

Summary of the Winter 2013 Pacific Coast Aerial Sea Duck Surveys in British Columbia

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INTRODUCTION

This survey was implemented as part of the second phase of the Pacific Coast Winter Sea Duck Survey (PCWSDS) design project funded by the Sea Duck Joint Venture in FY11. Washington Department of Fish and Wildlife (WDFW), in partnership with the Canadian Wildlife Service (CWS), were responsible for testing the proposed survey design along portions of the Pacific coast of British Columbia, Canada that would match those efforts being conducted in Alaska. The primary focus of this portion of the survey was to systematically survey the marine waters of British Columbia from the Strait of Juan de Fuca, then northward between Vancouver Island and the mainland, to assess efficiency, adequacy, and safety of the survey, and to estimate abundance of sea ducks wintering there.

METHODS

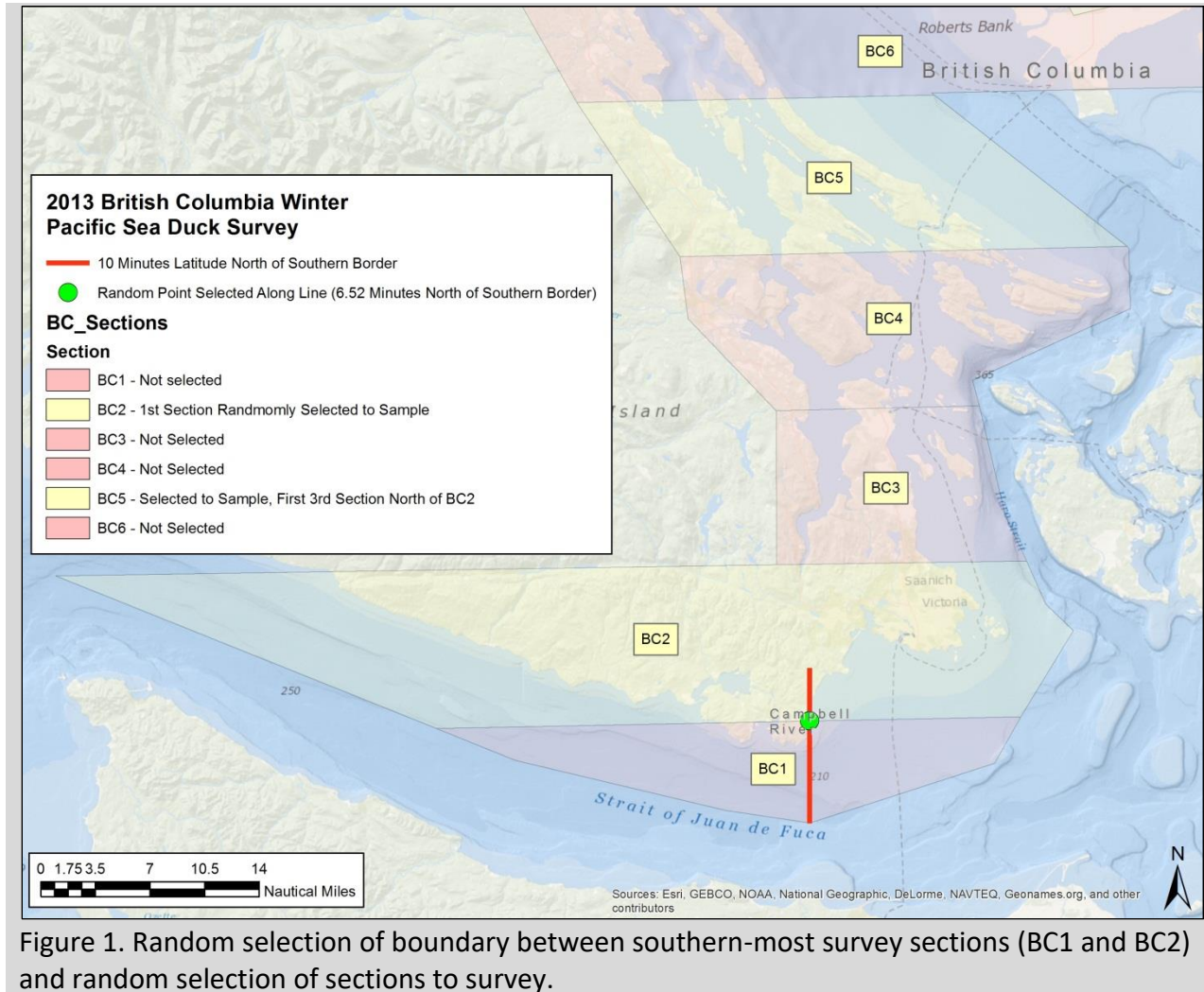
Aerial strip surveys were flown at 200ft (61m) AGL and 85-90 knots airspeed according to protocols developed by Jack Hodges as part of the Pacific Coast Winter Sea Duck Survey project. The aircraft utilized for the survey was a piston DHC-2 Beaver on straight floats equipped with bubble windows. The survey design split the marine waters into an offshore stratum and a shoreline stratum. The offshore stratum was defined as generally 300 m from shore and extending offshore to either 20 fms (36.58 m) or 3 NM (5056 km), whichever was greater.

All sample units were separated into 10 minute latitude sections, except the southern-most section, which was shorter (6.52 minute latitude section). The boundary separating the 1st (BC1) and 2nd (BC2) sections was randomly selected along 10 nautical mile line starting at the southern edge of the B.C. border with the U.S. extending north. The random latitude selected was 48° 20.02'. The area south of this point fell into the first section (BC1) while the 2nd section (BC2) began at this point and extended 10 minutes latitude north (Figure 1). Concurrent sections were placed every 10 minutes of latitude. As the survey design was to sample every third section, the first section was randomly selected from the three southernmost sections (BC1, BC2, and BC3). BC2 was selected as the starting section to sample; every third section was sampled from this section north. Within a sampled section, four latitudinal transects were surveyed at two minute latitude intervals, as well as all shoreline that could be safely surveyed.

Survey strip width for the shoreline stratum totaled 300m (100m on the shore-side of the aircraft, and 200m on the seaward side of the aircraft). Survey strip-width for the offshore stratum totaled 200m (100m on each side of the aircraft). The survey strips were delineated using two thin polypropylene strings tied onto the strut of the aircraft. The 100 meter strip was located between the upper edge of the aircraft float and the lower string, while the 200M strip was located between the upper edge of the float and the upper string. The lower and upper strings were placed at 24° and 14°, respectively.

The survey window was set from 01 through 22 February, 2013. The first of February was the earliest we could begin the survey due to other field commitments. 22 February was selected as the final date of the window; to extend past this would risk the possibility of changes in

distribution related to herring spawning events in the Strait of Georgia. The goal was to survey as much of the survey sections as possible during this window.



Transect location data were digitally recorded every second using Garmin nRoute software. Environmental conditions and events were recorded using in-house event logging software designed specifically for marine aerial surveys. All observations were recorded onto digital voice recorders, including count, species classification, and time. Observations, conditions, and events, were geo-referenced by interpolation to the log file using time.

Due to the inherent hazards in flying these complex waterways, the aircraft was staffed with four personnel, each with specific duties, to increase safety. The mid-seats on either side of the aircraft were staffed with the observers whose duties were to focus on observations. The right front seat was staffed with navigator who assisted the pilot in course plotting and hazard identification, and to operate the two computers operated on board the aircraft. Each computer ran Garmin nRoute navigation software, each displaying the aircraft position and course in real-time, with predetermined transects displayed. One computer displayed a focal

(zoomed-in) scale map for the pilot to follow, while the other computer was used by the navigator to plan the most efficient and safe flight paths to take to accomplish the mission. The pilot was able to focus on the safe operation of the aircraft while following transects along the shoreline and offshore areas. All personnel looked out for hazards.

STATISTICAL METHODS

Statistical methods were the same as those used for concurrent surveys in Alaska, coordinated by Jack Hodges. No detectability correction factors are applied to these data.

RESULTS

Seven days of successful surveys were flown from 7 – 20 February, 2013. These surveys covered six survey sections (BC2, BC5, BC8, BC11, BC14, and BC17) totaling 2,331 NM of transects (nearshore = 1699 KM; offshore = 632 KM) (Table 1, Figure 2).

Table 1. Summary of effort from the winter 2013 Pacific Coast Aerial Sea Duck Surveys in British Columbia. NS = nearshore strata, OS = offshore strata. All surveys dates are during February, 2013.

Section	Dates (Feb-2013)	Observers	Total Length of Transects (KM)			Area Sampled (KM ²)			Proportion of Sampled Area by Type		
			NS	OS	Total	NS	OS	Total	NS	OS	Total
BC2	19th	B. Murphie, T. Cyra	138	114	252	42	23	64	0.08	0.18	0.10
BC5	11th	B. Murphie, P. DeBruyn	223	80	303	67	16	83	0.13	0.13	0.13
BC8	12th, 13th	B. Murphie, P. DeBruyn	340	203	542	102	41	142	0.20	0.32	0.22
BC11	8th, 13th	B. Murphie, P. DeBruyn	114	112	226	34	22	57	0.07	0.18	0.09
BC14	7th, 8th	B. Murphie, T. Cyra	562	93	655	169	19	187	0.33	0.15	0.29
BC17	20th	B. Murphie, T. Cyra	322	30	352	96	6	103	0.19	0.05	0.16
Total	7 Days		1699	632	2331	510	126	636	1.00	1.00	1.00

Nearshore Stratum: All shoreline was surveyed that could be safely covered. These included all shoreline from six 10-minute survey sections. Each survey section was treated as a sample unit. Both weighted and un-weighted means and standard errors of counts per species or species groups of the sample units were calculated. Area sampled (KM²) within each sample was used to weight means and standard errors. We report these values as well, because there was considerable variation in sampled area between survey sections (Table 1). The mean and

standard errors were expanded to those sample units (immediately surrounding the sampled sections) that were not surveyed to derive a population estimate for this stratum (expansion value = 20.652 (0.652 is from survey section BC1, which did not comprise a full to minutes latitude)).

Offshore Stratum: The four transects in each 10 minute strip were totaled from the six. Each of these totals was treated as a sample unit. Like the nearshore stratum, both un-weighted and weighted means and standard errors were calculated. The means and standard errors were expanded by a factor of $(1852 * 10 / 800) * 20.652 = 478.0938$.

To correspond with the previous PCWSDS efforts, values reported in the text are un-weighted.

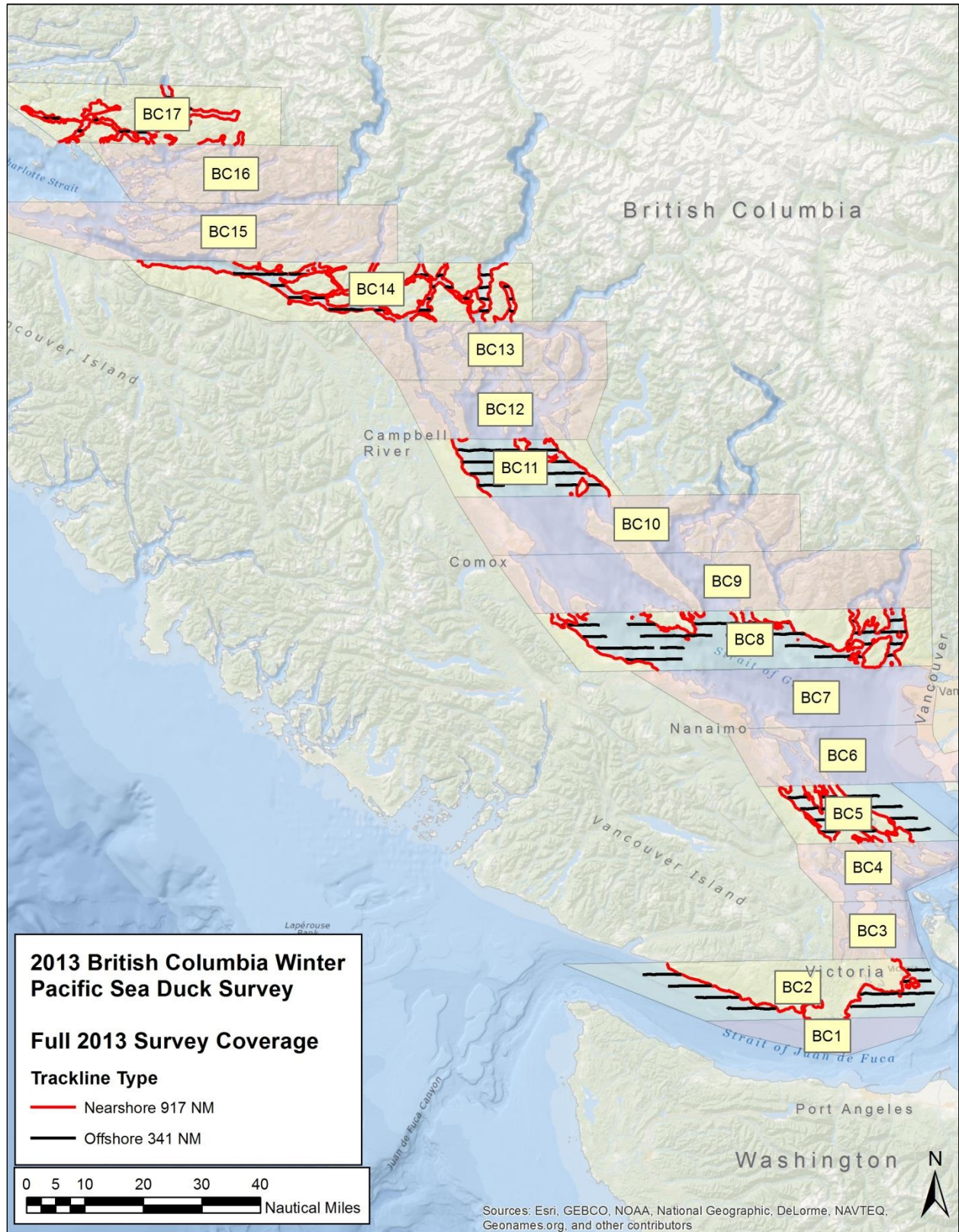


Figure 2. British Columbia aerial transects surveyed for sea ducks during winter (February) 2013. Labeled polygons denote the 10-minute survey sections.

Tables 2, 3, and 4 summarize the results by nearshore, offshore and combined (nearshore + offshore) stratum, respectively. Due to the considerable variation in survey area between the survey sections we also report densities for both the nearshore and offshore stratum in Table 5.

Eleven species of sea ducks were observed during these efforts. These include harlequin duck (*Histrionicus histrionicus*), black scoter (*Melanitta americana*), white-winged scoter (*M. fusca*), surf scoter (*M. perspicillata*), long-tailed duck (*Clangula hyemalis*), common goldeneye (*Bucephala clangula*), Barrow's goldeneye (*B. islandica*), bufflehead (*B. albeola*), hooded merganser (*Lophodytes cucullatus*), red-breasted merganser (*Mergus serrator*), and common merganser (*M. merganser*). The total estimate within the survey sections and their immediate neighboring un-surveyed sections was 96,760 (SE = 38,366).

The scoters were the most abundant of the sea duck species groups, comprising 33% of all sea ducks (32,101, SE = 9,938). Surf scoters were the most abundant of all the scoters classified to species with abundance estimates comprising 74.5% (20,313) of classified scoters. White-winged and black scoters abundance estimates comprised 16.8% (4,586) and 8.6% (2,355), respectively. Unclassified scoters comprised 15.1% (4,848) of the total scoter estimate (32,101). The majority of scoters were found in the nearshore stratum (67%) with surf scoters comprising 86% of the scoters classified to species there. 76% of surf scoters classified to species were found within the nearshore stratum, while White-winged scoters were split between the nearshore and offshore strata, 49.6% and 50.4%, respectively. Black scoters were predominantly found in the offshore stratum; 91.4% of the estimate for this species was in this stratum. In general, Surf scoters were found in most areas while white-winged scoters were much less common at the entrances to, and within, the fjords. Black scoters were not observed in the fjords, but were predominantly found on both west and eastern shores of the central Strait of Georgia (Figures 3, 9, and 10).

Goldeneyes were the second most abundant sea duck group, comprising 20% of all sea ducks (19,189, SE = 7,799). Of the goldeneyes classified to species (76% of the total), Barrow's goldeneye were slightly more abundant, comprising 52.5% of total for this species group. The goldeneyes in general were more common at the entrances to the fjords, and inside the fjords, and less common along the more exposed waters of the Straits of Georgia and Juan de Fuca (Figures 4, 11, and 12).

Bufflehead were the second most abundant sea duck classified to species with an estimate of 16,852 (SE = 4,048). They were distributed in all areas of the survey, but in smaller groups within the fjords (Figures 5, 13, and 14). This species was also highly associated with the nearshore strata, with 91% of their estimate found there.

Mergansers comprised 12.5% of the sea duck estimate (12,137, SE = 3,345). They were also evenly distributed in all of the survey sections, in both coastal and fjord habitats (Figures 8, 19, and 20). Common and hooded mergansers were most common within the nearshore strata with 89% and 100% of their estimates, respectively, found there. The estimate for common mergansers was split between the two strata. Red-breasted mergansers were the most

abundant comprising 65.5% of those classified to species. Common and hooded mergansers comprised 32.8% and 1.7% of the mergansers classified to species, respectively.

Long-tailed ducks made up 11% of the sea duck estimate (10,791, SE = 9,971). Distribution of this species was much more clumped and isolated to smaller areas, while being virtually absent from the fjord, being found exclusively near the coastline of the Straits of Georgia and Juan de Fuca (Figures 7, 17, and 18).

Harlequin ducks were the least abundant of the sea ducks comprising 6% of the estimate (5,690, SE = 3,264). They were predominantly observed along the coastlines of the straits, and much less common in the fjords. (Figures 6, 15, and 16).

Other species of water birds and marine mammals were also recorded and are represented in Tables 1, 2, 3, and 4, and in Appendix 1 (Figures 21-29).

RECOMMENDATIONS FOR FUTURE SURVEYS

In general, the survey design worked well, and we were able to fly the areas efficiently and safely.

1. Re-evaluate sample unit size. With the current design, each survey section is weighted equally even though there is large disparity between the sampled area per survey section. In addition, each survey section is treated as a single sample unit. This may exaggerate the standard error.
2. Evaluate what to do regarding “missed” hot-spots by identifying potential habitats that may have high numbers of sea ducks and survey them separately. An example of this is The Fraser River Delta and Boundary Bay. We know that the number of scoters utilizing these two areas during winter can surpass the total scoter estimate from this entire survey. If the goal is to look at only trends, then this design may suffice.
3. Obtain review of survey design status by SDJV monitoring committee.
4. Complete the remaining B.C. survey sections in 2014 and 2015 (Appendix 3).

ACKNOWLEDGEMENTS

These surveys were funded by the Sea Duck Joint Venture. A special thank you to pilot Bill Dutch and Corilair Charters, out of Campbell River, B.C., for providing the aircraft and both professional and safety conscious piloting. John “Jack” Hodges was instrumental in the survey design. Heather Tschaekofske flight followed all survey flights. We are exceptionally grateful to all of these parties. A special mention to Kamala Netter and Dan Buffett of Ducks Unlimited and Ducks Unlimited Canada for working out an extremely quick contract with a Corilair Charters – without their efforts the surveys would not have been possible this year.

Table 2: Summary of the results from the nearshore transects during winter 2013 Pacific Coast aerial surveys in British Columbia.

Section	BC2	BC5	BC8	BC11	BC14	BC17							
Latitude Range	48°, 20'-30'	48°50'-49°	49°, 20'-30'	49°50'-50°	50°, 20'-30'	50°50'-51°							
Area Sampled KM ²	41.5	67.0	101.9	34.2	168.5	96.5	509.7	Un-weighted			Weighted by area sampled		
N Transects	5	5	5	5	5	5	30						
Species/Transect #'s	1-5, 10-14	19-23	28-32, 37-41	46-50	55-59	64-68	Grand Total	Average	Expanded Pop.	S.E.	Average	Expanded Pop.	S.E.
Anatidae													
Merginae													
BLSC	0	0	59	0	0	0	59	9.83	203	203	11.79	244	219
SUSC	67	630	1534	838	637	876	4582	763.67	15771	4010	827.66	17093	3792
WWSC	0	18	188	123	62	270	661	110.17	2275	882	119.82	2475	873
UNSC	48	120	362	100	608	101	1339	223.17	4609	1843	318.91	6586	2273
Total Scoters	115	768	2143	1061	1307	1247	6641	1106.83	22858	5636	1278.18	26397	5281
Harlequin Ducks	59	33	287	301	170	16	866	144.33	2981	1078	145.96	3014	981
Long-tailed Ducks	6	3	17	5	2	0	33	5.50	114	51	5.28	109	56
BAGO	6	275	1079	17	430	415	2222	370.33	7648	3318	474.19	9793	3230
COGO	34	303	737	164	285	167	1690	281.67	5817	2052	326.78	6749	2064
UNGO	1	46	393	69	788	42	1339	223.17	4609	2626	357.80	7389	3294
Total Goldeneye	41	624	2209	250	1503	624	5251	875.17	18074	6938	1158.78	23931	7089
Bufflehead	923	1262	593	787	729	162	4456	742.67	15338	3072	684.25	14131	3016
COME	30	35	92	50	390	339	936	156.00	3222	1381	221.93	4583	1579
HOME	3	9	2	0	24	16	54	9.00	186	79	12.79	264	93
RBME	113	197	146	190	195	167	1008	168.00	3470	281	173.15	3576	249
UNME	0	21	8	29	173	47	278	46.33	957	541	72.41	1495	708
Total Mergansers	146	262	248	269	782	569	2276	379.33	7834	2051	480.28	9919	2460
Aythiinae													
SCAU	7	51	177	22	143	0	400	66.67	1377	634	91.41	1888	695
Anas													
AMWI	49	296	85	50	11	0	491	81.83	1690	921	66.90	1382	882
GADW	2	11	0	0	0	0	13	2.17	45	37	1.61	33	35
MALL	58	262	81	36	5	0	442	73.67	1521	820	59.44	1228	793
NOPI	0	234	0	0	0	0	234	39.00	805	805	30.77	635	734
Total Dabbling Ducks	109	803	166	86	16	0	1180	196.67	4062	2557	158.72	3278	2410
Anserinae													
BLBR	0	0	12	12	0	0	24	4.00	83	52	3.20	66	50
CAGO	30	40	32	0	29	15	146	24.33	503	121	26.53	548	97
Avian Piscivores													
HOGR	19	38	22	67	18	3	167	27.83	575	187	21.96	454	154
RNGR	7	4	6	7	51	25	100	16.67	344	156	24.36	503	198
WEGR	0	9	0	10	101	295	415	69.17	1428	988	91.11	1882	1014

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UNGR	0	1	0	0	0	2	3	0.50	10	7	0.51	11	7
Total Podicipediformes	26	52	28	84	170	325	685	114.17	2358	980	137.94	2849	1017
COLO	5	19	47	33	11	6	121	20.17	416	141	19.29	398	143
PALO	0	3	24	6	14	6	53	8.83	182	74	11.36	235	76
RTLO	2	4	2	0	5	4	17	2.83	59	15	3.50	72	15
UNLO	1	1	1	1	2	0	6	1.00	21	5	1.14	24	7
Total Gaviiformes	8	27	74	40	32	16	197	32.83	678	195	35.29	729	196
DCCO	79	20	18	6	39	24	186	31.00	640	218	30.51	630	163
BRCO	0	0	0	1	0	1	2	0.33	7	4	0.26	5	4
PECO	0	16	14	2	0	1	33	5.50	114	63	5.23	108	63
UNCO	92	58	123	56	248	87	664	110.67	2285	604	141.94	2931	771
Total Phalacrocoracidae	171	94	155	65	287	113	885	147.50	3046	663	177.93	3675	802
ANMU	0	0	5	0	0	0	5	0.83	17	17	1.00	21	19
COMU	0	22	32	32	6	12	104	17.33	358	114	15.69	324	106
MAMU	1	0	2	0	57	43	103	17.17	355	218	27.47	567	257
PIGU	9	24	6	5	9	7	60	10.00	207	59	9.73	201	53
RHAU	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
UNAC	0	0	2	2	0	0	4	0.67	14	9	0.53	11	8
Total Alcidae	10	46	47	39	72	62	276	46.00	950	180	54.42	1124	180
GWGU	13	92	686	16	115	50	972	162.00	3346	2191	198.83	4106	2297
MEGU	7	19	47	8	2	3	86	14.33	296	144	14.23	294	159
UBWG	16	28	14	45	616	38	757	126.17	2606	2026	221.67	4578	2709
UNGU	779	1101	4315	1280	2163	647	10285	1714.17	35401	11648	1994.31	41187	12279
Total Laridae	815	1240	5062	1349	2896	738	12100	2016.67	41648	14196	2429.04	50165	15023
Miscellaneous Avian Species													
GBHE	0	6	11	5	9	1	32	5.33	110	36	6.49	134	38
USSD	20	0	31	565	115	0	731	121.83	2516	1865	83.80	1731	1321
BAEA	2	14	28	8	64	19	135	22.50	465	187	32.90	679	233
UNDD (mostly sea ducks)	74	33	353	101	147	82	790	131.67	2719	966	151.83	3136	1010
UNDU	68	7	19	76	86	41	297	49.50	1022	272	51.56	1065	285
UNSB	0	0	0	0	5	2	7	1.17	24	17	2.03	42	22
Marine Mammals													
Pinnipedia													
CASL	3	0	11	0	0	2	16	2.67	55	36	2.82	58	39
HASE	135	876	627	249	93	4	1984	330.67	6829	2904	299.74	6190	2908
STSL	31	46	1727	37	28	2	1871	311.83	6440	5847	365.86	7556	6304
Cetacea													
DAPO	0	0	0	0	4	0	4	0.67	14	14	1.32	27	18
HAPO	0	0	0	0	26	2	28	4.67	96	88	8.98	185	118
UNPO	0	0	0	0	0	3	3	0.50	10	10	0.57	12	11
Other Marine Mammals													
UNMM	0	0	0	0	2	0	2	0.33	7	7	0.66	14	9

Table 2. Continued.

Table 3: Summary of the results from the offshore transects during winter 2013 Pacific Coast aerial surveys in British Columbia.

Section	BC2	BC5	BC8	BC11	BC14	BC17							
Latitude Range	48°, 20'-30'	48°50'-49°	49°, 20'-30'	49°50'-50°	50°, 20'-30'	50°50'-51°							
Area Sampled KM ²	22.8	15.9	40.6	22.5	18.6	6.0	126.4	Un-weighted			Weighted by area sampled		
N Transects	4	4	4	4	4	4	24						
Species/Transect #'s	1-5, 10-14	19-23	28-32, 37-41	46-50	55-59	64-68	Grand Total	Average	Expanded Pop.	S.E.	Average	Expanded Pop.	S.E.
Anatidae													
Merginae													
BLSC	0	0	27	0	0	0	27	4.50	2151	2151	8.67	4145	2839
SUSC	9	5	22	20	0	1	57	9.50	4542	1851	12.92	6176	2018
WWSC	7	0	6	16	0	0	29	4.83	2311	1237	6.03	2884	1189
UNSC	2	0	0	0	1	0	3	0.50	239	163	0.51	243	167
Total Scoters	18	5	55	36	1	1	116	19.33	9243	4302	28.13	13448	5013
Harlequin Ducks	0	0	0	28	6	0	34	5.67	2709	2186	5.86	2802	2246
Long-tailed Ducks	5	0	3	126	0	0	134	22.33	10677	9921	24.26	11600	10130
BAGO	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
COGO	0	0	11	3	0	0	14	2.33	1116	861	4.07	1944	1109
UNGO	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
Total Goldeneye	0	0	11	3	0	0	14	2.33	1116	861	4.07	1944	1109
Bufflehead	0	0	0	11	8	0	19	3.17	1514	975	3.13	1498	983
COME	0	1	0	0	4	0	5	0.83	398	313	0.71	342	301
HOME	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
RBME	0	18	11	12	2	4	47	7.83	3745	1355	8.42	4025	1284
UNME	0	0	0	0	2	0	2	0.33	159	159	0.29	141	152
Total Mergansers	0	19	11	12	8	4	54	9.00	4303	1295	9.43	4508	1198
Aythya													
SCAU	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
Anas													
AMWI	0	10	0	0	0	0	10	1.67	797	797	1.26	602	715
GADW	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
MALL	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
NOPI	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
Total Dabbling Ducks	0	10	0	0	0	0	10	1.67	797	797	1.26	602	715
Anserinae													
BLBR	0	0	0	48	0	0	48	8.00	3825	3825	8.53	4080	3925
CAGO	0	0	0	1	0	0	1	0.17	80	80	0.18	85	82
Avian Piscivores													
HOGR	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
RNGR	6	0	6	4	1	0	17	2.83	1355	558	3.87	1848	572
WEGR	2	7	7	0	368	0	384	64.00	30598	29075	57.66	27566	27607
UNGR	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0

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Total Podicipediformes	8	7	13	4	369	0	401	66.83	31953	28905	61.52	29414	27348
COLO	1	3	9	6	0	0	19	3.17	1514	714	4.51	2158	832
PALO	10	0	132	4	2	0	148	24.67	11793	10289	45.19	21607	13515
RTLO	5	2	1	0	0	0	8	1.33	637	384	1.47	704	381
UNLO	0	1	1	1	0	3	6	1.00	478	214	0.77	367	154
Total Gaviiformes	16	6	143	11	2	3	181	30.17	14422	10837	51.95	24837	14207
DCCO	3	0	2	6	0	0	11	1.83	877	469	2.25	1075	449
BRCO	0	0	0	0	0	0	0		0	0	0.00	0	0
PECO	0	2	0	0	0	0	2	0.33	159	159	0.25	120	143
UNCO	13	9	14	9	4	1	50	8.33	3984	985	10.21	4880	949
Total Phalacrocoracidae	16	11	16	15	4	1	63	10.50	5020	1275	12.71	6076	1158
ANMU	3	0	0	6	0	0	9	1.50	717	490	1.61	768	499
COMU	19	5	277	138	17	5	461	76.83	36734	21568	120.28	57503	26669
MAMU	0	1	2	68	13	2	86	14.33	6853	5215	14.87	7107	5357
PIGU	13	3	0	0	0	0	16	2.67	1275	1015	2.72	1300	1051
RHAU	2	1	0	0	0	0	3	0.50	239	163	0.49	232	167
UNAC	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
Total Alcidae	37	10	279	212	30	7	575	95.83	45817	23110	139.95	66911	26824
GWGU	7	8	64	9	8	2	98	16.33	7809	4583	25.69	12284	5985
MEGU	5	0	8	15	0	0	28	4.67	2231	1182	6.14	2934	1163
UBWG	30	10	22	18	28	2	110	18.33	8765	2101	21.14	10108	1712
UNGU	339	27	80	74	161	6	687	114.50	54742	23876	127.27	60846	23023
Total Laridae	381	45	174	116	197	10	923	153.83	73547	25870	180.24	86172	23841
Miscellaneous Avian Species													
GBHE	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
USSD	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
BAEA	0	1	1	0	0	0	2	0.33	159	101	0.45	214	109
UNDD (mostly sea ducks)	3	0	0	0	0	0	3	0.50	239	239	0.54	258	247
UNDU	0	0	0	0	2	0	2	0.33	159	159	0.29	141	152
UNSB	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
Marine Mammals													
Pinnipedia													
CASL	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
HASE	16	14	14	27	0	0	71	11.83	5657	2022	13.94	6665	1832
STSL	0	0	0	1	0	0	1	0.17	80	80	0.18	85	82
Cetacea													
DAPO	0	0	0	0	3	0	3	0.50	239	239	0.44	211	228
HAPO	2	0	0	1	0	3	6	1.00	478	247	0.68	326	210
UNPO	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0
Other Marine Mammals													
UNMM	0	0	0	0	0	0	0	0.00	0	0	0.00	0	0

Table 3. Continued.

Table 4: Combined nearshore and offshore population estimates from the winter 2013 Pacific Coast aerial surveys in British Columbia.

	Un-weighted						Weighted					
	Nearshore Expanded		Offshore Expanded		Total Expanded		Nearshore Expanded		Offshore Expanded		Total Expanded	
	Pop.	S.E.	Pop.	S.E.	Pop.	S.E.	Pop.	S.E.	Pop.	S.E.	Pop.	S.E.
Anatidae												
Merginae												
BLSC	203	203	2151	2151	2355	2355	244	219	4145	2839	4389	3058
SUSC	15771	4010	4542	1851	20313	5860	17093	3792	6176	2018	23269	5810
WWSC	2275	882	2311	1237	4586	2119	2475	873	2884	1189	5358	2062
UNSC	4609	1843	239	163	4848	2006	6586	2273	243	167	6829	2440
Total Scoters	22858	5636	9243	4302	32101	9938	26397	5281	13448	5013	39845	10294
Harlequin Ducks	2981	1078	2709	2186	5690	3264	3014	981	2802	2246	5817	3227
Long-tailed Ducks	114	51	10677	9921	10791	9971	109	56	11600	10130	11709	10186
BAGO	7648	3318	0	0	7648	3318	9793	3230	0	0	9793	3230
COGO	5817	2052	1116	861	6933	2913	6749	2064	1944	1109	8692	3173
UNGO	4609	2626	0	0	4609	2626	7389	3294	0	0	7389	3294
Total Goldeneye	18074	6938	1116	861	19189	7799	23931	7089	1944	1109	25875	8198
Bufflehead	15338	3072	1514	975	16852	4048	14131	3016	1498	983	15629	3998
COME	3222	1381	398	313	3620	1693	4583	1579	342	301	4925	1880
HOME	186	79	0	0	186	79	264	93	0	0	264	93
RBME	3470	281	3745	1355	7215	1636	3576	249	4025	1284	7601	1534
UNME	957	541	159	159	1116	701	1495	708	141	152	1636	860
Total Mergansers	7834	2051	4303	1295	12137	3345	9919	2460	4508	1198	14426	3658
Aythiinae												
SCAU	1377	634	0	0	1377	634	1888	695	0	0	1888	695
Anas												
AMWI	1690	921	797	797	2487	1718	1382	882	602	715	1984	1597
GADW	45	37	0	0	45	37	33	35	0	0	33	35
MALL	1521	820	0	0	1521	820	1228	793	0	0	1228	793
NOPI	805	805	0	0	805	805	635	734	0	0	635	734
Total Dabbling Ducks	4062	2557	797	797	4858	3354	3278	2410	602	715	3880	3125
Anserinae												
BLBR	83	52	3825	3825	3907	3877	66	50	4080	3925	4146	3975
CAGO	503	121	80	80	582	201	548	97	85	82	633	179
Avian Piscivores												
HOGR	575	187	0	0	575	187	454	154	0	0	454	154
RNGR	344	156	1355	558	1699	714	503	198	1848	572	2351	770
WEGR	1428	988	30598	29075	32026	30063	1882	1014	27566	27607	29447	28621
UNGR	10	7	0	0	10	7	11	7	0	0	11	7
Total Podicipediformes	2358	980	31953	28905	34310	29885	2849	1017	29414	27348	32263	28365
COLO	416	141	1514	714	1930	855	398	143	2158	832	2557	975
PALO	182	74	11793	10289	11975	10363	235	76	21607	13515	21841	13591

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RTLO	59	15	637	384	696	399	72	15	704	381	777	396
UNLO	21	5	478	214	499	219	24	7	367	154	391	161
Total Gaviiformes	678	195	14422	10837	15101	11033	729	196	24837	14207	25566	14403
DCCO	640	218	877	469	1517	686	630	163	1075	449	1705	612
BRCO	7	4	0	0	7	4	5	4	0	0	5	4
PECO	114	63	159	159	273	222	108	63	120	143	228	206
UNCO	2285	604	3984	985	6270	1589	2931	771	4880	949	7811	1720
Total Phalacrocoracidae	3046	663	5020	1275	8066	1939	3675	802	6076	1158	9750	1960
ANMU	17	17	717	490	734	507	21	19	768	499	789	518
COMU	358	114	36734	21568	37092	21681	324	106	57503	26669	57827	26775
MAMU	355	218	6853	5215	7207	5433	567	257	7107	5357	7675	5615
PIGU	207	59	1275	1015	1481	1075	201	53	1300	1051	1501	1104
RHAU	0	0	239	163	239	163	0	0	232	167	232	167
UNAC	14	9	0	0	14	9	11	8	0	0	11	8
Total Alcidae	950	180	45817	23110	46767	23290	1124	180	66911	26824	68035	27005
GWGU	3346	2191	7809	4583	11154	6775	4106	2297	12284	5985	16390	8283
MEGU	296	144	2231	1182	2527	1326	294	159	2934	1163	3227	1322
UBWG	2606	2026	8765	2101	11371	4127	4578	2709	10108	1712	14686	4421
UNGU	35401	11648	54742	23876	90143	35524	41187	12279	60846	23023	102033	35302
Total Laridae	41648	14196	73547	25870	115195	40066	50165	15023	86172	23841	136337	38863
Miscellaneous Avian Species												
GBHE	110	36	0	0	110	36	134	38	0	0	134	38
USSD	2516	1865	0	0	2516	1865	1731	1321	0	0	1731	1321
BAEA	465	187	159	101	624	288	679	233	214	109	893	342
UNDD (mostly sea ducks)	2719	966	239	239	2958	1205	3136	1010	258	247	3394	1256
UNDU	1022	272	159	159	1182	431	1065	285	141	152	1206	437
UNSB	24	17	0	0	24	17	42	22	0	0	42	22
Marine Mammals												
Pinnipedia												
CASL	55	36	0	0	55	36	58	39	0	0	58	39
HASE	6829	2904	5657	2022	12486	4927	6190	2908	6665	1832	12855	4740
STSL	6440	5847	80	80	6520	5926	7556	6304	85	82	7641	6386
Cetacea												
DAPO	14	14	239	239	253	253	27	18	211	228	238	246
HAPO	96	88	478	247	574	335	185	118	326	210	511	328
UNPO	10	10	0	0	10	10	12	11	0	0	12	11
Other Marine Mammals												
UNMM	7	7	0	0	7	7	14	9	0	0	14	9

Table 4. Continued.

Table 5: Summary nearshore and offshore densities, by transect and species, during winter 2013 Pacific Coast aerial surveys in British Columbia.

Section	Nearshore Transects							Offshore Transects						
	BC2	BC5	BC8	BC11	BC14	BC17	NS Total	BC2	BC5	BC8	BC11	BC14	BC17	OS Total
Latitude Range	48°, 20'-30'	48°50'-49°	49°, 20'-30'	49°50'-50°	50°, 20'-30'	50°50'-51°		48°, 20'-30'	48°50'-49°	49°, 20'-30'	49°50'-50°	50°, 20'-30'	50°50'-51°	
Area Sampled KM^2	41.5	67.0	101.9	34.2	168.5	96.5	509.7	22.8	15.9	40.6	22.5	18.6	6.0	126.4
N Transects	5	5	5	5	5	5	30	5	5	5	5	5	5	30
Species/Transect #'s	1-5, 10-14	19-23	28-32, 37-41	46-50	55-59	64-68		1-5, 10-14	19-23	28-32, 37-41	46-50	55-59	64-68	Grand Total
Anatidae														
Merginae														
BLSC	0.00	0.00	0.58	0.00	0.00	0.00	0.12	0.00	0.00	1.19	0.00	0.00	0.00	0.21
SUSC	1.61	9.40	15.06	24.48	3.78	9.08	8.99	0.40	0.31	0.97	0.89	0.00	0.17	0.45
WWSC	0.00	0.27	1.85	3.59	0.37	2.80	1.30	0.31	0.00	0.26	0.71	0.00	0.00	0.23
UNSC	1.16	1.79	3.55	2.92	3.61	1.05	2.63	0.09	0.00	0.00	0.00	0.05	0.00	0.02
Total Scoters	2.77	11.46	21.04	30.99	7.76	12.92	13.03	0.79	0.31	2.42	1.60	0.05	0.17	0.92
Harlequin Ducks	1.42	0.49	2.82	8.79	1.01	0.17	1.70	0.00	0.00	0.00	1.25	0.32	0.00	0.27
Long-tailed Ducks	0.14	0.04	0.17	0.15	0.01	0.00	0.06	0.22	0.00	0.13	5.61	0.00	0.00	1.06
BAGO	0.14	4.10	10.59	0.50	2.55	4.30	4.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COGO	0.82	4.52	7.24	4.79	1.69	1.73	3.32	0.00	0.00	0.48	0.13	0.00	0.00	0.11
UNGO	0.02	0.69	3.86	2.02	4.68	0.44	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Goldeneye	0.99	9.31	21.69	7.30	8.92	6.47	10.30	0.00	0.00	0.48	0.13	0.00	0.00	0.11
Bufflehead	22.22	18.83	5.82	22.99	4.33	1.68	8.74	0.00	0.00	0.00	0.49	0.43	0.00	0.15
COME	0.72	0.52	0.90	1.46	2.31	3.51	1.84	0.00	0.06	0.00	0.00	0.22	0.00	0.04
HOME	0.07	0.13	0.02	0.00	0.14	0.17	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RBME	2.72	2.94	1.43	5.55	1.16	1.73	1.98	0.00	1.13	0.48	0.53	0.11	0.66	0.37
UNME	0.00	0.31	0.08	0.85	1.03	0.49	0.55	0.00	0.00	0.00	0.00	0.11	0.00	0.02
Total Mergansers	3.52	3.91	2.43	7.86	4.64	5.90	4.47	0.00	1.19	0.48	0.53	0.43	0.66	0.43
Aythiinae														
SCAU	0.17	0.76	1.74	0.64	0.85	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anas														
AMWI	1.18	4.42	0.83	1.46	0.07	0.00	0.96	0.00	0.63	0.00	0.00	0.00	0.00	0.08
GADW	0.05	0.16	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MALL	1.40	3.91	0.80	1.05	0.03	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOPI	0.00	3.49	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Dabbling Ducks	2.62	11.98	1.63	2.51	0.09	0.00	2.32	0.00	0.63	0.00	0.00	0.00	0.00	0.08
Anserinae														
BLBR	0.00	0.00	0.12	0.35	0.00	0.00	0.05	0.00	0.00	0.00	2.14	0.00	0.00	0.38
CAGO	0.72	0.60	0.31	0.00	0.17	0.16	0.29	0.00	0.00	0.00	0.04	0.00	0.00	0.01
Avian Piscivores														
HOGR	0.46	0.57	0.22	1.96	0.11	0.03	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RNGR	0.17	0.06	0.06	0.20	0.30	0.26	0.20	0.26	0.00	0.26	0.18	0.05	0.00	0.13
WEGR	0.00	0.13	0.00	0.29	0.60	3.06	0.81	0.09	0.44	0.31	0.00	19.78	0.00	3.04

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UNGR	0.00	0.01	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Podicipediformes	0.63	0.78	0.27	2.45	1.01	3.37	1.34	0.35	0.44	0.57	0.18	19.84	0.00	3.17
COLO	0.12	0.28	0.46	0.96	0.07	0.06	0.24	0.04	0.19	0.40	0.27	0.00	0.00	0.15
PALO	0.00	0.04	0.24	0.18	0.08	0.06	0.10	0.44	0.00	5.80	0.18	0.11	0.00	1.17
RTLO	0.05	0.06	0.02	0.00	0.03	0.04	0.03	0.22	0.13	0.04	0.00	0.00	0.00	0.06
UNLO	0.02	0.01	0.01	0.03	0.01	0.00	0.01	0.00	0.06	0.04	0.04	0.00	0.50	0.05
Total Gaviiformes	0.19	0.40	0.73	1.17	0.19	0.17	0.39	0.70	0.38	6.29	0.49	0.11	0.50	1.43
DCCO	1.90	0.30	0.18	0.18	0.23	0.25	0.36	0.13	0.00	0.09	0.27	0.00	0.00	0.09
BRCO	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PECO	0.00	0.24	0.14	0.06	0.00	0.01	0.06	0.00	0.13	0.00	0.00	0.00	0.00	0.02
UNCO	2.22	0.87	1.21	1.64	1.47	0.90	1.30	0.57	0.57	0.62	0.40	0.22	0.17	0.40
Total Phalacrocoracidae	4.12	1.40	1.52	1.90	1.70	1.17	1.74	0.70	0.69	0.70	0.67	0.22	0.17	0.50
ANMU	0.00	0.00	0.05	0.00	0.00	0.00	0.01	0.13	0.00	0.00	0.27	0.00	0.00	0.07
COMU	0.00	0.33	0.31	0.93	0.04	0.12	0.20	0.84	0.31	12.17	6.14	0.91	0.83	3.65
MAMU	0.02	0.00	0.02	0.00	0.34	0.45	0.20	0.00	0.06	0.09	3.03	0.70	0.33	0.68
PIGU	0.22	0.36	0.06	0.15	0.05	0.07	0.12	0.57	0.19	0.00	0.00	0.00	0.00	0.13
RHAU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.06	0.00	0.00	0.00	0.00	0.02
UNAC	0.00	0.00	0.02	0.06	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Alcidae	0.24	0.69	0.46	1.14	0.43	0.64	0.54	1.63	0.63	12.26	9.44	1.61	1.16	4.55
GWGU	0.31	1.37	6.73	0.47	0.68	0.52	1.91	0.31	0.50	2.81	0.40	0.43	0.33	0.78
MEGU	0.17	0.28	0.46	0.23	0.01	0.03	0.17	0.22	0.00	0.35	0.67	0.00	0.00	0.22
UBWG	0.39	0.42	0.14	1.31	3.66	0.39	1.49	1.32	0.63	0.97	0.80	1.51	0.33	0.87
UNGU	18.76	16.43	42.36	37.39	12.84	6.70	20.18	14.90	1.70	3.52	3.29	8.66	0.99	5.44
Total Laridae	19.62	18.50	49.70	39.41	17.19	7.65	23.74	16.75	2.83	7.65	5.16	10.59	1.65	7.30
Miscellaneous Avian Species														
GBHE	0.00	0.09	0.11	0.15	0.05	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSD	0.48	0.00	0.30	16.50	0.68	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAEA	0.05	0.21	0.27	0.23	0.38	0.20	0.26	0.00	0.06	0.04	0.00	0.00	0.00	0.02
UNDD (mostly sea ducks)	1.78	0.49	3.47	2.95	0.87	0.85	1.55	0.13	0.00	0.00	0.00	0.00	0.00	0.02
UNDU	1.64	0.10	0.19	2.22	0.51	0.42	0.58	0.00	0.00	0.00	0.00	0.11	0.00	0.02
UNSB	0.00	0.00	0.00	0.00	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine Mammals														
Pinnipedia														
CASL	0.07	0.00	0.11	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HASE	3.25	13.07	6.16	7.27	0.55	0.04	3.89	0.70	0.88	0.62	1.20	0.00	0.00	0.56
STSL	0.75	0.69	16.95	1.08	0.17	0.02	3.67	0.00	0.00	0.00	0.04	0.00	0.00	0.01
Cetacea														
DAPO	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.16	0.00	0.02
HAPO	0.00	0.00	0.00	0.00	0.15	0.02	0.05	0.09	0.00	0.00	0.04	0.00	0.50	0.05
UNPO	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Marine Mammals														
UNMM	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5. Continued.

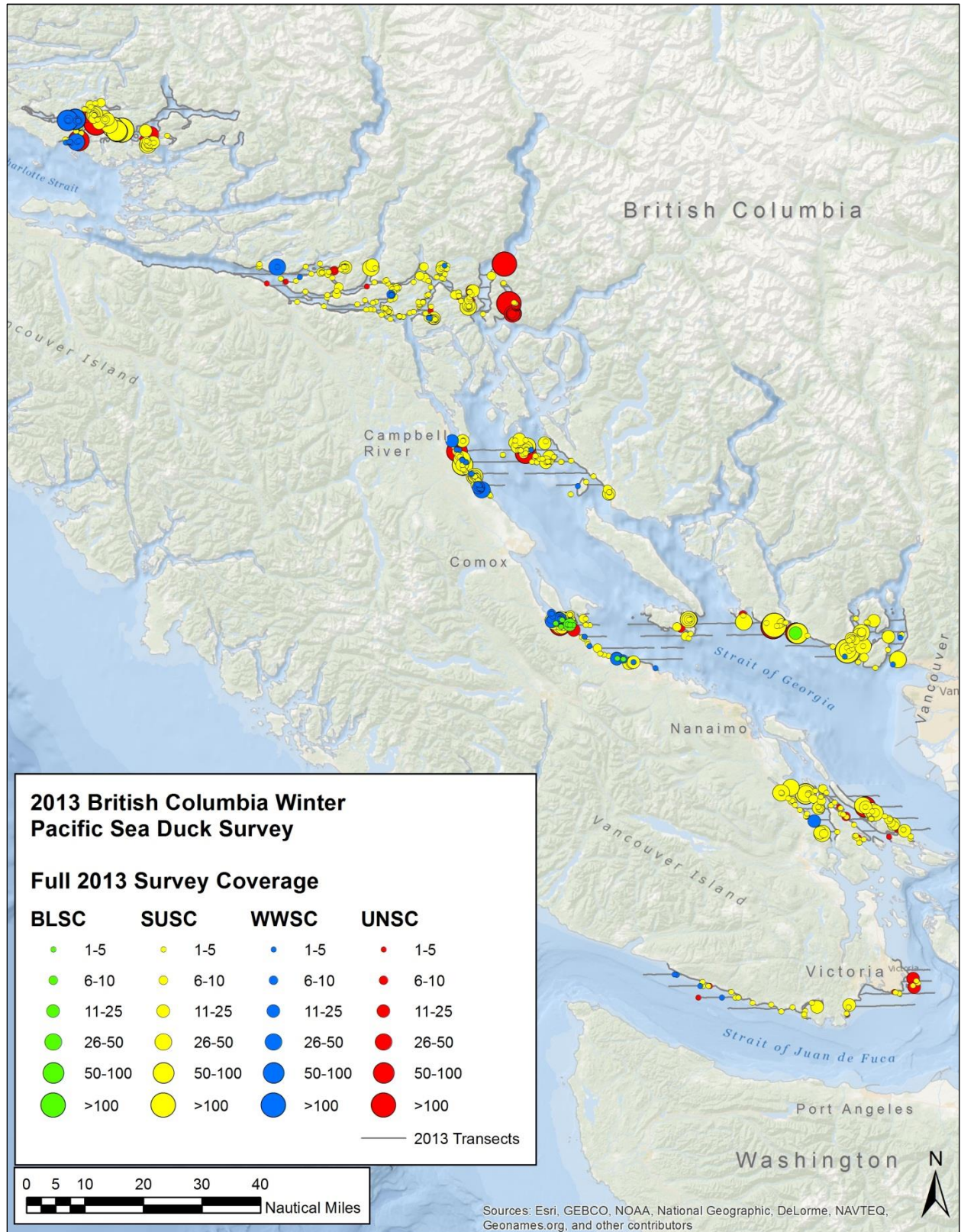


Figure 3. Scoter species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

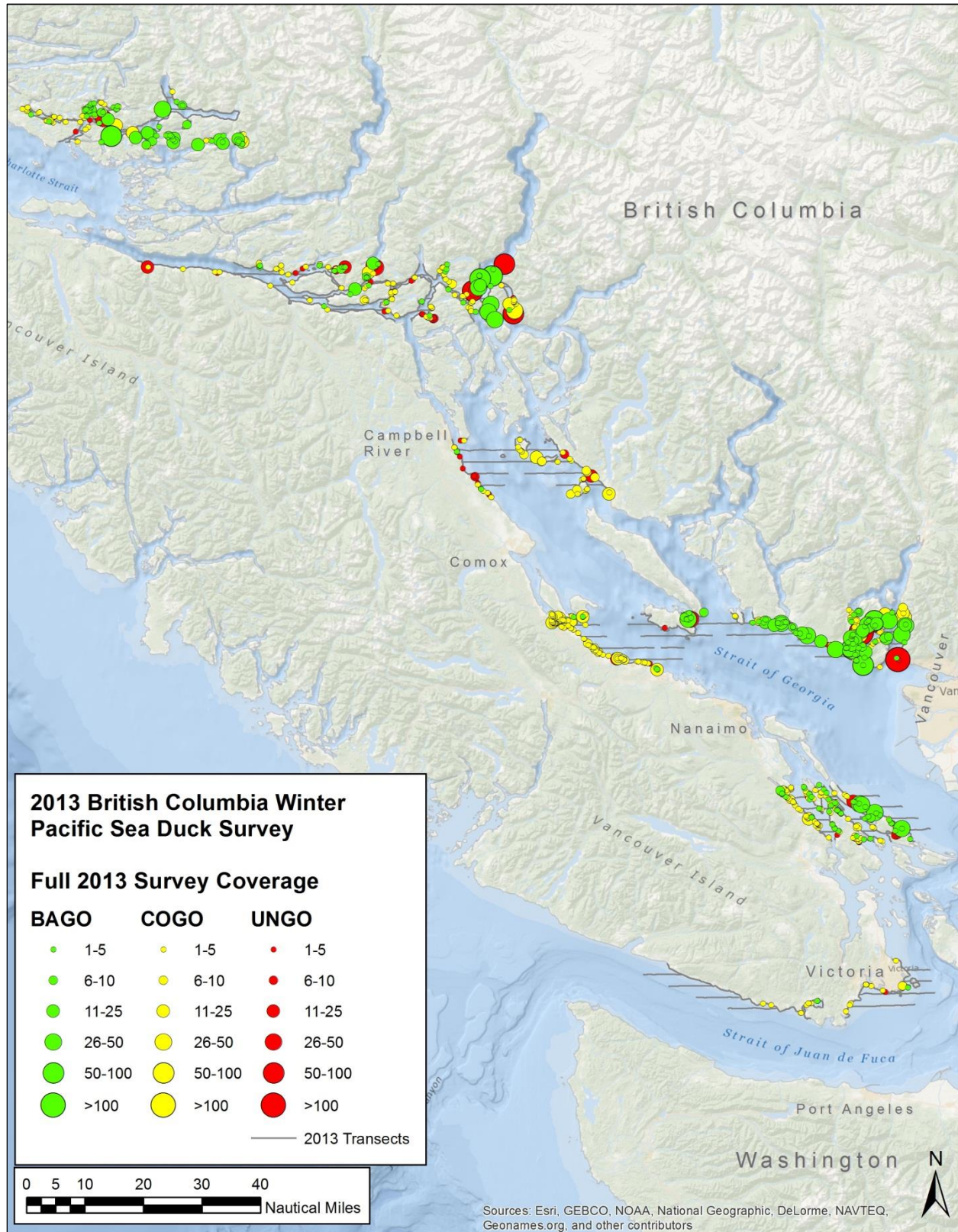


Figure 4. Goldeneye species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

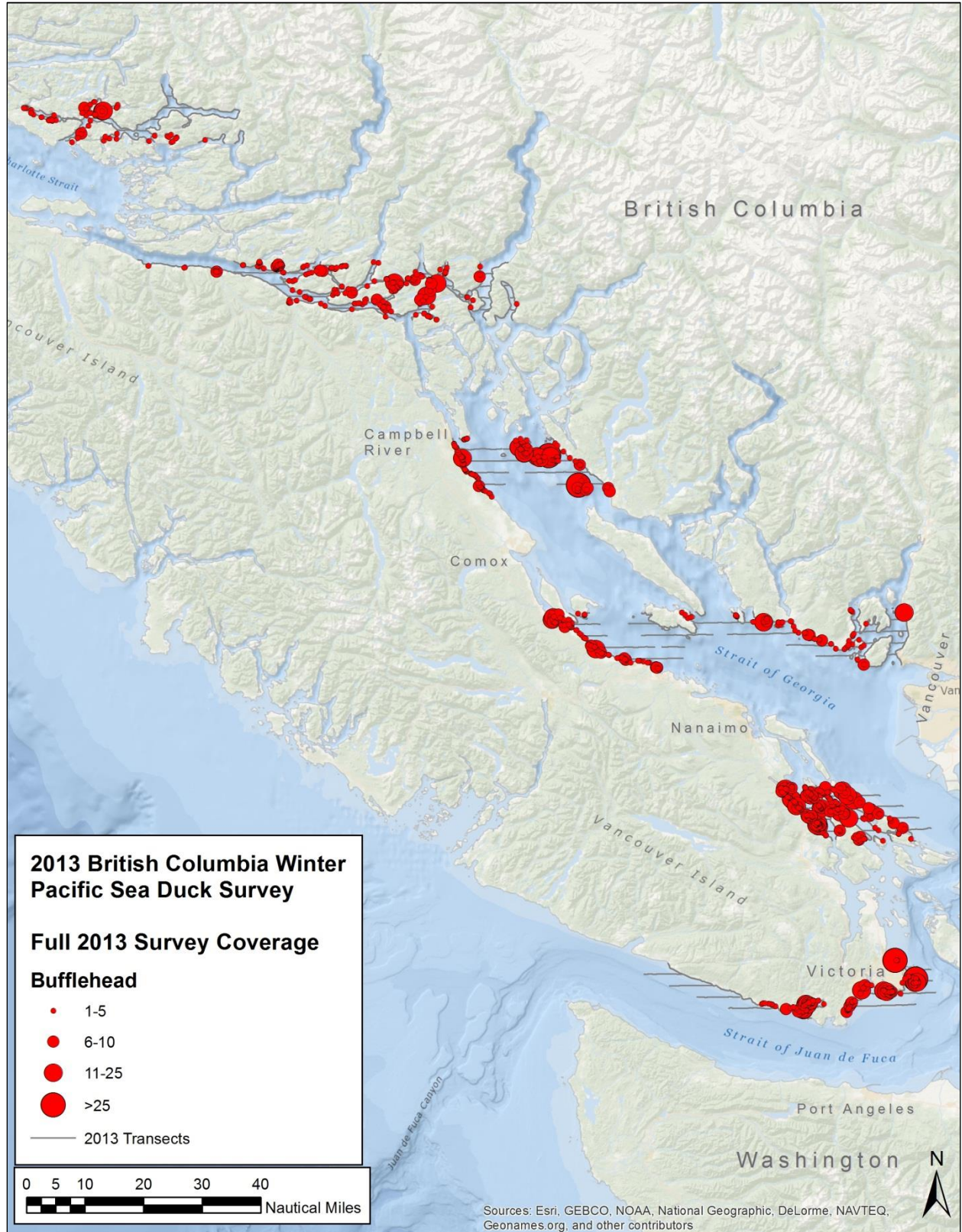


Figure 5. Bufflehead distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

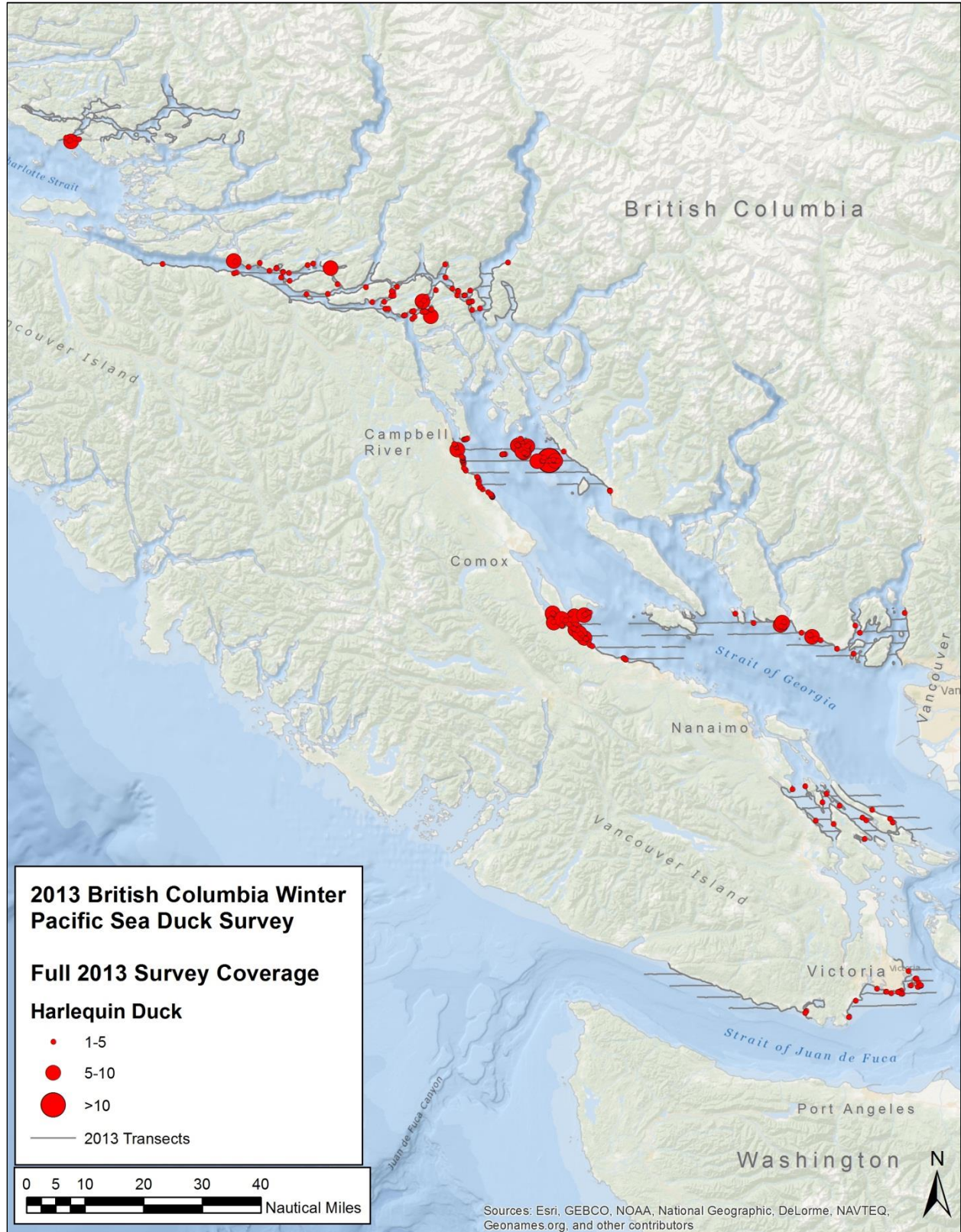


Figure 6. Harlequin Duck distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

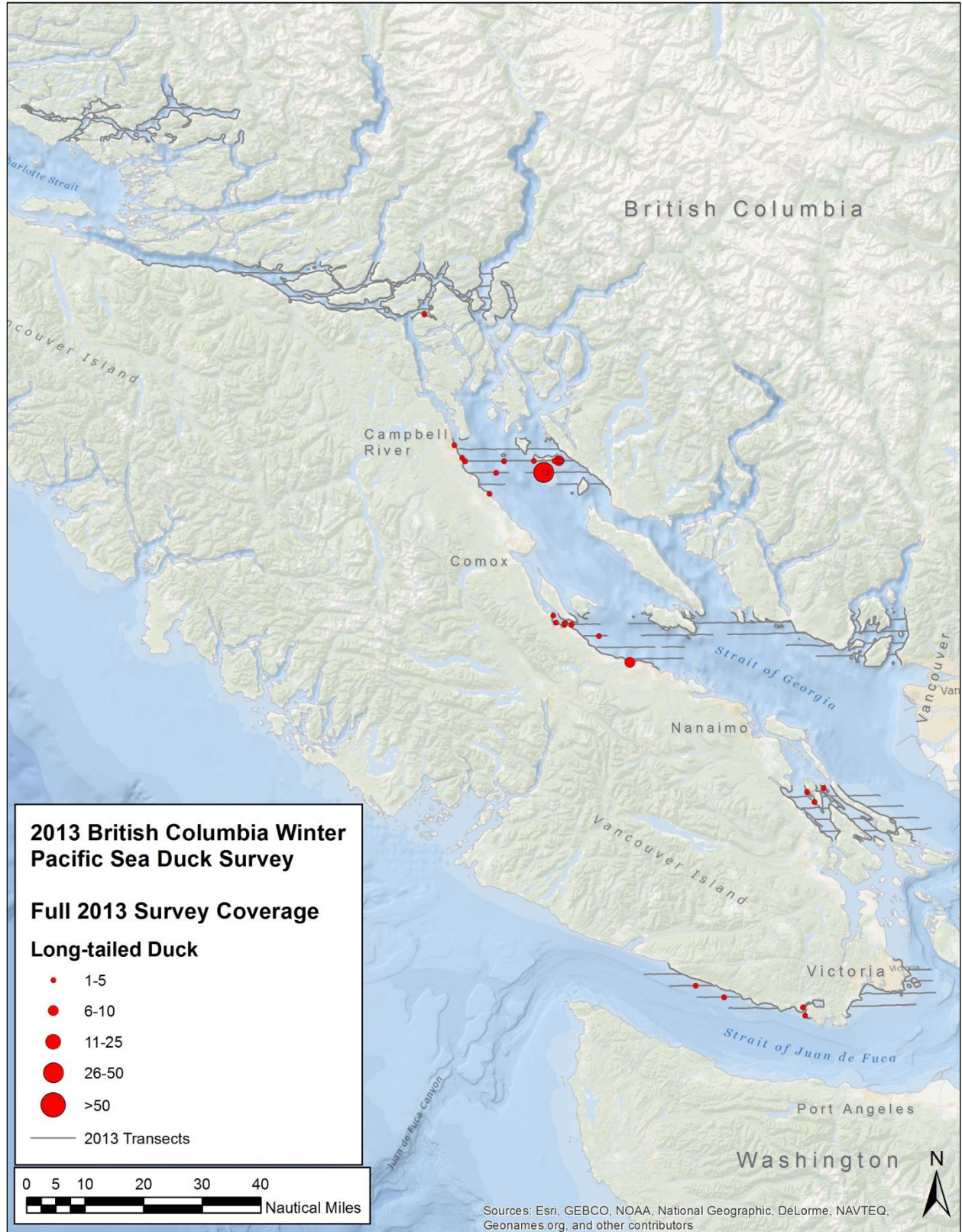


Figure 7. Long-tailed Duck distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

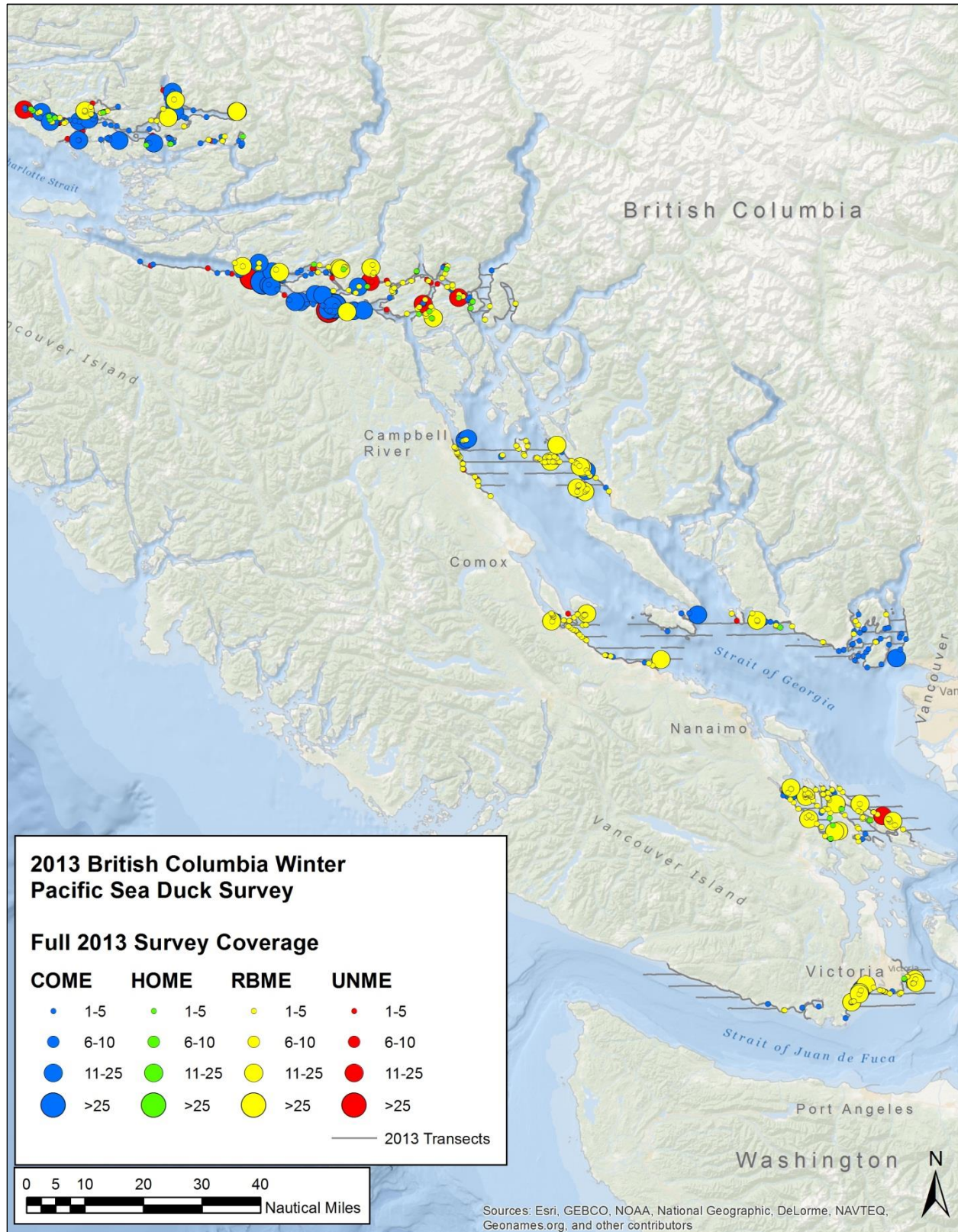


Figure 8. Merganser species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

Supplemental Sea Duck Distribution Figures

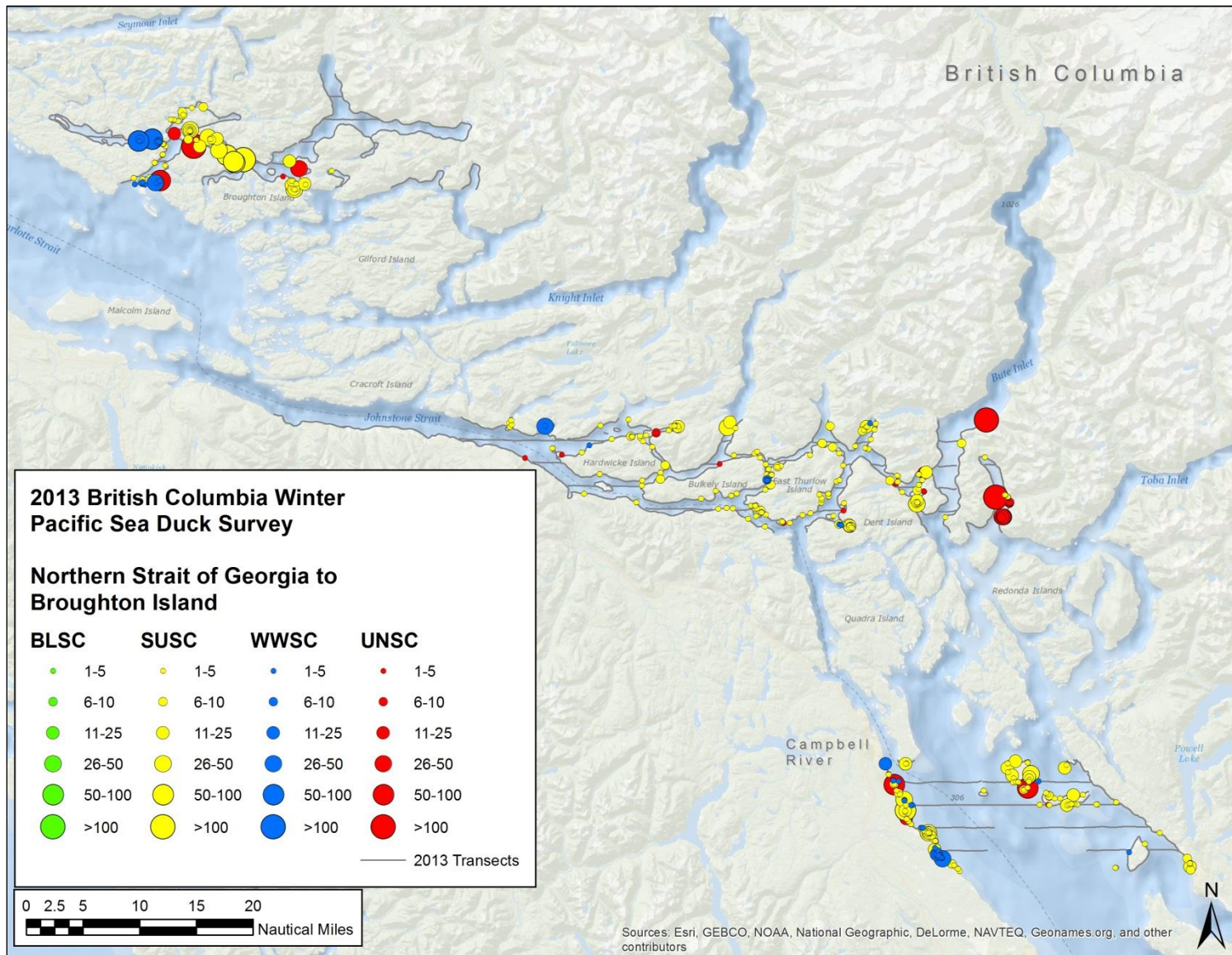


Figure 9. Scoter species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Northern Strait of Georgia through Broughton Island.

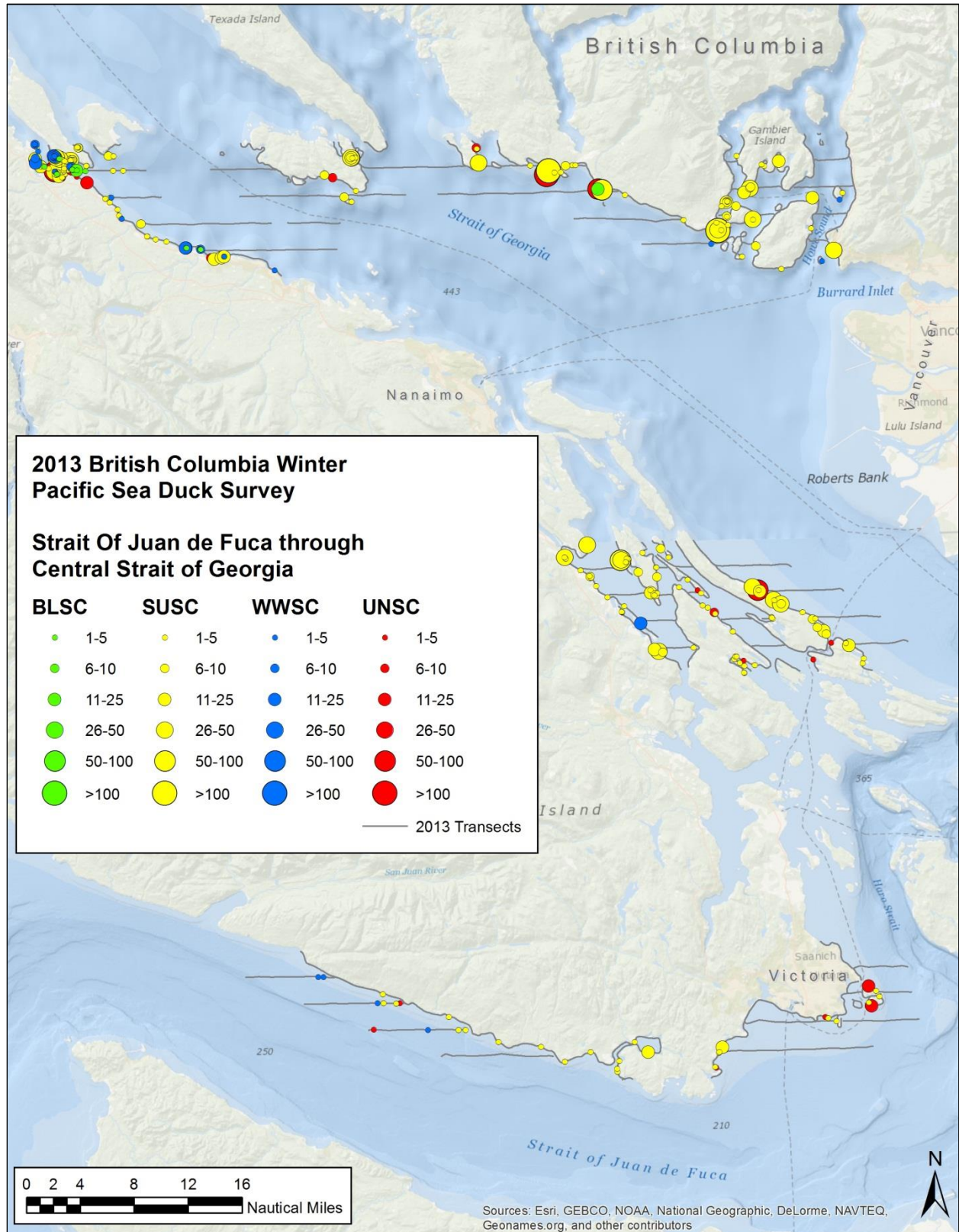


Figure 10. Scoter species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Strait of Juan de Fuca through central Strait of Georgia.

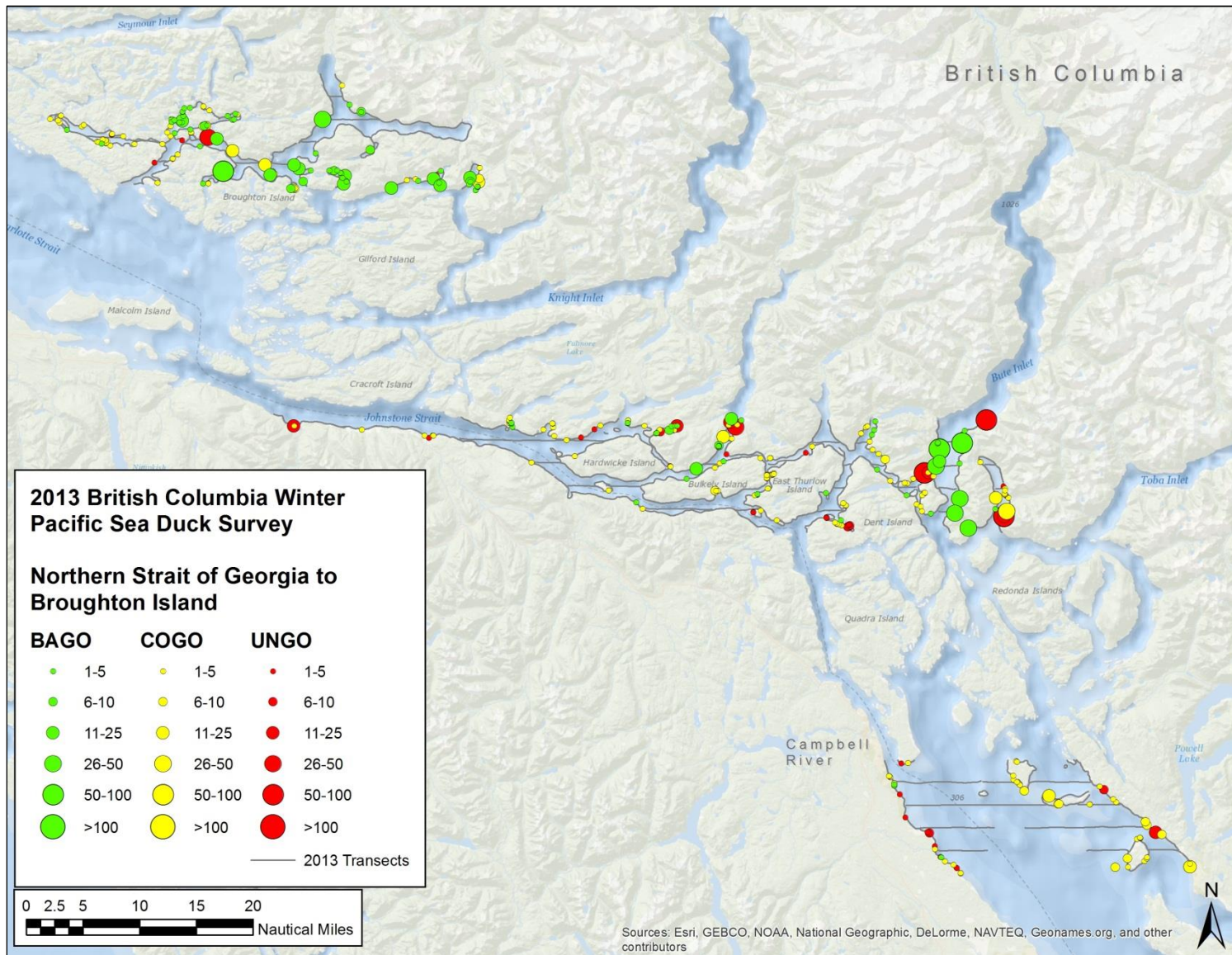


Figure 11. Goldeneye species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Northern Strait of Georgia through Broughton Island.

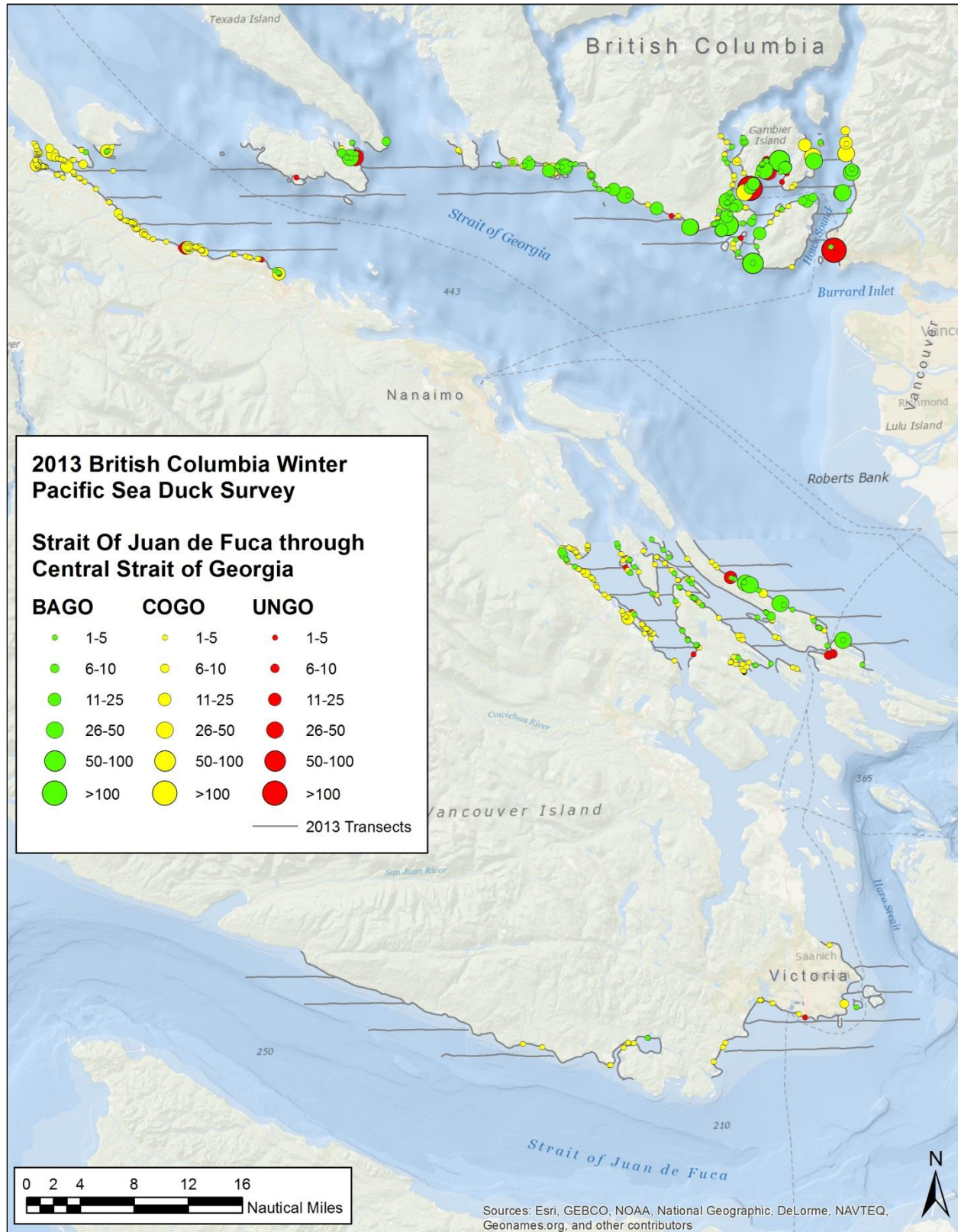


Figure 12. Goldeneye species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Strait of Juan de Fuca through central Strait of Georgia.

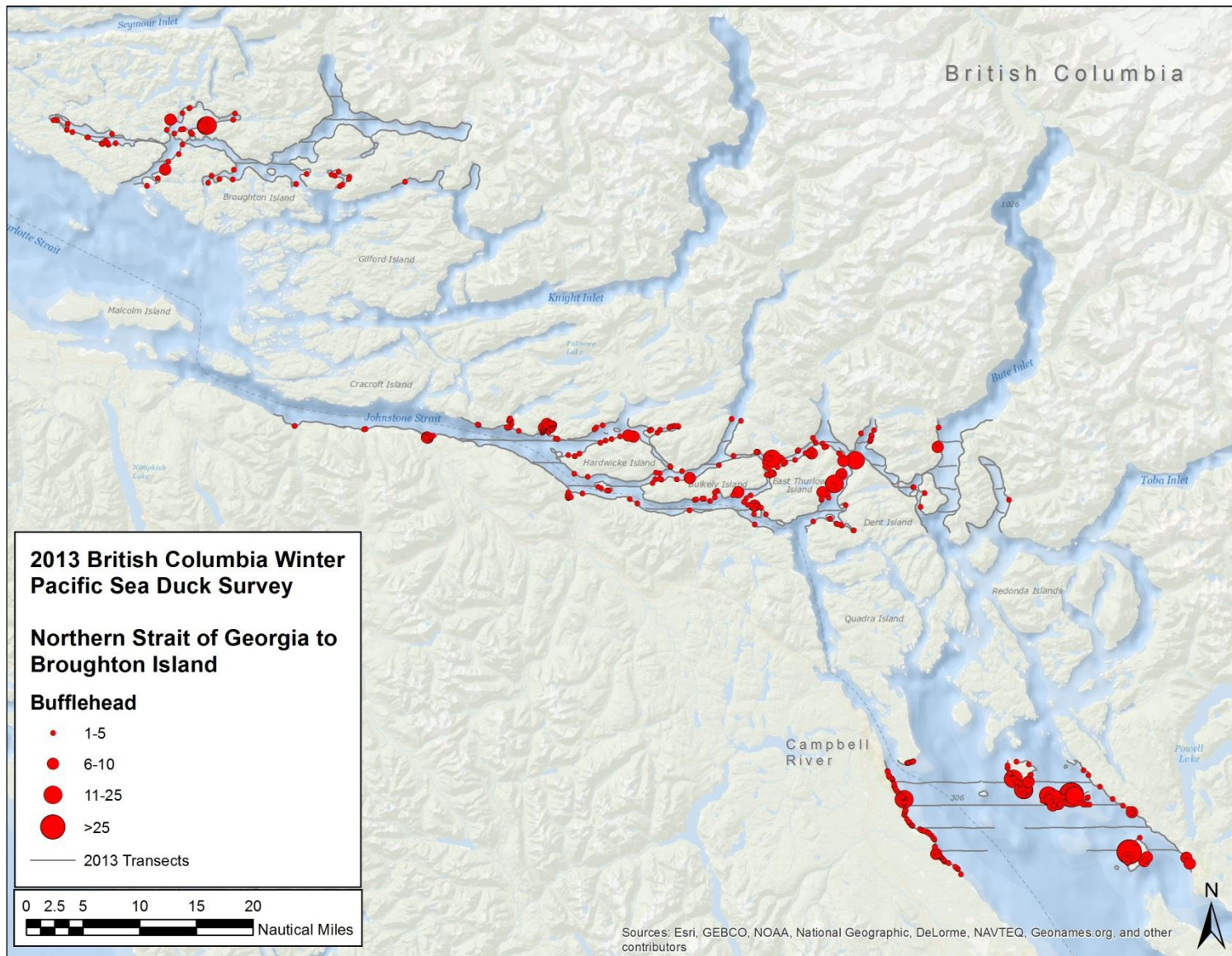


Figure 13. Bufflehead distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Northern Strait of Georgia through Broughton Island.

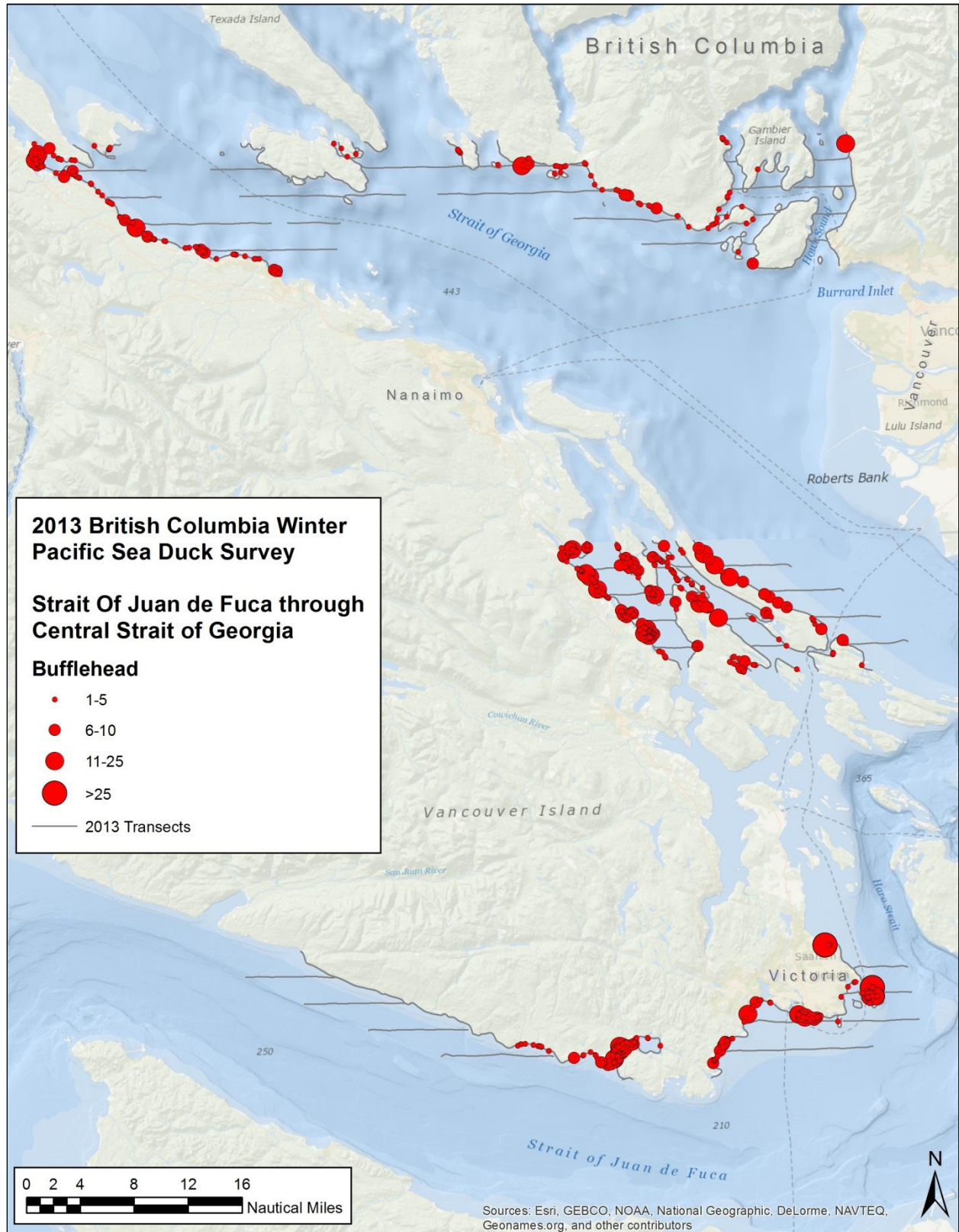


Figure 14. Bufflehead distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Strait of Juan de Fuca through central Strait of Georgia.

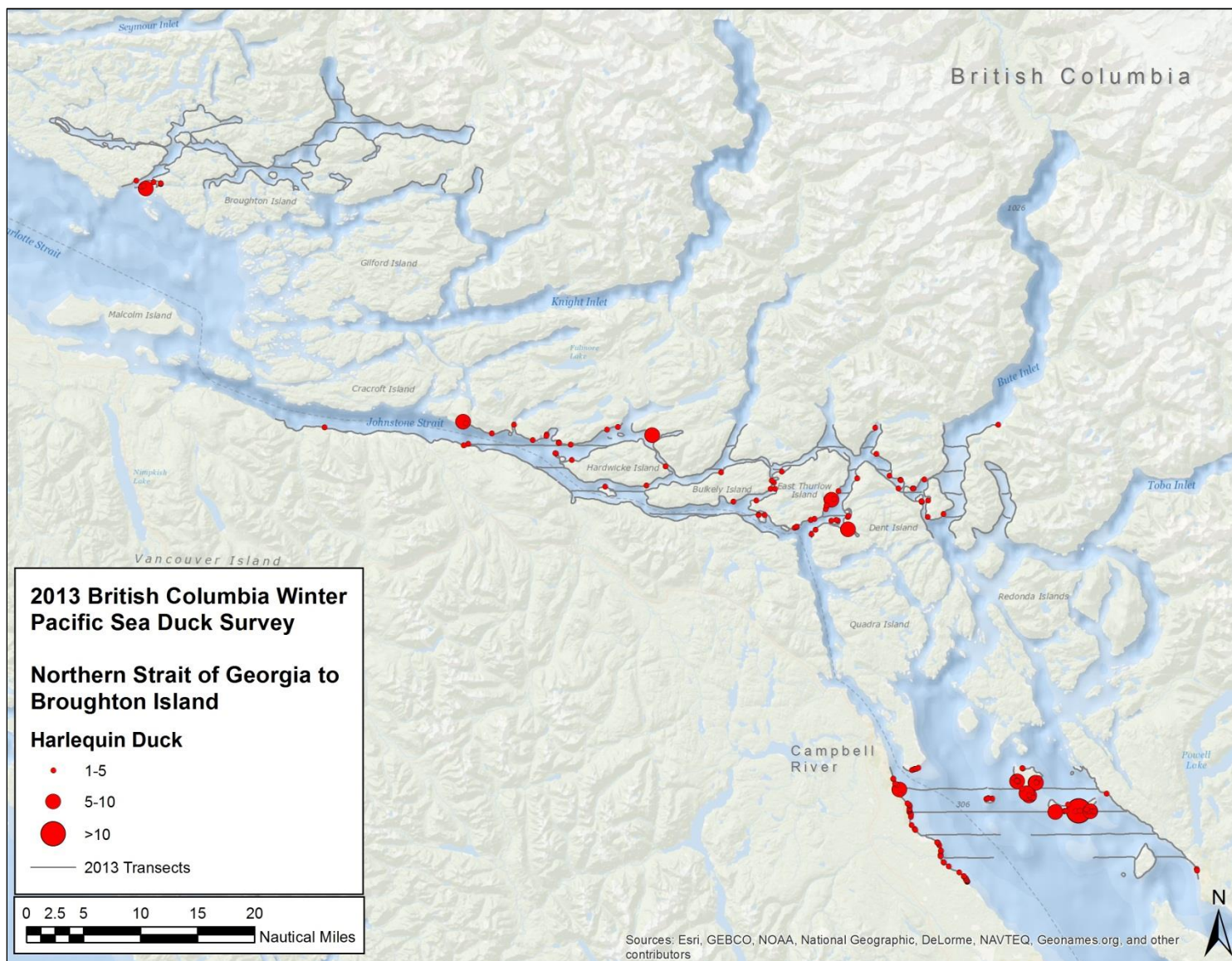


Figure 15. Harlequin Duck distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Northern Strait of Georgia through Broughton Island.

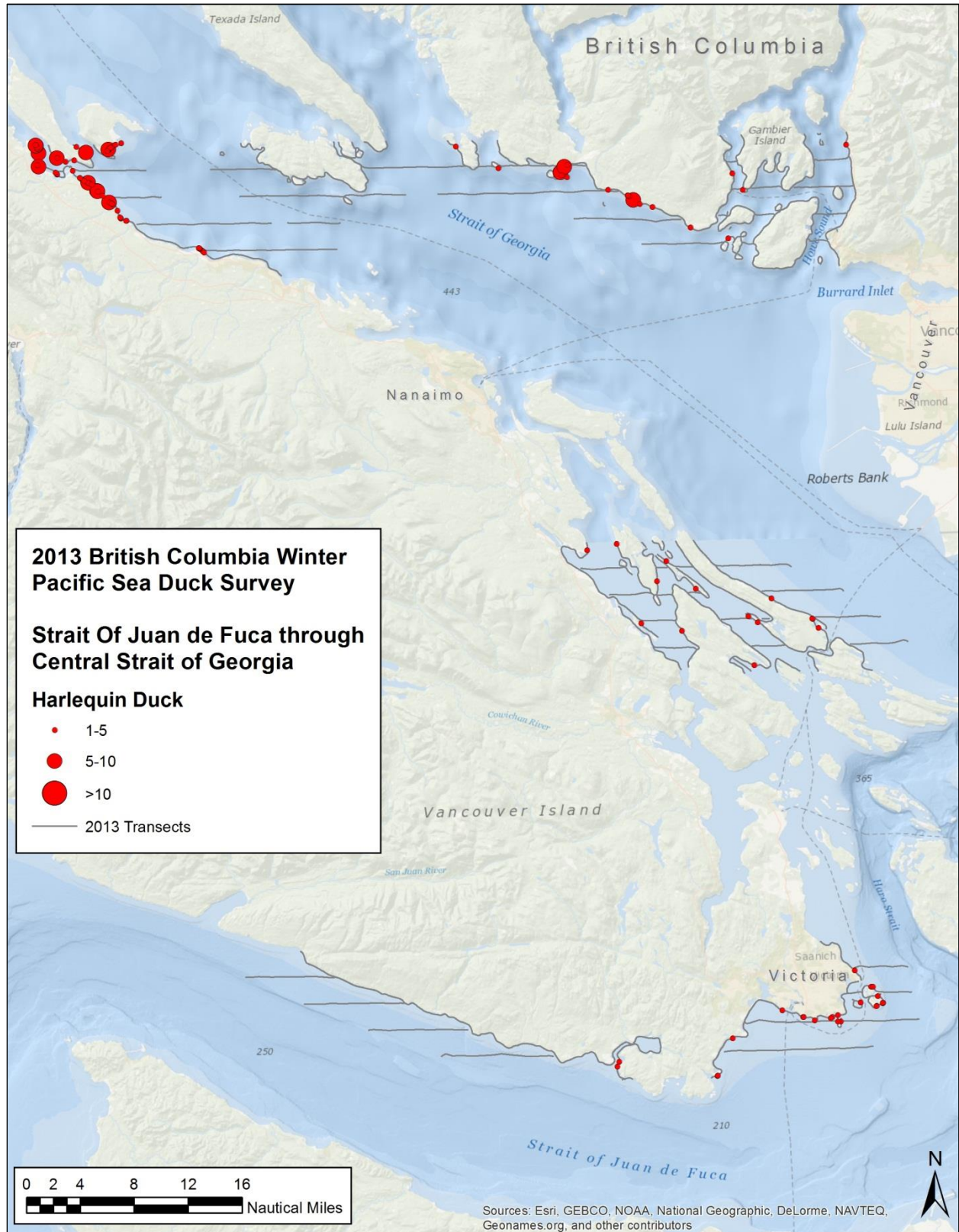


Figure 16. Harlequin Duck distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Strait of Juan de Fuca through central Strait of Georgia.

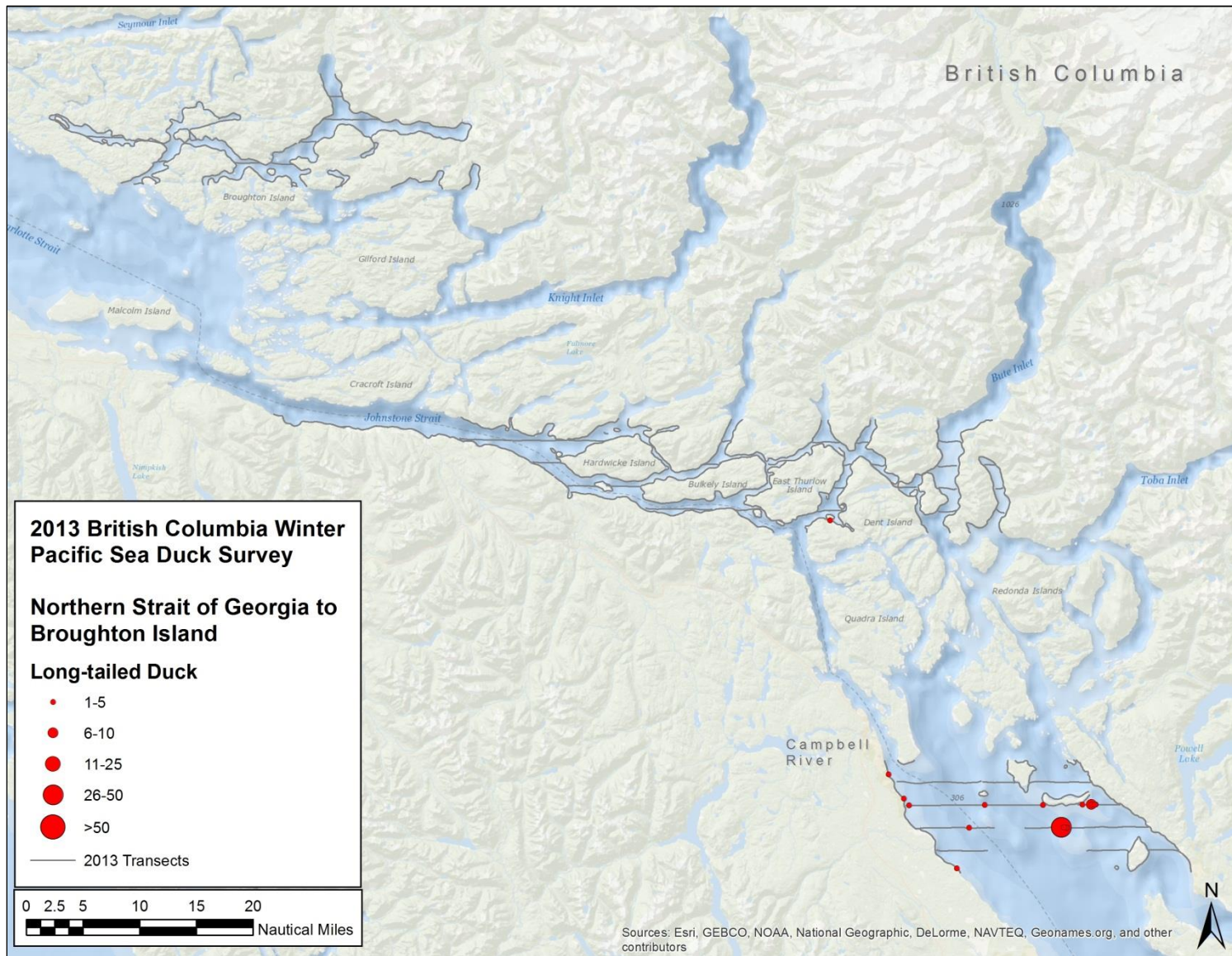


Figure 17. Long-tailed Duck distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Northern Strait of Georgia through Broughton Island.

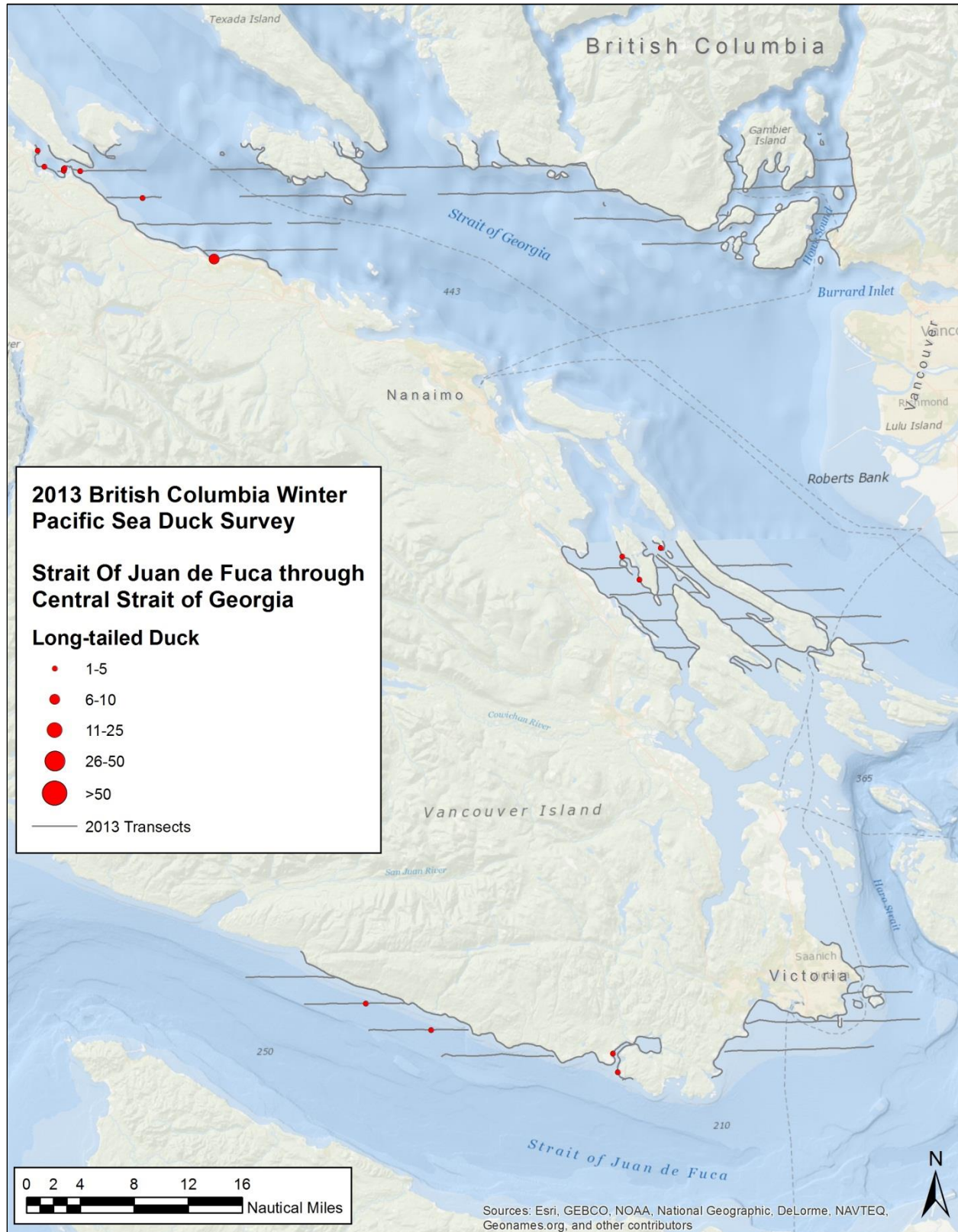


Figure 18. Long-tailed Duck distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Strait of Juan de Fuca through central Strait of Georgia.

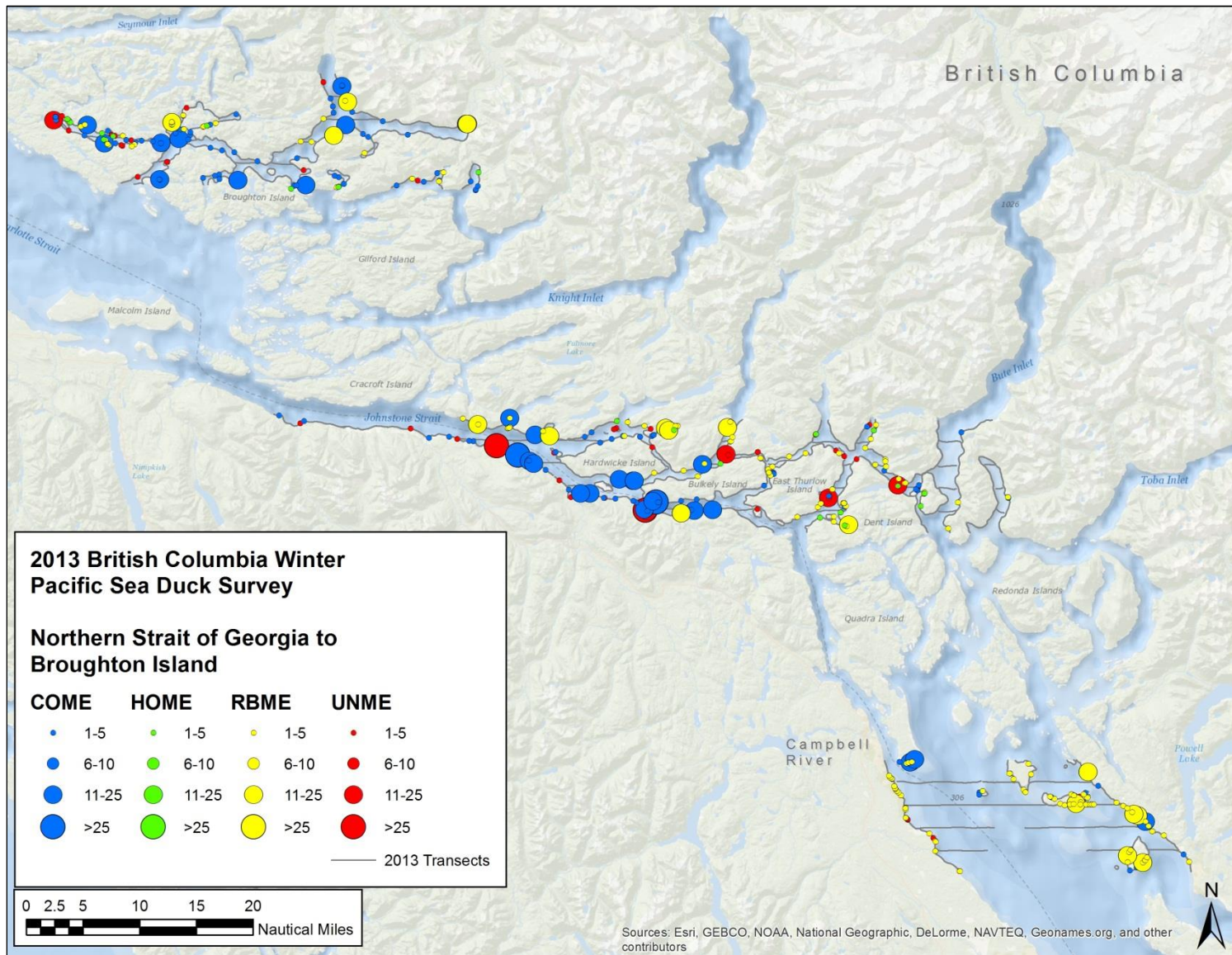


Figure 19. Merganser species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Northern Strait of Georgia through Broughton Island.

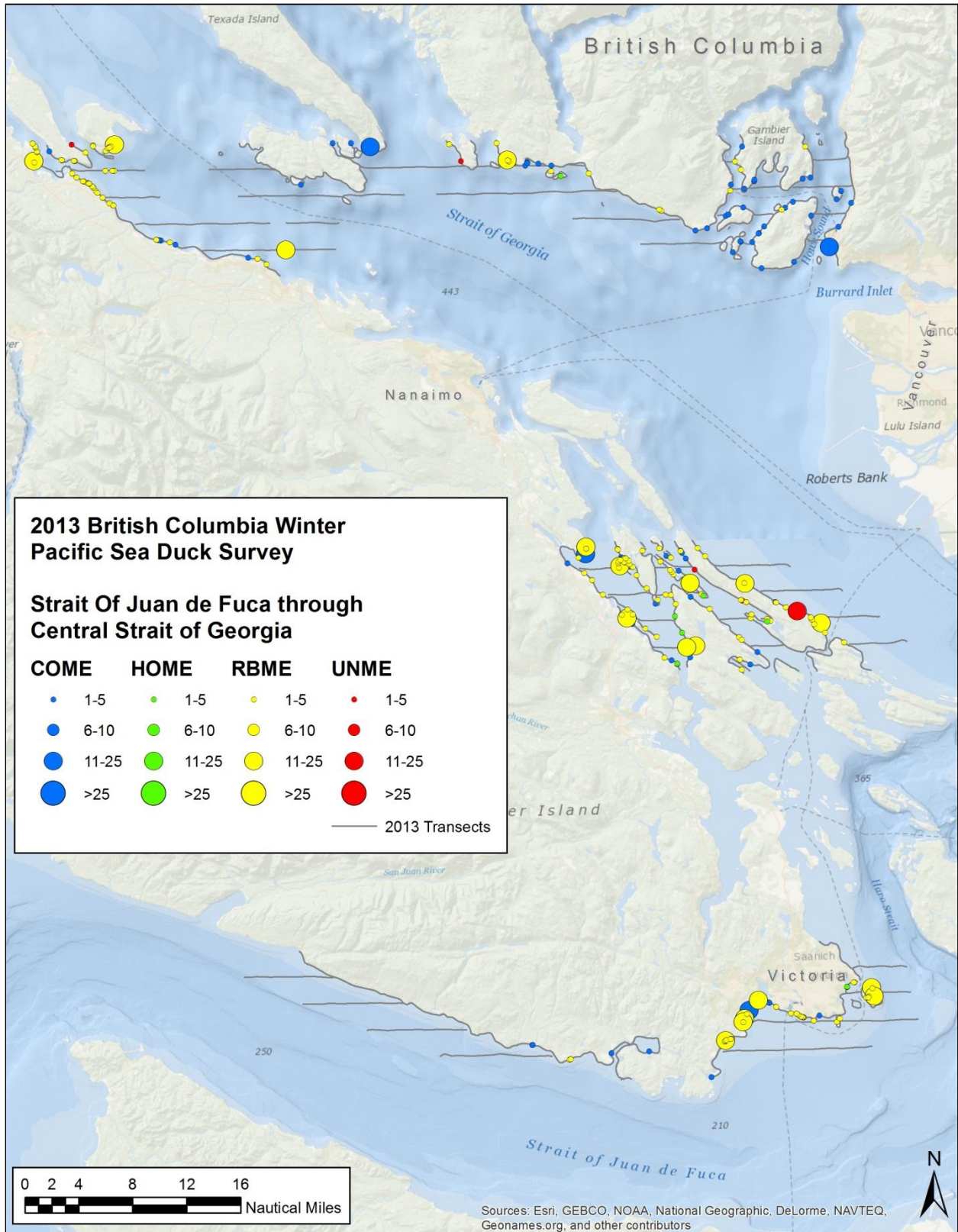


Figure 20. Merganser species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013, Strait of Juan de Fuca through central Strait of Georgia.

Appendix 2

Supplemental Distribution Figures: Other Waterbird Species and Marine Mammals

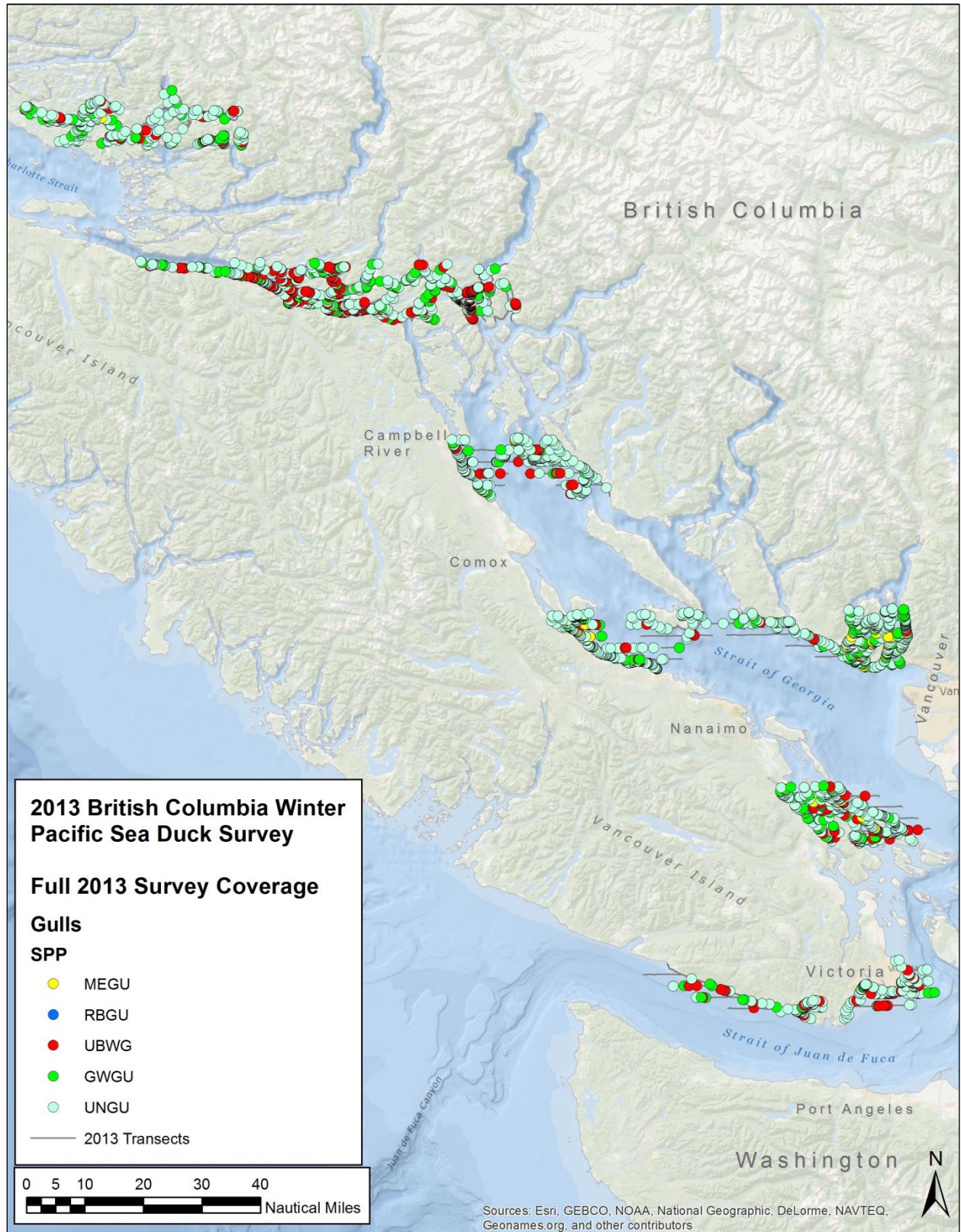


Figure 21. Gull species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

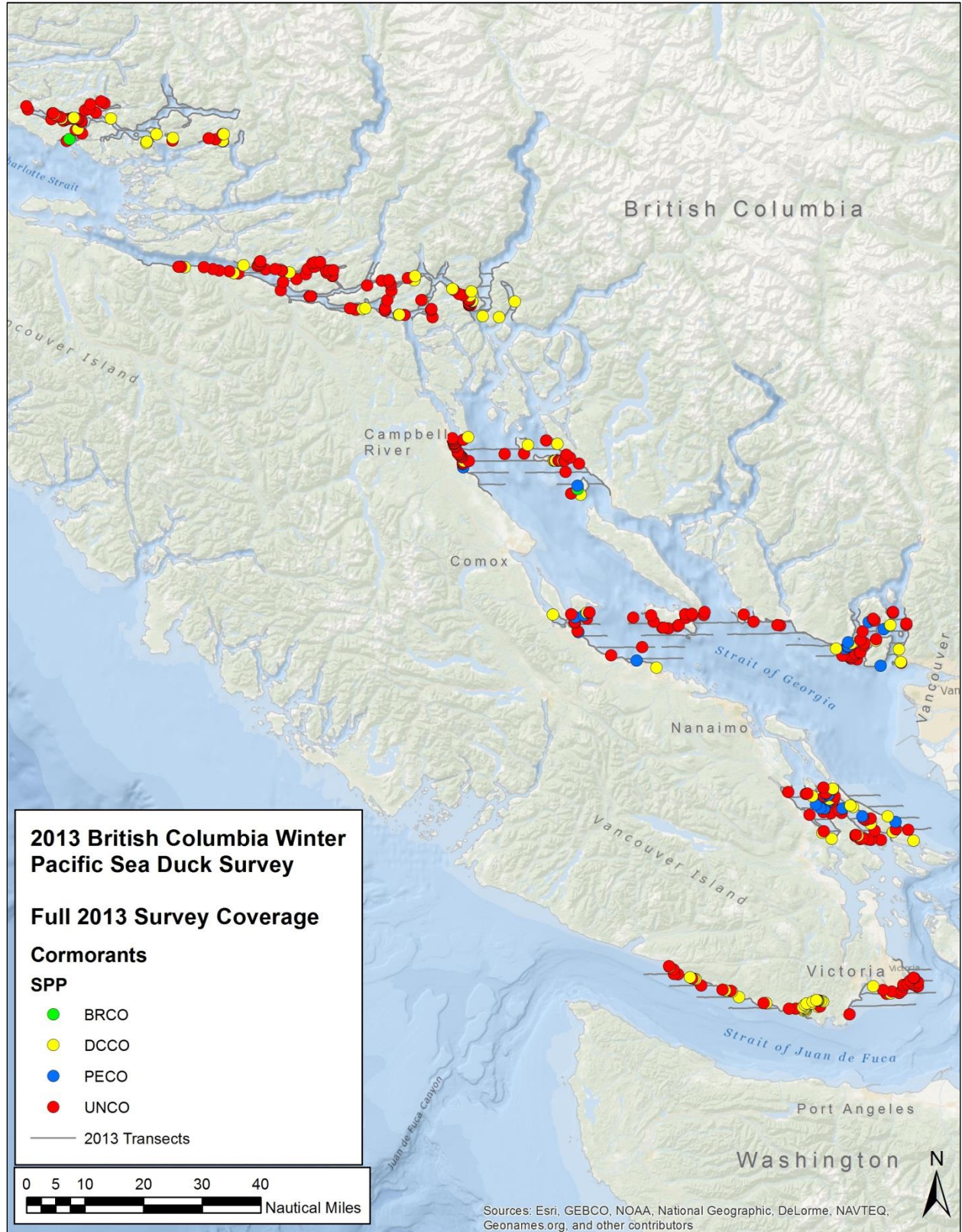


Figure 22. Cormorant species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

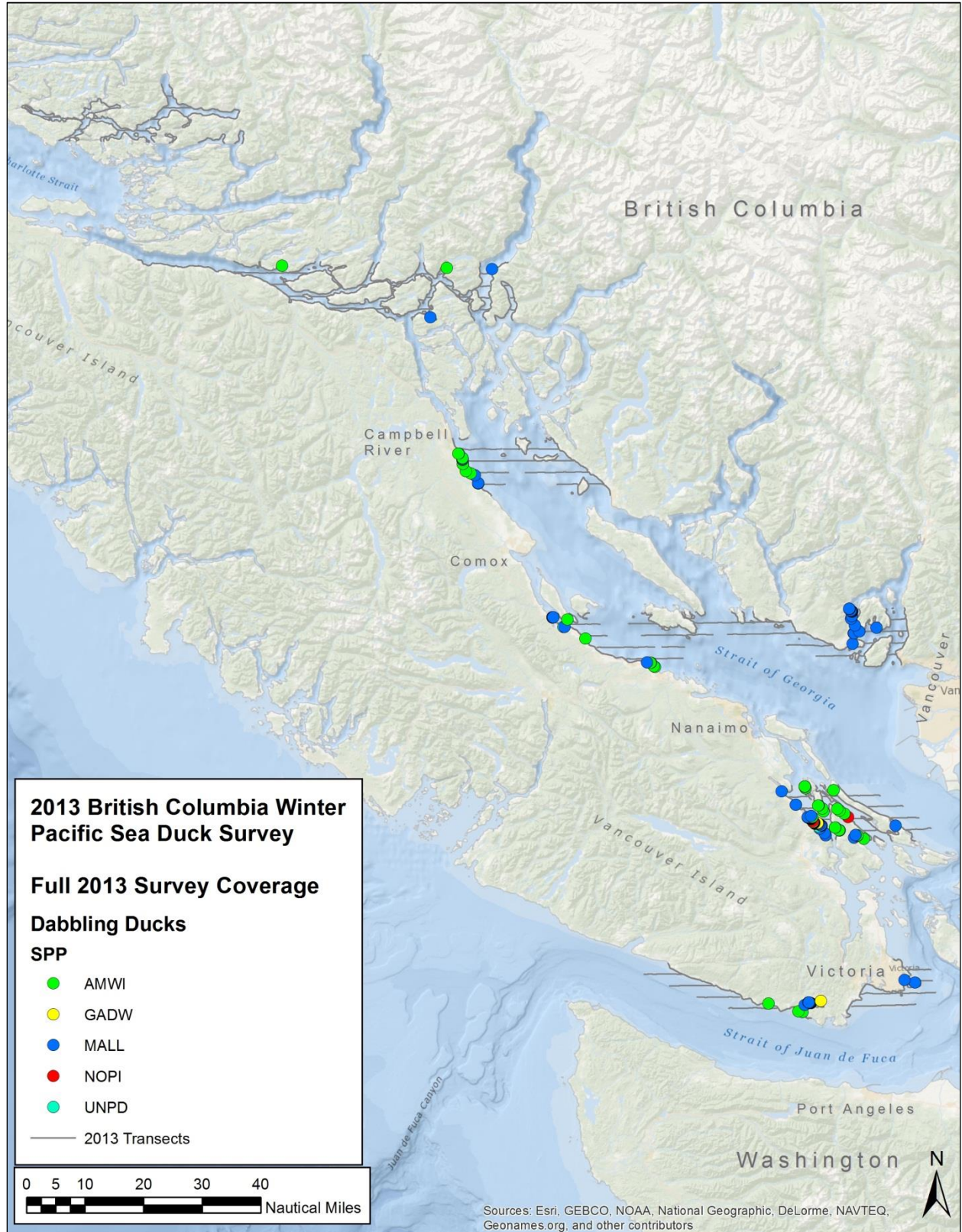


Figure 23. Dabbling duck distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

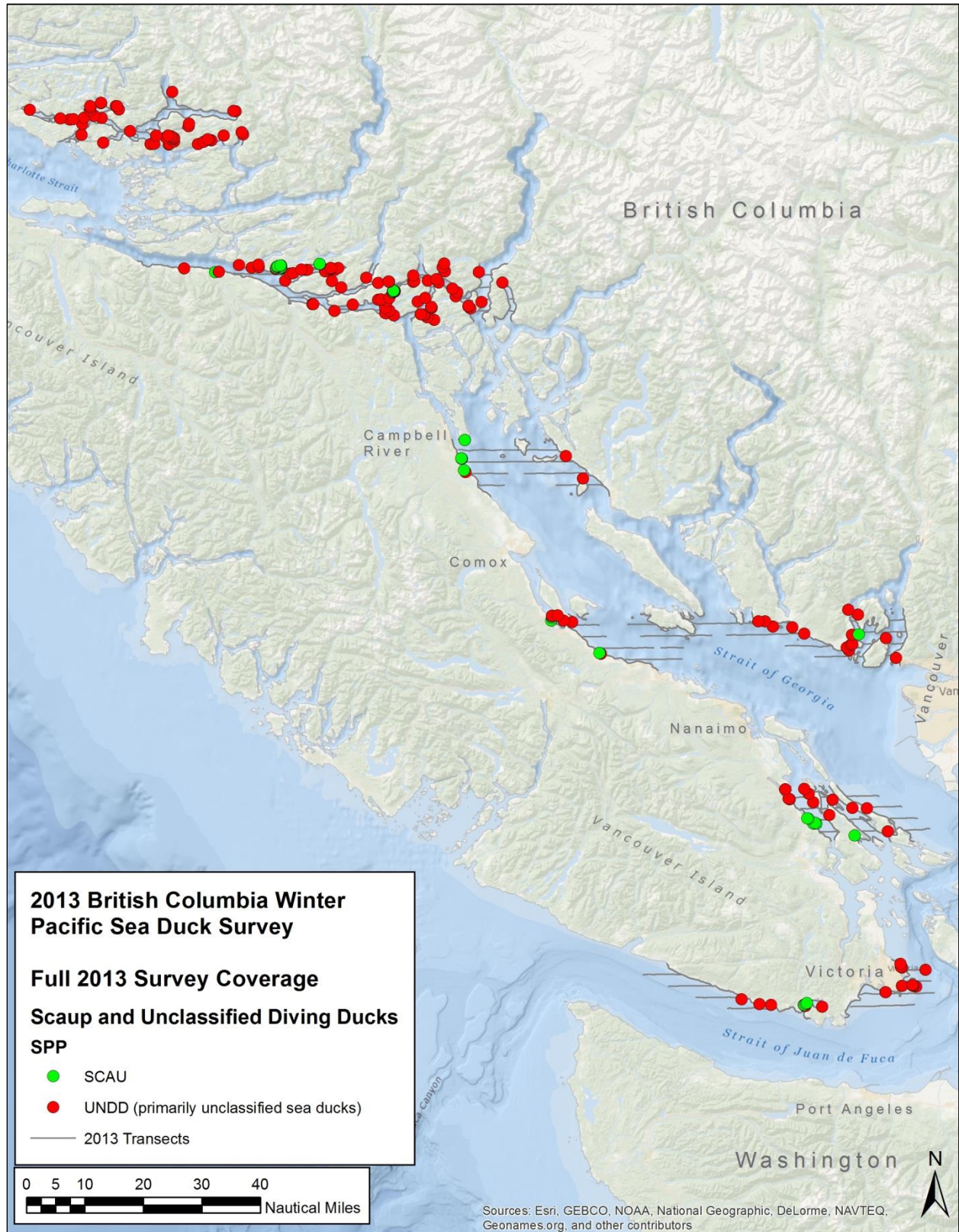


Figure 24. Scaup species and unclassified diving duck species (primarily unclassified sea ducks) distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

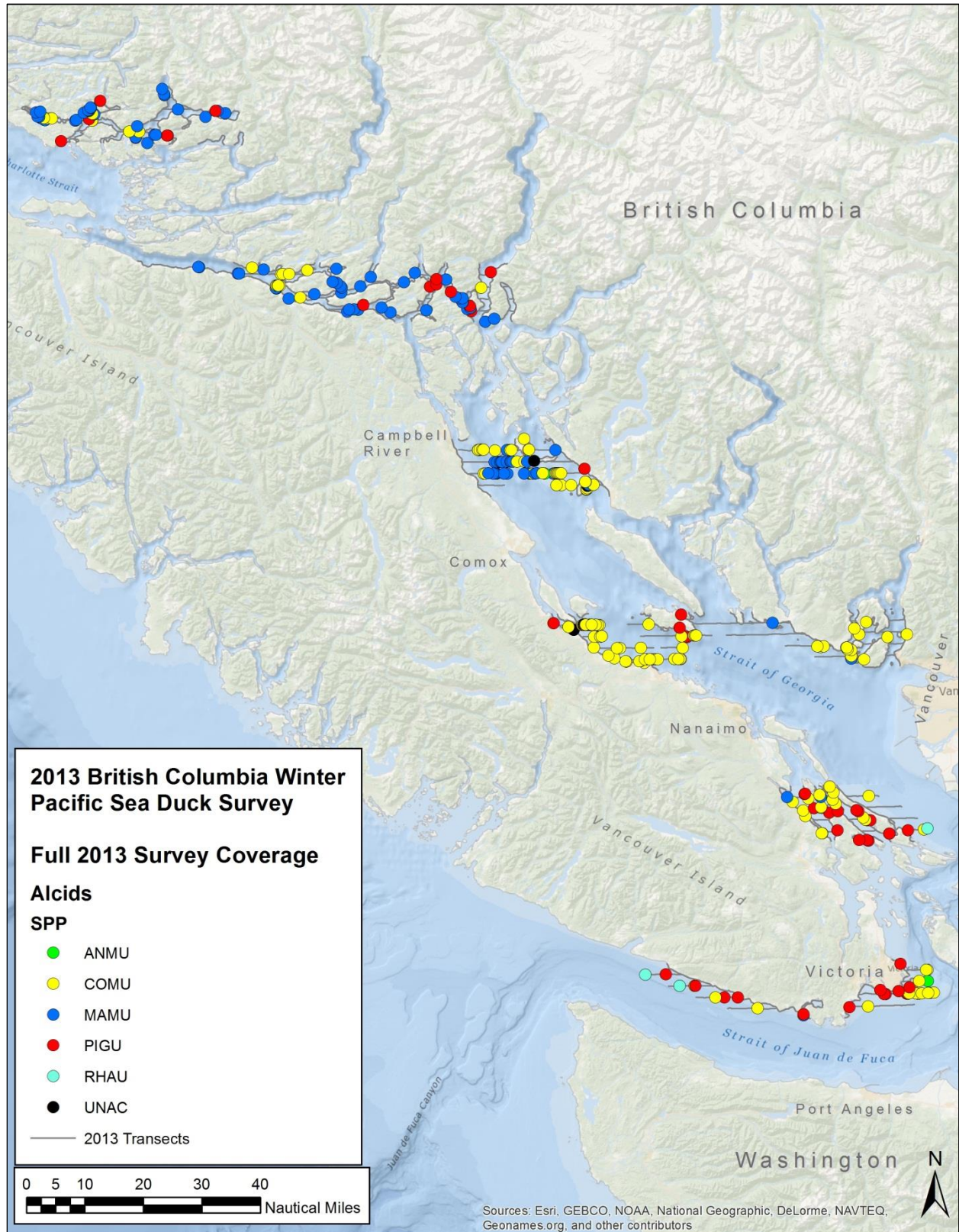


Figure 25. Alcid species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

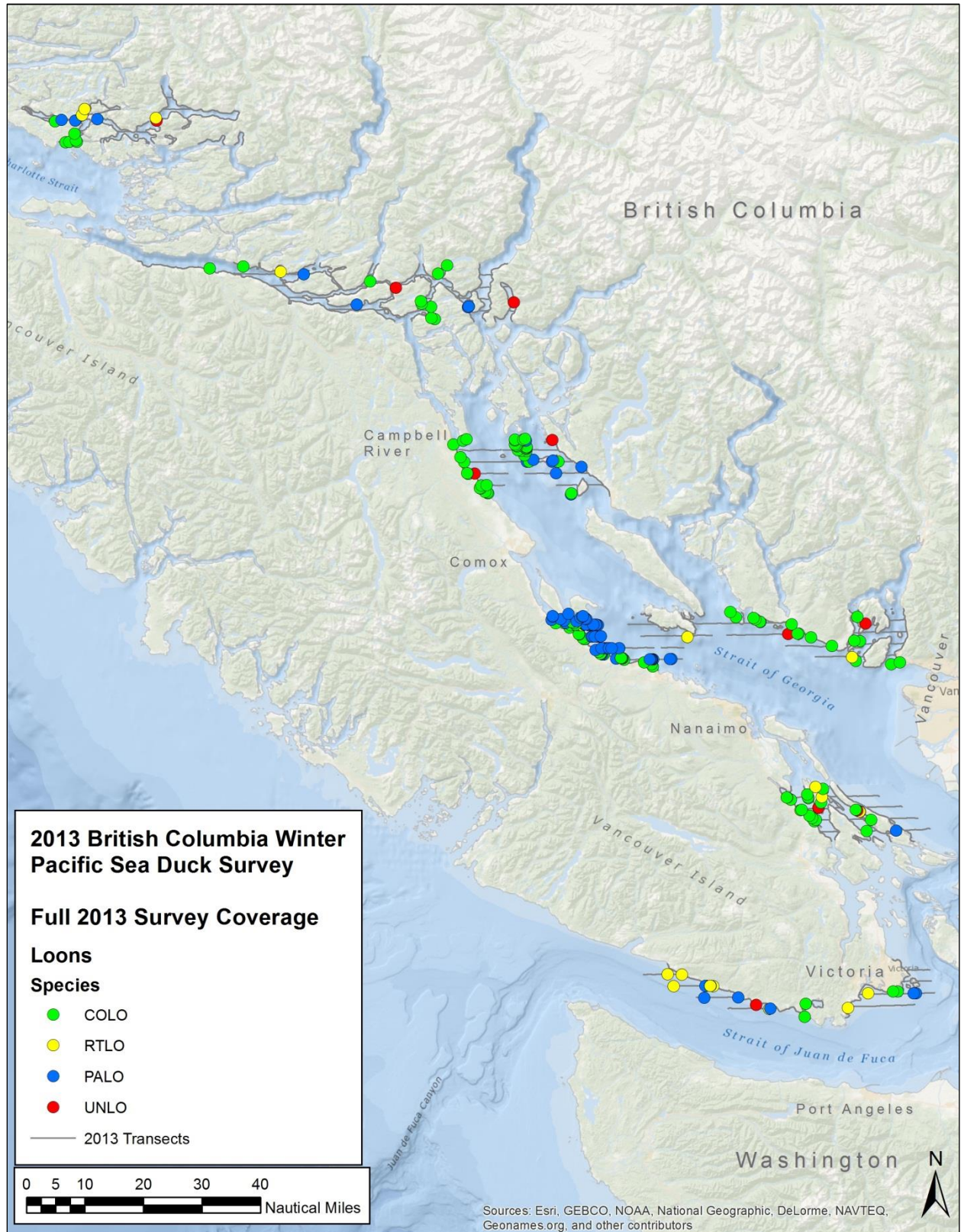


Figure 26. Loon species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

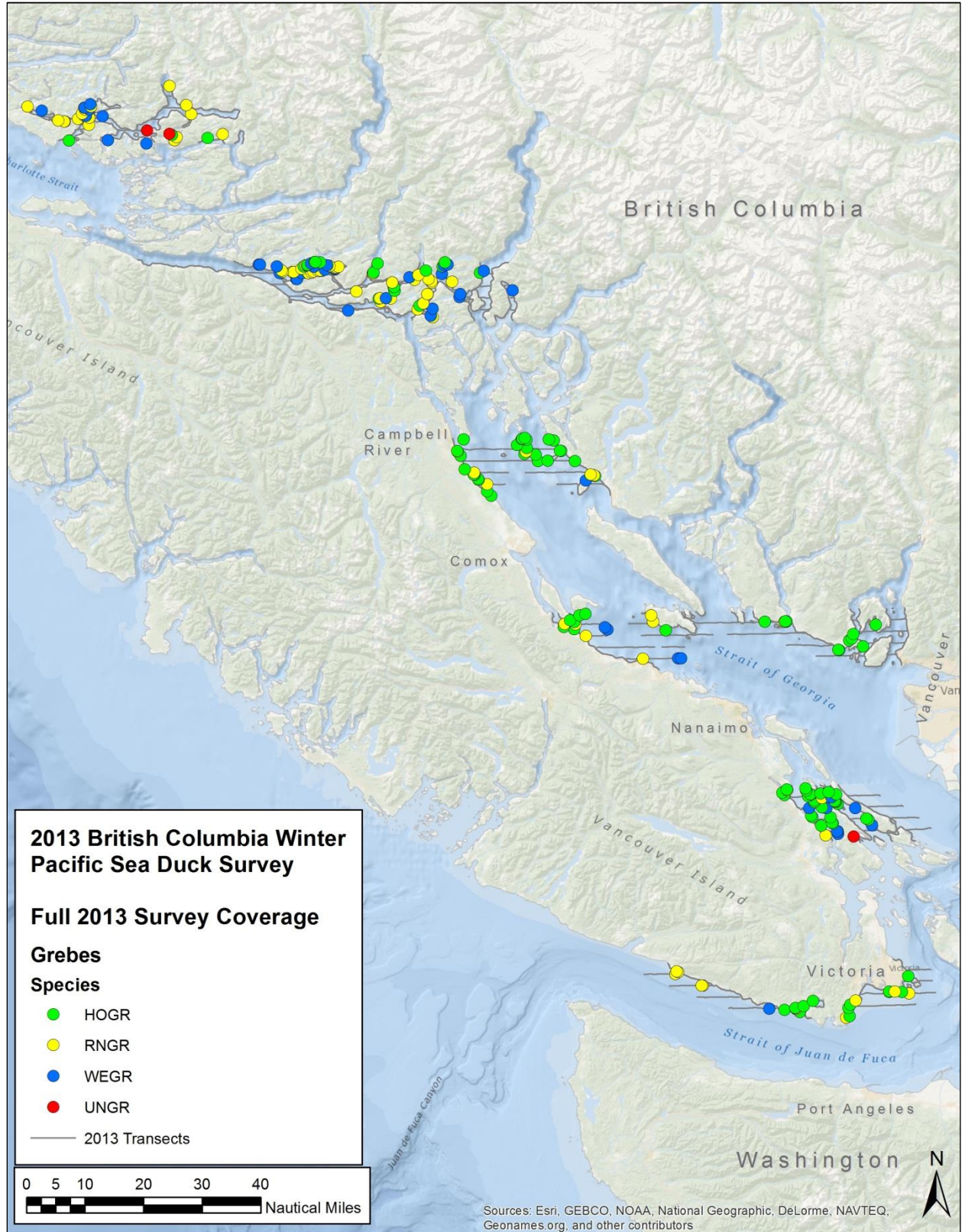


Figure 27. Grebe species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

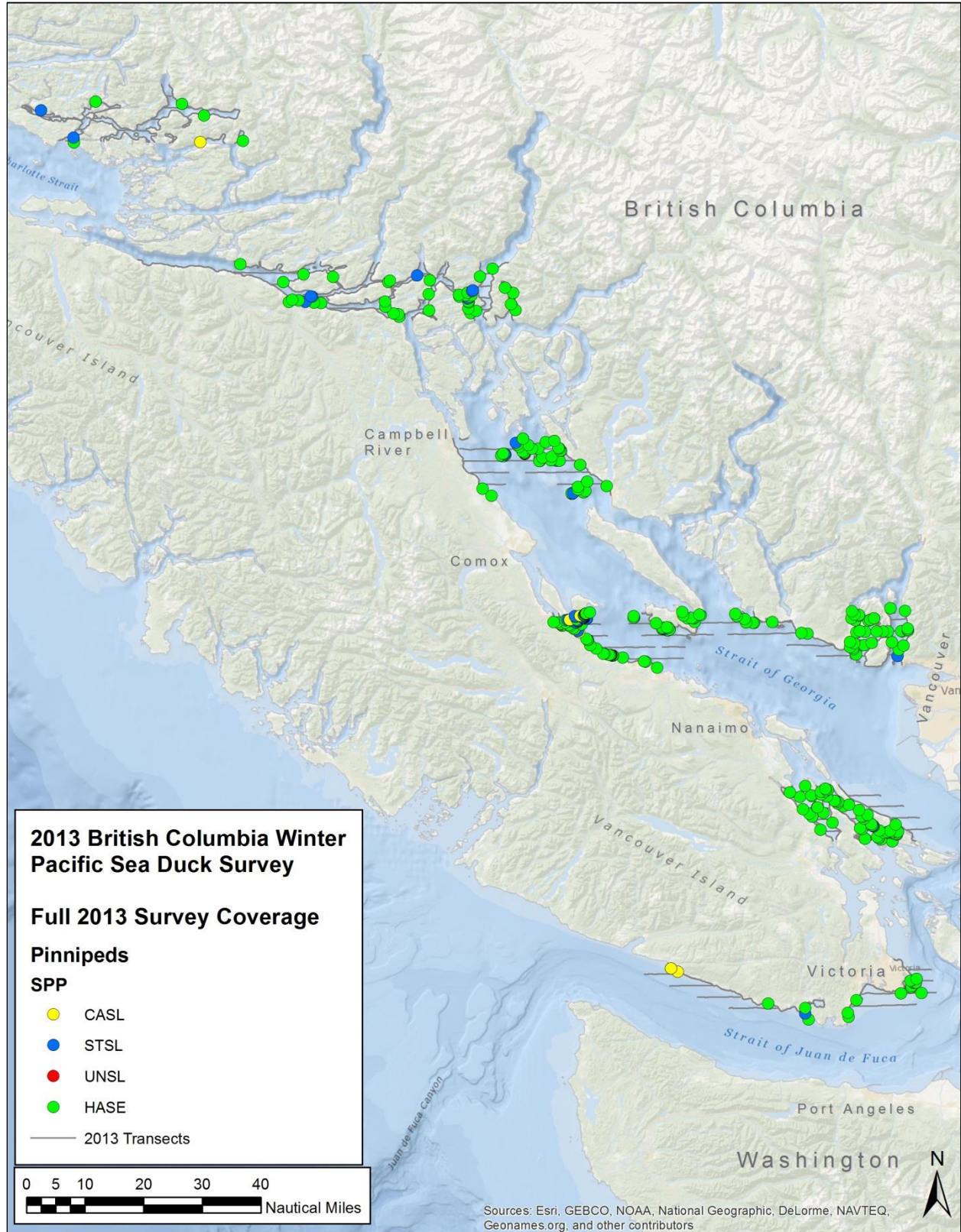


Figure 28. Pinniped species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

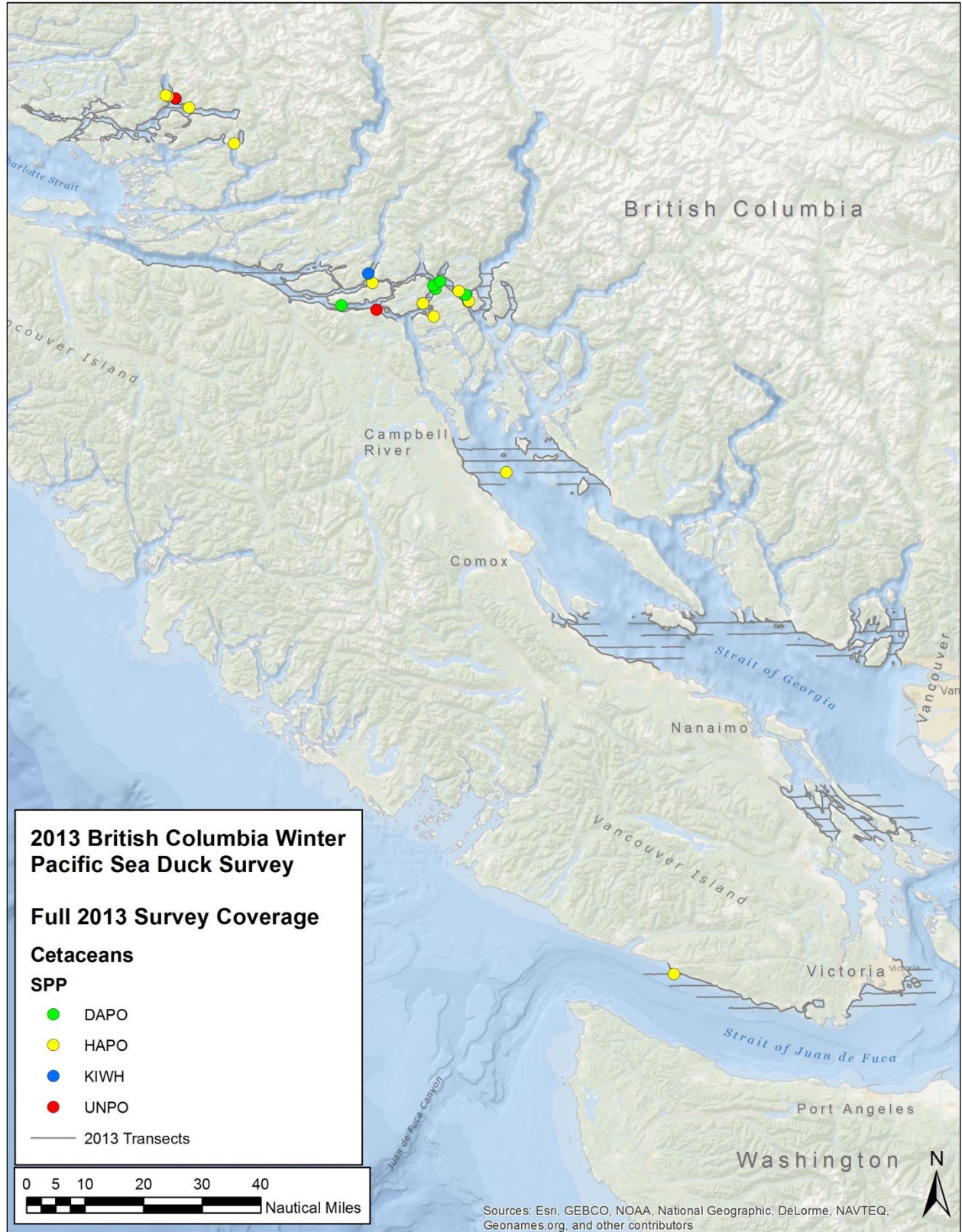


Figure 29. Cetacean species distribution from 2013 Winter British Columbia Pacific Sea Duck Surveys, February 2013.

Appendix 2

Remaining British Columbia Transects

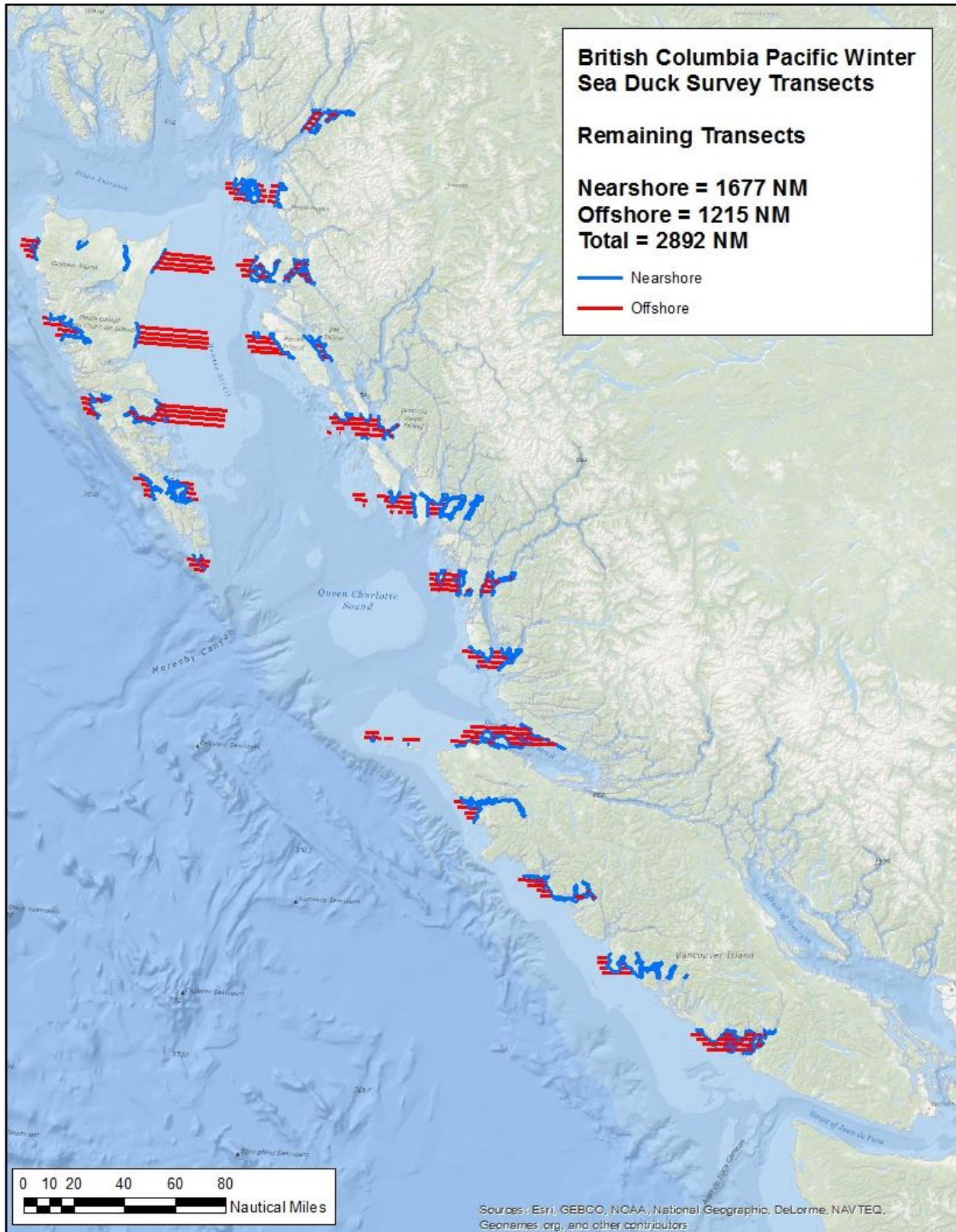


Figure 30. Remaining un-surveyed transects from the Pacific Coast Aerial Sea Duck Survey within British Columbia, Canada.