

Appendix I – Sleeping Bear Dunes National Lakeshore, Michigan

This appendix provides information on the numbers and information used in selecting the Sleeping Bear Dunes National Lakeshore, Michigan, portion of Lake Michigan as a Sea Duck Joint Venture key habitat site. All aerial survey data were collected during a project led by Kevin Kenow (U.S. Geological Survey Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin; Kenow et al. 2021). Additional information that assisted in designating key site boundaries, especially those areas containing mainly Long-tailed Ducks (*Clangula hyemalis*), comes from descriptions of habitat use and movements of Long-tailed Ducks radio-marked on Lake Michigan provided by Fara (2018).

Brief Description of Aerial Surveys

Aerial surveys were conducted during September through May, 2009 through 2014. Survey areas were selected to evaluate avian risk to type E botulism and to provide information on waterbird distributions to inform offshore wind energy development. Timing and selection of areas to be surveyed in a given month were focused on these issues and were highly influenced by plane availability and weather conditions. Surveys were flown along fixed-width transects. Transects generally paralleled shorelines and extended up to 32 km (20 mi) offshore. Surveys were flown at an average air speed of about 200 km/h (125 mph) and at an altitude of about 61–76 m (200–250 ft) above the water using a U.S. Fish and Wildlife Service (USFWS) fixed-wing aircraft (Partenavia P.68 Observer¹). Two observers, one on each side of the plane, identified and tallied waterbirds within 200-m-wide (1/8-mi) strip transects on either side of the plane. Distances were established using a clinometer, and the portion of the transect band beneath the plane that was not observable was estimated at 70.4 m (35.2 x 2) and 88 m (44 x 2) at 61 and 76 m above ground level (AGL), respectively.

Brief Description of Appendix Contents

This appendix contains nine tables and three figures. Tables S1, S4, and S7 provide the raw counts of sea ducks observed on (within the 200 m transect) and off (beyond the 200 m transect) transect for the surveys that were encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan, key site during fall (September–November), winter (December–February), and spring (March–May), respectively. Raw counts do not account for the visibility factors that may affect bird detectability during aerial surveys; therefore, we estimated the number of sea ducks using a visibility correction factor (Hodges et al. 2008) and present those numbers in tables S2, S5, and S8 for fall, winter, and spring, respectively. Tables S3, S6, and S9 provide the transect distance, observed area within the 200-m transect width at 61 m AGL, and the density of all sea ducks for both the raw and visibility corrected counts for fall, winter, and spring, respectively. Figures 1, 2, and 3 illustrate the distribution of sea ducks by month for the fall, winter, and spring seasons, respectively. In addition, all figures outline the aerial survey areas encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan, key site.

References

- Fara, L. J. 2018. Migration patterns, habitat use, prey items, and hunter harvest of long-tailed ducks (*Clangula hyemalis*) that overwinter on Lake Michigan. MS thesis, Southern Illinois University Carbondale, Carbondale, Illinois.
- Hodges, J. I., D. J. Groves, and B. P. Conant. 2008. Distribution and abundance of waterbirds near shore in Southeast Alaska. *Northwestern Naturalist* 89:85–96.
- Kenow, K. P., Fox, T. J., Houdek, S. C., Fara, L. J., and Lubinski, B. 2021. Lake Michigan Sea Duck Survey Data, 2009-2014: U.S. Geological Survey data release, <https://doi.org/10.5066/P9FGR77R>.

¹ Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. government.

Table S1. Raw counts of sea ducks, by species,¹ observed on and off transect during aerial surveys conducted over Lake Michigan during fall (September–November). Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan, key site.

Survey area	Survey date	On/Off transect	LTDU	WWSC	BLSC	SUSC	SCOT	COME	RBME	HOME	MERG	COGO	BUFF	Total sea ducks
Sleeping Bear Dunes National Lakeshore	8–9 Oct 2009	On	0	76	0	0	0	54	90	0	70	0	15	305
		Off	0	25	0	0	0	4	0	0	0	0	0	29
Sleeping Bear Dunes National Lakeshore	7 Oct 2010	On	92	334	0	0	0	208	0	0	0	3	0	637
		Off	0	15	0	0	0	75	0	0	0	0	0	90
Sleeping Bear Dunes National Lakeshore	9 Nov 2010	On	1292	962	0	0	0	460	0	0	0	24	62	2800
		Off	100	200	0	0	0	0	0	0	0	0	0	300
Sleeping Bear Dunes National Lakeshore	16 Sep 2011	On	47	0	0	0	0	1	0	0	0	0	0	48
		Off	0	0	0	0	0	0	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	4 Oct 2011	On	0	5	0	0	0	23	36	0	0	0	0	64
		Off	0	0	0	0	0	0	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	22 Oct 2012	On	489	1551	0	0	0	6	120	0	8	0	0	2174
		Off	0	60	0	0	0	0	0	0	0	0	0	60
Sleeping Bear Dunes National Lakeshore	28–29 Nov 2012	On	4651	825	2	0	103	81	51	0	18	38	0	5769
		Off	0	0	0	0	0	0	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	18–19 Sep 2013	On	0	0	0	0	2	2	0	0	9	0	0	13
		Off	0	0	0	0	0	0	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	29 Oct 2013	On	597	1144	1	0	1537	119	137	0	58	1	0	3594
		Off	1620	48	0	0	435	0	0	0	0	0	0	2103
Sleeping Bear Dunes National Lakeshore	17 Sep 2014	On	0	0	0	0	0	0	0	0	141	0	0	141
		Off	0	0	0	0	0	0	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	22 Oct 2014	On	907	76	0	0	0	0	120	0	1	0	0	1104
		Off	370	0	0	0	30	0	20	0	0	0	0	420
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		On	8075	4973	3	0	1642	954	554	0	305	66	77	16,649
		Off	2090	348	0	0	465	79	20	0	0	0	0	3002

¹ LTDU = Long-tailed Duck (*Clangula hyemalis*), WWSC = White-winged Scoter (*Melanitta deglandi*), BLSC = Black Scoter (*Melanitta americana*), SUSC = Surf Scoter (*Melanitta perspicillata*), SCOT = unidentified scoter species, COME = Common Merganser (*Mergus merganser*), RBME = Red-breasted Merganser (*Mergus serrator*), HOME = Hooded Merganser (*Lophodytes cucullatus*), MERG = unidentified merganser species, COGO = Common Goldeneye (*Bucephala clangula*), and BUFF = Bufflehead (*Bucephala albeola*).

Table S2. Estimated counts of sea ducks, by species or species groups,¹ observed on and off transect during aerial surveys conducted over Lake Michigan during fall (September–November) using a visibility correction factor (Hodges et al. 2008). Correction factor multipliers are shown in parentheses under each species or species group. Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan, key site.

Survey area	Survey date	On/Off transect	LTDU (3.46)	SCOTERS (1.74)	MERGANSERS (1.45)	COGO (1.60)	BUFF (3.26)	Total sea ducks
Sleeping Bear Dunes National Lakeshore	8–9 Oct2009	On	0	132	310	0	49	491
		Off	0	44	6	0	0	49
Sleeping Bear Dunes National Lakeshore	7 Oct2010	On	318	581	302	5	0	1206
		Off	0	26	109	0	0	135
Sleeping Bear Dunes National Lakeshore	9 Nov2010	On	4470	1674	667	38	202	7052
		Off	346	348	0	0	0	694
Sleeping Bear Dunes National Lakeshore	16 Sep2011	On	163	0	1	0	0	164
		Off	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	4 Oct2011	On	0	9	86	0	0	94
		Off	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	22 Oct2012	On	1692	2699	194	0	0	4585
		Off	0	104	0	0	0	104
Sleeping Bear Dunes National Lakeshore	28–29Nov2012	On	16,092	1618	218	61	0	17,989
		Off	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	18–19 Sep 2013	On	0	3	16	0	0	19
		Off	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	29 Oct 2013	On	2066	4667	455	2	0	7189
		Off	5605	840	0	0	0	6446
Sleeping Bear Dunes National Lakeshore	17 Sep 2014	On	0	0	204	0	0	204
		Off	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	22 Oct 2014	On	3138	132	175	0	0	3446
		Off	1280	52	29	0	0	1361
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		On	27,939	11,515	2628	106	251	42,439
		Off	7231	1414	144	0	0	8789

¹ LTDU = Long-tailed Duck (*Clangula hyemalis*), SCOTERS = Scoter species, MERGANSER = Merganser species, COGO = Common Goldeneye (*Bucephala clangula*), and BUFF = Bufflehead (*Bucephala albeola*).

Table S3. Fall (September–November) density estimates for all sea ducks combined using both raw counts and visibility corrected (Hodges et al. 2008) count estimates for observations on transect. Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan, key site.

Survey area	Survey date	Transect distance (km)	Transect area (km ²) at 61 m AGL	Raw count density (sea ducks/km ²)	Corrected count density (sea ducks/km ²)
Sleeping Bear Dunes National Lakeshore	8–9 Oct 2009	958.6	316.0	1.0	1.6
Sleeping Bear Dunes National Lakeshore	7 Oct 2010	1044.3	344.2	1.9	3.5
Sleeping Bear Dunes National Lakeshore	9 Nov 2010	1042.5	343.6	8.1	20.5
Sleeping Bear Dunes National Lakeshore	16 Sep 2011	672.9	221.8	0.2	0.7
Sleeping Bear Dunes National Lakeshore	4 Oct 2011	673.5	222.0	0.3	0.4
Sleeping Bear Dunes National Lakeshore	22 Oct 2012	704.6	232.2	9.4	19.7
Sleeping Bear Dunes National Lakeshore	28–29 Nov 2012	684.9	225.7	25.6	79.7
Sleeping Bear Dunes National Lakeshore	18–19 Sep 2013	520.6	171.6	0.1	0.1
Sleeping Bear Dunes National Lakeshore	29 Oct 2013	514.3	169.5	21.2	42.4
Sleeping Bear Dunes National Lakeshore	17 Sep 2014	497.6	164.0	0.9	1.2
Sleeping Bear Dunes National Lakeshore	22 Oct 2014	451.6	148.8	7.4	23.2
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		7765.4	2559.4	6.5	16.6

Table S4. Raw counts of sea ducks, by species,¹ observed on and off transect during aerial surveys conducted over Lake Michigan during winter (December–February). Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lake Shore, Michigan, key site.

Survey area	Survey date	On/Off transect	LTDU	WWSC	BLSC	SUSC	SCOT	COME	RBME	HOME	MERG	COGO	BUFF	Total sea ducks
Sleeping Bear Dunes National Lakeshore	1–2 Dec 2009	On	4741	4446	0	0	0	745	0	0	0	550	0	10,482
		Off	902	177	0	0	0	30	0	0	0	60	0	1169
Sleeping Bear Dunes National Lakeshore	14 Jan 2011	On	1540	307	0	0	0	1139	14	0	0	454	37	3491
		Off	89	161	0	0	0	8	1	0	0	3	0	262
Sleeping Bear Dunes National Lakeshore	6 Dec 2011	On	686	365	0	0	423	82	1	0	9	77	24	1667
		Off	2001	10	0	0	0	47	0	0	0	0	0	2058
Sleeping Bear Dunes National Lakeshore	20–21 Jan 2012	On	,055	958	0	0	0	101	35	0	228	996	0	3373
		Off	30	165	0	0	0	0	0	0	0	0	0	195
Sleeping Bear Dunes National Lakeshore	19 Dec 2013	On	1755	300	0	0	860	246	0	0	106	1046	7	4320
		Off	5000	0	0	0	0	0	0	0	0	0	0	5000
Sleeping Bear Dunes National Lakeshore	3 Feb 2014	On	1101	8	0	0	335	1	148	0	11	55	0	1659
		Off	0	0	0	0	0	0	0	0	0	0	0	0
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		On	10,878	6384	0	0	1618	2314	198	0	354	3178	68	24,992
		Off	8022	513	0	0	0	85	1	0	0	63	0	8684

¹ LTDU = Long-tailed Duck (*Clangula hyemalis*), WWSC = White-winged Scoter (*Melanitta deglandi*), BLSC = Black Scoter (*Melanitta americana*), SUSC = Surf Scoter (*Melanitta perspicillata*), SCOT = unidentified scoter species, COME = Common Merganser (*Mergus merganser*), RBME = Red-breasted Merganser (*Mergus serrator*), HOME = Hooded Merganser (*Lophodytes cucullatus*), MERG = unidentified merganser species, COGO = Common Goldeneye (*Bucephala clangula*), and BUFF = Bufflehead (*Bucephala albeola*).

Table S5. Estimated counts of sea ducks, by species or species groups,¹ observed on and off transect during aerial surveys conducted over Lake Michigan during winter (December–February) using a visibility correction factor (Hodges et al. 2008). Correction factor multipliers are shown in parentheses under each species or species group. Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan key site.

Survey area	Survey date	On/Off transect	LTDU (3.46)	SCOTERS (1.74)	MERGANSERS (1.45)	COGO (1.60)	BUFF (3.26)	Total sea ducks
Sleeping Bear Dunes National Lakeshore	1–2 Dec 2009	On	16,404	7736	1080	880	0	26,100
		Off	3121	308	44	96	0	3568
Sleeping Bear Dunes National Lakeshore	14 Jan 2011	On	5328	534	1672	726	121	8381
		Off	308	280	13	5	0	606
Sleeping Bear Dunes National Lakeshore	6 Dec 2011	On	2374	1371	133	123	78	4080
		Off	6923	17	68	0	0	7009
Sleeping Bear Dunes National Lakeshore	20–21 Jan 2012	On	3650	1667	528	1594	0	7439
		Off	104	287	0	0	0	391
Sleeping Bear Dunes National Lakeshore	19 Dec 2013	On	6072	2018	510	1674	23	10,298
		Off	17,300	0	0	0	0	17,300
Sleeping Bear Dunes National Lakeshore	3 Feb 2014	On	3809	597	232	88	0	4726
		Off	0	0	0	0	0	0
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		On	37,637	13,923	4155	5085	222	61,024
		Off	27,756	892	125	101	0	28,874

¹ LTDU = Long-tailed Duck (*Clangula hyemalis*), SCOTERS = Scoter species, MERGANSER = Merganser species, COGO = Common Goldeneye (*Bucephala clangula*), and BUFF = Bufflehead (*Bucephala albeola*).

Table S6. Winter (December–February) density estimates for all sea ducks combined using both raw counts and visibility corrected (Hodges et al. 2008) count estimates for observations on transect. Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan key site.

Survey area	Survey date	Transect distance (km)	Transect area (km ²) at 61 m AGL	Raw count density (sea ducks/km ²)	Corrected count density (sea ducks/km ²)
Sleeping Bear Dunes National Lakeshore	1–2 Dec 2009	1109.9	336.2	31.2	77.6
Sleeping Bear Dunes National Lakeshore	14 Jan 2011	499.5	164.6	21.2	50.9
Sleeping Bear Dunes National Lakeshore	6 Dec 2011	677.4	223.3	7.5	18.3
Sleeping Bear Dunes National Lakeshore	20–21 Jan 2012	756.0	249.2	13.5	29.9
Sleeping Bear Dunes National Lakeshore	19 Dec 2013	513.8	169.3	25.5	60.8
Sleeping Bear Dunes National Lakeshore	3 Feb 2014	289.8	95.5	17.4	49.5
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		3756.4	1238.1	20.2	49.3

Table S7. Raw counts of sea ducks, by species¹, observed on and off transect during aerial surveys conducted over Lake Michigan during Spring (March–May). Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan key site.

Survey area	Survey date	On/Off transect	LTDU	WWSC	BLSC	SUSC	SCOT	COME	RBME	HOME	MERG	COGO	BUFF	Total sea ducks
Sleeping Bear Dunes National Lakeshore	5 Apr 2012	On	215	26	0	0	0	152	33	0	46	44	0	516
		Off	0	0	0	0	0	0	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	5 Apr 2013	On	773	15	0	0	41	106	3	0	740	278	0	1956
		Off	0	0	0	0	0	58	0	0	25	101	0	184
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		On	988	41	0	0	41	258	36	0	786	322	0	2472
		Off	0	0	0	0	0	58	0	0	25	101	0	184

¹ LTDU = Long-tailed Duck (*Clangula hyemalis*), WWSC = White-winged Scoter (*Melanitta deglandi*), BLSC = Black Scoter (*Melanitta americana*), SUSC = Surf Scoter (*Melanitta perspicillata*), SCOT = unidentified scoter species, COME = Common Merganser (*Mergus merganser*), RBME = Red-breasted Merganser (*Mergus serrator*), HOME = Hooded Merganser (*Lophodytes cucullatus*), MERG = unidentified merganser species, COGO = Common Goldeneye (*Bucephala clangula*), and BUFF = Bufflehead (*Bucephala albeola*).

Table S8. Estimated counts of sea ducks, by species or species groups¹, observed on and off transect during aerial surveys conducted over Lake Michigan during spring (March–May) using a visibility correction factor (Hodges et al. 2008). Correction factor multipliers are shown in parentheses under each species or species group. Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan, key site.

Survey area	Survey date	On/Off transect	LTDU (3.46)	SCOTERS (1.74)	MERGANSERS (1.45)	COGO (1.60)	BUFF (3.26)	Total sea ducks
Sleeping Bear Dunes National Lakeshore	5 Apr 2012	On	744	45	335	70	0	1194
		Off	0	0	0	0	0	0
Sleeping Bear Dunes National Lakeshore	5 Apr 2013	On	2675	97	1231	445	0	4448
		Off	0	0	120	162	0	282
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		On	3419	142	1566	515	0	5642
		Off	0	0	120	162	0	282

¹ LTDU = Long-tailed Duck (*Clangula hyemalis*), SCOTERS = Scoter species, MERGANSER = Merganser species, COGO = Common Goldeneye (*Bucephala clangula*), and BUFF = Bufflehead (*Bucephala albeola*).

Table S9. Spring (March–May) density estimates for all sea ducks combined using both raw counts and visibility corrected (Hodges et al. 2008) count estimates for observations on transect. Survey areas listed are only those encompassed by the Sleeping Bear Dunes National Lakeshore, Michigan key site.

Survey area	Survey date	Transect distance (km)	Transect area (km ²) at 61 m AGL	Raw count density (sea ducks/km ²)	Corrected count density (sea ducks/km ²)
Sleeping Bear Dunes National Lakeshore	5 Apr 2012	665.7	219.4	2.4	5.4
Sleeping Bear Dunes National Lakeshore	5 Apr 2013	668.4	220.3	8.9	20.2
Total Sleeping Bear Dunes National Lakeshore, Michigan, key site		1334.1	439.7	5.6	12.8

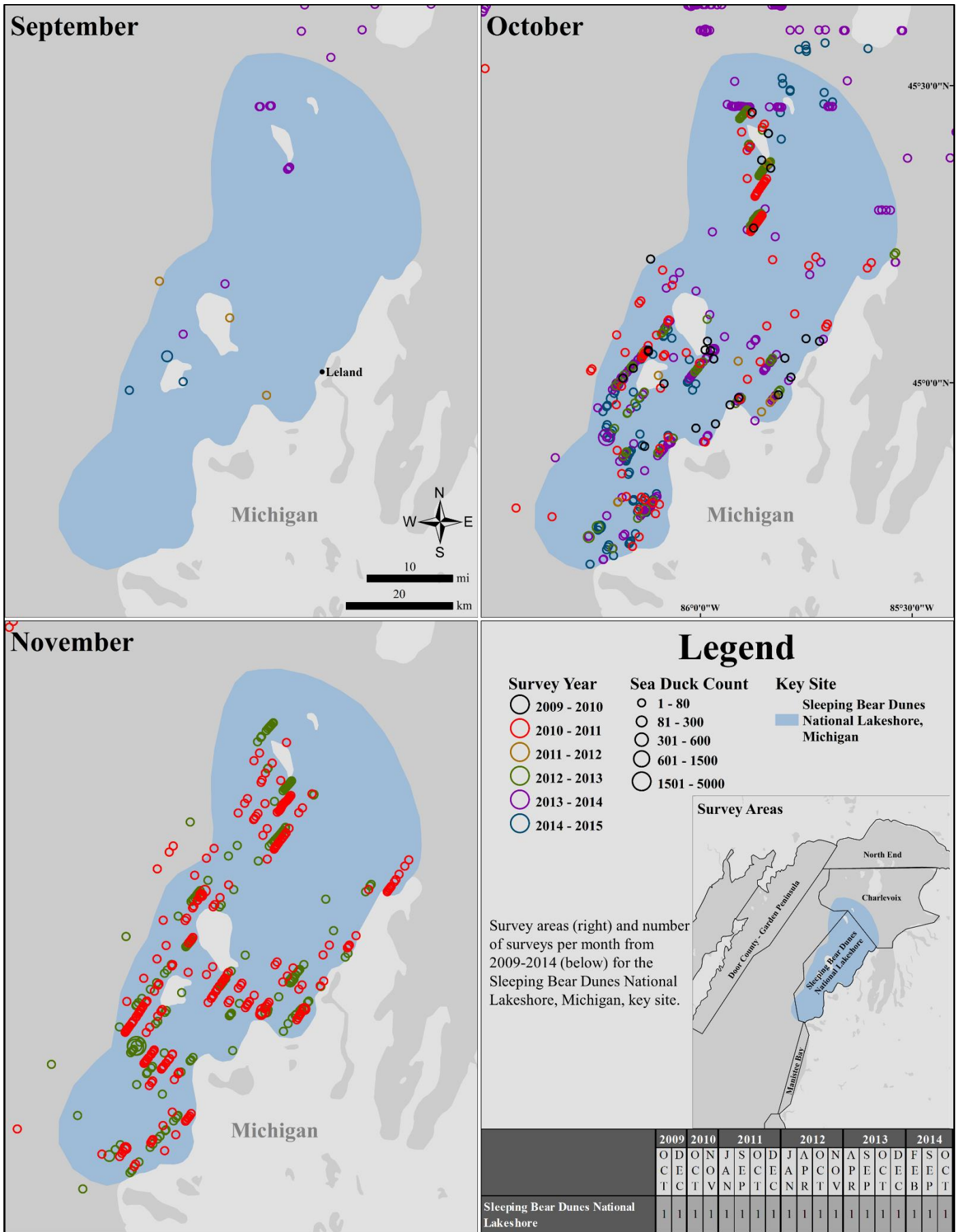


Figure S1. Maps depict sea duck counts from aerial surveys conducted over Lake Michigan from 2009–2014 during fall (September–November) for the Sleeping Bear Dunes National Lakeshore, Michigan, key site, by month.

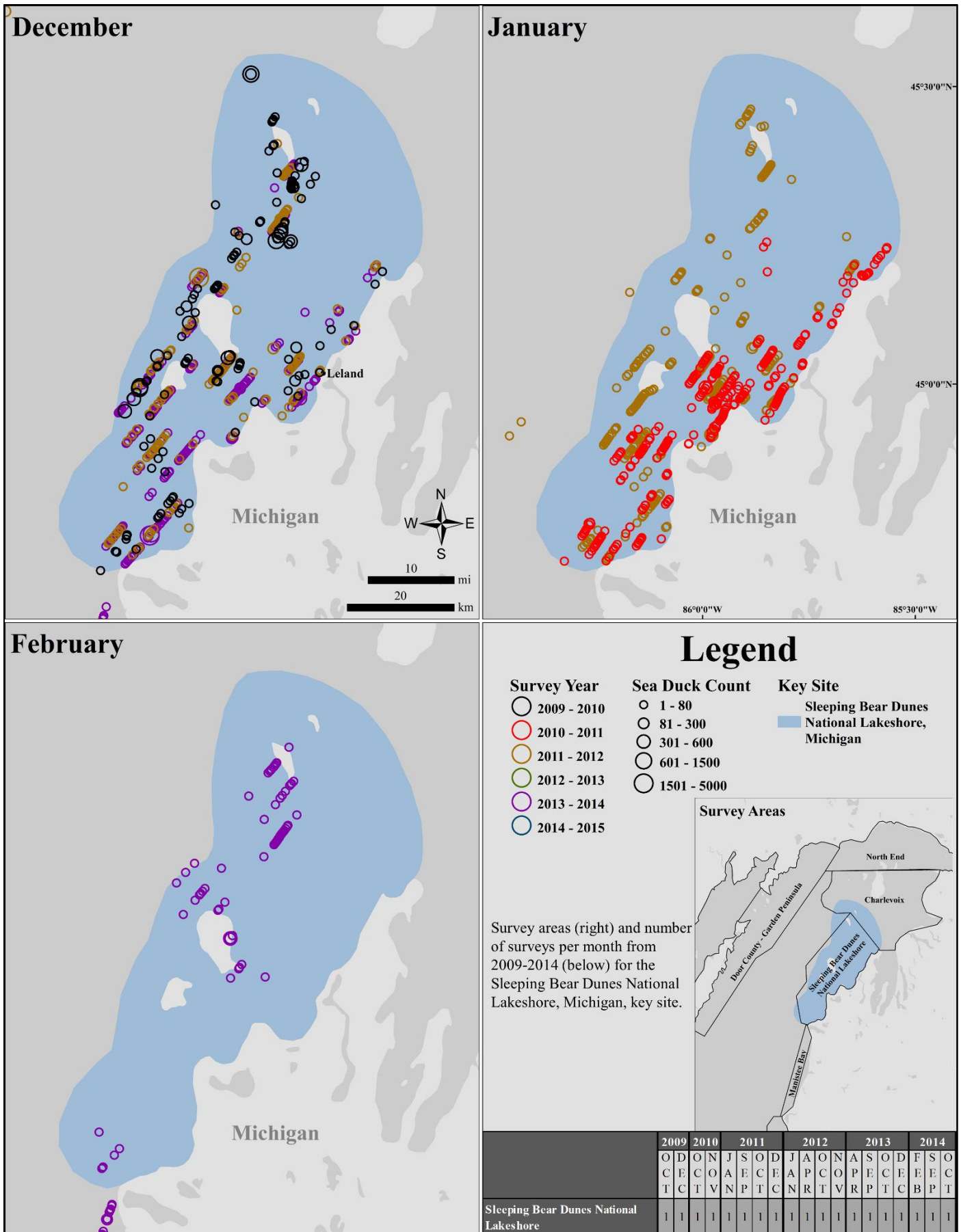


Figure S2. Maps depict sea duck counts from aerial surveys conducted over Lake Michigan from 2009–2014 during winter (December–February) for the Sleeping Bear Dunes National Lakeshore, Michigan, key site, by month.

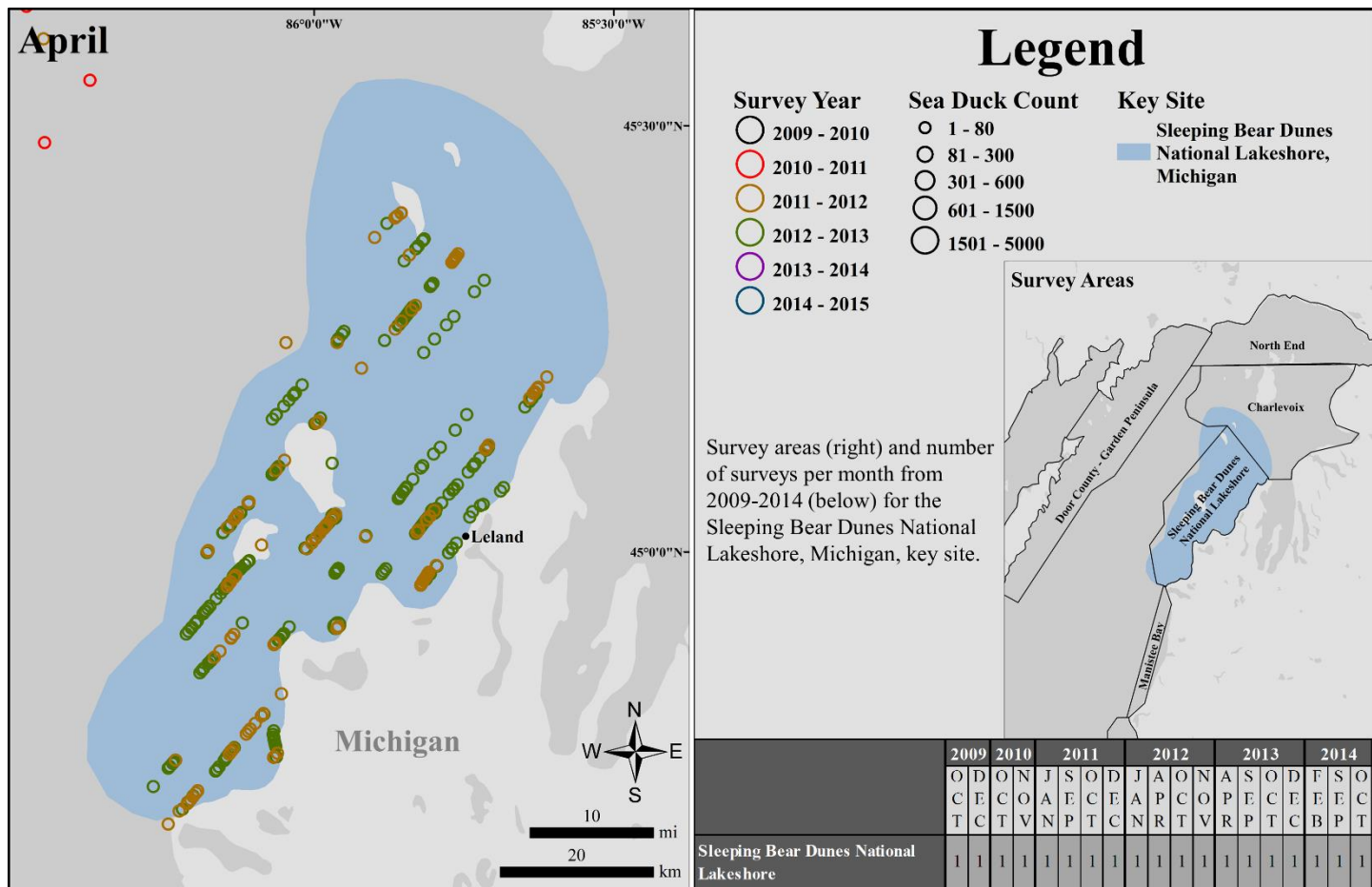


Figure S3. Maps depict sea duck counts from aerial surveys conducted over Lake Michigan from 2009–2014 during spring (March–May) for the Sleeping Bear Dunes National Lakeshore, Michigan, key site, by month. March and May are not depicted as no surveys were conducted in this key site during those months.