	DE/MD	0	0.89	0 - 0
	VA	0	0.82	0 - 0
	NC	0	0.74	0 - 0
	NC/SC	0	0.68	0 - 0.1
	GA	0	1.37	0 - 0
	FL	0.1	0.6	0 - 0.2
Winter (Dec-Feb)	RI/MA	0	0.98	0 - 0
	NY	0	1.03	0 - 0
	NJ	0	1.09	0 - 0
	DE/MD	0	0.99	0 - 0
	VA	0	1	0 - 0
	NC	0	0.84	0 - 0
	NC/SC	0	0.76	0 - 0
	GA	0	1.1	0 - 0
	FL	0.1	0.55	0 - 0.1

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

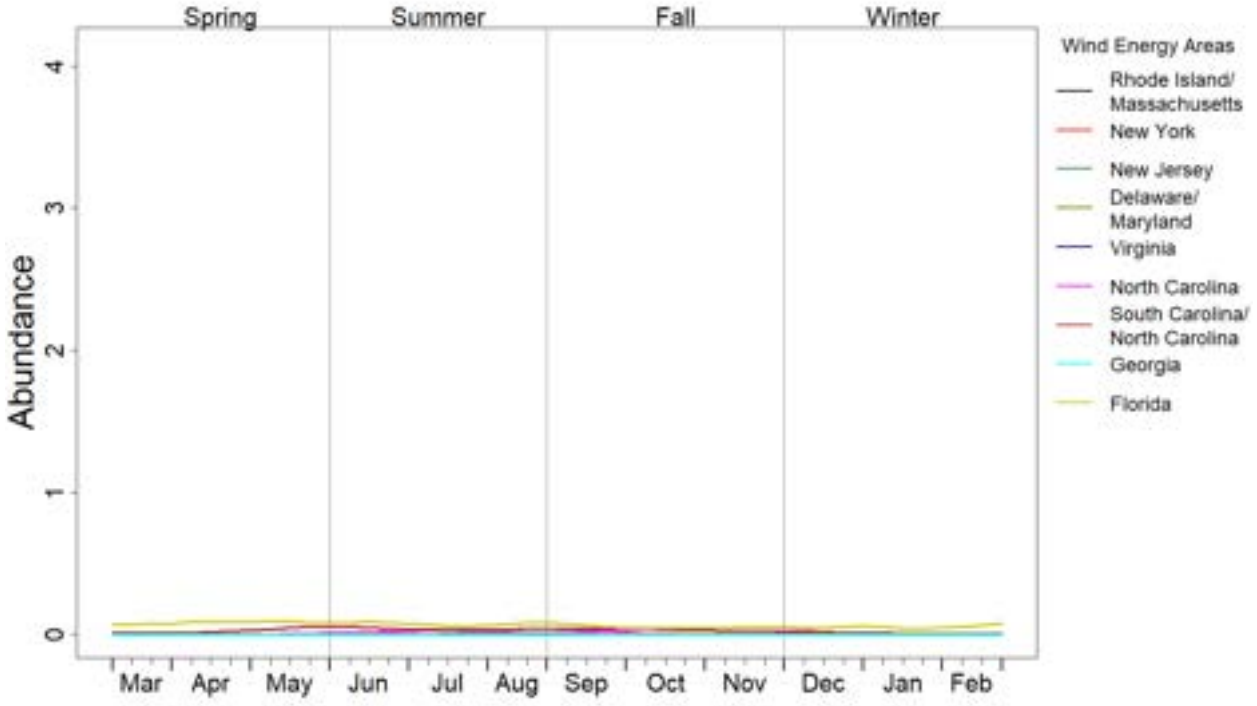

Figure B.9-22. Average seasonal abundance of Gervais' beaked whales in wind-energy study areas

B.10 True's Beaked Whales

Figure B.10-1. True's beaked whales
Image Credit: Marine Mammal Stranding Center

B.10.1 Data Collection

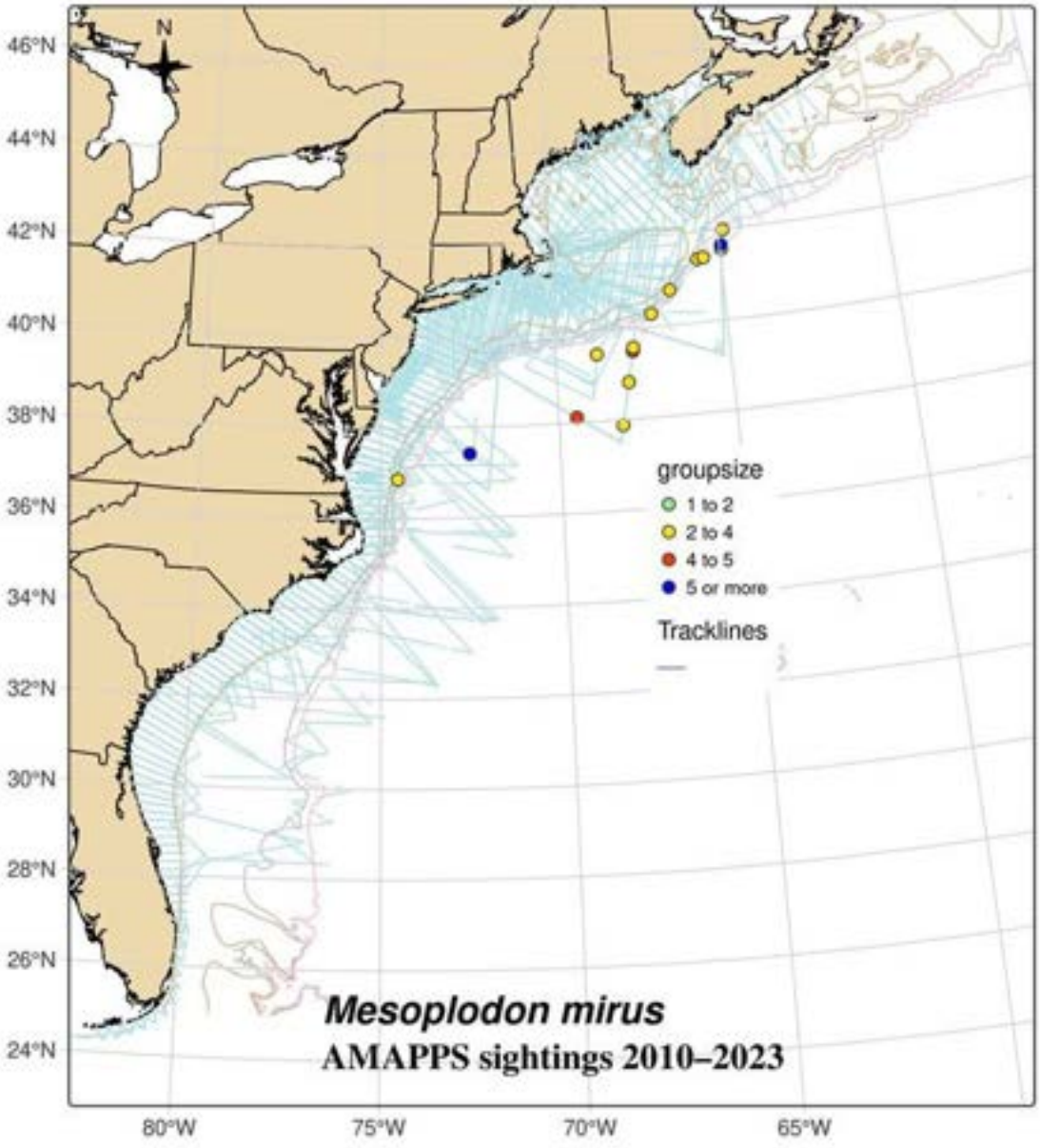

Figure B.10-2. Distribution of track lines and True's beaked whale sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.10-1. AMAPPS research effort 2010 to 2023 and True's beaked whale sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	0	0
NE Shipboard	Summer	49,064	64	166
NE Aerial	Spring	38,839	0	0
NE Aerial	Summer	52,003	0	0
NE Aerial	Fall	87,311	0	0
NE Aerial	Winter	24,747	0	0
SE Shipboard	Spring	2,604	0	0
SE Shipboard	Summer	18,331	2	3
SE Shipboard	Fall	2,673	0	0
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	0	0
SE Aerial	Summer	43,285	0	0
SE Aerial	Fall	21,153	0	0
SE Aerial	Winter	19,152	0	0

B.10.2 Mark-Recapture Distance Sampling Analysis

Table B.10-2. Intermediate parameters in True's beaked whale mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	p(0)	p(0) CV	Chi-square p-value	CvM p-value
SE–aerial group 4	distance + observer + quality + glare	550	Distance + quality	550	HR	0.86	0.07	0.15
NE–aerial group 2	distance * observer + log(group size) + sea state	380	distance + sea state + glare	600	HR	0.75	0.07	0.06
NE–shipboard group 6	distance * observer + log(group size) + sea state	3900	distance + glare + time of day	3900	HR	0.37	0.13	0.14
SE–shipboard group 4	distance * observer + log(group size)	5000	Distance + log(group size)	5000	HR	0.35	0.29	0.28

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

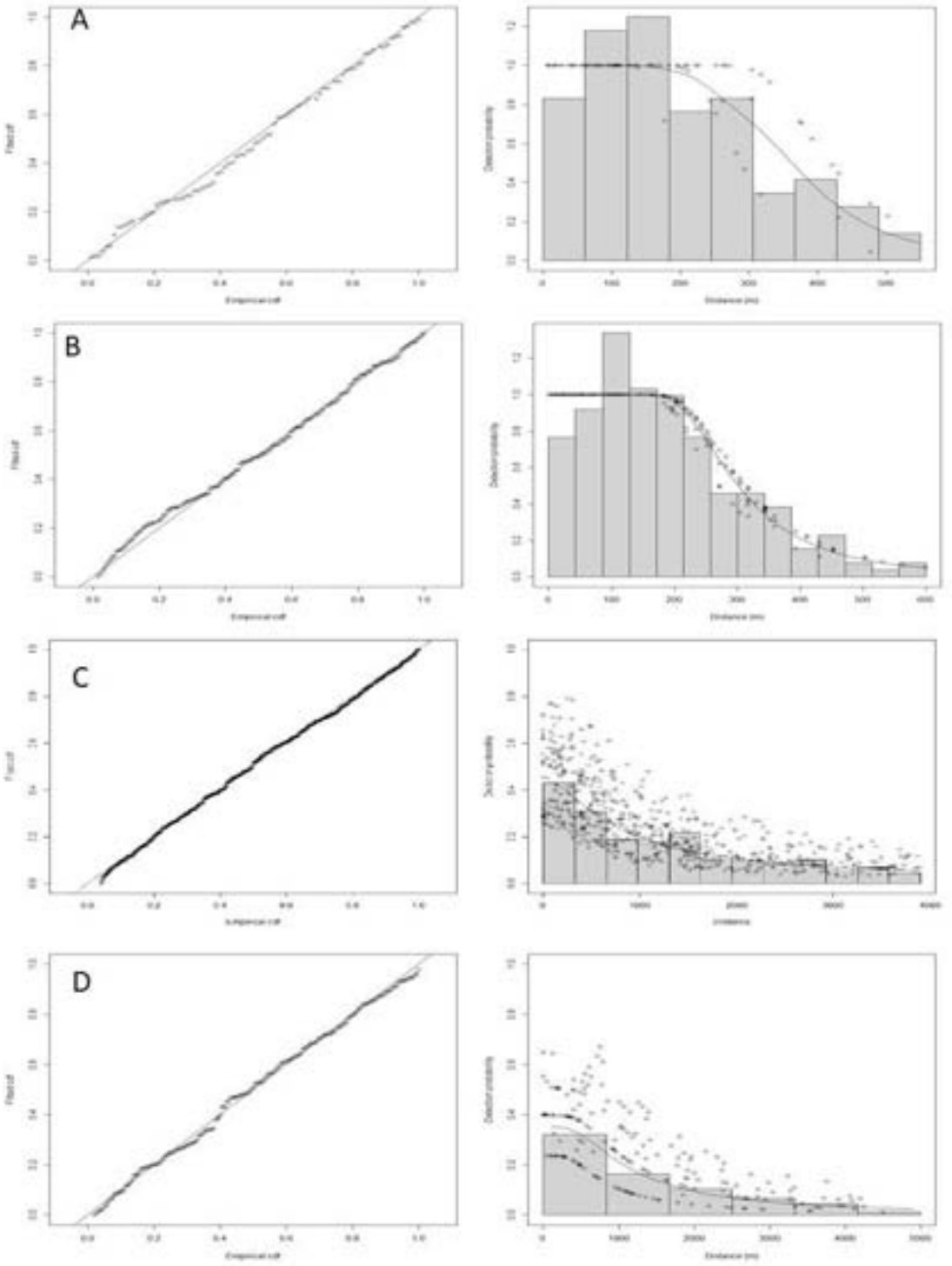

Figure B.10-3. Q-Q plots and detection functions from the True's beaked whale MRDS analyses
A) SE-aerial analysis set 4; B) NE-aerial analysis set 2; C) NE-shipboard analysis set 6; D) SE-shipboard analysis set 4.

B.10.3 Generalized Additive Model Analysis

Table B.10-3. 2010 to 2023 density-habitat model output for True's beaked whales

Covariates	Edf	Ref.df	F	C.dev	p-value
s(chla)	0.94	9	1.55	7.35	0.0001
s(depth)	3.05	9	2.24	17.00	<0.0001
s(latdd)	1.06	9	2.28	12.60	<0.0001

Adjusted R^2 =0.0372. Deviance explained = 37%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

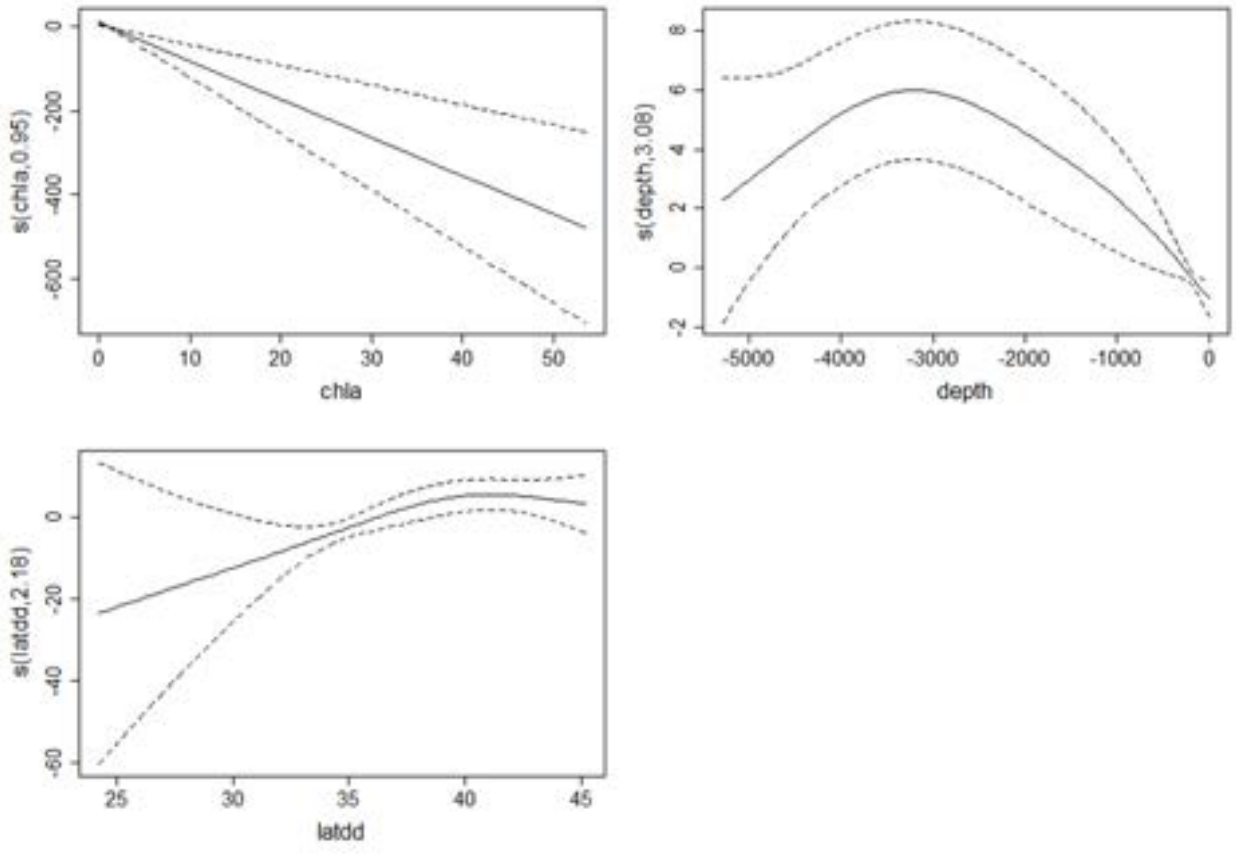

Figure B.10-4. True's beaked whale density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.10.4 Model Cross-Validation

Table B.10-4. Diagnostic statistics from the True's beaked whale density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
RHO	Spearman rank correlation	Non-zero density	0.351	Excellent
MAPE	Mean absolute percentage error	Non-zero density	91.943	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.065	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.0004	Excellent
MAPE	Mean absolute percentage error	All data divided in 25 random samples	91.928	Fair to good

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.10.5 Abundance Estimates for AMAPPS Study Area

Table B.10-5. True's beaked whale average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	165	0.59	57 – 482
Summer (June–August)	851	0.45	367 – 1,975
Fall (September–November)	467	0.50	185 – 1,179
Winter (December–February)	284	0.53	107 – 753
Summer 2011 U.S. surveys[1]	7,092	0.54	3,690 – 13,631
Summer 2016 U.S. surveys[1]	10,107	0.27	7,215 – 14,158
Summer 2021 U.S. surveys[1]	4,480	0.34	2,343 – 8,567

[1]Hayes et al. 2024

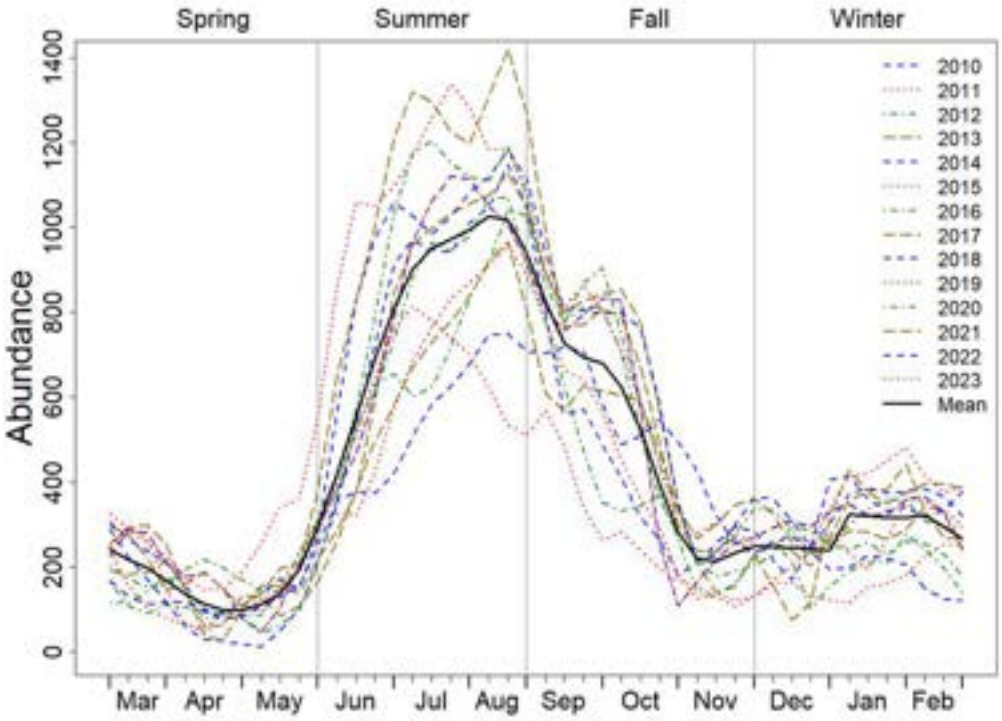

Figure B.10-5. Annual abundance trends for True's beaked whales in the AMAPPS study area

B.10.6 Seasonal Prediction Maps

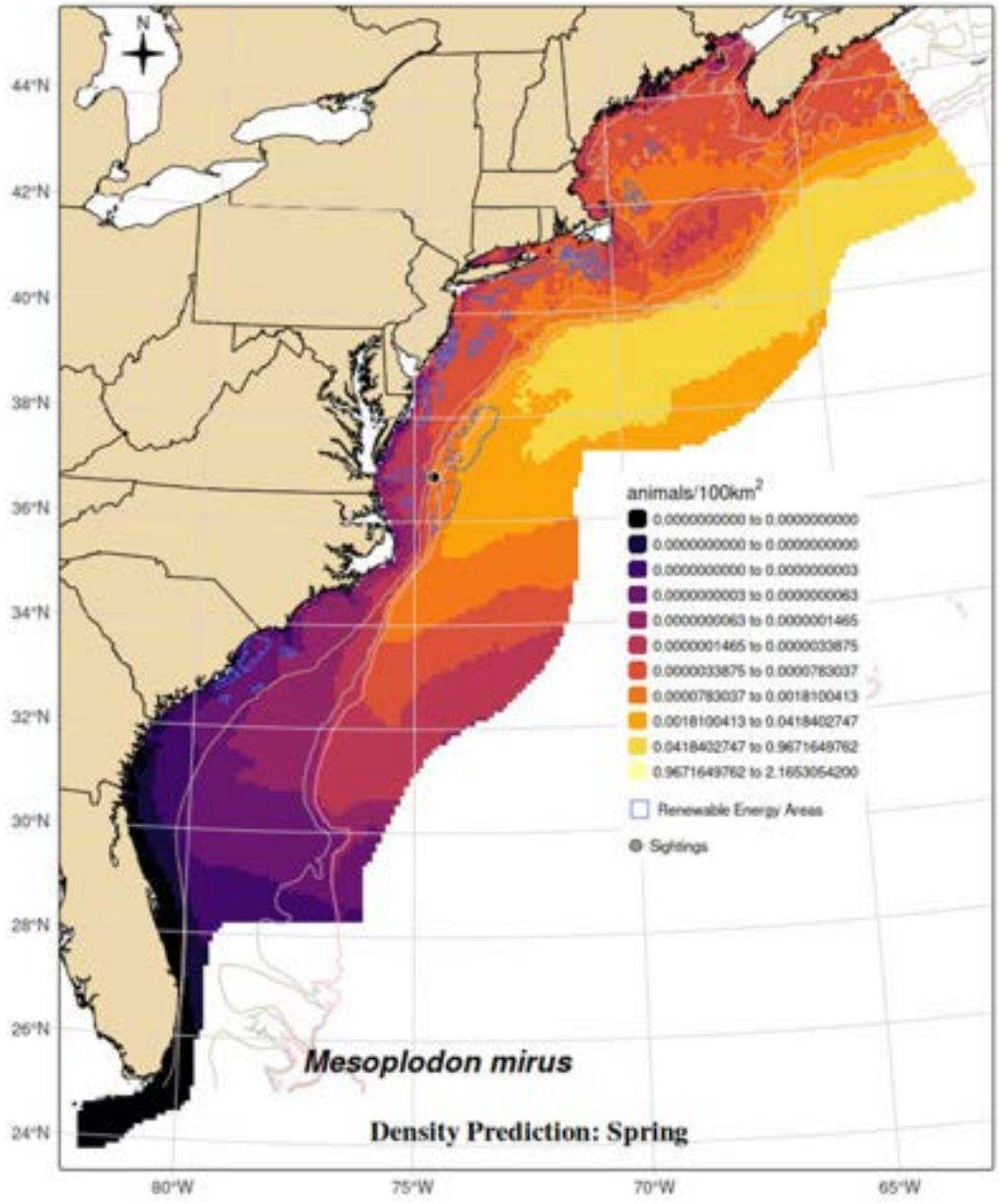

Figure B.10-6. True's beaked whale spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

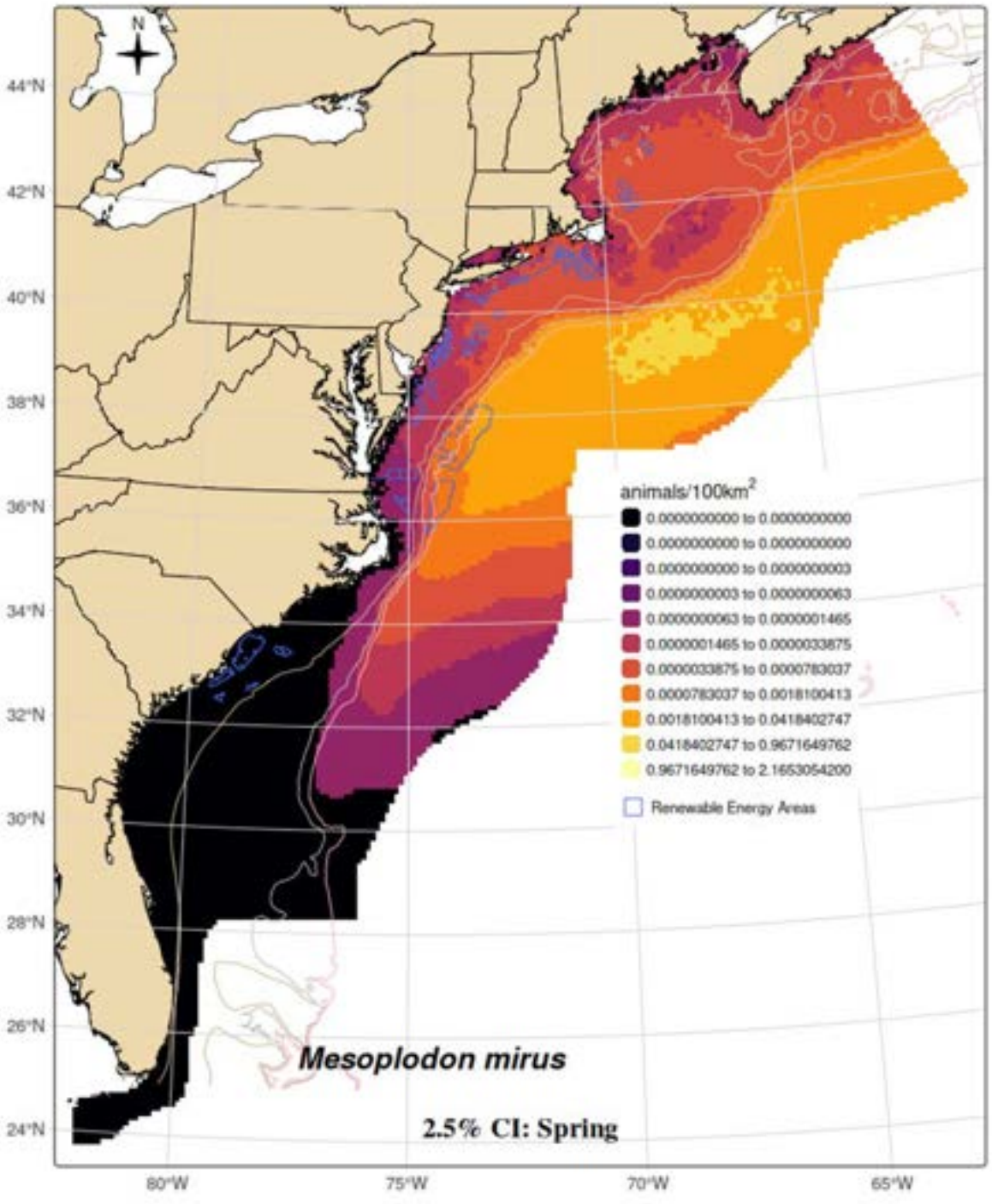

Figure B.10-7. Lower 2.5% confidence interval of spring True's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

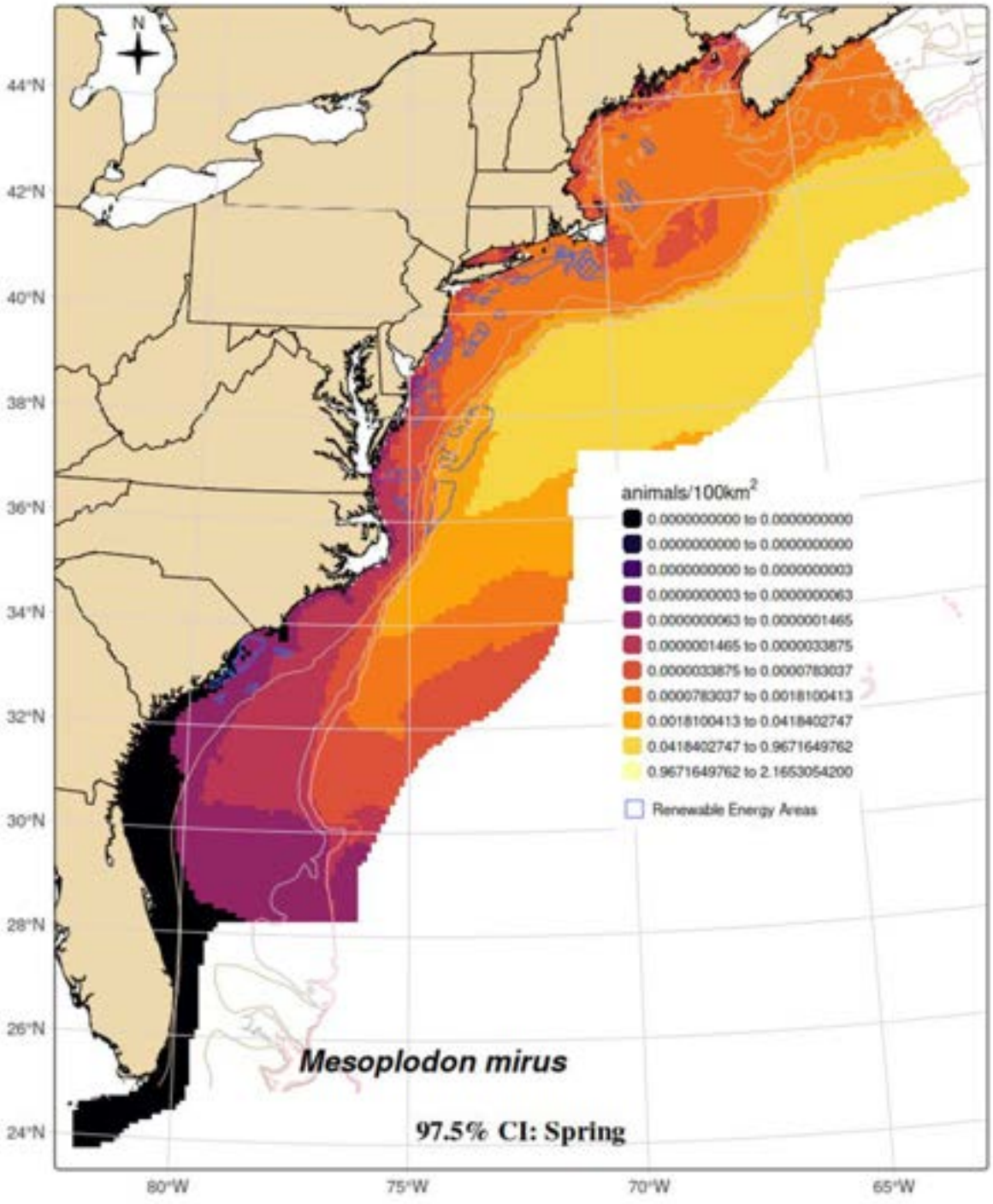

Figure B.10-8. Upper 97.5% confidence interval of spring True's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

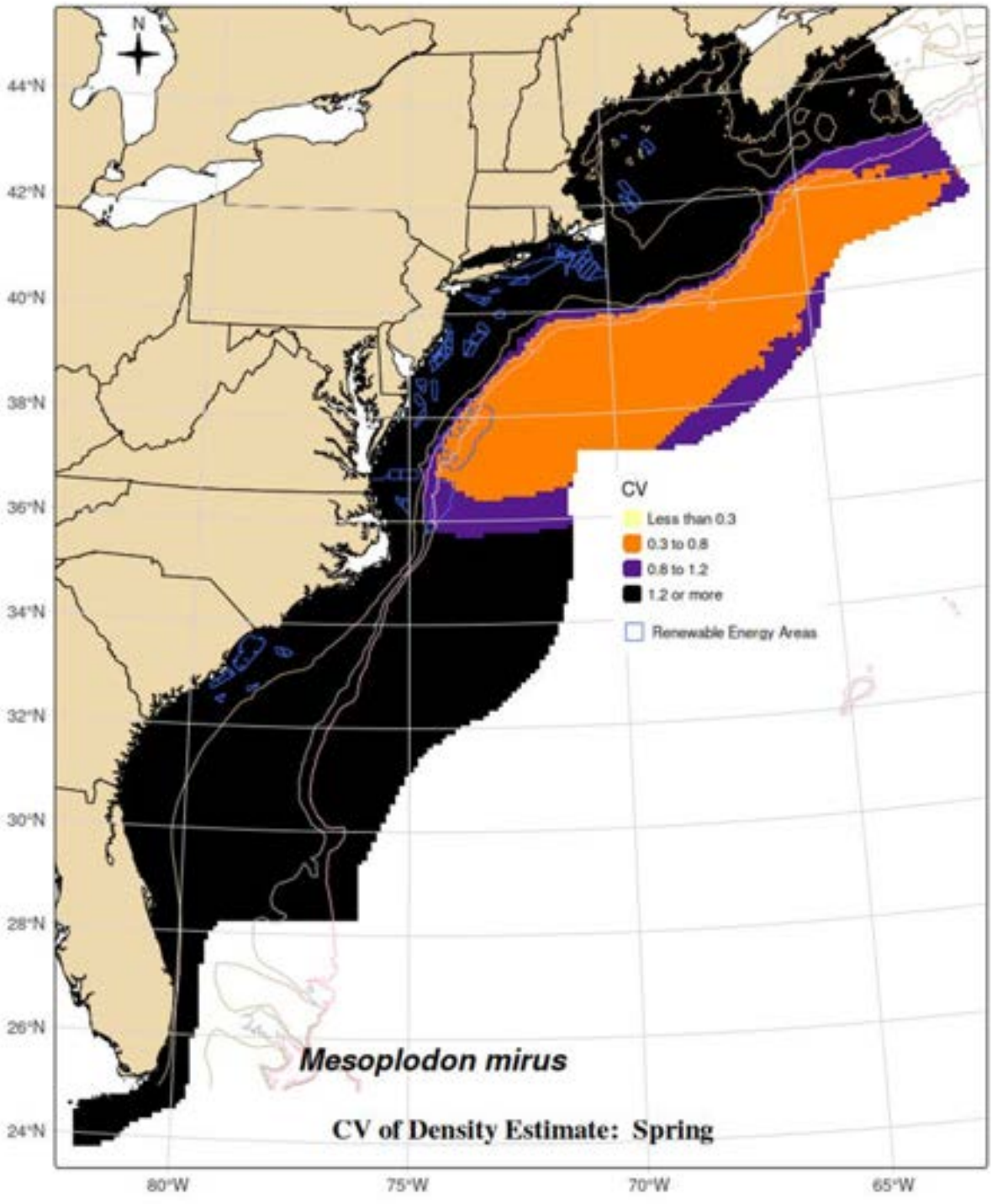

Figure B.10-9. CV of spring True's whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

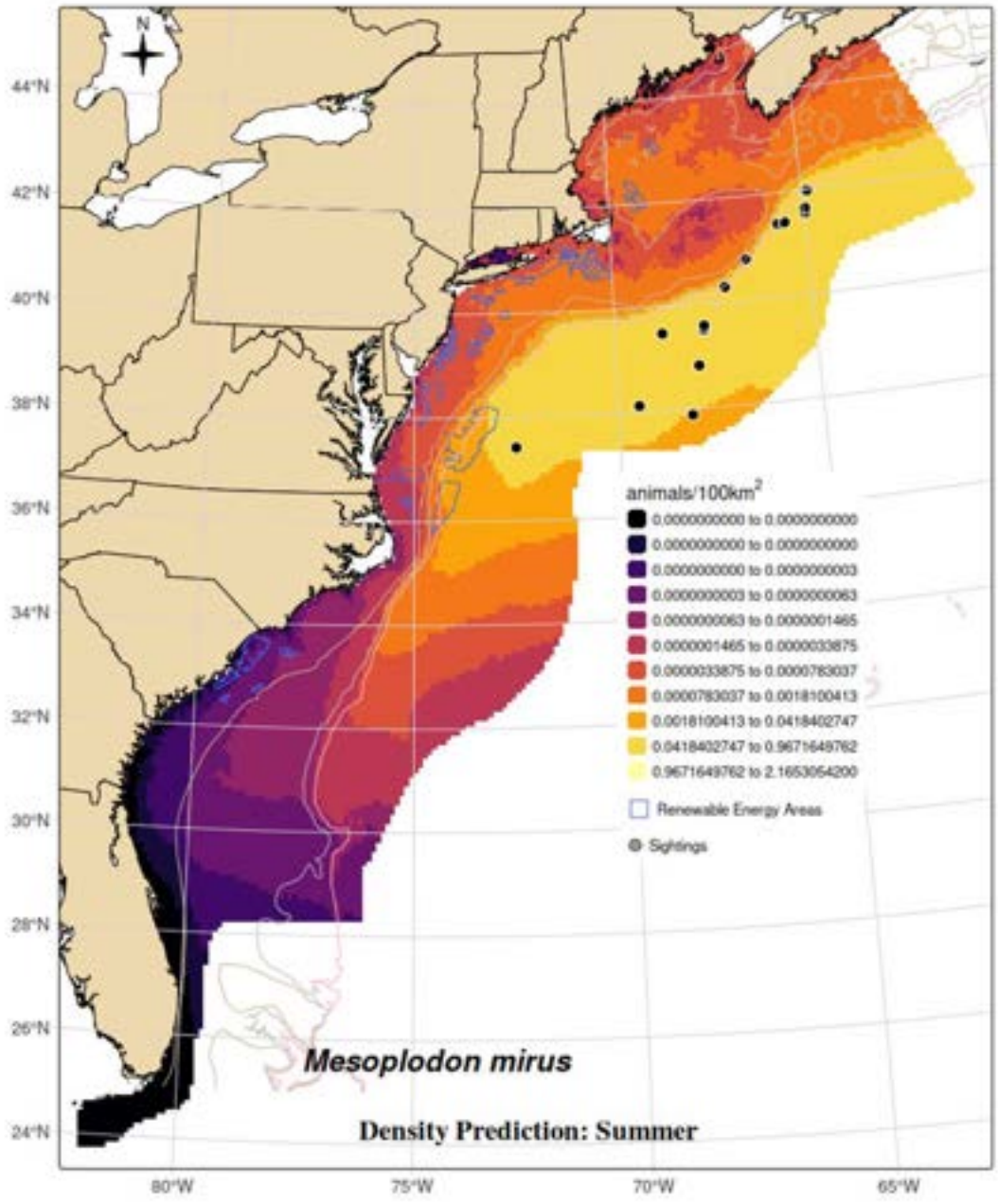

Figure B.10-10. True's beaked whale summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

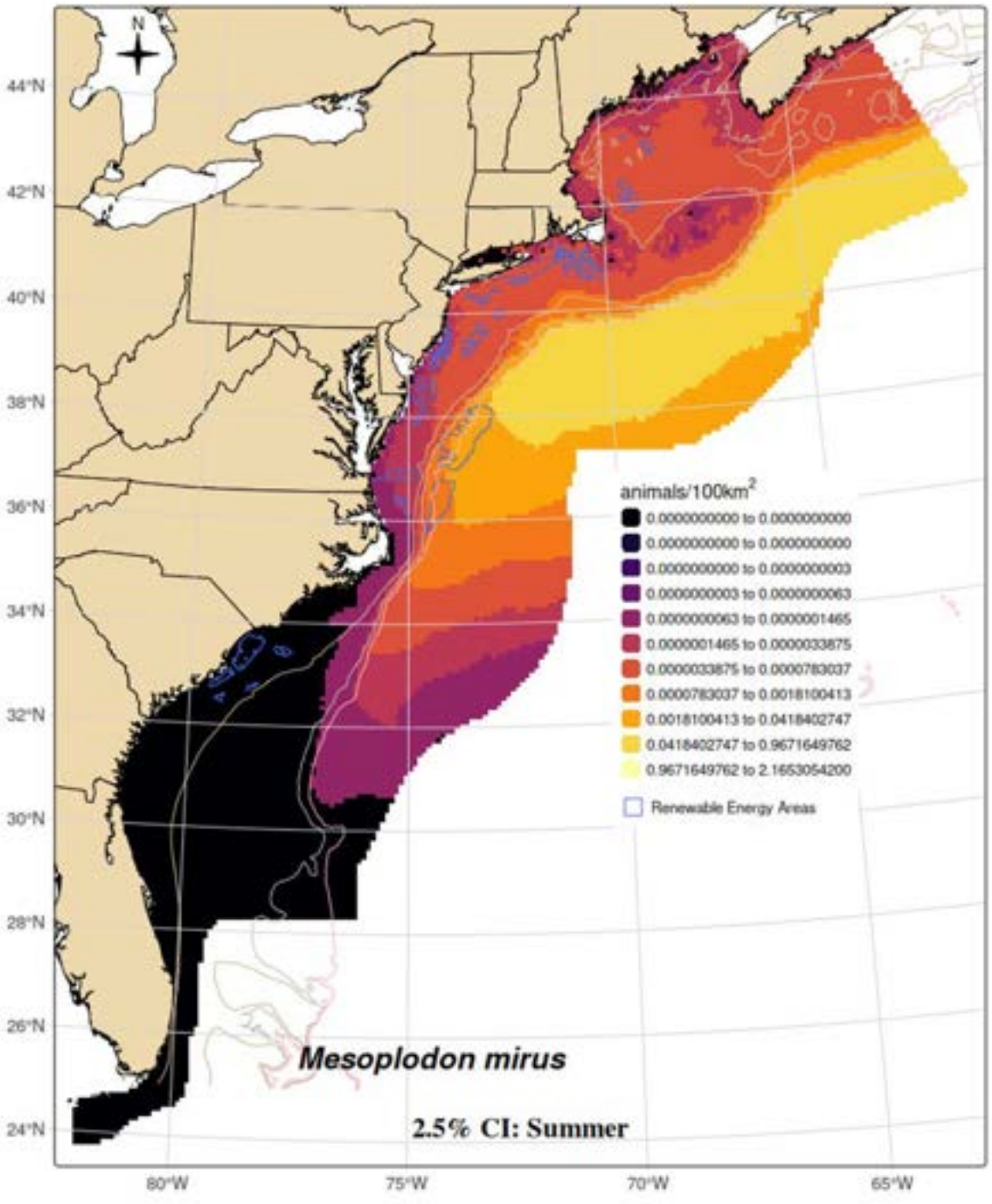

Figure B.10-11. Lower 2.5% confidence interval of summer True's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

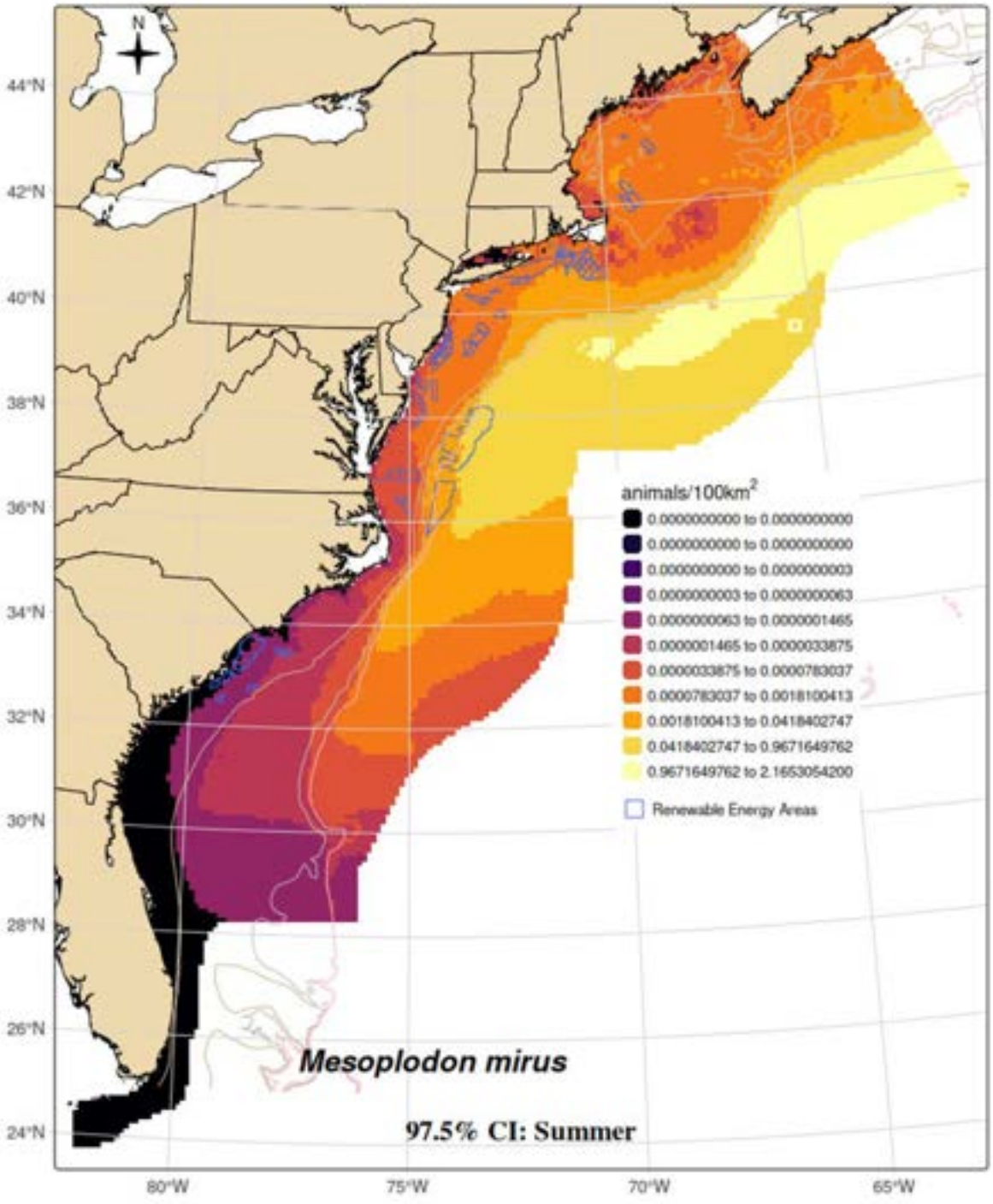

Figure B.10-12. Upper 97.5% confidence interval of summer True's beaked whale density estimates

Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

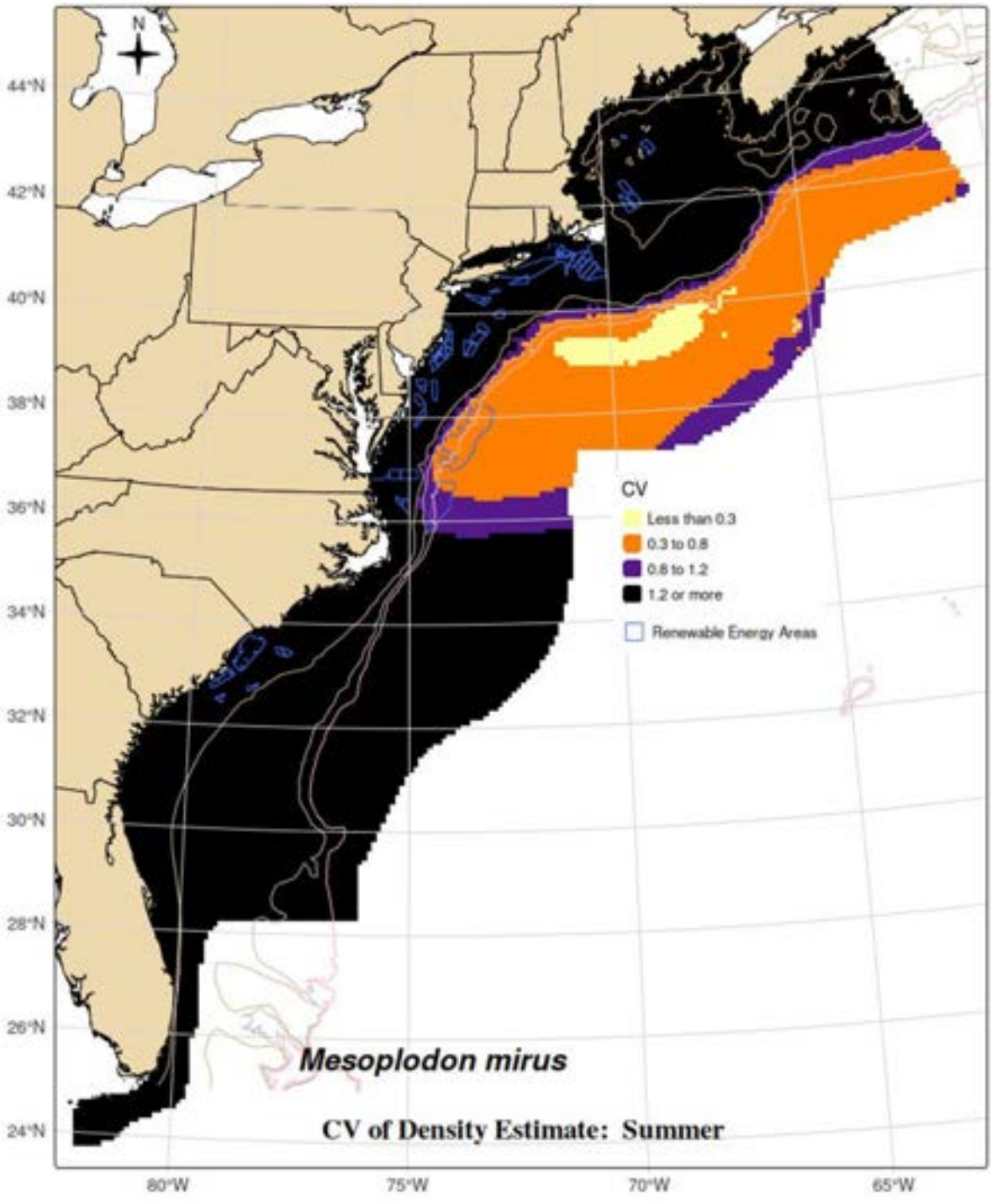

Figure B.10-13. CV of summer True's beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

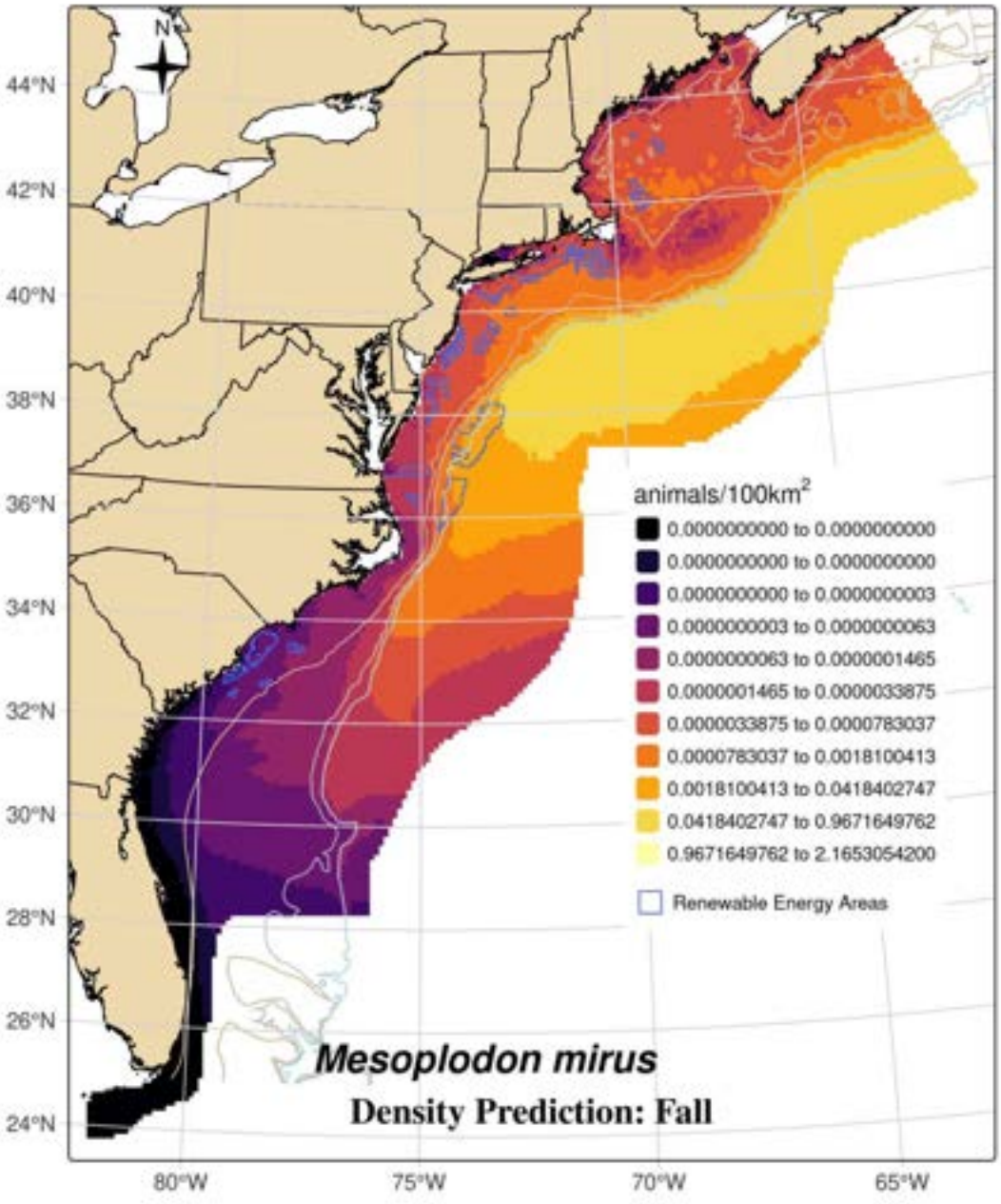

Figure B.10-14. True's beaked whale fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

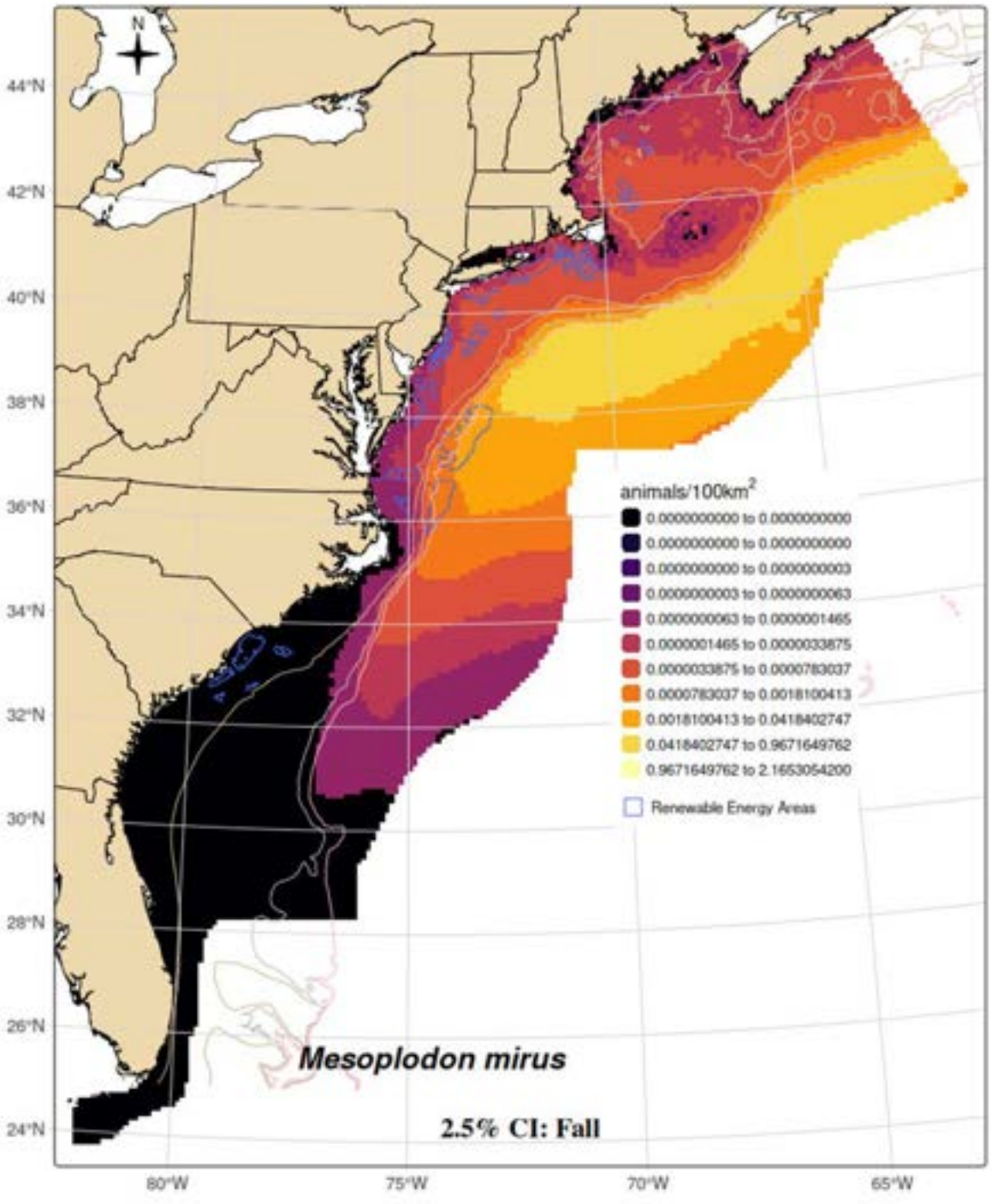

Figure B.10-15. Lower 2.5% confidence interval of the fall True's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

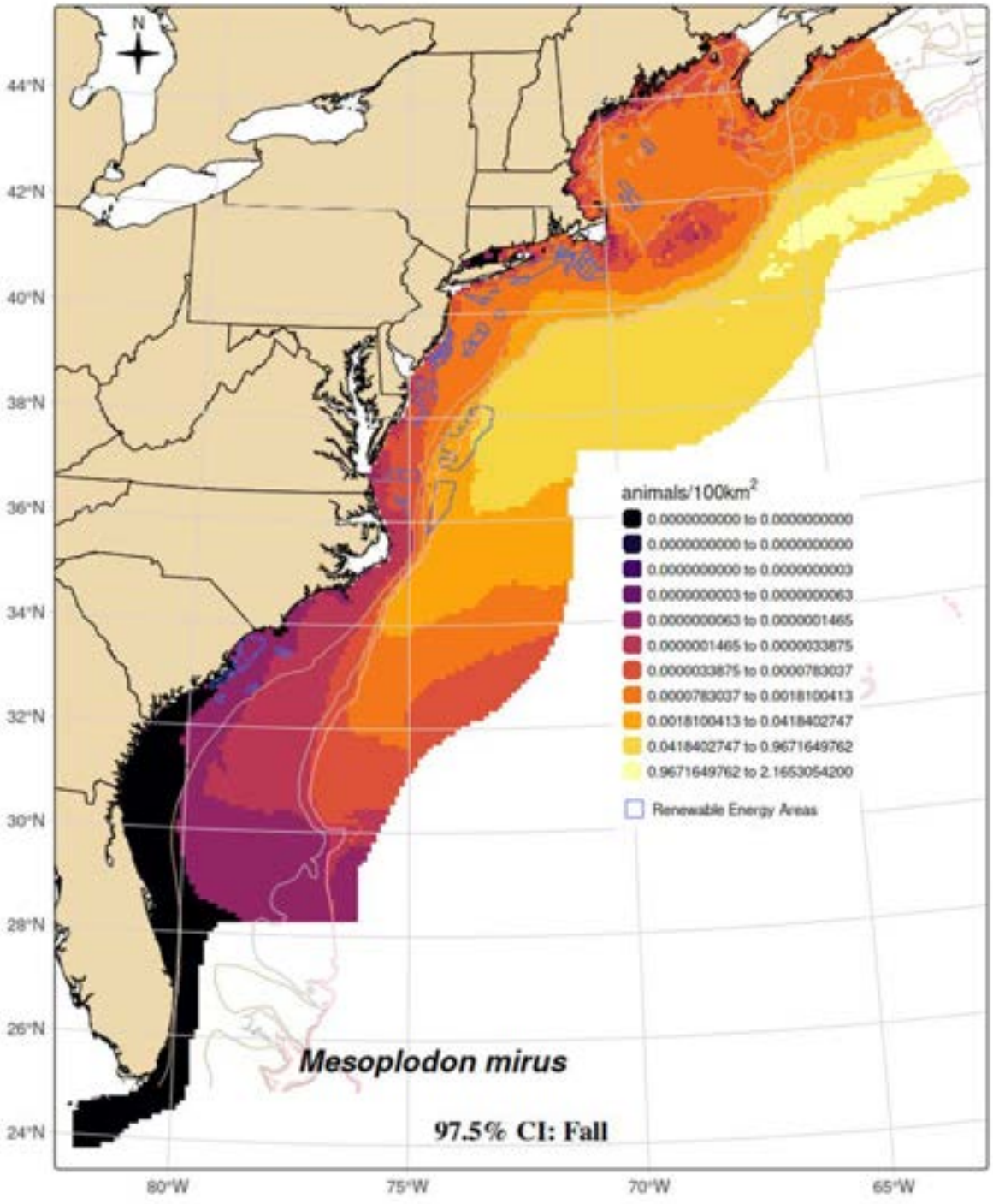

Figure B.10-16. Upper 97.5% confidence interval of the fall True's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,00016 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

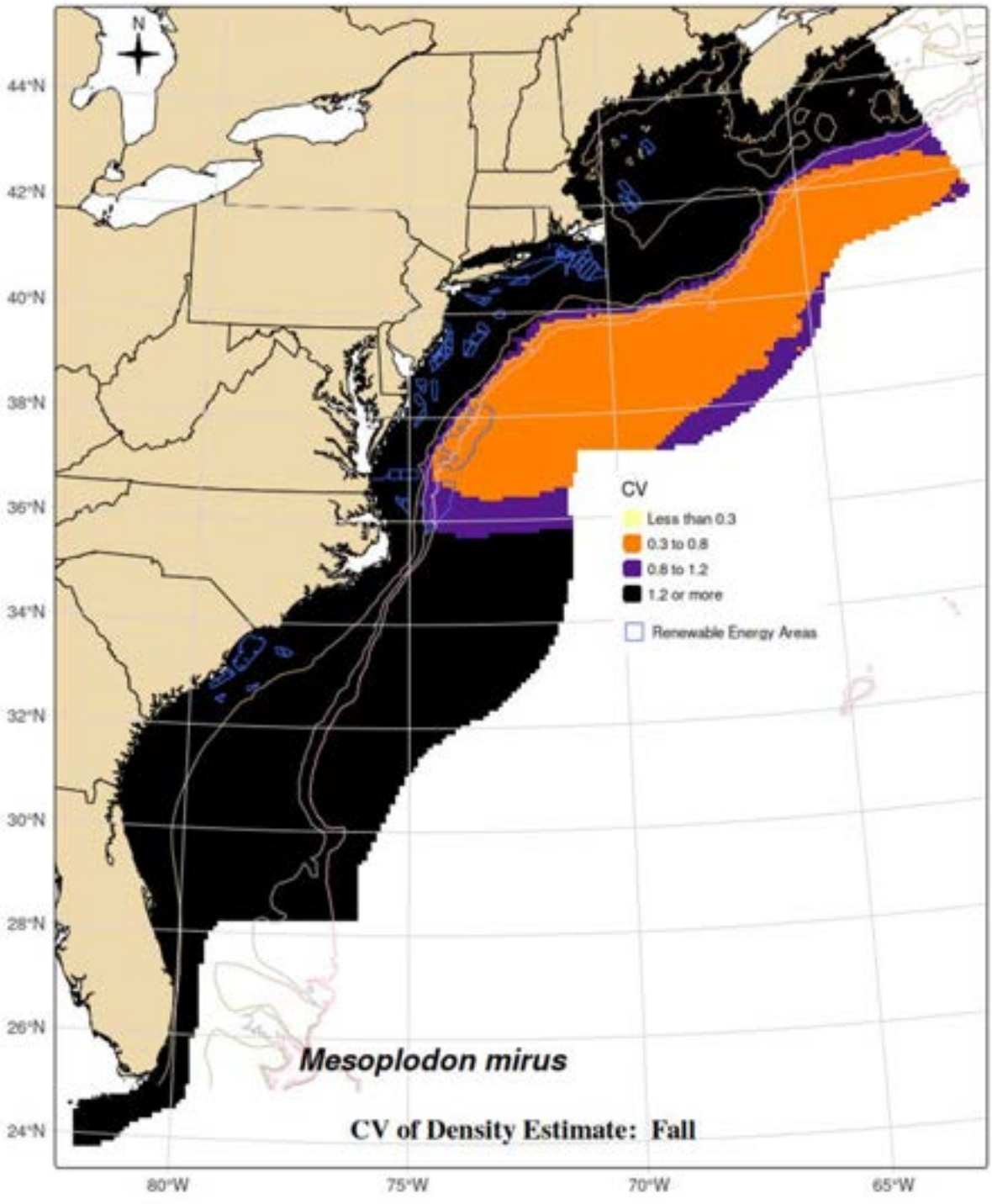

Figure B.10-17. CV of fall True's beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

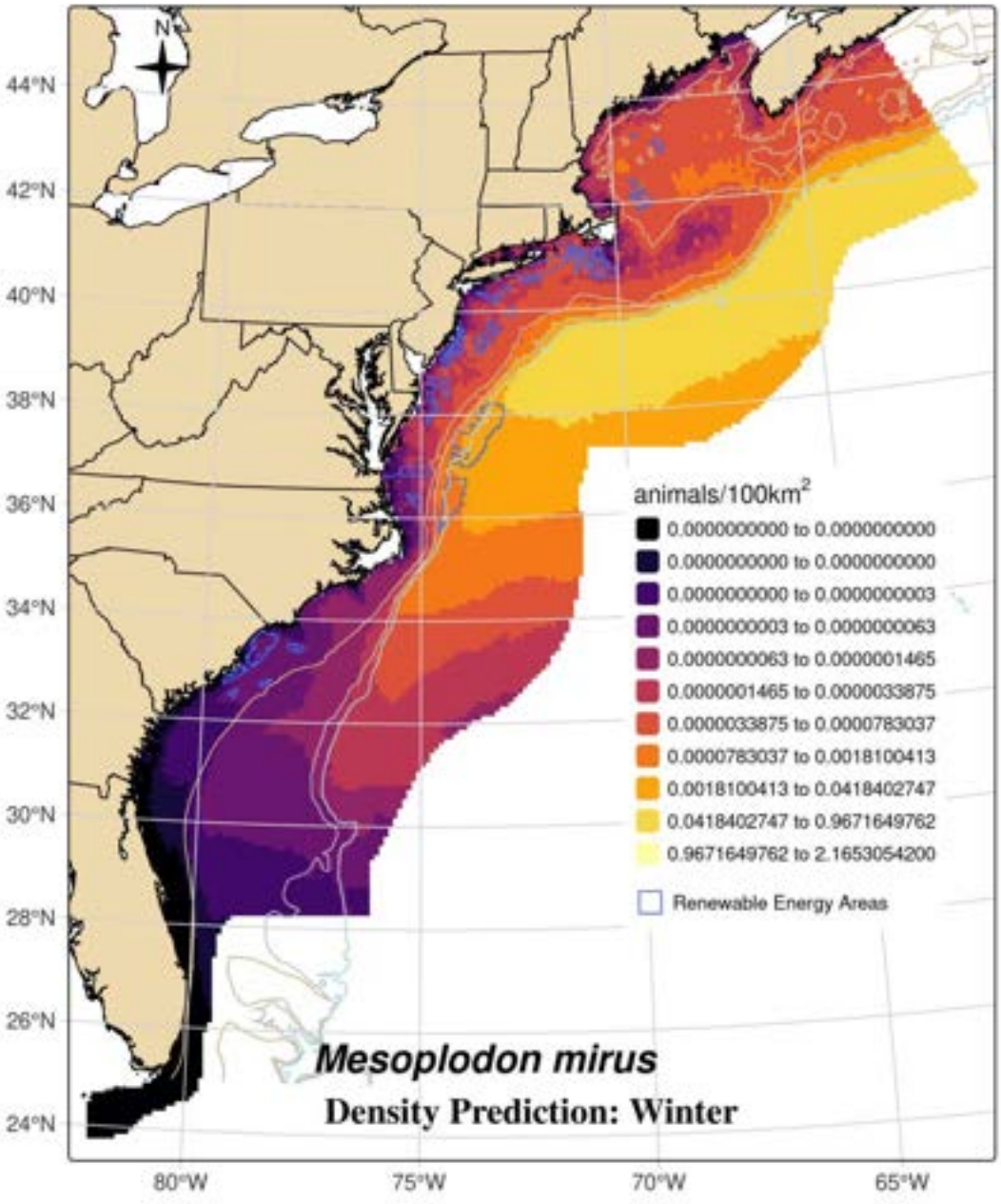

Figure B.10-18. True's beaked whale winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

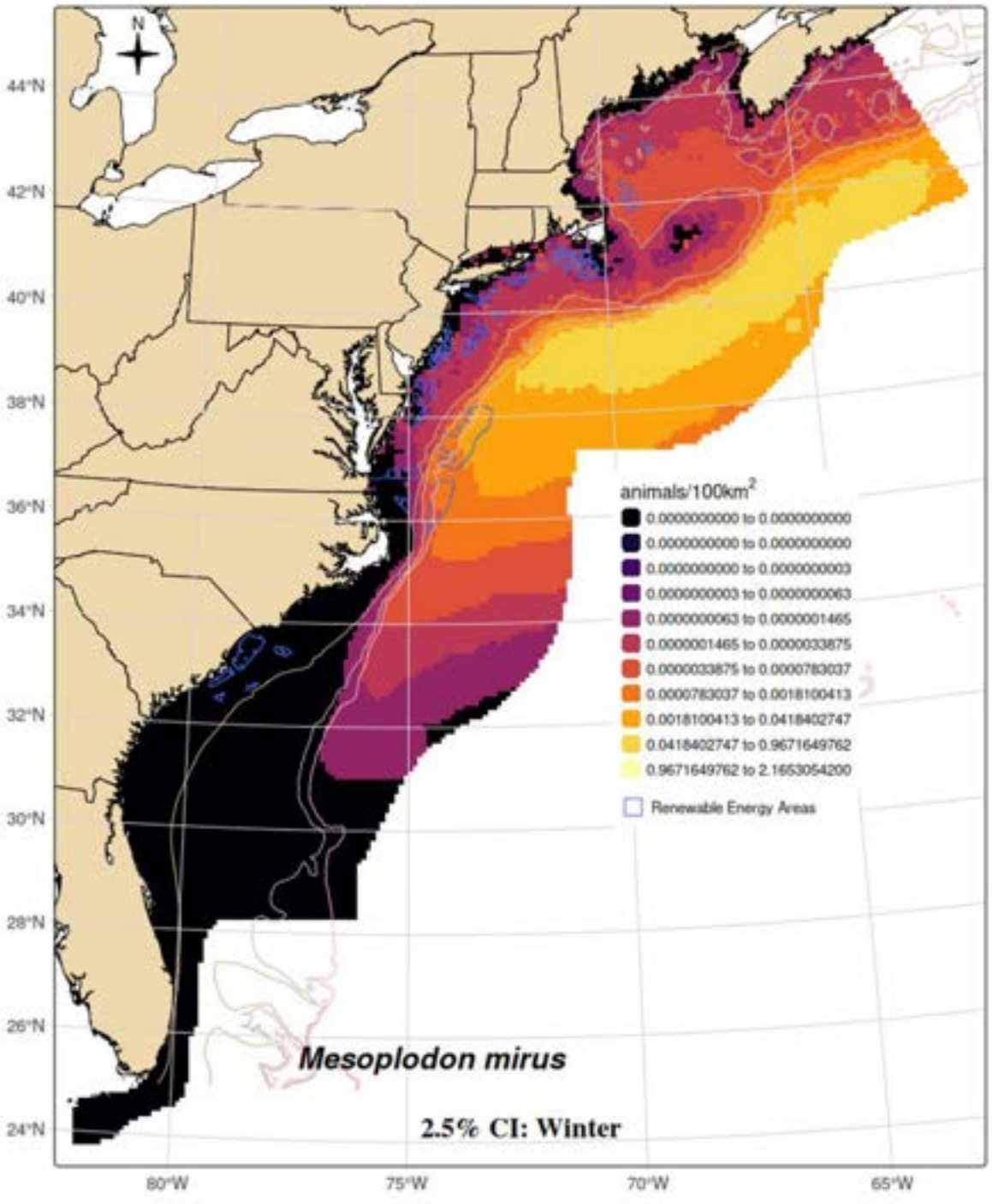

Figure B.10-19. Lower 2.5% confidence interval of winter True's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

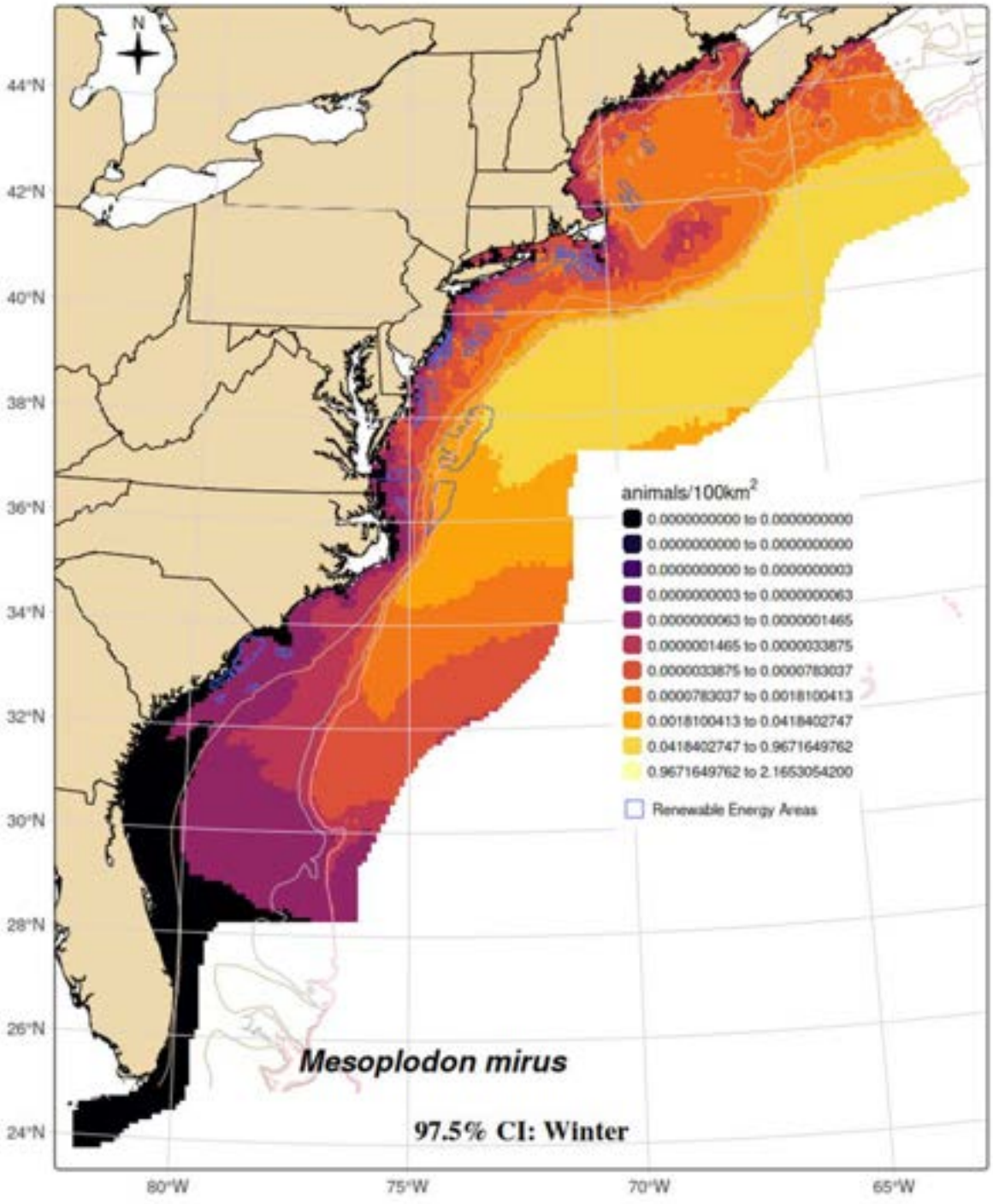

Figure B.10-20. Upper 97.5% confidence interval of winter True's beaked whale density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

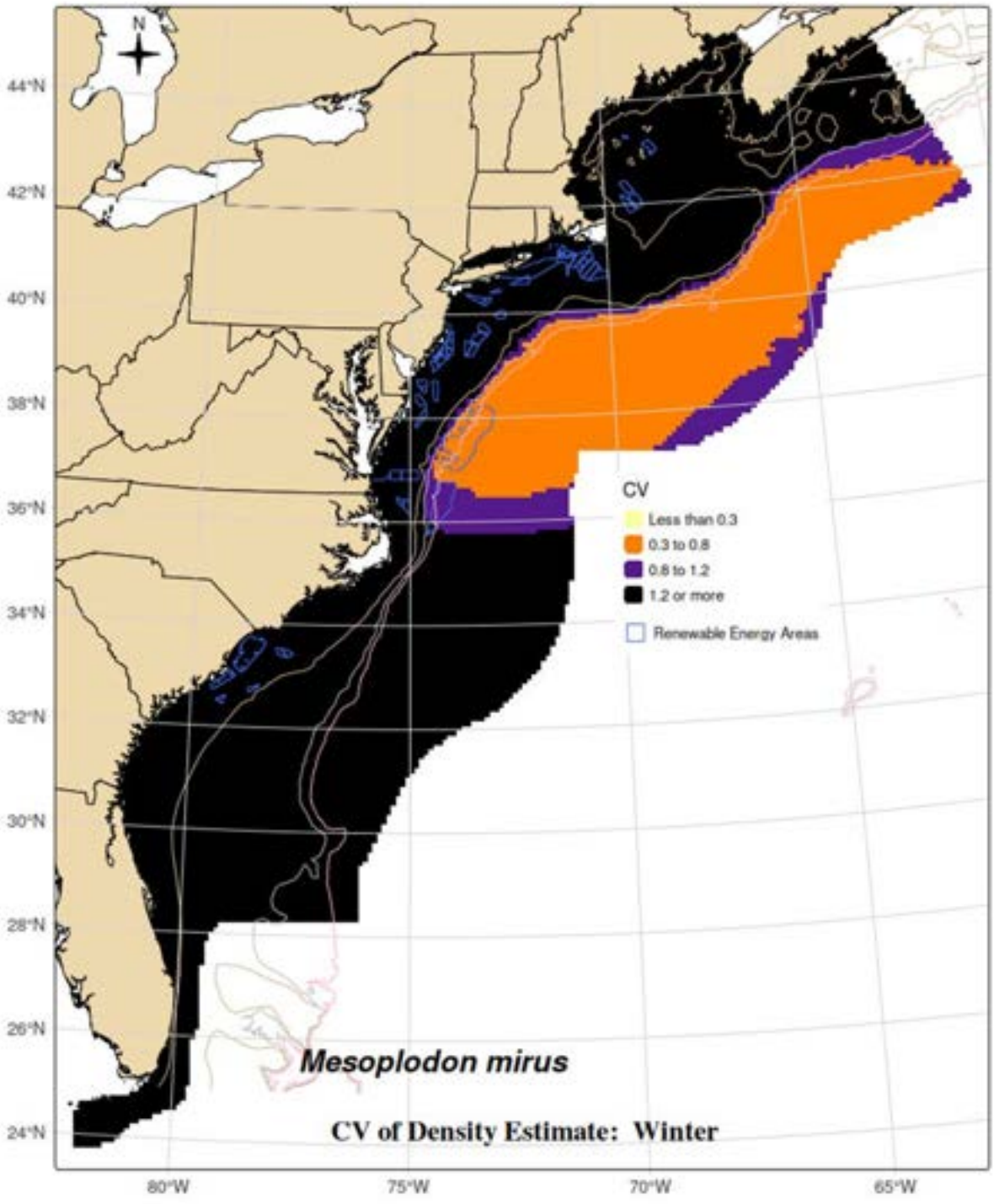

Figure B.10-21. CV of summer True's beaked whale density estimates
CV's are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.10.7 Offshore Energy Development Areas

Table B.10-6. True's beaked whale abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	0	1.41	0 - 0
	NY	0	1.45	0 - 0
	NJ	0	1.43	0 - 0
	DE/MD	0	1.44	0 - 0
	VA	0	1.55	0 - 0
	NC	0	1.64	0 - 0
	NC/SC	0	3.88	0 - 0
	GA	0	5.64	0 - 0
	FL	0	16.18	0 - 0
Summer (Jun-Aug)	RI/MA	0	1.39	0 - 0.1
	NY	0	1.42	0 - 0
	NJ	0	1.44	0 - 0
	DE/MD	0	1.43	0 - 0
	VA	0	1.52	0 - 0
	NC	0	1.61	0 - 0
	NC/SC	0	3.85	0 - 0
	GA	0	5.65	0 - 0
	FL	0	16.18	0 - 0
Fall (Sep-Nov)	RI/MA	0	1.37	0 - 0
	NY	0	1.41	0 - 0
	NJ	0	1.44	0 - 0
	DE/MD	0	1.45	0 - 0
	VA	0	1.54	0 - 0
	NC	0	1.61	0 - 0
	NC/SC	0	3.82	0 - 0
	GA	0	5.57	0 - 0
	FL	0	16.18	0 - 0
Winter (Dec-Feb)	RI/MA	0	1.40	0 - 0
	NY	0	1.48	0 - 0
	NJ	0	1.41	0 - 0
	DE/MD	0	1.46	0 - 0
	VA	0	1.58	0 - 0
	NC	0	1.65	0 - 0
	NC/SC	0	3.83	0 - 0
	GA	0	5.74	0 - 0
	FL	0	16.18	0 - 0

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

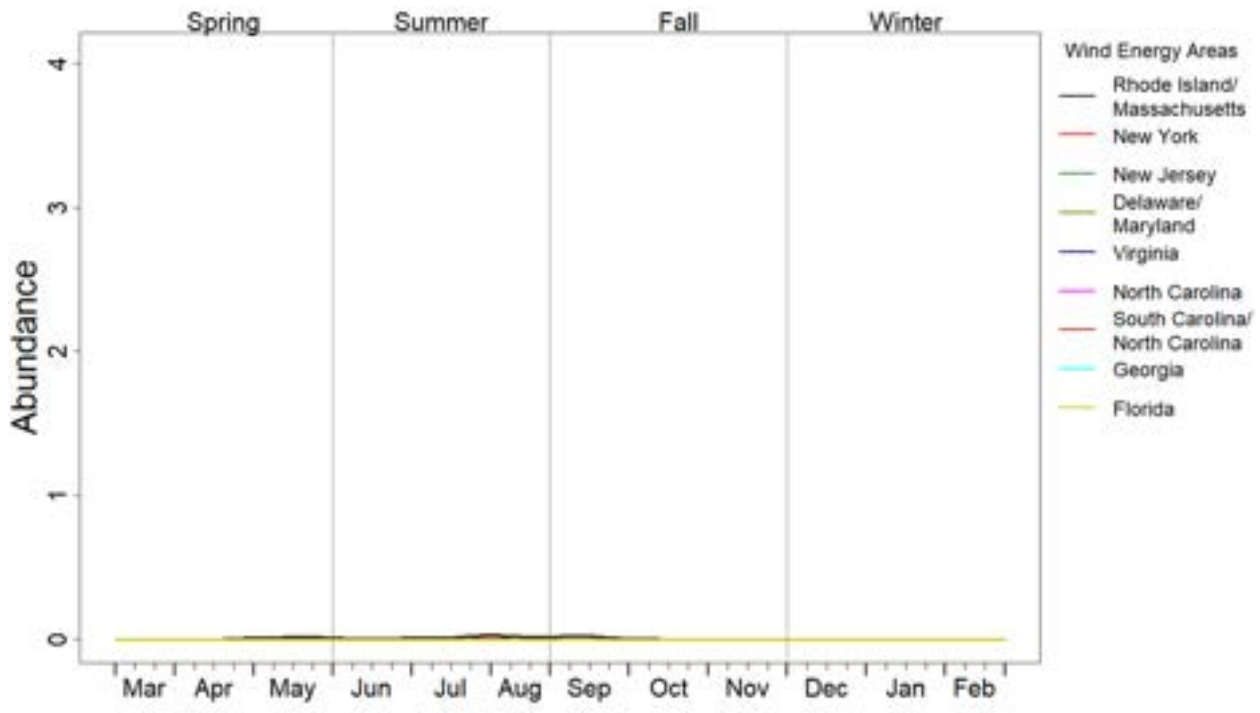

Figure B.10-22. Average seasonal abundance of True's beaked whales in wind-energy study areas

B.11 Pygmy Sperm Whale or Dwarf Sperm Whale (*Kogia* spp.)

Figure B.11-1. Pygmy sperm whale or dwarf sperm whale
Image collected under MMPA research permit #779-1638. Credit: NOAA/SEFSC.

B.11.1 Data Collection

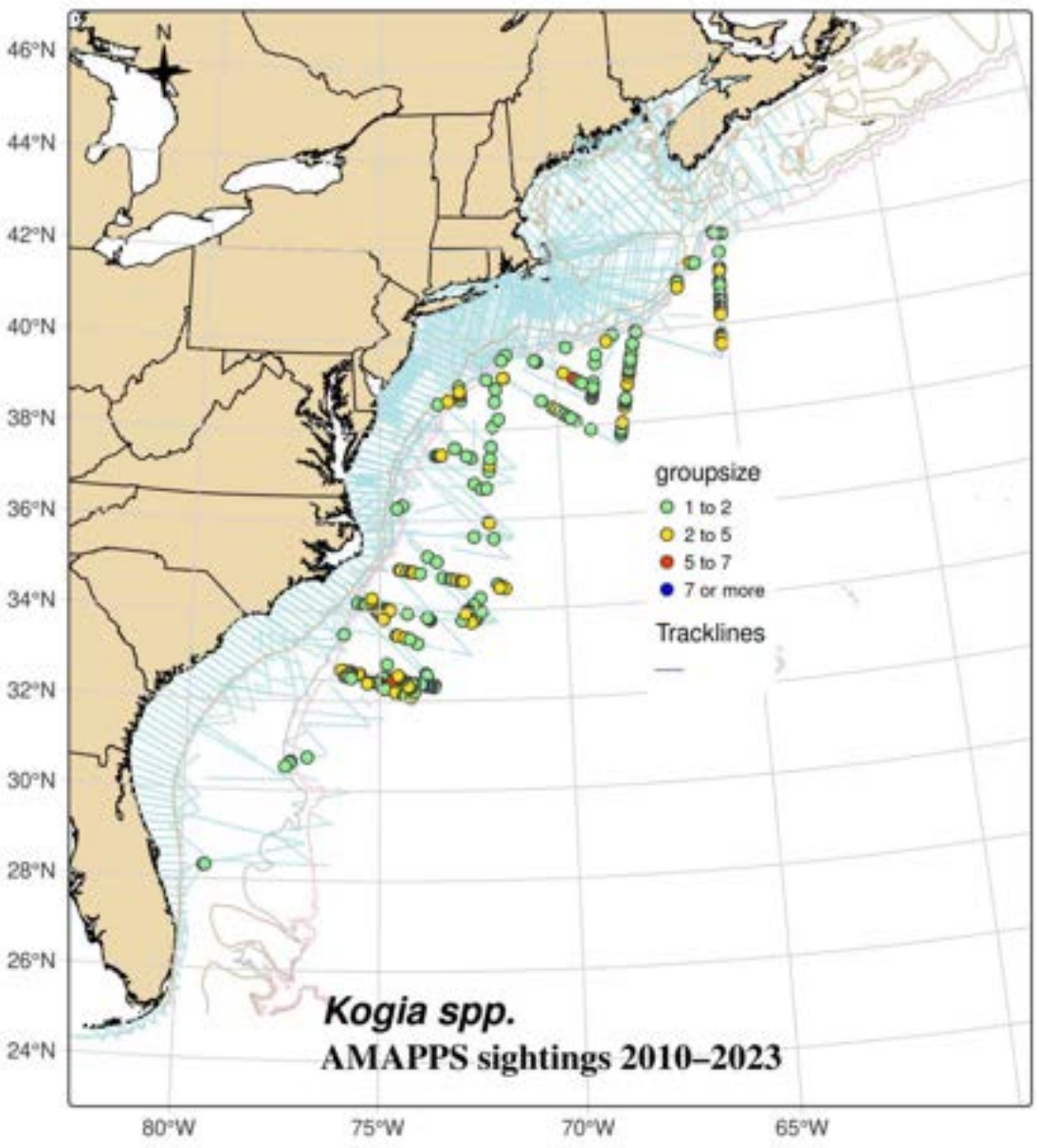

Figure B.11-2. Distribution of track lines and *Kogia* spp. sightings 2010 to 2023
Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours.

Table B.11-1. AMAPPS research effort 2010 to 2023 and *Kogia* spp. sightings

Survey Region and Platform	Season	Effort (km)	Number of Groups	Number of Animals
NE Shipboard	Spring	8,883	0	0
NE Shipboard	Summer	49,064	141	211
NE Aerial	Spring	38,839	0	0
NE Aerial	Summer	52,003	0	0
NE Aerial	Fall	87,311	0	0
NE Aerial	Winter	24,747	0	0
SE Shipboard	Spring	2,604	13	23
SE Shipboard	Summer	18,331	143	266
SE Shipboard	Fall	2,673	2	2
SE Shipboard	Winter	302	0	0
SE Aerial	Spring	48,634	1	1
SE Aerial	Summer	43,285	0	0
SE Aerial	Fall	21,153	0	0
SE Aerial	Winter	19,152	0	0

B.11.2 Mark-Recapture Distance Sampling Analysis

Table B.11-2. Intermediate parameters in *Kogia* spp. mark-recapture distance sampling (MRDS) models

Analysis Set	MR Model	MR Truncation (m)	DS Model	DS Truncation (m)	Key function	p(0)	p(0) CV	Chi-square p-value	CvM p-value
NE–shipboard group 6	distance * observer + log(group size) + sea state	3900	distance + glare + time of day	3900	HR	0.43	0.12	0.14	0.81
SE–shipboard group 6	distance + glare	3000	distance + glare	3000	HR	0.42	0.23	0.24	0.96

MR=Mark-Recapture, DS=Distance Sampling, HR=Hazard Rate, HN= Half Normal, CV=Coefficient of variation. Values of p>0.5 for Chi-square and Cramer-von Mises test (CvM) indicate good fit. The definition of p(0) is the probability of detecting a group on the track line. Species included in the analysis sets are explained in main text Tables 4-20 and 4-21.

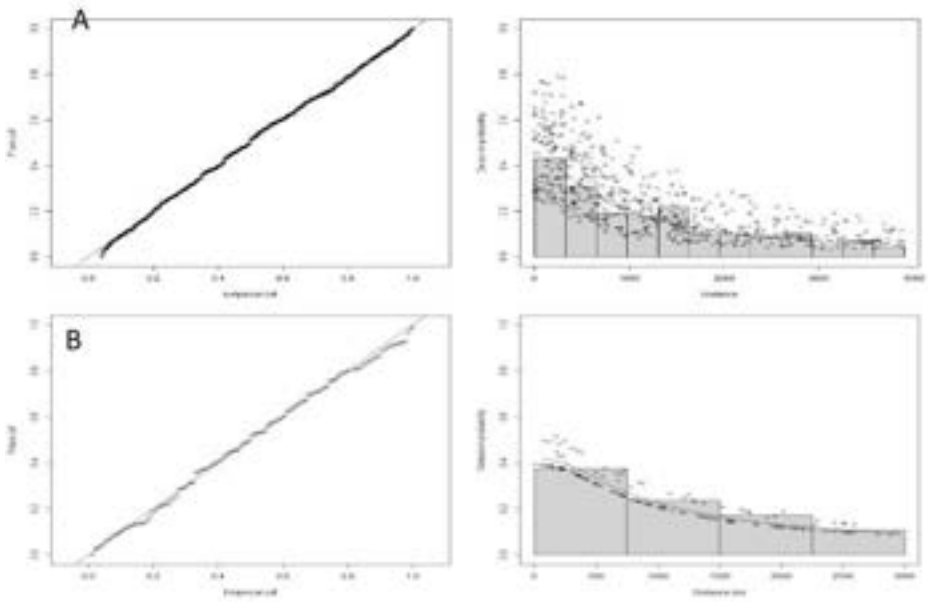

Figure B.11-3. Q-Q plots and detection functions from the *Kogia* spp. MRDS analyses
A) NE-shipboard analysis set 6; B) SE-shipboard analysis set 6.

B.11.3 Generalized Additive Model Analysis

Table B.11-3. 2010 to 2023 density-habitat model output for *Kogia* spp.

Covariates	Edf	Ref.df	F	C.dev	p-value
s(chla)	0.96	5	4.32	1.19	<0.0001
s(depth)	2.73	5	46.41	49.42	<0.0001
s(dist2GSNw)	2.56	5	3.38	1.86	0.0001
s(dist2GSSw)	1.85	5	8.09	6.27	<0.0001
s(mlp)	0.93	5	2.34	1.16	0.0004

Adjusted R^2 = 0.0724. Deviance explained = 59.9%.
Includes the estimated degrees of freedom (Edf), reference degrees of freedom (Ref.df), contribution to the deviance (C.dev) explained for each habitat covariate and its associated p-value. Covariate abbreviations explained in main text in Table 4-2.

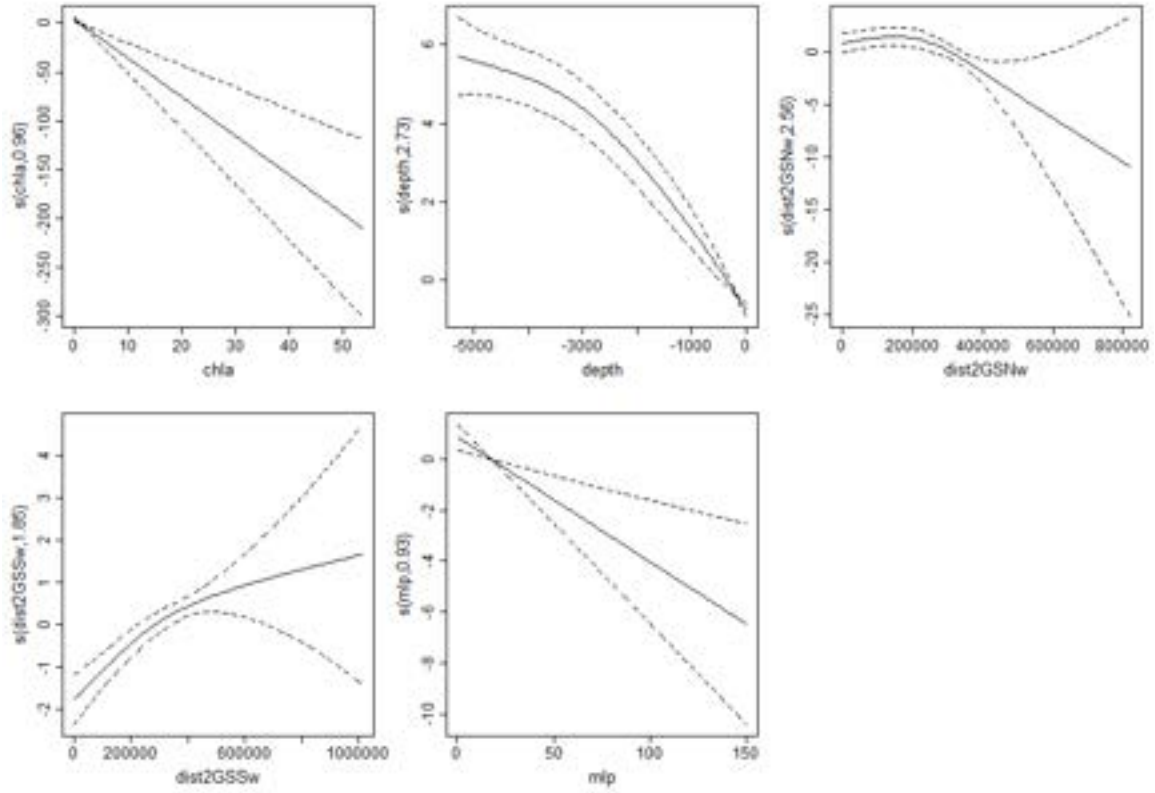

Figure B.11-4. *Kogia* spp. density relative to significant habitat covariates
Plots represent the partial smooths and interaction terms of the density-habitat model. Covariate abbreviations explained in main text in Table 4-2.

B.11.4 Model Cross-Validation

Table B.11-4. Diagnostic statistics from the Kogia spp. density-habitat model

Diagnostic Statistic	Description	Calculated with	Model Values (x)	Score
MAPE	Mean absolute percentage error	Non-zero density	87.326	Fair to good
RHO	Spearman rank correlation	Non-zero density	0.219	Fair to good
MAPE	Mean absolute percentage error	All data divided in 25 random samples	87.248	Fair to good
RHO	Spearman rank correlation	All data divided in 25 random samples	0.115	Fair to good
MAE	Mean absolute error	All data divided in 25 random samples	0.001	Excellent

RHO: Poor= x<0.05; Fair to good =0.05<=x<0.3; Excellent= x>0.3
MAPE: Poor= x>150%; Fair to good= 150%>=x>50%; Excellent= x<=50%
MAE: Poor= x>1; Fair to good = 1>=x>0.25; Excellent= x<=0.25

B.11.5 Abundance Estimates for AMAPPS Study Area

Table B.11-5. *Kogia* spp. average abundance estimates for the AMAPPS study area

Season	Average Abundance	CV	95% Confidence Interval
Spring (March–May)	1,313	0.35	674 – 2,556
Summer (June–August)	5,436	0.24	3,419 – 8,644
Fall (September–November)	2,054	0.32	1,114 – 3,788
Winter (December–February)	340	0.64	108 – 1,072
Summer 2011 U.S. surveys[1]	3,785	0.47	2,125 – 6,740
Summer 2016 U.S. surveys[1]	7,750	0.38	4,840 – 12,410
Summer 2021 U.S. surveys[1]	9,474	0.36	4,780 – 18,780

[1]Hayes et al. 2024

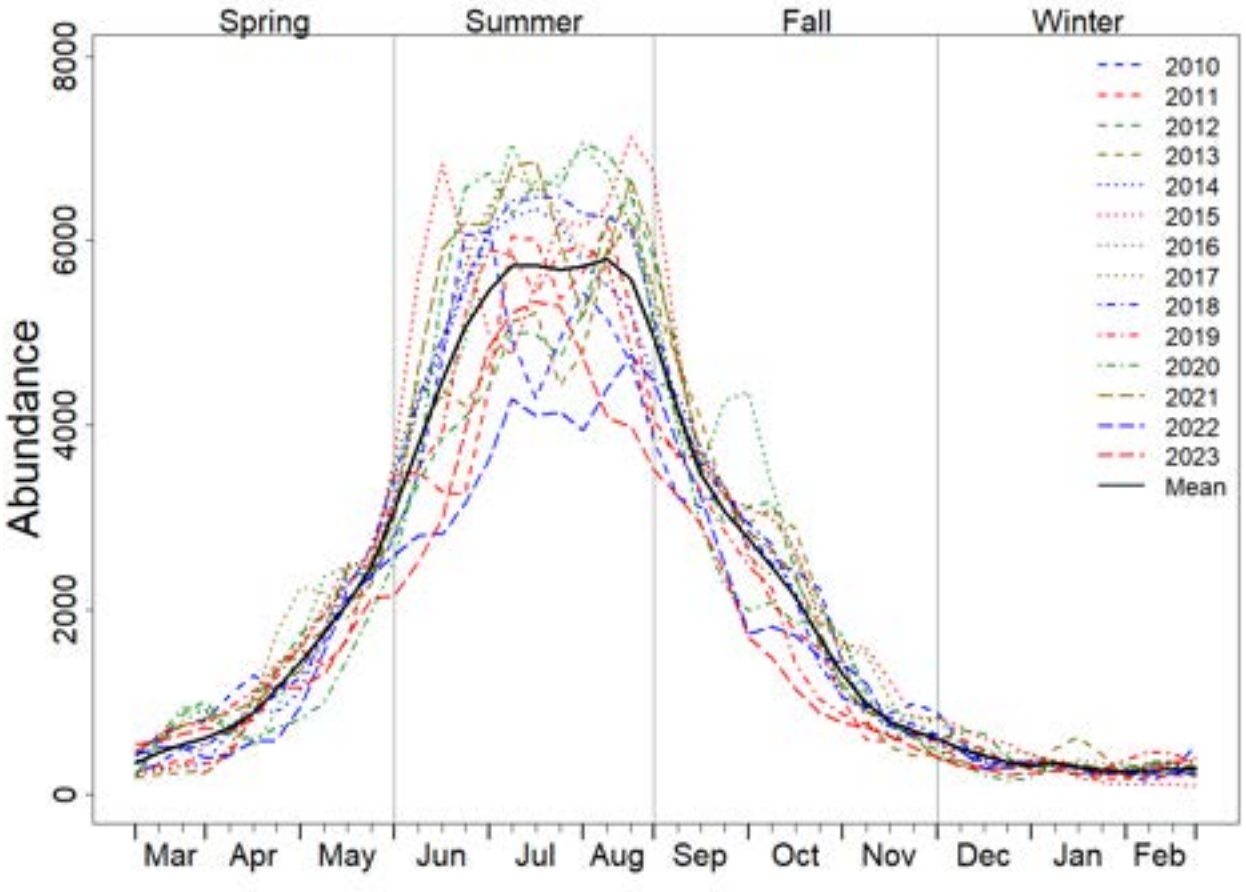

Figure B.11-5. Annual abundance trends for *Kogia* spp. in the AMAPPS study area

B.11.6 Seasonal Prediction Maps

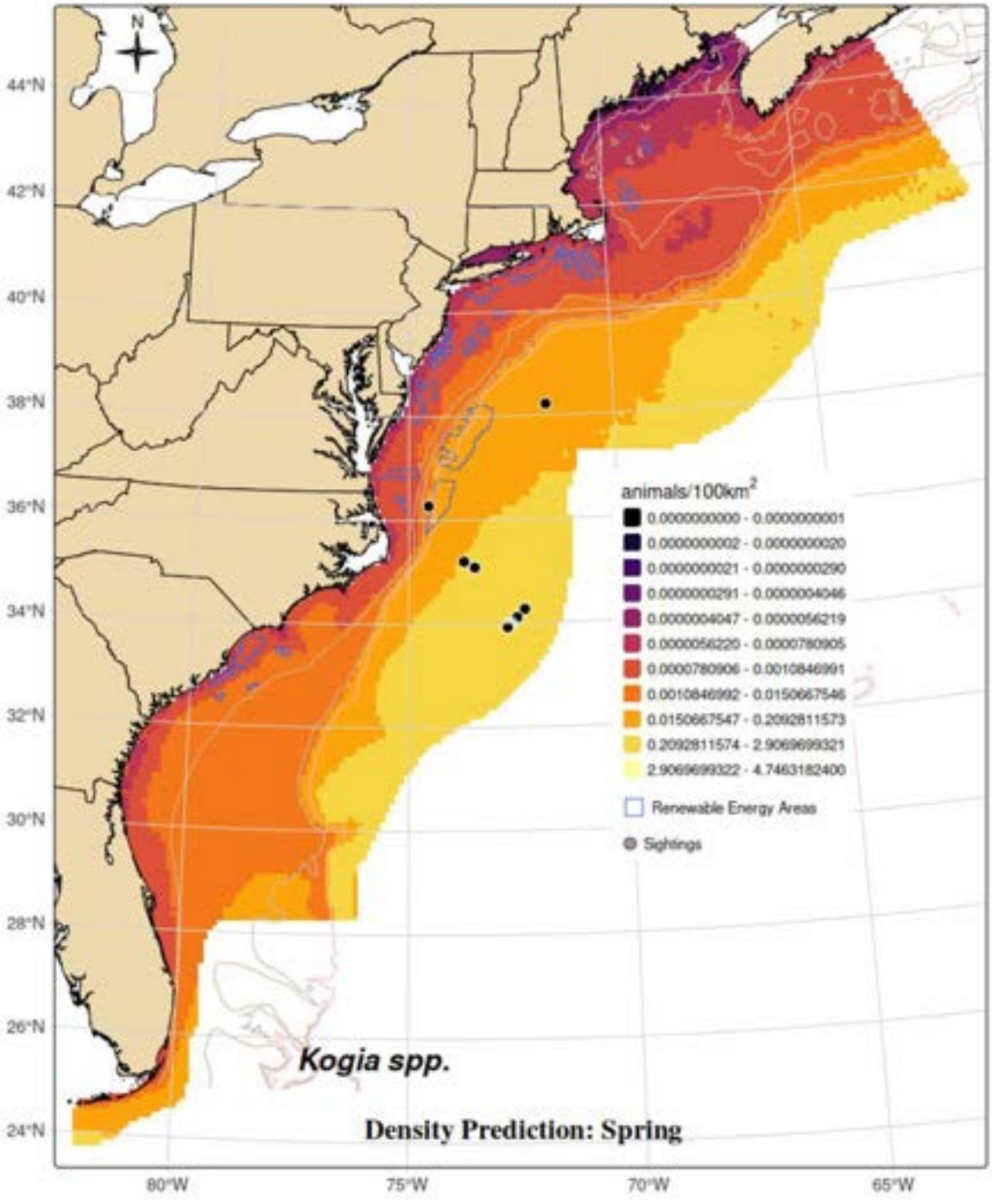

Figure B.11-6. *Kogia* spp. spring average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

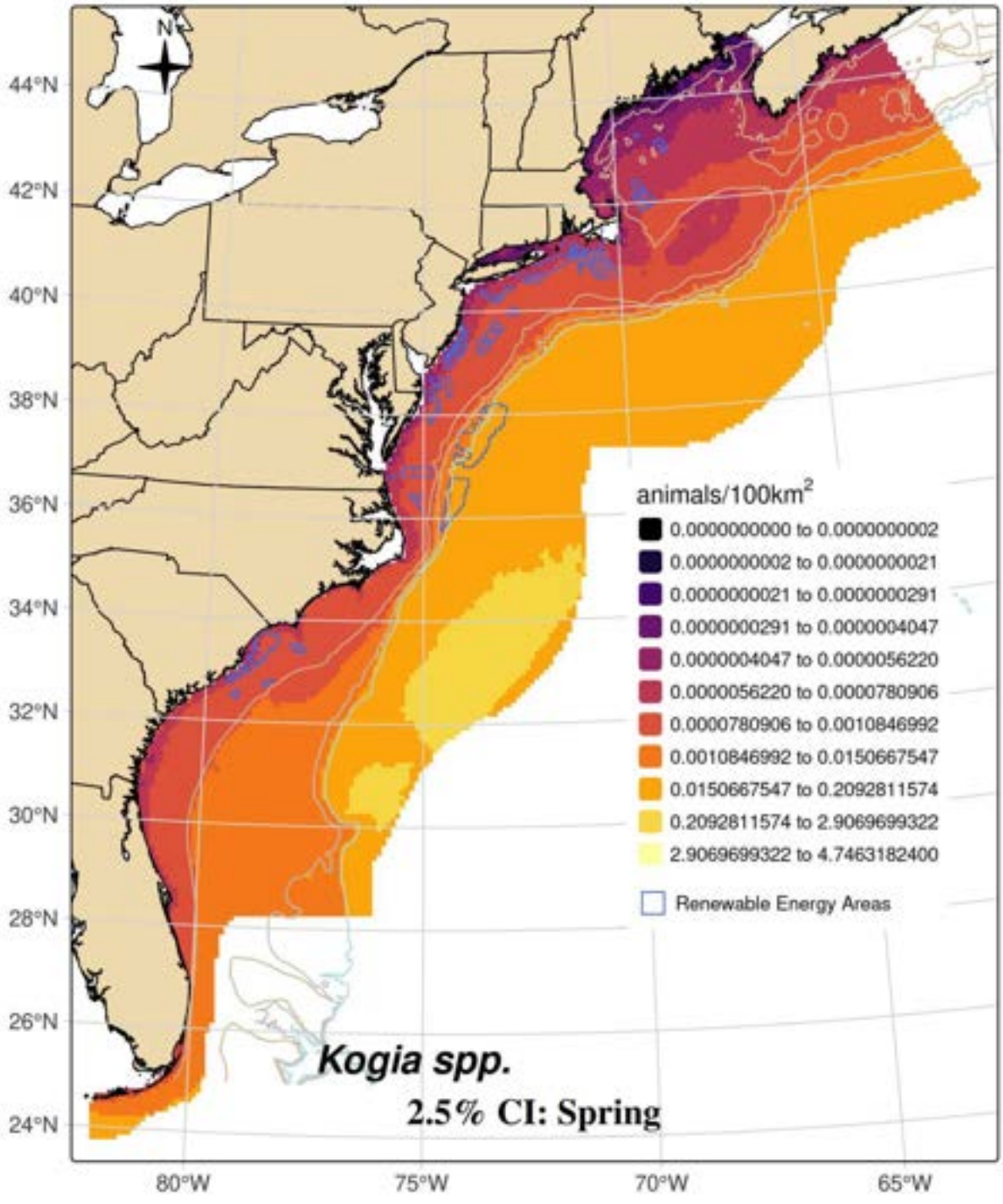

Figure B.11-7. Lower 2.5% confidence interval of the spring *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

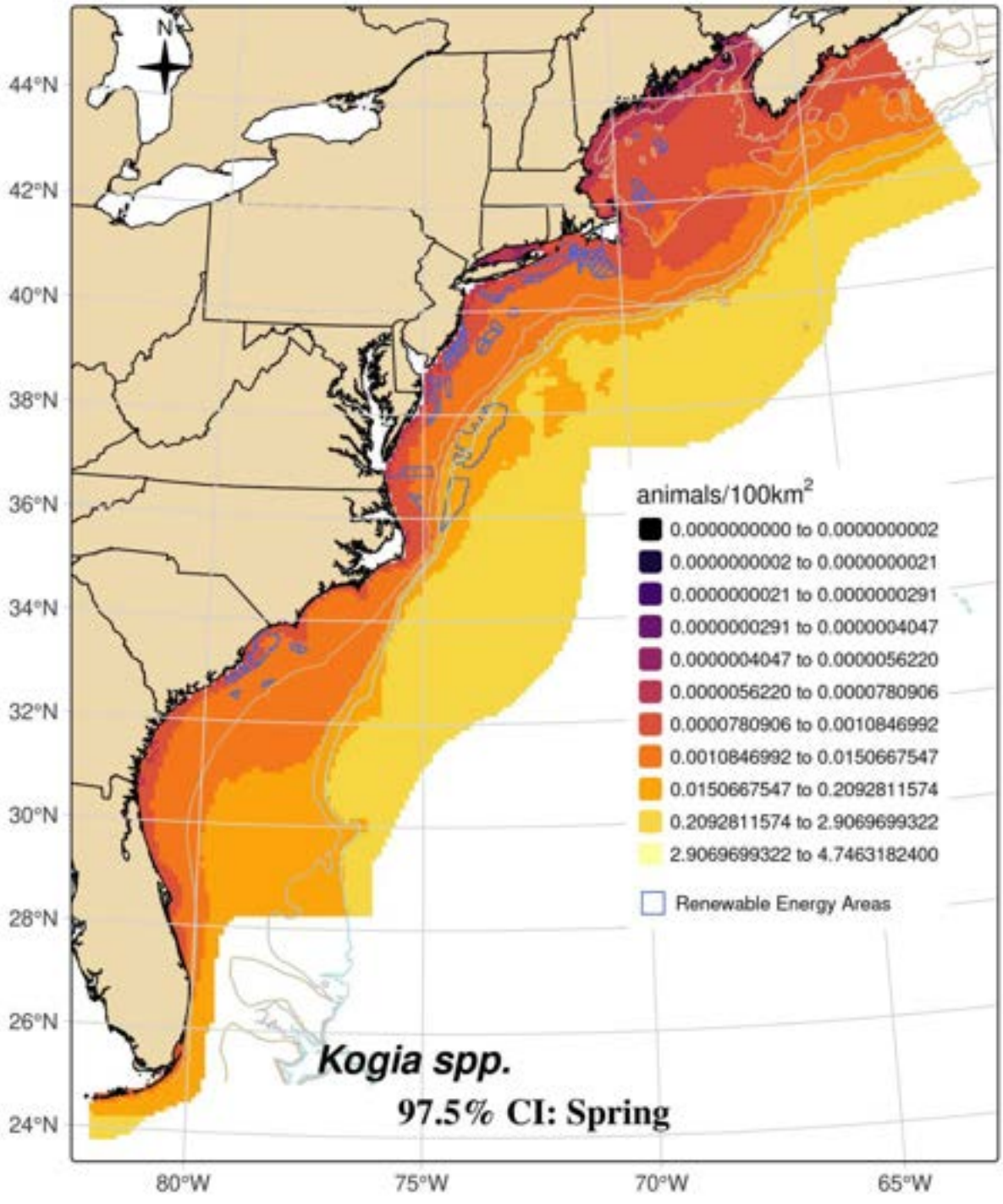

Figure B.11-8. Upper 97.5% confidence interval of the spring *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

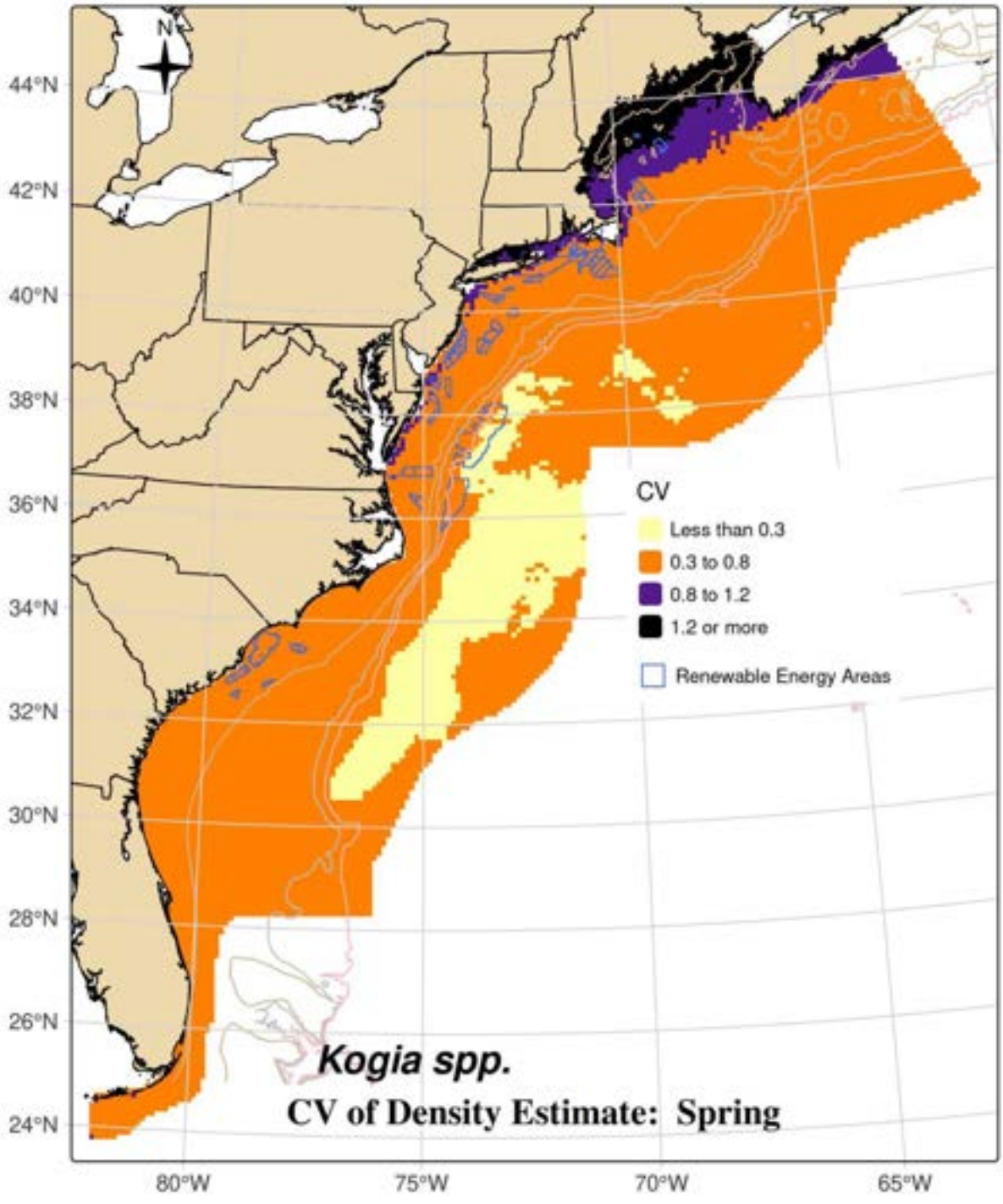

Figure B.11-9. CV of spring *Kogia* spp. density estimates
CVs are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

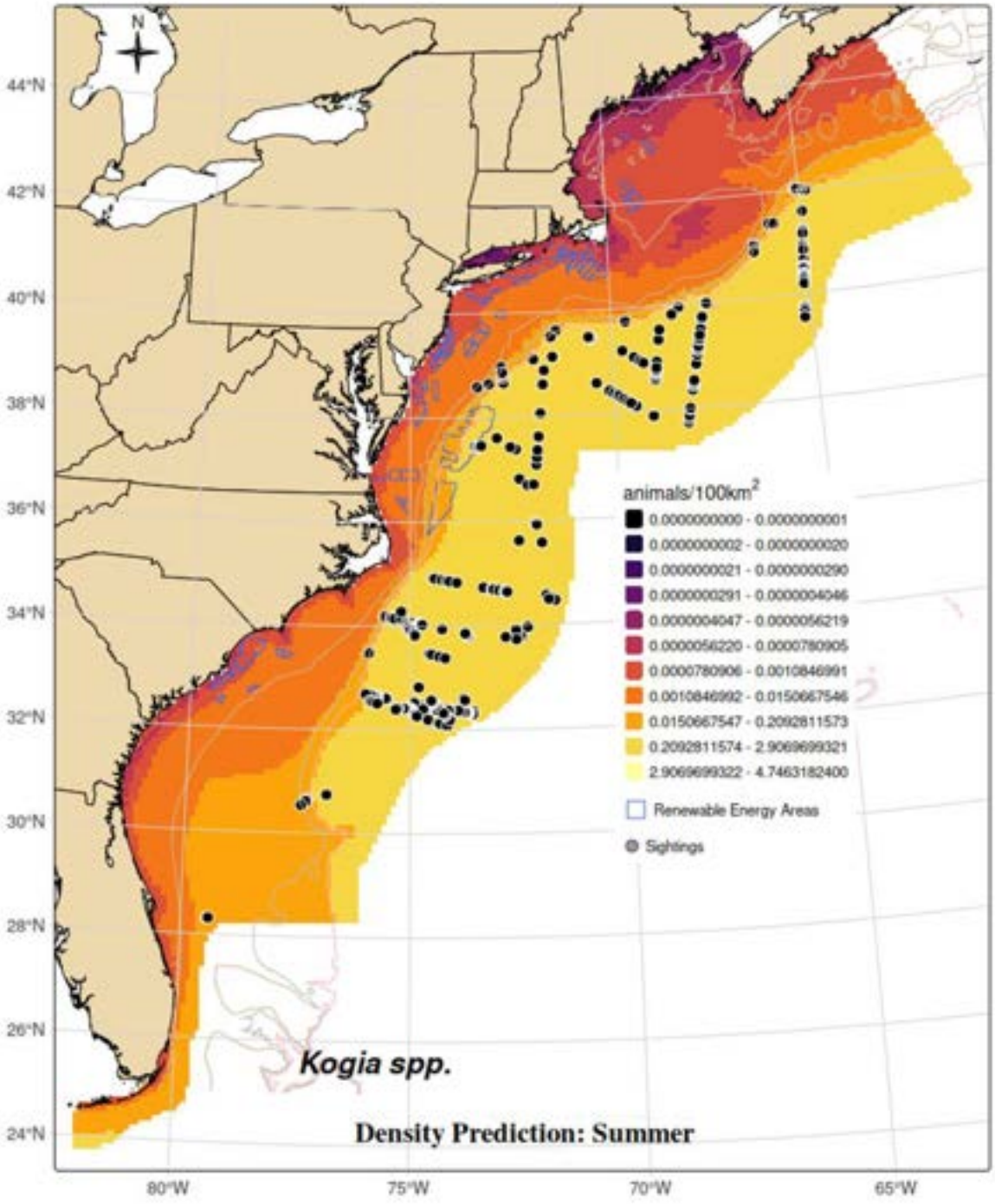

Figure B.11-10. *Kogia* spp. summer average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

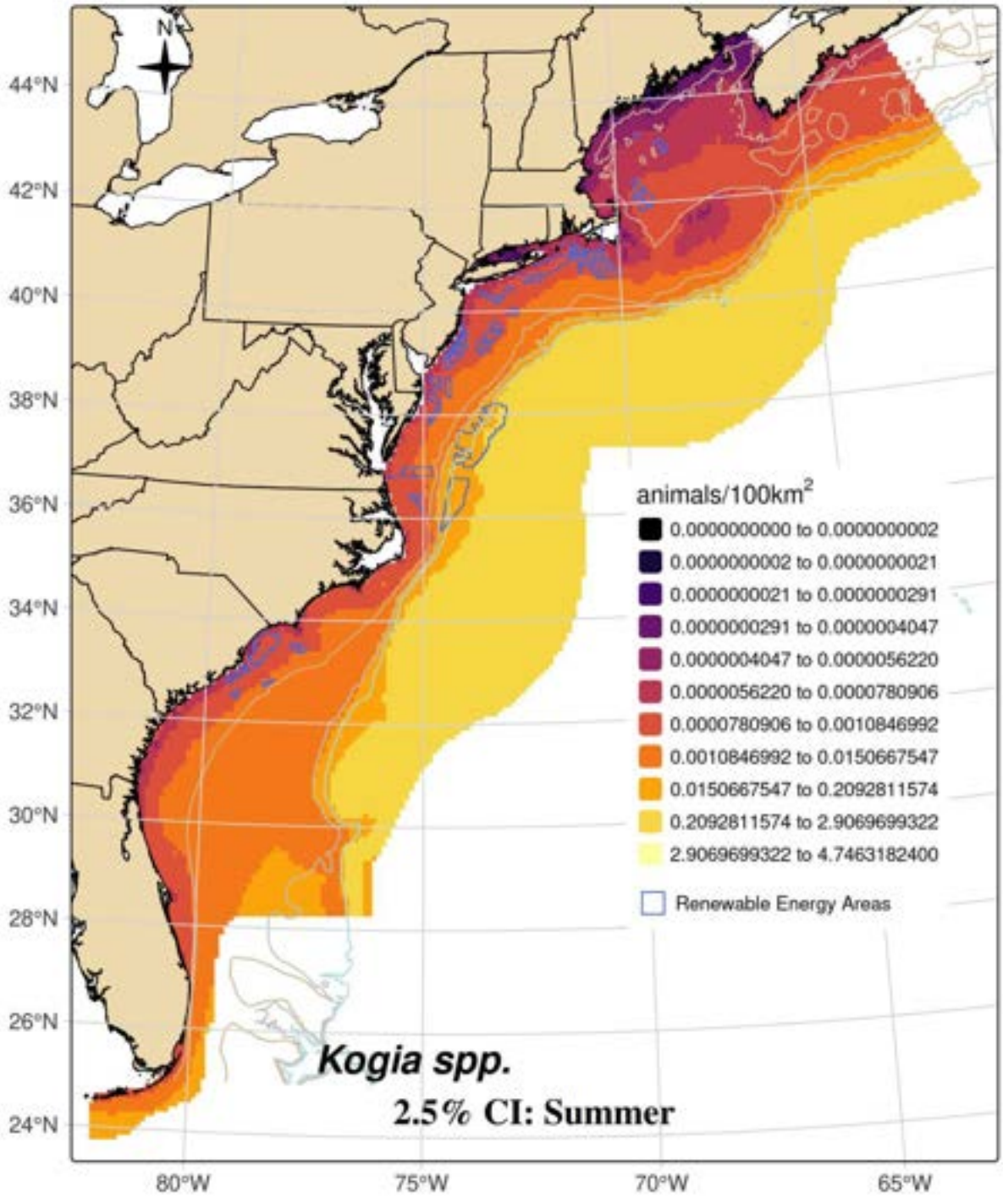

Figure B.11-11. Lower 2.5% confidence interval of the summer *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

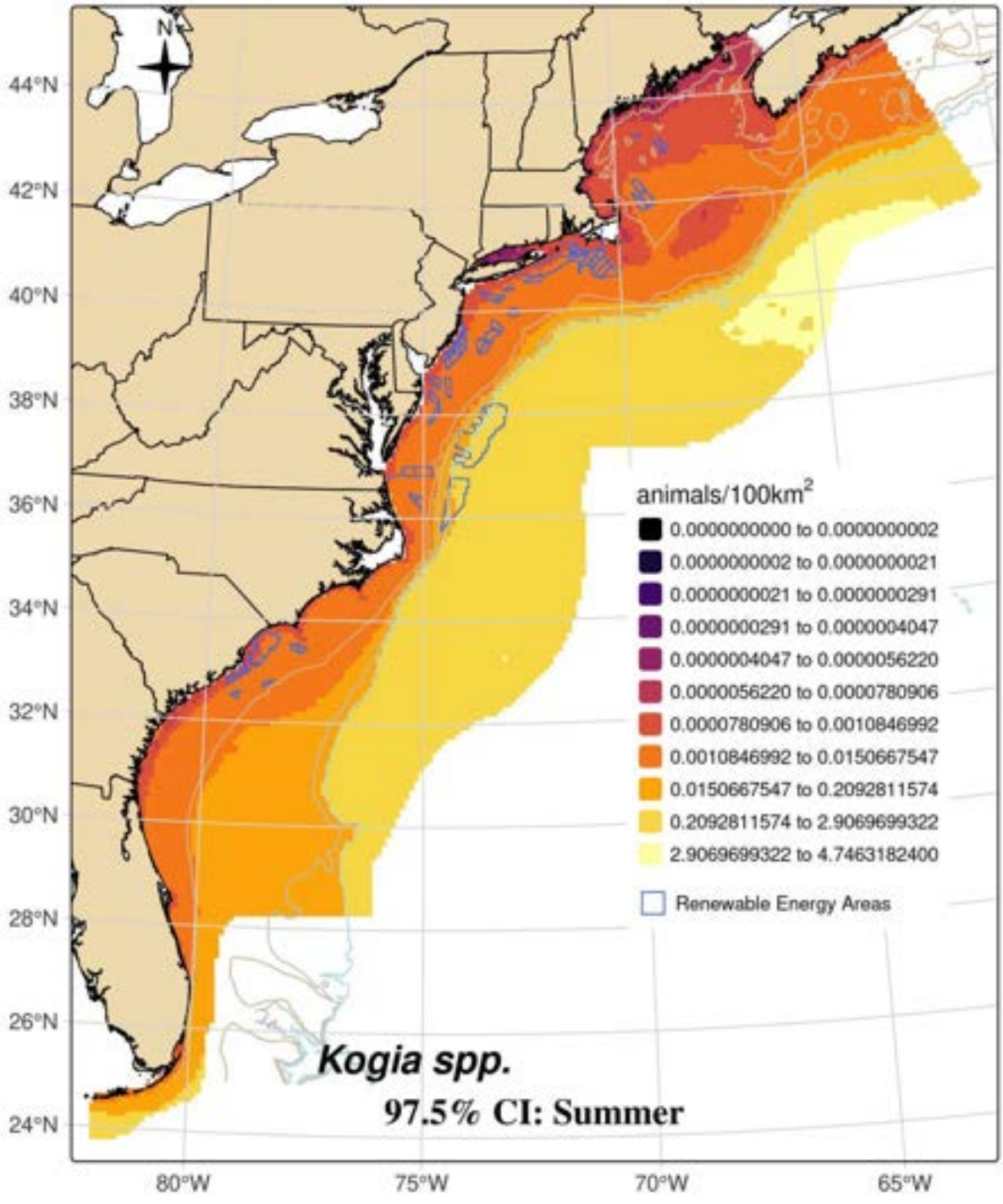

Figure B.11-12. Upper 97.5% confidence interval of the summer *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

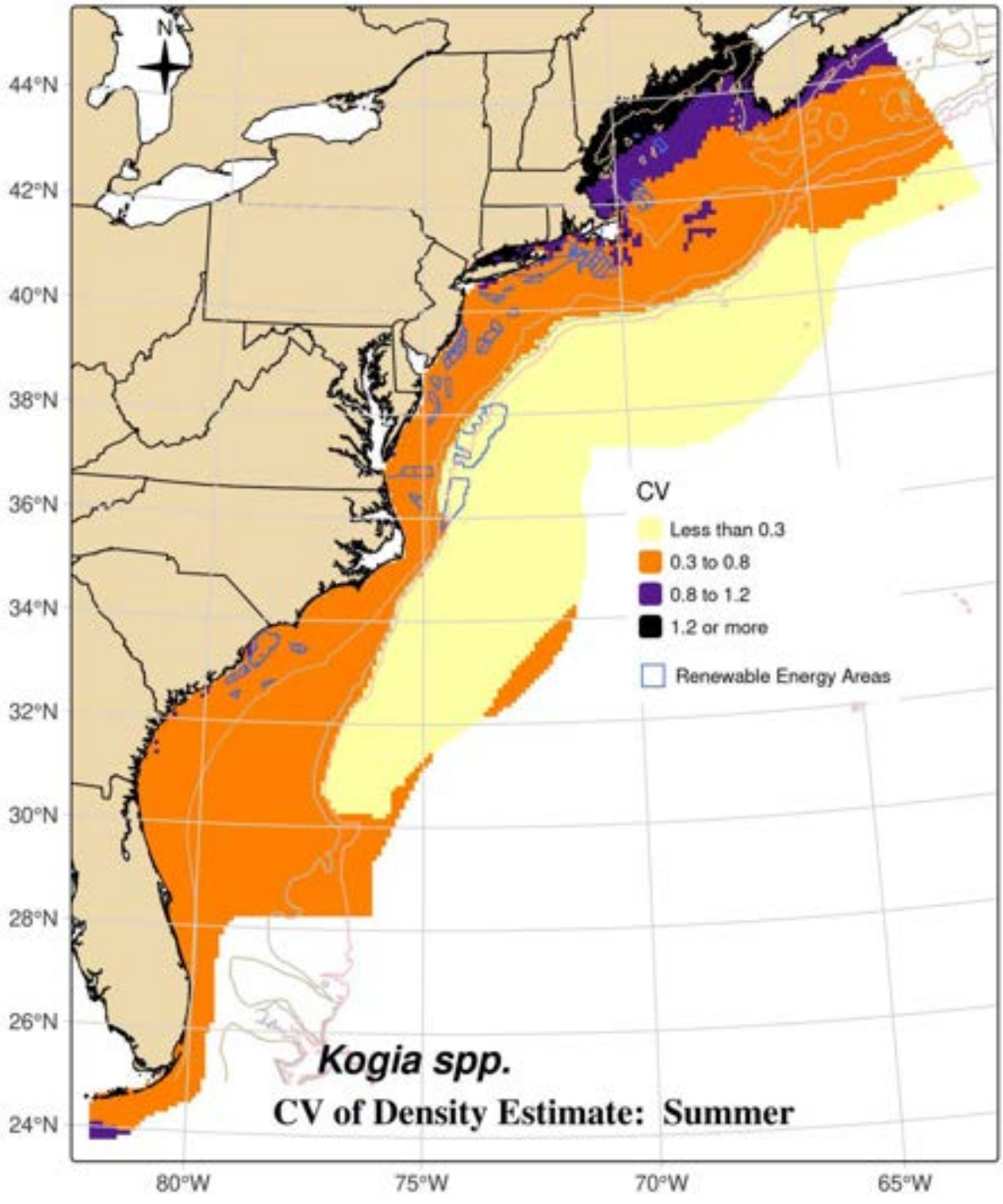

Figure B.11-13. CV of summer *Kogia* spp. density estimates
CVs are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

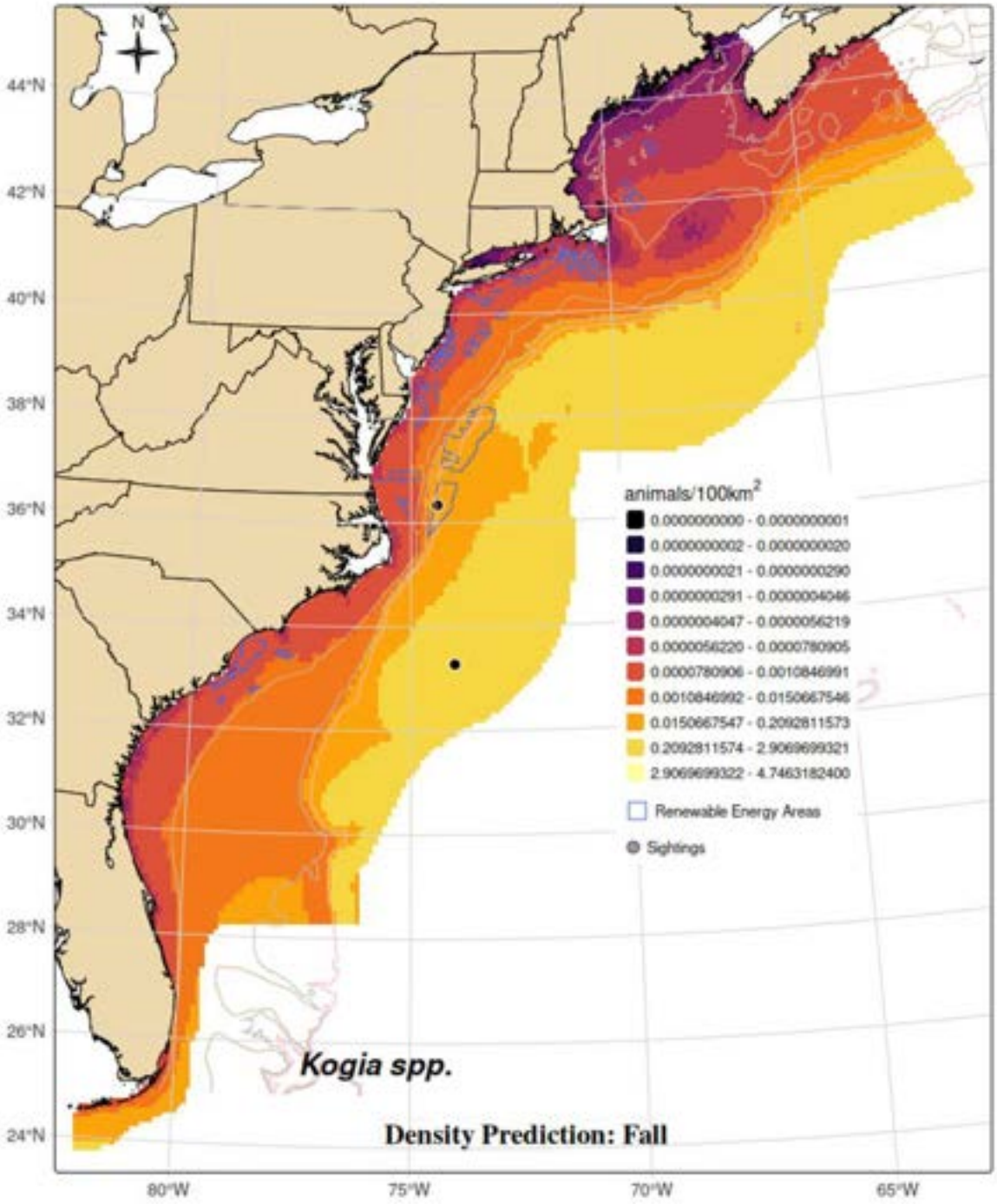

Figure B.11-14. *Kogia* spp. fall average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Black circles indicate locations of animal sightings. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

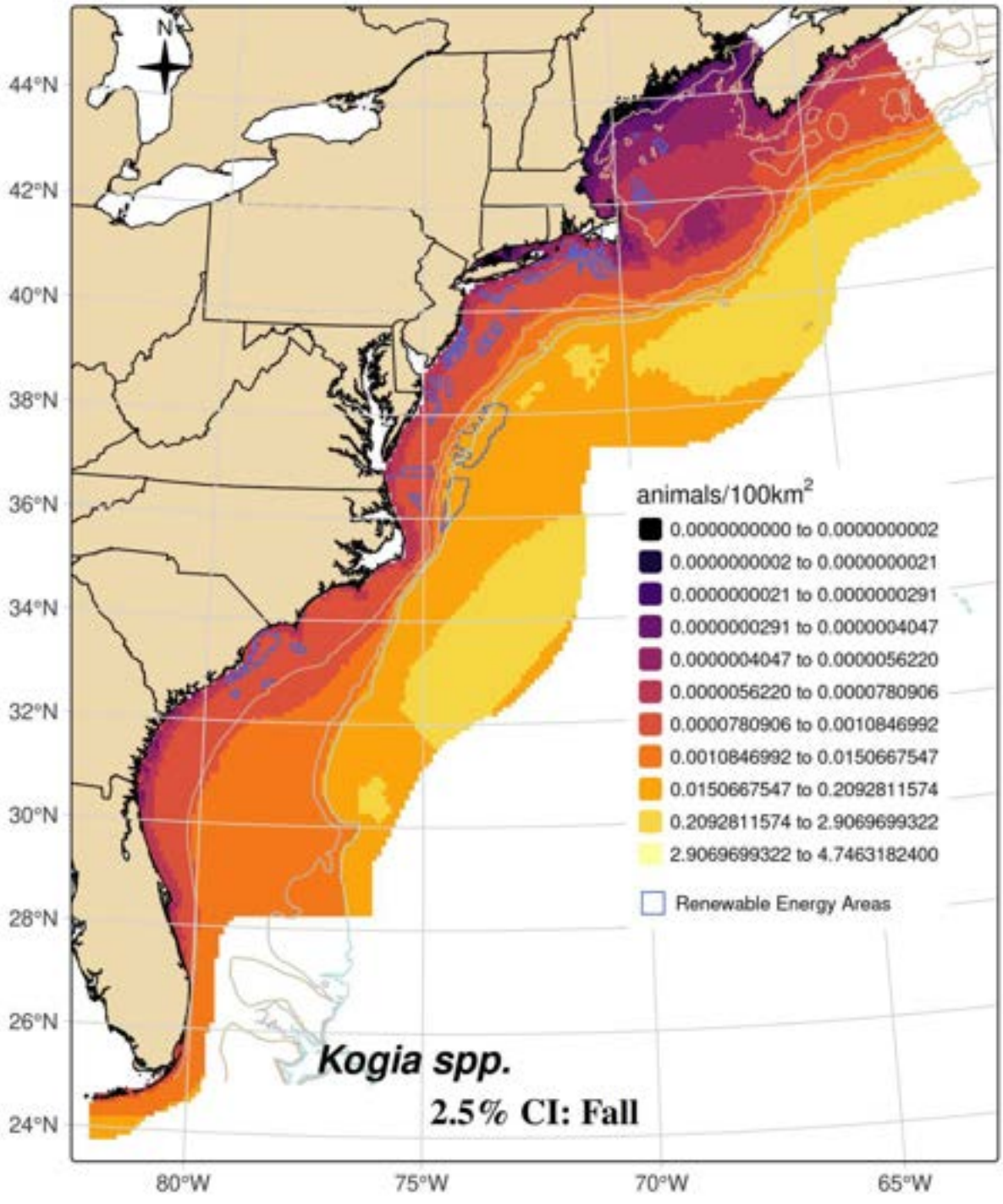

Figure B.11-15. Lower 2.5% confidence interval of the fall *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

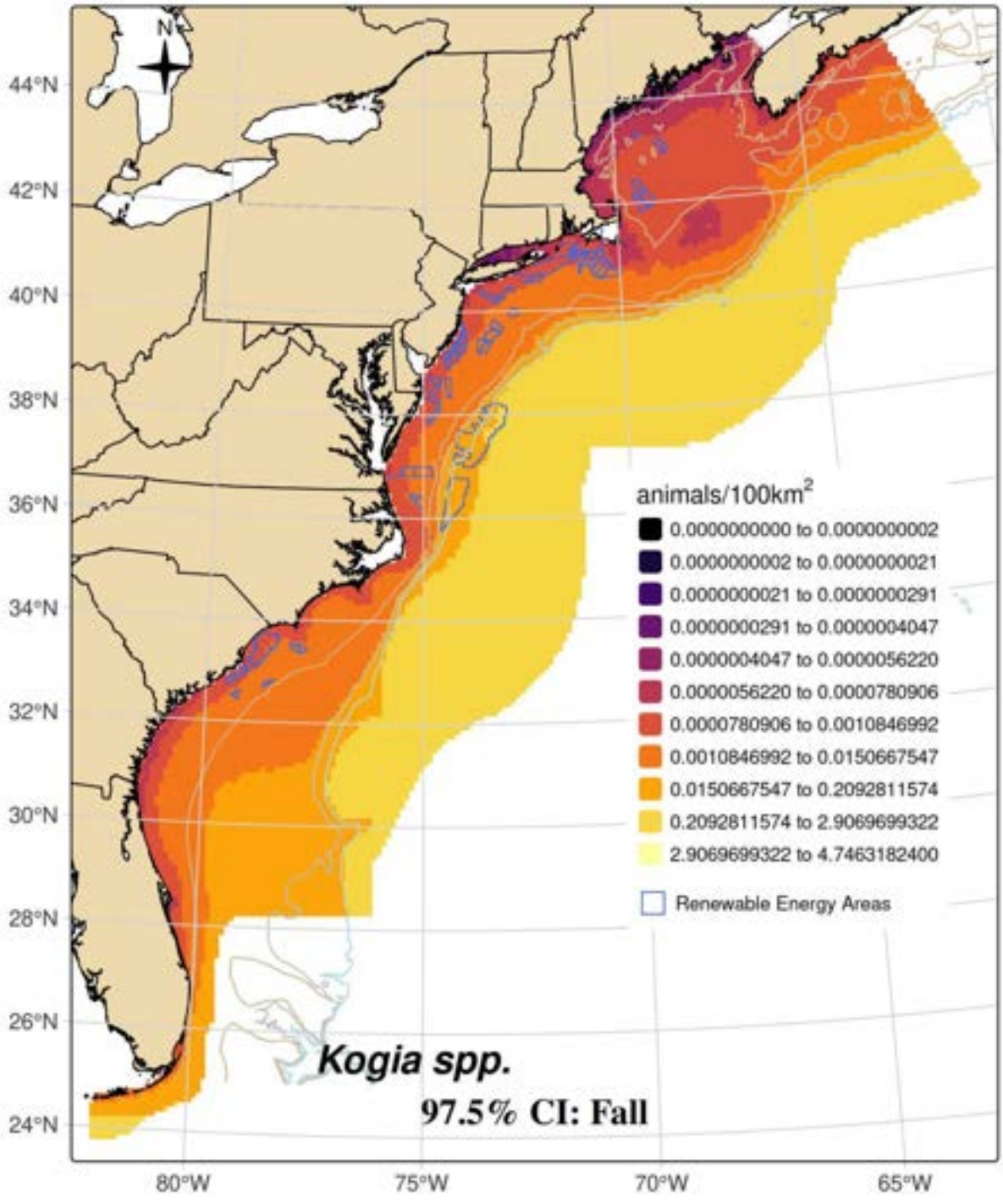

Figure B.11-16. Upper 97.5% confidence interval of the fall *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

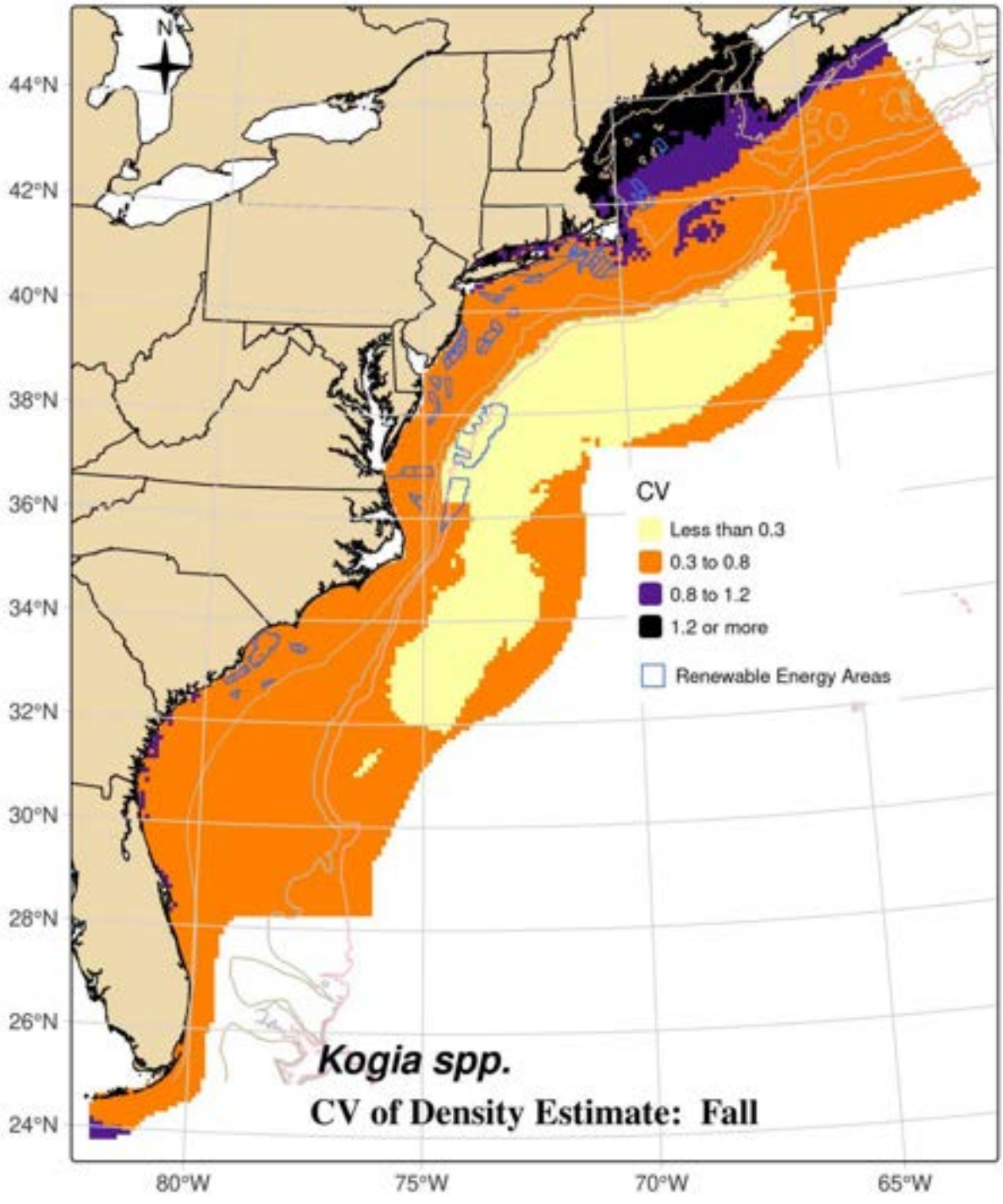

Figure B.11-17. CV of fall *Kogia* spp. density estimates
CVs are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

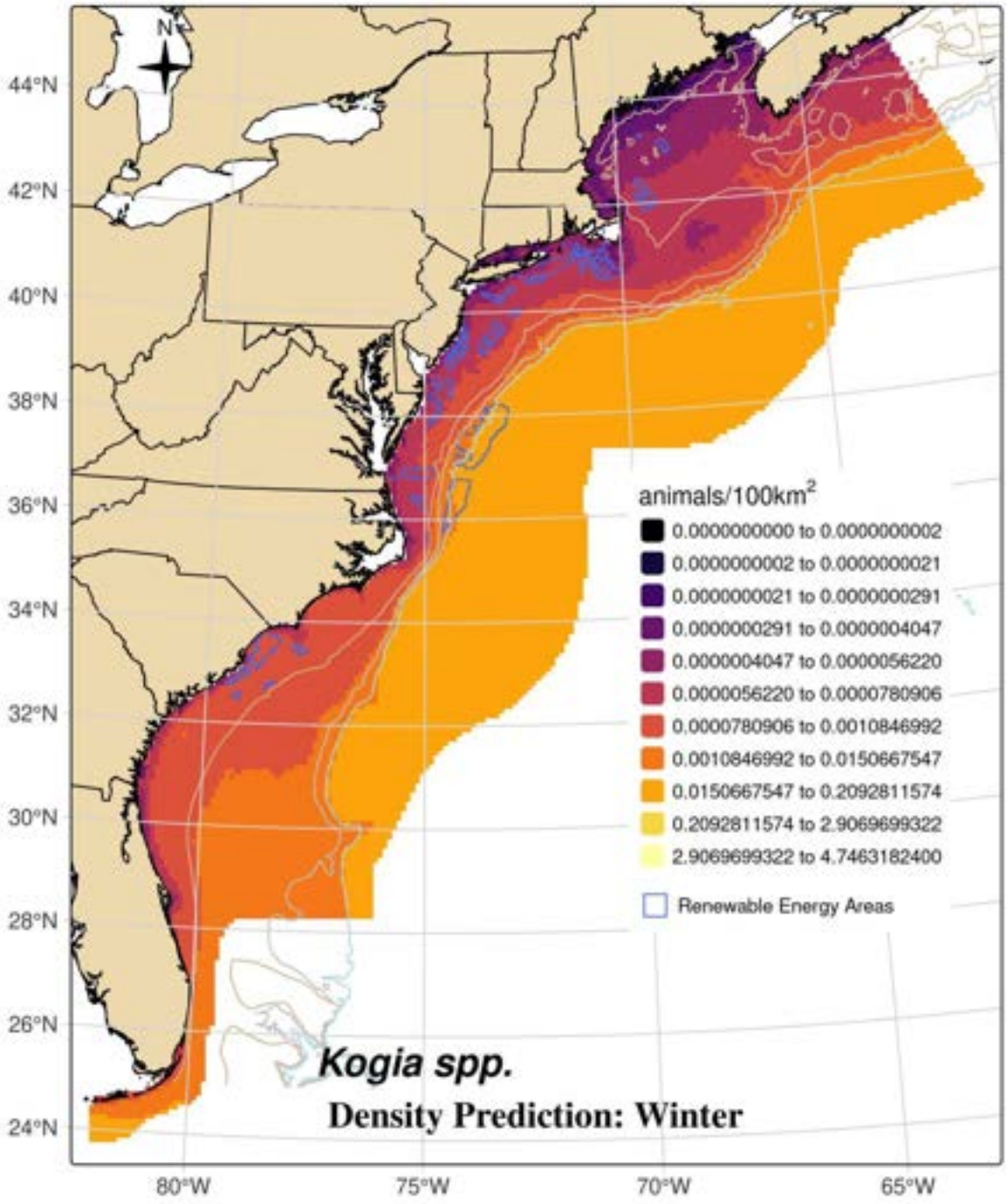

Figure B.11-18. *Kogia* spp. winter average density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

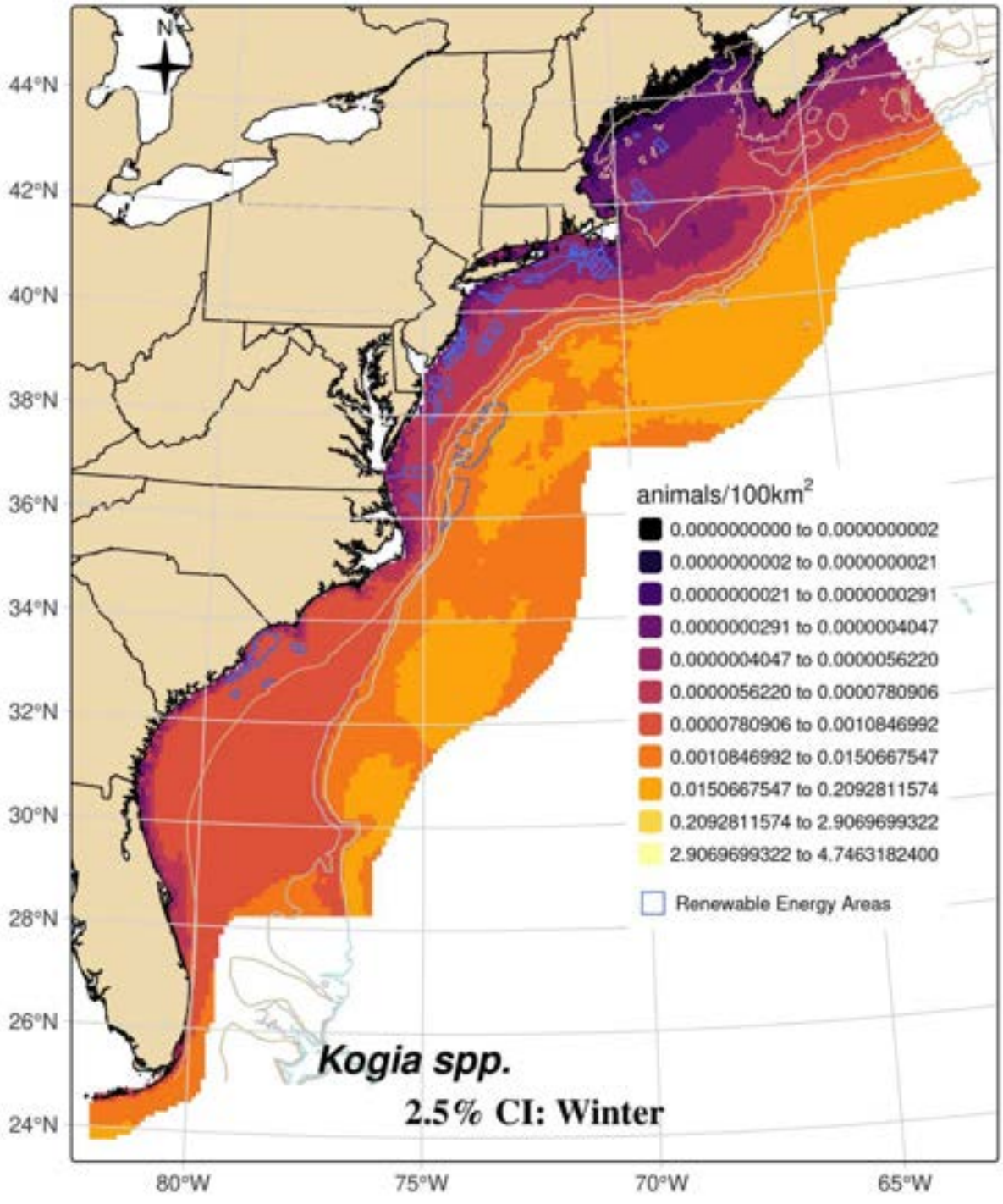

Figure B.11-19. Lower 2.5% confidence interval of the winter *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

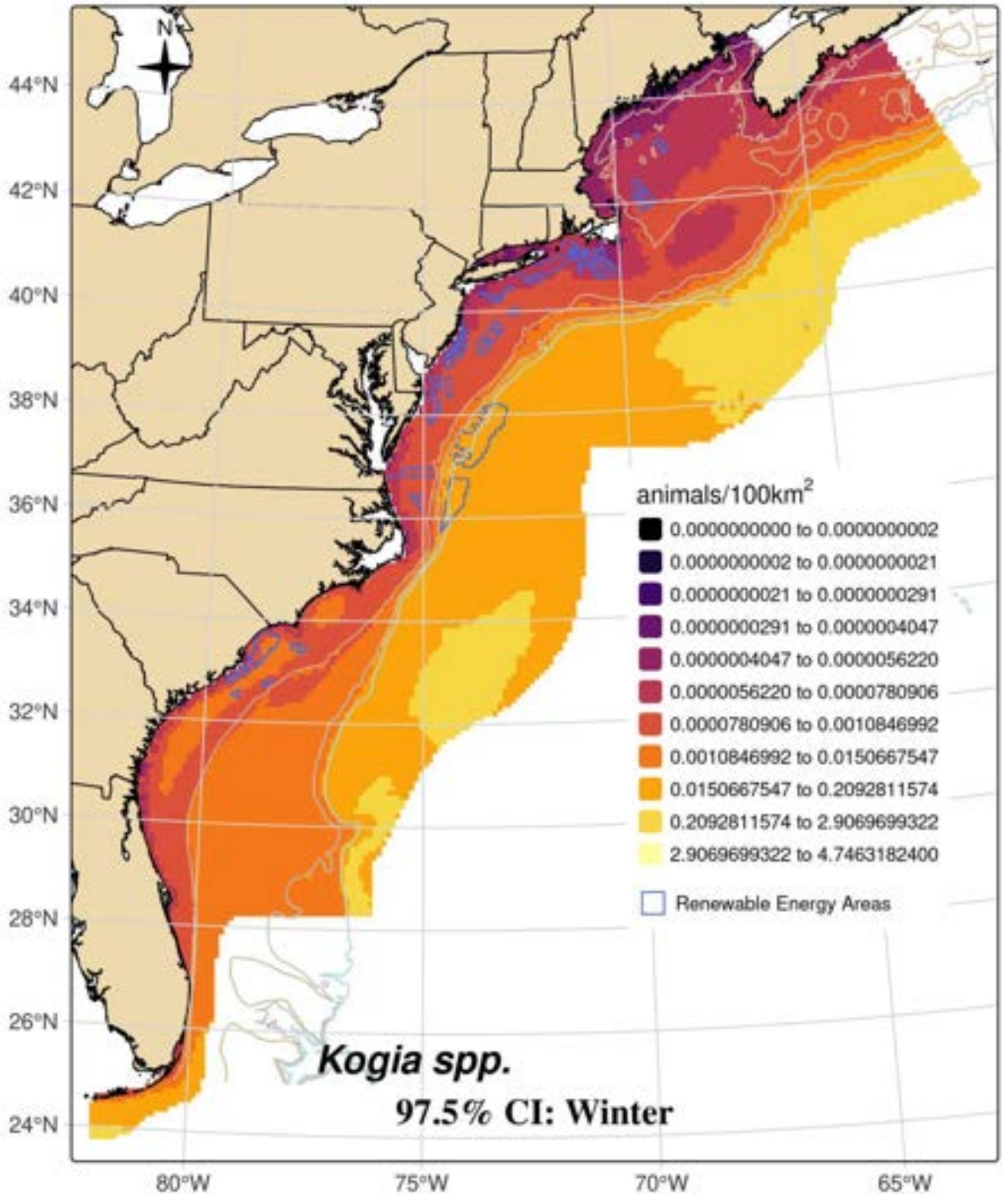

Figure B.11-20. Upper 97.5% confidence interval of the winter *Kogia* spp. density estimates
Densities are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

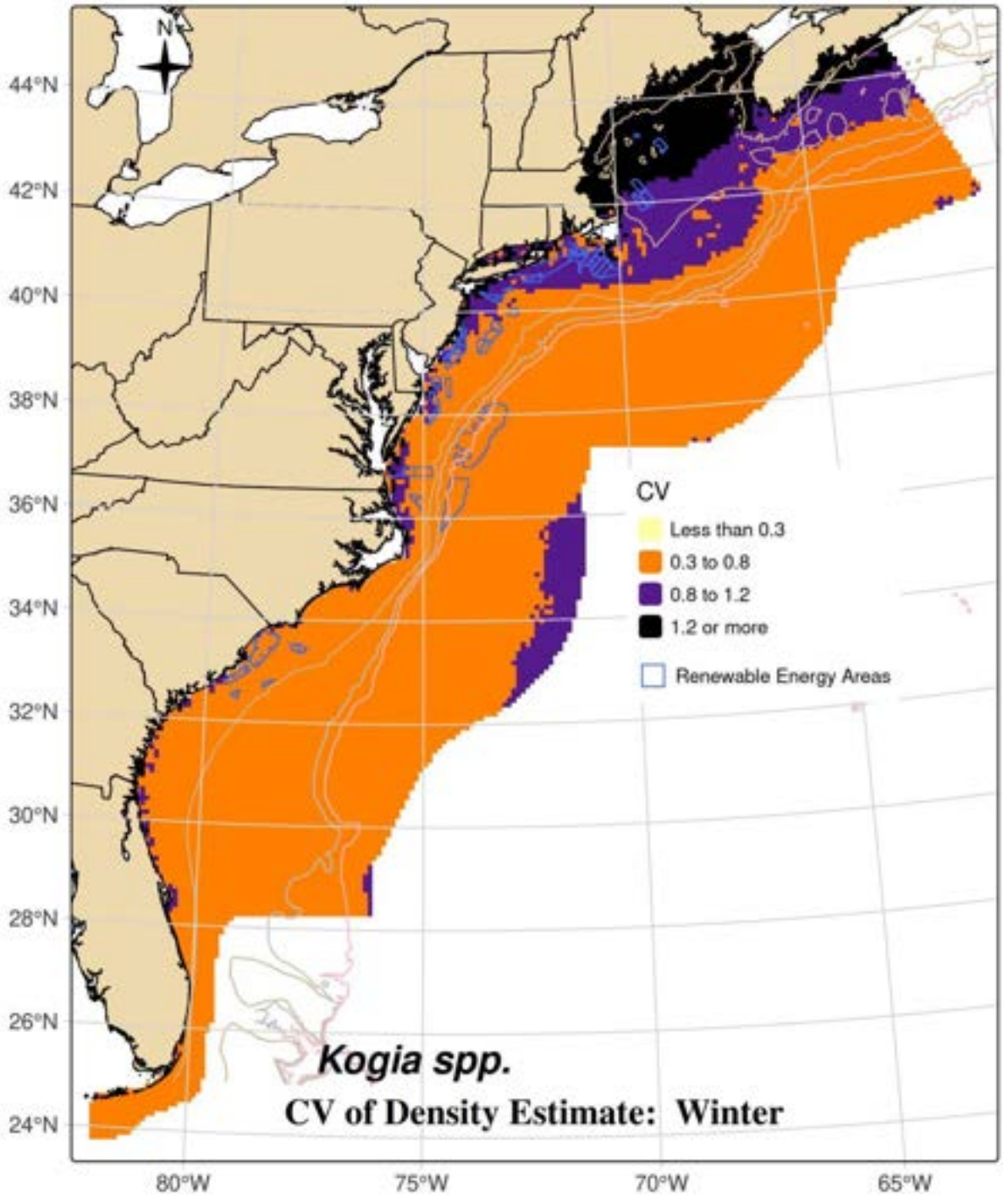

Figure B.11-21. CV of winter *Kogia* spp. density estimates
CVs are for grid cells of 10 km x 10 km with the exception of the coastal region. Tan, gray, and pink lines indicate the 100, 1,000 and 2,000 m depth contours. Blue polygons indicate locations of wind-energy study areas.

B.11.7 Offshore Energy Development Areas

Table B.11-6. *Kogia* spp. abundance estimates for wind-energy study areas

Season	Wind-Energy Study Area	Abundance*	CV	95% Confidence Interval*
Spring (Mar-May)	RI/MA	0	0.52	0 - 0.1
	NY	0	0.58	0 – 0
	NJ	0	0.58	0 – 0
	DE/MD	0	0.54	0 – 0
	VA	0	0.51	0 – 0
	NC	0	0.47	0 – 0
	NC/SC	0.1	0.44	0.1 - 0.3
	GA	0	0.49	0 – 0
	FL	0.1	0.54	0.1 - 0.4
Summer (Jun-Aug)	RI/MA	0.1	0.49	0 - 0.3
	NY	0	0.54	0 – 0
	NJ	0	0.47	0 - 0.1
	DE/MD	0	0.45	0 - 0.1
	VA	0.1	0.42	0 - 0.1
	NC	0.1	0.40	0 - 0.1
	NC/SC	0.2	0.42	0.1 - 0.4
	GA	0	0.52	0 – 0
	FL	0.3	0.62	0.1 - 0.8
Fall (Sep-Nov)	RI/MA	0	0.47	0 - 0.1
	NY	0	0.52	0 – 0
	NJ	0	0.48	0 – 0
	DE/MD	0	0.48	0 – 0
	VA	0	0.47	0 – 0
	NC	0	0.43	0 – 0
	NC/SC	0.1	0.45	0 - 0.2
	GA	0	0.54	0 – 0
	FL	0.1	0.58	0 - 0.4
Winter (Dec-Feb)	RI/MA	0	0.88	0 – 0
	NY	0	0.84	0 – 0
	NJ	0	0.70	0 – 0
	DE/MD	0	0.71	0 – 0
	VA	0	0.73	0 – 0
	NC	0	0.59	0 – 0
	NC/SC	0.1	0.47	0 - 0.1
	GA	0	0.49	0 – 0
	FL	0	0.56	0 - 0.1

***** We rounded the mean abundance and 95% confidence interval to the nearest tenth of an animal. If this resulted in a zero for the mean abundance, we calculated the CV using the actual abundance value as estimated by the density-habitat model and then rounded to the nearest tenth. If a wind-energy study area is not included, then we assumed the abundance was zero.

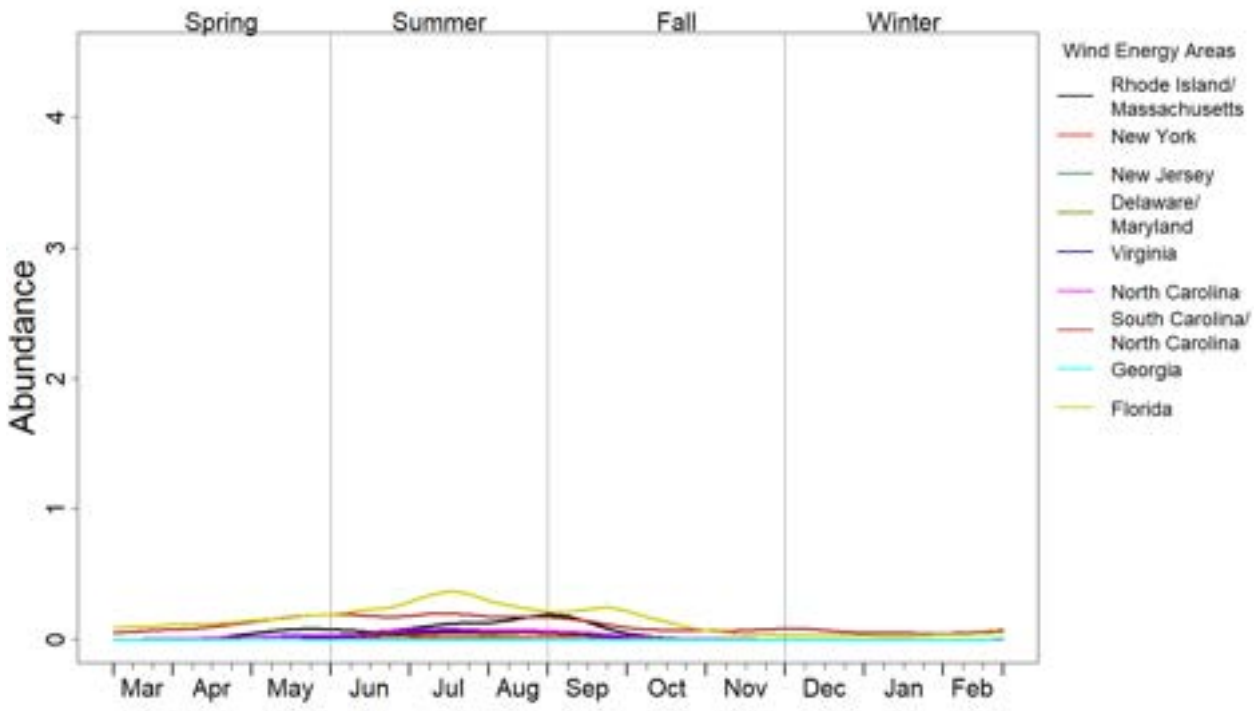

Figure B.11-22. Average seasonal abundance of *Kogia* spp. in the wind-energy study areas

B.12 References Cited

Hayes SA, Josephson E, Maze-Foley K, Rosel PE, McCordic J, Brossard A, Chavez-Rosales S, Cole TVN, Garrison LP, Hatch J, et al. 2024. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2023. NOAA Technical Memorandum NMFS-NE-321. https://www.fisheries.noaa.gov/s3/2025-01/Atlantic-MMSAR-122025.pdf