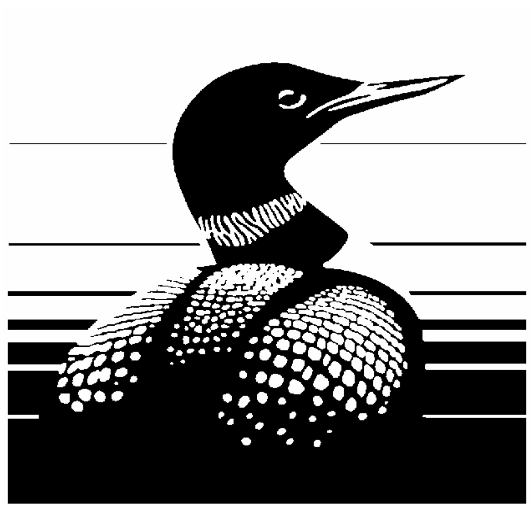
ABUNDANCE AND DISTRIBUTION OF WATERBIRDS ON THE WEST COAST OF VANCOUVER ISLAND DURING SPRING 1999 AND WINTER 2000

Ramūnas Žydelis[1], W. Sean Boyd[2], André Breault[2] and Terrance M. Sullivan[3]

Pacific and Yukon Region 2005
Canadian Wildlife Service
Environmental Conservation Branch



Technical Report Series Number 437

Environment Canada
Canadian Wildlife Service

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Canada

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Technical Report Series No. 437
Pacific and Yukon Region 2005
Canadian Wildlife Service

This series may be cited as:

Žydelis, R., W. S. Boyd, A. Breault, and T. M. Sullivan. 2005.
Abundance and distribution of waterbirds on the west coast of Vancouver
Island during spring 1999 and winter 2000.
Technical Report Series No. 437. Canadian Wildlife Service,
Pacific and Yukon Region, British Columbia.

Issued under the Authority of the
Minister of Environment
Canadian Wildlife Service

Catalogue No. CW69-5/437E
ISBN 0-662-40398-3
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service
Pacific and Yukon Region
5421 Robertson Road, RR #1
Delta, British Columbia
Canada V4K 3N2

This document is printed on EcoLogo[M] certified paper.

ABSTRACT

This report presents the results of six aerial surveys of waterbirds conducted on the west coast of Vancouver Island during the spring of 1999 and the winter of 2000. The surveys covered approximately 50% of the 3900 km shoreline between Cape Scott and Port San Juan. During each survey, waterbird abundance was estimated in 274 pre-determined shoreline-based transects, each associated with a unique marine ecological unit (eco-unit). The replicated surveys of individual shoreline transects were processed to determine: 1) distribution and abundance of waterbirds on the near-shore portion of the west coast of Vancouver Island, 2) waterbird densities across marine ecological units and 3) seasonal variability in waterbird distribution and abundance. This report also identifies waterbird distribution and abundance at active spawning sites of Pacific Herring (*Clupea pallasi*) on the west coast. The purpose of the report is to provide spatial, habitat-based and species-specific information to wildlife managers or others interested in or involved with bird or near-shore management on the west coast of Vancouver Island.

The number of waterbirds observed along the nearshore during the surveys ranged from 22,000 to 34,000 in winter, climbed to nearly 48,000 in early spring during herring spawn, and then dropped to 11,000 during the last spring survey. Gulls were the most abundant group of waterbirds found on the west coast (comprising 26% of all birds in winter and 41% in spring), followed by scoters (18% in winter and 32% in spring) and loons (7% in winter and 9% in spring). Waterbirds were present in all of the eco-units surveyed during winter. The marine eco-unit LCLLM, which covered 36% of the surveyed area, supported 35% of all waterbirds sighted. In spring the two areas supporting the most birds were Barkley Sound and Hesquiat Harbour. The largest bird aggregations in spring were observed in eco-units MBLLS and MCHLM, which respectively comprise only 2.4% and 1.4% of the study area. The overall mean density of birds in winter was 14.2 individuals per linear kilometer of shoreline. Marine eco-unit LBHLM supported the highest bird density (24 individuals per kilometer of shoreline) during the winter while the highest spring bird abundances were observed in eco-units MBLLS and MCHLM. In the spring, the largest bird concentrations were found in the sections of Barkley Sound and Hesquiat Harbour where there were extensive Pacific herring spawns. The key groups of birds aggregating at herring spawn were loons, scoters and gulls.

RÉSUMÉ

Nous présentons les résultats de six relevés aériens d'oiseaux aquatiques menés sur la côte ouest de l'île de Vancouver au printemps 1999 et à l'hiver 2000. Les relevés ont couvert environ 50% des 3900 km de la ligne de côte entre le cap Scott et Port San Juan. Durant chaque relevé, nous avons évalué l'abondance des oiseaux dans 274 transects côtiers préétablis, chacun étant associé à une seule unité écologique marine (éco-unité). Nous avons analysé les données des relevés répétés le long de chaque transect afin de déterminer: 1) la répartition et l'abondance des oiseaux aquatiques sur le littoral de la côte ouest de l'île de Vancouver; 2) les densités d'oiseaux dans les unités écologiques marines; et 3) la variabilité saisonnière de la répartition et de l'abondance des oiseaux. De plus, nous avons étudié la répartition et l'abondance des oiseaux aquatiques dans les frayères du hareng du Pacifique (*Clupea pallasi*) de la côte ouest. Le rapport vise à fournir des renseignements sur la répartition et l'habitat de chaque espèce d'oiseau aux gestionnaires de la faune ou à d'autres personnes intéressées par les oiseaux ou par l'aménagement du littoral sur la côte ouest de l'île.

Durant les relevés, le nombre d'oiseaux aquatiques observés sur la côte a varié de 22,000 à 34,000 en hiver, a grimpé à près de 48,000 tôt au printemps durant la fraye du hareng, puis a baissé à 11,000 durant le dernier relevé printanier. Les goélands et les mouettes constituaient le plus grand groupe d'oiseaux aquatiques observés sur la côte ouest (représentant 26% de tous les oiseaux présents en hiver et 41% au printemps), suivis par les macreuses (18% des oiseaux présents en hiver et 32% au printemps) et les plongeons (7% des oiseaux présents en hiver et 9% au printemps). Nous avons observé des oiseaux aquatiques dans toutes les éco-unités ayant fait l'objet de relevés durant l'hiver. L'éco-unité marine de type LCLLM, qui représente 36% de la zone d'étude, a accueilli 35% de tous les oiseaux observés. Au printemps, les deux secteurs ayant accueilli le plus grand nombre d'oiseaux étaient la baie Barkley et le havre Hesquiat. De plus, nous avons observé les plus grandes concentrations d'oiseaux printanières dans les éco-unités de type MBLLS et MCHLM, qui représentent respectivement seulement 2.4% et 1.4% de la zone d'étude. Dans l'ensemble, la densité moyenne d'oiseaux en hiver était de 14,2 individus par kilomètre linéaire de côte. En hiver, nous avons mesuré les plus fortes densités d'oiseaux dans l'éco-unité de type LBHLM (24 individus par kilomètre de rivage) et, au printemps, les plus fortes abondances dans les éco-unités de type MBLLS et MCHLM. Au printemps, nous avons vu les plus fortes concentrations d'oiseaux dans les secteurs de la baie Barkley et du havre Hesquiat où on observe la fraye de grands bancs de hareng du Pacifique. Les principaux groupes d'oiseaux concentrés près des frayères de hareng étaient des plongeons, des macreuses, des goélands et des mouettes.

ACKNOWLEDGEMENTS

Like all such projects, this was a group effort. Sean Cullen assisted Terry Sullivan and André Breault with waterbird identification. Stephanie Hazlitt and Jeffrey Paleczny operated the on-board GPS, assisted the pilot with navigation, kept the airplane on transect and were responsible for recording the bird sightings and the location of all flocks sighted.

The surveys were flown with Mr. Bob “Eagle-Eye” Prescesky of Cooper Air Inc. He willingly shared his knowledge of the west coast, kept the crew’s stomachs under control and skillfully and consistently delivered safe and smooth flying.

The geo-spatial component of this project was overseen by Jason Komaromi and Stephen Shisko of the Canadian Wildlife Service, working with Terry Sullivan. Data entry and quality control were done by Murray Lashmar, Saskia Arnesen, Krista Amey and Pippa Shepherd.

Peter Watts reviewed an earlier draft of the report. Special thanks go to Pippa Shepherd, who oversaw the re-organisation and re-write of earlier drafts of the report.

Funding for this project was supplied by The Nestucca Trust Fund and by the Canadian Wildlife Service.

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1. INTRODUCTION

This report presents the results of six aerial surveys of waterbirds conducted on the west coast of Vancouver Island in 1999 and 2000. The surveys were funded by the Nestucca Trust Fund, established after the December 1988 spill of 875,000 liters of oil in Washington State by the "Nestucca" barge. The spill resulted in the loss of an estimated 56,250 birds representing 31 species (Burger 1993). Oiled birds were found along the entire west coast of Vancouver Island, and oil was detected as far north as Bella-Bella on the mainland coast (Rodway *et al.* 1989). The Nestucca spill highlighted the need for comprehensive data on waterbird distribution and abundance on the British Columbia coast, particularly to assist with the management and the assessment of the impacts of spills on waterbird populations.

We employed an aerial survey method to estimate waterbird abundance in near-shore areas of the west coast of Vancouver Island between Cape Scott and Port San Juan. Prior to the surveys, the shoreline was divided into distinct transects associated with unique marine ecological units. Replicated surveys were used to produce a large-scale assessment of waterbird distribution and abundance, evaluate habitat-species relationships, and assess seasonal variability, particularly as they related to Pacific Herring spawn. The purpose of the report is to provide spatial, habitat-based and species-specific information to wildlife managers or others interested in waterbird and near-shore management. The results of this study could be used as background material on waterbird abundance and distribution along west coast of Vancouver Island. Also, the habitat-based survey design allows for an extrapolation to unsurveyed areas to infer expected waterbird abundance and distribution under natural conditions.

2. METHODS

2.1 Study Area

There are approximately 3870 km of coastline between Cape Scott and Port San Juan on the west coast of Vancouver Island, of which 1964 km (50.8%) were surveyed in this project. For compilation purposes, the study area was subdivided into four subregions: 1) Cape Scott to Brooks Peninsula; 2) Kyuquot Sound to Nootka Sound; 3) Clayoquot Sound; and 4) Pacific Rim National Park (Fig. 1).

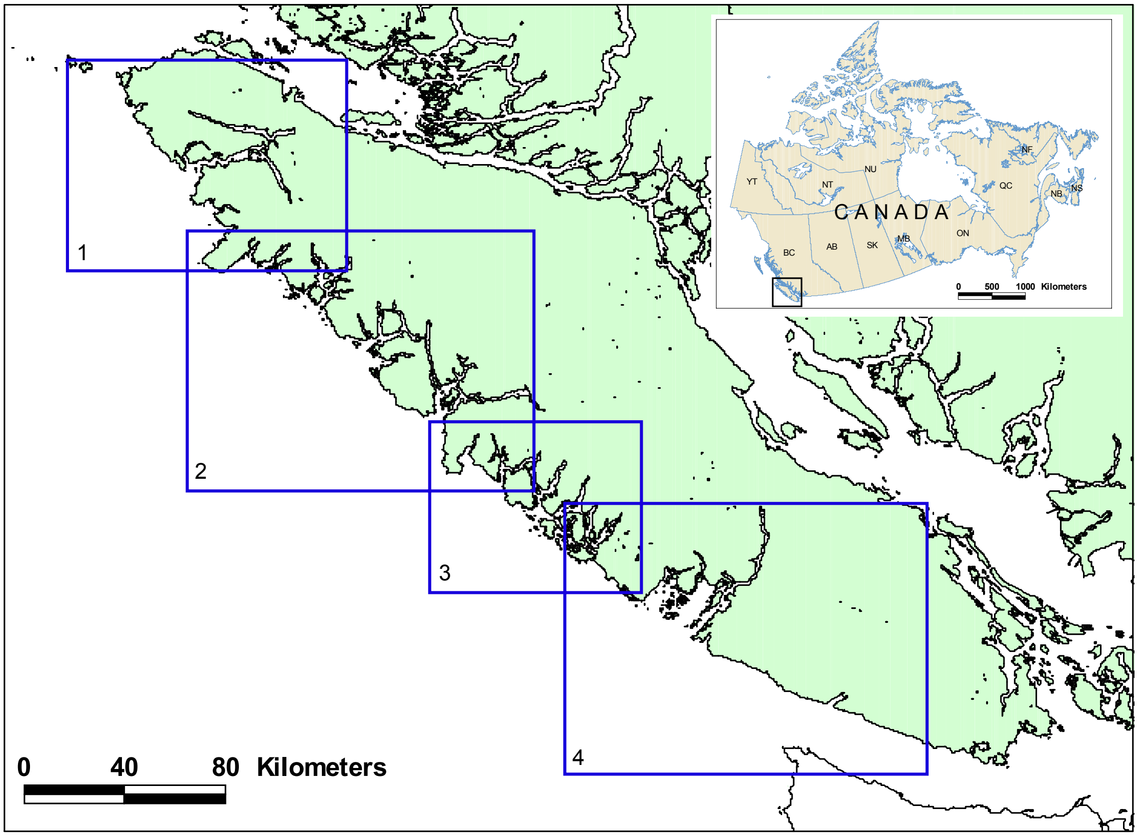


Figure 1. Index map of study area divided into four subregions for mapping purposes: 1) North – Cape Scot to Brooks Peninsula; 2) North Central – Kyuquot Sound to Nootka Sound; 3) South Central – Clayoquot Sound; 4) South – Pacific Rim National Park.

The west coast of Vancouver Island contains 22 marine eco-units as identified in the Marine Ecological Classification system (Zacharias and Howes 1998) (Fig. 2, Table 1). In this system, eco-units are delineated by physical parameters such as wave exposure, water depth, bottom relief, water current, and type of substrate (Table 2).

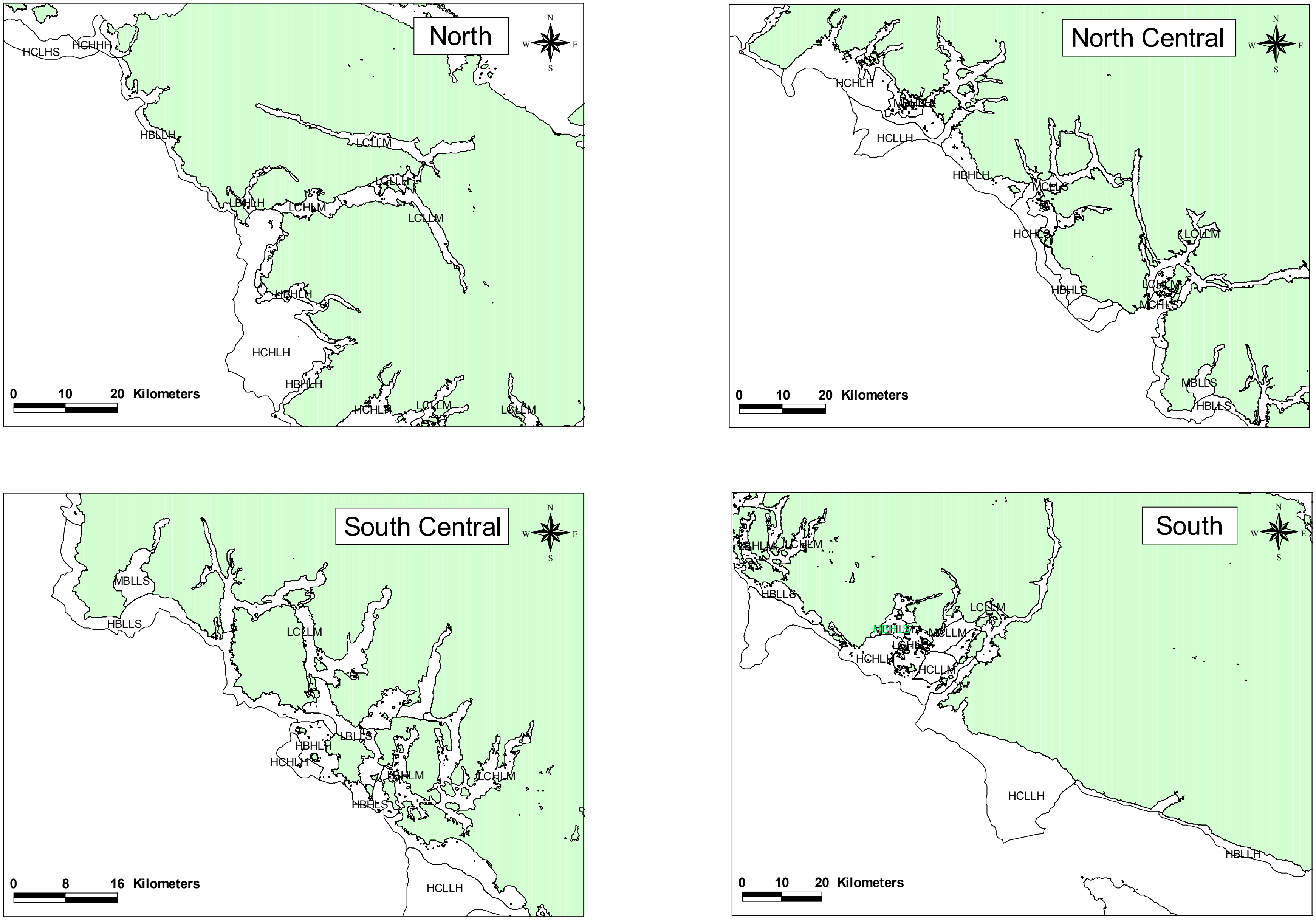


Figure 2. Marine eco-units along west coast of Vancouver Island.

Table 1. Total lengths and surveyed lengths (in km) of eco-unit types between Cape Scott and Port San Juan on the west coast of Vancouver Island, B.C.[1]

Eco-unit	Total km	Total %	Surveyed km	Surveyed %
HBHLH	356.3	9.2	187.0	52.5
HBHLS	60.9	1.6	41.9	68.8
HBLLH	121.6	3.1	84.6	69.6
HBLLS	254.1	6.6	165.6	65.1
HCHLH	240.6	6.2	145.1	60.3
HCHLS	47.1	1.2	35.4	75.2
HCLLH	110.8	2.9	79.2	71.5
HCLLM	3.5	0.1	2.7	77.6
HCLLS	13.6	0.4	9.6	70.5
LBHLH	61.1	1.6	40.1	65.6
LBHLM	143.8	3.7	64.8	45.1
LBLLS	60.5	1.6	45.9	75.9
LCHLH	105.5	2.7	41.0	38.9
LCHLM	440.1	11.4	174.0	39.5
LCLLH	47.8	1.2	11.1	23.2
LCLLM	1473.2	38.1	713.9	48.5
MBHLH	54.9	1.4	18.4	33.5
MBLLS	94.2	2.4	52.2	55.5
MCHLM	54.1	1.4	28.2	52.1
MCHLS	24.7	0.6	6.3	25.3
MCLLM	81.3	2.1	13.1	16.1
MCLLS	20.1	0.5	4.6	22.9
Total	**3869.8**	**100.0**	**1964.4**	**50.8**

[1] The letters of each eco-unit type correspond to physical features of the site. The letters, in sequence, represent wave exposure, water depth, bottom relief, water currents and bottom substrate (see Table 2 for parameter definitions).

Table 2. Themes, classes and description of eco-unit parameters of the British Columbia Marine Ecological Classification system used to delineate survey transects (from Zacharias and Howes 1998).

Theme	Class	Description
Wave Exposure	High (H)	Fetch > 500 km. Ocean swell environment
	Moderate (M)	Fetch 50 -500 km. Some swell areas; open sound and straits
	Low (L)	Fetch < 50 km. Protected areas; some small sounds and straits
Water Depth	Photic (B)	0 -20 m
	Shallow C)	20 - 200 m
	Moderate (D)	200 - 1,000 m
	Abyssal (E)	> 1000 m
Bottom Relief	High (H)	Abundant cover and diversity of bottom habitats
	Low (L)	Smooth or gently undulating bottom
Water Currents	High (H)	Maximum current > 3 knots
	Low (L)	Maximum current < 3 knots
Substrate	Hard (H)	Bedrock, boulders, cobble, and some sand/gravel areas
	Sand (S)	Sand, gravel/sand, and some muddy areas
	Mud (M)	Mud and sandy mud
	Unknown (U)	Not sampled

2.2 Survey design

2.2.1 Defining shoreline-based surveys

Surveys were designed by dividing the coastline into 274 shoreline-based transects, ranging from 0.7 km to 21.9 km in length (Mean ± SD = 7.2 ± 3.4 km). Each transect was comprised of a single marine eco-unit type and all 22 marine eco-units were represented (Figs. 2-3, Table 1). The start and end locations of each survey transect, which are summarized in Appendix 1, were determined using three criteria. First, way-points were positioned on marine eco-unit boundaries, determined using Geographic Information Systems (GIS) data from the Land Use Coordination Office of the Province of British Columbia (Zacharias and Howes 1998). Second, way-points were positioned at the heads of inlets to separate inlets from estuaries. Finally, large marine eco-units were further sub-divided into units not more than 22 km apart (or ~10 min. flight time). Way-points were programmed into a hand-held GPS unit to ensure that the survey route was replicated during subsequent surveys.

2.2.2 Survey effort

Six aerial surveys were conducted in total, three during spring 1999 (13-15 March, 30 March-1 April and 27-29 April) and three during winter 2000 (16-18 January, 21-23 January and 2-4 February). Each survey took three consecutive days to complete and covered the entire study area. All surveys were conducted in a Cessna 206 float plane, flying at 80-90 knots (kt), 45-60 m above sea level and 50-100 m off-shore. Two observers, both in the rear of the aircraft, recorded all birds along transect within 50 m of either side of the plane. A third person, seated in the front, recorded the observations and ensured that the pilot followed the survey route. Groups of birds off the transect route were treated as point counts and their locations were recorded with a Garmin hand held Global Positioning System (GPS) unit. A 35 mm camera with ISO-800 film was used to photograph large concentrations of birds, which were later counted in the lab.

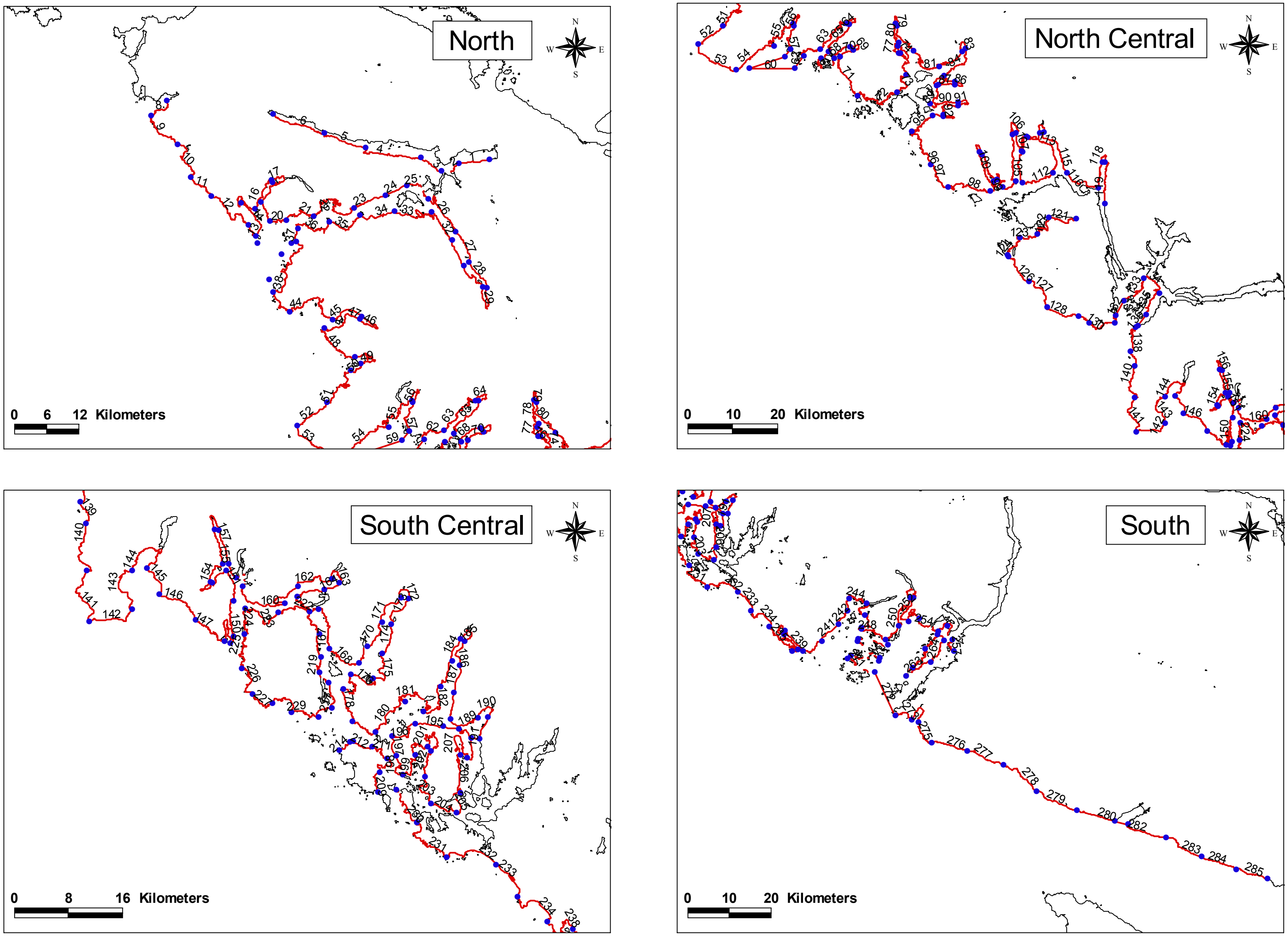


Figure 3. Location of shoreline-based transects between Cape Scott and Port San Juan on the west coast of Vancouver Island. Dots indicate transect start and end points, and each number represents transect ID.

2.2.3 Species coverage

All waterbird species plus sightings of Bald Eagles and marine mammals were recorded. For the assessment of waterbird abundance and density distribution, related species were merged into the following categories: loons, grebes, cormorants, dabbling ducks, scoters, goldeneyes, mergansers and gulls. Abundance and distribution of swans, geese, herons, shorebirds and alcids were not analyzed separately, but those taxonomic groups were included into the category *All birds*.

2.3 Data processing

2.3.1 Calculating waterbird abundance

Counts from both sides of the aircraft, photo counts and point counts were summed to determine the total number of birds present. During winter surveys, bird numbers were tallied under two categories: 1) on the transect route; 2) off the transect route. Birds on the transect route were those observed within 50 m of either side of the aircraft. Birds observed off the transect route were typically in large flocks. During spring counts, bird observations were recorded as 1) associated with the herring spawn sites, which included individuals both on and off the transect route; 2) non-spawning sites, which, similar to the winter surveys, were categorized into on and off the transect route. The data presented in this report have not been adjusted by Visibility Correction Factors (VCF).

2.3.2 Geographic and ecological reporting

Waterbird abundance and distribution are presented in three ways in this report.

1) Total bird abundance within marine eco-units, which was assessed to identify the eco-units supporting most and least waterbirds. All birds counted “On transect”, “Off transect”, and on “On spawn” were included and summed for each eco-unit.

2) Bird densities within marine eco-units, which were calculated to assess the importance of specific eco-units to birds. Bird density was calculated as a number of birds counted “On transect” per linear kilometer of shoreline. Each transect was treated as a sampling unit to calculate bird densities within different eco-units. Eco-units with cumulative transect length less than 1% of the total coastline surveyed were not considered representative for bird density estimates. The data, however, are presented in tables.

3) Total number of birds per survey mapped for the west coast of Vancouver Island, which was used to demonstrate the geographical distribution of birds. All birds counted “On transect”, “Off transect”, and on “On spawn” were included.

Results were mapped ranking number of birds per transect into five classes using the “Natural Breaks” classification method available in ArcView 3.2 software (ESRI, 1999). This classification method identifies breakpoints between classes using Jenk’s optimization statistical formula (Slocum 1999). The Jenk’s method minimizes the sum of the variance within each of the classes. “Natural Breaks” finds groupings and patterns inherent in the input data.

2.3.3 Seasonal and Herring Spawn effects

Although spring surveys were conducted in 1999 prior winter surveys carried out in 2000, in this report we present data following the sequence of seasons – i.e. results from winter data are followed by spring data. Data were summarized for each survey separately. Also, mean values were obtained from three winter surveys, since it was assumed that winter surveys could be treated as replicates, whereas records from spring surveys were not averaged due to strong influence of herring spawn and bird migration on overall bird abundance and distribution during each survey.

3. RESULTS AND DISCUSSION

3.1 Overall waterbird and marine mammal abundance

3.1.1 Waterbirds

Over the three winter surveys in 2000, a total of 86,066 waterbirds were observed (Table 3), including 74,515 birds (86.6%) on the transect route and 11,720 birds (13.4%) off the route. The number of waterbirds detected per survey increased over the duration of winter surveys (Table 3; Fig. 4). Over the three winter 2000 surveys combined, gulls were most abundant waterbirds (26.4%), followed by scoters (18.4%), goldeneyes (8.9%), grebes (7.9%) and loons (7.2%).

Over the three spring surveys in 1999, a total of 106,804 waterbirds were observed (Table 4), including 53,550 (50.1%) on the transect route, 10,820 birds (10.1%) off the transect route and a further 42,434 birds (39.7%) associated with herring spawn. The waterbirds detected during the first and second surveys were similar in both numbers and relative

Table 3. Waterbird and marine mammal species and their total numbers observed during three surveys in winter 2000 (16-18 January, 21-23 January, 2-4 February).

	Survey 1		Survey 2		Survey 3		All 3 surveys	
Species	**TOTAL**	**Total %**	**TOTAL**	**total %**	**TOTAL**	**total %**	**TOTAL**	**total %**
Pacific Loon	5	0.0	14	0.0	1335	3.9	1354	1.6
Common Loon	82	0.4	654	2.2	22	0.1	758	0.9
Unidentified Loons	25	0.1	145	0.5	3956	11.7	4126	4.8
Horned Grebe	24	0.1	62	0.2	61	0.2	147	0.2
Red-necked Grebe	532	2.4	348	1.2	899	2.7	1779	2.1
Western Grebe	1343	6.1	1486	4.9	990	2.9	3819	4.4
Unidentified Grebes	29	0.1	246	0.8	751	2.2	1026	1.2
Double-crested Cormorant	269	1.2	90	0.3	92	0.3	451	0.5
Pelagic Cormorant	444	2.0	243	0.8	176	0.5	863	1.0
Unidentified Cormorants	726	3.3	1219	4.0	1400	4.1	3345	3.9
Great Blue Heron	18	0.1	33	0.1	24	0.1	75	0.1
Unidentified Swans	142	0.6	150	0.5	126	0.4	418	0.5
Brant	0	0.0	0	0.0	0	0.0	0	0.0
Canada Goose	728	3.3	721	2.4	370	1.1	1819	2.1
Green-winged Teal	2	0.0	0	0.0	0	0.0	2	0.0
Mallard	756	3.4	804	2.7	577	1.7	2137	2.5
American Wigeon	260	1.2	82	0.3	637	1.9	979	1.1
Unidentified dabbling ducks	789	3.6	328	1.1	284	0.8	1401	1.6
Unidentified Scaup	56	0.3	65	0.2	80	0.2	201	0.2
Harlequin Duck	47	0.2	25	0.1	16	0.0	88	0.1
Long-tailed Duck	37	0.2	43	0.1	73	0.2	153	0.2
Black Scoter	95	0.4	171	0.6	646	1.9	912	1.1
Surf Scoter	2890	13.0	2961	9.8	2472	7.3	8323	9.7
White-winged Scoter	36	0.2	199	0.7	52	0.2	287	0.3
Unidentified Scoters	784	3.5	2430	8.0	3133	9.3	6347	7.4
Common Goldeneye	46	0.2	16	0.1	12	0.0	74	0.1
Barrows Goldeneye	65	0.3	431	1.4	67	0.2	563	0.7
Unidentified Goldeneye	1797	8.1	3215	10.6	2003	5.9	7015	8.1
Bufflehead	586	2.6	738	2.4	571	1.7	1895	2.2
Hooded Merganser	1	0.0	14	0.0	0	0.0	15	0.0
Common Merganser	590	2.7	719	2.4	1128	3.3	2437	2.8
Red-breasted Merganser	82	0.4	68	0.2	101	0.3	251	0.3
Unidentified Merganser	84	0.4	195	0.6	123	0.4	402	0.5
Bald Eagle	123	0.6	409	1.4	182	0.5	714	0.8
Black Oystercatcher	7	0.0	61	0.2	89	0.3	157	0.2
Black Turnstone	0	0.0	0	0.0	83	0.2	83	0.1
Surfbird	321	1.4	884	2.9	886	2.6	2091	2.4
Unidentified shorebirds	1095	4.9	2465	8.2	1430	4.2	4990	5.8
Mew Gull	159	0.7	198	0.7	146	0.4	503	0.6
Herring Gull	8	0.0	7	0.0	2	0.0	17	0.0
Glaucous Gull	793	3.6	734	2.4	666	2.0	2193	2.5
Unidentified Gulls	5674	25.6	6828	22.6	7498	22.2	20000	23.2
Common Murre	39	0.2	10	0.0	70	0.2	119	0.1
Pigeon Guillemot	0	0.0	0	0.0	0	0.0	0	0.0
Marbled Murrelet	57	0.3	70	0.2	65	0.2	192	0.2
Unidentified Alcids	21	0.1	11	0.0	175	0.5	207	0.2
Belted Kingfisher	3	0.0	8	0.0	3	0.0	14	0.0
Unidentified waterbirds	501	2.3	621	2.1	371	1.1	1493	1.7
All birds	22171	100	30221	100	33843	100	86235	100
Sea Otter	69	4.3	251	13.3	373	15.3	693	11.6
River Otter	2	0.1	0	0.0	1	0.0	3	0.1
Unidentified Sea Lion	1204	74.2	1456	77.0	1830	75.0	4490	75.4
Harbour Seal	348	21.4	180	9.5	236	9.7	764	12.8
Killer Whale	0	0.0	3	0.2	0	0.0	3	0.1
Grey Whale	0	0.0	0	0.0	0	0.0	0	0.0
Unidentified Porpoise	0	0.0	0	0.0	0	0.0	0	0.0
All marine mammals	1623	100	1890	100	2440	100	5953	100

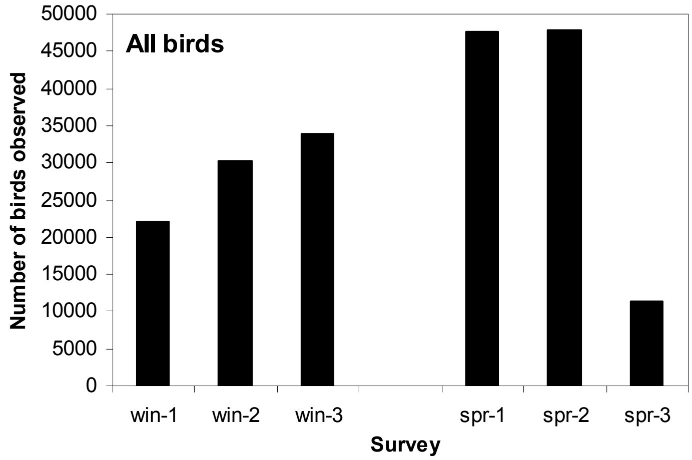


Figure 4. Total numbers of all birds counted per survey during three winter and three spring surveys. See methods for survey date.

Table 4. Waterbird and marine mammal species and their total numbers observed during three surveys in spring 1999 (13-15 March, 30 March – 1 April, 27-29 April).

	Survey 1		Survey 2		Survey 3		All 3 surveys	
Species	**TOTAL**	**total %**	**TOTAL**	**total %**	**TOTAL**	**total %**	**TOTAL**	**total %**
Pacific Loon	7569	15.9	1397	2.9	633	5.6	9599	9.0
Common Loon	20	0.0	26	0.1	66	0.6	112	0.1
Unidentified Loons	56	0.1	15	0.0	51	0.5	122	0.1
Horned Grebe	46	0.1	54	0.1	17	0.2	117	0.1
Red-necked Grebe	3	0.0	264	0.6	81	0.7	348	0.3
Western Grebe	1121	2.4	1382	2.9	306	2.7	2809	2.6
Unidentified Grebes	7	0.0	59	0.1	0	0.0	66	0.1
Double-crested Cormorant	136	0.3	111	0.2	34	0.3	281	0.3
Pelagic Cormorant	505	1.1	565	1.2	144	1.3	1214	1.1
Unidentified Cormorants	245	0.5	708	1.5	61	0.5	1014	0.9
Great Blue Heron	7	0.0	25	0.1	2	0.0	34	0.0
Unidentified Swans	22	0.0	2	0.0	0	0.0	24	0.0
Brant	0	0.0	0	0.0	445	3.9	445	0.4
Canada Goose	586	1.2	812	1.7	234	2.1	1632	1.5
Green-winged Teal	0	0.0	0	0.0	0	0.0	0	0.0
Mallard	159	0.3	580	1.2	238	2.1	977	0.9
American Wigeon	4	0.0	45	0.1	15	0.1	64	0.1
Unidentified dabbling ducks	536	1.1	259	0.5	244	2.2	1039	1.0
Unidentified Scaup	249	0.5	92	0.2	12	0.1	353	0.3
Harlequin Duck	17	0.0	0	0.0	2	0.0	19	0.0
Long-tailed Duck	37	0.1	100	0.2	13	0.1	150	0.1
Black Scoter	9	0.0	7	0.0	0	0.0	16	0.0
Surf Scoter	4369	9.2	16820	35.1	1870	16.5	23059	21.6
White-winged Scoter	129	0.3	43	0.1	0	0.0	172	0.2
Unidentified Scoters	5550	11.7	4593	9.6	835	7.4	10978	10.3
Common Goldeneye	0	0.0	439	0.9	36	0.3	475	0.4
Barrows Goldeneye	0	0.0	457	1.0	0	0.0	457	0.4
Unidentified Goldeneye	770	1.6	714	1.5	89	0.8	1573	1.5
Bufflehead	781	1.6	979	2.0	318	2.8	2078	1.9
Hooded Merganser	0	0.0	0	0.0	0	0.0	0	0.0
Common Merganser	831	1.7	1028	2.1	269	2.4	2128	2.0
Red-breasted Merganser	9	0.0	13	0.0	97	0.9	119	0.1
Unidentified Merganser	0	0.0	0	0.0	0	0.0	0	0.0
Bald Eagle	332	0.7	446	0.9	229	2.0	1007	0.9
Black Oystercatcher	19	0.0	4	0.0	1	0.0	24	0.0
Black Turnstone	0	0.0	0	0.0	0	0.0	0	0.0
Surfbird	0	0.0	0	0.0	0	0.0	0	0.0
Unidentified shorebirds	25	0.1	0	0.0	0	0.0	25	0.0
Mew Gull	254	0.5	347	0.7	73	0.6	674	0.6
Herring Gull	24	0.1	4	0.0	1	0.0	29	0.0
Glaucous Gull	1556	3.3	784	1.6	905	8.0	3245	3.0
Unidentified Gulls	21264	44.7	14546	30.4	3857	34.1	39667	37.1
Common Murre	1	0.0	1	0.0	6	0.1	8	0.0
Pigeon Guillemot	7	0.0	2	0.0	2	0.0	11	0.0
Marbled Murrelet	12	0.0	77	0.2	7	0.1	96	0.1
Unidentified Alcids	27	0.1	10	0.0	2	0.0	39	0.0
Belted Kingfisher	1	0.0	0	0.0	0	0.0	1	0.0
Unidentified waterbirds	321	0.7	75	0.2	108	1.0	504	0.5
All birds	**47616**	**100.0**	**47885**	**100.0**	**11303**	**100.0**	**106804**	**100**
Sea Otter	100	14.3	163	10.3	235	22.0	498	14.9
River Otter	0	0.0	0	0.0	0	0.0	0	0.0
Sea Lion spp.	538	77.2	1183	74.8	540	50.7	2261	67.6
Harbour Seal	51	7.3	199	12.6	281	26.4	531	15.9
Killer Whale	0	0.0	0	0.0	0	0.0	0	0.0
Grey Whale	8	1.1	33	2.1	4	0.4	45	1.3
Porpoise spp.	0	0.0	3	0.2	6	0.6	9	0.3
All marine mammals	**697**	**100.0**	**1581**	**100.0**	**1066**	**100.0**	**3344**	**100**

proportions among taxa. However, the number of waterbirds observed during the third survey was substantially lower (Table 4, Fig. 4). Over all spring 1999 surveys, gulls were the most frequently observed waterbirds (40.7%), followed by scoters (32.1%) and loons (9.2%) (Table 4).

3.1.2 Marine mammals

Over the winter 2000 surveys, a total of 5953 marine mammals were observed (Table 3). Sealions were most frequently observed (75.4%), followed by harbour seals (12.8%) and sea otters (11.6%).

Over the spring 1999 surveys, 3,344 marine mammals were observed (Table 4). Again, Sealions were most frequently observed (67.6%), followed by harbour seals (15.9%), and sea otters (14.9%).

3.2 Waterbird abundance and densities by marine eco-unit

3.2.1 Waterbird abundance in winter

The greatest abundance of waterbirds occurred in eco-units LCLLM, HBLLS, MBLLS, LCHLM, and LBHLM during winter. These eco-units supported 35%, 10%, 9%, 9% and 8% of all birds, respectively (Fig. 5, Tables 5-8). Three of these eco-units (LCLLM, HBLLS, LCHLM) covered an extensive proportion of the shoreline surveyed (36%, 9% and 9%, respectively), however, the remaining two covered only 2.7% (MBLLS) and 3.4% (LBHLM) of the surveyed shoreline (Table 1). Four of the five most heavily used eco-units (LCLLM, HBLLS, LCHLM, LBHLM) supported high numbers of waterbirds in all three surveys (Tables 5-8). The importance of eco-unit MBLLS was due to the occurrence of a high number of loons in one transect during the third winter survey.

Bird abundance by taxonomic group is reported for each marine eco-unit and each survey in Tables 5 to 8.

3.2.2 Waterbird abundance in spring

During the first spring survey (13-15 March 1999), eco-unit MBLLS supported the highest number of birds (49.9%), followed by LCLLM and LCHLM, where 18.9% and 7.8% of all birds occurred, respectively (Fig. 6, Table 9). Large herring spawn occurred in eco-unit MBLLS (chapter 3.4 in this report) and the highest numbers of loons, cormorants, scoters, mergansers and gulls were recorded specifically in this habitat. During the second spring survey (30 March – 4 April 1999) eco-unit MCHLM supported the highest number of birds, followed by LCLLM and

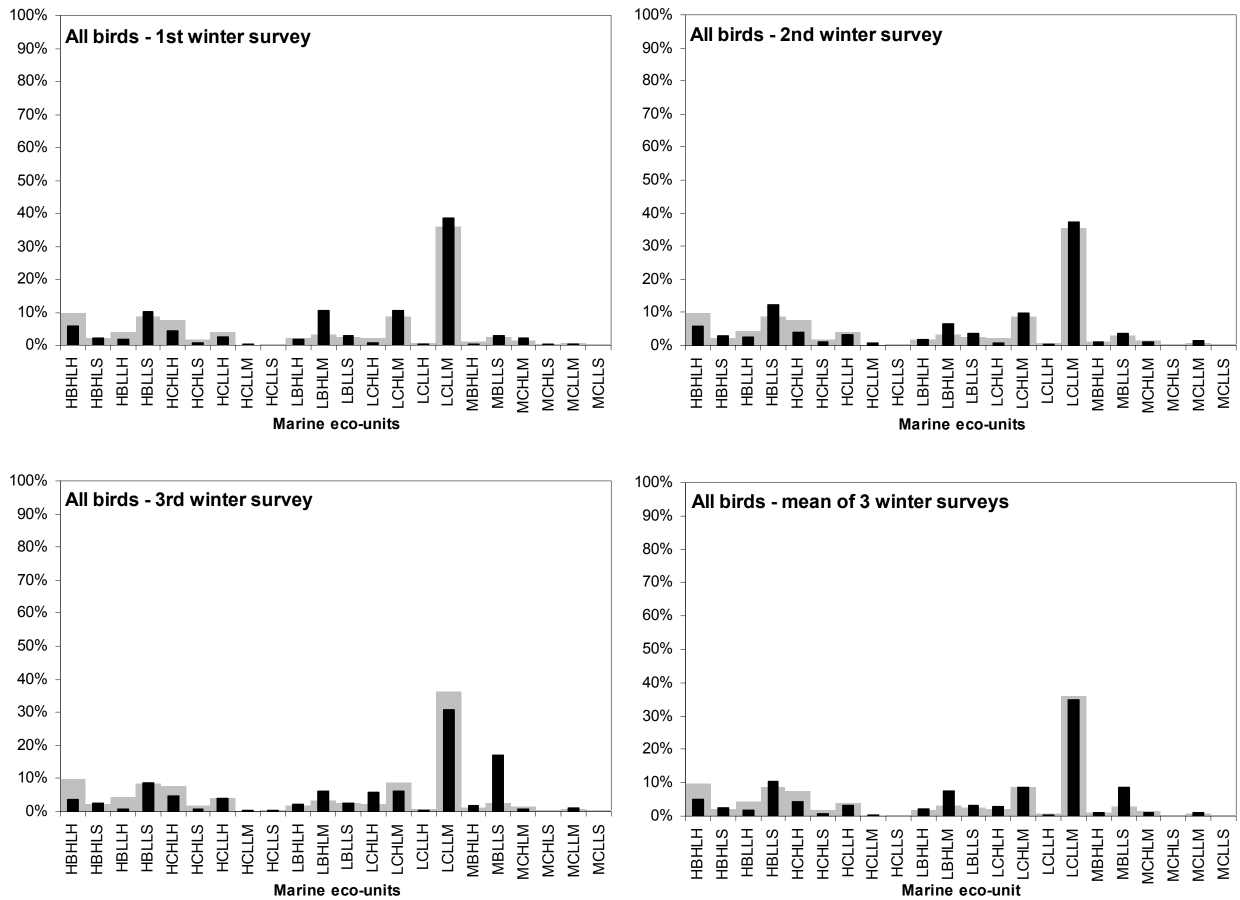


Figure 5. Percentage of all birds observed within different marine eco-units in winter (black bars). Shaded zone indicates percentage of area covered by each eco-unit.

Table 5. Waterbird abundance by eco-unit (mean of three winter 2000 surveys, “On transect” and “Off transect”). The numbers in bold indicate the three highest values for each group of birds.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	695	35.9	**10052**	55	**878**	**198**	**402**	**2069**	**1894**	**418**	**2531**
HBHLH	187	9.7	1427	21	33	**194**	20	282	33	39	488
LCHLM	168	8.7	2467	17	**496**	36	98	331	**265**	**143**	**735**
HBLLS	166	8.6	**2992**	**151**	97	**353**	59	261	24	62	**1398**
HCHLH	145	7.5	1213	27	77	88	44	354	41	40	273
HBLLH	83	4.3	494	8	14	97	0	14	17	4	203
HCLLH	79	4.1	934	8	10	103	0	32	4	1	698
LBHLM	65	3.4	2144	18	192	52	**648**	**560**	35	53	165
MBLLS	52	2.7	**2497**	**1267**	**231**	30	15	**504**	**67**	**125**	89
LBLLS	46	2.4	885	34	72	55	0	449	15	16	118
HBHLS	41	2.1	752	7	6	71	50	122	3	20	288
LCHLH	41	2.1	802	**418**	24	142	2	34	2	6	53
HCHLS	35	1.8	224	1	26	5	9	49	39	12	64
LBHLH	35	1.8	575	1	22	12	**156**	44	63	30	99
MCHLM	28	1.5	361	6	18	16	2	50	33	23	87
MBHLH	18	1.0	314	34	7	22	0	33	7	10	188
MCLLM	13	0.7	289	1	5	11	0	83	2	22	11
LCLLH	11	0.6	81	1	43	1	2	0	8	5	16
HCLLS	10	0.5	51	0	1	15	0	4	0	1	19
MCHLS	6	0.3	21	0	1	2	0	0	0	0	14
MCLLS	5	0.2	12	0	1	0	0	8	0	0	1
HCLLM	3	0.1	101	0	1	12	0	7	0	0	25
Total	1932	100	28689	2076	2256	1514	1506	5288	2551	1030	7563

* in addition to waterbird taxonomic groups listed in the table, column *All birds* includes abundance of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 6. Waterbird abundance by eco-unit during the first winter survey on 16-18 January, 2000 ("On transect" and "Off transect"). The numbers in bold indicate the three highest values for each group of birds.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	696.0	36.0	**8523**	**18**	**734**	**208**	**427**	**1924**	**1341**	**267**	**2374**
HBHLH	187.0	9.7	1327	**15**	8	**340**	20	285	13	22	444
LCHLM	169.9	8.8	**2348**	6	**582**	41	**147**	**358**	**270**	**97**	**506**
HBLLS	165.6	8.6	2294	**17**	31	**291**	25	115	13	**97**	**1357**
HCHLH	145.1	7.5	961	7	39	86	61	191	38	59	316
HCLLH	79.2	4.1	549	3	11	45	0	6	4	0	427
HBLLH	78.5	4.1	387	7	11	86	0	25	16	9	178
LBHLM	64.8	3.3	**2364**	6	91	73	**962**	**292**	15	25	218
MBLLS	52.2	2.7	647	7	60	55	0	242	**66**	68	81
LBLLS	45.9	2.4	681	8	**188**	53	0	119	18	16	63
HBHLS	41.0	2.1	493	6	3	63	0	87	3	10	242
LCHLH	41.0	2.1	158	6	36	17	7	0	2	8	44
LBHLH	40.1	2.1	437	1	17	22	**147**	22	0	32	51
HCHLS	35.4	1.8	154	0	35	10	0	53	21	10	18
MCHLM	28.2	1.5	448	3	29	12	5	71	56	17	135
MBHLH	18.4	0.9	102	0	1	5	0	8	20	0	46
MCLLM	13.1	0.7	73	1	11	2	0	4	5	13	23
LCLLH	11.1	0.6	70	1	41	0	6	0	7	4	8
HCLLS	9.6	0.5	39	0	0	14	0	3	0	2	16
MCHLS	6.3	0.3	51	0	0	0	0	0	0	0	40
MCLLS	4.6	0.2	3	0	0	0	0	0	0	0	1
HCLLM	2.7	0.1	60	0	0	15	0	0	0	0	45
Total	1935.5	100	22169	112	1928	1438	1807	3805	1908	756	6633

* in addition to waterbird taxonomic groups listed in the table, column *All birds* includes abundance of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 7. Waterbird abundance by eco-unit during the second winter survey on 21-23 January, 2000 ("On transect" and "Off transect"). The numbers in bold indicate the three highest values for each group of birds.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	681.4	35.6	**11254**	**63**	**923**	**234**	**314**	**2052**	**2873**	**358**	**2355**
HBHLH	187.0	9.8	1696	36	41	**137**	9	438	71	54	507
HBLLS	165.6	8.6	**3760**	**417**	13	**366**	139	279	43	72	**1702**
LCHLM	164.8	8.6	**2947**	18	**744**	23	84	319	**341**	**115**	**960**
HCHLH	145.1	7.6	1149	31	48	126	68	267	29	29	165
HBLLH	84.6	4.4	812	4	29	82	0	5	34	4	312
HCLLH	79.2	4.1	958	7	18	98	0	21	9	1	643
LBHLM	64.8	3.4	1965	22	**150**	51	**288**	**811**	27	11	241
MBLLS	52.2	2.7	1126	20	32	25	32	428	**76**	**164**	64
LBLLS	45.9	2.4	1138	56	23	107	0	**596**	20	20	198
HBHLS	41.0	2.1	867	9	1	58	98	228	4	44	282
LCHLH	41.0	2.1	270	8	27	117	0	24	2	4	27
HCHLS	35.4	1.8	277	1	14	0	20	83	28	12	100
LBHLH	33.1	1.7	570	2	4	12	**162**	63	**76**	34	31
MCHLM	28.2	1.5	370	11	19	22	0	10	25	26	106
MBHLH	18.4	1.0	274	**101**	0	25	0	90	0	26	21
MCLLM	13.1	0.7	407	1	5	20	0	13	0	4	7
LCLLH	11.1	0.6	80	1	45	2	0	0	4	4	21
HCLLS	9.6	0.5	36	0	0	3	0	6	0	0	0
MCHLS	6.3	0.3	9	0	2	5	0	0	0	0	2
MCLLS	4.6	0.2	25	0	0	0	0	25	0	0	0
HCLLM	2.7	0.1	165	1	1	5	0	0	0	0	8
Total	1914.9	100	30155	809	2139	1518	1214	5758	3662	982	7752

* in addition to waterbird taxonomic groups listed in the table, column *All birds* includes abundance of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 8. Waterbird abundance by eco-unit during the third winter survey on 2-4 February, 2000 ("On transect" and "Off transect"). The numbers in bold indicate the three highest values for each group of birds.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	706.0	36.3	**10380**	**84**	**978**	151	**465**	**2232**	**1467**	**628**	**2865**
HBHLH	187.0	9.6	1259	11	50	106	30	124	16	42	512
LCHLM	169.9	8.7	2105	27	162	43	63	316	**184**	**218**	738
HBLLS	165.6	8.5	**2922**	18	248	**401**	13	389	17	18	**1134**
HCHLH	145.1	7.5	1530	43	144	53	2	603	55	31	337
HBLLH	84.6	4.3	283	12	2	124	0	12	2	0	118
HCLLH	79.2	4.1	1294	14	2	**165**	0	68	0	2	**1024**
LBHLM	64.8	3.3	2103	27	**336**	31	**695**	576	62	122	35
MBLLS	52.2	2.7	**5717**	**3773**	**602**	11	12	**841**	59	**144**	123
LBLLS	45.9	2.4	837	38	6	4	0	**631**	6	13	94
HBHLS	41.9	2.2	895	7	13	92	53	52	1	5	341
LCHLH	41.0	2.1	1978	**1241**	8	**292**	0	77	2	5	87
HCHLS	35.4	1.8	241	2	29	5	7	10	67	13	74
LBHLH	33.1	1.7	719	1	45	2	**158**	46	**112**	24	215
MCHLM	28.2	1.4	265	5	5	13	0	69	18	26	21
MBHLH	18.4	0.9	567	2	21	35	0	0	0	5	498
MCLLM	13.1	0.7	388	0	0	11	0	231	0	48	4
LCLLH	11.1	0.6	94	1	44	1	0	0	14	8	20
HCLLS	9.6	0.5	77	0	2	29	0	3	0	0	41
MCHLS	6.3	0.3	2	0	0	0	0	0	0	0	0
MCLLS	4.6	0.2	7	0	2	1	0	0	0	0	3
HCLLM	2.7	0.1	79	0	1	15	0	22	0	0	21
Total	1904.7		33742	5306	2700	1585	1498	6302	2082	1352	8305

* in addition to waterbird taxonomic groups listed in the table, column *All birds* includes abundance of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

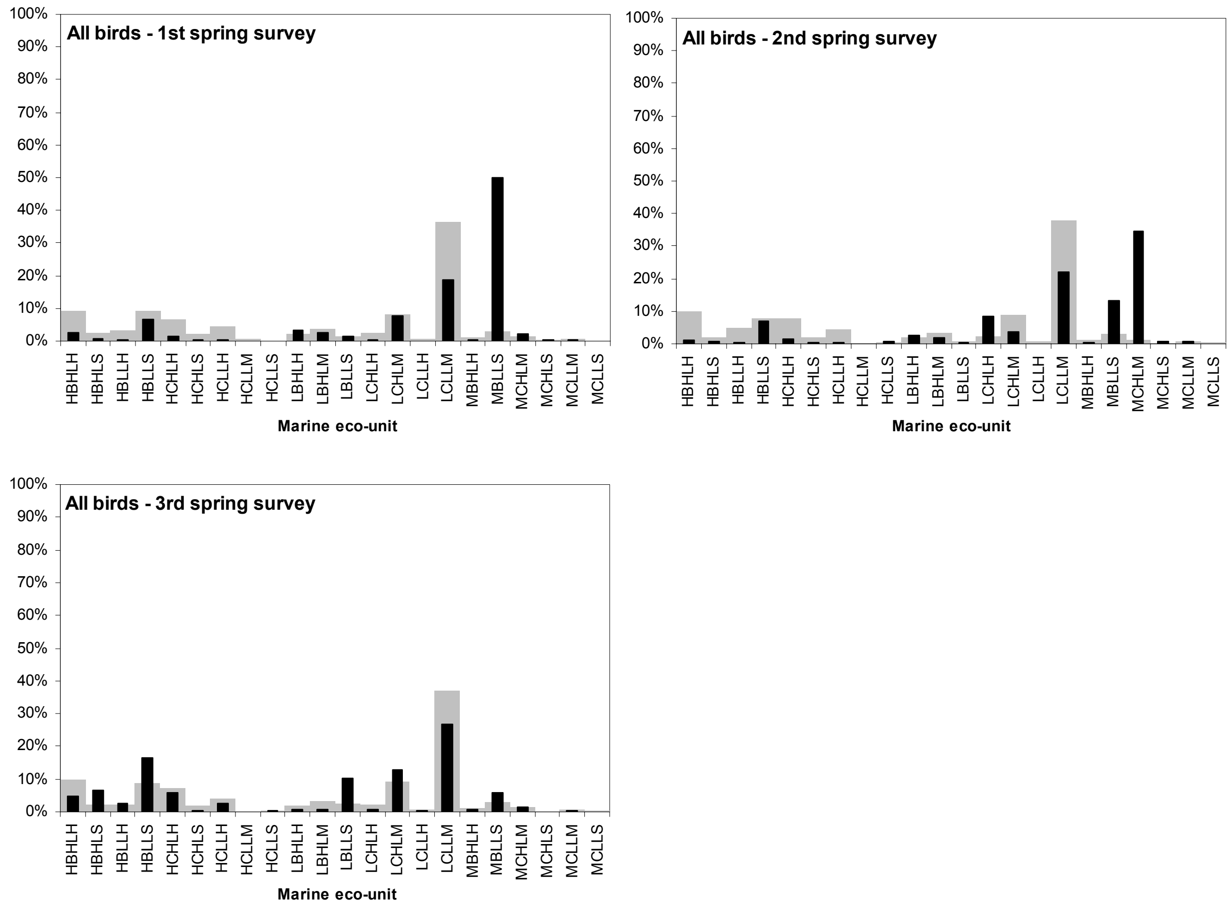


Figure 6. Percentage of all birds observed within different marine eco-units during spring first, second and third surveys (black bars). Shaded zone indicates percentage of area covered by each eco-unit.

Table 9. Waterbird abundance by eco-unit during the first spring survey on 13-15 March, 1999 ("On transect", "Off transect" and "On spawn"). The numbers in bold indicate the three highest values for each group of birds.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	630.2	36.5	**8921**	**125**	**449**	**175**	**516**	**1216**	**549**	**297**	**4962**
HBLLS	160.4	9.3	3135	**307**	46	**173**	0	**722**	1	8	1799
HBHLH	159.9	9.3	1151	10	**171**	61	3	350	21	10	503
LCHLM	141.1	8.2	**3679**	19	79	31	0	206	**34**	**58**	**3149**
HCHLH	114.0	6.6	652	6	20	28	**75**	141	13	11	304
HCLLH	79.2	4.6	252	12	8	56	0	37	0	3	118
LBHLM	64.8	3.8	1138	8	22	8	4	370	12	46	115
HBLLH	54.6	3.2	115	15	10	34	0	22	0	0	30
MBLLS	52.2	3.0	**23599**	**7076**	**176**	**192**	**55**	**6188**	24	**319**	**9195**
LCHLH	42.1	2.4	222	8	45	31	0	27	0	4	94
HBHLS	41.9	2.4	298	5	58	2	0	61	2	0	116
LBHLH	40.1	2.3	1590	1	37	21	0	350	8	11	760
HCHLS	35.4	2.1	113	0	7	1	13	7	14	11	49
MCHLM	24.6	1.4	1014	8	0	1	0	28	**49**	9	890
LBLLS	23.6	1.4	733	29	2	37	0	197	1	0	453
MBHLH	18.4	1.1	225	0	25	1	33	53	20	0	38
HCLLM	15.6	0.9	8	0	0	3	0	3	0	0	1
MCLLM	13.1	0.8	188	10	3	1	0	56	10	9	94
LCLLH	11.1	0.6	63	0	16	0	0	2	4	10	21
MCHLS	3.3	0.2	196	1	0	0	0	1	0	0	194
Total	1725.5	100	47292	7640	1174	856	699	10037	762	806	22885

* in addition to waterbird taxonomic groups listed in the table, column *All birds* includes abundance of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

MBLLS, which supported 34.4%, 21.9% and 13.1% of all birds, respectively (Fig. 6, Table 10). Similar to the previous spring survey, the highest abundance of birds in eco-units MCHLM and MBLLS coincided with herring spawn (chapter 3.4 in this report). The third spring survey (27-29 April 1999) was distinguished by generally low numbers of all birds (Figs. 5-6, Table 11). Eco-units LCLLM, HBLLS, and LCHLM supported the highest number of birds (26.6%, 16.3% and 12.6%, respectively). The variability of bird distribution across marine eco-units in spring could be related to the occurrence of herring spawn in specific locations and the unequal response of different bird species to these events as well as spring migration of birds along the coast.

3.2.3 Waterbird densities in winter

The overall mean density of waterbirds in winter was 14.2 birds per linear kilometer of shoreline. Eco-units LBHLM, LBLLS, and MBLLS supported the highest densities whereas eco-units HCHLS, HBLLH, and HBHLH supported lowest densities (Fig. 7, Table 12).

Bird densities varied across eco-unit types, presumably indicating specific habitat preferences (Table 12). High variation in bird densities and use of different eco-units also was observed between winter surveys (Fig. 7, Tables 13-15).

3.2.4 Waterbird densities in spring

The overall density of waterbirds was 18.2 birds per linear kilometer during the first spring survey, 15.8 birds/km on the second survey and 5.3 birds/km during the third survey (Fig. 8).

Eco-units MBLLS and MCHLM supported the highest waterbird densities during the first and second spring surveys (Fig. 8). Intensive herring spawn occurred within these eco-units. Eco-units MBLLS, HBHLS and HBLLS supported the highest bird densities during the third spring survey (Fig. 8). Bird densities were substantially lower during the third spring survey, relative to the previous spring surveys. Waterbirds also appeared to be more dispersed over the different eco-units during the third survey (Fig. 8, Tables 16-18).

Note: bird densities in marine eco-units supporting fish spawn are underrepresented, since the majority of birds counted on such areas were ascribed to the category “on spawn”, which has not been used in density estimates (see methods for details).

Table 10. Waterbird abundance by eco-unit during the second spring survey on 30 March – 1 April, 1999 ("On transect", "Off transect" and "On spawn"). The numbers in bold indicate the three highest values for each group of birds.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	680.3	37.8	**10419**	**22**	**744**	**413**	**470**	1217	**1141**	**507**	**4927**
HBHLH	180.7	10.0	448	12	32	40	0	160	19	23	101
LCHLM	158.7	8.8	1773	6	**196**	30	72	76	69	91	1039
HBLLS	136.7	7.6	3331	11	38	124	8	520	6	36	**2515**
HCHLH	136.7	7.6	633	8	14	49	6	6	70	65	343
HBLLH	84.6	4.7	240	1	3	39	0	6	0	0	80
HCLLH	79.2	4.4	163	2	8	12	0	0	0	1	120
LBHLM	59.0	3.3	958	5	123	63	12	175	**70**	21	43
MBLLS	52.2	2.9	**6248**	7	**418**	**163**	**120**	**1404**	5	**113**	**3633**
LCHLH	41.0	2.3	3943	**924**	38	103	0	**2410**	28	5	361
HCHLS	35.4	2.0	126	2	36	14	0	5	22	19	16
LBHLH	33.1	1.8	1198	2	6	0	**100**	250	**96**	48	665
HBHLS	31.9	1.8	277	3	15	14	46	155	8	1	14
MBHLH	18.4	1.0	139	3	9	18	50	0	0	0	11
MCHLM	18.1	1.0	**16367**	**404**	45	**294**	0	**14597**	62	**82**	843
LBLLS	14.6	0.8	125	4	2	2	0	97	0	1	12
MCLLM	13.1	0.7	379	1	4	6	0	60	4	22	275
LCLLH	11.1	0.6	5	0	0	0	0	1	2	0	1
HCLLS	8.7	0.5	428	1	20	0	0	30	0	0	377
MCLLS	4.6	0.3	62	0	7	0	0	1	6	6	6
MCHLS	3.3	0.2	316	0	0	0	0	255	0	0	61
Total	1801.5	100	47578	1418	1758	1384	884	21425	1608	1041	15443

* in addition to waterbird taxonomic groups listed in the table, column *All birds* includes abundance of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 11. Waterbird abundance by eco-unit during the third spring survey on 27-29 April, 1999 ("On transect", "Off transect" and "On spawn"). The numbers in bold indicate the three highest values for each group of birds.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	698.6	37.0	**3003**	41	**178**	**61**	**218**	434	**75**	**184**	**1393**
HBHLH	187.0	9.9	557	23	13	10	0	26	**34**	6	419
LCHLM	172.7	9.1	**1429**	16	26	**37**	14	122	**6**	20	**692**
HBLLS	165.6	8.8	**1846**	**464**	**36**	12	0	**540**	0	3	**734**
HCHLH	136.3	7.2	655	**55**	31	22	**16**	77	2	13	367
HCLLH	79.2	4.2	279	25	6	21	0	12	0	0	209
LBHLM	64.8	3.4	71	11	1	4	0	4	0	24	23
MBLLS	52.2	2.8	671	13	28	1	**240**	7	0	**49**	269
LBLLS	45.9	2.4	1148	**57**	**63**	2	0	**813**	0	3	56
HBLLH	44.8	2.4	298	0	1	**47**	0	5	0	0	244
HBHLS	41.0	2.2	745	4	1	3	0	**594**	0	2	133
LCHLH	41.0	2.2	78	15	0	10	0	0	0	6	38
HCHLS	35.4	1.9	28	2	6	1	9	0	0	3	5
LBHLH	33.1	1.8	84	2	1	1	0	0	2	**34**	31
MCHLM	28.2	1.5	153	12	5	0	0	17	2	16	88
MBHLH	18.4	1.0	95	3	5	0	0	54	0	1	6
MCLLM	13.1	0.7	60	0	0	4	0	0	0	0	51
LCLLH	11.1	0.6	36	1	3	0	0	0	4	2	21
HCLLS	9.6	0.5	37	5	0	2	0	0	0	0	29
MCLLS	4.6	0.2	0	0	0	0	0	0	0	0	0
MCHLS	3.3	0.2	11	1	0	1	0	0	0	0	9
HCLLM	2.7	0.1	19	0	0	0	0	0	0	0	19
Total	1888.5	100	11303	750	404	239	497	2705	125	366	4836

* in addition to waterbird taxonomic groups listed in the table, column *All birds* includes abundance of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

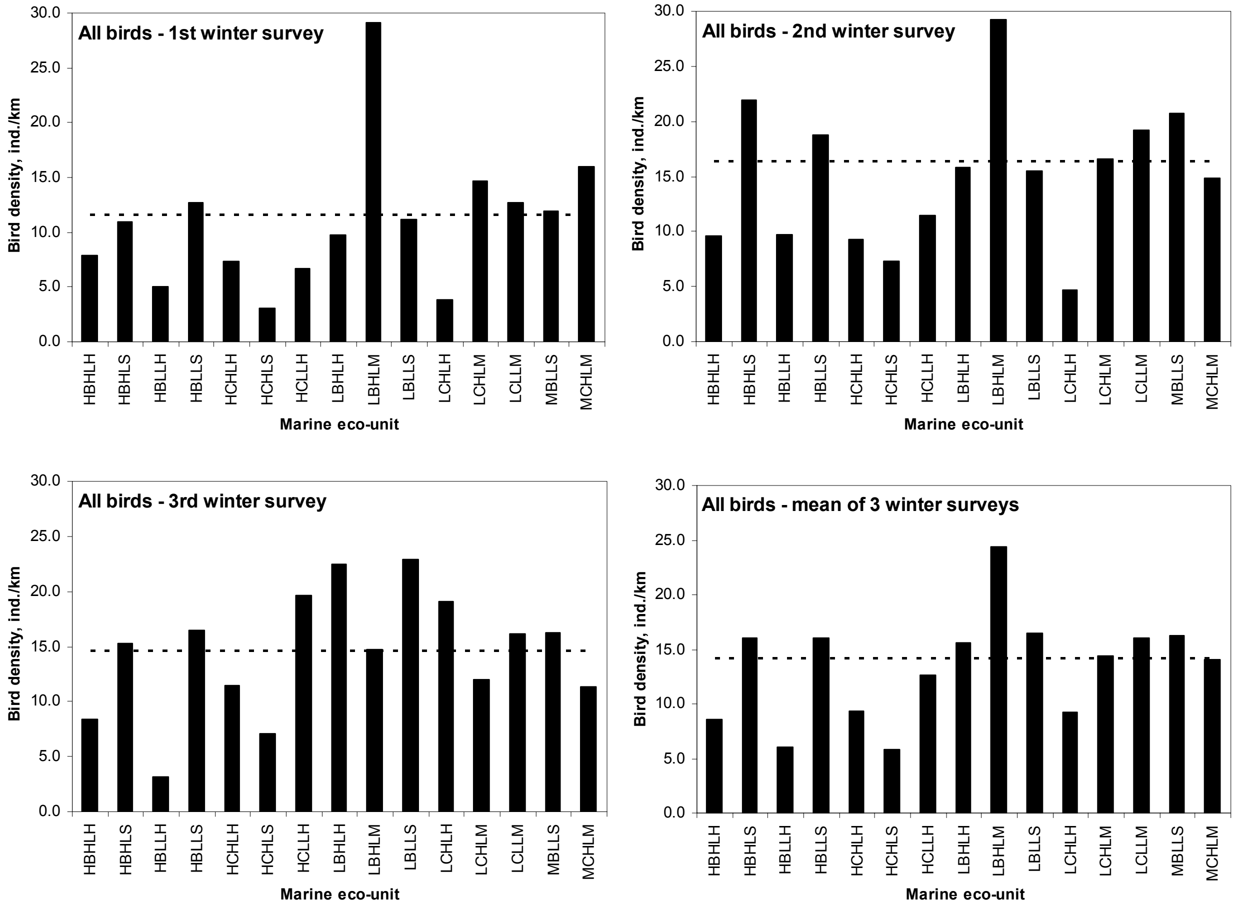


Figure 7. Linear densities of all birds observed within different marine eco-units during winter surveys (black bars). Dashed line indicates the mean density of birds within entire study area.

Table 12. Mean waterbird densities per eco-unit during three winter surveys in 2000. The numbers in bold indicate the three highest values for each group of birds. Eco-units covering less than 1% of the total survey length were not considered as representative and they are shown below the dashed line and in italics.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	2083.5	36.0	16.0	0.1	**1.6**	0.4	0.6	2.9	**3.1**	0.7	4.3
HBHLH	560.9	9.7	8.6	0.1	0.2	1.0	0.1	2.0	0.2	0.2	2.9
LCHLM	504.7	8.7	14.4	0.1	**1.7**	0.3	0.4	2.3	**1.6**	**0.8**	5.1
HBLLS	496.7	8.6	16.0	0.1	0.3	**2.1**	0.3	1.6	0.1	0.4	**8.2**
HCHLH	435.3	7.5	9.3	0.1	0.3	0.6	0.3	2.4	0.3	0.3	2.1
HBLLH	247.7	4.3	6.0	0.1	0.2	**1.2**	0.0	0.2	0.3	0.1	2.4
HCLLH	237.7	4.1	12.6	0.1	0.1	1.4	0.0	0.4	0.1	0.0	**9.5**
LBHLM	194.4	3.4	**24.3**	0.3	0.9	0.9	**4.8**	**7.2**	0.5	0.4	2.6
MBLLS	156.7	2.7	**16.3**	0.3	**1.1**	0.6	0.3	**6.3**	1.2	**2.2**	1.5
LBLLS	137.7	2.4	**16.5**	**0.7**	0.6	1.1	0.0	**8.2**	0.4	0.4	2.2
HBHLS	123.9	2.1	16.0	0.2	0.1	1.0	**1.3**	2.6	0.1	0.5	**6.1**
LCHLH	123.0	2.1	9.2	**0.8**	0.6	**2.8**	0.1	0.8	0.0	0.1	1.1
HCHLS	106.2	1.8	5.9	0.0	0.5	0.1	0.3	1.2	1.1	0.3	1.6
LBHLH	106.2	1.8	15.6	0.0	0.6	0.4	**3.9**	1.2	**1.8**	**0.8**	3.0
MCHLM	84.5	1.5	14.0	**0.4**	0.6	0.6	0.1	2.1	1.1	0.7	3.2
MBHLH	*55.1*	*0.9*	*12.9*	*0.1*	*0.4*	*0.8*	*0.0*	*0.1*	*0.4*	*0.1*	*10.2*
MCLLM	*39.2*	*0.7*	*15.8*	*0.0*	*0.4*	*0.7*	*0.0*	*1.6*	*0.2*	*1.6*	*0.9*
LCLLH	*33.2*	*0.6*	*7.0*	*0.1*	*3.4*	*0.1*	*0.2*	*0.0*	*0.9*	*0.5*	*1.4*
HCLLS	*28.8*	*0.5*	*11.1*	*0.0*	*0.0*	*1.5*	*0.0*	*0.2*	*0.0*	*0.0*	*7.8*
MCHLS	*18.8*	*0.3*	*3.4*	*0.0*	*0.1*	*0.3*	*0.0*	*0.0*	*0.0*	*0.0*	*2.3*
MCLLS	*13.8*	*0.2*	*2.5*	*0.0*	*0.1*	*0.1*	*0.0*	*1.8*	*0.0*	*0.0*	*0.3*
HCLLM	*8.1*	*0.1*	*37.5*	*0.1*	*0.2*	*4.3*	*0.0*	*2.7*	*0.0*	*0.0*	*9.1*
Total	5795.9	100	14.2	0.2	1.0	0.8	0.6	2.7	1.6	0.6	4.2

* in addition to densities of waterbird taxonomic groups listed in the table, column *All birds* includes densities of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 13. Mean waterbird densities per eco-unit during the first winter survey (16-18 January 2000). The numbers in bold indicate the three highest values for each group of birds. Eco-units covering less than 1% of the total survey length were not considered as representative and they are shown below the dashed line and in italics.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	696.0	36.0	12.7	0.0	0.9	0.4	**0.7**	2.3	**2.1**	**0.5**	3.9
HBHLH	187.0	9.7	7.8	0.1	0.0	**1.7**	0.1	2.1	0.1	0.1	2.4
LCHLM	169.9	8. 8	**14.7**	0.0	**2.1**	0.3	0.6	2.5	**1.5**	0.5	**4.9**
HBLLS	165.6	8. 5	12.8	0.1	0.2	**1.8**	0.2	0.7	0.1	0.6	**7.5**
HCHLH	145.1	7.5	7.3	0.0	0.2	0.6	0.4	1.6	0.3	0.4	2.5
HCLLH	79.2	4.1	6.6	0.0	0.1	0.6	0.0	0.1	0.1	0.0	5.0
HBLLH	78.5	4.1	5.1	0.1	0.2	1.2	0.0	0.3	0.2	0.1	2.4
LBHLM	64.8	3.4	**29.1**	0.1	**1.3**	1.2	**5.3**	**3.8**	0.3	0.5	3.6
MBLLS	52.2	2.7	11.9	0.1	1.0	1.0	0.0	**5.0**	1.1	**1.1**	1.3
LBLLS	45.9	2.4	11.1	**0.2**	1.2	1.1	0.0	1.9	0.5	0.4	0.7
HBHLS	41.0	2.1	10.9	**0.1**	0.1	**1.4**	0.0	2.0	0.1	0.3	**5.3**
LCHLH	41.0	2.1	3.9	**0.1**	**1.0**	0.4	0.2	0.0	0.1	0.2	1.0
LBHLH	40.1	2.1	9.7	0.0	0.4	0.6	**3.1**	0.5	0.0	**0.8**	1.2
HCHLS	35.4	1.8	3.1	0.0	0.2	0.2	0.0	1.3	0.5	0.2	0.4
MCHLM	28.2	1.5	**16.0**	0.1	1.1	0.5	0.2	**2.9**	**1.9**	0.5	4.7
MBHLH	*18.4*	*0.9*	*5.5*	*0.0*	*0.1*	*0.3*	*0.0*	*0.4*	*1.1*	*0.0*	*2.5*
MCLLM	*13.1*	*0.7*	*6.1*	*0.1*	*1.0*	*0.2*	*0.0*	*0.4*	*0.5*	*1.1*	*1.7*
LCLLH	*11.1*	*0.6*	*6.0*	*0.1*	*3.2*	*0.0*	*0.7*	*0.0*	*0.8*	*0.3*	*0.7*
HCLLS	*9.6*	*0.5*	*8.0*	*0.0*	*0.0*	*0.8*	*0.0*	*0.2*	*0.0*	*0.1*	*4.8*
MCHLS	*6.3*	*0.3*	*8.6*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*6.7*
MCLLS	*4.6*	*0.2*	*0.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*
HCLLM	*2.7*	*0.1*	*22.2*	*0.0*	*0.0*	*5.6*	*0.0*	*0.0*	*0.0*	*0.0*	*16.7*
Total	1935.5	100	11.6	0.1	0.8	0.7	0.6	1.9	1.1	0.4	3.7

* in addition to densities of waterbird taxonomic groups listed in the table, column *All birds* includes densities of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 14. Mean waterbird densities per eco-unit during the second winter survey (21-23 January 2000). The numbers in bold indicate the three highest values for each group of birds. Eco-units covering less than 1% of the total survey length were not considered as representative and they are shown below the dashed line and in italics.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	681.4	35.6	19.2	0.1	**1.9**	0.5	0.6	3.2	**5.1**	0.5	4.5
HBHLH	187.0	9.8	9.6	0.2	0.3	0.6	0.1	2.6	0.4	0.3	3.0
HBLLS	165.6	8.7	18.8	0.1	0.1	**2.0**	0.8	1.5	0.2	0.4	**9.5**
LCHLM	164.8	8.6	16.6	0.1	**2.1**	0.2	0.3	2.2	**2.1**	0.7	6.1
HCHLH	145.1	7.6	9.3	0.2	0.3	0.8	0.5	1.5	0.2	0.2	1.1
HBLLH	84.6	4.4	9.7	0.0	0.3	1.1	0.0	0.1	0.6	0.1	3.3
HCLLH	79.2	4.1	11.5	0.1	0.2	1.1	0.0	0.3	0.1	0.0	**7.6**
LBHLM	64.8	3.4	**29.2**	0.3	**1.1**	0.9	**5.6**	**10.6**	0.5	0.2	3.6
MBLLS	52.2	2.7	**20.7**	**0.5**	0.5	0.5	0.6	**8.2**	1.5	**2.9**	1.1
LBLLS	45.9	2.4	15.5	**1.1**	0.5	**2.2**	0.0	4.3	0.5	0.5	4.1
HBHLS	41.0	2.1	**21.9**	0.2	0.0	**1.3**	**3.1**	**5.0**	0.2	**1.1**	**6.3**
LCHLH	41.0	2.1	4.7	0.2	0.7	1.1	0.0	0.6	0.0	0.1	0.7
HCHLS	35.4	1.9	7.3	0.0	0.3	0.0	0.8	2.0	0.7	0.3	2.6
LBHLH	33.1	1.7	15.8	0.0	0.1	0.4	**4.0**	1.8	**2.1**	**1.0**	1.1
MCHLM	28.2	1.5	14.8	**0.9**	0.7	0.6	0.0	0.3	0.8	0.8	4.3
MBHLH	*18.4*	*0.9*	*2.2*	*0.1*	*0.0*	*0.3*	*0.0*	*0.0*	*0.0*	*0.1*	*1.1*
MCLLM	*13.1*	*0.7*	*27.4*	*0.1*	*0.3*	*1.3*	*0.0*	*1.2*	*0.0*	*0.4*	*0.6*
LCLLH	*11.1*	*0.6*	*6.7*	*0.1*	*3.6*	*0.2*	*0.0*	*0.0*	*0.4*	*0.4*	*1.7*
HCLLS	*9.6*	*0.5*	*2.1*	*0.0*	*0.0*	*0.2*	*0.0*	*0.3*	*0.0*	*0.0*	*0.0*
MCHLS	*6.3*	*0.3*	*1.4*	*0.0*	*0.3*	*0.8*	*0.0*	*0.0*	*0.0*	*0.0*	*0.3*
MCLLS	*4.6*	*0.2*	*5.4*	*0.0*	*0.0*	*0.0*	*0.0*	*5.4*	*0.0*	*0.0*	*0.0*
HCLLM	*2.7*	*0.1*	*61.1*	*0.4*	*0.4*	*1.9*	*0.0*	*0.0*	*0.0*	*0.0*	*3.0*
Total	1914.9	100	16.4	0.2	1.1	0.8	0.7	2.8	2.4	0.5	4.3

* in addition to densities of waterbird taxonomic groups listed in the table, column *All birds* includes densities of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 15. Mean waterbird densities per eco-unit during the third winter survey (2-4 February 2000). The numbers in bold indicate the three highest values for each group of birds. Eco-units covering less than 1% of the total survey length were not considered as representative and they are shown below the dashed line and in italics.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	706.0	36.3	16.2	0.1	**2.0**	0.2	0.7	3.2	**2.2**	**1.1**	4.6
HBHLH	187.0	9.6	8.4	0.1	0.3	0.7	0.2	1.3	0.1	0.3	3.4
LCHLM	169.9	8.7	12.0	0.2	0.8	0.4	0.2	2.2	1.1	**1.3**	4.3
HBLLS	165.6	8.5	16.5	0.1	0.8	**2.6**	0.1	2.6	0.1	0.1	**7.7**
HCHLH	145.1	7.5	11.4	0.2	0.5	0.4	0.0	4.0	0.4	0.3	2.7
HBLLH	84.6	4.4	3.1	0.1	0.0	1.2	0.0	0.1	0.0	0.0	1.4
HCLLH	79.2	4.1	**19.7**	0.2	0.0	**2.5**	0.0	0.8	0.0	0.0	**16.0**
LBHLM	64.8	3.3	14.8	**0.4**	0.3	0.5	**3.5**	**7.3**	0.9	0.5	0.7
MBLLS	52.2	2.7	16.3	0.3	**1.8**	0.2	0.2	**5.9**	1.0	**2.5**	2.1
LBLLS	45.9	2.4	**22.9**	**0.7**	0.1	0.1	0.0	**18.5**	0.2	0.4	1.9
HBHLS	41.9	2.2	15.2	0.1	0.3	0.3	**0.9**	1.0	0.0	0.1	**6.7**
LCHLH	41.0	2.1	19.1	**2.0**	0.2	**7.0**	0.0	1.9	0.1	0.1	1.5
HCHLS	35.4	1.8	7.1	0.0	1.0	0.2	0.2	0.2	**2.2**	0.3	1.9
LBHLH	33.1	1.7	**22.4**	0.0	**1.2**	0.1	**4.9**	1.5	**3.7**	0.7	7.0
MCHLM	28.2	1.5	11.3	0.3	0.1	0.6	0.0	3.1	0.6	0.9	0.7
MBHLH	*18.4*	*0.9*	*30.8*	*0.1*	*1.1*	*1.9*	*0.0*	*0.0*	*0.0*	*0.3*	*27.1*
MCLLM	*13.1*	*0.7*	*13.8*	*0.0*	*0.0*	*0.7*	*0.0*	*3.2*	*0.0*	*3.4*	*0.3*
LCLLH	*11.1*	*0.6*	*8.2*	*0.1*	*3.4*	*0.1*	*0.0*	*0.0*	*1.4*	*0.9*	*1.7*
HCLLS	*9.6*	*0.5*	*23.2*	*0.0*	*0.1*	*3.6*	*0.0*	*0.2*	*0.0*	*0.0*	*18.7*
MCHLS	*6.3*	*0.3*	*0.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
MCLLS	*4.6*	*0.2*	*1.5*	*0.0*	*0.4*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.7*
HCLLM	*2.7*	*0.1*	*29.3*	*0.0*	*0.4*	*5.6*	*0.0*	*8.2*	*0.0*	*0.0*	*7.8*
Total	1945.5	100	14.7	0.2	1.1	0.8	0.5	3.3	1.2	0.7	4.5

* in addition to densities of waterbird taxonomic groups listed in the table, column *All birds* includes densities of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

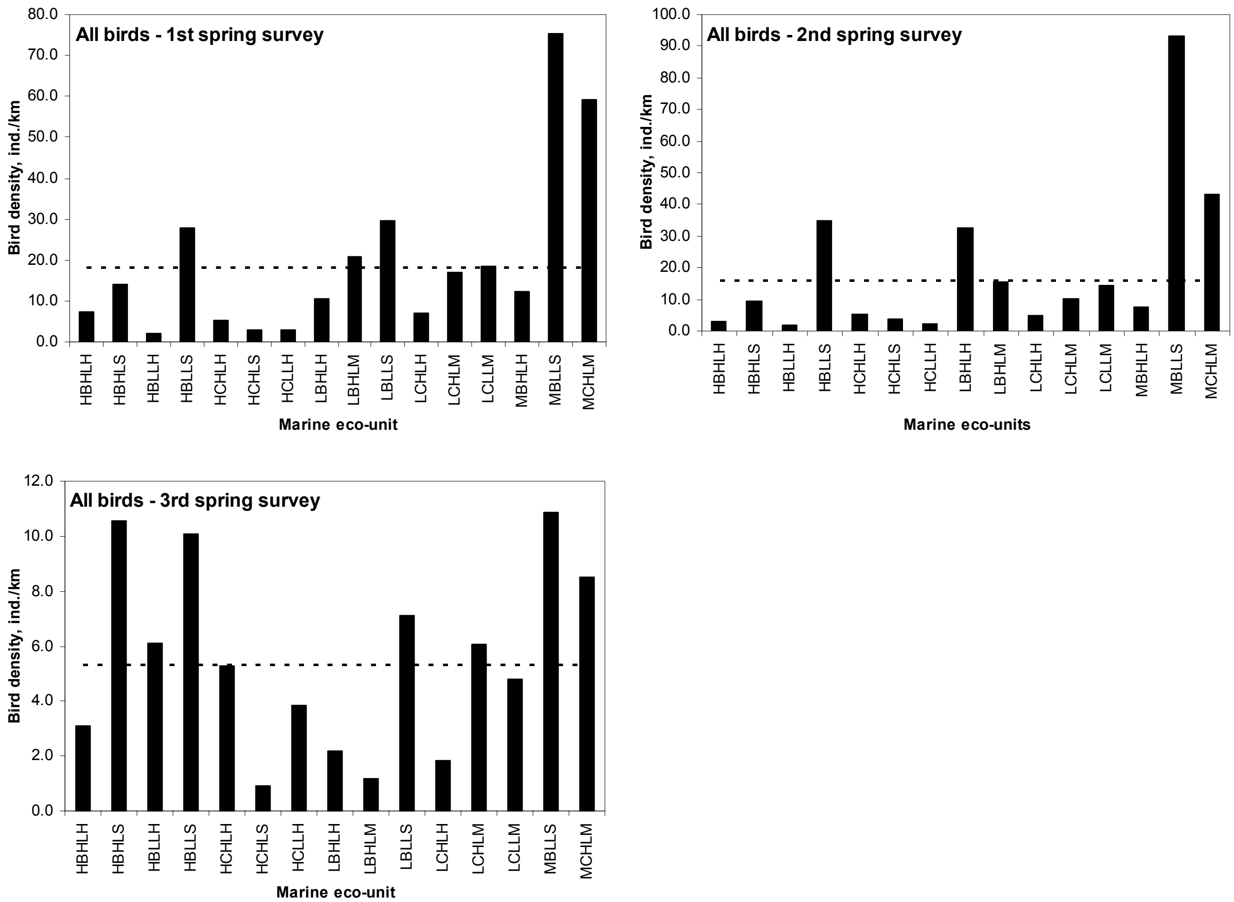


Figure 8. Linear densities of all birds observed within different marine eco-units during spring surveys (black bars). Dashed line indicates the mean density of birds within entire study area.

Table 16. Mean waterbird densities per eco-unit during the first spring survey (13-15 March 1999). The numbers in bold indicate the three highest values for each group of birds. Eco-units covering less than 1% of the total survey length were not considered as representative and they are shown below the dashed line and in italics.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	627.5	37.7	18.5	0.3	0.8	0.3	**1.0**	2.1	**0.9**	**0.7**	11.3
HBHLH	159.9	9.6	7.4	0.1	**1.1**	0.4	0.0	2.2	0.2	0.1	3.2
HBLLS	150.9	9.1	27.9	**2.3**	0.4	**1.4**	0.0	**5.9**	0.0	0.0	**15.8**
LCHLM	141.1	8.5	16.9	0.1	0.6	0.2	0.0	1.5	0.2	0.3	13.2
HCHLH	98.6	5.9	5.1	0.1	0.1	0.2	0.8	1.4	0.1	0.1	2.3
HCLLH	68.6	4.1	2.8	0.2	0.1	0.7	0.0	0.5	0.0	0.0	1.0
LBHLM	64.8	3.9	20.7	0.1	0.3	0.1	0.1	**6.8**	0.3	**0.7**	1.5
HBLLH	54.6	3.3	2.1	0.3	0.1	1.0	0.0	0.2	0.0	0.0	0.5
LCHLH	42.1	2.5	6.9	0.6	0.0	1.2	0.0	2.1	0.0	0.1	2.5
HBHLS	41.9	2.5	14.2	0.3	**6.3**	0.1	0.0	3.7	0.0	0.0	2.7
LBHLH	40.1	2.4	10.4	0.0	0.9	0.2	0.0	0.0	0.1	0.0	6.7
HCHLS	35.4	2.1	3.0	0.0	0.2	0.0	0.3	0.2	0.4	0.3	1.2
MBLLS	29.9	1.8	**75.2**	**17.7**	0.0	**5.4**	**1.6**	1.4	0.4	**3.1**	**44.3**
MCHLM	24.6	1.5	**59.2**	0.8	0.0	0.0	0.0	1.5	**3.8**	0.3	**49.7**
LBLLS	23.6	1.4	**29.5**	**1.1**	0.1	**1.5**	0.0	**10.1**	0.0	0.0	16.1
MBHLH	18.4	1.1	12.2	0.0	**1.4**	0.1	**1.8**	2.9	**1.1**	0.0	2.1
HCLLM	*15.6*	*0.9*	*0.5*	*0.0*	*0.0*	*0.2*	*0.0*	*0.2*	*0.0*	*0.0*	*0.1*
MCLLM	*13.1*	*0.8*	*15.7*	*0.9*	*0.2*	*0.1*	*0.0*	*4.0*	*0.9*	*0.8*	*8.3*
LCLLH	*11.1*	*0.7*	*6.4*	*0.0*	*1.6*	*0.0*	*0.0*	*0.2*	*0.4*	*1.1*	*2.1*
MCHLS	*3.3*	*0.2*	*59.6*	*0.3*	*0.0*	*0.0*	*0.0*	*0.3*	*0.0*	*0.0*	*59.0*
Total	1665.0	100.0	18.2	0.8	0.7	0.5	0.5	2.5	0.6	0.4	10.7

* in addition to densities of waterbird taxonomic groups listed in the table, column *All birds* includes densities of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 17. Mean waterbird densities per eco-unit during the second spring survey (30 March – 1 April 1999). The numbers in bold indicate the three highest values for each group of birds. Eco-units covering less than 1% of the total survey length were not considered as representative and they are shown below the dashed line and in italics.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	675.3	39.4	14.6	0.1	**1.0**	0.2	0.7	2.0	**1.4**	**1.0**	6.4
LCHLM	158.7	9.3	10.1	0.0	0.4	0.2	0.5	0.5	0.4	0.6	6.1
HBHLH	143.5	8.4	3.0	0.1	0.2	0.2	0.0	1.1	0.1	0.2	0.7
HCHLH	136.7	8.0	5.3	0.1	0.1	0.4	0.1	0.0	0.5	0.4	3.2
HBLLS	127.2	7.4	**34.9**	0.1	0.3	0.7	0.1	0.5	0.0	0.0	**32.5**
HBLLH	84.6	4.9	2.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0	1.1
HCLLH	66.6	3.9	2.3	0.0	0.1	0.1	0.0	0.0	0.0	0.0	1.9
LBHLM	59.0	3.4	15.7	0.1	**2.5**	**1.0**	0.1	3.0	1.1	0.4	0.7
LCHLH	41.0	2.4	5.1	**0.3**	**0.8**	0.4	0.0	0.0	0.6	0.1	1.2
HCHLS	35.4	2.1	3.6	0.1	0.8	0.5	0.0	0.1	0.6	0.5	0.5
LBHLH	33.1	1.9	32.6	0.1	0.1	0.0	**4.0**	**6.2**	**3.7**	**1.2**	16.4
HBHLS	31.9	1.9	9.5	0.1	0.4	0.4	1.3	**5.8**	0.3	0.0	0.5
MBLLS	29.9	1.7	**93.2**	0.1	0.3	**1.7**	**3.5**	**6.8**	0.0	0.2	**78.3**
MBHLH	18.4	1.1	7.6	**0.2**	0.5	**1.0**	**2.7**	0.0	0.0	0.0	0.6
MCHLM	18.1	1.1	**43.3**	**0.1**	0.1	0.4	0.0	0.0	**2.5**	**4.3**	**32.5**
LBLLS	*14.6*	*0.9*	*11.7*	*0.3*	*0.1*	*0.2*	*0.0*	*9.4*	*0.0*	*0.1*	*0.9*
MCLLM	*13.1*	*0.8*	*27.5*	*0.1*	*0.3*	*0.4*	*0.0*	*5.5*	*0.4*	*1.8*	*18.5*
LCLLH	*11.1*	*0.6*	*0.5*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.2*	*0.0*	*0.1*
HCLLS	*8.7*	*0.5*	*49.4*	*0.1*	*2.3*	*0.0*	*0.0*	*3.5*	*0.0*	*0.0*	*43.5*
MCLLS	*4.6*	*0.3*	*13.5*	*0.0*	*1.5*	*0.0*	*0.0*	*0.2*	*1.3*	*1.3*	*1.3*
MCHLS	*3.3*	*0.2*	*96.1*	*0.0*	*0.0*	*0.0*	*0.0*	*77.6*	*0.0*	*0.0*	*18.6*
Total	1714.7	100	15.8	0.1	0.7	0.4	0.6	2.0	0.9	0.7	9.1

* in addition to densities of waterbird taxonomic groups listed in the table, column *All birds* includes densities of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

Table 18. Mean waterbird densities per eco-unit during the third spring survey (27-29 April 1999). The numbers in bold indicate the three highest values for each group of birds. Eco-units covering less than 1% of the total survey length were not considered as representative and they are shown below the dashed line and in italics.

Eco-unit	Length km	Length %	All birds*	Loons	Grebes	Cormo-rants	Dabbling ducks	Scoters	Golden-eyes	Mergan-sers	Gulls
LCLLM	698.6	37.0	4.8	0.1	**0.3**	0.2	**0.3**	0.7	**0.1**	0.2	2.2
HBHLH	187.0	9.9	3.1	0.2	0.1	0.0	0.0	0.2	**0.1**	0.0	2.3
LCHLM	172.7	9.1	6.1	0.1	0.1	0.2	0.1	0.6	0.1	0.1	4.5
HBLLS	165.6	8.8	**10.1**	**2.1**	0.2	0.1	0.0	**2.0**	0.0	0.0	**5.3**
HCHLH	136.3	7.2	5.3	0.4	0.2	0.1	0.1	0.5	0.0	0.1	3.2
HCLLH	79.2	4.2	3.8	0.4	0.1	**0.3**	0.0	0.1	0.0	0.0	2.8
LBHLM	64.8	3.4	1.2	0.2	0.0	0.1	0.0	0.0	0.0	0.4	0.4
MBLLS	52.2	2.8	**10.9**	0.2	**0.5**	0.0	**3.3**	0.2	0.0	**0.9**	4.5
LBLLS	45.9	2.4	7.1	**0.6**	**0.8**	0.0	0.0	**4.3**	0.0	0.1	1.2
HBLLH	44.8	2.4	6.1	0.0	0.0	**1.1**	0.0	0.1	0.0	0.0	**4.8**
HBHLS	41.0	2.2	**10.6**	0.1	0.0	0.1	0.0	**7.1**	0.0	0.0	3.1
LCHLH	41.0	2.2	1.9	0.4	0.0	**0.2**	0.0	0.0	0.0	0.1	0.9
HCHLS	35.4	1.9	0.9	0.0	0.2	0.0	**0.4**	0.0	0.0	0.1	0.1
LBHLH	33.1	1.8	2.2	0.1	0.0	0.0	0.0	0.0	0.0	**0.8**	0.8
MCHLM	28.2	1.5	8.5	**0.4**	0.1	0.0	0.0	0.7	**0.1**	**0.7**	**5.9**
MBHLH	*18.4*	*0.9*	*5.2*	*0.2*	*0.3*	*0.0*	*0.0*	*2.9*	*0.0*	*0.1*	*0.3*
MCLLM	*13.1*	*0.7*	*4.2*	*0.0*	*0.0*	*0.3*	*0.0*	*0.0*	*0.0*	*0.0*	*3.6*
LCLLH	*11.1*	*0.6*	*3.7*	*0.1*	*0.3*	*0.0*	*0.0*	*0.0*	*0.4*	*0.2*	*2.2*
HCLLS	*9.6*	*0.5*	*6.0*	*0.3*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*5.5*
MCLLS	*4.6*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
MCHLS	*3.3*	*0.2*	*3.3*	*0.3*	*0.0*	*0.3*	*0.0*	*0.0*	*0.0*	*0.0*	*2.7*
HCLLM	*2.7*	*0.1*	*7.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*7.0*
Total	1888.5	100	5.3	0.3	0.2	0.1	0.2	0.9	0.1	0.2	2.8

* in addition to densities of waterbird taxonomic groups listed in the table, column *All birds* includes densities of swans, geese, shorebirds, alcids, and Bald Eagles, which numbers are given in Tables 3 and 4.

3.3 Waterbird abundance and distribution by bird group

3.3.1 Loons

"Loons" includes Pacific Loons, Common Loons and unidentified loons. Pacific Loons made up 93% of all identified loons (Tables 3-4).

Loon abundance varied between surveys: the highest numbers were observed during the third winter (5313 birds) and the first spring counts (7645 birds), and the lowest in early winter and late spring surveys (112 and 750 birds respectively) (Fig. 9). The majority of wintering loons were observed in marine eco-units MBLLS and LCHLH and occurred in low numbers over the rest of the area surveyed (Fig. 10; Table 5). The majority of loons during the first spring survey were recorded in marine eco-unit MBLLS (Fig. 10, Table 9). Eco-units LCHLM and MCHLM supported the highest number of loons during the second spring survey (Fig. 10, Table 10). Marine eco-unit HBLLS supported the highest percentage of birds during the third spring survey (Figs. 10, Table 11). The linear density of loons varied across marine eco-units in different surveys and corresponded closely to the eco-units where the highest numbers of loons were recorded (Fig. 11, Tables 12-18). Loon densities, however, could not be compared between surveys, because an appreciable proportion of the loons were counted "On spawn" during spring surveys. Only birds counted "On transect" were included in the density calculations (see methods for detailed description).

Loons were observed throughout the entire coast during the winter, with the largest aggregations in Hesquiat Harbour and Barkley Sound (Fig.12). The majority of loons recorded during the first spring survey (13-15 March 1999), were primarily observed in Hesquiat Harbour, where herring spawn occurred (Fig. 13). During the second spring survey (30 March – 1 April 1999), the largest aggregation occurred in Barkley Sound, another important herring spawning location (Fig. 14). During the third spring survey (27-29 April 1999) loons were dispersed over the west coast of Vancouver Island (Fig. 15).

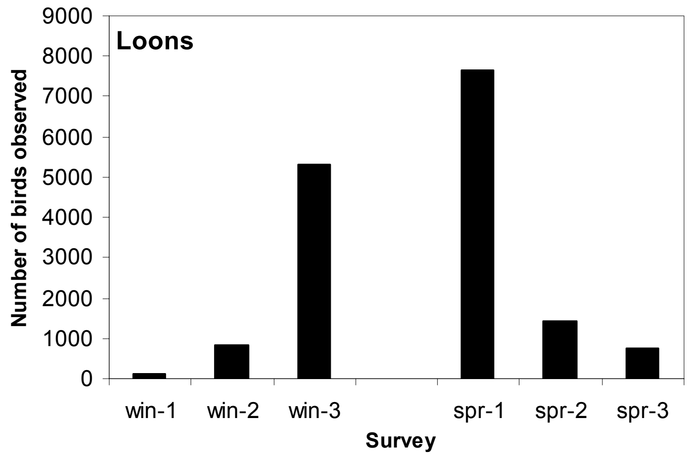
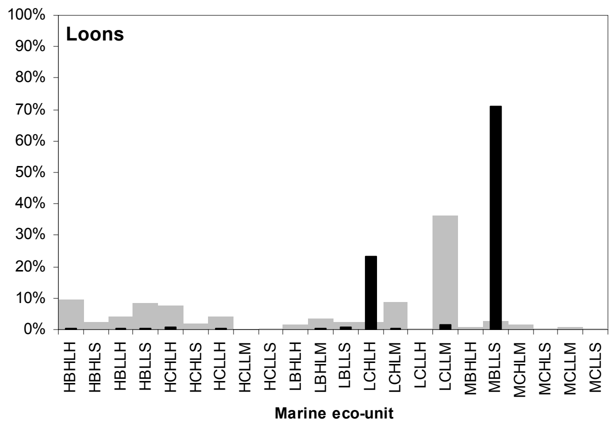
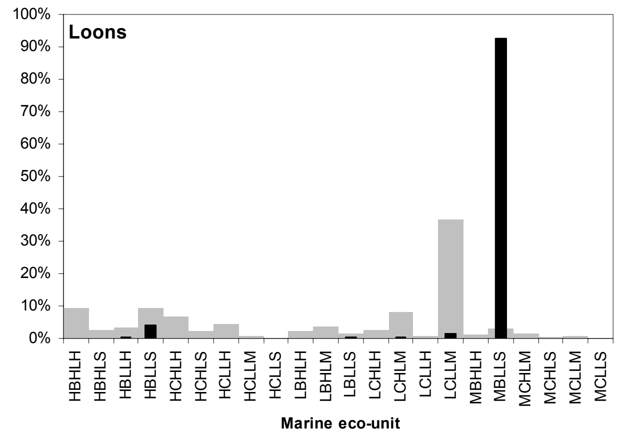


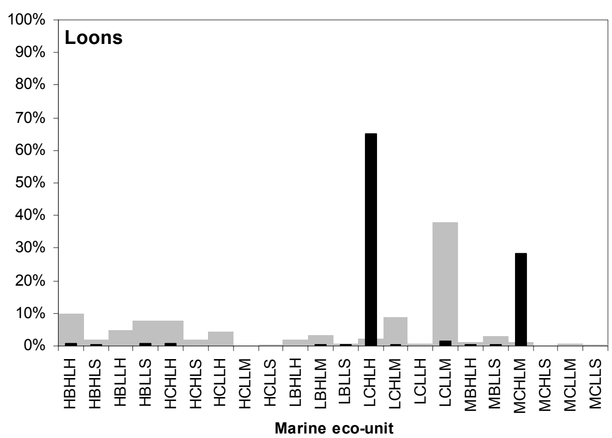
Figure 9. Loon abundance during winter and spring surveys. See methods for survey date.



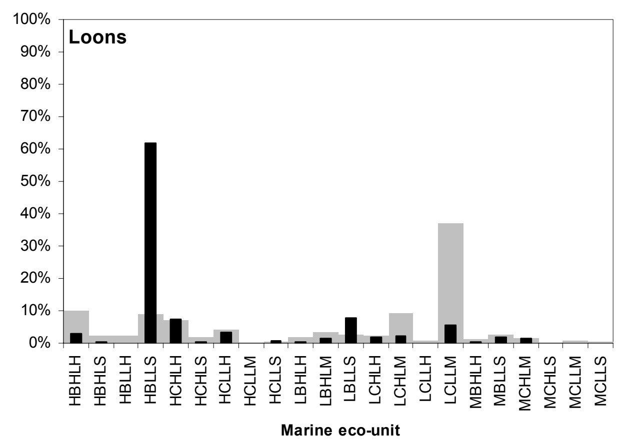
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)

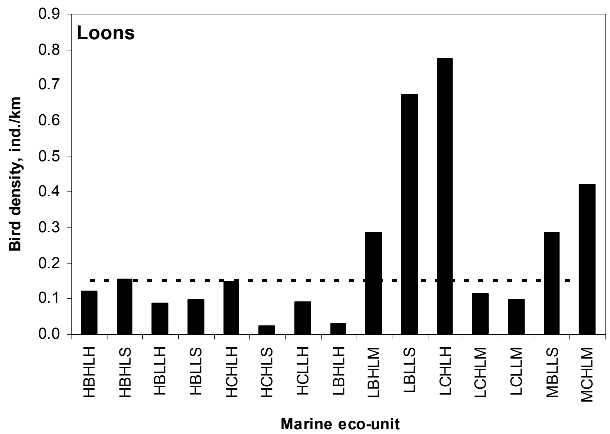


second spring survey (30 March – 1 April 1999)

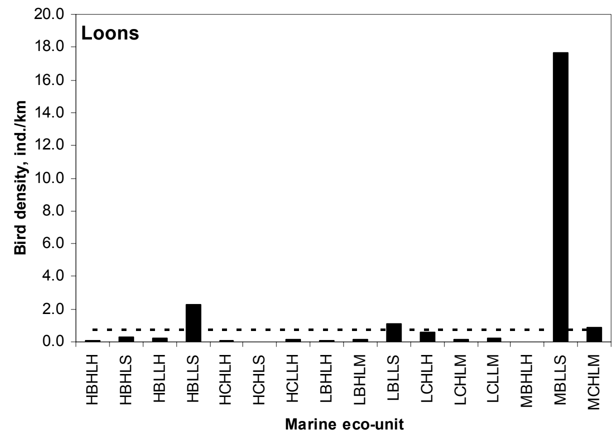


third spring survey (27-29 April 1999)

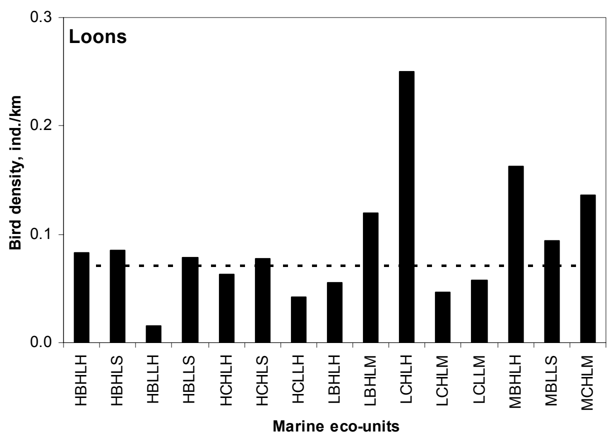
Figure 10. Percentage of loons observed within different marine eco-units. Black bars indicate the percentage of all loons in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.



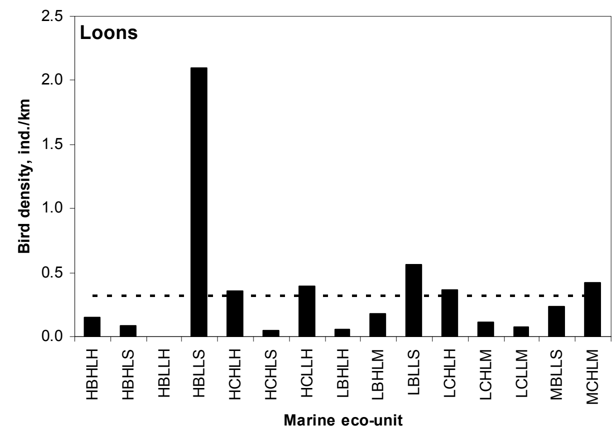
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)



second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 11. Average linear densities of loons in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

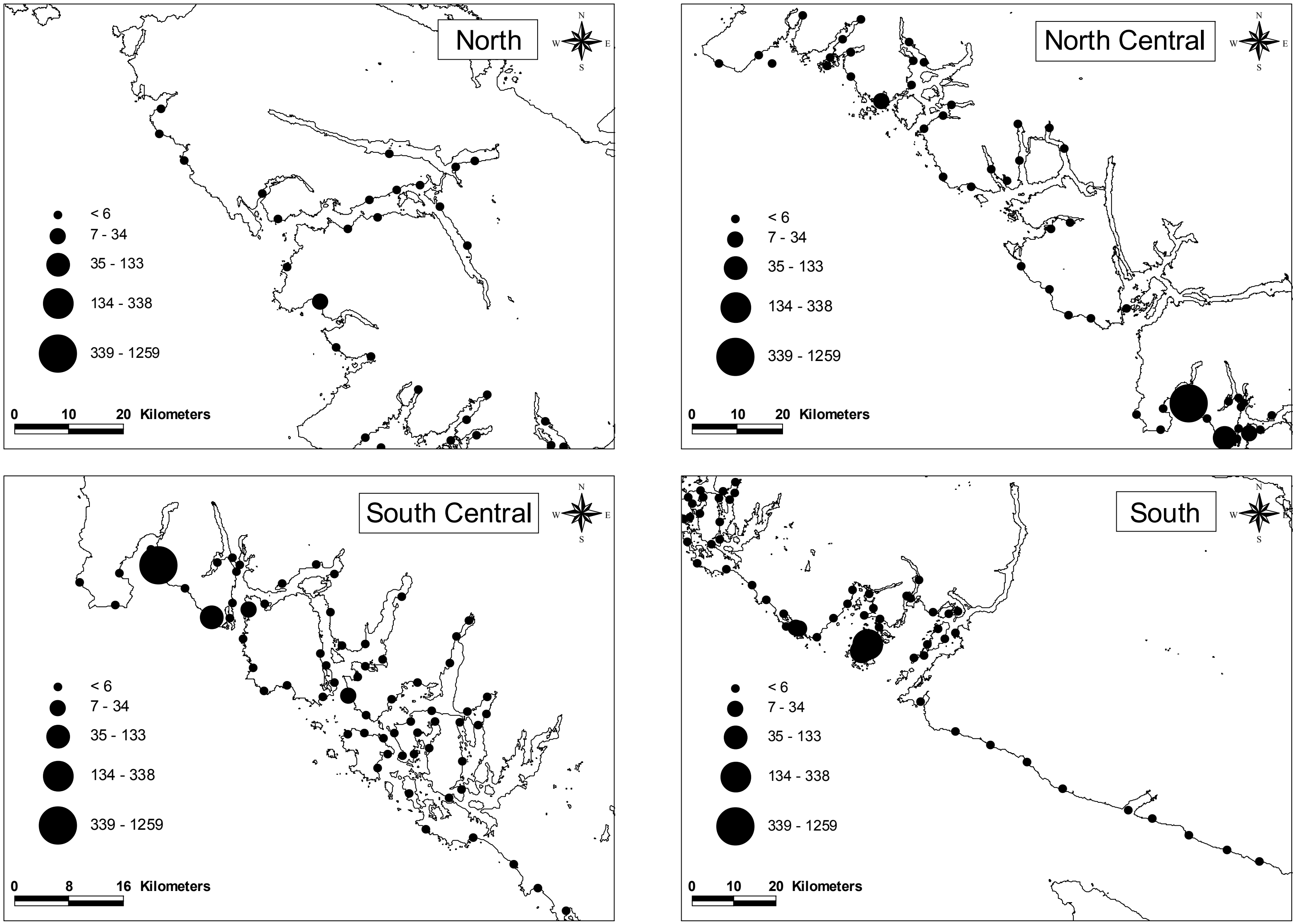


Figure 12. Abundance and distribution of loons during winter (mean of 3 winter surveys).

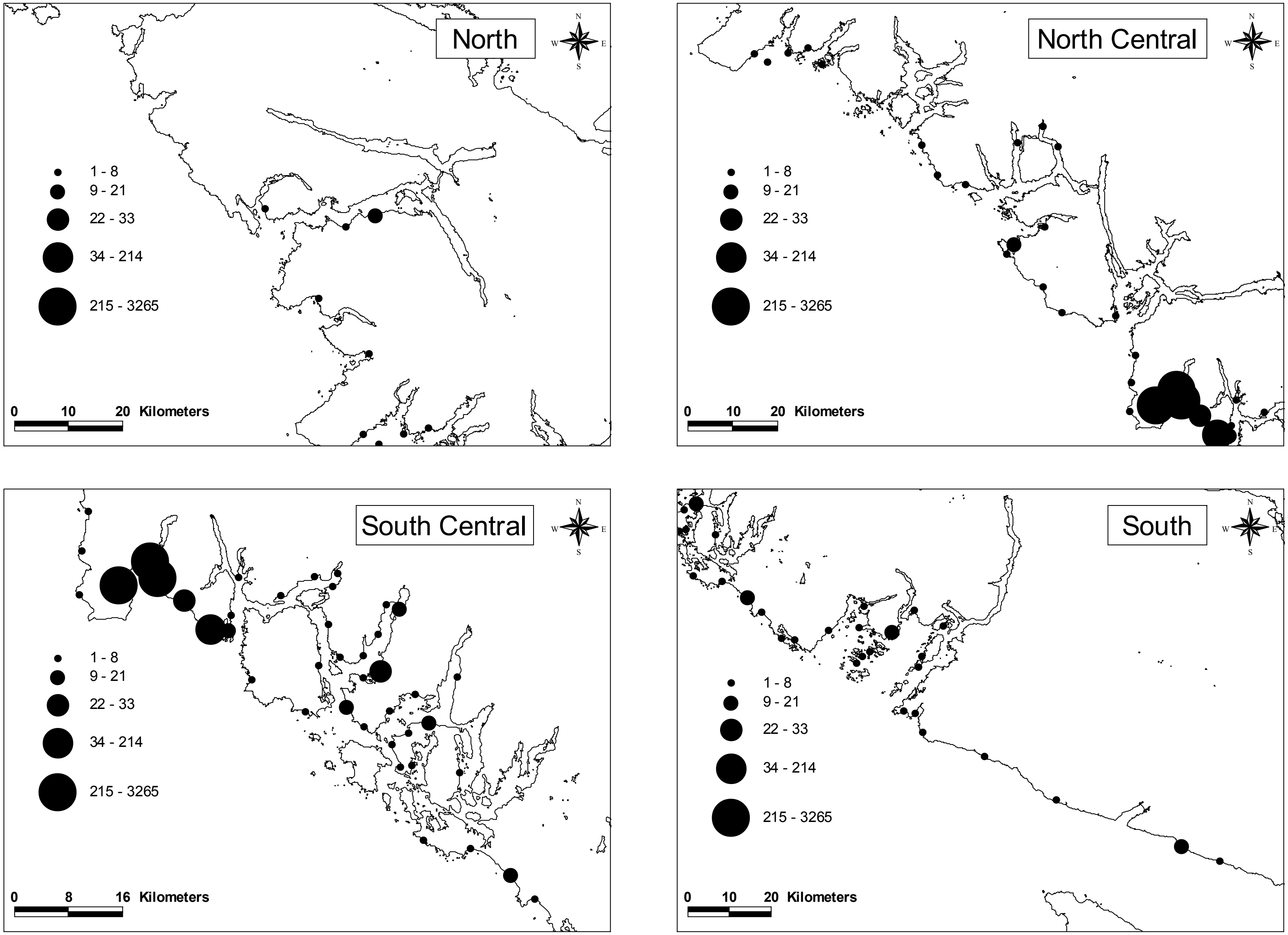


Figure 13. Abundance and distribution of loons during the first spring survey (13-15 March 1999).

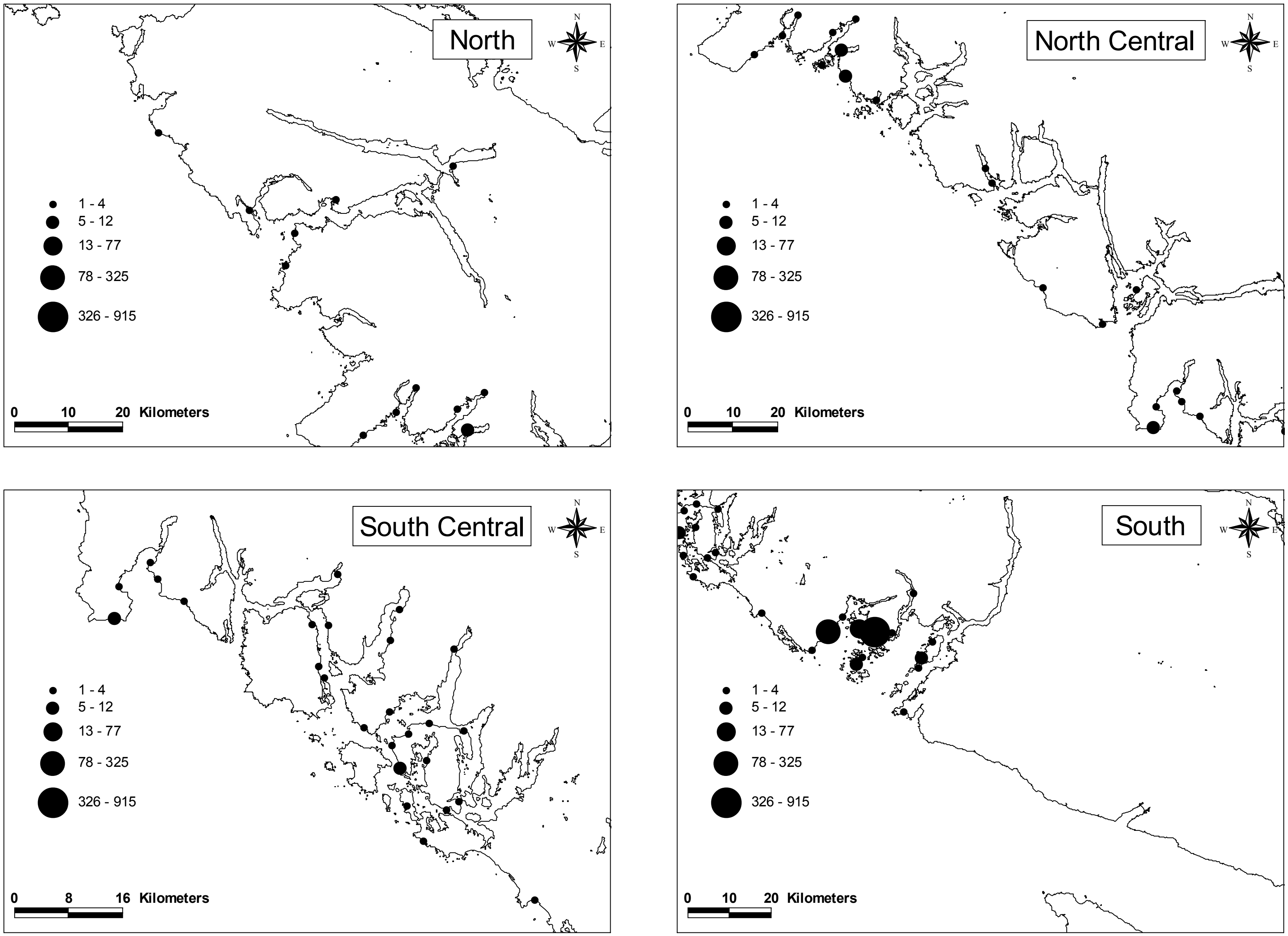


Figure 14. Abundance and distribution of loons during the second spring survey (30 March – 1 April 1999).

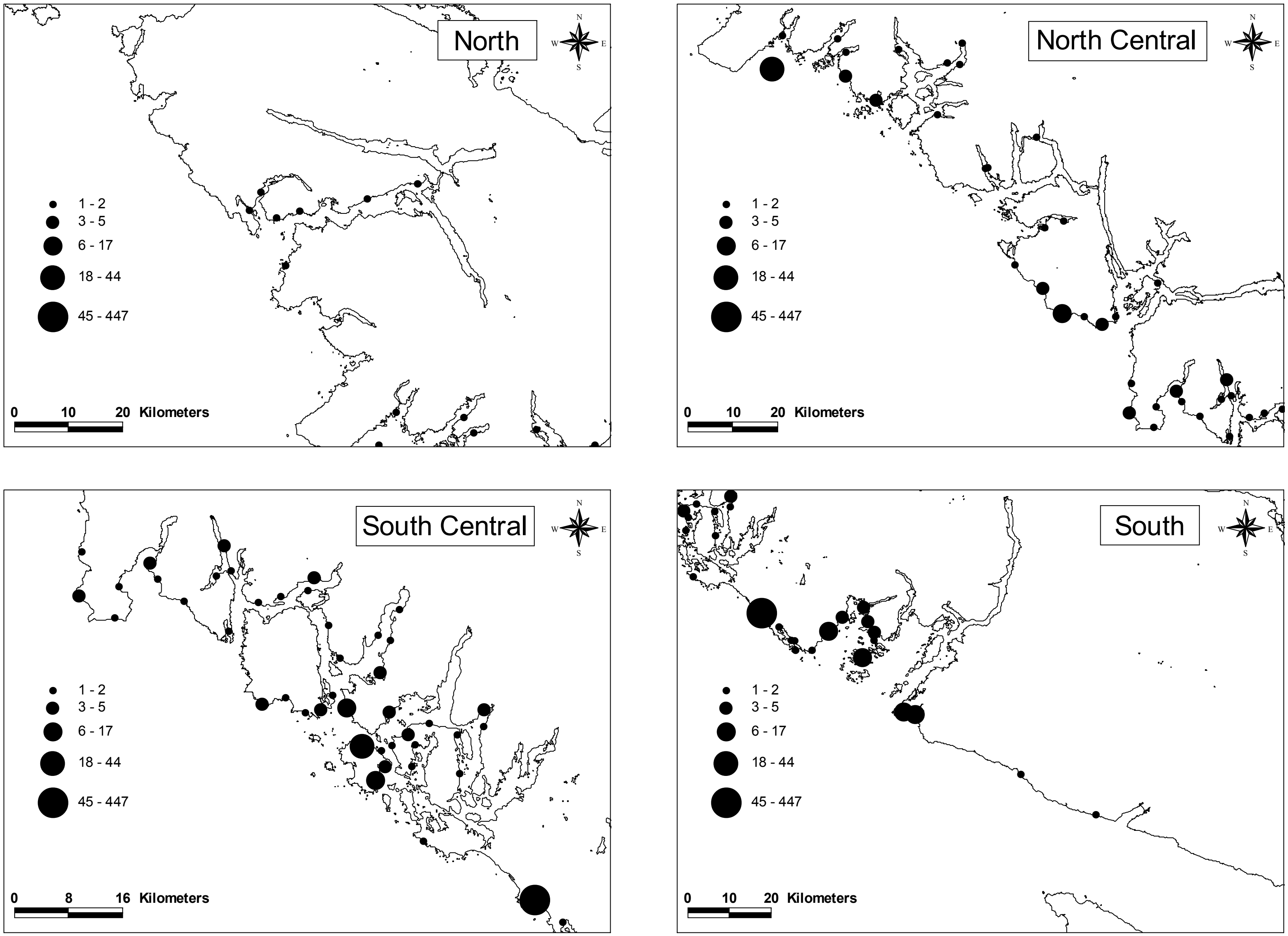


Figure 15. Abundance and distribution of loons during the third spring survey (27-29 April 1999).

3.3.2 Grebes

"Grebes" includes Horned Grebes, Red-necked Grebes, Western Grebes and unidentified grebes. Western Grebes were the most abundant and made up 67% of all identified grebes in winter and 86% in spring (Tables 3-4). The Red-necked Grebe was the second most abundant grebe species in winter, accounting for 31% of all identified grebes (Tables 3-4).

Grebe abundance increased with each winter survey (range = 1928 - 2701 birds) and winter abundance was higher than that observed during the spring surveys (range = 404 - 1759 birds) (Fig. 16). Grebes were observed within all eco-unit types, with a slightly higher percentage of birds occurring in eco-units with low to moderate exposure to wave and wind action (Fig. 17). The linear density of grebes varied across marine eco-units in different surveys and there was no single eco-unit that constantly supported a high density of these birds (Fig. 18, Tables 12-18).

Wintering grebes were widespread across the entire west coast of Vancouver Island, and were more abundant in inlets and bays (Fig. 19). Grebe geographical distribution and use of marine eco-unit in spring was similar to those observed in winter (Figs. 20-22).

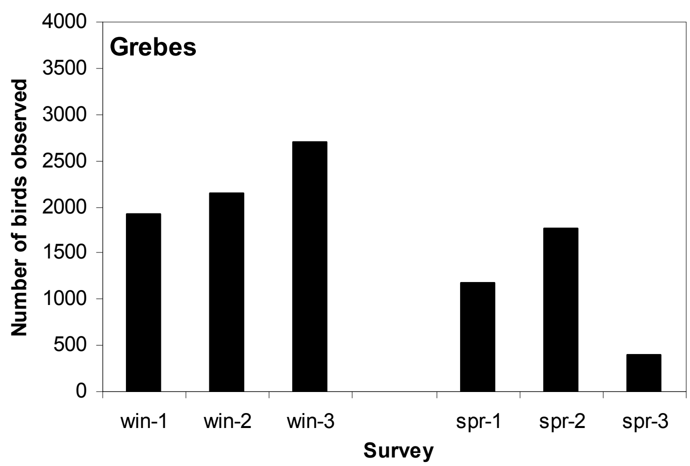
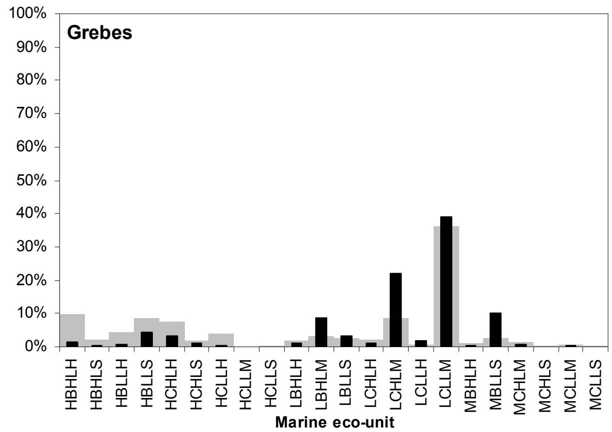
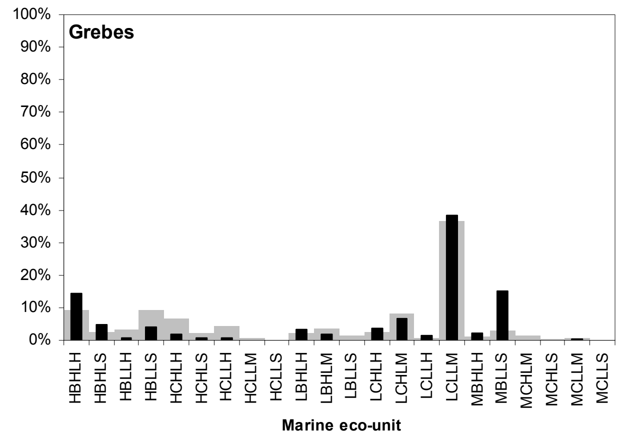


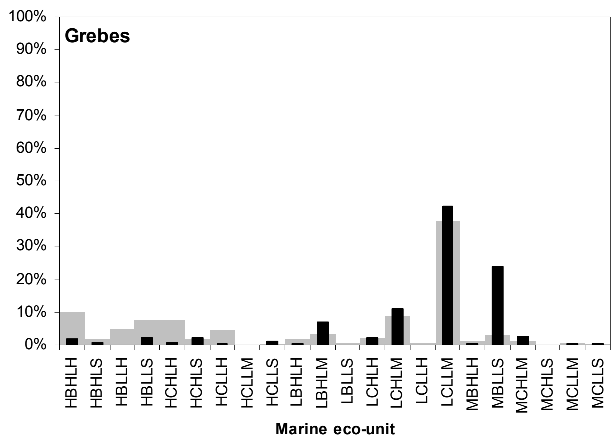
Figure 16. Grebe abundance during winter and spring surveys. See methods for survey date.



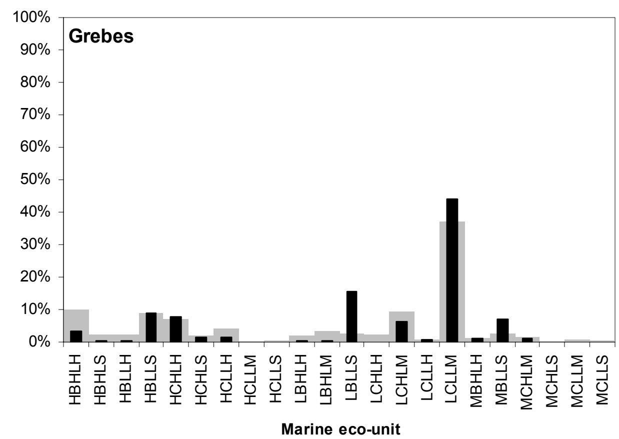
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)

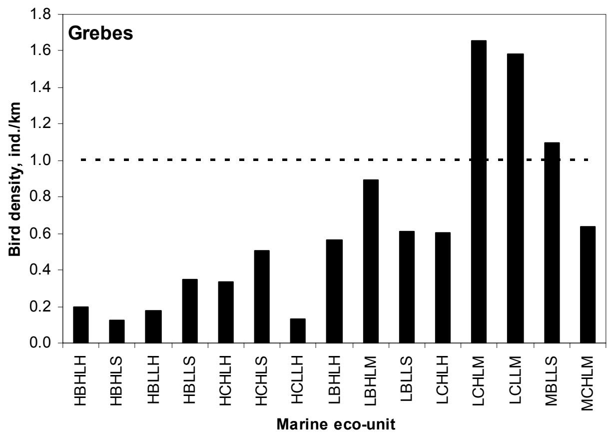


second spring survey (30 March – 1 April 1999)

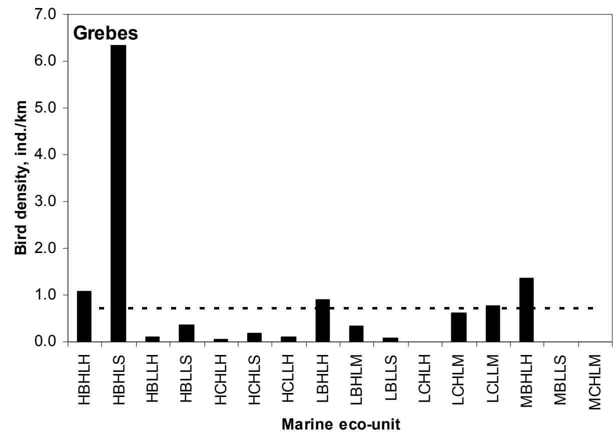


third spring survey (27-29 April 1999)

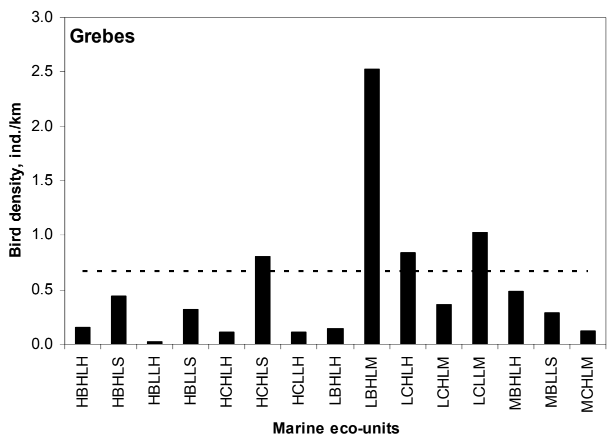
Figure 17. Percentage of grebes observed within different marine eco-units. Black bars indicate the percentage of all grebes in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.



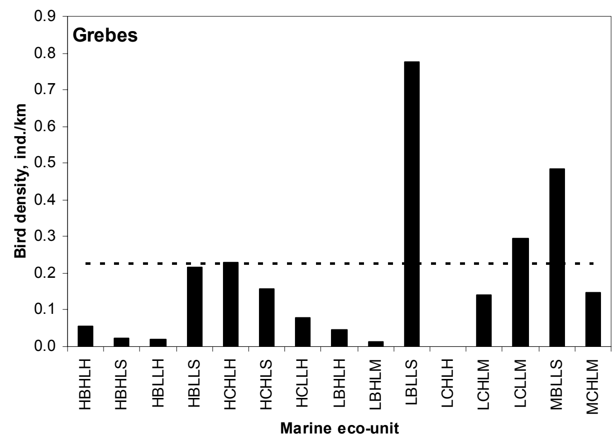
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)



second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 18. Average linear densities of grebes in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

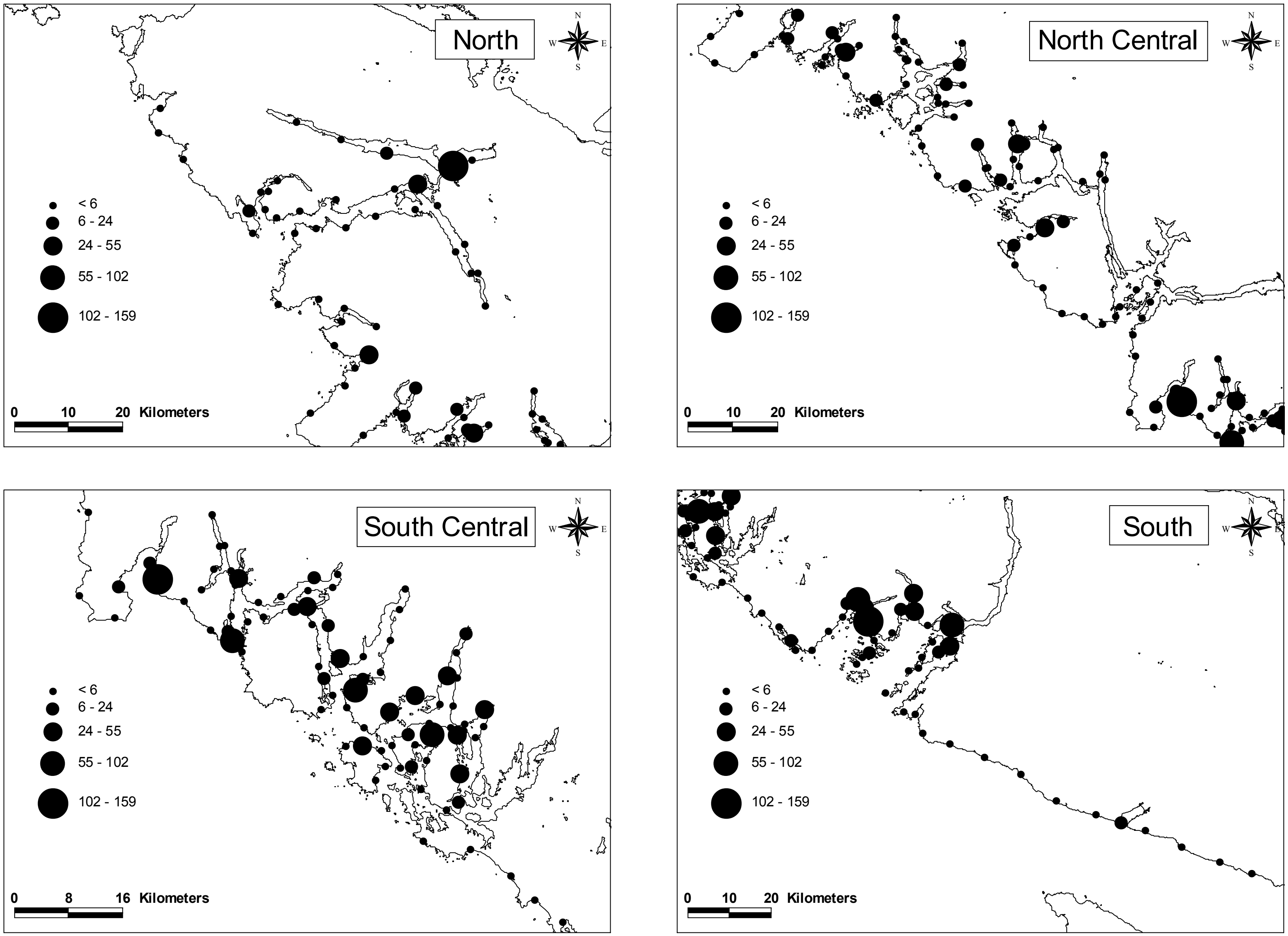


Figure 19. Abundance and distribution of grebes during winter (mean of 3 winter surveys)

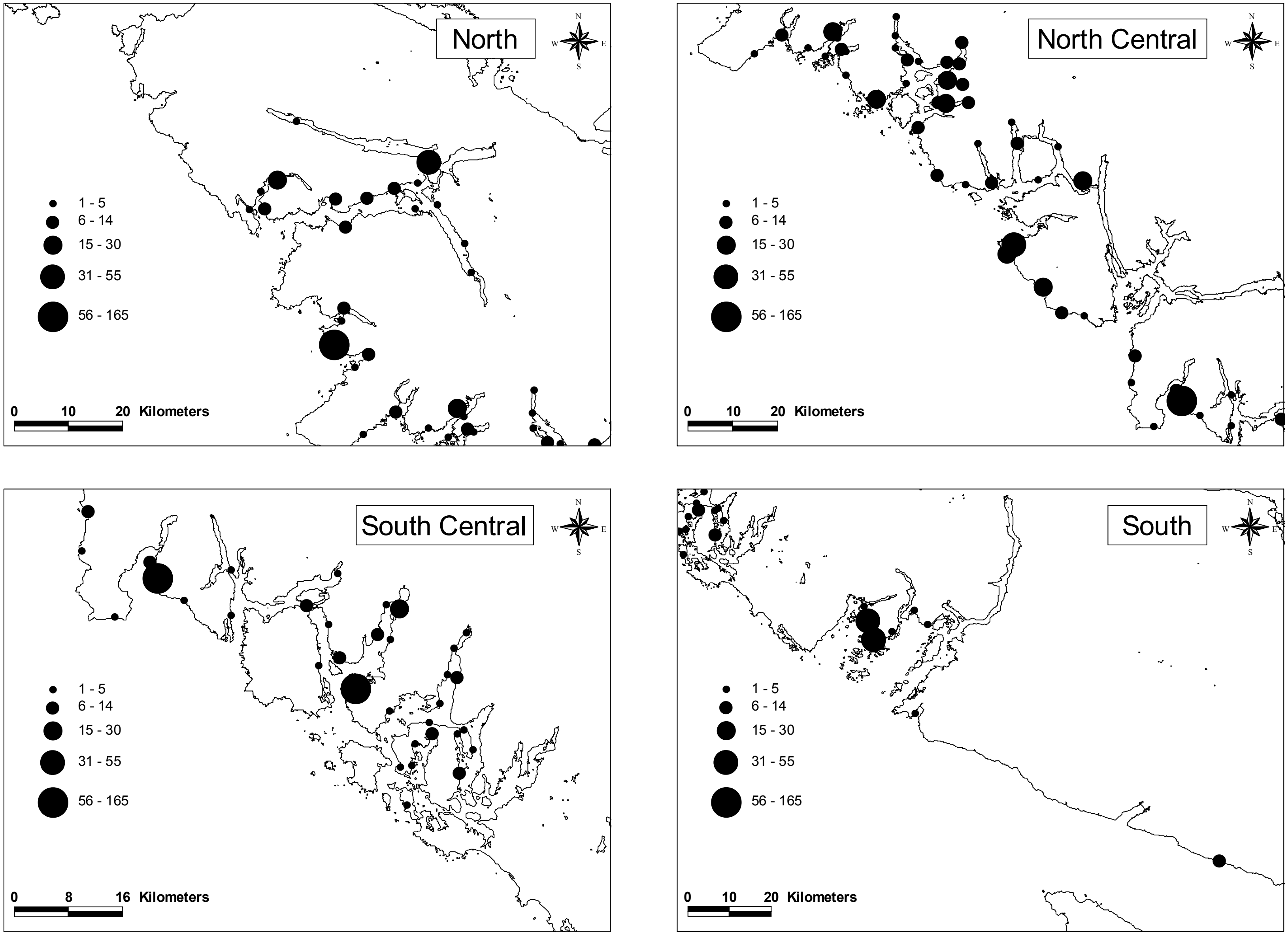


Figure 20. Abundance and distribution of grebes during the first spring survey (13-15 March 1999).

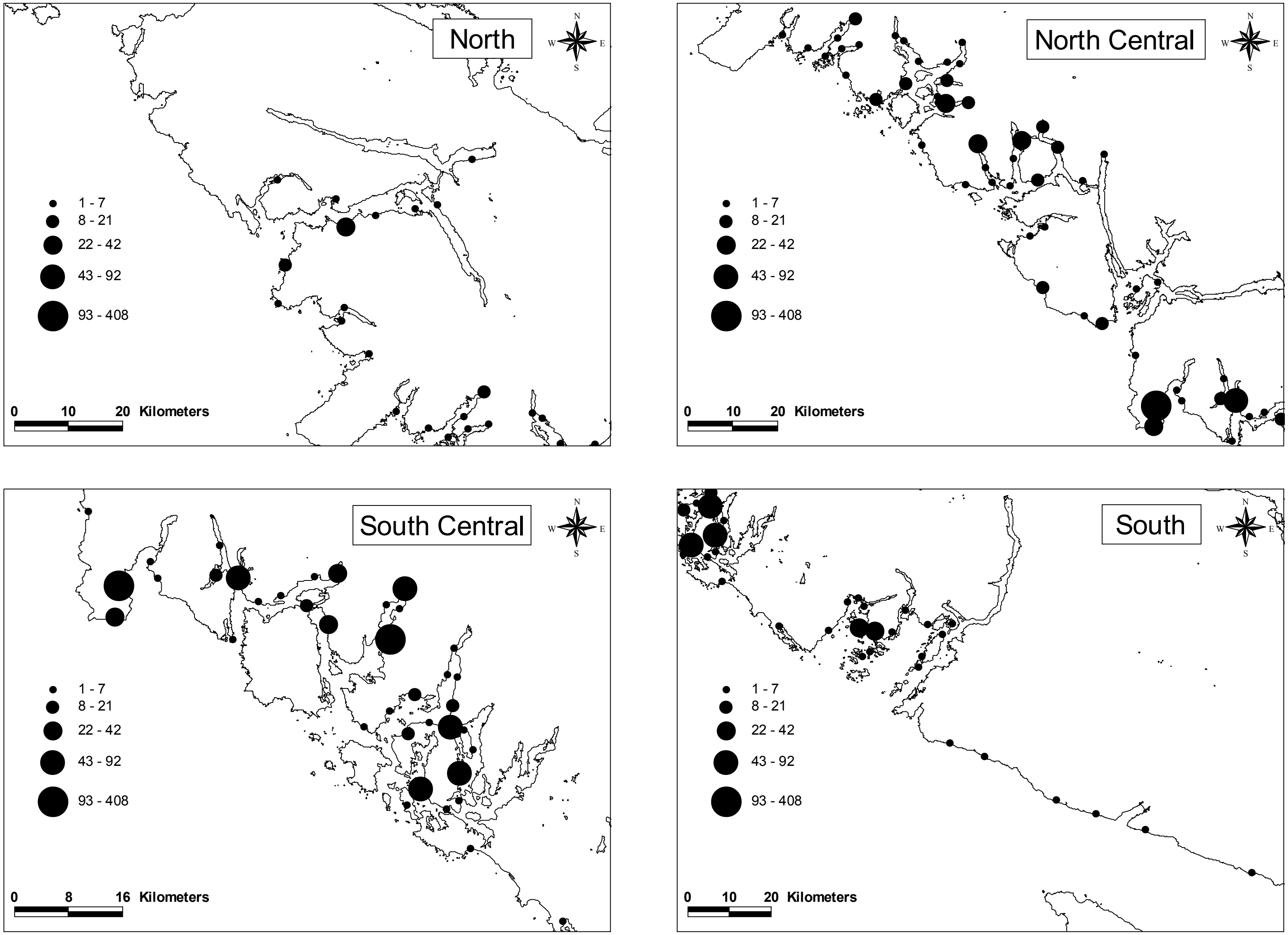


Figure 21. Abundance and distribution of grebes during the second spring survey (30 March – 1 April 1999).

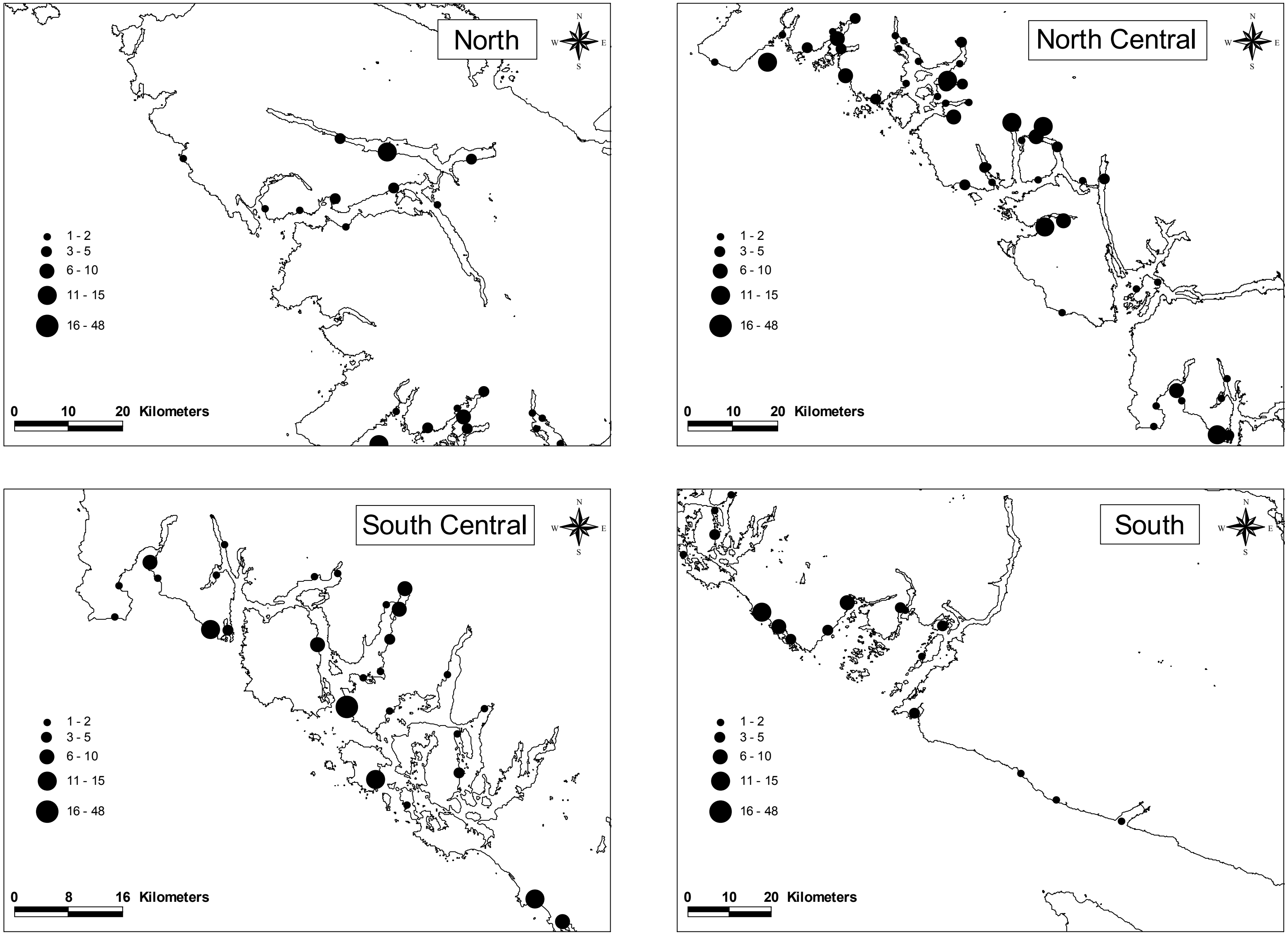


Figure 22. Abundance and distribution of grebes during the third spring survey (27-29 April 1999).

3.3.3 Cormorants

"Cormorants" include Double-crested Cormorant, Pelagic Cormorant and unidentified cormorants. Pelagic Cormorants made up 66% of all identified cormorants in winter and 81% in spring (Tables 3-4).

Cormorant abundance was similar during winter surveys (1439–1668 birds) but more variable and lower during spring counts (239–1384 birds) (Fig. 23). Wintering cormorants were observed in all marine eco-units, with eco-units HBLLS, HBHLH and LCLLM supporting the highest number of individuals (Fig. 24; Table 5). In spring, high numbers of cormorants were also observed in eco-units where herring spawn occurred: MBLLS and MCHLM (Fig. 24, Tables 9-10). The linear density of cormorants varied across marine eco-units: in winter cormorant density was highest in eco-units LCHLH, HBLLS and HCLLH; during the first spring survey the highest density was observed in eco-unit MBLLS, during the second spring survey densities were highest in MBLLS, LBHLM and MBHLH eco-units, and during the third spring survey in eco-unit HBLLH (Fig. 25, Tables 12-18).

Wintering cormorants were widespread over the entire study area, with higher numbers on the open coastline (Fig. 26). During spring surveys, cormorants also occurred over the entire study area. However, some birds positively responded to herring spawn and higher aggregations were observed in Hesquiat Harbour during the first spring survey and in Barkley Sound during the second spring survey (Figs. 27-29). These sites supported major herring spawns in spring 1999 (see chapter 3.4 for details).

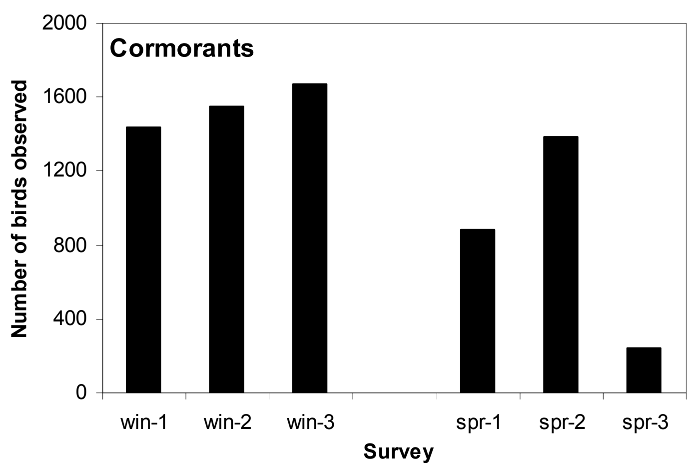
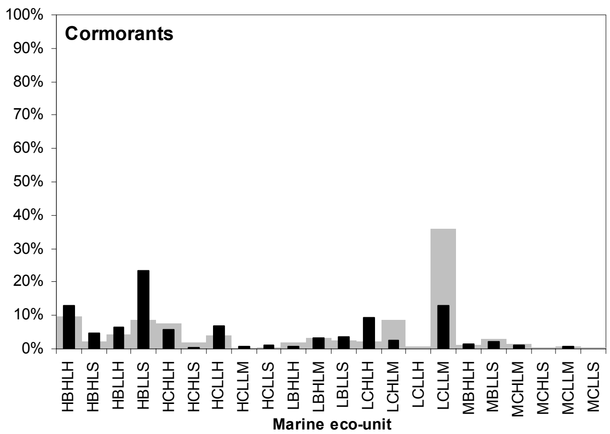
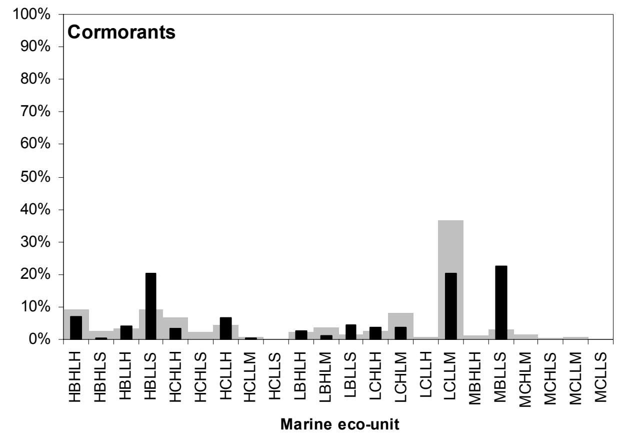


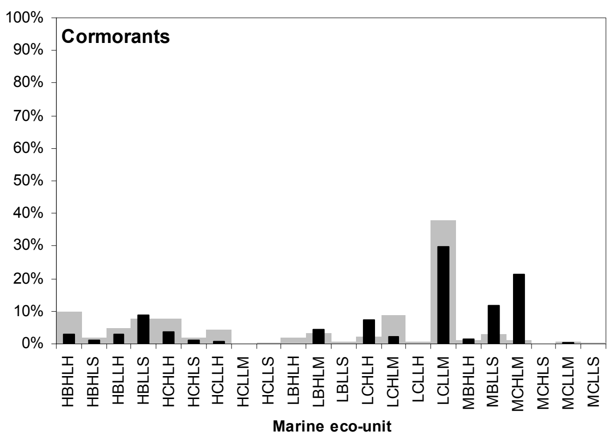
Figure 23. Cormorant abundance during winter and spring surveys. See methods for survey date.



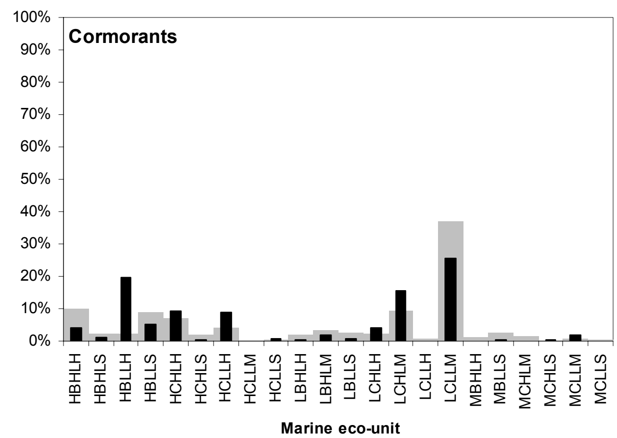
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)

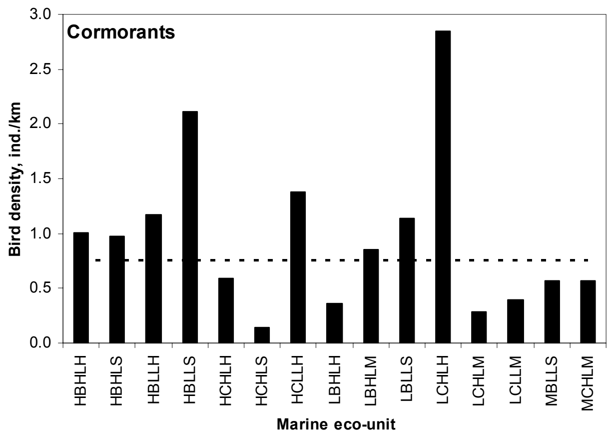


second spring survey (30 March – 1 April 1999)

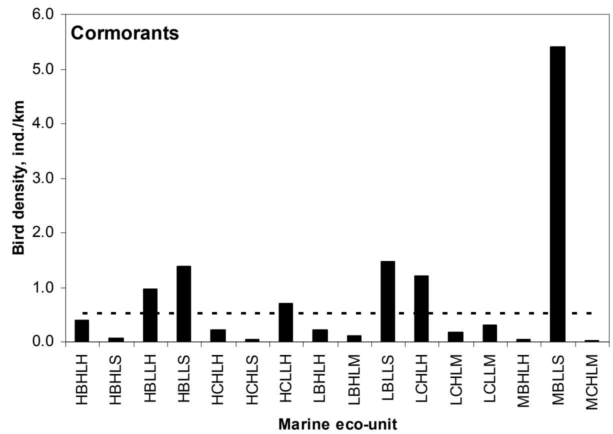


third spring survey (27-29 April 1999)

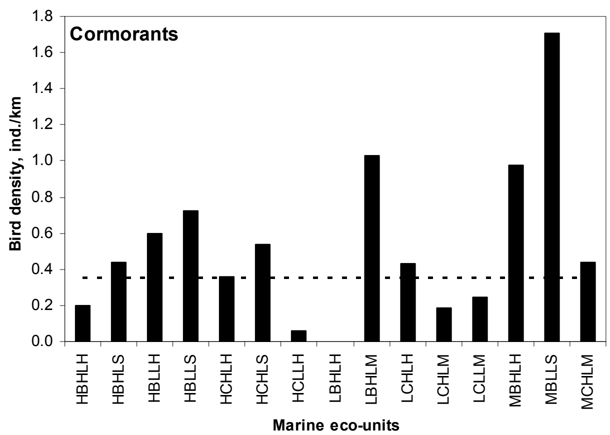
Figure 24. Percentage of cormorants observed within different marine eco-units. Black bars indicate the percentage of all cormorants in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.



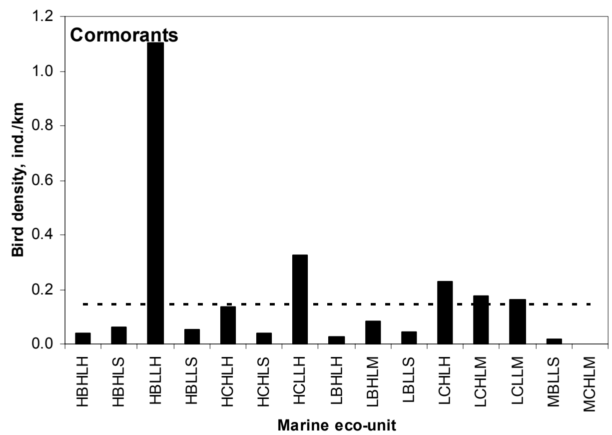
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)



second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 25. Average linear densities of cormorants in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

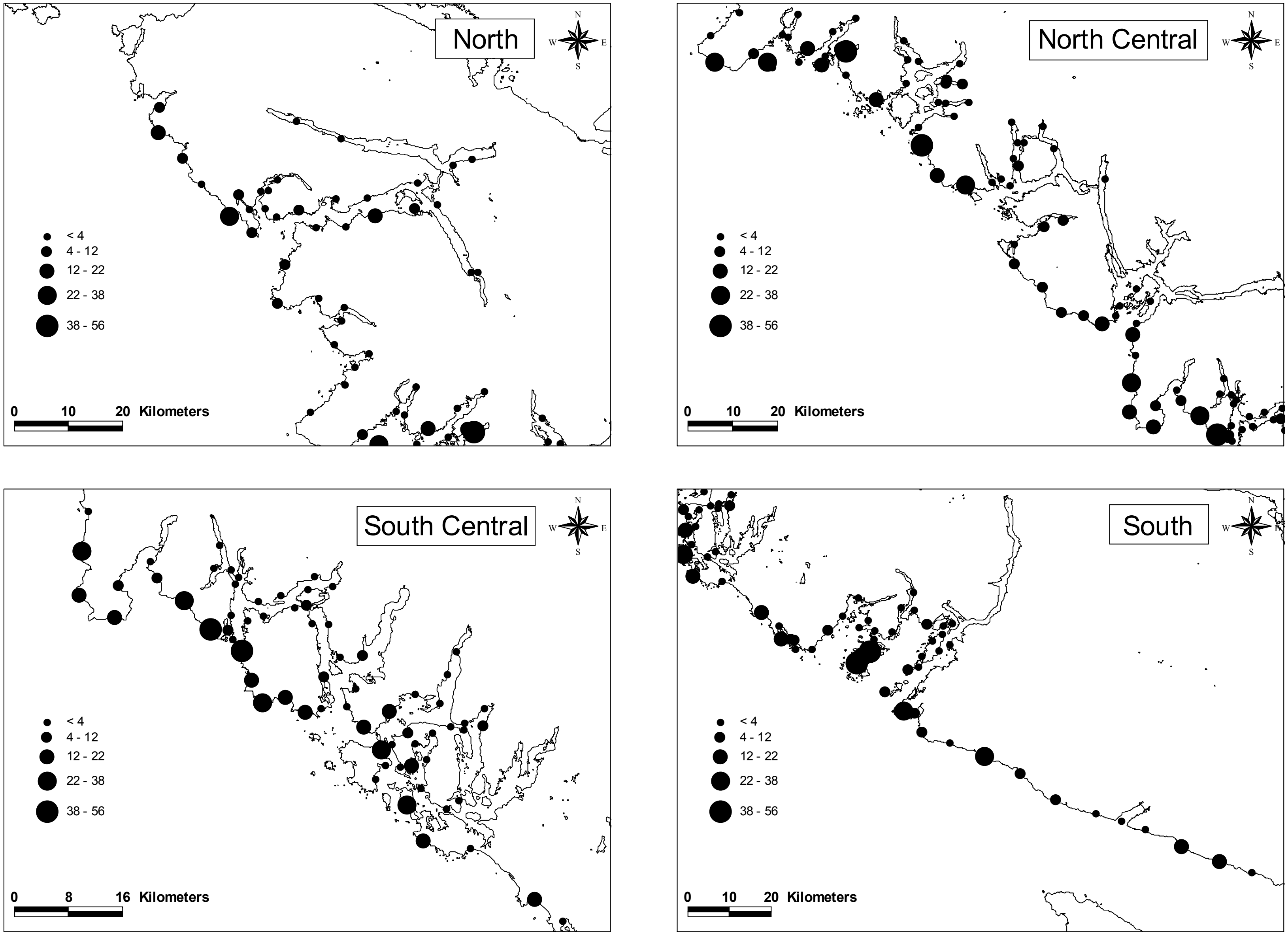


Figure 26. Abundance and distribution of cormorants during winter (mean of 3 winter surveys)

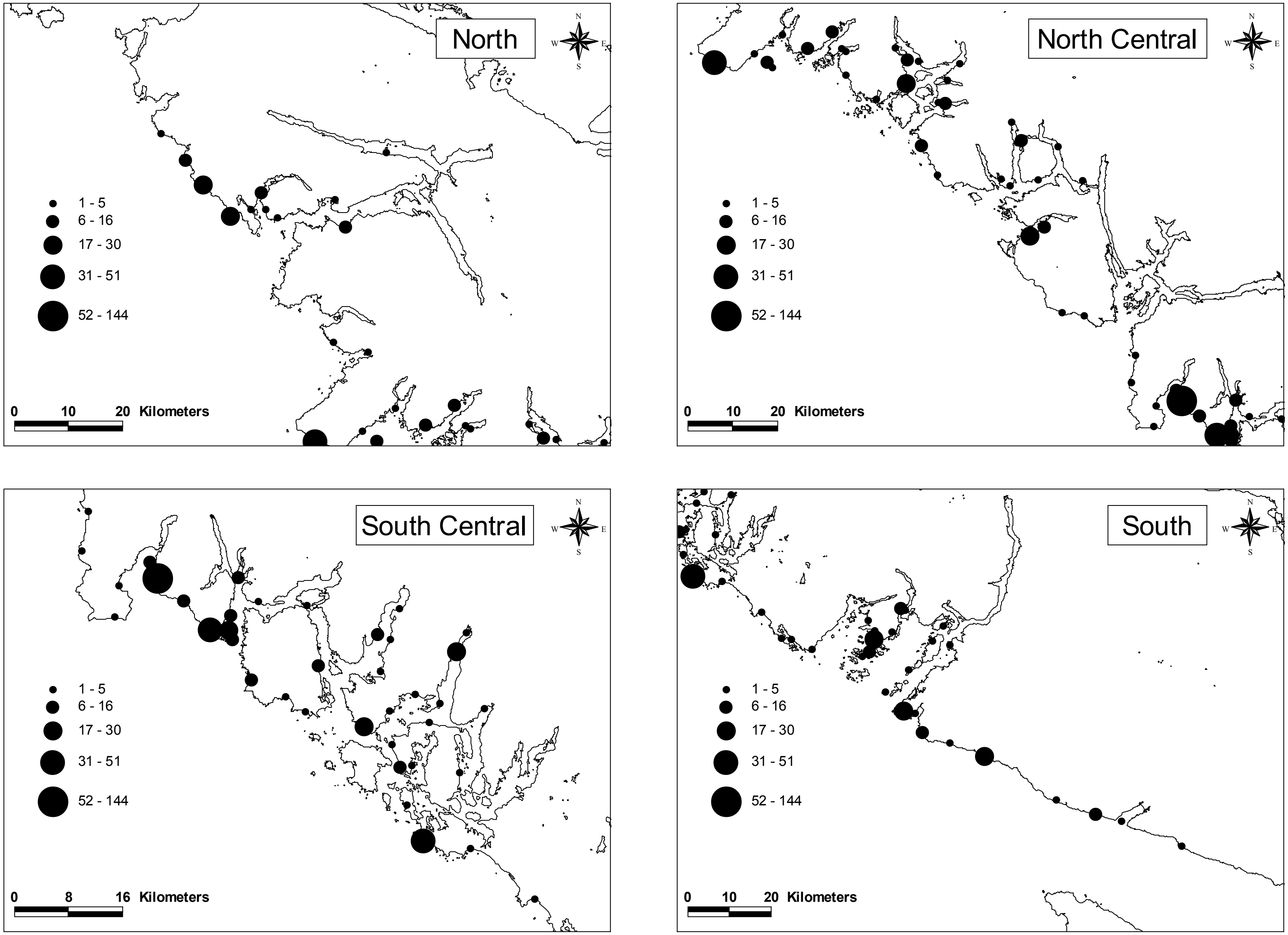


Figure 27. Abundance and distribution of cormorants during the first spring survey (13-15 March 1999).

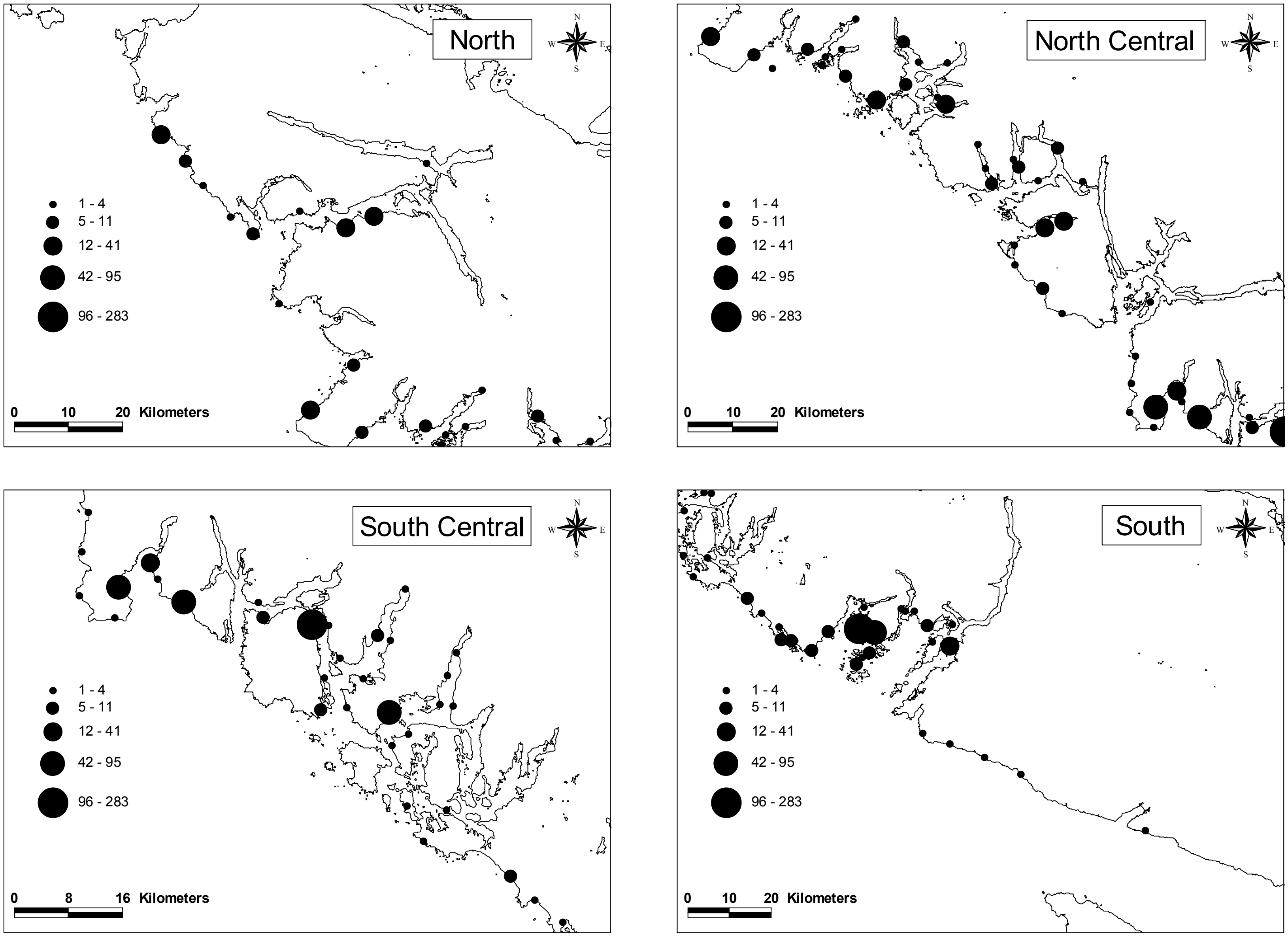


Figure 28. Abundance and distribution of cormorants during the second spring survey (30 March– 1 April 1999).

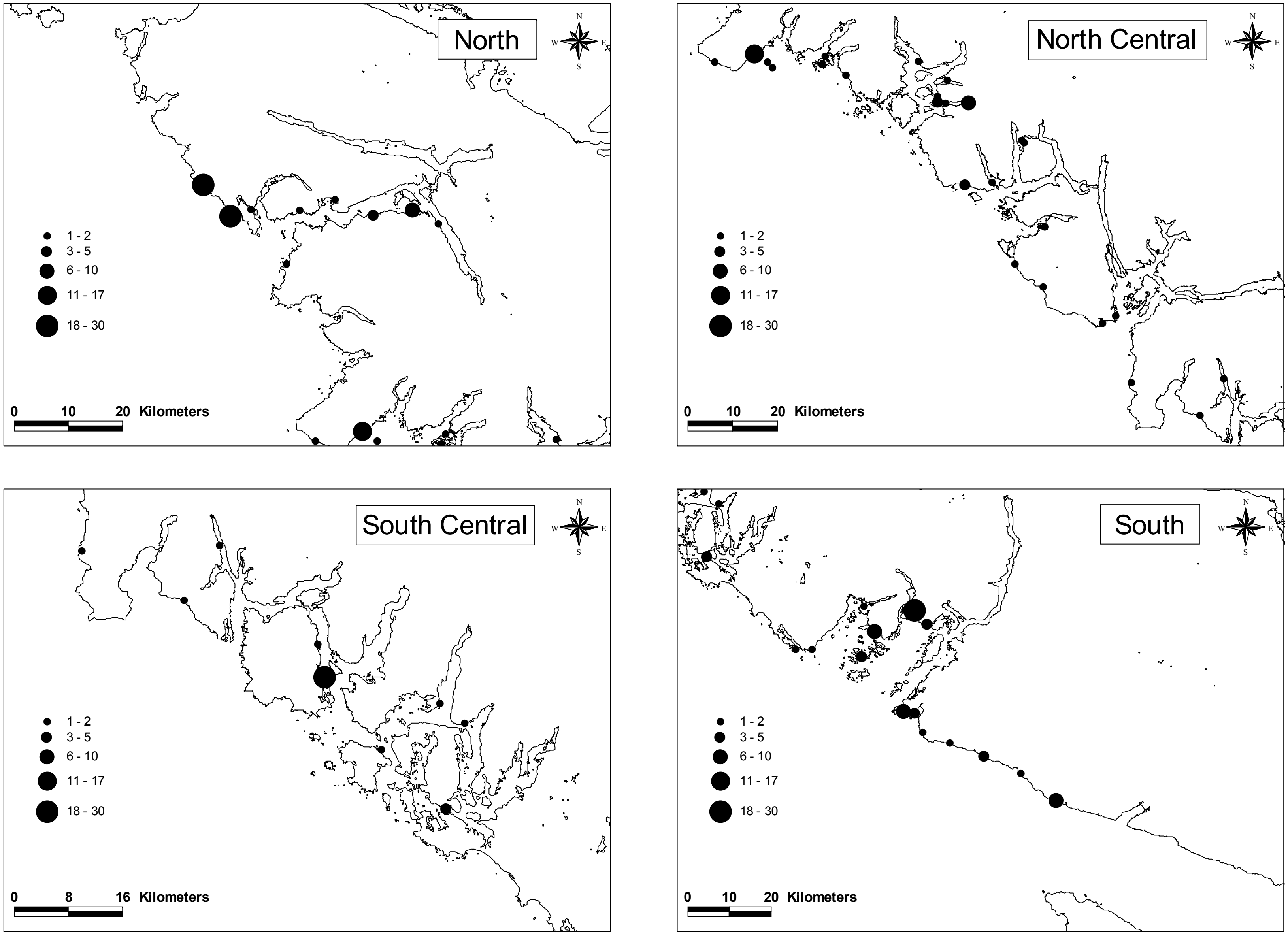


Figure 29. Abundance and distribution of cormorants during the third spring survey (27-29 April 1999).

3.3.4 Dabbling ducks

"Dabbling ducks" includes Green-winged Teal, Mallard, American Wigeon and unidentified dabbling ducks. Mallards were the most numerous dabbling ducks, comprising 69% of all identified dabbling duck species in winter and 94% in spring (Tables 3-4).

Dabbling duck abundance was approximately twice as high during winter surveys (1214–1807 birds) as in the spring (497–884 birds) (Fig. 30). Marine eco-units LBHLM, LCLLM and LBHLH supported the highest number of dabbling ducks in winter (Fig. 31, Table 5) and marine eco-units LCLLM and MBLLS were the most intensively used in spring (Fig. 31, Tables 9-11). The highest linear density of dabbling ducks in winter was observed in marine eco-units LBHLM and LBHLH (Fig. 32, Tables 12-18). Eco-unit MBLLS supported the highest density of dabbling ducks during all three spring counts (Fig. 32, Tables 16-18). Geographically, dabbling ducks were widespread, found primarily in inlets and bays both in winter and spring periods (Figs. 33-36).

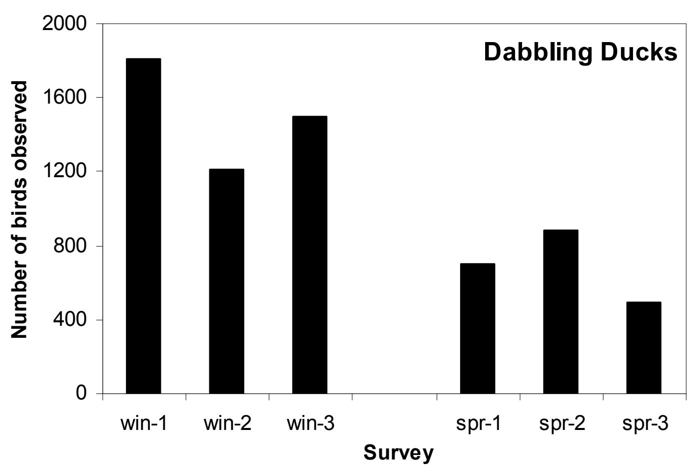
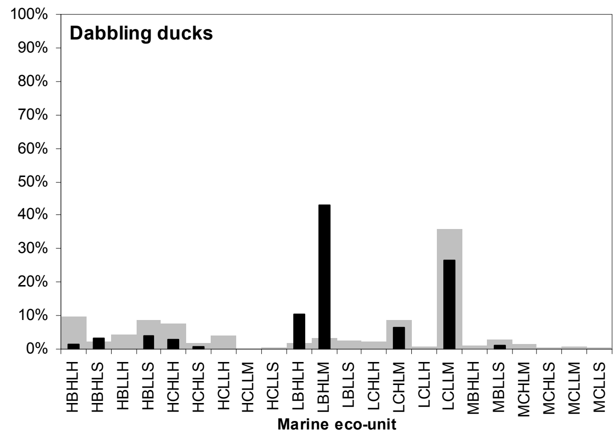
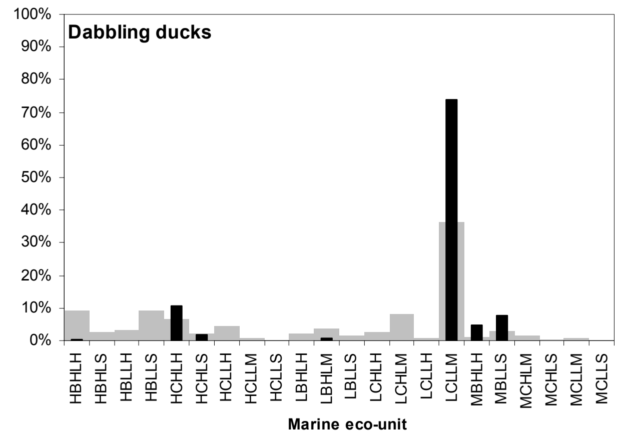


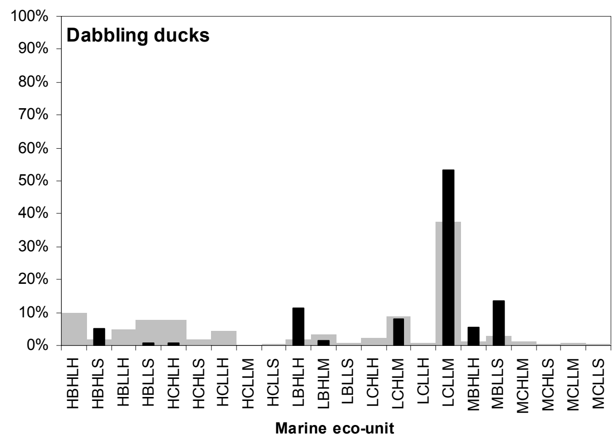
Figure 30. Dabbling duck abundance during winter and spring surveys. See methods for survey date.



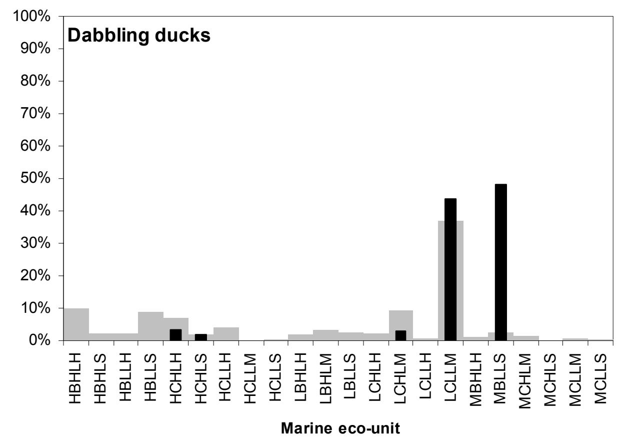
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)



second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 31. Percentage of dabbling ducks observed within different marine eco-units. Black bars indicate the percentage of all dabbling ducks in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.

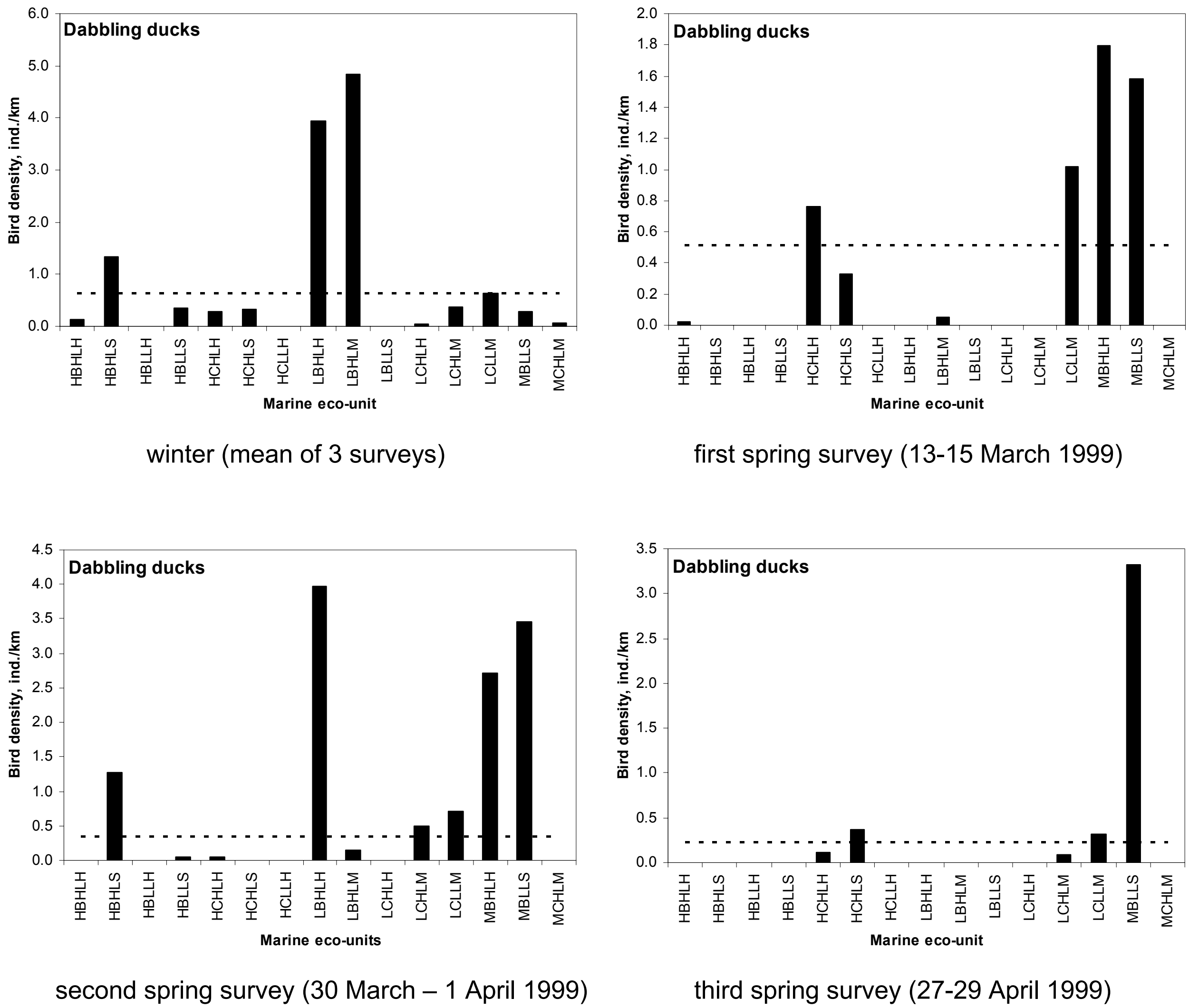


Figure 32. Average linear densities of dabbling ducks in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

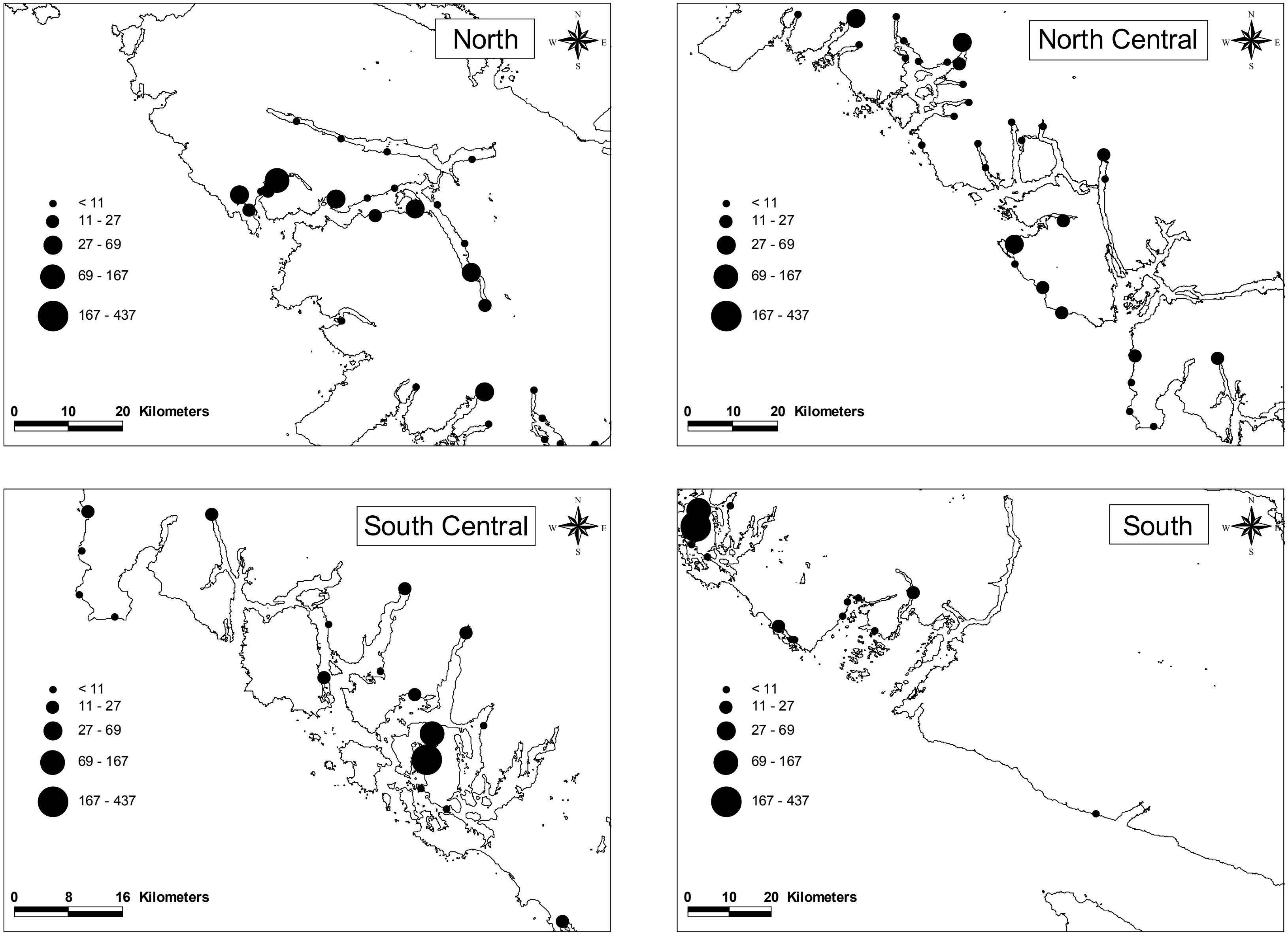


Figure 33. Abundance and distribution of dabbling ducks during winter (mean of 3 winter surveys).

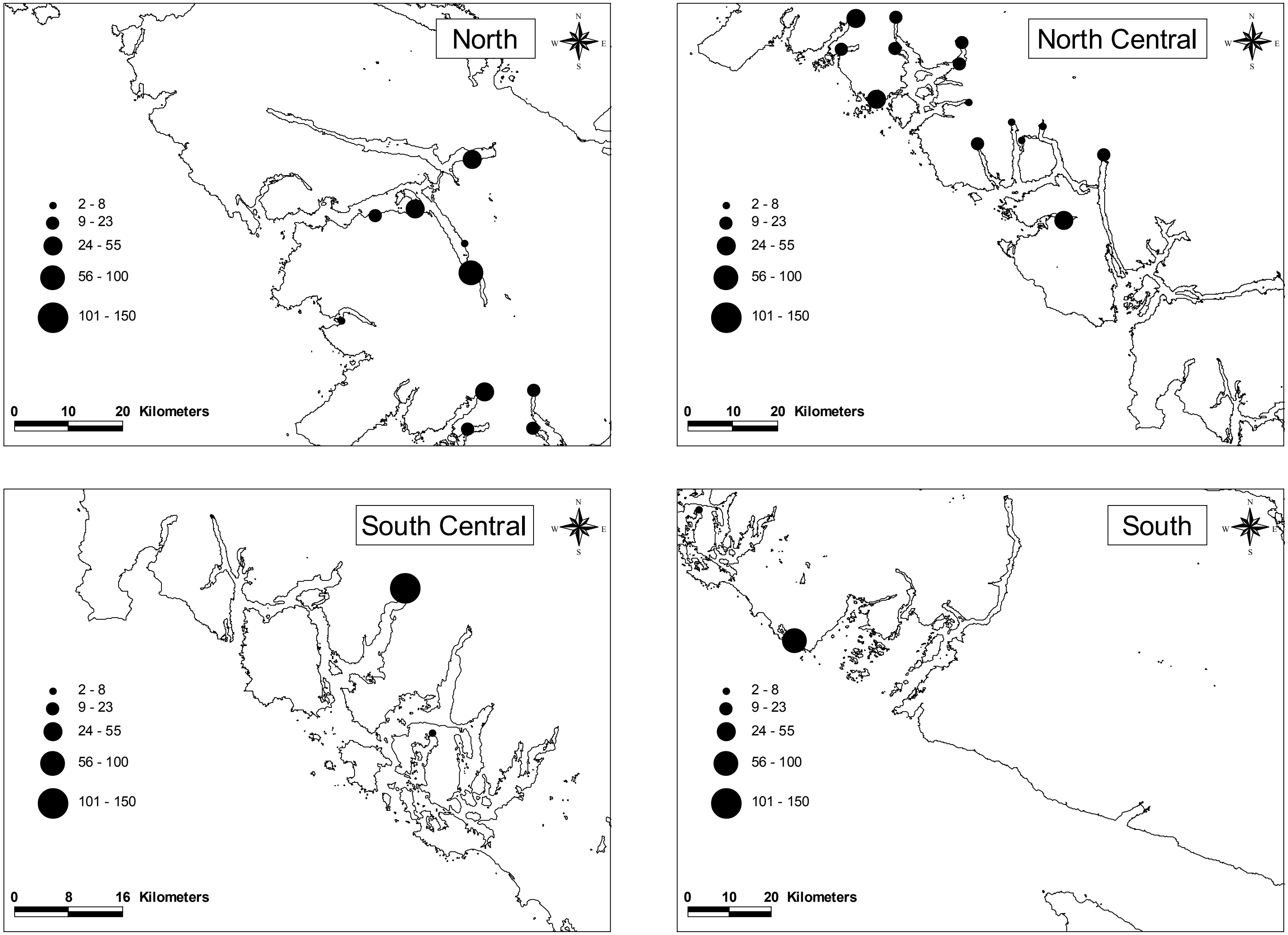


Figure 34. Abundance and distribution of dabbling ducks during the first spring survey (13-15 March 1999).

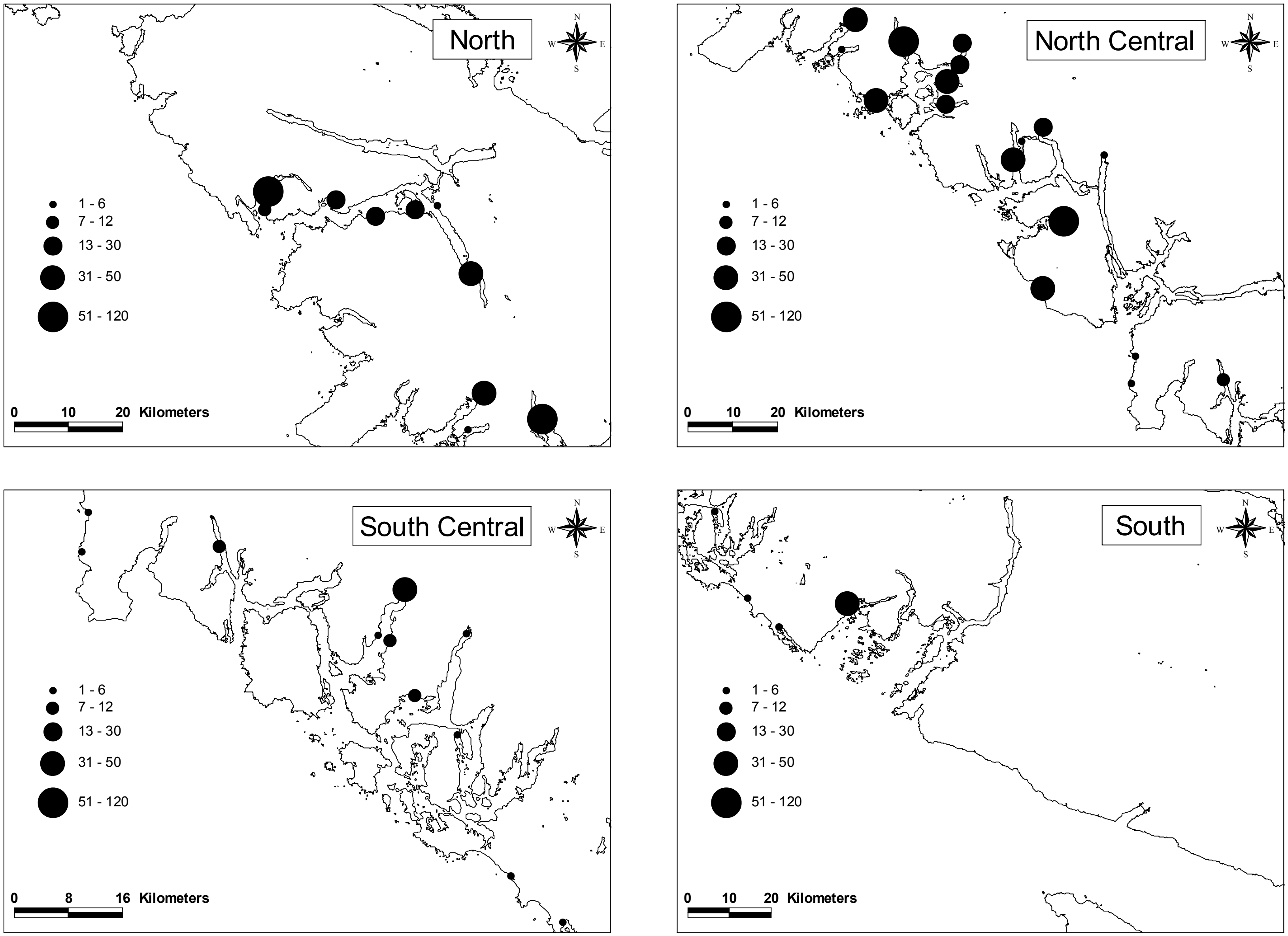


Figure 35. Abundance and distribution of dabbling ducks during the second spring survey (30 March– 1 April 1999).

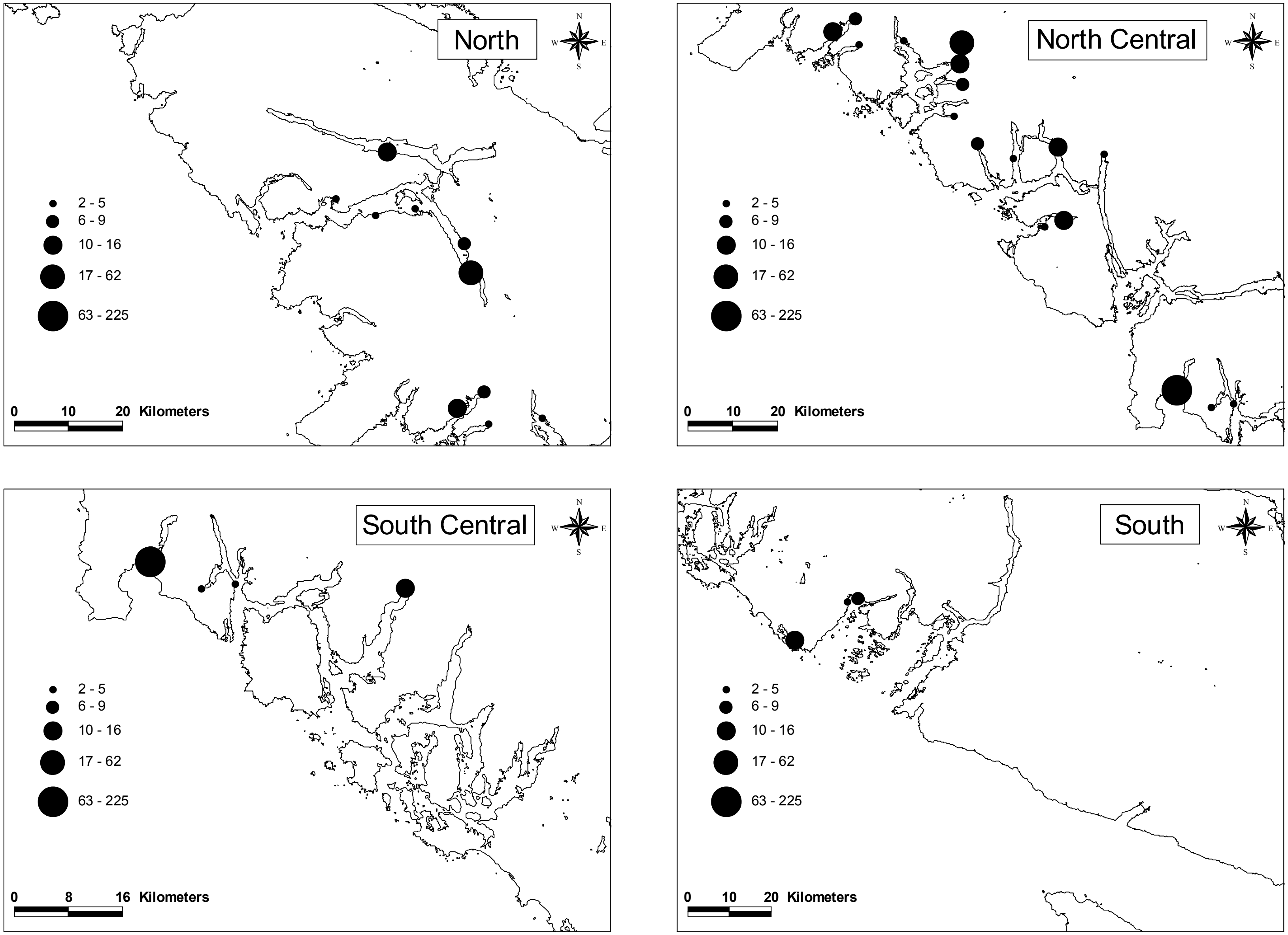


Figure 36. Abundance and distribution of dabbling ducks during the third spring survey (27-29 April 1999).

3.3.5 Scoters

"Scoters" includes Black Scoter, Surf Scoter, White-winged Scoter and unidentified scoters. Surf Scoters made up 87% of all identified scoters in winter and 99% in spring (Tables 3-4).

Scoter abundance increased with each winter survey from ca. 3800 observed during the first count to ca. 6300 during the third survey (Fig. 37). The first and second spring counts yielded considerably more birds than recorded in winter surveys (Fig. 37), with 10,000 and 21,500 birds observed. The majority of wintering scoters were observed in marine eco-units LCLLM, LBHLM, LBLLS and MBLLS (Fig. 38; Table 5). Marine eco-units MBLLS and MCHLM held the highest number of scoters during the first and second spring surveys respectively. The highest numbers of scoters during the third spring survey were observed in marine eco-units LBLLS, HBHLS and HBLLS (Fig. 38, Tables 9-11). The linear density of wintering scoters was the highest in marine eco-units LBLLS, LBHLM and MBLLS (Fig. 39, Tables 12-18). Bird densities, however, cannot be compared between different surveys since the majority of scoters were counted "On spawn" during spring surveys, whereas only birds counted "On transect" were included into density calculations (see methods for more detailed description). Wintering scoters were widespread over the entire study area, with higher numbers occurring in protected inlets than exposed segments of the coastline (Fig. 40). During the first spring survey (13-15 March 1999) the majority of scoters aggregated in Hesquiat Harbour (eco-unit MBLLS), where herring spawn was extensive (Fig. 41). The highest number of scoters was recorded during the second spring survey (30 March – 1 April 1999), when most birds concentrated in Barkley Sound (eco-unit MCHLM) (Fig. 42), where another extensive herring spawn took place (see chapter 3.4). Observed scoter abundance dropped to less than 3000 birds during the third spring survey (27-29 April 1999), when Clayoquot Sound and Vargas Island area supported the largest concentrations (Fig. 43).

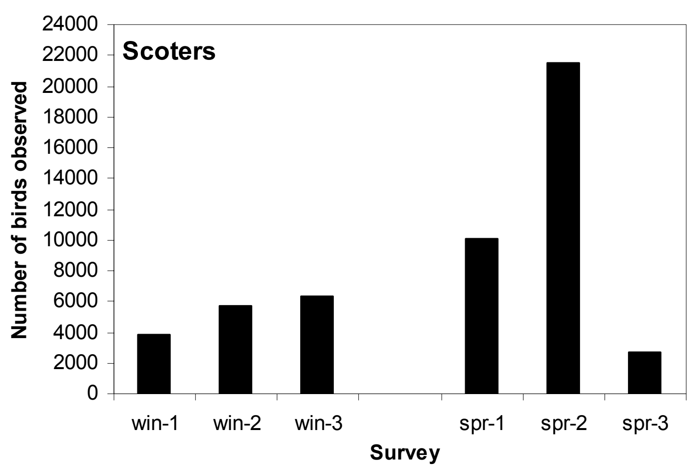
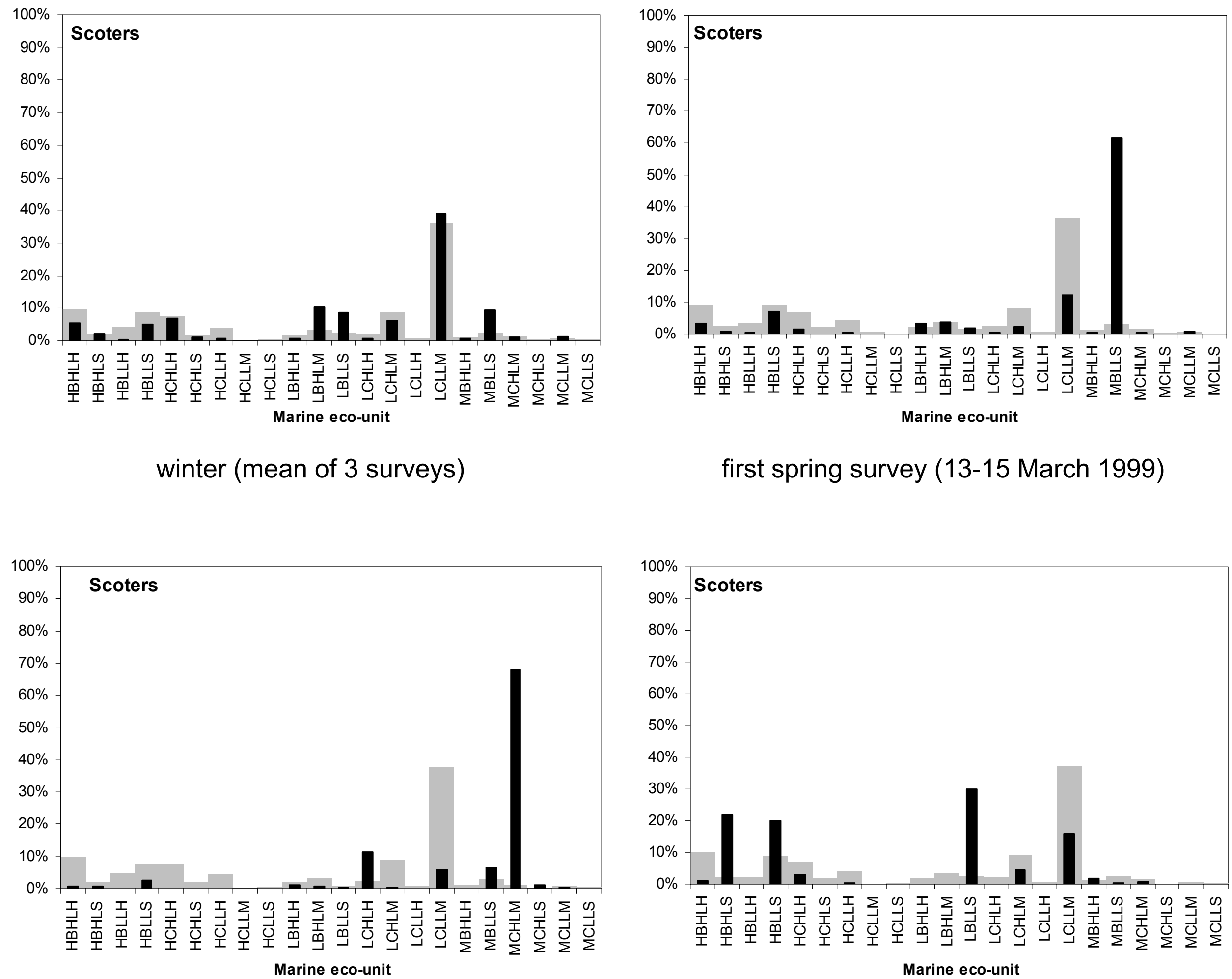


Figure 37. Scoter abundance during winter and spring surveys. See methods for survey date.



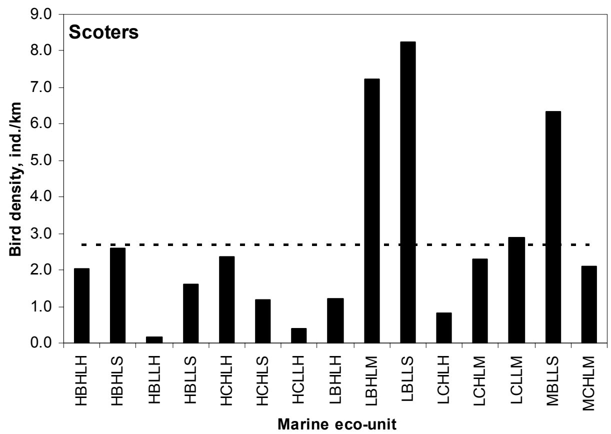
winter (mean of 3 surveys)

first spring survey (13-15 March 1999)

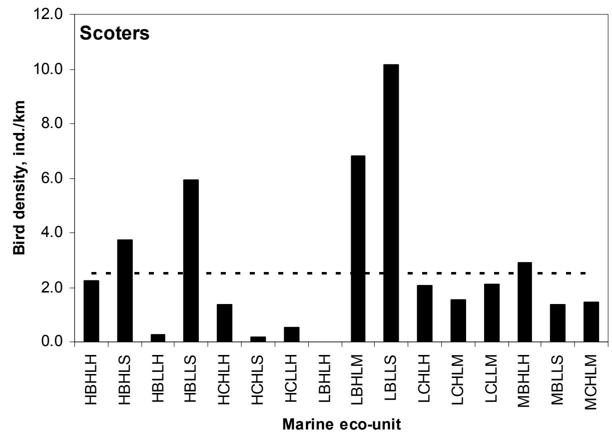
second spring survey (30 March – 1 April 1999)

third spring survey (27-29 April 1999)

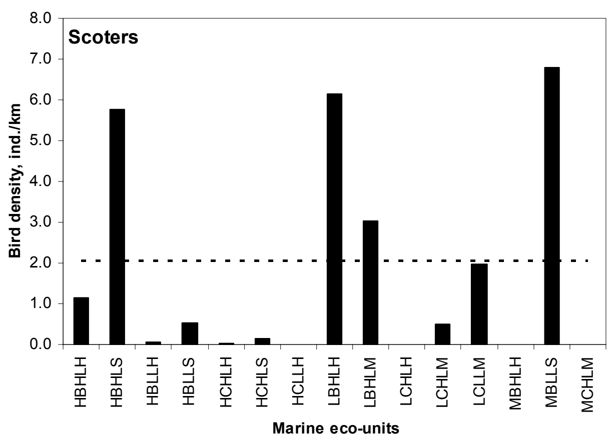
Figure 38. Percentage of scoters observed within different marine eco-units. Black bars indicate the percentage of all scoters in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.



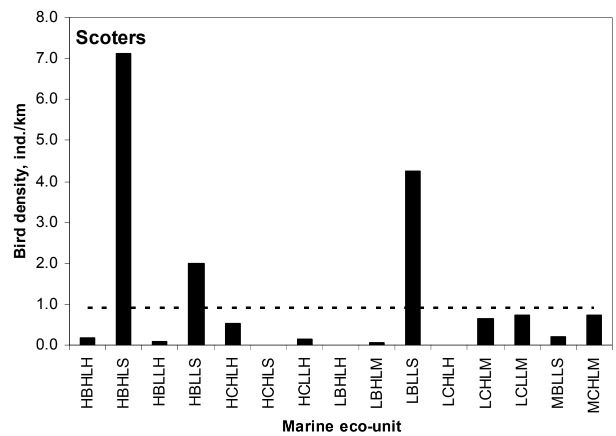
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)



second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 39. Average linear densities of scoters in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

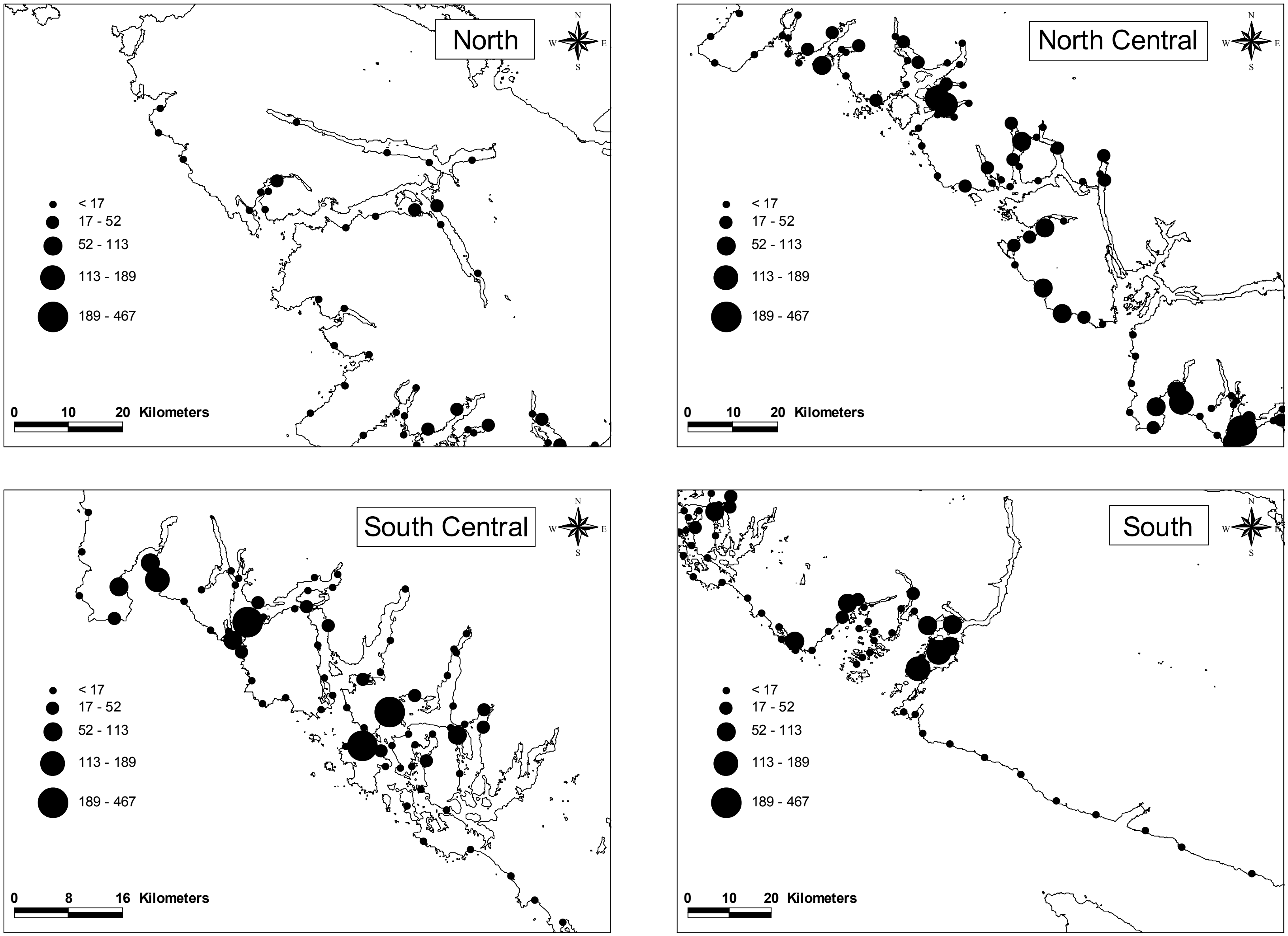


Figure 40. Abundance and distribution of scoters during winter (mean of 3 winter surveys)

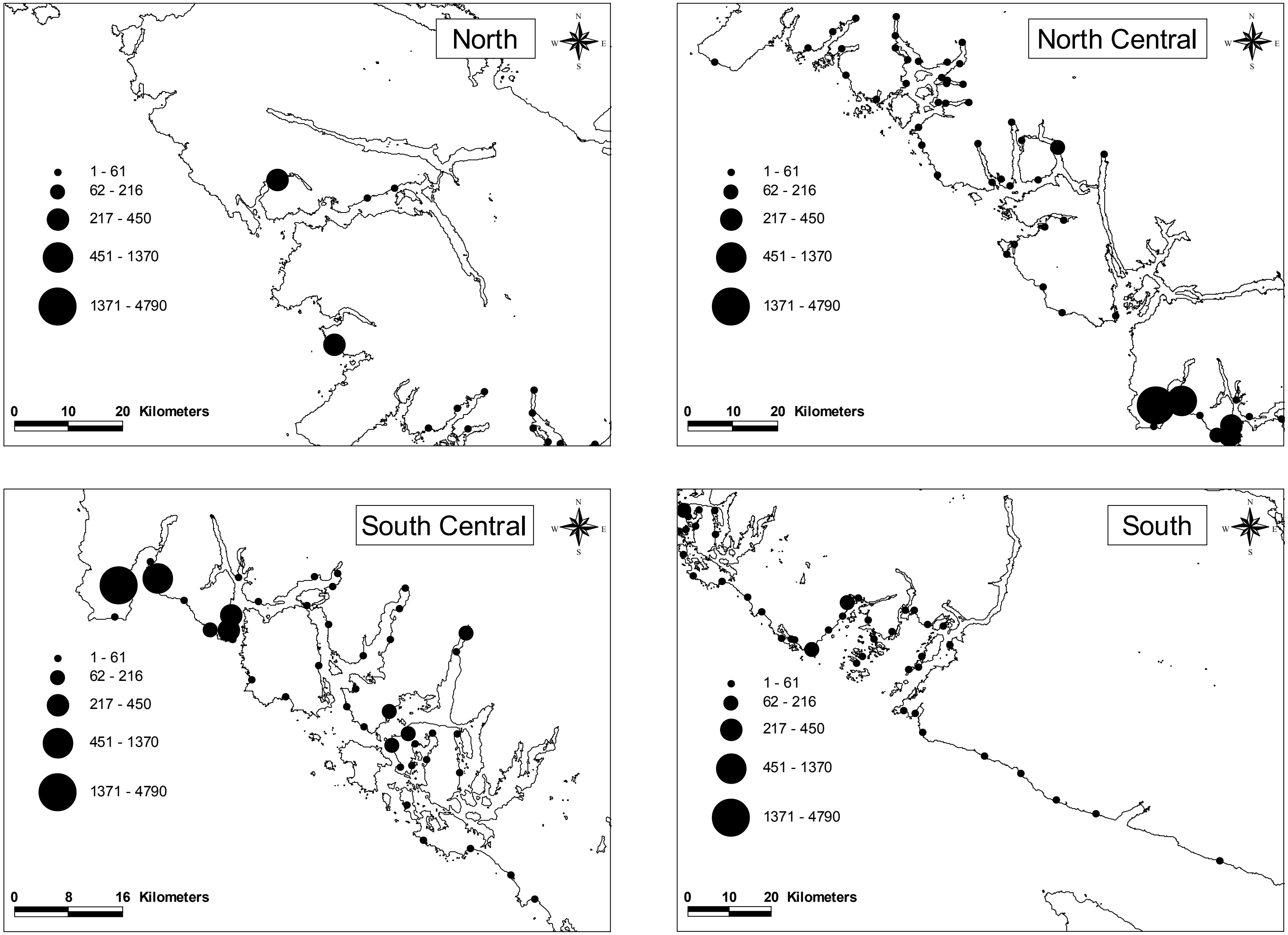


Figure 41. Abundance and distribution of scoters during the first spring survey (13-15 March 1999).

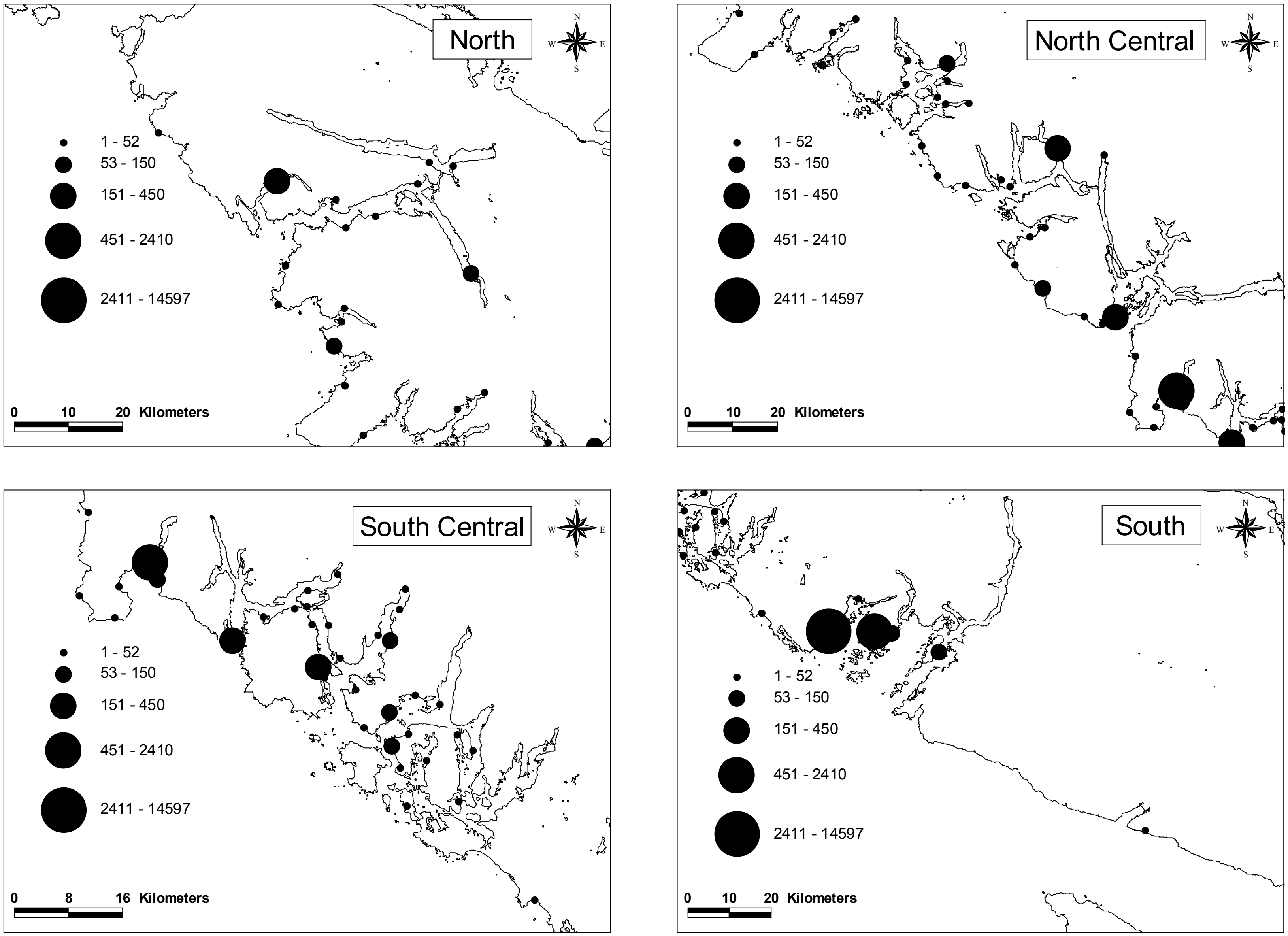


Figure 42. Abundance and distribution of scoters during the second spring survey (30 March – 1 April 1999).

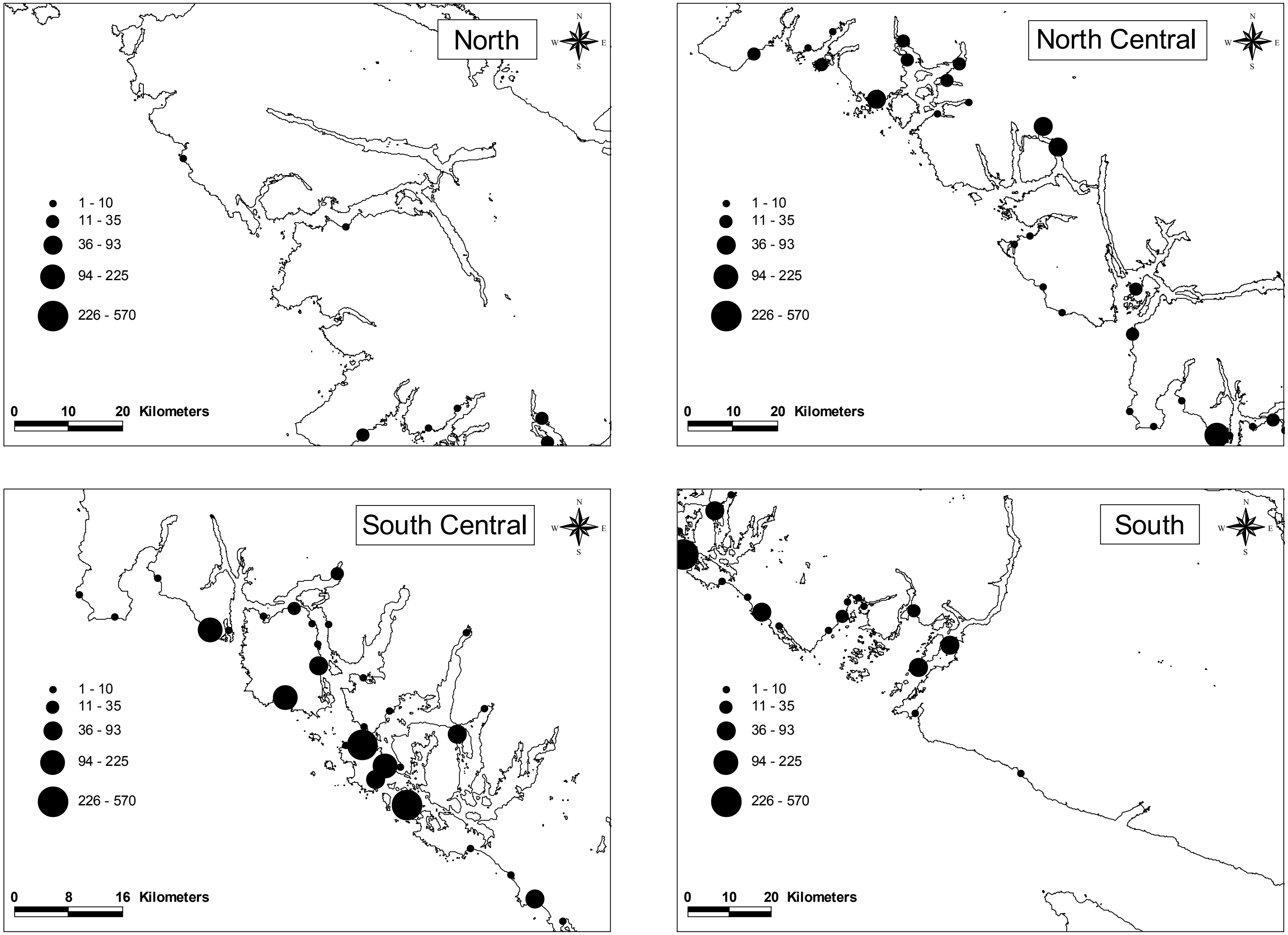


Figure 43. Abundance and distribution of scoters during the third spring survey (27-29 April 1999).

3.3.6 Goldeneyes

"Goldeneyes" includes Common Goldeneye, Barrows Goldeneye and unidentified goldeneyes. Barrows Goldeneyes made up 88% of all identified goldeneyes in winter, but proportions of both species were nearly equal in spring (Tables 3-4).

Goldeneyes were generally more numerous in winter than in spring and the highest number (3662 birds) recorded during the second winter survey (Fig 44). The highest number of goldeneyes in spring was observed during the second survey (1610 birds) and only 125 individuals were counted during the last spring survey (Fig. 44). Marine eco-unit LCLLM supported the highest number of goldeneyes during all counts (Fig. 45, Tables 5-11). The same marine eco-unit (LCLLM) also supported above-average goldeneye densities during each survey (Fig. 46). However, different eco-units, usually covering only small proportion of the entire study area, peaked with high goldeneye densities during different surveys: MCHLM during the first spring survey, LBHLH and MCHLM during the second spring survey, and HBHLH during the third spring survey (Fig. 46, Tables 12-18). Wintering goldeneyes were widespread over the entire study area, but most birds were found in protected inlets and bays (Fig. 47). Generally the same distribution pattern was observed during spring surveys (Figs. 48-50).

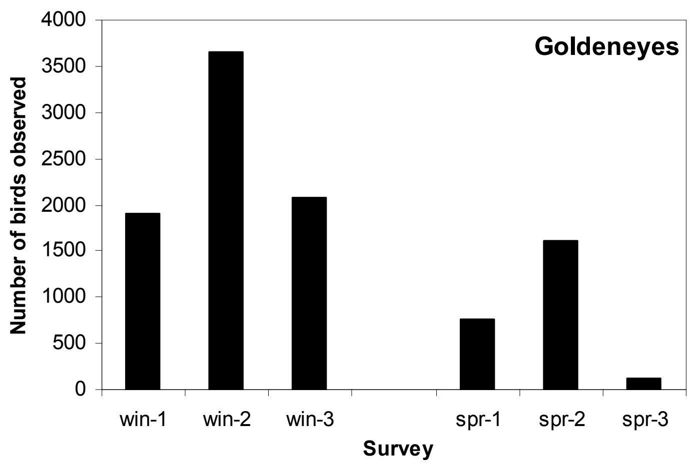
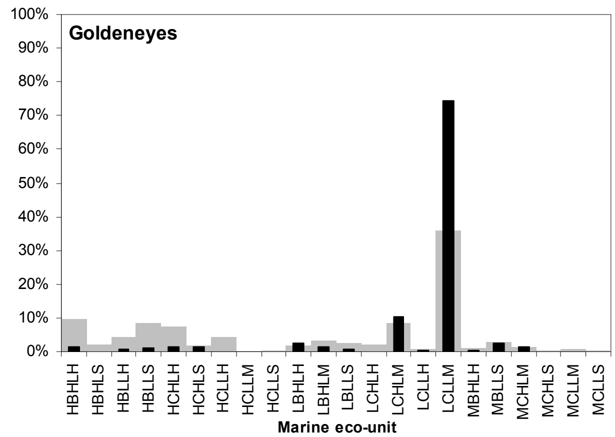
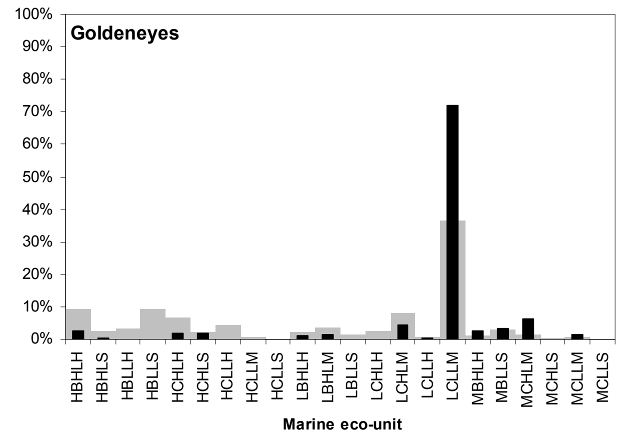


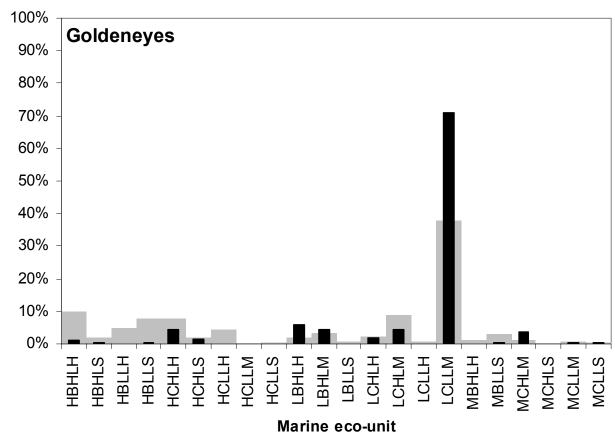
Figure 44. Goldeneye abundance during winter and spring surveys. See methods for survey date.



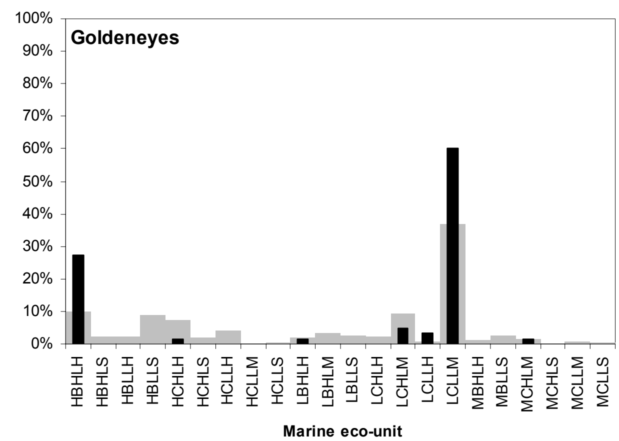
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)

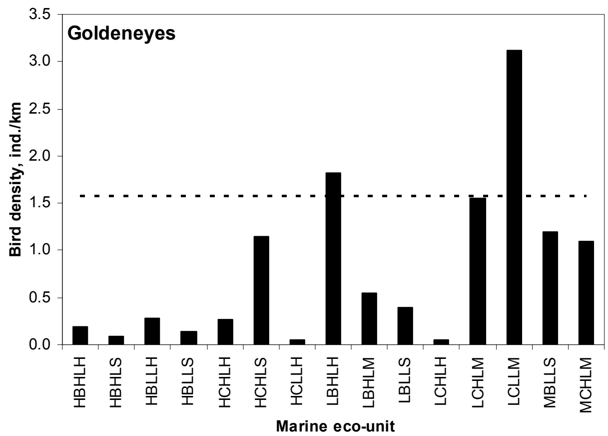


second spring survey (30 March – 1 April 1999)

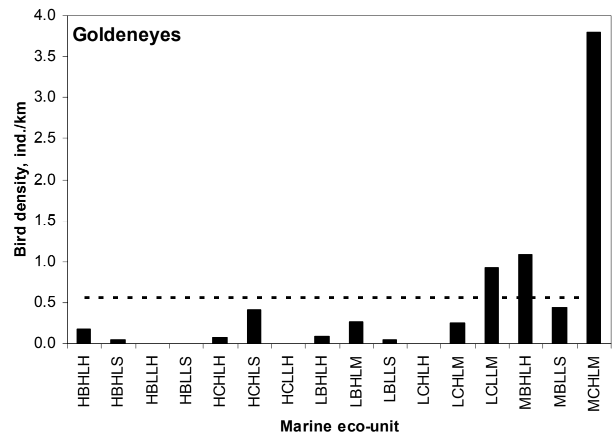


third spring survey (27-29 April 1999)

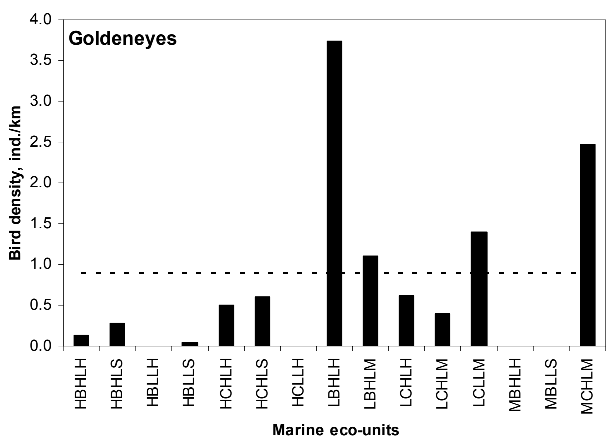
Figure 45. Percentage of goldeneyes observed within different marine eco-units. Black bars indicate the percentage of all goldeneyes in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.



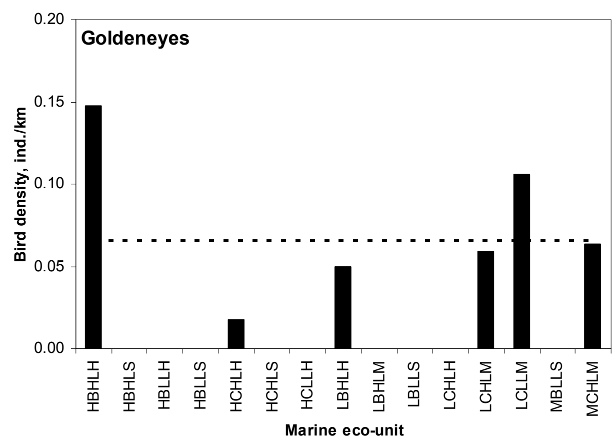
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)



second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 46. Average linear densities of goldeneyes in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

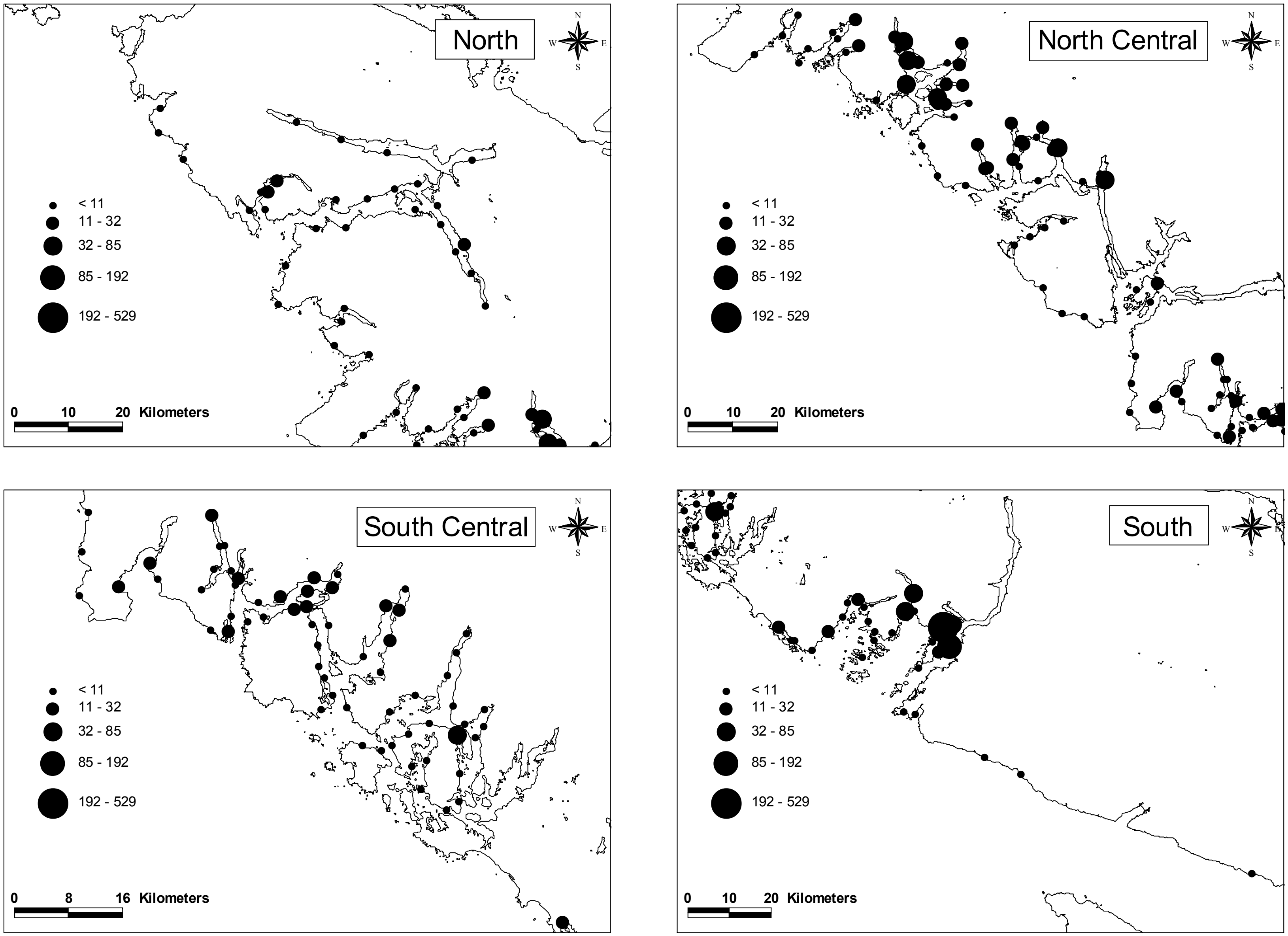


Figure 47. Abundance and distribution of goldeneyes during winter (mean of 3 winter surveys).

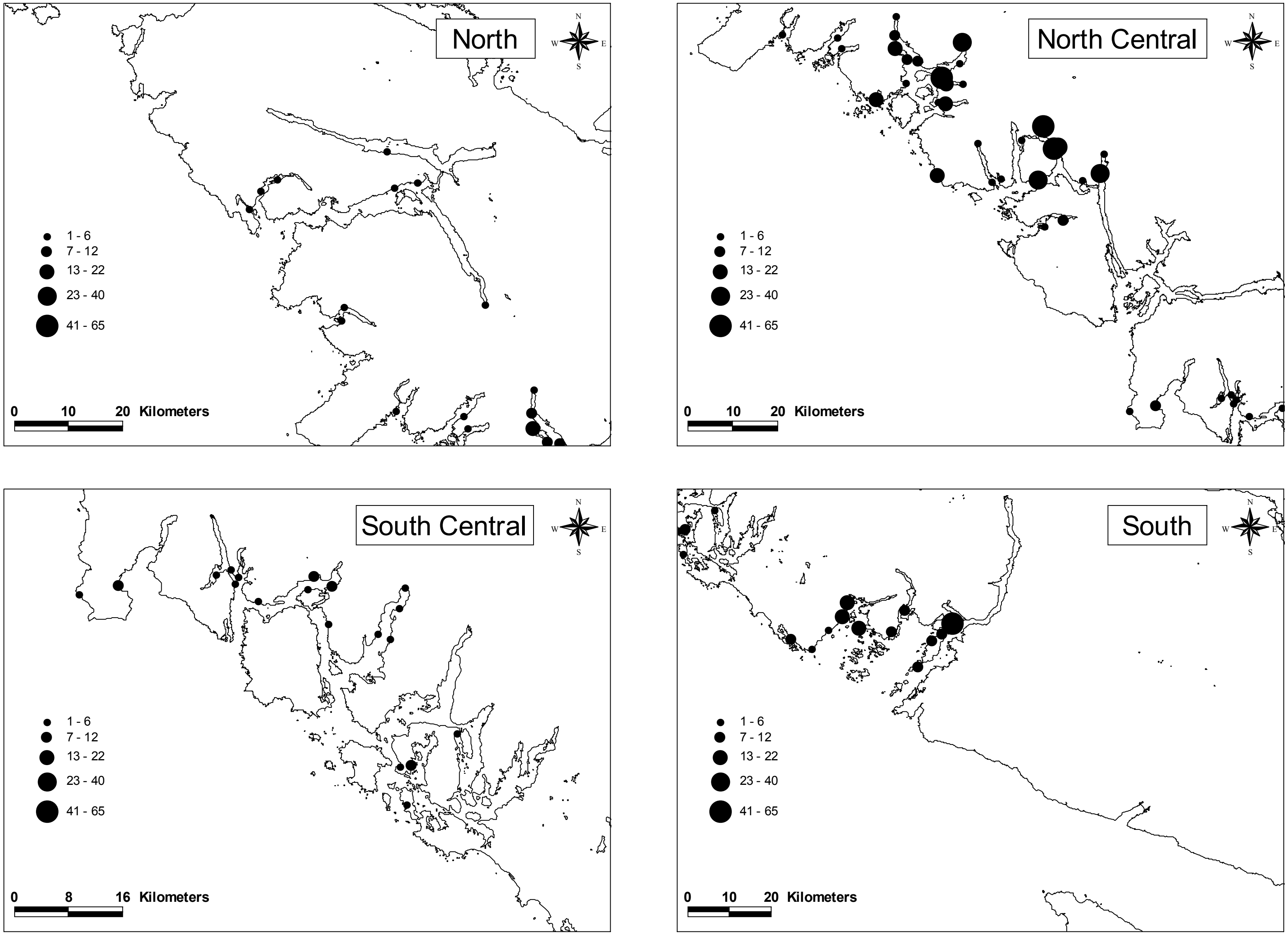


Figure 48. Abundance and distribution of goldeneyes during the first spring survey (13-15 March 1999).

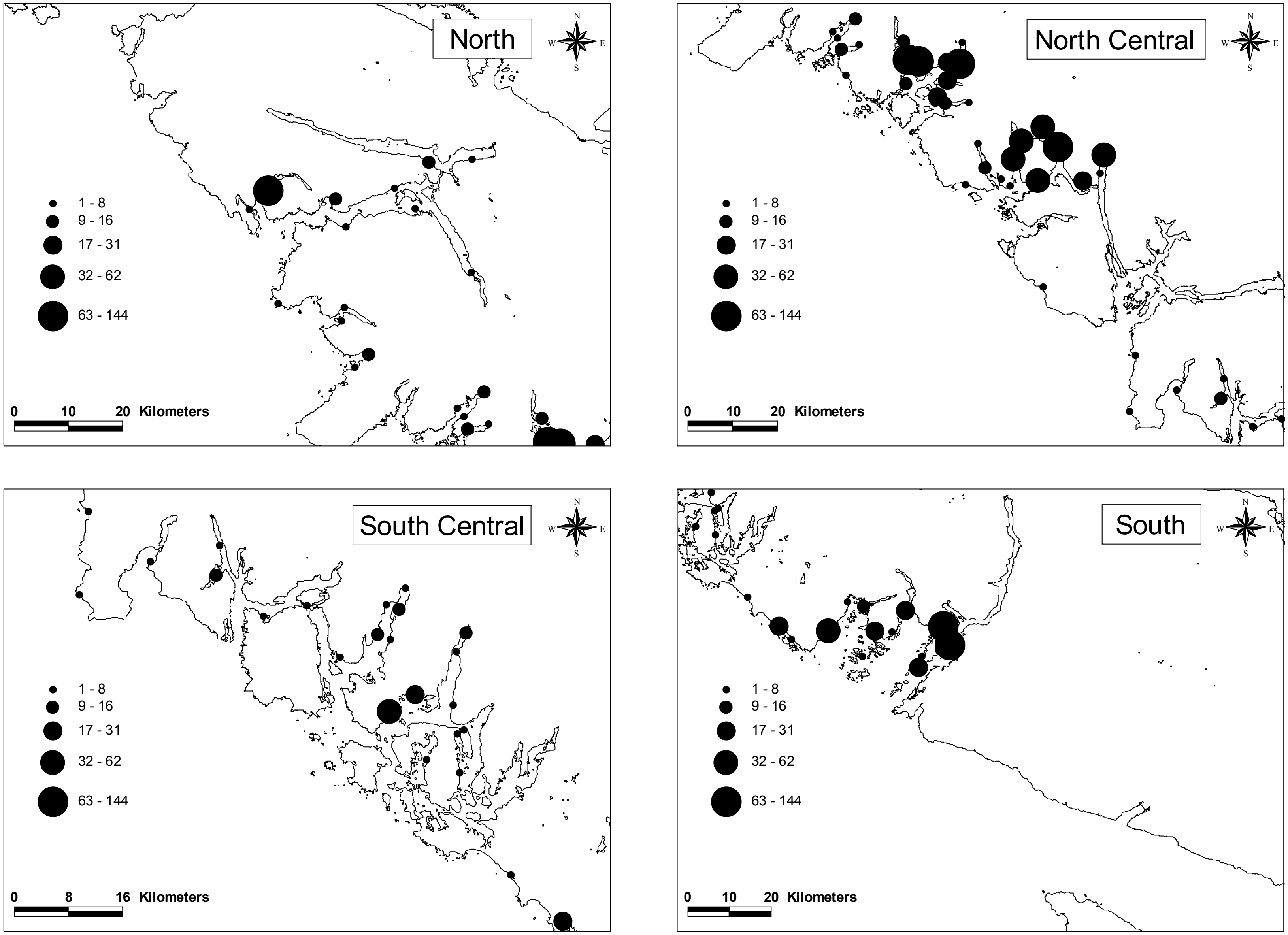


Figure 49. Abundance and distribution of goldeneyes during the second spring survey (30 March – 1 April 1999).

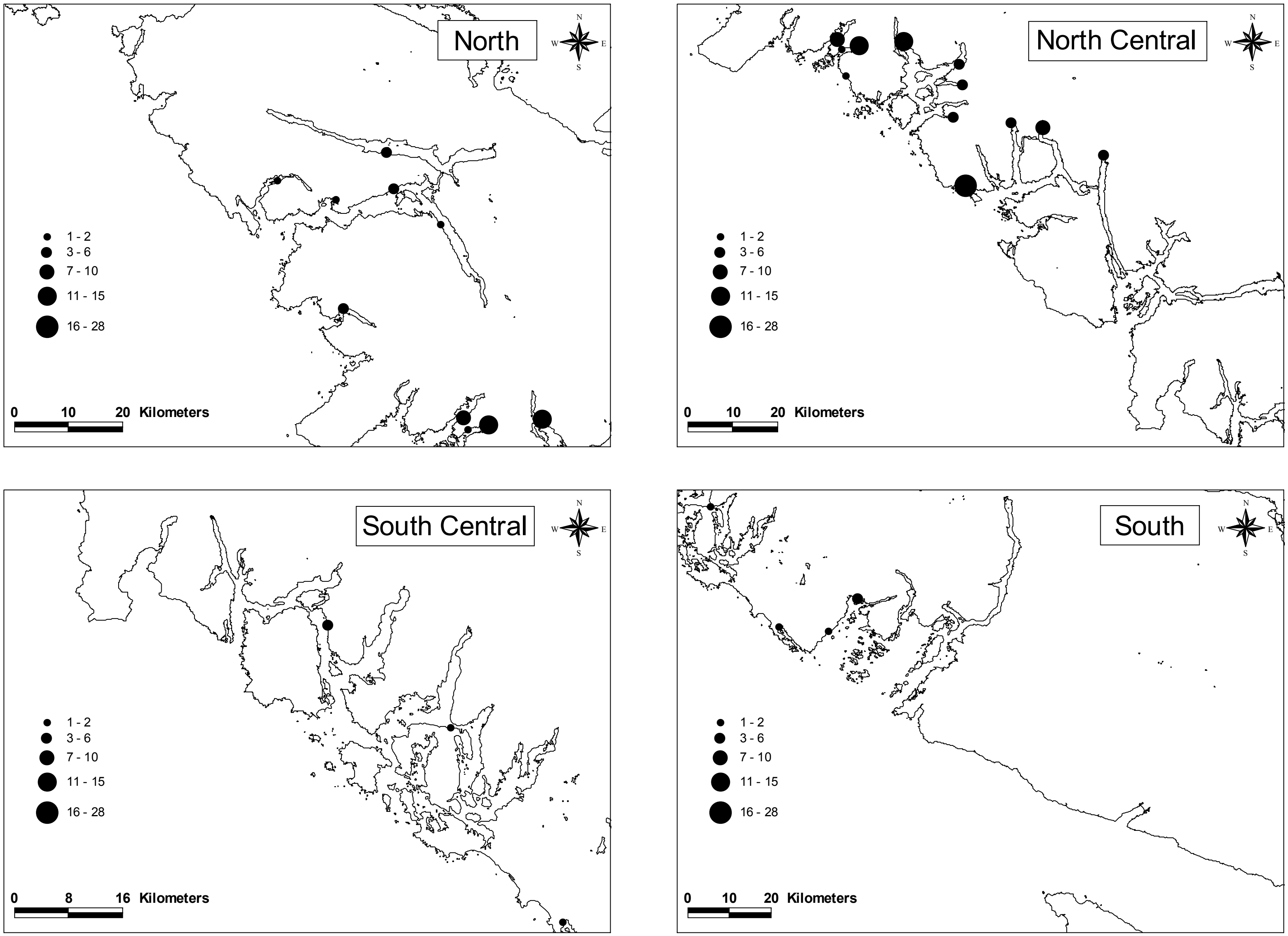


Figure 50. Abundance and distribution of goldeneyes during the third spring survey (27-29 April 1999).

3.3.7 Mergansers

"Mergansers" includes Common Merganser, Red-breasted Merganser and unidentified mergansers. Common Mergansers made up 90% and 95% of all identified mergansers in winter and spring respectively (Tables 3-4).

Merganser abundance ranged from ca. 800 to ca. 1300 birds during different winter and spring surveys and only the late spring survey yielded fewer than 400 birds (Fig. 51). Marine eco-units LCLLM and MBLLS supported the highest number of mergansers (Fig. 52; Tables 5-11). Marine eco-unit MBLLS supported the highest linear densities of mergansers during all surveys, except the second spring survey (Fig. 53; Tables 12-18). A large herring spawn took place in eco-unit MBLLS during the second spring survey, with the majority of birds recorded as "On spawn". Merganser geographical distribution patterns were similar during winter and spring, with birds tending to be observed in protected bays and inlets over the entire study area (Figs. 54-57).

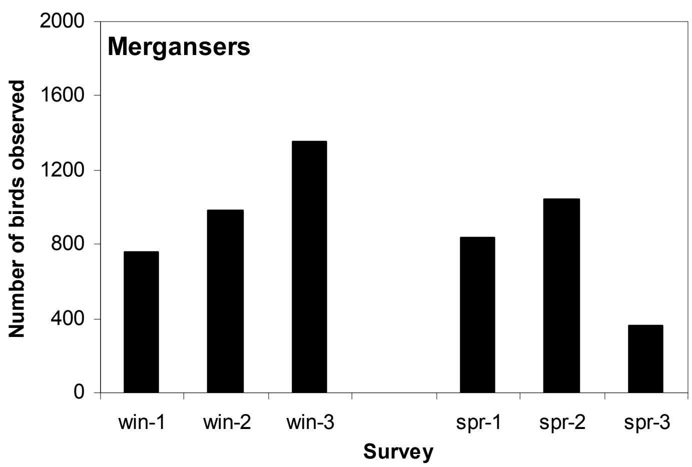
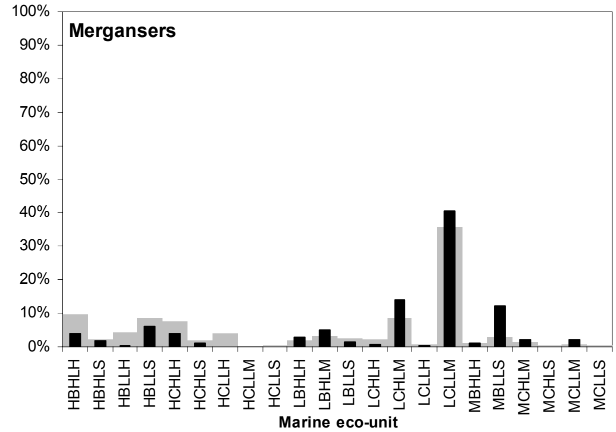
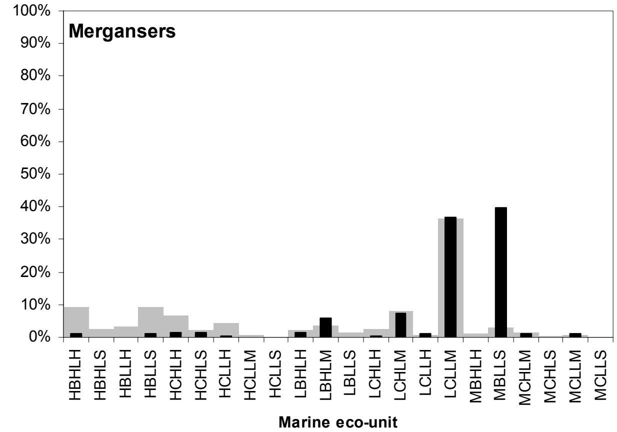


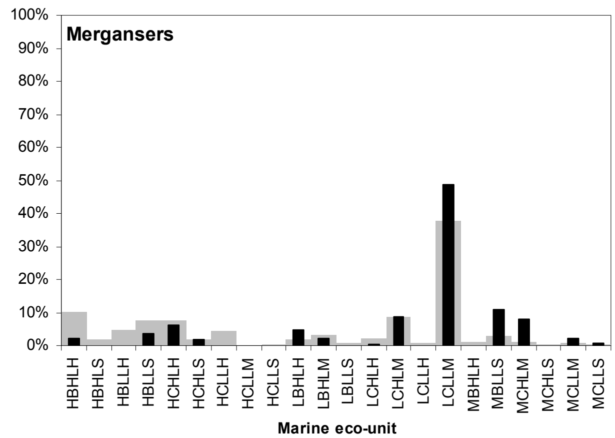
Figure 51. Merganser abundance during winter and spring surveys. See methods for survey date.



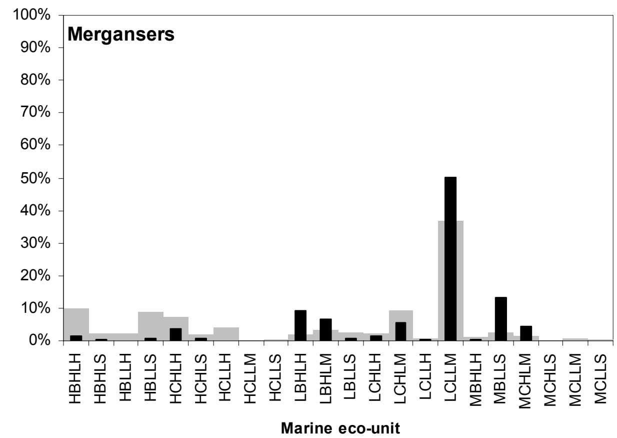
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)

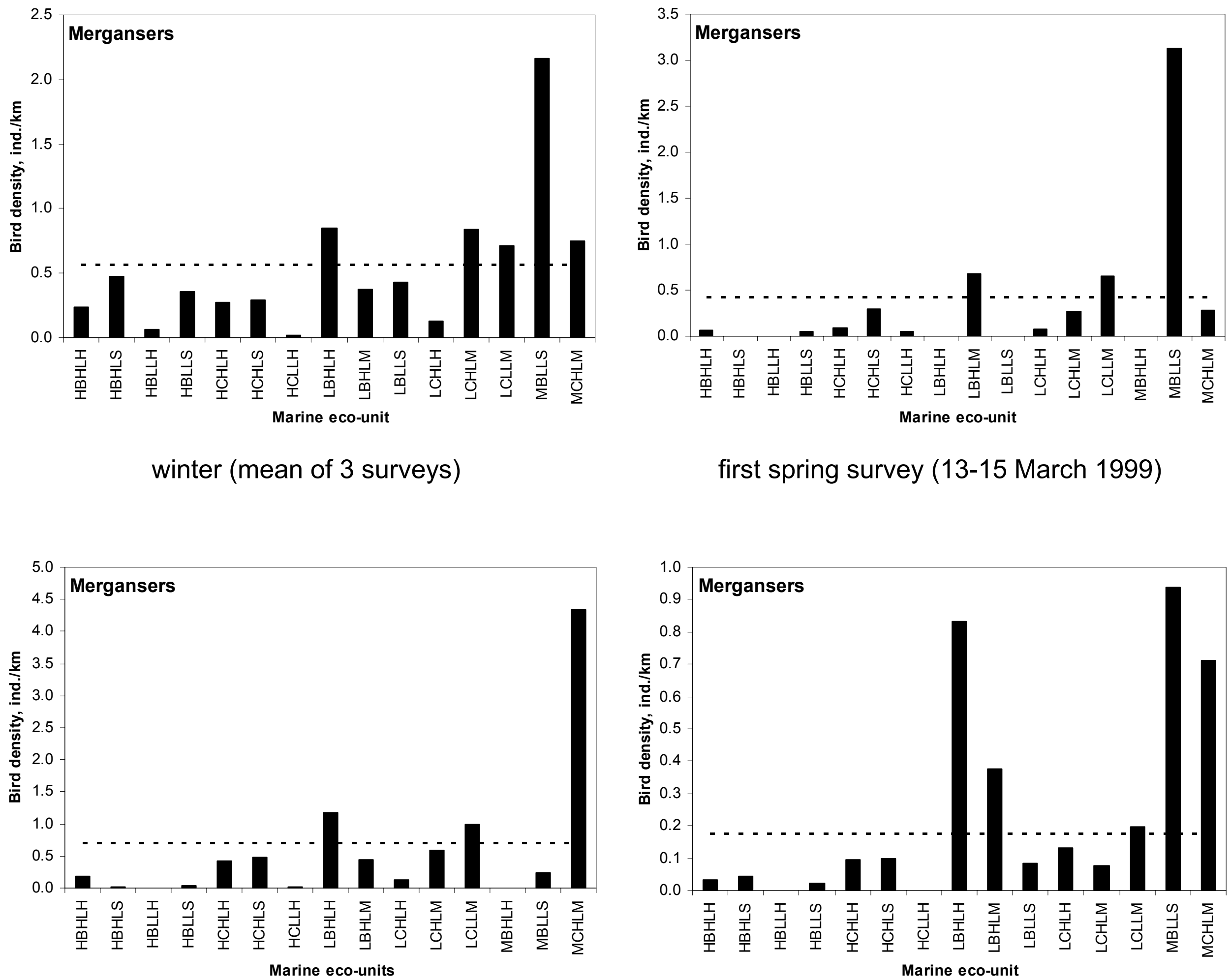


second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 52. Percentage of mergansers observed within different marine eco-units. Black bars indicate the percentage of all mergansers in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.



winter (mean of 3 surveys)

first spring survey (13-15 March 1999)

second spring survey (30 March – 1 April 1999)

third spring survey (27-29 April 1999)

Figure 53. Average linear densities of mergansers in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

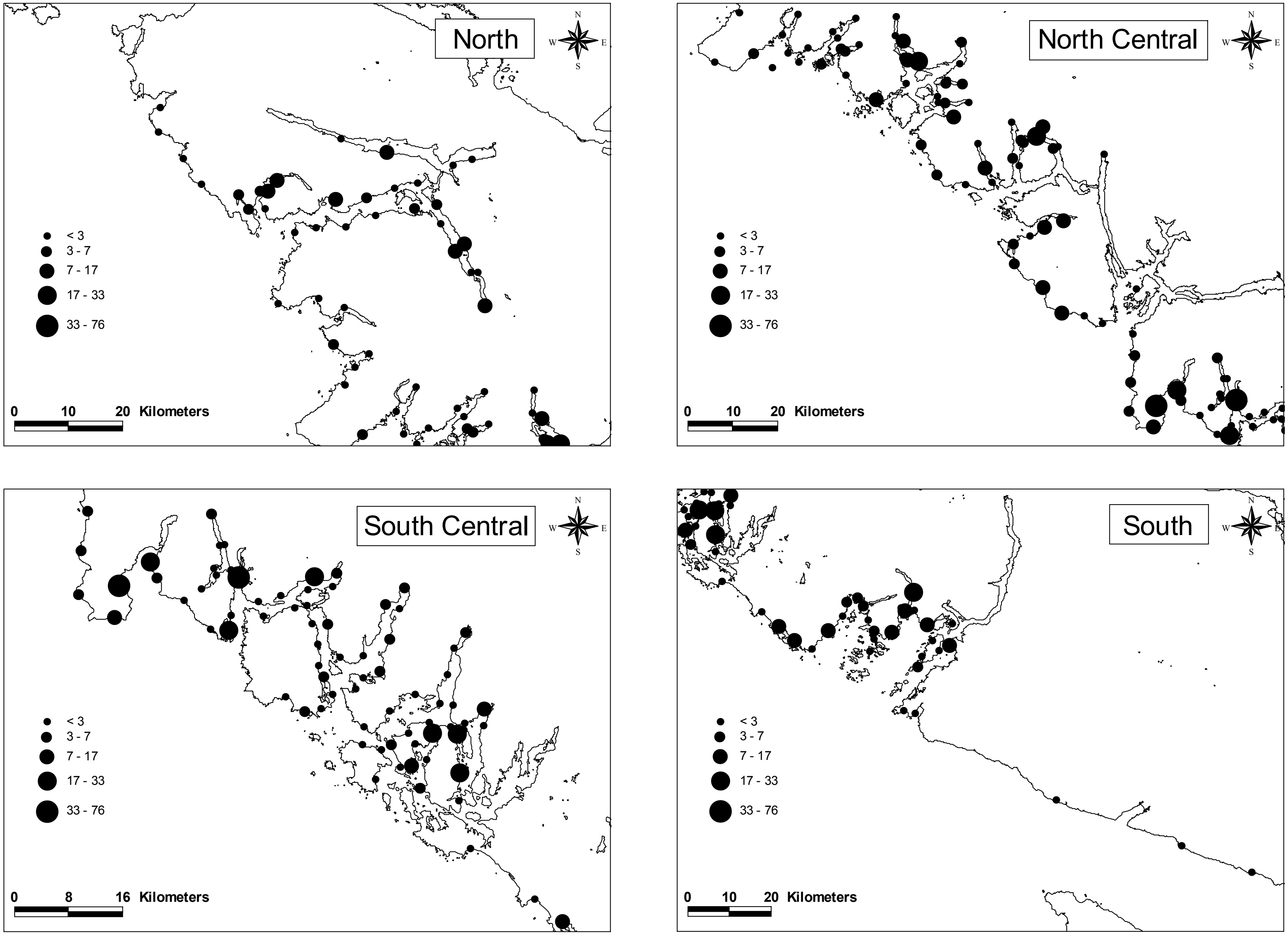


Figure 54. Abundance and distribution of mergansers during winter (mean of 3 winter surveys).

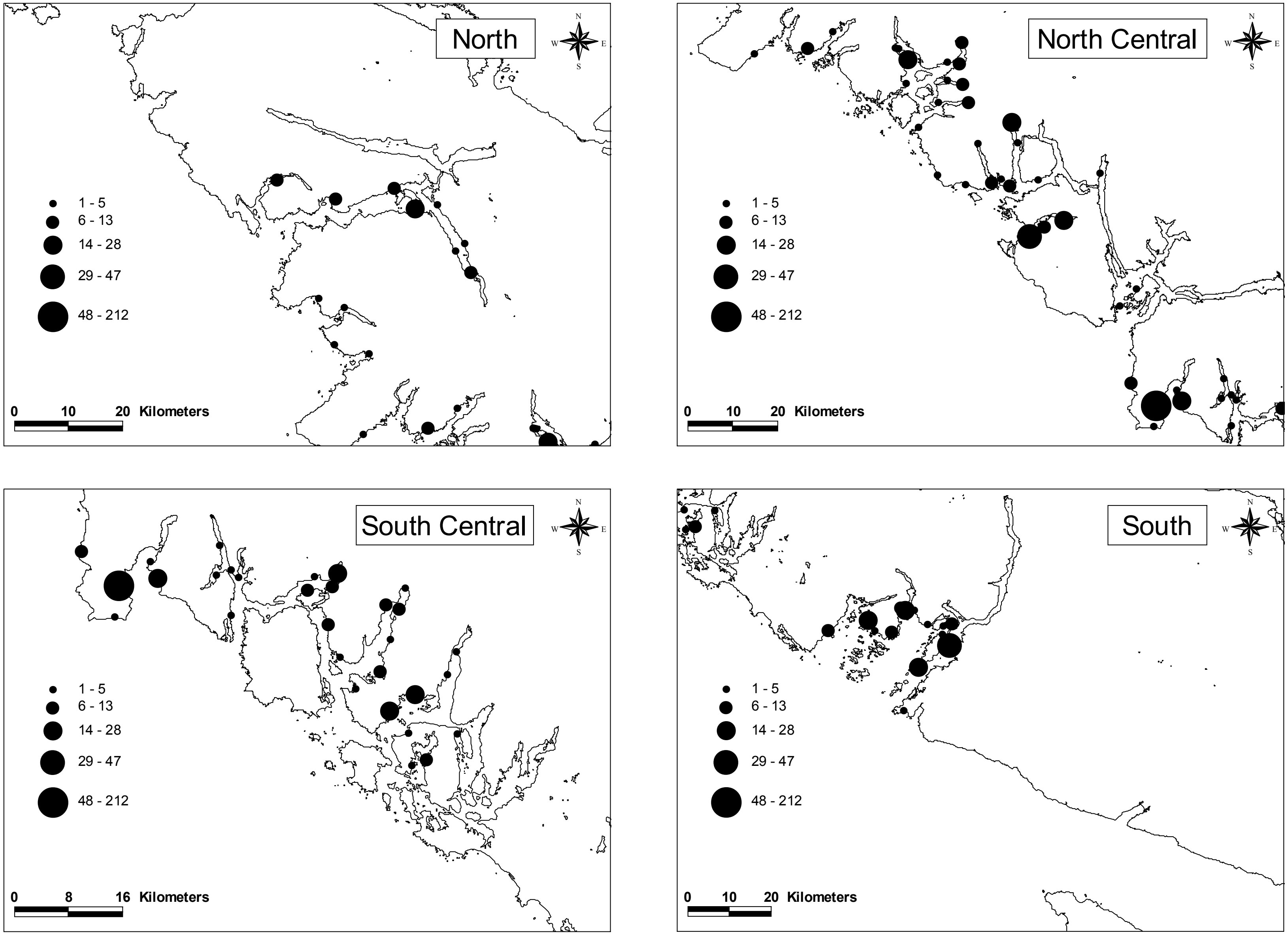


Figure 55. Abundance and distribution of mergansers during the first spring survey (13-15 March 1999).

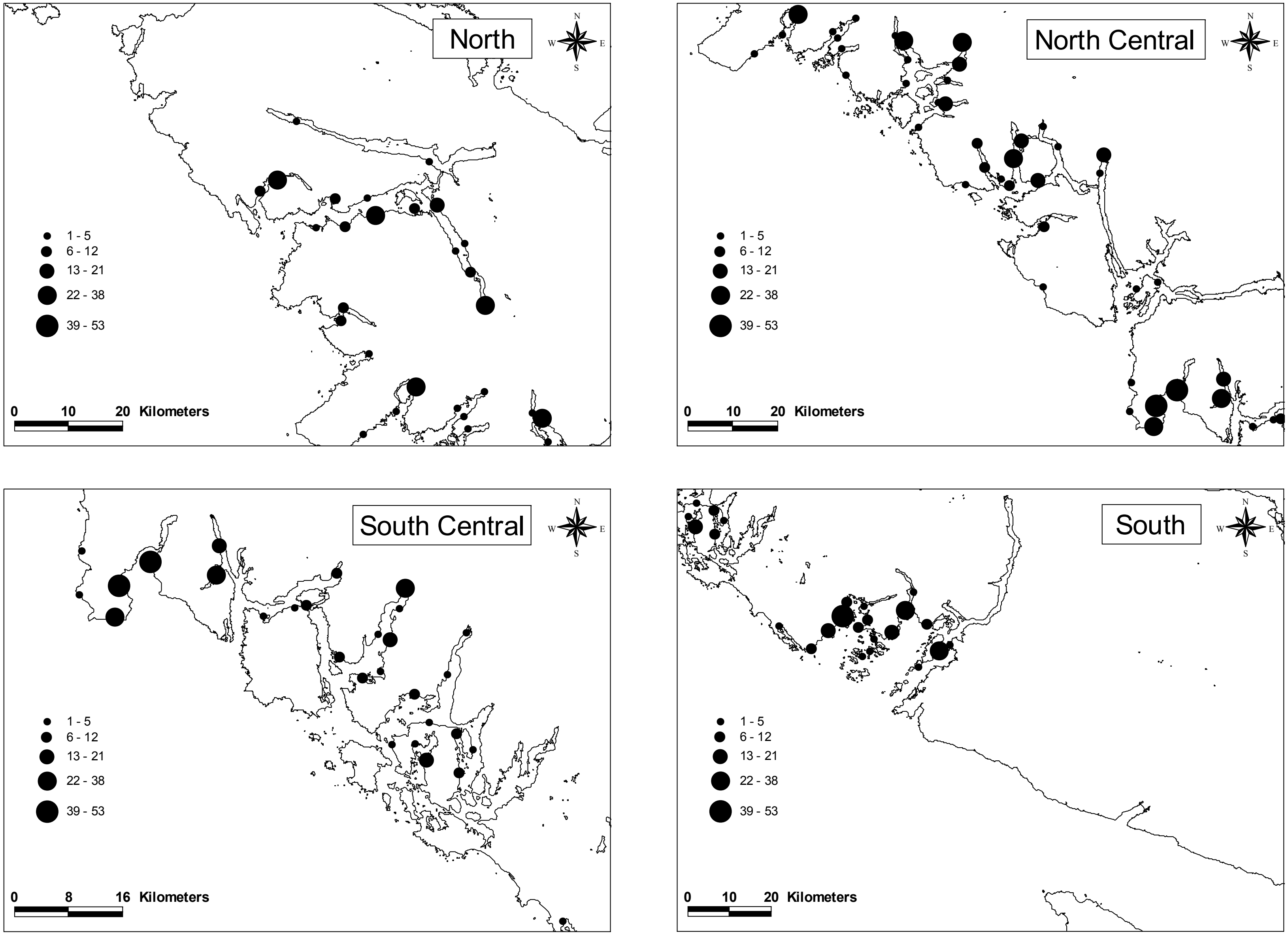


Figure 56. Abundance and distribution of mergansers during the second spring survey (30 March – 1 April 1999).

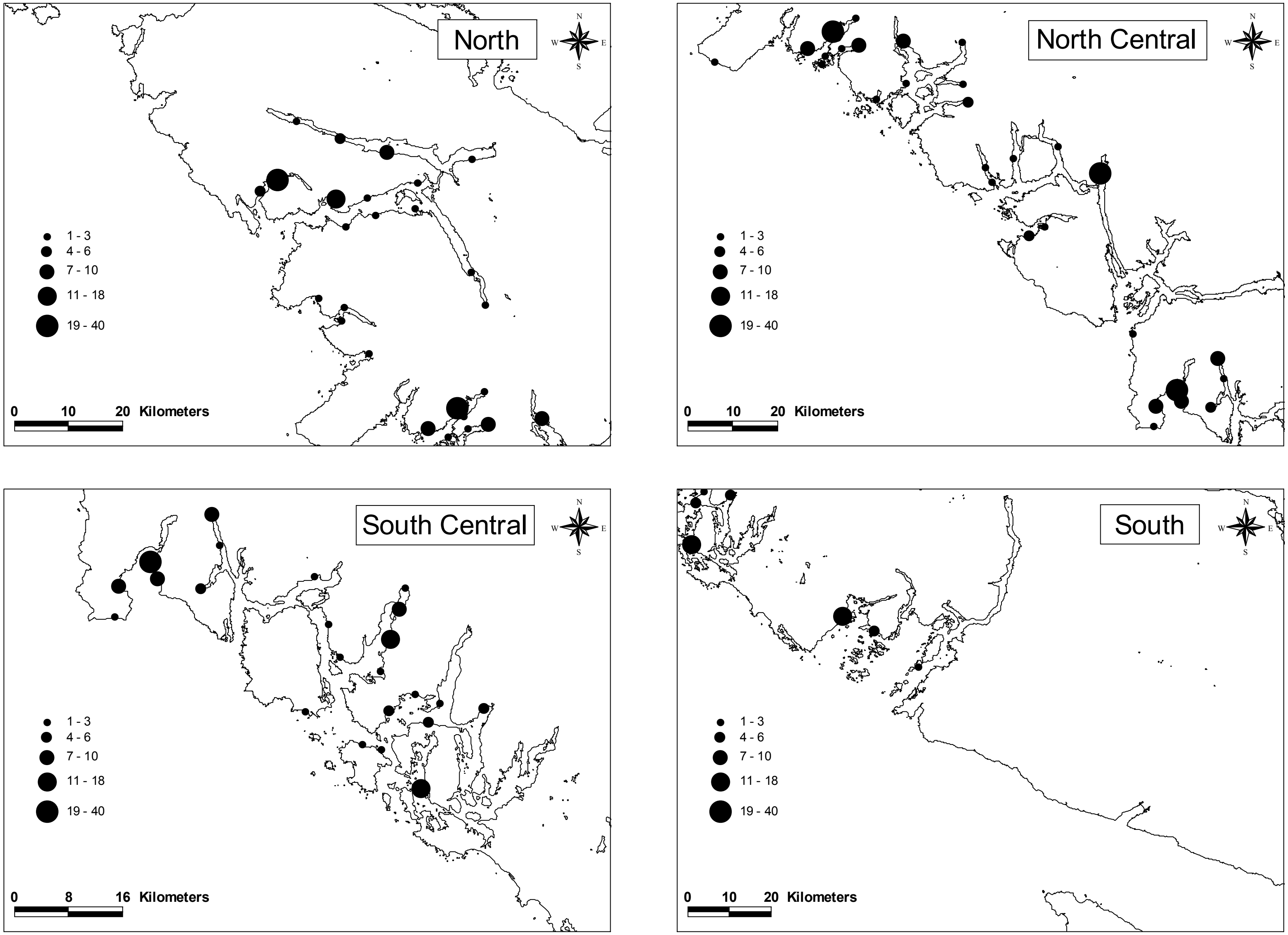


Figure 57. Abundance and distribution of mergansers during the third spring survey (27-29 April 1999).

3.3.8 Gulls

"Gulls" includes Mew Gull, Herring Gull, Glaucous Gull and unidentified gulls. Glaucous Gulls made up 81% of all identified gulls during winter and spring counts (Tables 3-4).

Gulls were the most abundant group of birds observed in the study area during the winter and spring counts. Gull abundance was relatively stable throughout the winter, with surveys averaging at ca. 7500 individuals. During the first spring survey nearly 23,000 birds counted, and more than 15,500 gulls recorded during the second spring survey (Fig. 58). Winter gull distribution was nearly proportional to the area covered by each eco-unit, and only eco-units HBLLS and HCLLH supported more birds than expected (Fig. 59; Table 5). During the first and the second spring surveys eco-unit MBLLS supported more birds than expected (Fig. 59; Tables 9-11). The highest linear densities of gulls in winter were detected in eco-units HCLLH, HBLLS and HBHLS in winter (Fig. 60; Tables 12-15). During spring surveys, bird densities also were high in eco-units associated with herring spawning sites (MBLLS and MCHLM) (Fig. 60, Tables 16-18). Geographically, gulls were widespread over the entire study area both in winter and spring periods (Figs. 61-64).

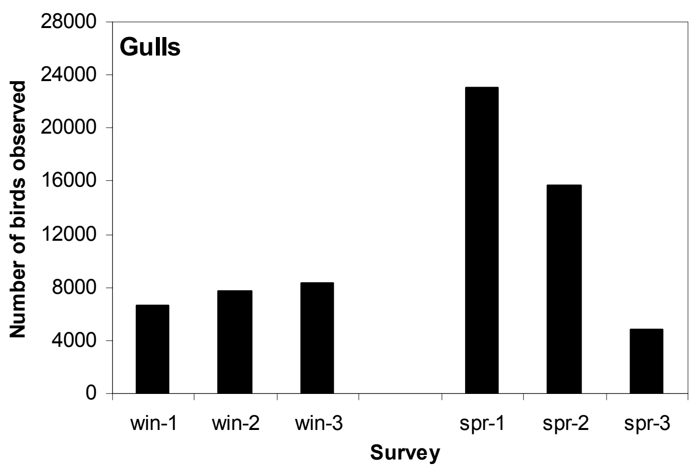
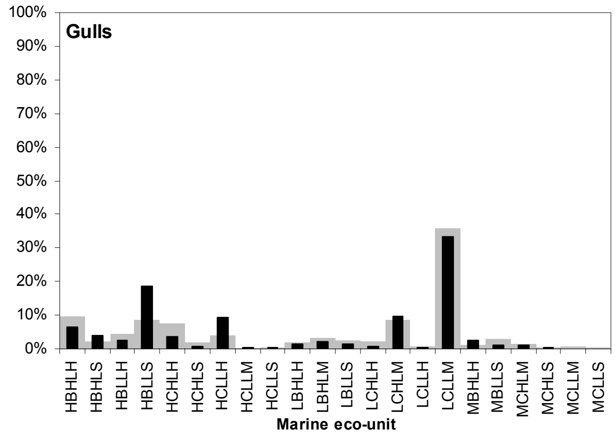
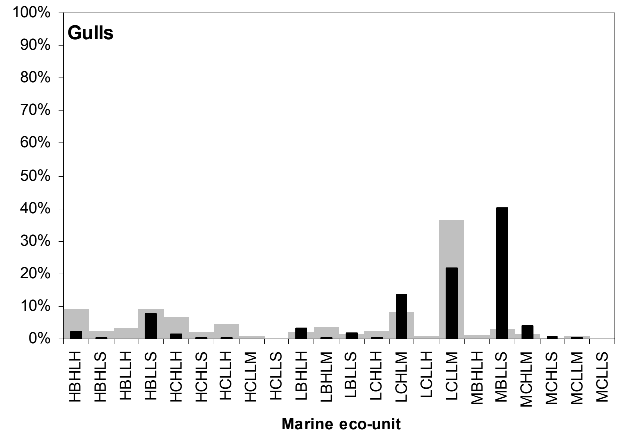


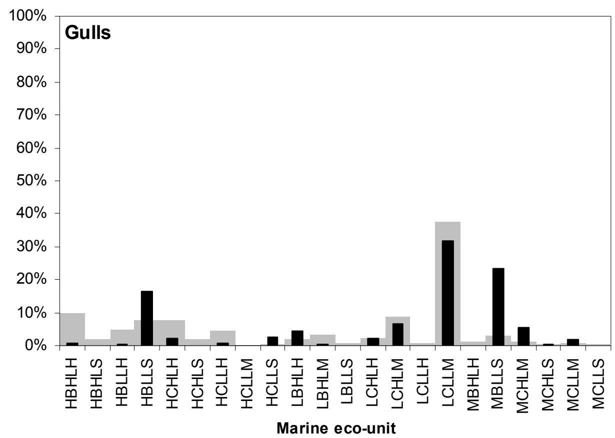
Figure 58. Gull abundance during winter and spring surveys. See methods for survey date.



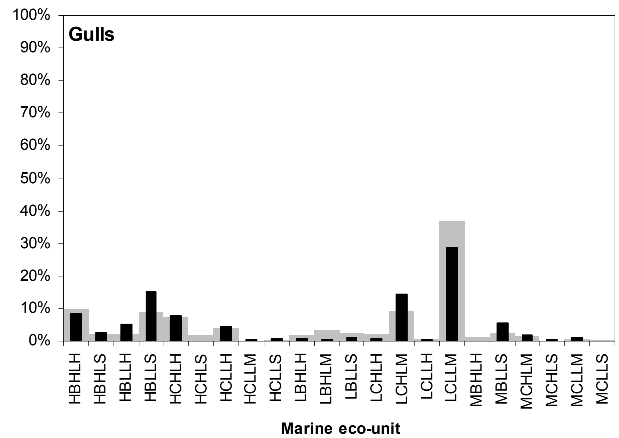
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)

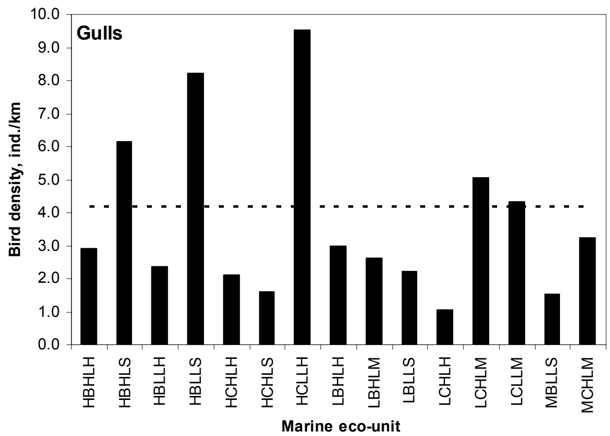


second spring survey (30 March – 1 April 1999)

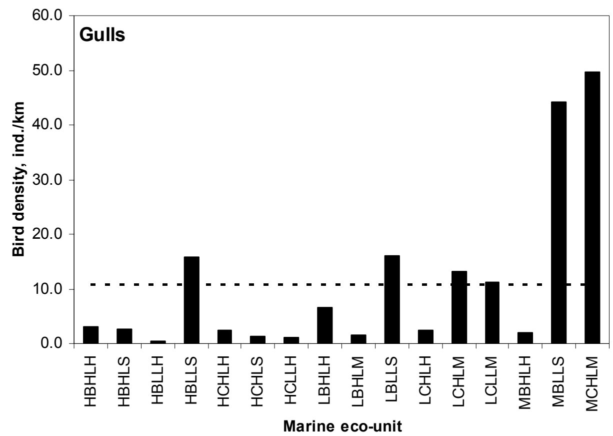


third spring survey (27-29 April 1999)

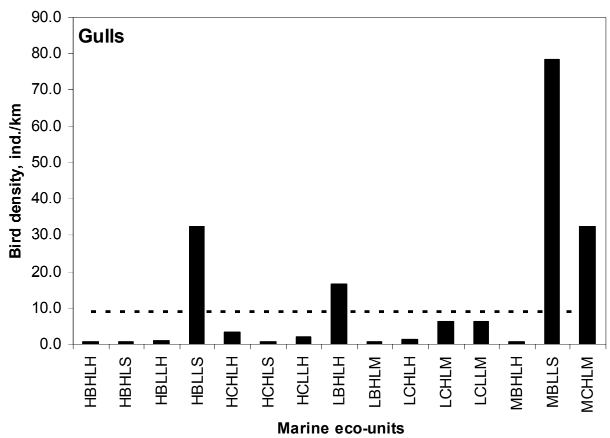
Figure 59. Percentage of gulls observed within different marine eco-units. Black bars indicate the percentage of all gulls in each eco-unit during winter (mean of 3 surveys) and during three separate spring surveys. Shaded bars indicate the percentage of the survey area covered by each eco-unit.



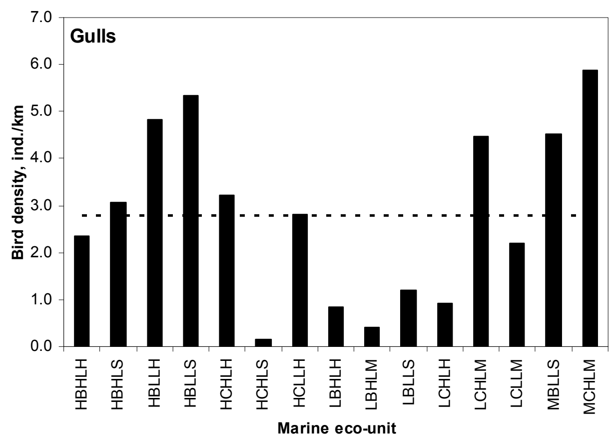
winter (mean of 3 surveys)



first spring survey (13-15 March 1999)



second spring survey (30 March – 1 April 1999)



third spring survey (27-29 April 1999)

Figure 60. Average linear densities of gulls in different marine eco-units in winter (mean of 3 surveys) and during 3 spring surveys (black bars). Dashed line indicates mean density of birds within the entire study area.

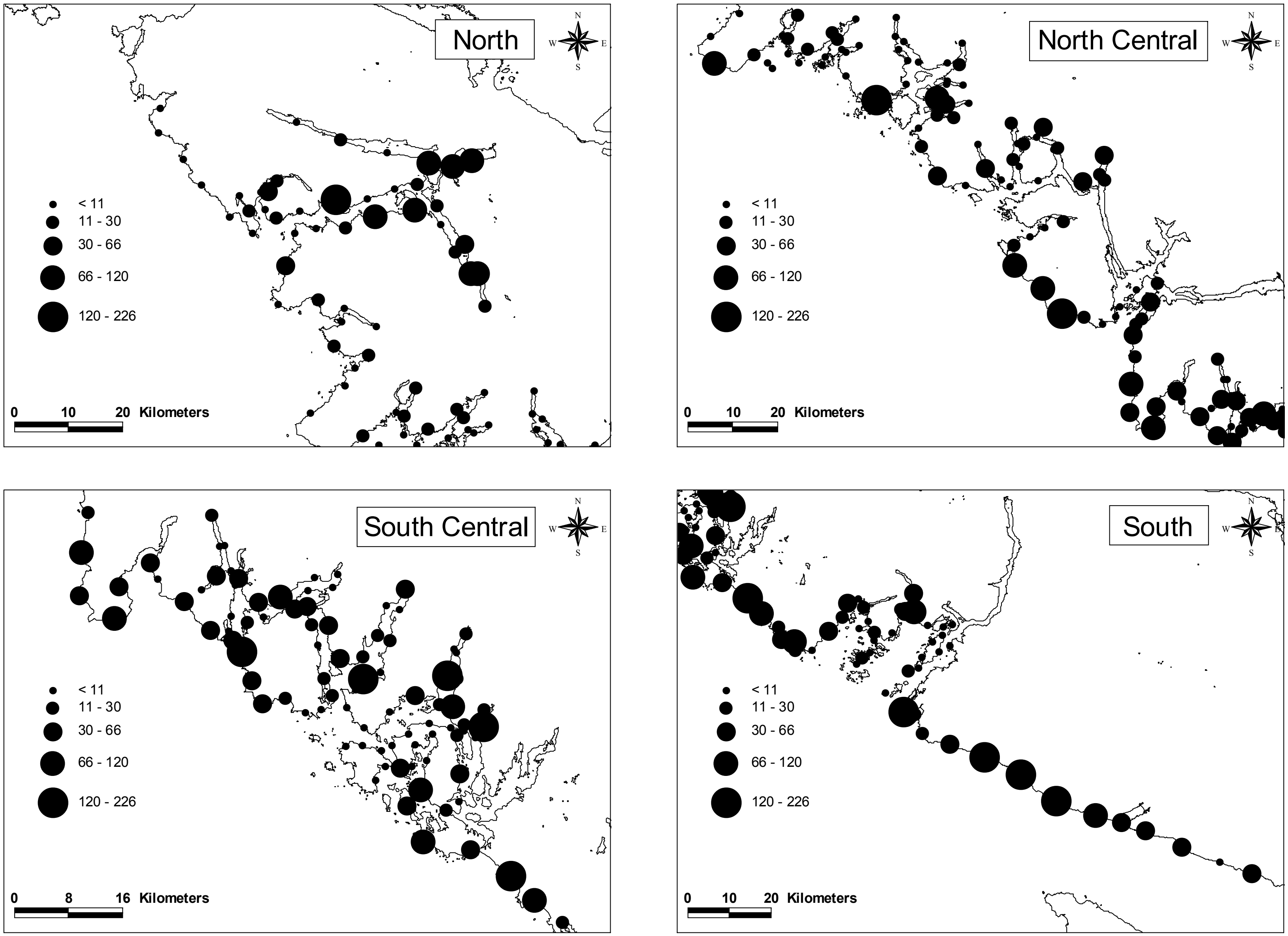


Figure 61. Abundance and distribution of gulls during winter (mean of 3 winter surveys).

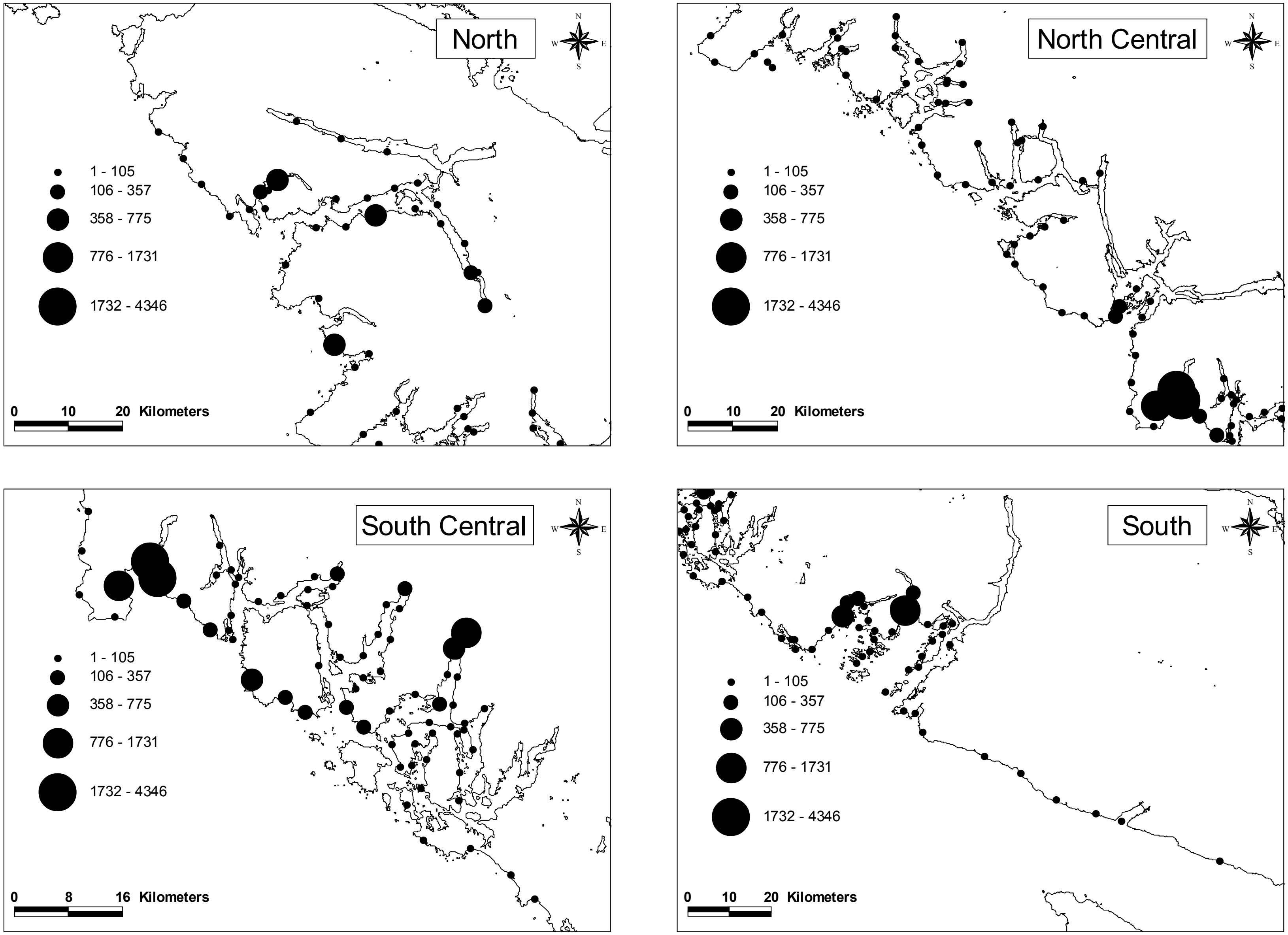


Figure 62. Abundance and distribution of gulls during the first spring survey (13-15 March 1999).

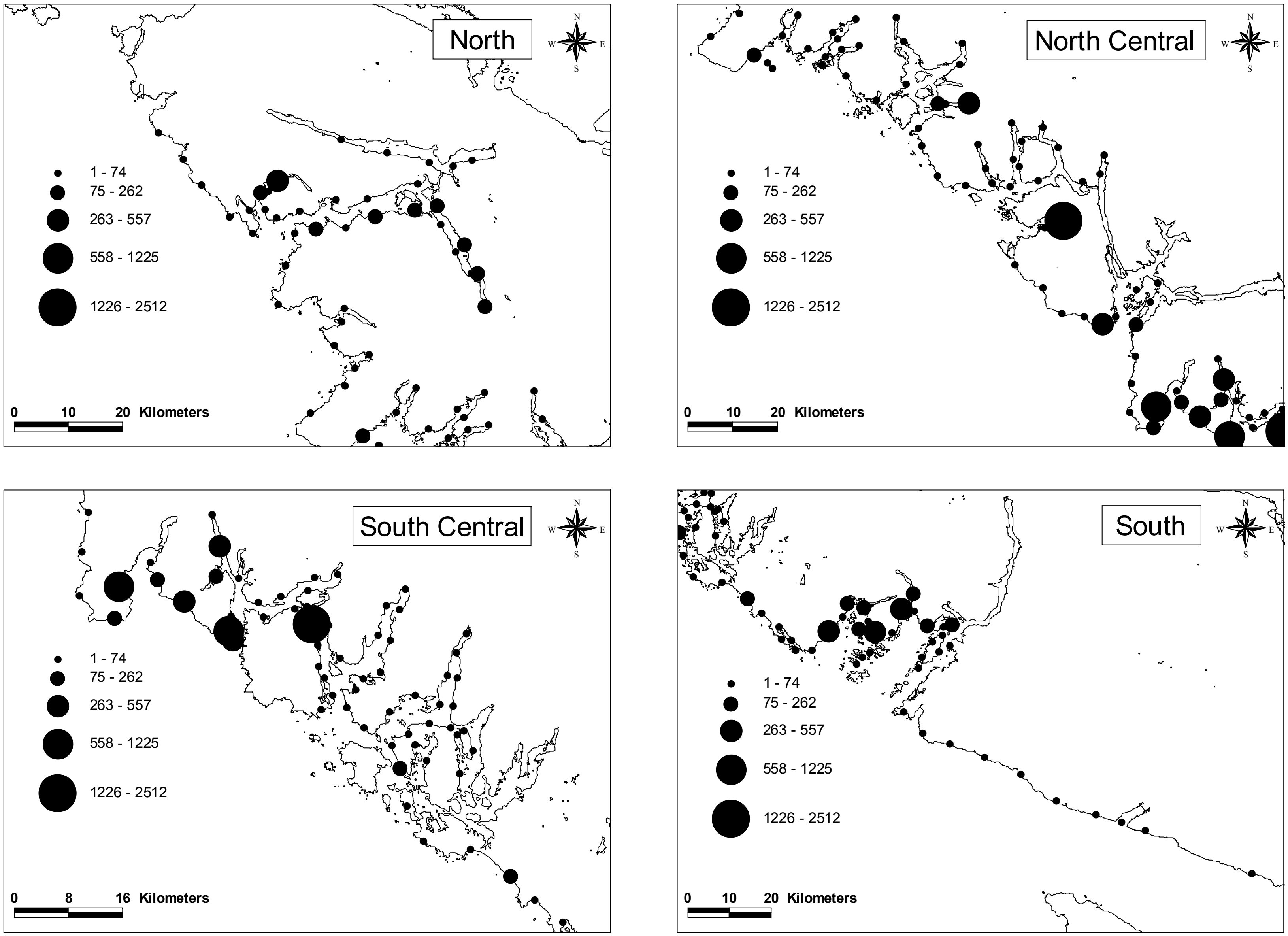


Figure 63. Abundance and distribution of gulls during the second spring survey (30 March – 1 April 1999).

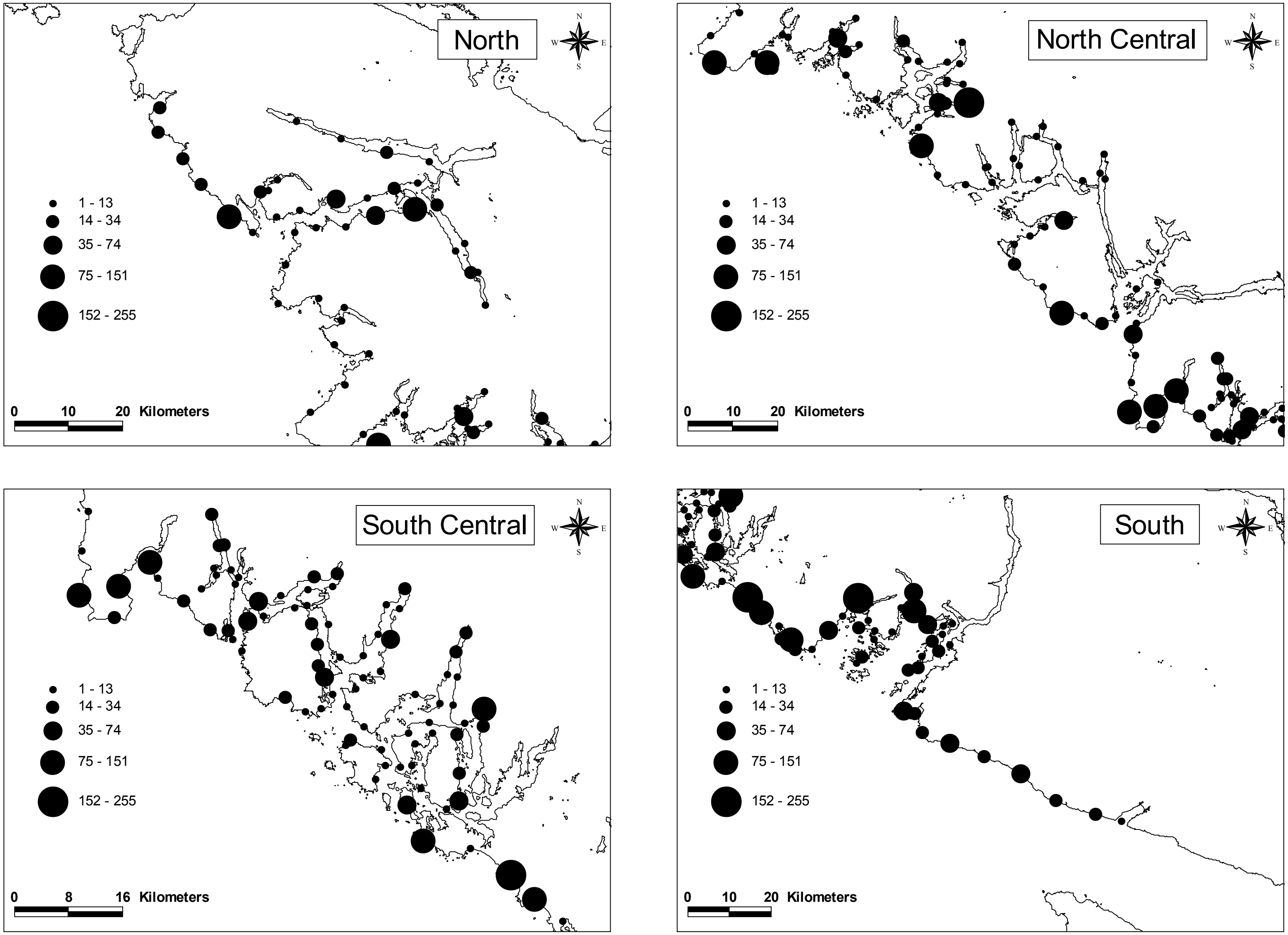


Figure 64. Abundance and distribution of gulls during the third spring survey (27-29 April 1999).

3.4 Waterbirds associated with herring spawn

Herring spawn clearly influenced the abundance and distribution pattern of waterbirds on the west coast of Vancouver Island. During bird surveys in spring 1999, Pacific herring were observed spawning at 11 sites (Fig. 65, Table 19). The spawns ranged from small, restricted ones with little or no waterbirds present, to large spawns with thousands of birds, 40 – 50 whales, hundreds of sea lions, and close to 100 sea otters. The largest spawns occurred in eco-units with moderate to low wave exposure, while spawns occurring in highly exposed eco-units tended to be smaller and have few waterbirds present. Eco-units MBLLS and MCHLM supported large herring spawns and had the greatest number of birds during the first two spring surveys (Table 19). Herring spawn locations identified during the bird surveys (Fig. 65) matched those described by the Department of Fisheries and Oceans (DFO) for the west coast of Vancouver Island (Table 19, Appendix 2). The largest herring spawn events occurred in western Barkley Sound and in Hesquiat Harbour, where spawning occurred over an extensive area and prolonged period of time.

More than 20,000 waterbirds (or nearly half of the total number observed) and about 200 marine mammals were found at spawn sites during each of the first two spring surveys in 1999 (Table 20). Loons and scoters demonstrated the strongest response to herring spawn. More than 90% of all loons detected during the first spring survey and 23% during the second spring survey were at spawn sites. Nearly 62% of all scoters were recorded at herring spawns during the first spring survey and 74% during the second. Grebes, cormorants, mergansers and gulls showed moderate responses to herring spawn, with on average 20-30% of observed birds associated with herring spawn sites during the first and second spring surveys (Table 20). Dabbling ducks and goldeneyes were not observed aggregating at herring spawning sites.

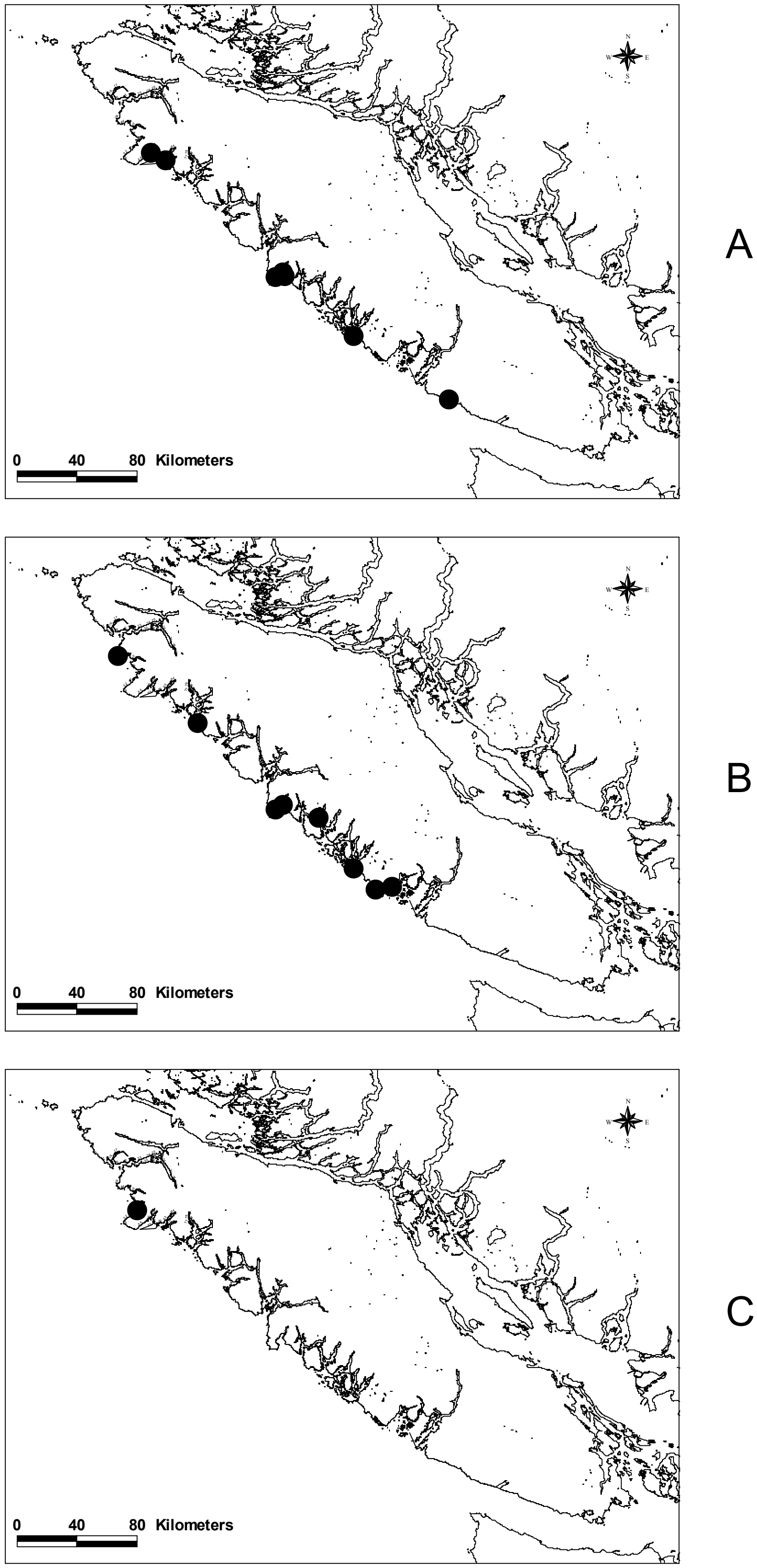


Figure 65. Herring spawn locations observed during three spring surveys in 1999; A – 13-15 March 1999; B – 30 March – 1 April 1999; C – 27-29 April 1999.

Table 19. Date, location, and description of Pacific herring (*Clupea harengus*) spawn sites observed during spring waterbird surveys on the west coast of Vancouver Island, B. C., in 1999.

Date	Location	Eco-unit	Comments
14 March	Southeast coast of Brooks Peninsula (transect 55)	HCHLH	Small spawn: 10 Western Grebes, 4 Pelagic Cormorants, 1 goldeneye, 37 gulls
14 March	Checleset Bay/Bunsby Island (transect 66)	LCLLM	1 Western Grebe, Bald Eagle
14 March	Hesquiat Harbour (transects 143, 144, 145)	MBLLS	Large spawn, thousands of waterbirds
15 March	Wickininnish Bay (transect 232)	HBLLS	1 Pacific Loon, 2 Pelagic Cormorants, 20 scoters, 18 gulls
15 March	West of Tsuquanah Point (transect 277)	HCLLH	1 Pacific Loon, 10 Double-crested Cormorants, 10 Pelagic Cormorants, 2 Surf Scoters, 35 gulls
30 March	Newton Entrance/Brooks Bay (transect 43)	HBHLH	1 Western Grebe, 3 Red-necked Grebes, 1 Pelagic Cormorant, 6 scoters, 1 goldeneye, 3 gulls, 1 Bald Eagle and 3 Sea Otters present
31 March	Clear Passage/Kyuquot Sound (transect 96)	HBHLH	2 red-necked Grebes, 6 scoters, 7 gulls, 3 Bald Eagles present
31 March	Hesquiat Harbour (transect 143, 144)	MBLLS	Many scoters and Long-tailed Ducks still present, well over 100 Sea Nettle Jellyfish (*Cyanea capillata*) sighted in harbour
1 April	Sydney Inlet (transect 221)	LCLLM	2 Pacific Loons, 251 Pelagic Cormorants, 20 scoters, 1,792 gulls and 5 Bald Eagles, 1 sea lion and 4 Grey Whales present
1 April	Ucluth Peninsula (transect 235)	HCLLH	8 Double-crested Cormorants, 6 gulls, 5 Bald Eagles present
1 April	Wickaninnish Bay (transect 232)	HBLLS	1 Western Grebe, 5 gulls present
1 April	Loudoun Channel (transect 241)	MCHLM	325 loons, 14,600 scoters, 175 sea lions present
27 April	N.W. side of Brooks Peninsula (transect 51)	HBHLH	11 gulls, 3 Common Murres, 1 Bald Eagle and 14 sea otters present

[1] The letters of each eco-unit correspond to physical features of the site. The letters, in sequence, represent wave exposure (H = high; M = Moderate; L = Low), Water Depth (B = Photic; C = Shallow; D = Moderate; E = Abyssal), Bottom Relief (H = High; L = Low), Water Currents (H = High; L = Low) and Bottom Substrate (H = Hard; S = Sand; M = Mud; U = Unknown) (Zacharias and Howes 1998).

Table 20. Abundance and percentage of total number of birds at herring spawn locations during surveys in spring 1999.

	Spring-1 (1999/03/13-15)		Spring-2 (1999/03/30-04/01)	
	On spawn	% of total	On spawn	% of total
Loons	7,077	92.6	332	23.1
Grebes	187	15.9	419	23.8
Cormorants	185	20.9	371	26.8
Dabbling Ducks	0	0.0	0	0.0
Scoters	6,187	61.5	15,887	74.0
Goldeneyes	9	1.2	68	4.2
Mergansers	236	28.1	122	11.7
Gulls	9,188	39.8	3,352	21.4
All birds	23,397	49.1	20,877	43.6
Marine mammals	225	32.3	196	12.4

4. USE OF SURVEY RESULTS

Aerial surveys indicate that the west coast of Vancouver Island supports a numerous and diverse community of waterbirds in winter, and is important for staging birds during spring migration.

Our survey design, which was linked to marine eco-units (Zacharias and Howes, 1998), permitted similar effort across replicate surveys. It also allowed us to relate waterbird species abundance and distribution patterns to general environmental features. However, marine eco-units are too coarse to assess specific habitat preferences; waterbirds likely respond to habitat features at a much finer scale in the near-shore zone. Nevertheless, survey design linked to marine eco-units, could be used to extrapolate waterbird abundance and distribution over a large-scale. To illustrate this, we extrapolated winter waterbird abundance for unsurveyed shoreline sections of the west coast of Vancouver Island in three different ways:

1) Proportional projection of abundance per marine eco-unit yielded a total number of 56,514 birds (Table 21).

2) Extrapolation, based on mean linear density within each marine eco-unit, resulted in a total number of 54,112 ± 17,907 (± CI; Table 21).

3) Estimation of the total abundance based on mean linear density of birds per transect, without accounting for eco-units, yielded a total number of 62,604 ± 10,315 (± CI).

Extrapolations using either of above three methods suggested rather similar estimates. However, proportional projection does not account for variability, whereas the extrapolation methods based on linear densities allow for the calculation of confidence intervals.

Table 21. Extrapolation of total wintering waterbird numbers for the entire west coast of Vancouver Island. Extrapolation was based on proportional coverage of each marine eco-unit and average linear densities within marine eco-units.

Marine eco-unit	Total length, km	Percent of total length	Surveyed length, km	Percent surveyed	Observed number of birds (mean of 3 winter surveys)	Proportional projection of waterbird numbers	Mean winter density	Conf. Intervals	Extrapolation of waterbird abundance		
									Lower 95% limit	Mean	Upper 95% limit
HBHLH	356.3	9.2	187.0	52.5	1,427	2,720	8.6	3.32	1,881	3,065	4,249
HBHLS	60.9	1.6	41.9	68.8	752	1,093	16.0	5.93	613	974	1,336
HBLLH	121.6	3.1	84.6	69.6	494	710	6.0	2.70	401	729	1,057
HBLLS	254.1	6.6	165.6	65.1	2,992	4,593	16.0	3.68	3,129	4,065	5,001
HCHLH	240.6	6.2	145.1	60.3	1,213	2,012	9.3	3.24	1,468	2,247	3,026
HCHLS	47.1	1.2	35.4	75.2	224	298	5.9	2.66	150	276	401
HCLLH	110.8	2.9	79.2	71.5	934	1,306	12.6	8.02	507	1,396	2,285
HCLLM	3.5	0.1	2.7	77.6	101	131	37.5	23.45	49	131	212
HCLLS	13.6	0.4	9.6	70.5	51	72	11.1	12.60	0	151	322
LBHLH	61.1	1.6	40.1	65.6	575	876	15.6	7.47	497	954	1,410
LBHLM	143.8	3.7	64.8	45.1	2,144	4,759	24.3	12.27	1,736	3,501	5,266
LBLLS	60.5	1.6	45.9	75.9	885	1167	16.5	11.59	297	998	1,698
LCHLH	105.5	2.7	41.0	38.9	802	2,063	9.2	6.28	312	974	1,637
LCHLM	440.1	11.4	174.0	39.5	2,467	6,239	14.4	4.69	4,268	6,330	8,392
LCLLH	47.8	1.2	11.1	23.2	81	351	7.0	2.11	233	334	435
LCLLM	1473.2	38.1	713.9	48.5	10,052	20,746	16.0	2.76	19,501	23,567	27,632
MBHLH	54.9	1.4	18.4	33.5	314	939	12.9	17.73	0	706	1,680
MBLLS	94.2	2.4	52.2	55.5	2,497	4,502	16.3	5.56	1,012	1,535	2,059
MCHLM	54.1	1.4	28.2	52.1	361	693	14.0	6.58	404	760	1,116
MCHLS	24.7	0.6	6.3	25.3	21	82	3.4	5.16	0	85	212
MCLLM	81.3	2.1	13.1	16.1	289	1,801	15.8	14.76	83	1,283	2,482
MCLLS	20.1	0.5	4.6	22.9	12	51	2.5	2.88	0	51	109
Total	3869.8	100.0	1964.4	50.8	28,689	56,514			36,543	54,112	72,019

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Zacharias, M.A., and D.E. Howes, 1998. An analysis of marine protected areas in British Columbia using a Marine Ecological Classification. Natural Areas Journal 18: 4-13.

APPENDIX 1: Transect start/end point coordinates

Table 1-1. Transect start/end point coordinates, used during waterbird surveys along west coast of Vancouver Island in spring 1999 and winter 2000.

Point ID	LAT	LONG	Point ID	LAT	LONG	Point ID	LAT	LONG
1	50 34 52	-127 26 25	55	50 07 52	-127 41 09	105	49 52 17	-126 55 48
2	50 34 25	-127 31 09	56	50 10 34	-127 37 43	106	49 57 49	-126 56 26
3	50 33 35	-127 33 49	57	50 10 21	-127 37 30	107	49 58 04	-126 55 49
4	50 34 55	-127 37 10	58	50 07 29	-127 38 01	108	49 55 53	-126 54 44
5	50 35 46	-127 45 53	59	50 08 01	-127 38 52	109	49 57 38	-126 53 47
6	50 37 08	-127 52 25	60	50 06 00	-127 45 06	110	49 57 32	-126 53 45
7	50 38 51	-128 00 35	61	50 05 12	-127 37 55	111	49 55 43	-126 54 38
8	50 39 53	-128 17 15	62	50 06 44	-127 35 40	112	49 52 08	-126 54 33
9	50 38 21	-128 19 42	63	50 07 39	-127 32 36	113	49 53 17	-126 48 55
10	50 35 30	-128 15 26	64	50 10 44	-127 27 44	114	49 58 06	-126 51 21
11	50 32 16	-128 13 11	65	50 10 42	-127 27 19	115	49 58 08	-126 50 41
12	50 30 27	-128 09 48	66	50 07 20	-127 30 60	116	49 53 24	-126 46 14
13	50 27 39	-128 03 51	67	50 06 31	-127 32 24	117	49 51 34	-126 40 23
14	50 26 38	-128 02 38	68	50 06 35	-127 29 53	118	49 54 41	-126 39 42
15	50 29 55	-128 05 12	69	50 07 57	-127 26 59	119	49 54 41	-126 39 13
16	50 29 20	-128 02 58	70	50 07 33	-127 26 26	120	49 49 44	-126 39 13
17	50 32 14	-128 00 26	71	50 06 44	-127 28 50	121	49 47 55	-126 44 27
18	50 32 01	-128 00 17	72	50 02 09	-127 25 22	122	49 47 59	-126 49 29
19	50 30 01	-128 02 02	73	50 02 39	-127 18 09	123	49 45 59	-126 51 42
20	50 28 12	-128 00 33	74	50 04 44	-127 16 24	124	49 45 36	-126 54 51
21	50 28 15	-127 58 02	75	50 08 12	-127 18 04	125	49 43 29	-126 57 09
22	50 28 46	-127 53 47	76	50 07 16	-127 17 32	126	49 43 14	-126 56 59
23	50 29 44	-127 47 29	77	50 07 17	-127 17 54	127	49 40 18	-126 53 02
24	50 30 59	-127 42 34	78	50 08 32	-127 17 54	128	49 37 17	-126 49 42
25	50 32 01	-127 39 12	79	50 10 52	-127 18 39	129	49 36 16	-126 43 55
26	50 30 49	-127 35 52	80	50 10 36	-127 18 16	130	49 35 27	-126 41 51
27	50 27 33	-127 31 26	81	50 07 38	-127 15 12	131	49 35 31	-126 37 06
28	50 24 32	-127 29 15	82	50 05 46	-127 10 15	132	49 36 24	-126 37 01
29	50 22 01	-127 26 24	83	50 07 38	-127 05 60	133	49 38 09	-126 35 28
30	50 22 03	-127 26 56	84	50 08 02	-127 05 30	134	49 40 53	-126 31 49
31	50 24 13	-127 29 60	85	50 04 43	-127 09 26	135	49 39 06	-126 28 60
32	50 26 44	-127 31 60	86	50 04 03	-127 07 18	136	49 36 30	-126 31 23
33	50 29 28	-127 35 12	87	50 03 41	-127 07 18	137	49 35 15	-126 32 55
34	50 29 27	-127 41 06	88	50 03 37	-127 10 22	138	49 35 03	-126 33 23
35	50 28 56	-127 46 28	89	50 03 31	-127 10 45	139	49 32 06	-126 34 13
36	50 28 12	-127 51 14	90	50 01 23	-127 11 55	140	49 30 24	-126 33 29
37	50 27 30	-127 56 08	91	50 01 37	-127 06 44	141	49 26 39	-126 33 21
38	50 26 09	-127 56 21	92	50 01 11	-127 06 44	142	49 22 34	-126 32 60
43	50 21 03	-127 59 43	93	50 00 06	-127 09 20	143	49 23 35	-126 27 48
44	50 19 09	-127 57 07	94	49 59 55	-127 09 24	144	49 26 41	-126 27 46
45	50 18 27	-127 50 24	95	49 59 58	-127 11 20	145	49 26 51	-126 25 56
46	50 18 51	-127 45 48	96	49 57 60	-127 15 12	146	49 24 46	-126 24 28
47	50 18 34	-127 46 05	97	49 54 08	-127 11 35	147	49 22 43	-126 19 57
48	50 17 35	-127 51 35	98	49 51 25	-127 08 13	148	49 21 03	-126 16 28
49	50 14 45	-127 46 42	99	49 51 04	-127 00 23	149	49 20 54	-126 15 46
50	50 14 07	-127 45 50	100	49 52 13	-126 59 54	150	49 21 27	-126 15 23
51	50 13 26	-127 47 19	101	49 55 39	-127 02 30	151	49 24 18	-126 15 20
52	50 10 09	-127 50 52	102	49 55 24	-127 02 04	152	49 26 43	-126 16 14
53	50 07 48	-127 55 22	103	49 52 27	-126 59 17	153	49 25 43	-126 17 58
54	50 04 51	-127 48 12	104	49 51 37	-126 58 08	154	49 25 48	-126 18 14

Table 1-1 continued….

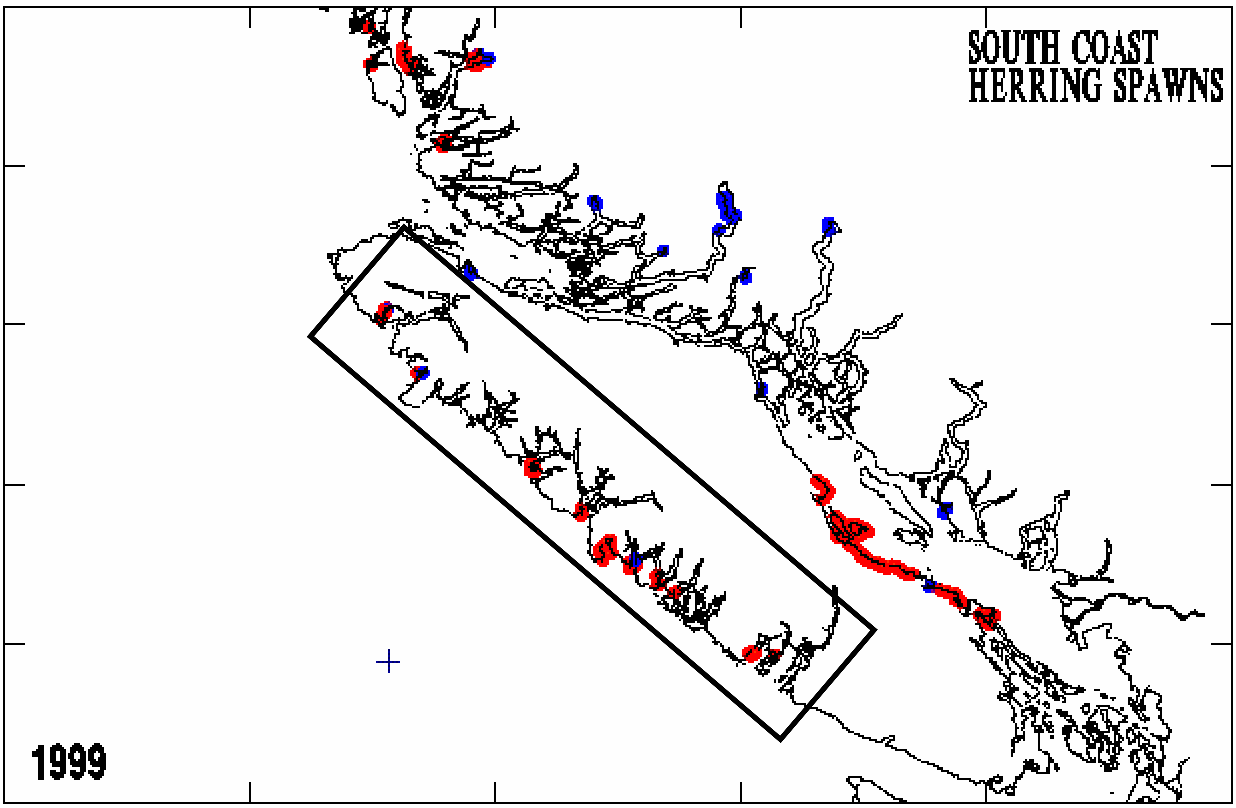
Point ID	LAT	LONG	Point ID	LAT	LONG	Point ID	LAT	LONG
155	49 27 13	-126 16 43	205	49 07 19	-125 48 07	255	48 57 45	-125 03 58
156	49 30 00	-126 17 44	206	49 08 53	-125 47 39	256	48 58 25	-125 02 07
157	49 29 58	-126 17 15	207	49 11 54	-125 47 38	257	48 56 35	-125 01 11
158	49 27 15	-126 15 58	208	49 11 43	-125 46 47	258	48 55 06	-125 00 55
159	49 26 06	-126 15 06	209	49 08 59	-125 57 44	259	48 56 30	-125 02 45
160	49 25 26	-126 14 13	210	49 10 33	-125 57 27	260	48 57 15	-125 04 02
161	49 24 07	-126 09 02	211	49 11 42	-125 56 32	261	48 55 30	-125 06 29
162	49 25 27	-126 07 26	212	49 12 37	-125 58 22	262	48 53 03	-125 09 04
163	49 26 05	-126 03 17	213	49 13 03	-126 00 44	263	48 51 60	-125 10 23
164	49 25 46	-126 02 24	214	49 12 58	-126 01 08	264	48 53 47	-125 05 25
165	49 25 13	-126 04 12	215	49 12 19	-126 02 26	265	48 56 03	-125 13 51
166	49 24 37	-126 07 36	216	49 14 58	-126 04 57	266	48 56 50	-125 19 40
167	49 23 37	-126 04 57	217	49 15 42	-126 03 21	267	48 56 32	-125 19 51
168	49 20 27	-126 03 37	218	49 17 45	-126 03 43	268	48 54 21	-125 15 32
169	49 19 18	-126 00 00	219	49 18 32	-126 04 52	269	48 53 58	-125 15 36
170	49 20 39	-125 58 57	220	49 19 47	-126 04 37	270	48 54 43	-125 21 11
171	49 22 34	-125 57 11	221	49 21 37	-126 04 52	271	48 54 19	-125 21 49
172	49 24 32	-125 54 49	222	49 23 25	-126 06 04	272	48 52 35	-125 16 27
173	49 24 30	-125 53 56	223	49 23 20	-126 09 56	273	48 46 52	-125 12 32
174	49 22 25	-125 56 01	224	49 23 42	-126 13 54	274	48 46 14	-125 09 23
175	49 20 02	-125 57 12	225	49 21 38	-126 14 02	275	48 45 52	-125 07 59
176	49 18 05	-125 58 14	226	49 18 51	-126 14 16	276	48 43 11	-125 05 25
177	49 18 23	-126 00 59	227	49 16 50	-126 12 57	277	48 42 04	-124 58 30
178	49 17 12	-126 01 56	228	49 16 05	-126 10 35	278	48 40 13	-124 51 33
179	49 14 41	-126 00 48	229	49 15 23	-126 08 14	279	48 36 39	-124 45 01
180	49 13 47	-125 57 57	230	49 09 09	-125 55 26	280	48 34 07	-124 37 18
181	49 16 13	-125 54 19	231	49 06 33	-125 52 55	281	48 32 34	-124 29 49
182	49 15 26	-125 52 08	232	49 03 43	-125 49 21	282	48 32 08	-124 27 23
183	49 17 23	-125 49 58	233	49 03 08	-125 43 21	283	48 30 21	-124 20 03
184	49 19 26	-125 48 37	234	49 00 34	-125 40 47	284	48 27 43	-124 13 09
185	49 21 15	-125 47 31	235	48 58 32	-125 37 10	285	48 25 55	-124 06 24
186	49 21 03	-125 47 02	236	48 55 18	-125 32 40			
187	49 19 09	-125 47 39	237	48 55 34	-125 31 38			
188	49 16 57	-125 48 24	238	48 57 29	-125 34 21			
189	49 14 49	-125 48 47	239	48 57 58	-125 34 06			
190	49 14 52	-125 45 32	240	48 55 18	-125 30 37			
191	49 14 58	-125 44 14	241	48 56 37	-125 26 46			
192	49 13 15	-125 45 17	242	48 58 49	-125 23 32			
193	49 13 20	-125 46 20	243	49 00 29	-125 21 45			
194	49 14 03	-125 47 46	244	49 02 09	-125 21 20			
195	49 14 15	-125 49 42	245	49 01 31	-125 17 59			
196	49 14 28	-125 53 10	246	48 59 58	-125 18 24			
197	49 13 26	-125 55 59	247	48 58 19	-125 19 05			
198	49 11 52	-125 55 26	248	48 58 07	-125 18 58			
199	49 10 19	-125 54 38	249	48 56 43	-125 14 16			
200	49 11 56	-125 53 07	250	48 58 28	-125 11 39			
201	49 12 35	-125 51 37	251	49 02 08	-125 09 23			
202	49 12 15	-125 51 17	252	49 02 07	-125 08 45			
203	49 10 12	-125 51 56	253	48 59 06	-125 09 48			
204	49 08 02	-125 51 15	254	48 59 26	-125 07 38			

APPENDIX 2: Data on herring spawn

Herring spawning locations in 1999 from DFO website:

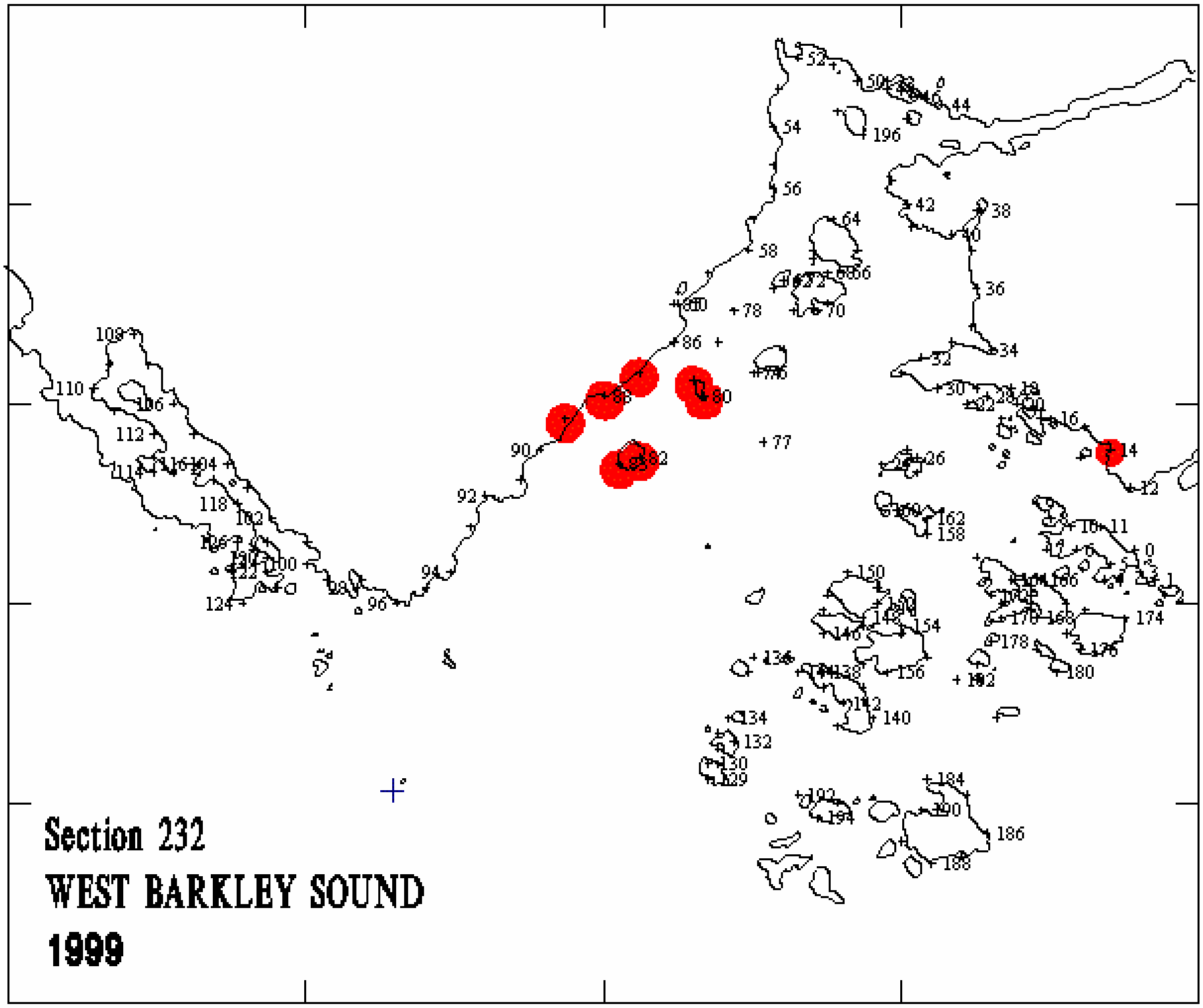
http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/GIF/BC_South.GIF

(Last accessed on 15 July 2004)



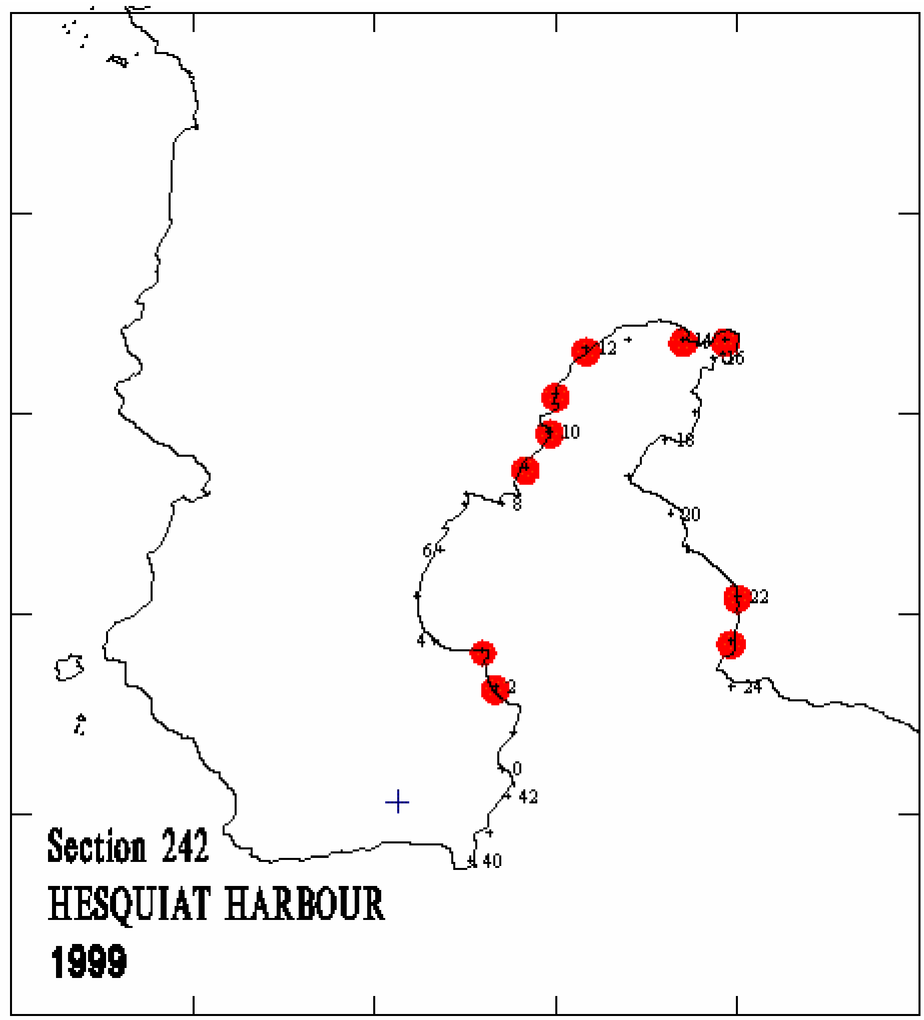
HERRING SPAWN SUMMARY - Region 6: west coast Vancouver Island (rectangle)
Spawn Habitat Index = Sum of [length*median(width*layers)]
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

Year	1999
Total records	43
Spawn habitat index	2095246
Total length, m	57910
Mean width, m	106
Mean layers	1.79
Spawn date (DOY)	
Mean	81.4 (Mar-22)
St.Dev.	8.51
Wgt	*
Min	63 (Mar-4)
Max	90 (Mar-31)
Diver survey, %	99



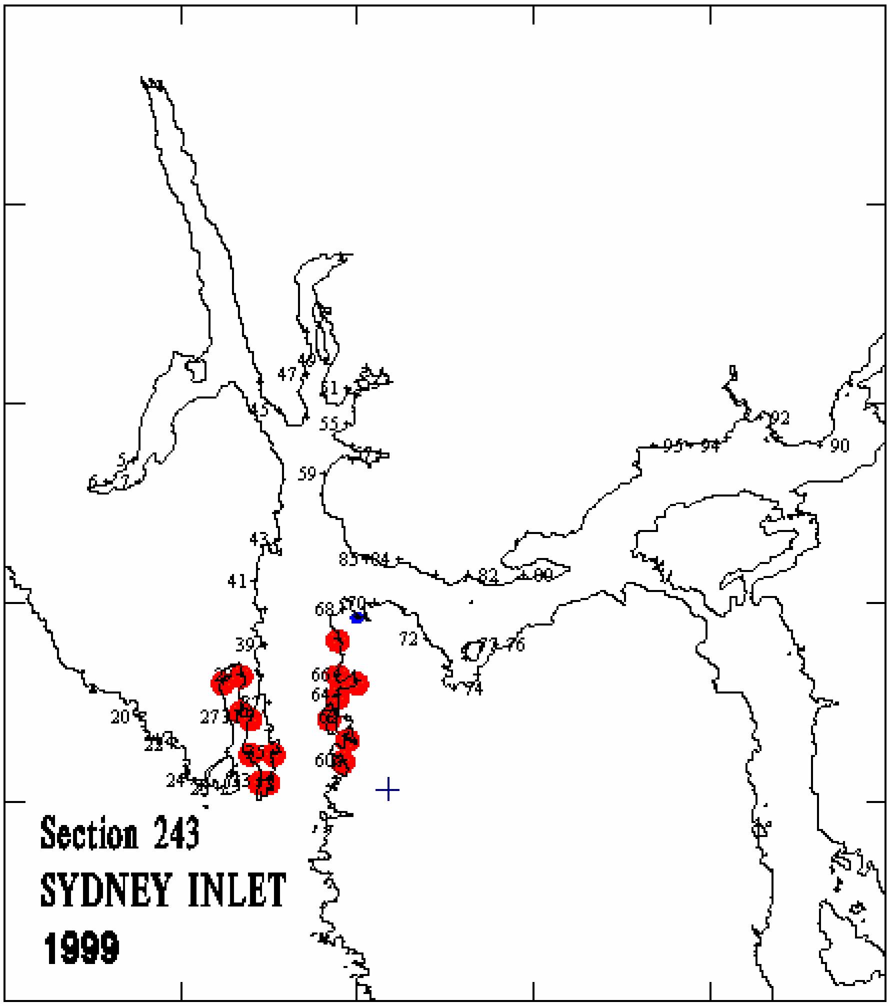
HERRING SPAWN SUMMARY - Section 232 (West Barkley Sound)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

Year	1999
Total records	5
Spawn habitat index	266679
Total length, m	5400
Mean width, m	228
Mean layers	2.04
Spawn date (DOY)	
Mean	82.2 (Mar – 23)
St.Dev.	4.60
Wgt	81.8 (Mar – 22)
Min	79 (Mar - 20)
Max	89 (Mar-30)
Diver survey, %	100



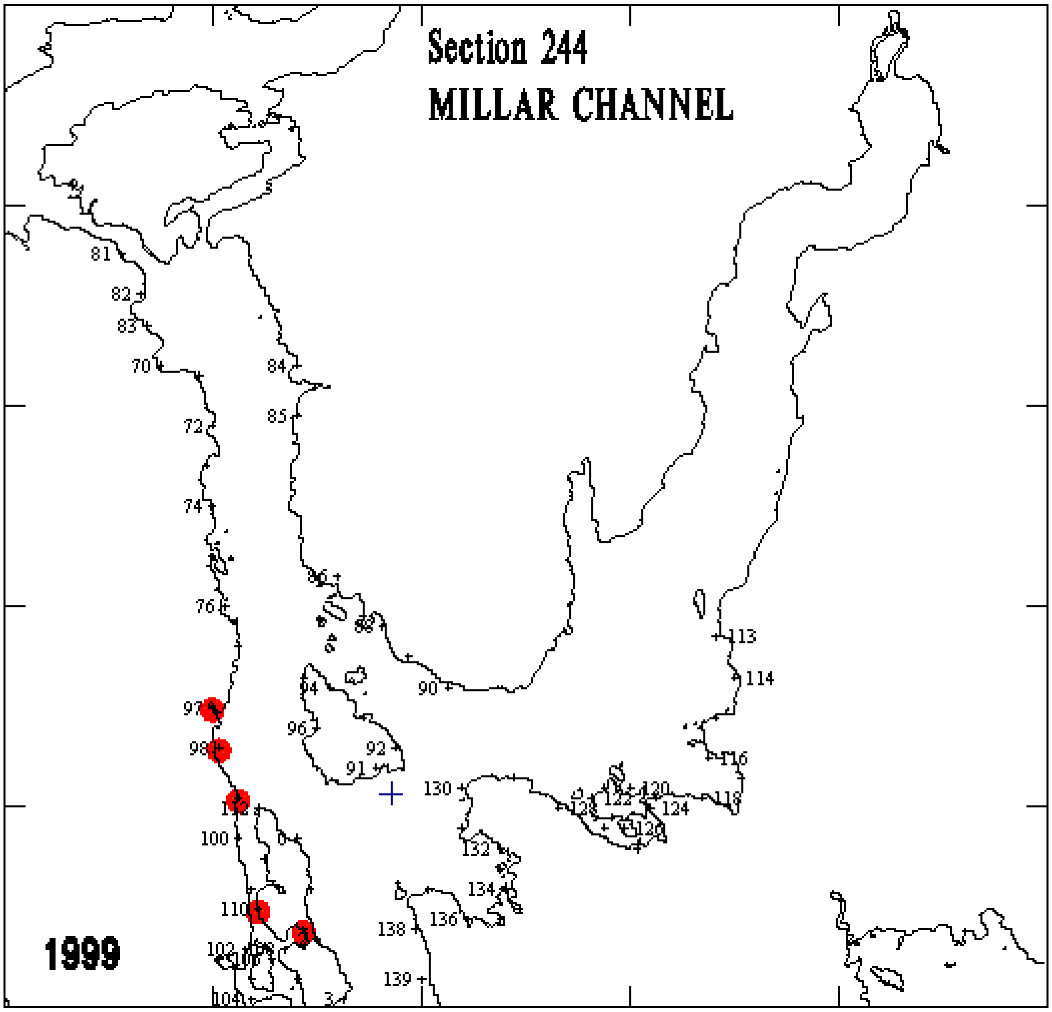
HERRING SPAWN SUMMARY - Section 242 (Hesquiat Harbour)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

<u>Year</u>	1999
<u>Total records</u>	7
<u>Spawn habitat index</u>	373957
<u>Total length, m</u>	10150
<u>Mean width, m</u>	88
<u>Mean layers</u>	0.79
<u>Spawn date (DOY)</u>	
Mean	79.6 (Mar - 20)
St.Dev.	9.50
Wgt	77.8 (Mar – 18)
Min	65(Mar-6)
Max	89 (Mar-30)
<u>Diver survey, %</u>	100



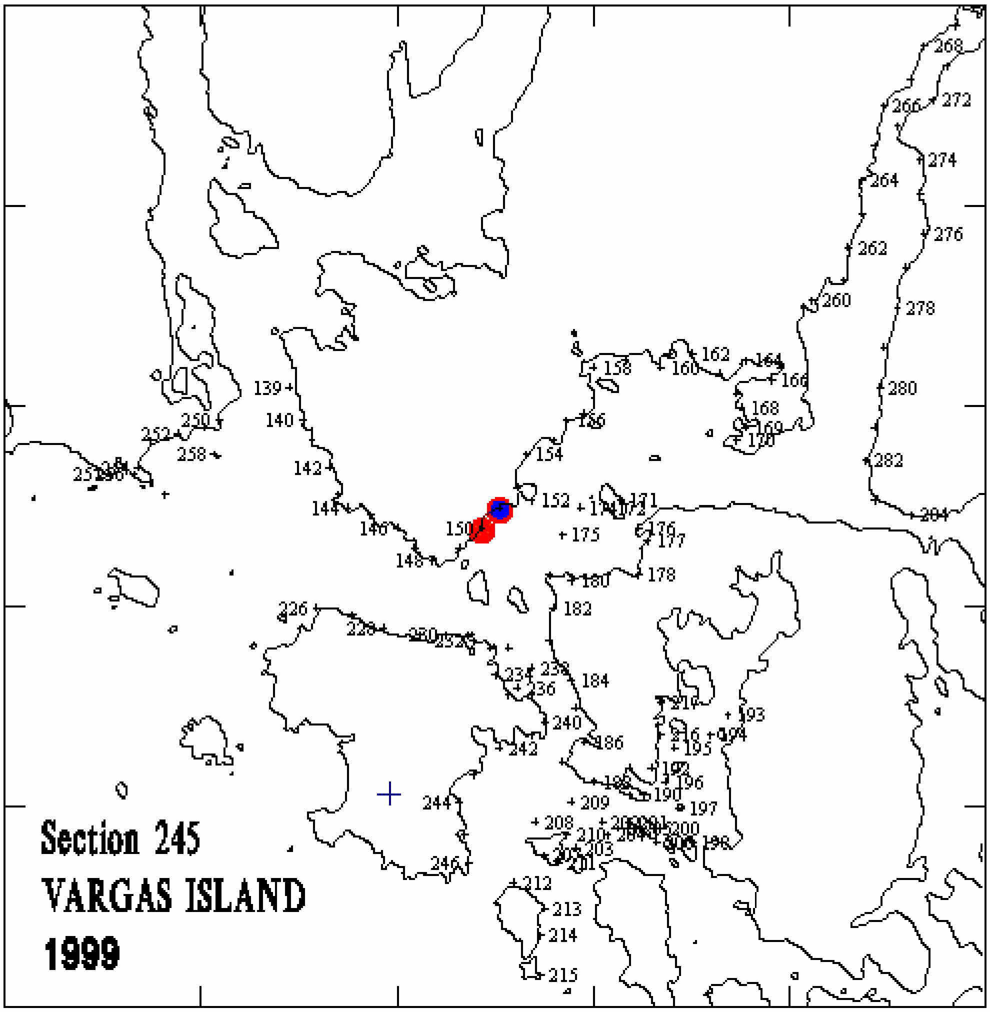
HERRING SPAWN SUMMARY - Section 243 (Sydney Inlet)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

<u>Year</u>	1999
<u>Total records</u>	6
<u>Spawn habitat index</u>	263697
<u>Total length, m</u>	13750
<u>Mean width, m</u>	88
<u>Mean layers</u>	2.19
<u>Spawn date (DOY)</u>	
Mean	88.0 (Mar – 29)
St.Dev.	1.00
Wgt	*
Min	87 (Mar – 28)
Max	89 (Mar-30)
<u>Diver survey, %</u>	100



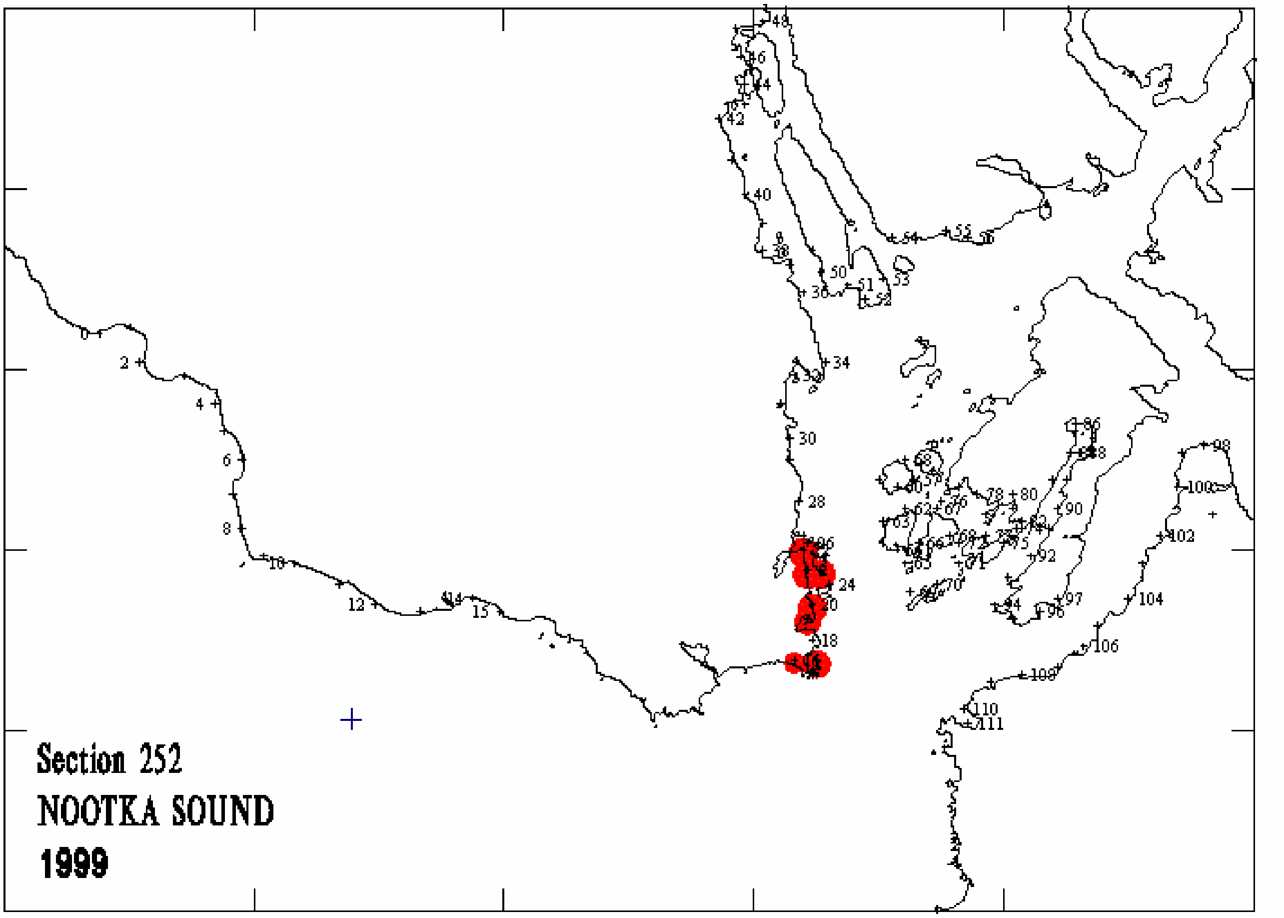
HERRING SPAWN SUMMARY - Section 244 (Millar Channel)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

Year	1999
Total records	3
Spawn habitat index	91884
Total length, m	4150
Mean width, m	30
Mean layers	1.08
Spawn date (DOY)	
Mean	88.0 (Mar-29)
St.Dev.	0.00
Wgt	88.0 (Mar-29)
Min	88 (Mar-29)
Max	88 (Mar-29)
Diver survey, %	100



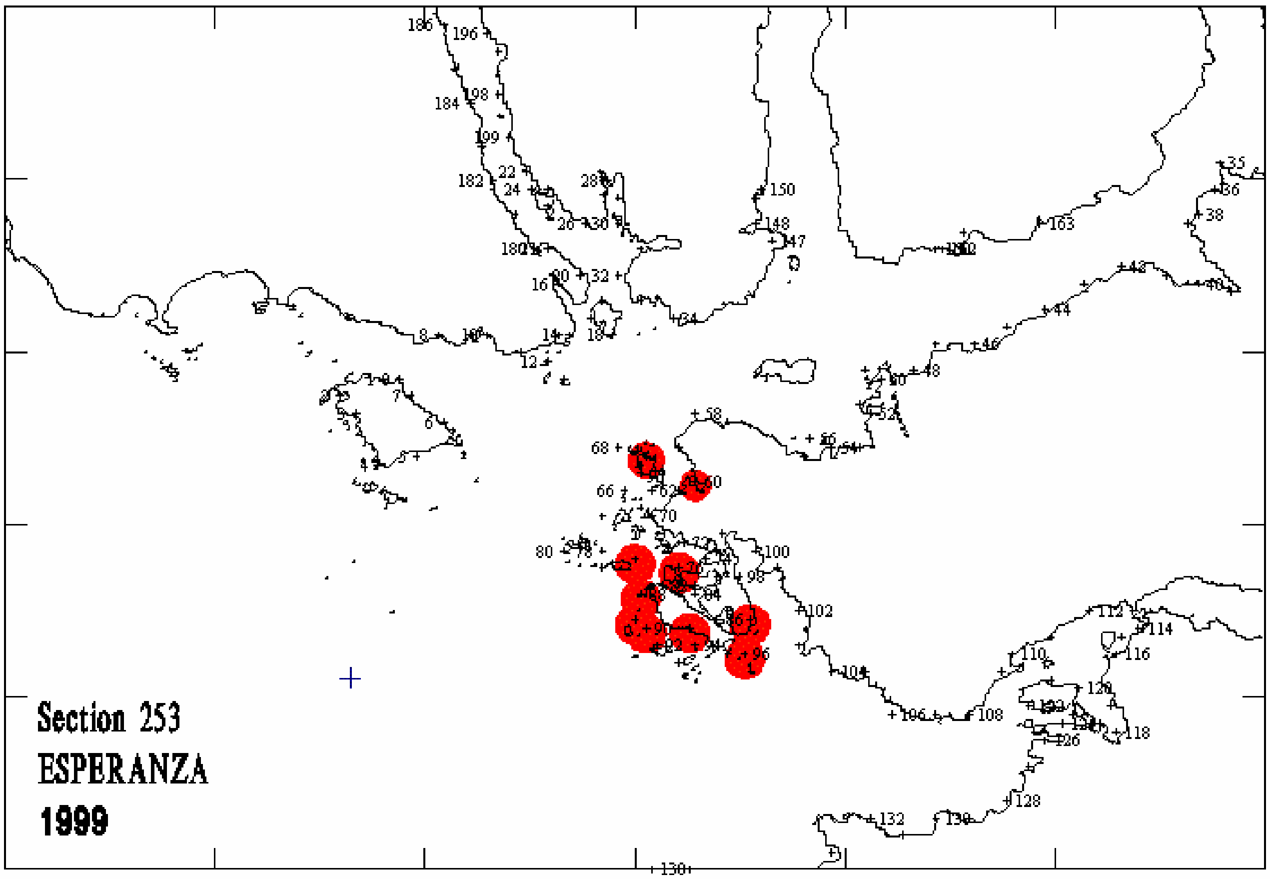
HERRING SPAWN SUMMARY - Section 245 (Vargas Island)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

Year	1999
Total records	2
Spawn habitat index	81686
Total length, m	1950
Mean width, m	58
Mean layers	2.49
Spawn date (DOY)	
Mean	90.0 (Mar-31)
St.Dev.	0.00
Wgt	90.0 (Mar-31)
Min	90 (Mar-31)
Max	90 (Mar-31)
Diver survey, %	87



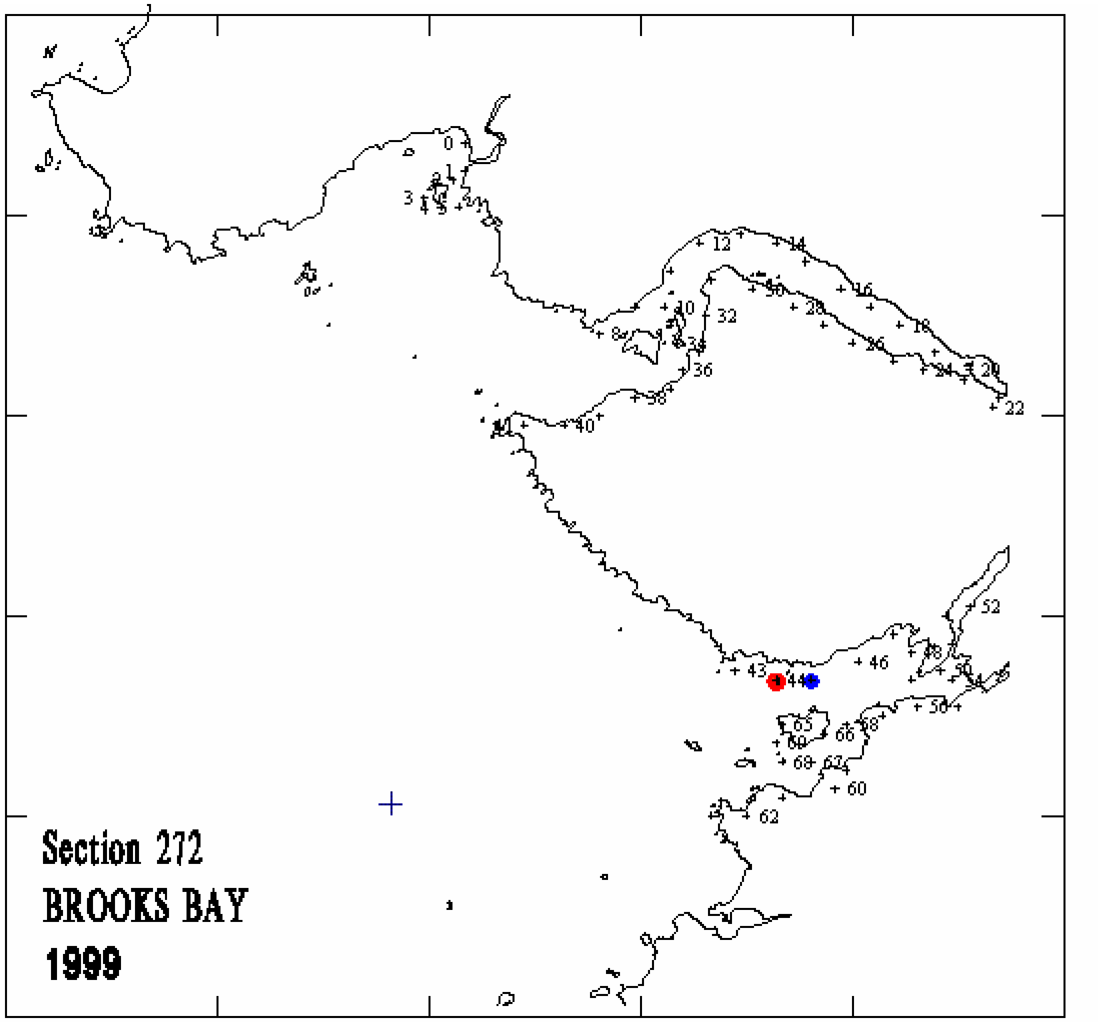
HERRING SPAWN SUMMARY - Section 252 (Nootka Sound)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

Year	1999
Total records	7
Spawn habitat index	171201
Total length, m	6250
Mean width, m	112
Mean layers	3.53
Spawn date (DOY)	
Mean	80.0 (Mar-21)
St.Dev.	2.45
Wgt	*
Min	75 (Mar-16)
Max	81 (Mar-22)
Diver survey, %	100



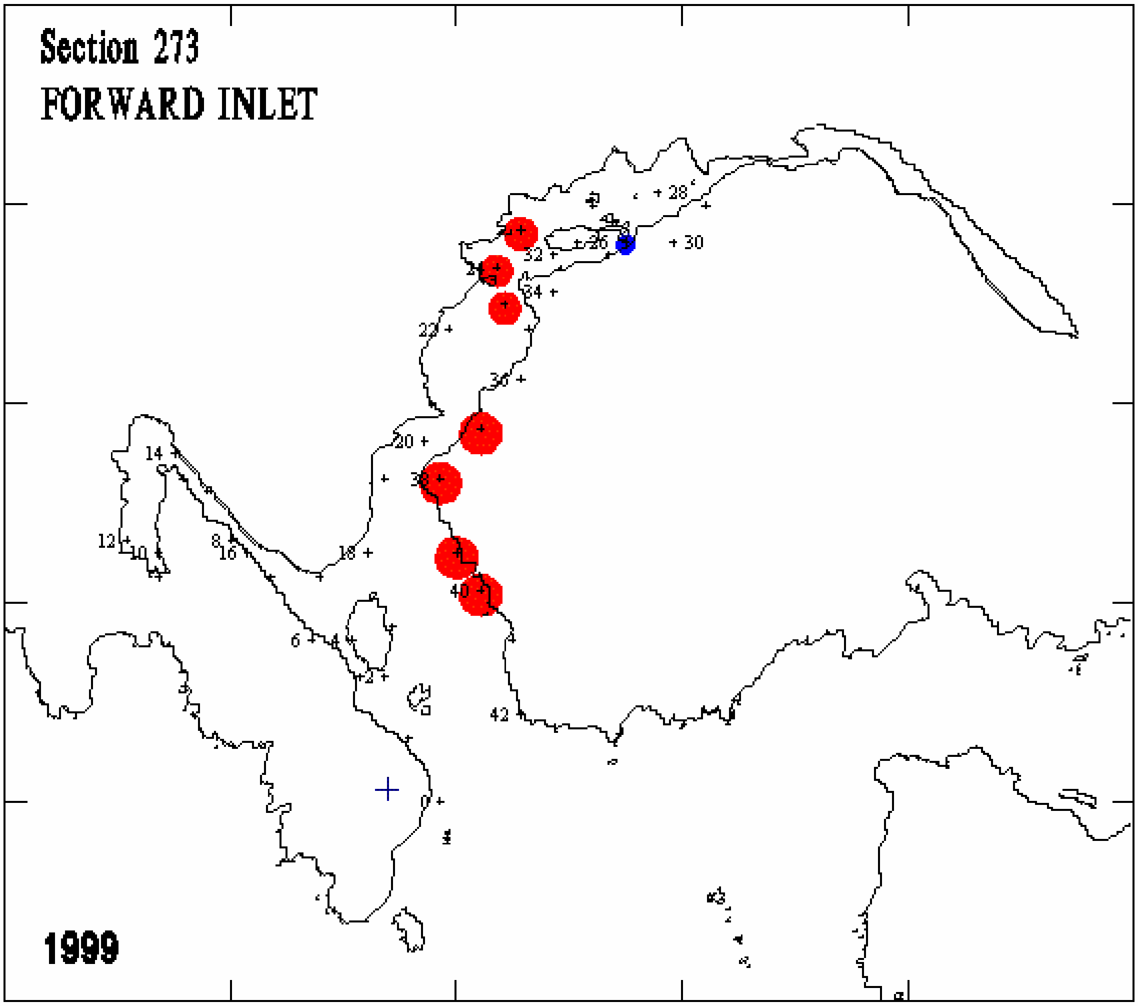
HERRING SPAWN SUMMARY - Section 253 (Esperanza Inlet)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

Year	1999
Total records	5
Spawn habitat index	445058
Total length, m	7550
Mean width, m	191
Mean layers	1.81
Spawn date (DOY)	
Mean	63.3(Mar-4)
St.Dev.	0.58
Wgt	*
Min	63 (Mar-4)
Max	64 (Mar-5)
Diver survey, %	100



HERRING SPAWN SUMMARY - Section 272 (Brooks Bay)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

<u>Year</u>	1999
<u>Total records</u>	2
<u>Spawn habitat index</u>	9287
<u>Total length, m</u>	270
<u>Mean width, m</u>	30
<u>Mean layers</u>	1.33
<u>Spawn date (DOY)</u>	
Mean	0
St.Dev.	0
Wgt	*
Min	0
Max	0
<u>Diver survey, %</u>	74



HERRING SPAWN SUMMARY - Section 273 (Forward Inlet)
Spawn Habitat Index = Sum of [length*median(width*layers)
Wgt = Mean spawn date (Day Of Year) weighted by Spawn Habitat Index (see p.103 for details)

Year	1999
Total records	6
Spawn habitat index	391797
Total length, m	8440
Mean width, m	47
Mean layers	0.59
Spawn date (DOY)	
Mean	0
St.Dev.	0
WGT	*
Min	0
Max	0
Diver survey, %	97

Table 2-1. Explanation of terms and abbreviations provided next to DFO herring spawning maps.

Year	***Calendar year of spawn survey***
Total records	Total number of spawn records (spawning events).
Spawn Habitat Index	Sum of the product of each measured spawn length (m) and the median of the product of each spawn width (m) and egg layers adjusted by percent cover and pooled geographically.
Total length	Total length (along shoreline) of the spawning area (m).
Mean width	Mean width (perpendicular to shoreline) of the spawning area (m).
Mean layers	Mean number of egg layers (spawn thickness or egg density).
Mean date	Mean spawn date (Day-Of-Year, DOY).
Stdev date	Standard deviation of the mean spawn date.
Wgt date	Mean spawn date (Day-Of-Year, DOY) - the date is adjusted by the Spawn Habitat Index to incorporate differences in the magnitude of spawns at different sites within statistical areas or herring sections.
Min date	Earliest spawn date (Day-Of-Year, DOY).
Max date	Latest spawn date (Day-Of-Year, DOY)
Diver Survey	Percentage of recorded spawn deposition assessed by SCUBA divers.

APPENDIX 3: List of English and Scientific names of species mentioned in the report

English name	Scientific name
FISH	
Pacific Herring	*Clupea pallasi*
BIRDS	
Pacific Loon	*Gavia pacifica*
Common Loon	*Gavia immer*
Unidentified Loons	*Gavia sp.*
Horned Grebe	*Podiceps auritus*
Red-necked Grebe	*Podiceps grisigena*
Western Grebe	*Aechmophorus occidentalis*
Unidentified Grebes	*Podicepididae*
Double-crested Cormorant	*Phalacrocorax auritus*
Pelagic Cormorant	*Phalacrocorax pelagicus*
Unidentified Cormorants	*Phalacrocorax sp.*
Great Blue Heron	*Ardea herodias*
Unidentified Swans	*Cygnus sp.*
Brant	*Branta bernicla*
Canada Goose	*Branta canadensis*
Green-winged Teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
American Wigeon	*Anas americana*
Unidentified dabbling ducks	*Anas sp.*
Unidentified Scaup	*Aythya marila, A. affinis*
Harlequin Duck	*Histrionicus histrionicus*
Long-tailed Duck	*Clangula hyemalis*
Black Scoter	*Melanitta nigra*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Unidentified Scoters	*Melanitta sp.*
Common Goldeneye	*Bucephala clangula*
Barrows Goldeneye	*Bucephala islandica*
Unidentified Goldeneye	*Bucephala clangula, B. islandica*
Bufflehead	*Bucephala albeola*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Unidentified Merganser	*Mergus sp.*
Bald Eagle	*Haliaeetus leucocephalus*
Black Oystercatcher	*Haematopus bachmani*
Black Turnstone	*Arenaria melanocephala*
Surfbird	*Aphriza virgata*
Mew Gull	*Larus canus*
Herring Gull	*Larus argentatus*
Glaucous Gull	*Larus hyperboreus*
Unidentified Gulls	*Larus sp.*
Common Murre	*Uria aalge*
Pigeon Guillemot	*Cepphus columba*
Marbled Murrelet	*Brachyramphus marmoratus*
Unidentified Alcids	*Alcidae*
Belted Kingfisher	*Ceryle alcyon*
MARINE MAMMALS	
Sea Otter	*Enhydra lutris*
River Otter	*Lontra canadensis*
Harbour Seal	*Phoca vitulina*
Killer Whale	*Orcinus orca*
Grey Whale	*Eschrichtius robustus*