Population status of Kittlitz's and Marbled Murrelets and surveys for other marine bird and mammal species in the Kenai Fjords area, Alaska

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ABSTRACT

The Kittlitz's murrelet (*Brachyramphus brevirostris*) is a rare seabird that nests in alpine terrain and generally forages near tidewater glaciers during the breeding season. More than 95% of the global population breeds in Alaska, with the remainder occurring in the Russian Far East. A global population estimate using best-available data in the early 1990s was 20,000 individuals. However, survey data from two core areas (Prince William Sound and Glacier Bay) suggest that populations have declined by 80-90% during the past 10-20 years. In response to these declines, a coalition of environmental groups petitioned the USFWS in May of 2001 to list the Kittlitz's murrelet under the Endangered Species Act. In 2002, we began a three-year project to examine population status and trend of Kittlitz's Murrelets in areas where distribution and abundance are poorly known. Here we report on the first field season, focused on the south coast of the Kenai Peninsula. We re-surveyed selected historical transects to evaluate trends, and surveyed new transects for improved population estimation during early July 2002. From a total of 66 Kittlitz's Murrelets seen on transects, we estimate a total population of 509 Kittlitz's Murrelets along the south coast of the Kenai Peninsula. Comparisons with past surveys suggest a decline of 83% since 1976, with an average rate of decline calculated as–6.9 % per annum. This decline is in agreement with population declines observed elsewhere in the species' core glaciated range, indicating that steep population declines observed to date are likely to be a range-wide phenomenon. While the focus of the study was Kittlitz's Murrelets, other species of marine birds and mammals were also surveyed. Populations of the closely related Marbled Murrelet appear to have increased during the same time period. The abundance and distribution of other species are presented in appendices.

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INTRODUCTION

This report summarizes results from the first year of a three-year survey of Kittlitz's Murrelets (*Brachyramphus brevirostris*) in areas where significant populations were expected to occur, but where few data on populations are available. The Kittlitz's Murrelet is one of the rarest seabirds in North America, and most aspects of its biology remain obscure. A summary of limited data as of 1993 suggested a total world population of about 20,000 Kittlitz's murrelets (van Vliet 1993). Except for small populations in the Russian Far East, most breed in Alaska. The most recent population assessment concluded that the current Alaska population of Kittlitz's Murrelets is between 9,000 and 25,000 birds, though that estimate was qualified as "speculative and dated" (U.S. Fish and Wildlife Service, 2003). In May of 2001, a coalition of environmental groups petitioned the USFWS to list the Kittlitz's murrelet under the Endangered Species Act, partly in response to available evidence from replicated Kittlitz's murrelet surveys showing indications of alarming declines in the species across their core geographic range.

Preliminary analysis of surveys conducted in Glacier Bay (GLBA) in 1991 (Piatt et al. 1991) and 1999/2000 (Robards et al. 2003) suggest that populations declined by more than 80% during that period. Even greater declines have been observed in Prince William Sound (PWS) during the past 25 years (Kendall and Agler 1998; Agler et al. 1999; see also summarized reports referenced in USFWS 2003). Replicated surveys across similar time scales in other areas of Alaska have either not been carried out or remain unanalyzed. Because the species is rare and declining, accurate population estimates are needed to assess the true status of the species. In particular, we need to conduct broad-scale surveys in areas where the species is known to occur but has not been monitored in the past, and replication of surveys in core areas to produce more precise information on population trends.

Population trends for most seabirds are typically assessed from census counts at breeding colonies. However, the Kittlitz's murrelet is not colonial, and only around 20 nests have ever been documented across the species' entire range in the North Pacific and Bering Sea (Day et al. 1999). Kittlitz's murrelet abundance must therefore be estimated

from observations of birds at sea obtained during pelagic and coastal seabird surveys. While core population centers in PWS and GLBA have been recently surveyed, many areas known to support significant populations of Kittlitz's murrelets have been incompletely surveyed. Examples include the southern coast of the Kenai Peninsula, the southern coast of the Alaska Peninsula, and northwest Alaska.

A broad-scale, rapid assessment of Kittlitz's murrelet populations across their range is critical for assessing population trends and conservation planning. In addition, such an assessment allows us to evaluate some hypotheses about mechanisms that are driving population trends. Potential factors include direct mortality from oil spills and gill-net fishing (Wynne et al. 1991), and indirect effects such as natural changes in food abundance, loss of foraging habitat due to glacial recession, and vessel disturbance in core foraging areas (van Vliet 1993; van Vliet and McAllister 1994; Day et al. 1999). The impact of these factors is not evenly distributed across the species' range (e.g. vessel disturbance differs across glaciated areas of KEFJ, PWS, and GLBA, and extent of glaciation differs across the Gulf of Alaska and Bering Sea populations), and therefore if we evaluate population trends in light of these factors, we may be able to narrow our focus on the most likely mechanisms causing population declines.

It is useful to compare population trends of Kittlitz's Murrelet with other marine birds, particularly those that overlap in diet and share foraging habitats. For example, a number of piscivorous seabird species in the Gulf of Alaska have suffered population declines over recent decades due to climate-mediated changes in fish community composition (Agler et al. 1999; Piatt and Anderson 1996), and Kittlitz's Murrelets have likely also been affected by these broad-scale changes in trophic organization. Marbled Murrelets (*Brachyramphus marmoratus*), which have a high degree of dietary overlap with Kittlitz's Murrelets, have also declined in Glacier Bay (Robards et al. 2003) and Prince William Sound (Stephensen et al. 2001) lending support to the hypothesis that broader ecological changes have impacted Kittlitz's Murrelets.

Here we briefly summarize the status of the USGS Science Support project on Kittlitz's Murrelets, and we present detailed findings from the first year of this three-year project, focusing on population status and trend of Kittlitz's and Marbled Murrelets along the south coast of the Kenai Peninsula.

METHODS

Our overall approach in surveying for Kittlitz's Murrelets in poorly documented areas is to emphasize the spatial scale and accuracy of population estimates over the precision of those estimates. Ideally, surveys could be both broad-scale and precise, but this is generally difficult to achieve given limited resources (ship and personnel time). Relatively fine-scale monitoring efforts are ongoing in two core population centers (PWS and GLBA). Given the lack of basic information on populations elsewhere in the species' range, our objectives at this stage were not to increase the range of fine-scale monitoring but rather to broaden the geographical scope across which we will have current information about the status of Kittlitz's Murrelet populations.

Sampling protocol and statistics: There is large body of work on the application of at-sea surveys to population estimation for marine birds. Results of recent work on murrelets (Becker et al. 1997, Agler et al. 1998) indicate that surveys with high temporal replication and large spatial coverage are ideal for establishment of a monitoring program that will enable detection of population trends with acceptable statistical power. But given our immediate objective for surveying the Kenai Fjords region (documentation of the meso-scale distribution, abundance, and population trends of Kittlitz's Murrelets), we used stratified, systematic sampling (without replication) for maximum spatial coverage. Fortunately, systematic surveys for non-colonial marine birds in this area had been done in the past (see below), so we were able to re-survey historical transects for trend estimation. In addition, we established a new set of nearshore and offshore transects that could be used in future years as the basis for a more intensive population monitoring program.

We surveyed a total of 554 linear kilometers (166.35 km^2) along the south coast of the Kenai Peninsula, from Cape Resurrection to Gore Point (Figure 1), during 3-13 July 2002. Reports by Bailey (1976) and Nishimoto and Rice (1987) provide details on the geology and natural history of the study area. We used standard FWS strip survey methods (Gould and Forsell 1989; Kendall and Agler, 1998; Agler et al. 1999; Irons et al. 2000) with a 300-m wide strip, counting from the flying bridge of a 42' seiner. We

counted all birds (on water and flying) within 150 meters to each side, ahead, and above the vessel and classified bird behavior for each record (e.g. "flying", "on water"). Flying birds were counted continuously. Data were recorded using DOS-based, real-time, GPS-integrated software that continuously wrote positional data to record the trackline ("dLOG" software; Glenn Ford Consulting, Inc., Portland, OR). For each bird observed, data were recorded on species, number, behavior, time, and GPS location. Vessel speed was maintained at 6-8 knots. Surveys were done during periods without heavy precipitation, fog, glare, or seas greater than 0.6 m.

Species distributions were mapped using ArcMap (ArcGIS v. 8.2; ESRI) after flat data files were imported into a Microsoft Access geodatabase. Transects were buffered for the width of the surveyed strip (300 m), and the buffered area (equal to the total area sampled) was calculated for each stratum (Table 1). Total area per stratum was calculated using ArcMap with available shoreline GIS coverages. Estimators of density, abundance, and variance for each stratum and for pooled strata were calculated using model-based analyses within Program Distance (Thomas et al. 2002), under the assumptions that all objects within the strip were detected and that animals did not move off the strip in response to observers (Buckland et al. 2001). Point values of densities and abundances calculated within Program Distance were similar to those calculated using the standard FWS ratio estimator approach (Klosiewski and Laing 1994; Cochran 1977), but variances were smaller and strata were pooled with weighted values and variances. Satterthwaite's procedure for adjusting degrees of freedom for small sample sizes was used (Buckland et al. 2001). Confidence intervals are log-based, allowing for the asymmetric shape of the sampling distribution of density estimates generated from small sample sizes. Our survey lines were representative of the appropriate study area (i.e. nearshore lines were an unbiased sample of the nearshore environment, and offshore [fjord] lines were an unbiased sample of the offshore fjord environment), meeting the basic assumption for density and abundance estimation (Buckland et al. 2001).

Historical comparisons and survey design: For trend estimation, we used historical data from Fish and Wildlife Service and National Park Service reports (Bailey 1976; Nishimoto and Rice 1987; Bailey and Rice 1989). Raw and summarized data from

those reports were provided by USFWS, Anchorage (K. Kuletz, Migratory Bird Management). Comparison with past surveys was complicated by differences in survey methods and sampling protocols (see Fig. 2 for maps showing extent of historical and current surveys). The 1976 survey (Bailey 1976) was a straightforward month-long survey of the entire nearshore area from Gore Point to Cape Resurrection. Bailey (1976) subdivided the whole coastline into 11 geographic units. In 1986, the whole nearshore area was resurveyed (Nishimoto and Rice 1987), and the coastline was further subdivided into about 150 smaller survey subunits. The 1989 survey (Bailey and Rice 1989) covered a randomly selected subset of the whole-shoreline 1986 survey subunits (referred to throughout this report as "pre-existing transects"). To maximize comparison with past results while reducing the large operating costs demanded by a whole-shoreline area survey, in 2002 we repeated the survey of the random subset of transects selected in 1989.

However, the 1989 set of transects was not ideal for Kittlitz's Murrelet population estimation for several reasons. First, those transects did not include any offshore waters. They also spanned the entire coastline, with significant effort in outer areas where Kittlitz's Murrelets were unlikely to be found. Furthermore, the random subset missed some key glacier-affected habitat where Kittlitz's Murrelets were likely to be found (most notably nearly all of Northwestern Fjord; see Appendices 1 and 2). We therefore designed a new set of surveys for improved accuracy and precision in estimating current Kittlitz's Murrelet populations (see Fig. 2). These surveys systematically covered all five of the major fjords within the study area, with roughly equal effort within the nearshore ("new shoreline") and offshore ("new pelagic") strata. All transect locations and numbers are shown in Appendices 1-4. The pre-existing and new shoreline transect sets were overlapping; therefore estimation of the fjord-based Kittlitz's Murrelet populations used only the new shoreline and new pelagic transect data, while estimation of the more broadly distributed Marbled Murrelet populations used only data from pre-existing shoreline and new pelagic transects.

All four comparable surveys (1976, 1986, 1989, and 2002) were conducted during the same period of summer (mid-June through mid-July; see Appendix 5). Methods of data collection differed somewhat among surveys (see Appendix 6 for summary).

Observers on the first three surveys counted all birds observed, and they did not define a survey strip. This would tend to inflate past population estimates in comparison to our strip transect approach, if murrelets could be detected beyond our 150-m strip half-width. However, detailed work on Marbled Murrelets has shown that they tend not to be detected much beyond 100 m (Ralph and Miller, 1995) so inflation of past survey results is likely to be insignificant. In addition to using 40'-50' vessels, past surveys also used inflatable skiffs as survey platforms for a minority of selected nearshore transects; murrelets tend not to be detected from skiffs beyond 50 meters (Z. Peery, University of California Berkeley, pers. comm.), so this would reduce detection of murrelets relative to observations from our 42' vessel. The 1976 survey did not record unidentified *Brachyramphus* murrelets (all *Brachyramphus* murrelets seen were recorded as either Marbled or Kittlitz's Murrelets), and the proportion of unidentified murrelets varied among the 1986, 1989, and 2002 surveys (Appendices 5 and 6). Here we have analyzed only those murrelets identified to species.

Trend estimation statistical analysis: The significant negative change in Kittlitz's murrelet population over time was modeled using least-squares linear regression (Fig. 3). Extremely small sample sizes precluded analysis of marbled murrelet population changes.

An alternative approach to examining population changes is to express estimated or directly counted population sizes as the natural logarithm of the percentage of the initial count, then plot the transformed results against time. The slope of the resulting linear regression equals the growth constant (or decay constant if the slope is negative, as in this case). This "growth constant" model stems from integrating the basic differential equation for exponential growth or decay: $dN/dt = rN$, where t = time period, N is the quantity growing, and r is the growth rate. This approach assumes that the growth rate remains unchanged throughout the interval in question, that is, that the growth or decay is exponential at the average rate for the entire period. That assumption is unlikely to be met in the natural situation, but the growth constant model can still serve as a useful guide for comparing populations and for evaluating possibilities.

Other marine bird and mammal species: While the specific aim of the present survey was evaluation of the status and distribution of Kittlitz's Murrelets (key target species) and Marbled Murrelets (closely related species used for comparison), we were also interested in other marine bird and mammal species as comparative components of the same ecosystem, and for basic documentation of current population status. We therefore collected the same information for all other marine bird and mammal species, using the same methods as detailed above for murrelets. But no single survey design is equally effective for all species, since distribution, population size, and behaviors differ. Each species or genus requires a focused analysis and discussion, and we have therefore not calculated densities or estimated population sizes for species other than the congeneric murrelets. However, we do present distribution maps for species observed, together with total numbers observed that can be used for simple comparisons between years. Raw data will be made available for future analyses.

RESULTS and DISCUSSION

Current distribution: Kittlitz's Murrelets were found almost exclusively near glacier faces or outflows, and were wholly absent from exposed outer coasts and outer fjords (Fig. 3). Marbled Murrelets were found along most of the surveyed shoreline, especially in protected bays and coves (Fig. 4). The lowest densities of Marbled Murrelets were in ice-affected waters that supported the highest densities of Kittlitz's Murrelets (Figs. 3 and 4). The two murrelet species were infrequently observed in mixed groups- usually a single Kittlitz's Murrelet together with two or more Marbled Murrelets.

Abundance and distribution of all marine bird and mammal species are summarized and mapped in Appendices 7-9.

Current Kittlitz's Murrelet population size: To estimate the size of the Kittlitz's Murrelet population in the Kenai Fjords region, we stratified our surveys to target nearshore and offshore marine areas that were expected to be preferred Kittlitz's Murrelet habitat. We counted 32 Kittlitz's Murrelets on transects in the nearshore area, and 34 on

offshore transects (Table 1). Our analyses of survey results (Table 2) suggest that there are 444 (95% CI 94-2099) Kittlitz's Murrelets in offshore portions of the five main fjords of Kenai Fjords NP (Nuka Bay North Arm; McCarty Fjord; Two Arm Bay; Harris Bay/Northwestern Fjord; and Aialik Bay; see Fig. 1 for locations). There are an estimated 65 (95% CI 28-150) Kittlitz's Murrelets in nearshore waters of the same area. The pooled total population estimate (mean of stratum estimates weighted by stratum area) is 509 (95% CI 126-2050) Kittlitz's Murrelets.

Note that this total population estimate is a minimum, since unidentified *Brachyramphus* murrelets (BRMU) were recorded on some transects, and some unknown proportion of those BRMU is likely to be Kittlitz's Murrelets. However, most BRMU were seen in areas that did not overlap with Kittlitz's Murrelet distribution, and we generally stopped the survey to inspect possible Kittlitz's Murrelets, so any population underestimate due to Kittlitz's Murrelets being recorded as BRMU is likely to be small.

It is also possible that additional Kittlitz's Murrelets occur outside the range of our new shoreline and new pelagic surveys used for population estimation (see "Historical comparisons and survey design" within Methods above). Results from the pre-existing transects covering a randomly selected portion of the entire shoreline between Gore Point and Cape Resurrection (see Fig. 2 "pre-existing transects"; excludes waters to the north of Renard Island in Resurrection Bay), together with results from opportunistic offshore surveys not included in the population estimate, indicate that most Kittlitz's Murrelets in the population between Gore Point and Cape Resurrection are found in the fjord waters used for the above population estimate (Fig. 3).

Current Marbled Murrelet population size: Marbled Murrelets were found along the whole coastline (not only within fjords), and therefore in order to estimate the size of the Marbled Murrelet population in the Kenai Fjords region, we used data from the pre-existing transects combined with the new offshore marine transects (Table 3). We estimate that there are 3,879 (95% CI 2,449-6,144) Marbled Murrelets in offshore portions of the five main fjords of Kenai Fjords NP (Nuka Bay North Arm; McCarty Fjord; Two Arm Bay; Harris Bay/Northwestern Fjord; and Aialik Bay; see Fig. 1 for locations). There are an estimated 5,675 (95% CI 4,003-8,045) Marbled Murrelets in

nearshore waters of the whole coastline. The pooled total population estimate (mean of stratum estimates weighted by stratum area) is 9,554 (95% CI 7,239-12,610) Marbled Murrelets.

Note that this total population estimate is a minimum, since unidentified *Brachyramphus* murrelets (BRMU) were recorded on transect (BRMU comprised 12% of all murrelets seen on transect), and some unknown proportion of those BRMU are likely to be Marbled Murrelets. For the reasons listed above under "Kittlitz's Murrelet population size", we expect that most BRMU were likely to be Marbled Murrelets.

Kittlitz's Murrelet population trend: Evaluation of a population trend for Kittlitz's Murrelets along the Kenai Peninsula is tenuous, given the small sample sizes and spatial variation that results in wide confidence intervals. The most parsimonious approach (requiring the fewest assumptions) is to make direct comparisons of only those transects that were resampled in each year. The whole shoreline between Gore Point and Cape Resurrection was surveyed in 1986. In 1989, a subsample of the 1986 survey units was randomly selected for survey in that year. In 2002, we surveyed the same subset of transects that were surveyed in 1989 (see "pre-existing transects" in Fig. 2). Thus, we can make direct comparisons between transects surveyed in 1986, 1989, and in 2002. A total of 31 Kittlitz's Murrelets were seen on the transect subset in 1986, 26 in 1989, and 8 in 2002. This represents a ca. 74% decline between 1986 and 2002.

Despite extensive survey effort (in terms of number of transects and square kilometers surveyed; see Table 1), the small numbers of Kittlitz's Murrelets actually observed suggests we should be cautious in our interpretation of trends. However, the subset of survey units was a reasonably extensive sample (31%) of the whole shoreline, a reasonably large number of birds were seen on the original transects in 1986, and the exact same portions of the nearshore habitat, at the same time of season, were sampled across years. This direct comparison is probably our best measure of population change, and we conclude that our estimate of the decline rate is realistic.

To increase the temporal scope of our analysis, we extrapolated population estimates for the whole nearshore area from the 1989 and 2002 subset of transects, then applied a linear regression to those estimates together with the results from 1976 and

1986 surveys that directly counted the whole nearshore area (see Fig. 5). This approach yields an estimated 83% decline across the 26 years between 1976 and 2002, in general agreement with the trend calculated from direct counts on subsampled transects.

To examine the validity of our entire-nearshore population estimation, we extrapolated the 1986 nearshore population from the 1986 subsampled survey units, using the same methods as used for the 1989 and 2002 extrapolations. We then compared the extrapolated population total to the population total that was counted directly. The 1986 estimated population was 104 ± 36.7 SE, in general agreement with the 86 birds actually counted in the entire nearshore area during the same survey (Fig. 5).

The Kittlitz's murrelet population trend appears to be undergoing exponential decay. With populations expressed as the natural logarithms of the percentages of the first year's count, linear regressions model the population decline. We found a significant negative relationship between year and Kittlitz's murrelet population size counted directly on the subsample of nearshore survey units ($y = -0.0865x + 176.4$; $R^2 = 0.997$; $F_{1,1} = 297.8$, $P = 0.037$). This corresponds to a decay constant of about –8.7% per annum. Using two years of direct whole-shoreline counts (1976 and 1986) and two years of estimated counts (1989 and 2002), there was a significant negative relationship between year and nearshore Kittlitz's Murrelet population size in the entire study area ($y = -0.0686x + 140.25$; $R^2 = 0.970$; $F_{1,2} = 64.1$, $P = 0.015$). This corresponds to a decay constant of about –6.9% per annum.

But it is important to note that the subset of pre-existing transects used for population trend analysis in 1989 and 2002 fails to include a substantial portion of glacier-affected marine waters where Kittlitz's Murrelets tend to concentrate. One way to address this bias is to compare the 1976 and 1986 whole-shoreline counts (162 and 86 Kittlitz's Murrelets, respectively) with an estimate derived by extrapolation from our systematic shoreline transects conducted in 2002 (65, with 95% CI 28-150; "new shoreline", Table 3). This suggests a decline of only 60%, but the result is not significant owing to the wide confidence intervals of the 2002 estimate. We hesitate to draw conclusions from this direct comparison between results of a random survey and a systematic survey. All things considered, we believe that the most conservative analysis

of Kittlitz's Murrelet population trend is the direct comparison between surveyed subunits explained above and shown in Figure 5.

Marbled Murrelet population trend: Evaluation of population trend for Marbled Murrelets along the Kenai Peninsula is subject to similar biases as for Kittlitz's Murrelets, although spatial variation and clumping were much less extreme. As with the Kittlitz's Murrelet, we made direct comparisons between transects surveyed in 1986, 1989, and in 2002, and indirect comparisons using whole-nearshore counts (1976 and 1986) combined with estimated whole-nearshore populations (1989 and 2002). These analyses suggest that Marbled Murrelet populations were generally declining by ca. 62% during the 1976-1989 period, but then grew five-fold by 2002 (Fig. 6). We have insufficient data to use linear regressions to model the Marbled Murrelet population growth or decay. However, available data indicate a decrease from 1976-1986 on the order of –7% per annum and a steep increase from 1989-2002 of ca. +10% per annum.

CONCLUSIONS and RECOMMENDATIONS

The population estimate presented here of 509 (95% CI 126-2050) Kittlitz's Murrelets along the southern Kenai Peninsula means that the region supports roughly 2-6 % of the best-estimate total world population (9,000 – 25,000; USFWS 2003). Our work suggests that Kittlitz's Murrelet populations are declining along the southern shores of the Kenai Peninsula, and extends the geographic range for which we have evidence of Kittlitz's Murrelet population declines. Relatively complete trend information available from Glacier Bay and Prince William Sound show population declines on the scale of 70-80 % over the past 10-20 years (Robards et al., 2003; USFWS, 2003). Our surveys and historical surveys along the southern coast of the Kenai Peninsula suggest a comparable population decline of 83 % since 1976. The rate of decline in Kittlitz's Murrelet populations in the Kenai Fjords region appears to be fairly steady across the 26 years since 1976.

The fact that Kittlitz's Murrelet populations are apparently declining at a similar rate across three disjunct population centers (Glacier Bay, Prince William Sound, southern Kenai Peninsula) provides some insight into possible mechanisms that may be driving declines. The three regions are influenced by large-scale Gulf of Alaska (GOA) marine features, but are characterized by somewhat different local oceanographic situations. Since populations are declining across these different systems, however, we can hypothesize that Kittlitz's population declines are unlikely to be driven by mechanisms related to local oceanography. By the same logic, we hypothesize that broader-scale, GOA-wide changes in the marine ecosystem could be a mechanism driving the declines in disjunct Kittlitz's Murrelet populations.

One factor common to all three areas is the presence of large ice fields and tidewater glaciers. Our surveys along the southern Kenai Peninsula showed that Kittlitz's Murrelets were found almost exclusively near glacier faces or outflows, and the same distribution has been observed in Prince William Sound (Kendall and Agler 1998; Day et al., 2000; USFWS, 2003; Kuletz et al. *in prep.*) and Glacier Bay (Kendall and Agler 1998; Robards et al. 2003). Alaskan glaciers have been thinning and losing mass at a high rate over the past 50 years (Arendt et al. 2002), and we hypothesize that Kittlitz's Murrelet population declines are related in some way to glacier thinning and retreat. The mechanisms that link Kittlitz's Murrelet foraging and glacier-influenced marine waters remain unclear, however, and would be a fruitful area for further research.

Glacier Bay, Prince William Sound, and the Kenai Fjords region are all visited by commercial vessels (cruise ships, tour boats, fishing boats, and tankers). Cruise ships and tour boats tend to visit marine waters near glacier faces, i.e., preferred Kittlitz's Murrelet feeding habitat. This potential for conflict (directly or indirectly, via noise and/or chemical and petroleum pollution) has not been overlooked by conservationists, and was identified as a potential threat in the petition for listing Kittlitz's Murrelets under the Endangered Species Act (http://www.sw-center.org/swcbd/species/murrelet/Petition.pdf), and the U.S. Fish and Wildlife Candidate Assessment (USFWS 2003). As yet, there has been no study to evaluate the impact of vessel traffic on Kittlitz's Murrelets.

We found that Marbled Murrelets were widely distributed along the south coast of the Kenai Peninsula, and they were generally found in nearshore waters less directly

affected by glacial processes. There was minimal overlap between the distribution of Marbled Murrelets and the distribution of Kittlitz's Murrelets. Marbled Murrelets far outnumbered the congeneric Kittlitz's Murrelet; the region supported an estimated 9,554 Marbled Murrelets. This comprises a proportion of the total Alaskan population of Marbled Murrelets that is roughly equivalent to the local Kittlitz's Murrelet proportion (ca. 3-4% of estimated 280,000 total Marbled Murrelets in Alaska; Piatt and Naslund 1995).

In contrast to Kittlitz's Murrelet populations, Marbled Murrelet populations along the south coast of the Kenai Peninsula appear to have undergone a five-fold increase since 1989, following moderate declines between 1976 and 1989. It is possible that 2002 represented an anomalous year, similar to population "spikes" seen over years of surveys of Marbled Murrelet populations in Prince William Sound (K. Kuletz, unpubl. data). However, it is clear that Marbled Murrelets in the Kenai Fjords region are not declining, in contrast to Glacier Bay and Prince William Sound where Marbled Murrelets have decreased during the past 15 years (though not to the extent of Kittlitz's declines in the same areas).

What explains these opposing recent trends in murrelet populations along the southern Kenai Peninsula? It is unlikely that a region-wide change in prey availability (regime shift; Piatt and Anderson 1996) is the cause, because these species closely overlap in types of prey consumed during the breeding season (although Kittlitz's Murrelets do eat more zooplankton than Marbled Murrelets; Day et al. 1999). Competition may be a factor. Given that Kittlitz's Murrelets prefer to feed at tidewater glacier faces and glacier river outflows, populations may be disproportionately impacted by receding glaciers (Arendt et al. 2002). A recent observation of a Kittlitz's Murrelet nest built on surface moraine near a glacier terminus suggests that receding glaciers may also adversely impact Kittlitz's nesting habitat (Van Pelt et al., unpubl. data).

Priorities for future work

A. Continue monitoring known concentrations in PWS and GLBA; initiate monitoring programs in other areas with accessible concentrations of Kittlitz's

Murrelets (Kenai Fjords, Icy Bay, Kachemak Bay). Work with US Fish and Wildlife personnel to build most effective and efficient monitoring program.

B. Initiate surveys in peripheral or low-density Kittlitz's Murrelet populations (e.g. eastern Gulf of Alaska outer coasts, southern coasts of the Alaska Peninsula, the Aleutian Islands, and the Bering and Chukchi seas), to establish status of global population and to further investigate environmental correlates with population trends.
C. Details of feeding and habitat use should be examined, in relation to glacial influence and vessel traffic.
D. Obtain trend data for areas with existing data; e.g. Lower Cook Inlet
E. Conduct genetic analyses to decipher population and metapopulation structure, providing information for definition of conservation priorities, enabling efficient and effective management of the species.
F. Investigate population status in Russian territory via cooperation with or sponsorship of Russian specialists, support cooperative management of the global population.

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Table 1. Strata used for Kittlitz's Murrelet (KIMU) and Marbled Murrelet (MAMU) population estimations.

Stratum	# of transects	km^2 surveyed	total stratum km^2	prop.sampled (%)	# KIMU	# MAMU
pre-existing shoreline	49	95.06	312.95	30.6	8	1690
new shoreline	26	42.74	113.33	37.7	24	1312
new pelagic	26	28.55	349.94	8.1	34	297
total	101	166.35	776.22	21.4	66	3299

Table 2. Kittlitz's murrelet density (D) and population (N) estimates for area along south coast of Kenai Peninsula, Alaska. See Methods for definintion of strata and for explanation of estimate and variance calculation.

Stratum		Estimate	%CV	df	95% confidence interval	
pre-existing shoreline	D	0.086	47.1	52.79	0.035	0.211
	N	27.0	47.1	52.79	11.0	66.0
new shoreline	D	0.574	42.6	31.23	0.250	1.320
	N	65.0	42.6	31.23	28.0	150.0
pelagic	D	1.269	80.7	11.28	0.268	5.999
	N	444.0	80.7	11.28	94.0	2099.0
pooled	D	1.099	70.6	11.42	0.273	4.425
(new shoreline + pelagic)	N	509.0	70.6	11.42	126.0	2050.0

Table 3. Marbled murrelet density (D) and population (N) estimates for area along south coast of Kenai Peninsula, Alaska. See Methods for definintion of strata and for explanation of estimate and variance calculation.

Stratum		Estimate	%CV	df	95% confidence interval	
pre-existing shoreline	D	18.134	17.7	81.64	12.793	25.705
	N	5675.0	17.7	81.64	4003.0	8045.0
new shoreline	D	31.391	23.2	35.80	19.746	49.901
	N	3557.0	23.2	35.80	2238.0	5655.0
pelagic	D	11.085	23.2	46.77	6.999	17.556
	N	3879.0	23.2	46.77	2779.0	6144.0
pooled	D	14.413	14.1	124.89	10.92	19.023
(pre-existing shoreline + pelagic)	N	9554.0	14.1	124.89	7239.0	12610.0

FIGURE CAPTIONS

Figure 1. Map of the study area along the southern coast of the Kenai Peninsula, Alaska, with names and locations of major features.

Figure 2. Map showing extent of historical and current surveys in the Kenai Fjords region. The 1976 and 1986 surveys covered the entire nearshore area between Gore Point and Cape Resurrection. In 1989 and 2002, a randomly selected subset of the 1986 survey units was surveyed ("pre-existing transects"). "New transects" were established in 2002 to improve the accuracy and precision of the Kittlitz's Murrelet population estimate. See Methods for further detail.

Figure 3. Distribution and abundance of Kittlitz's Murrelets seen on transects along the southern coast of the Kenai Peninsula, Alaska, 3-13 July 2002.

Figure 4. Distribution and abundance of Marbled Murrelets seen on transects along the southern coast of the Kenai Peninsula, Alaska, 3-13 July 2002.

Figure 5. Negative trend in Kittlitz's Murrelet population in nearshore (< 300 m from shore) area of the Kenai Fjords region, from Cape Resurrection to Gore Point. "Nearshore total individuals" are total numbers of individuals seen on 1976 and 1986 surveys that transected the entire nearshore area (open squares), and estimates from 1989 and 2002 surveys that randomly subsampled the entire nearshore (filled squares; see Methods for estimation details). For illustration, the extrapolated 1986 nearshore population (filled 1986 square) is presented together with the number of birds counted directly (open 1986 square). Population change over time is modeled by a least-squares linear regression using the 1976 and 1986 direct counts and 1989 and 2002 estimated counts ($y = -5.05 + 10134$; $R^2 = 0.959$; $F_{1,2} = 46.32$, $P = 0.021$).

Figure 6. Marbled Murrelets in the Kenai Fjords area declined by ca. 62% from 1976-1989, then increased five-fold by 2002. "Nearshore total individuals" are total numbers of individuals seen on 1976 and 1986 surveys that transected the entire nearshore area (open squares), and estimates from 1989 and 2002 surveys that randomly subsampled the entire nearshore (filled squares; see Methods for estimation details). For illustration, the extrapolated 1986 nearshore population (filled 1986 square) is presented together with the number of birds counted directly (open 1986 square; boxes nudged apart for clarity).

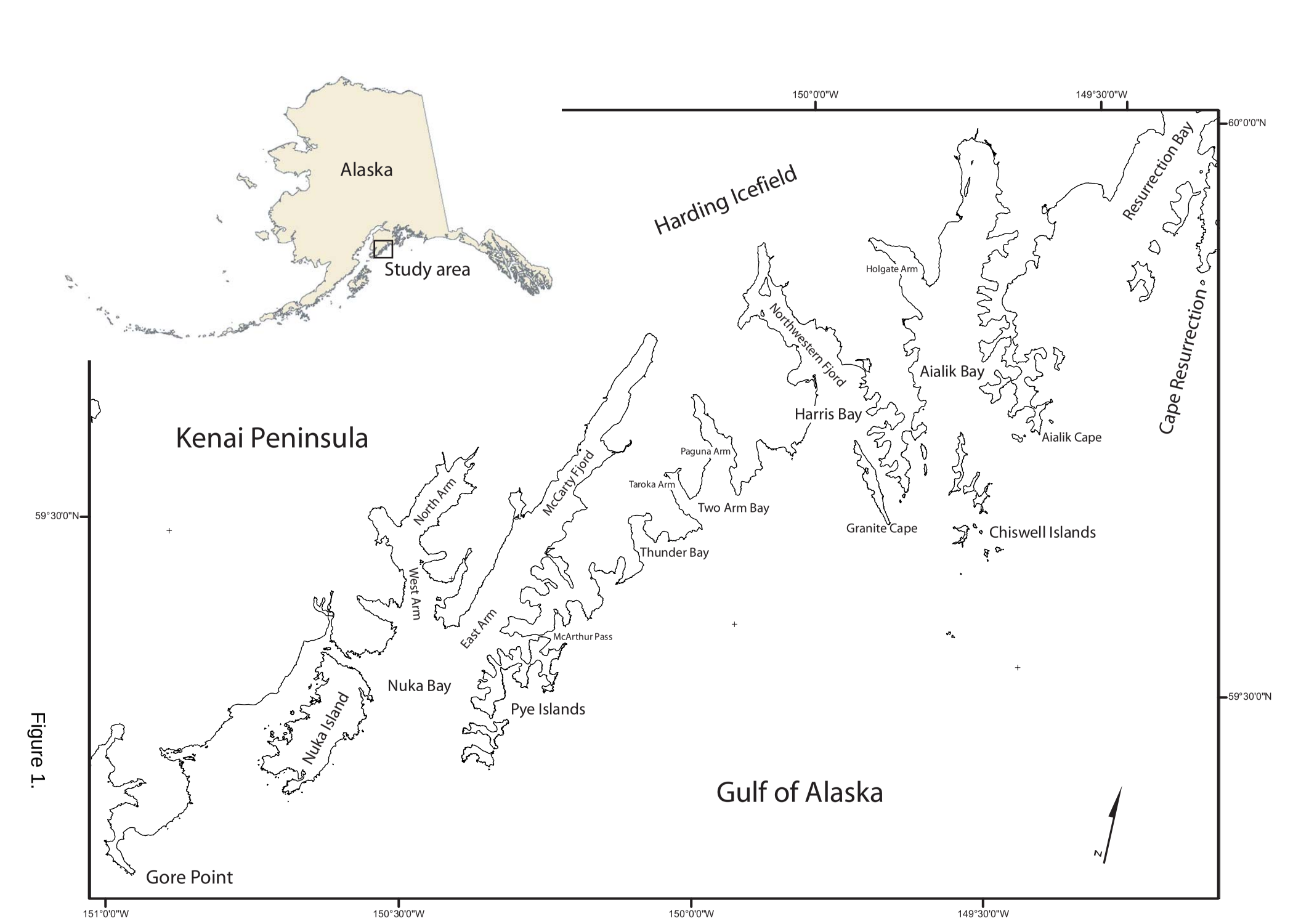

Alaska
Study area
Harding Icefield
Kenai Peninsula
Gulf of Alaska
Resurrection Bay
Cape Resurrection
Holgate Arm
Northwestern Fjord
Aialik Bay
Harris Bay
Aialik Cape
Paguna Arm
Taroka Arm
Two Arm Bay
Granite Cape
Chiswell Islands
Thunder Bay
McCarty Fjord
North Arm
West Arm
East Arm
McArthur Pass
Nuka Bay
Nuka Island
Pye Islands
Gore Point
150°0'0"W
149°30'0"W
60°0'0"N
59°30'0"N
151°0'0"W
150°30'0"W
N

Figure 1.

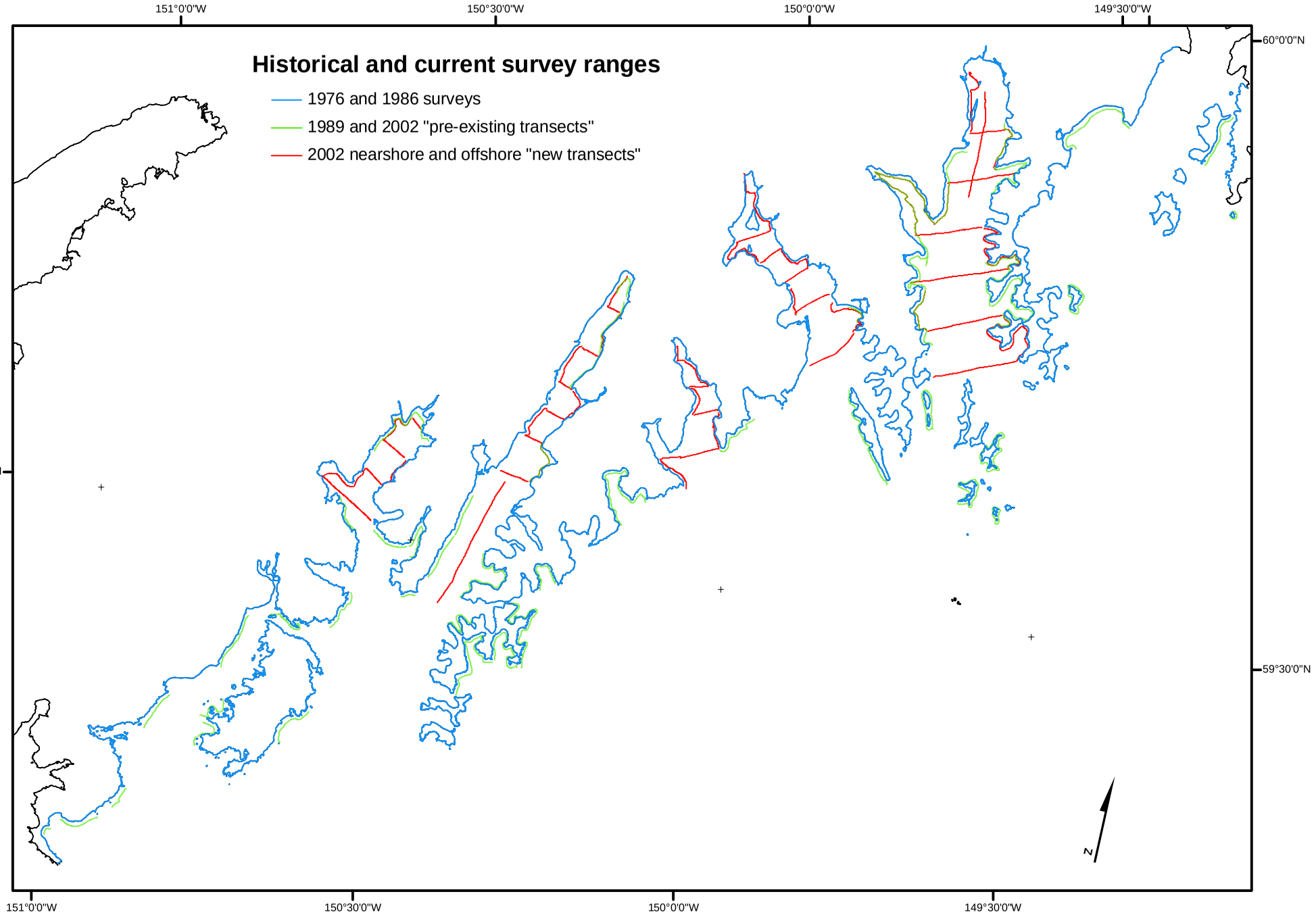

Historical and current survey ranges
1976 and 1986 surveys
1989 and 2002 "pre-existing transects"
2002 nearshore and offshore "new transects"
151°0'0"W
150°30'0"W
150°0'0"W
149°30'0"W
60°0'0"N
59°30'0"N
N

Figure 2.

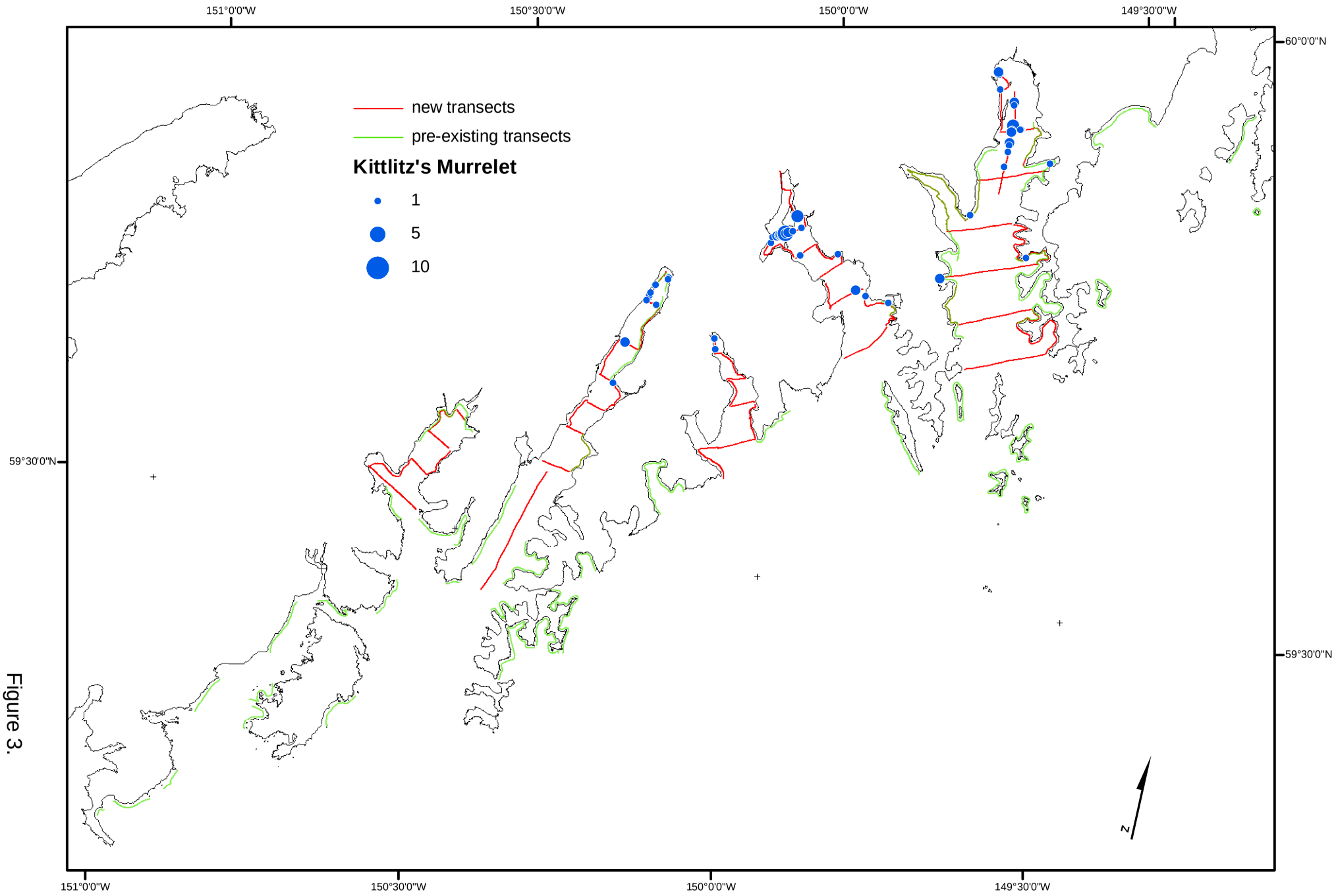

151°0'0"W
150°30'0"W
150°0'0"W
149°30'0"W
60°0'0"N
59°30'0"N
new transects
pre-existing transects
Kittlitz's Murrelet
1
5
10
N

Figure 3.

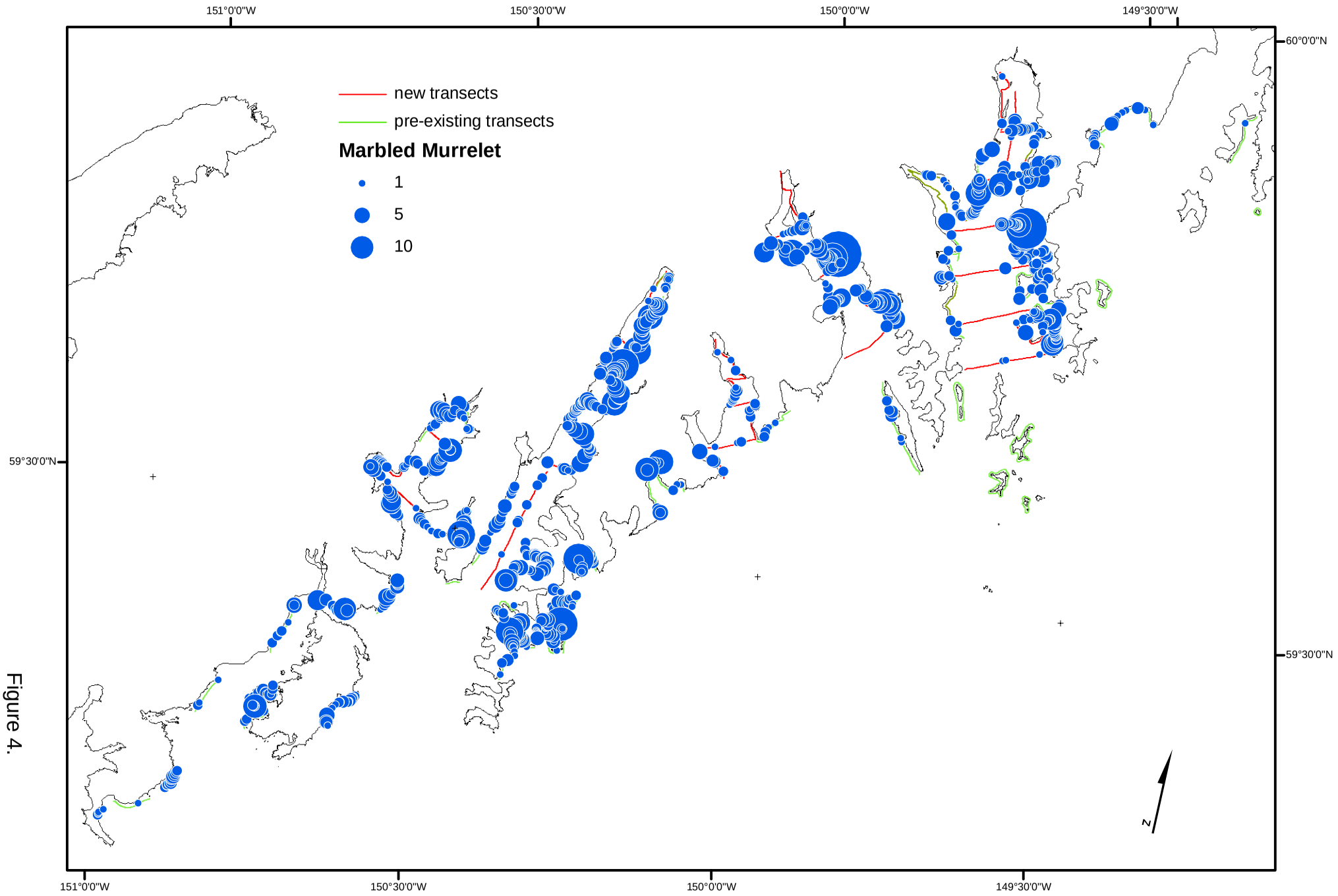

151°0'0"W
150°30'0"W
150°0'0"W
149°30'0"W
60°0'0"N
59°30'0"N
new transcects
pre-existing transcects
Marbled Murrelet
1
5
10
N

Figure 4.


Kittlitz's Murrelet
Nearshore total individuals
200
180
160
140
120
100
80
60
40
20
0
1970
1975
1980
1985
1990
1995
2000
2005
Year of survey

Figure 5.

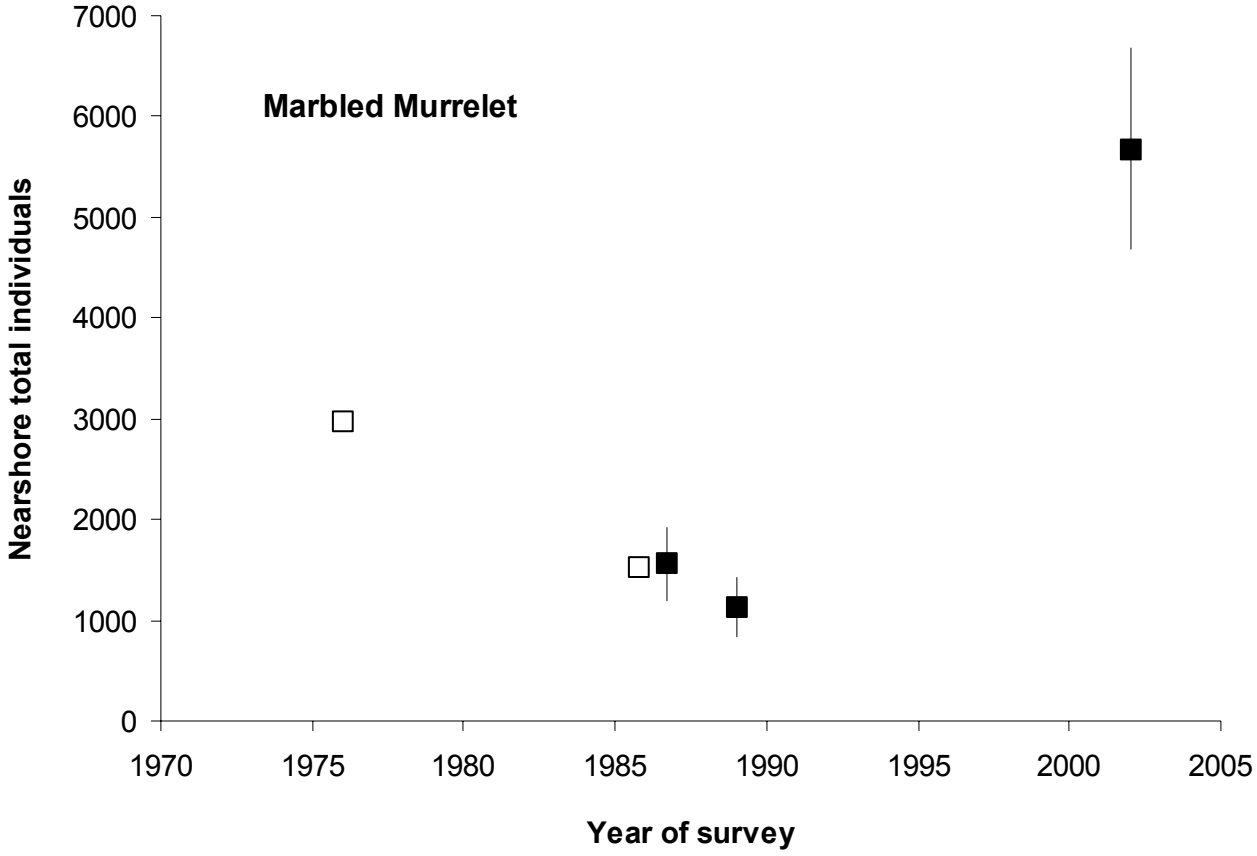
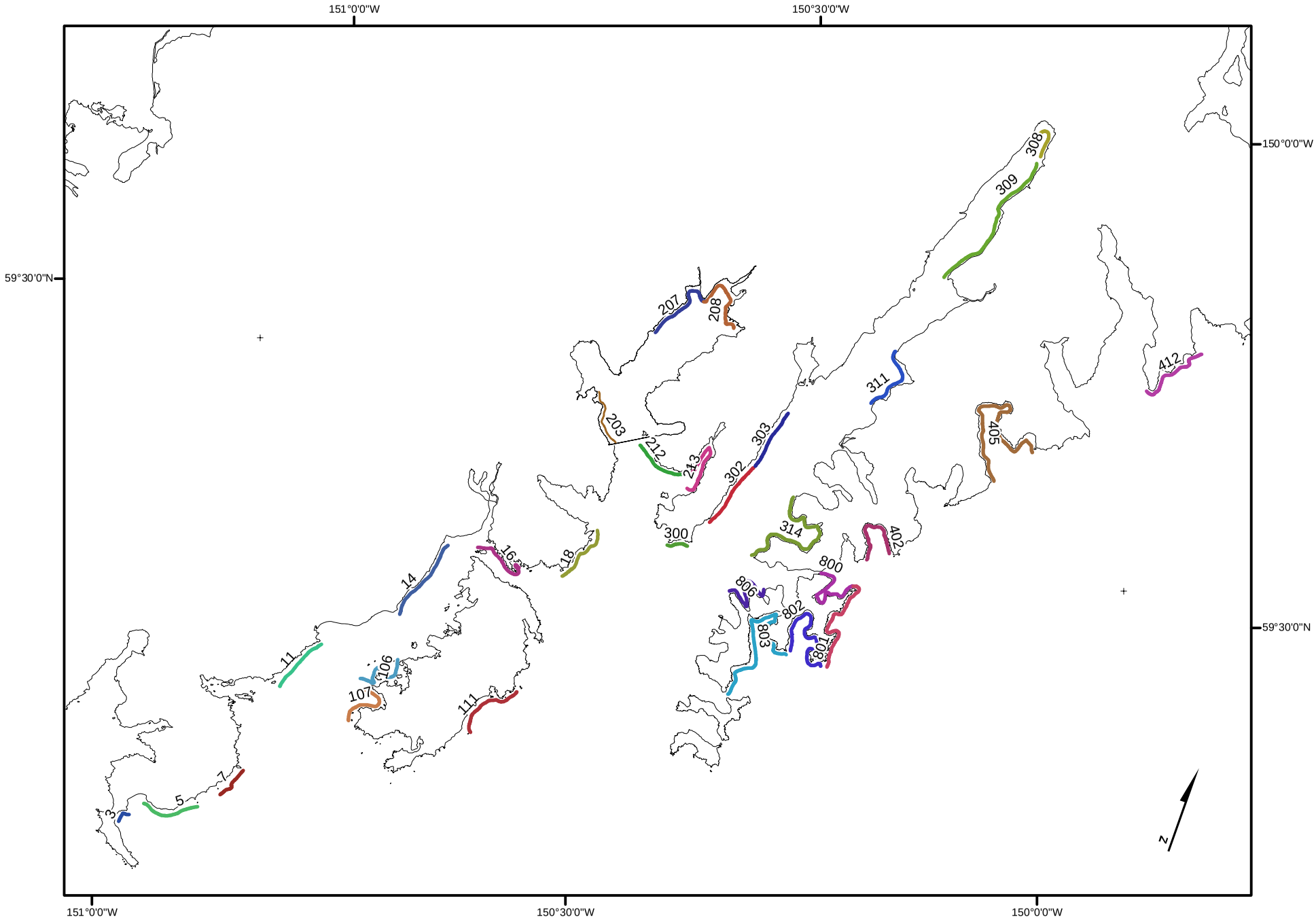
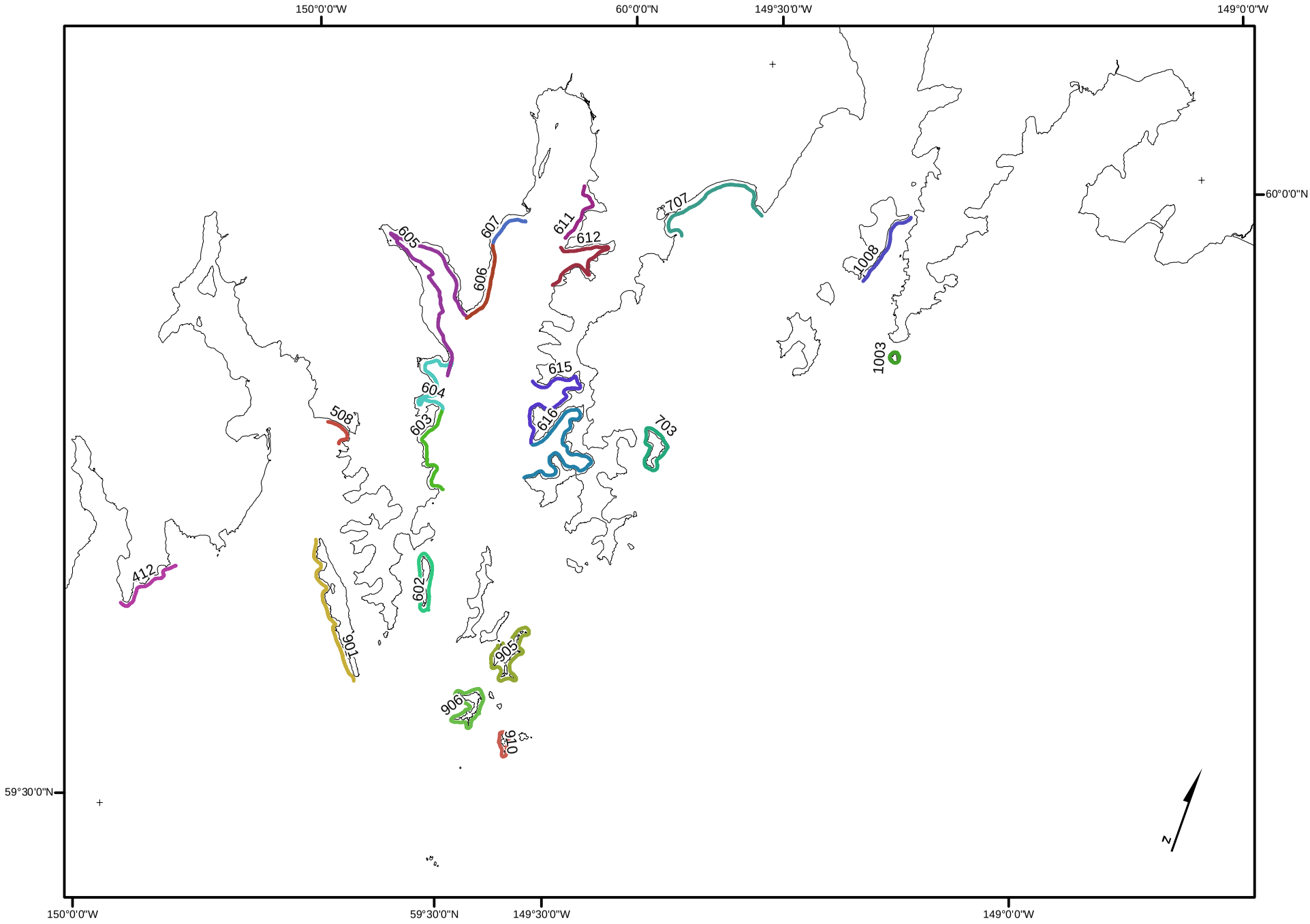
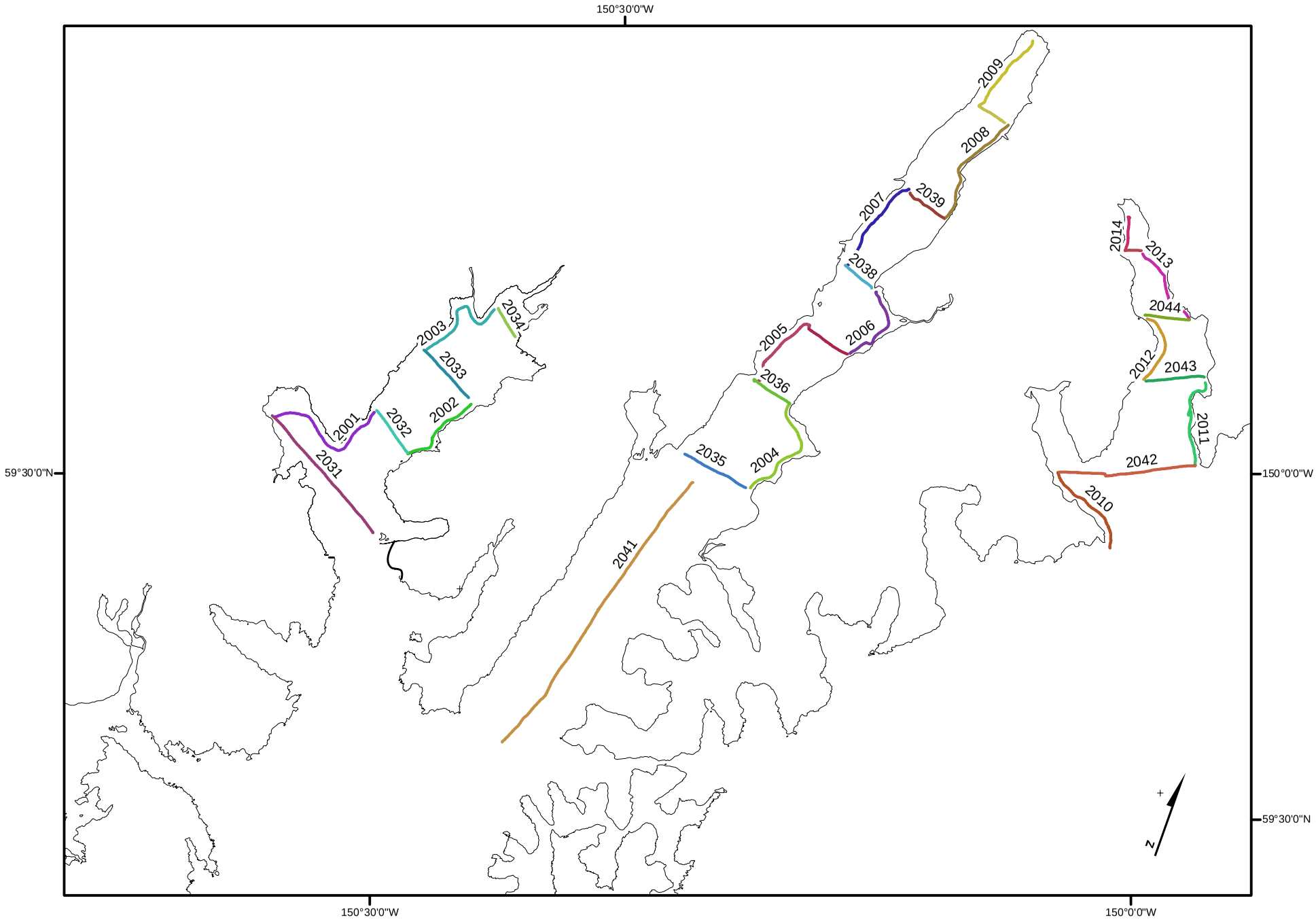

Marbled Murrelet
Nearshore total individuals
7000
6000
5000
4000
3000
2000
1000
0
1970
1975
1980
1985
1990
1995
2000
2005
Year of survey

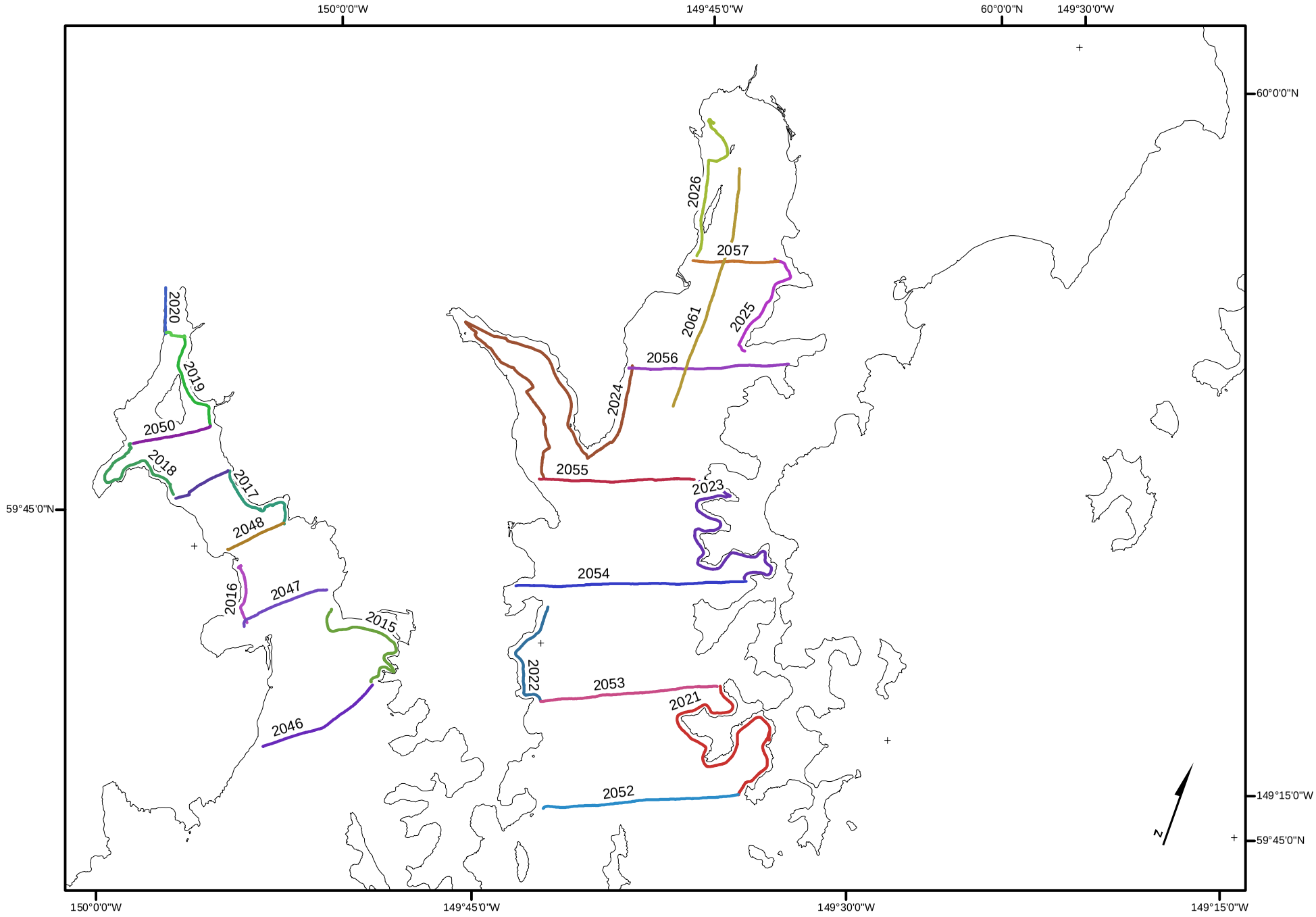
Figure 6.

LIST OF APPENDICES


151°0'0"W
150°30'0"W
150°0'0"W
59°30'0"N
3
5
7
11
14
16
18
106
107
111
203
207
208
212
243
300
302
303
308
309
311
314
402
405
412
800
802
803
806
808
N


150°0'0"W
60°0'0"N
149°30'0"W
149°0'0"W
59°30'0"N
605
607
611
612
606
707
1008
1003
615
604
603
616
508
703
412
602
901
905
906
910
N


150°30'0"W
59°30'0"N
150°0'0"W
2009
2008
2007
2039
2038
2005
2006
2036
2035
2004
2041
2003
2034
2033
2001
2032
2002
2031
2014
2013
2044
2012
2043
2011
2042
2010
N


150°0'0"W
149°45'0"W
60°0'0"N
149°30'0"W
59°45'0"N
149°15'0"W
2026
2057
2061
2025
2056
2024
2055
2023
2054
2022
2053
2021
2052
2020
2019
2050
2018
2017
2048
2016
2047
2015
2046
N

Appendix 5. Total numbers of *Brachyramphus* murrelets observed on nearshore surveys along the south coast of the Kenai Peninsula, Alaska. Current and historical survey results are shown; historical data are from U.S. Fish and Wildlife unpublished reports (Bailey 1976; Nishimoto and Rice 1987; Bailey and Rice 1989). Observations are summed by species (MAMU=Marbled Murrelet, KIMU=Kittlitz's Murrelet, BRMU=unidentified *Brachyramphus* murrelet) and by area. Areas are binned into the eleven survey units originally defined by Bailey (1976); for cross-reference, the corresponding smaller survey units defined for the 1986 and later surveys by Nishimoto and Rice (1987) are also shown by group (e.g. 600s = 600 series [601, 602, ...], etc.). "KFNP total" refers to totals within the Kenai Fjords National Park boundaries; "GP to CR" refers to the whole study area, Cape Resurrection to Gore Point.

Survey type	Survey year	Species	600s-12, 413, 500s AIAL	600s-12, 413, 500s SURA	200s YALH	300s HARM	700s AICA	400-411 MACS	800s PYES	900s CHIS	**KFNP total**	000s GOYA	100s NUKA	1000s RESU	**GP to CR**
entire	1976	MAMU	826	401	251	446	30	202	270	17	**2443**	156	360	11	**2970**
		KIMU	5	139	0	10	0	8	0	0	**162**	0	0	0	**162**
		TOTAL *Brachyramphus*	831	540	251	456	30	210	270	17	**2605**	156	360	11	**3132**
entire	1986	MAMU	461	388	49	164	90	66	127	51	**1396**	22	33	83	**1534**
		KIMU	28	29	1	17	2	0	9	0	**86**	0	0	0	**86**
		BRMU	225	6	0	3	46	2	13	0	**295**	0	0	5	**300**
		MAMU+BRMU	686	394	49	167	136	68	140	51	**1691**	22	33	88	**1834**
		TOTAL *Brachyramphus*	714	423	50	184	138	68	149	51	**1777**	22	33	88	**1920**
31% random	1986	MAMU	228	46	0	67	1	20	27	15	**404**	10	5	3	**422**
		KIMU	12	0	1	12	0	0	6	0	**31**	0	0	0	**31**
		BRMU	140	0	0	1	11	0	0	0	**152**	0	0	0	**152**
		MAMU+BRMU	368	46	0	68	12	20	27	15	**556**	10	5	3	**574**
		TOTAL *Brachyramphus*	380	46	1	80	12	20	33	15	**587**	10	5	3	**605**
31% random	1989	MAMU	186	4	12	69	13	22	4	5	**315**	18	1	2	**336**
		KIMU	17	0	0	3	5	0	1	0	**26**	0	0	0	**26**
		BRMU	335	0	0	1	29	0	0	0	**365**	0	0	4	**369**
		MAMU+BRMU	521	4	12	70	42	22	4	5	**680**	18	1	6	**705**
		TOTAL *Brachyramphus*	538	4	12	73	47	22	5	5	**706**	18	1	6	**731**
31% random	2002	MAMU	287	70	208	408	23	124	269	16	**1405**	157	137	1	**1700**
		KIMU	5	1	0	2	0	0	0	0	**8**	0	0	0	**8**
		BRMU	72	12	12	29	9	11	43	14	**202**	6	19	1	**228**
		MAMU+BRMU	359	82	220	437	32	135	312	30	**1607**	163	156	2	**1928**
		TOTAL *Brachyramphus*	364	83	220	439	32	135	312	30	**1615**	163	156	2	**1936**

Appendix 6. Current and historical survey methods used along the south coast of the Kenai Peninsula, Alaska. "BRMU recorded" refers to whether undentified *Brachyramphus* murrelets (Marbled and Kittlitz's) were recorded as "BRMU" ("yes" in table), or whether all *Brachyramphus* murrelets seen were classified to species ("no" in table). Platform refers to the type of boat used for observations. Historical methods are found in unpublished U.S. Fish and Wildlife Reports (Bailey 1976; Nishimoto and Rice 1987; Bailey and Rice 1989).

Survey year	Nearshore habitat sampled	Offshore survey?	Start date	End date	Platform	Survey strip width	BRMU recorded?	% total *Brachyramphus* not identified to species
1976	entire coast	no	19-Jun	14-Jun	13 m vessel, plus some use of 4.3 m inflatable	not specified	no	n/a
1986	entire coast	no	25-Jun	12-Jul	4.7 m inflatable, plus some use of 9.6 m vessel	not specified	yes	15.6
1989	31% random	no	27-Jun	07-Jul	9.6 m vessel, plus some use of 4.7 m inflatable	not specified	yes	50.5
2002	31% random	yes, in fjords	03-Jul	13-Jul	12.8 m seiner	300 m	yes	11.8

Appendix 7. Numbers of *Brachyramphus* murrelets seen on strip transects along the south coast of the Kenai Peninsula, grouped by transect number and behavior. See Appendices 1-4 for delineation of transects.

Transect number	Count by species and behavior								
	KIMU			MAMU			unidentified *Brachyramphus*		
pre-existing transects	flying	on water	total	flying	on water	total	flying	on water	total
3					6	6			
5					1	1			
7					38	38		1	1
11					5	5			
14					21	21		2	2
16					47	47		1	1
18				2	37	39		2	2
106					55	55	4	4	8
107					34	34			
111				2	45	47		11	11
203					43	43		4	4
207				2	28	30			
208					24	24		8	8
212					14	14			
213					91	91			
300									
302					25	25			
303					23	23	1		1
308		2	**2**		8	8		2	2
309					171	171		1	1
311				3	52	55	1	1	2
314					126	126	4	19	23
402				7	56	63		7	7
405					61	61		4	4
412					6	6	1	1	2
508		1	**1**	3	61	64	3	7	10
602									
603					5	5		8	8
604		2	**2**		17	17		3	3
605				2	27	29	6	3	9
606		1	**1**	3	58	61		6	6
607					27	27		5	5
611					9	9			
612		1	**1**	1	69	70		16	16
615		1	**1**	4	22	26	3	2	5
616					41	41		20	20
703									
707					23	23		9	9
800				2	38	40	1	18	19
801					33	33		1	1
802				2	57	59	2	9	11
803				3	124	127	6		6
806					9	9		6	6
901				2	14	16	5	9	14
905									
906									
910									
1003									
1008					1	1	1		1
total pre-existing shoreline	0	8	8	38	1652	1690	38	190	228

Appendix 7. (continued) Numbers of *Brachyramphus* murrelets seen on strip transects along the south coast of the Kenai Peninsula, grouped by transect number and behavior. See Appendices 1-4 for delineation of transects.

new shoreline transects									
2001				1	27	28		2	2
2002					76	76		1	1
2003					37	37			
2004				3	52	55	1	1	2
2005					82	82			
2006		1	**1**	2	87	89		1	1
2007				2	21	23			
2008				2	95	97	3	11	14
2009		6	**6**		1	1			
2010					18	18		2	2
2011					14	14			
2012					19	19			
2013					3	3			
2014	1	1	**2**						
2015		2	**2**	2	136	138	2		2
2016				1	10	11			
2017		1	**1**		126	126		1	1
2018		2	**2**		53	53	1	3	4
2019		3	**3**		5	5			
2020									
2021					137	137		7	7
2022					2	2		8	8
2023					199	199	1		1
2024		1	**1**	4	80	84	5	5	10
2025					12	12			
2026		6	**6**		3	3		1	1
total new shoreline	1	23	24	17	1295	1312	13	43	56
new pelagic transects									
2031				2	18	20		2	2
2032					7	7			
2033					9	9			
2034					4	4			
2035				7	5	12			
2036				3	16	19			
2037				4	23	27	2		2
2038					13	13	2	3	5
2039		2	**2**	2	4	6			
2040	1	1	**2**	1	20	21			
2042				4		4			
2043									
2044									
2045					1	1			
2046					3	3			
2047		2	**2**		45	45			
2048				2	9	11	1	1	2
2049		1	**1**		13	13		3	3
2050	2	22	**24**	1	17	18			
2051									
2052				2	1	3			
2053					1	1			
2054				1	10	11	6	2	8
2055					12	12		5	5
2056					13	13			
2057		3	**3**	2	22	24			
total new pelagic	3	31	34	31	266	297	11	16	27
new pelagic transects used only for distribution mapping, not for density or population estimations									
2041					11	11	4	1	5
2061	1	14	**15**	1	39	40	1	6	7

Appendix 8. Total numbers of birds and mammals observed on **all** transects along the south coast of the Kenai Peninsula, Alaska, from Cape Resurrection to Gore Point, 3-13 July 2002. Species are listed in taxonomic order. Species totals include only those animals observed while on transect (i.e. not while travelling between transects) and within the strip transect (300 m width). See Methods for further details of observation protocol and transect locations.

Order	Family	Common name	Scientific name	Species code	Total
Birds					
Gaviiformes	Gaviidae	Common Loon	*Gavia immer*	COLO	7
		Pacific Loon	*Gavia pacifica*	PALO	6
		Red-throated Loon	*Gavia stellata*	RTLO	1
Procellariiformes	Procellariidae	unidentified Shearwater spp.	*Puffinus* spp.	UNSH	1
Pelecaniformes	Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*	DCCO	265
		Red-faced Cormorant	*Phalacrocorax urile*	RFCO	100
		Pelagic Cormorant	*Phalacrocorax pelagicus*	PECO	376
		Unidentified Cormorant	*Phalacrocorax* spp.	UNCO	190
Anseriformes	Anatidae	American Wigeon	*Anas americana*	AMWI	1
		Harlequin Duck	*Histrionicus histrionicus*	HADU	273
		Surf Scoter	*Melanitta perspicillata*	SUSC	69
		White-winged Scoter	*Melanitta fusca*	WWSC	63
		Unidentified Scoter	*Melanitta* spp.	UNSC	150
		Long-tailed Duck	*Clangula hyemalis*	LTDU	1
		Barrow's Goldeneye	*Bucephala islandica*	BAGO	7
		Common Merganser	*Mergus merganser*	COME	348
Falconiformes	Accipitridae	Bald Eagle	*Haliaeetus leucocephalus*	BAEA	46
Charadriiformes	Haematopodidae	Black Oystercatcher	*Haematopus bachmani*	BLOY	23
	Scolopacidae	Black Turnstone	*Arenaria melanocephala*	BLTU	1
	Laridae	Mew Gull	*Larus canus*	MEGU	46
		Herring Gull	*Larus argentatus*	HEGU	1
		Glaucous-winged Gull	*Larus glaucescens*	GWGU	4148
		Black-legged Kittiwake	*Rissa tridactyla*	BLKI	1191

Appendix 8 (Continued). Total numbers of birds and mammals observed on **all** transects along the south coast of the Kenai Peninsula, Alaska, from Cape Resurrection to Gore Point, 3-13 July 2002. Species are listed in taxonomic order. Species totals include only those animals observed while on transect (i.e. not while travelling between transects) and within the strip transect (300 m width). See Methods for further details of observation protocol and transect locations.

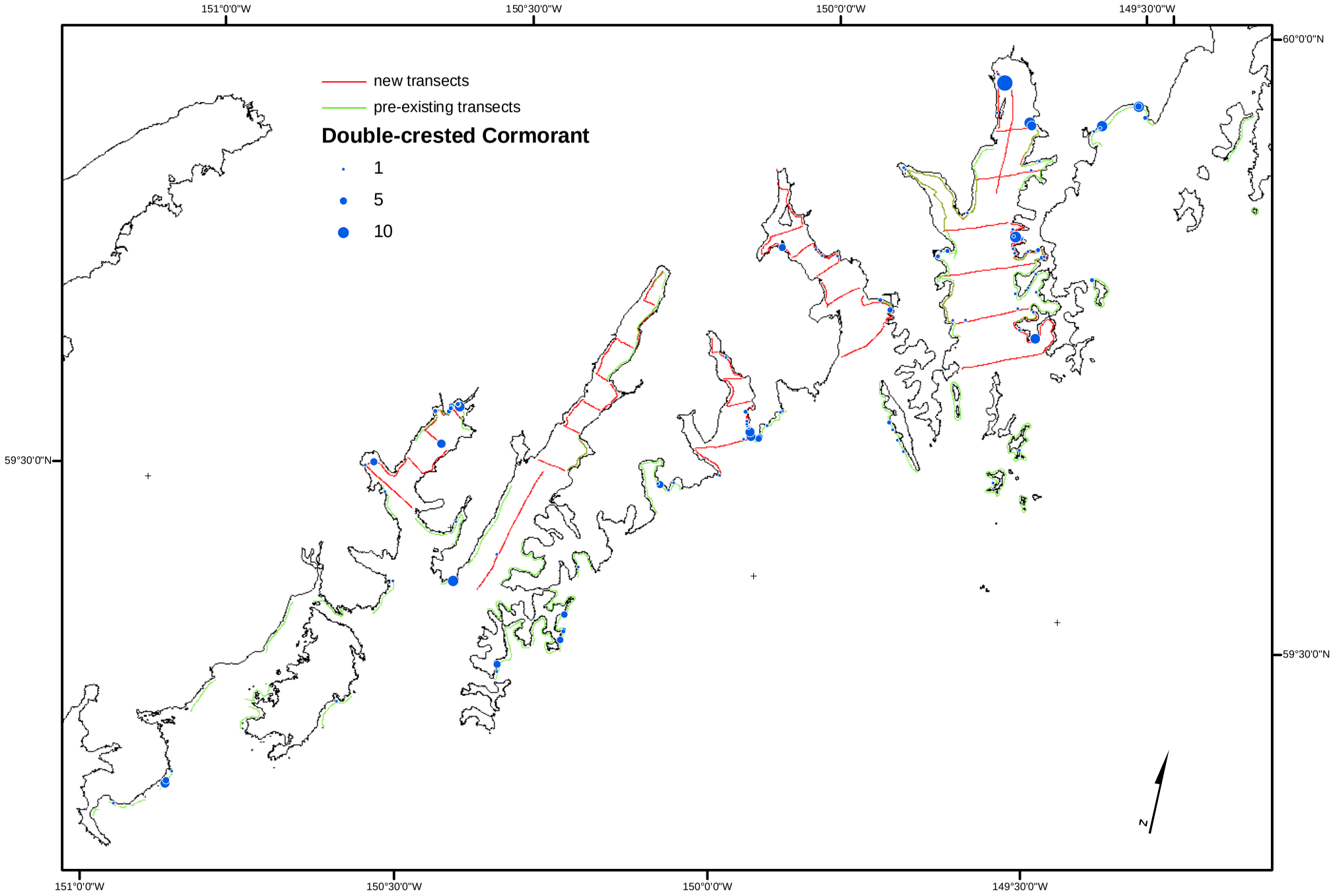
Order	Family	Common name	Scientific name	Species code	Total
	Alcidae	Common Murre	*Uria aalge*	COMU	1074
		Thick-billed Murre	*Uria lomvia*	TBMU	1
		Unidentified Murre	*Uria* spp.	UNMU	1
		Pigeon Guillemot	*Cepphus columba*	PIGU	760
		Marbled Murrelet	*Brachyramphus marmoratus*	MAMU	3311
		Kittlitz's Murrelet	*Brachyramphus brevirostris*	KIMU	66
		Unidentified *Brachyramphus* Murrelet	*Brachyramphus* spp.	BRMU	311
		Rhinoceros Auklet	*Cerorhinca monocerata*	RHAU	393
		Horned Puffin	*Fratercula corniculata*	HOPU	1706
		Tufted Puffin	*Fratercula cirrhata*	TUPU	1886
Passeriformes	Corvidae	Northwestern Crow	*Corvus caurinus*	NOCR	37
		Common Raven	*Corvus corax*	CORA	1
Mammals					
Carnivora	Mustelidae	Sea Otter	*Enhydra lutris*	SEOT	122
		River Otter	*Lutra canadensis*	RIOT	3
	Otariidae	Steller Sea Lion	*Eumetopias jubatus*	STSL	30
	Phocidae	Harbor Seal	*Phoca vitulina*	HASE	174
Cetacea (Mysticeti)	Balaenopteridae	Humpback Whale	*Megaptera novaeangliae*	HUWH	6
Cetacea (Odontoceti)	Delphinidae	Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	PWSD	2
	Phocoenidae	Harbor Porpoise	*Phocoena phocoena*	HAPO	1
		Dall's Porpoise	*Phocoenoides dalli*	DAPO	4

Appendix 9. Total numbers of birds and mammals observed on 49 **pre-existing** transects along the south coast of the Kenai Peninsula, Alaska, from Cape Resurrection to Gore Point, 3-13 July 2002. Species are listed in taxonomic order. Species totals include only those animals observed while on transect (i.e. not while travelling between transects) and within the strip transect (300 m width). See Methods for further details of observation protocol and transect locations.

Order	Family	Common name	Scientific name	Species code	Total
Birds					
Gaviiformes	Gaviidae	Common Loon	*Gavia immer*	COLO	3
		Pacific Loon	*Gavia pacifica*	PALO	4
		Red-throated Loon	*Gavia stellata*	RTLO	1
Procellariiformes	Procellariidae	unidentified Shearwater spp.	*Puffinus* spp.	UNSH	1
Pelecaniformes	Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*	DCCO	146
		Red-faced Cormorant	*Phalacrocorax urile*	RFCO	99
		Pelagic Cormorant	*Phalacrocorax pelagicus*	PECO	363
		Unidentified Cormorant	*Phalacrocorax* spp.	UNCO	145
Anseriformes	Anatidae	Harlequin Duck	*Histrionicus histrionicus*	HADU	109
		Surf Scoter	*Melanitta perspicillata*	SUSC	51
		White-winged Scoter	*Melanitta fusca*	WWSC	50
		Long-tailed Duck	*Clangula hyemalis*	LTDU	1
		Common Merganser	*Mergus merganser*	COME	187
Falconiformes	Accipitridae	Bald Eagle	*Haliaeetus leucocephalus*	BAEA	29
Charadriiformes	Haematopodidae	Black Oystercatcher	*Haematopus bachmani*	BLOY	11
	Laridae	Mew Gull	*Larus canus*	MEGU	25
		Herring Gull	*Larus argentatus*	HEGU	1
		Glaucous-winged Gull	*Larus glaucescens*	GWGU	2614
		Black-legged Kittiwake	*Rissa tridactyla*	BLKI	952
	Alcidae	Common Murre	*Uria aalge*	COMU	904
		Thick-billed Murre	*Uria lomvia*	TBMU	1
		Unidentified Murre	*Uria* spp.	UNMU	1
		Pigeon Guillemot	*Cepphus columba*	PIGU	545

Appendix 9 (Continued). Total numbers of birds and mammals observed on 49 **pre-existing** transects along the south coast of the Kenai Peninsula, Alaska, from Cape Resurrection to Gore Point, 3-13 July 2002. Species are listed in taxonomic order. Species totals include only those animals observed while on transect (i.e. not while travelling between transects) and within the strip transect (300 m width). See Methods for further details of observation protocol and transect locations.

Order	Family	Common name	Scientific name	Species code	Total
		Marbled Murrelet	*Brachyramphus marmoratus*	MAMU	1700
		Kittlitz's Murrelet	*Brachyramphus brevirostris*	KIMU	8
		Unidentified *Brachyramphus* Murrelet	*Brachyramphus* spp.	BRMU	228
		Rhinoceros Auklet	*Cerorhinca monocerata*	RHAU	103
		Horned Puffin	*Fratercula corniculata*	HOPU	1458
		Tufted Puffin	*Fratercula cirrhata*	TUPU	1609
Passeriformes	Corvidae	Northwestern Crow	*Corvus caurinus*	NOCR	13
Mammals					
Carnivora	Mustelidae	Sea Otter	*Enhydra lutris*	SEOT	37
	Otariidae	Steller Sea Lion	*Eumetopias jubatus*	STSL	30
	Phocidae	Harbor Seal	*Phoca vitulina*	HASE	15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pre-existing transcects
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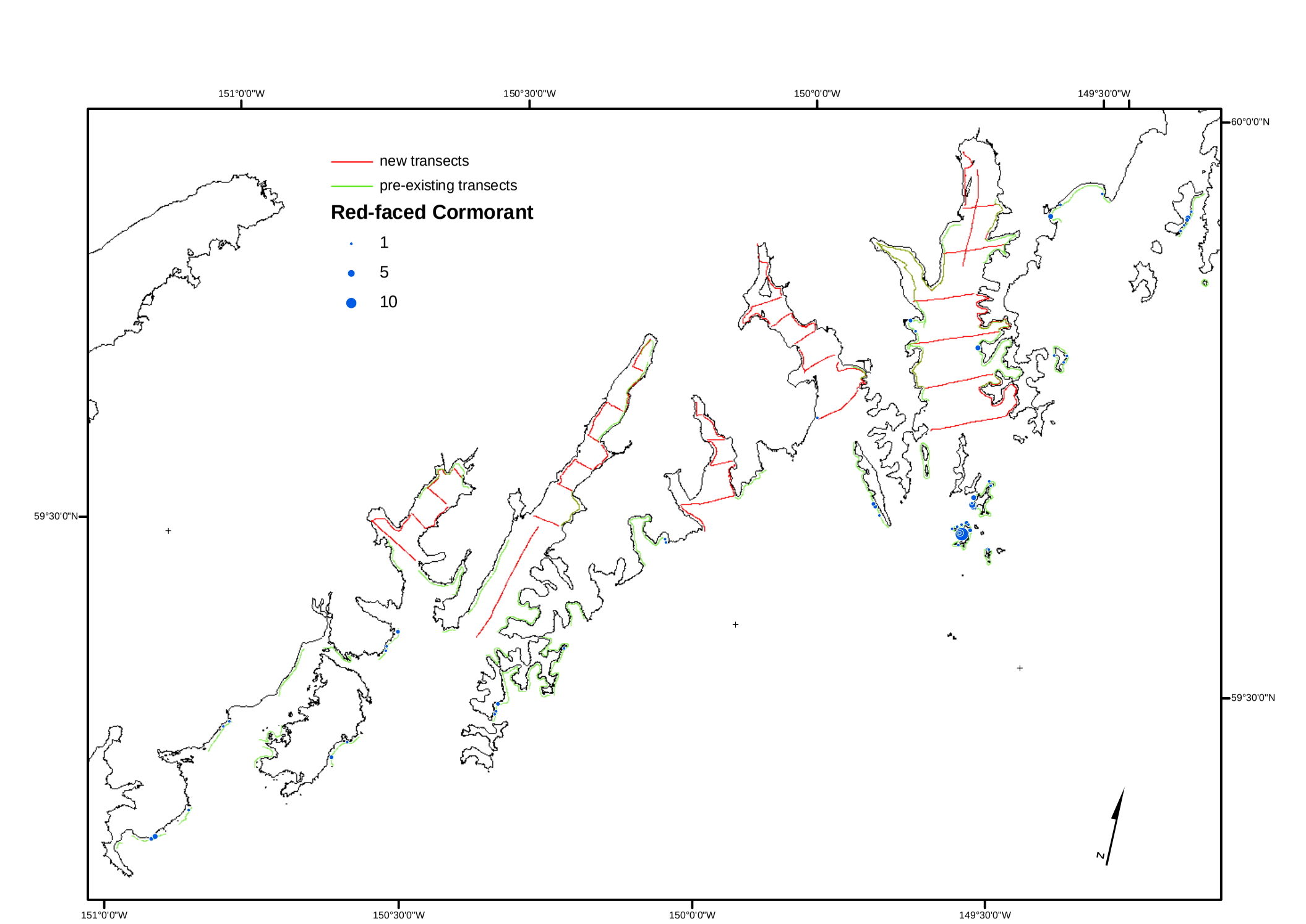
1
5
10
N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pre-existing transcects
Red-faced Cormorant
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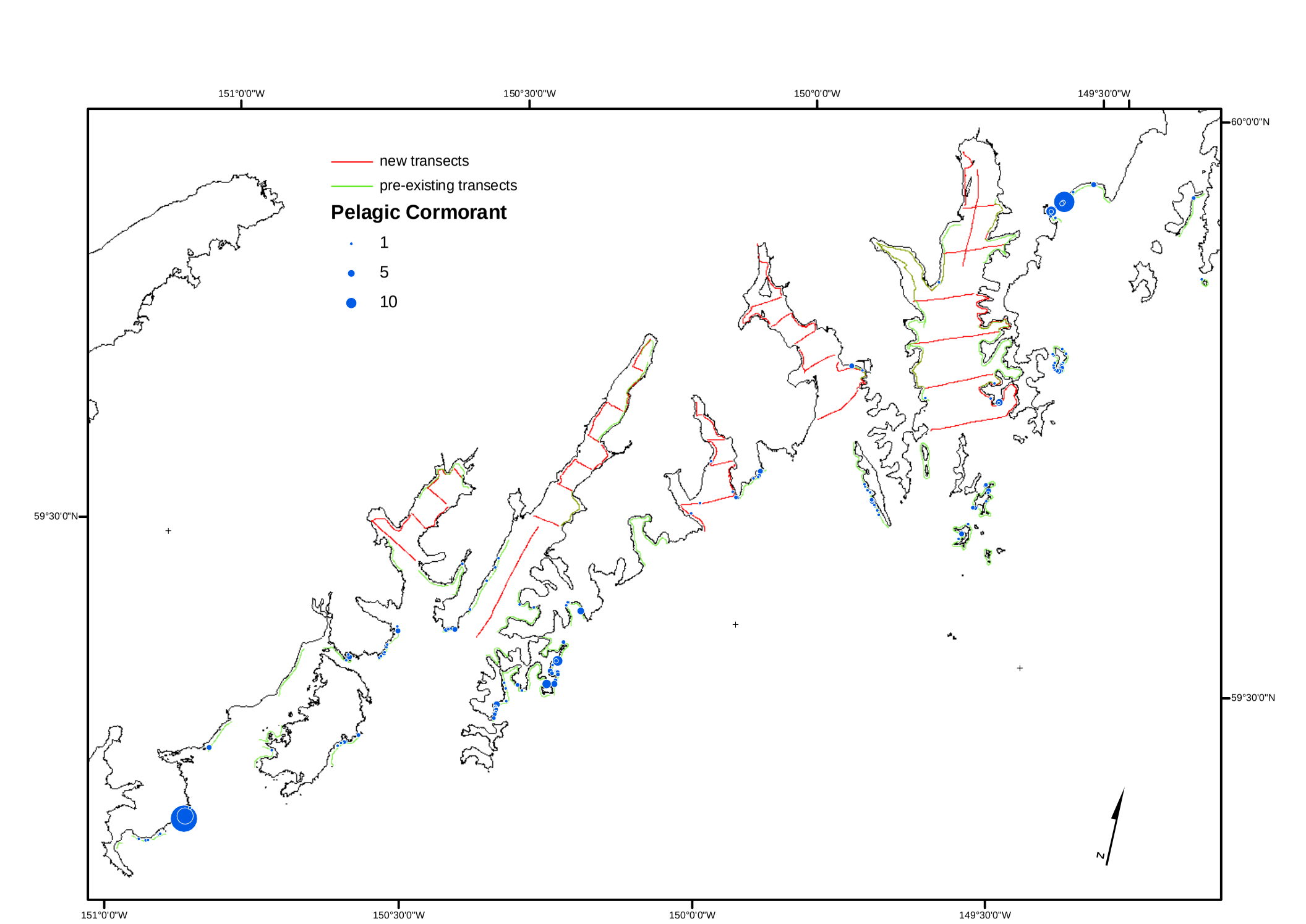
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pre-existing transcects
Pelagic Cormorant
1
5
10
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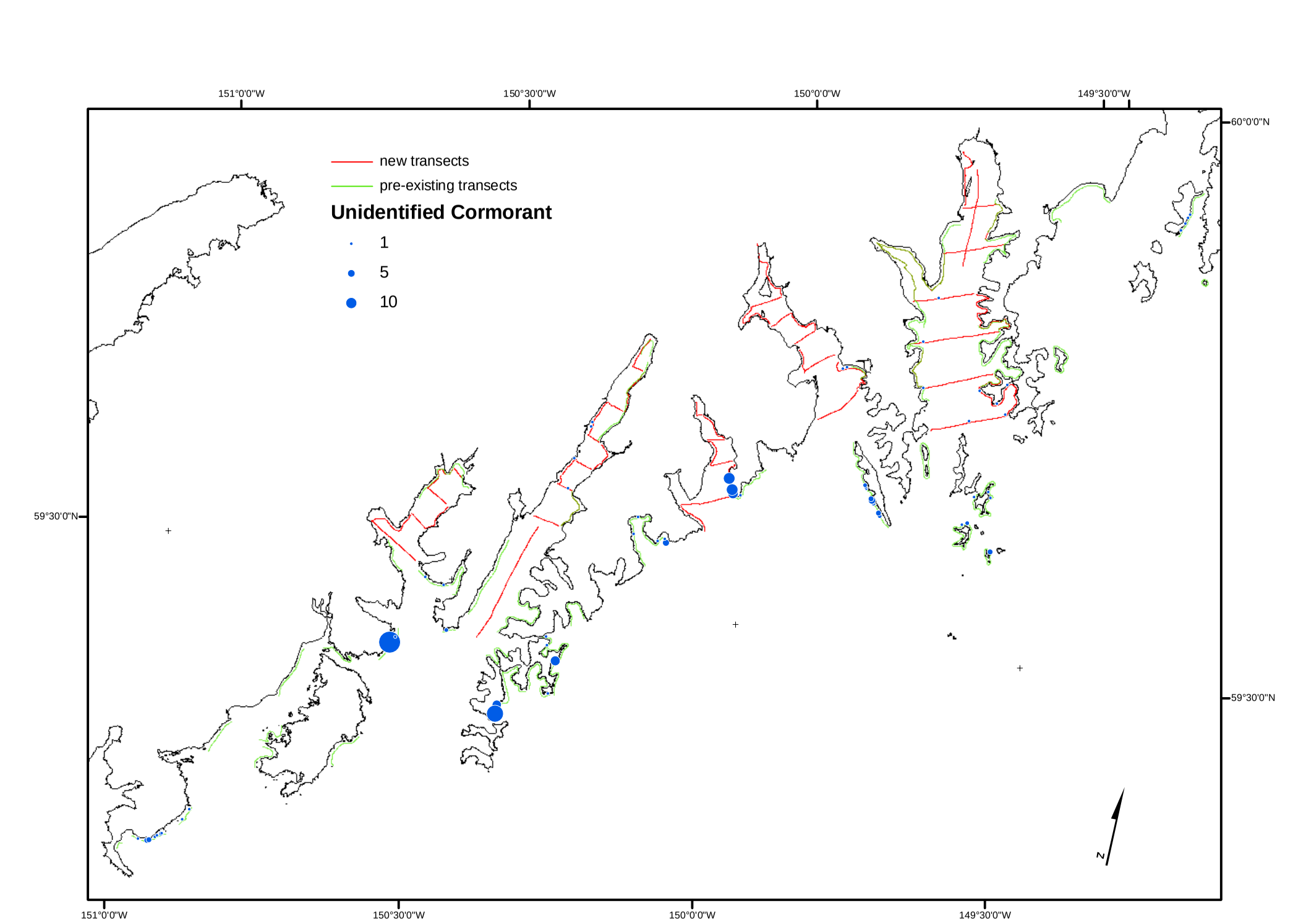
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Unidentified Cormorant
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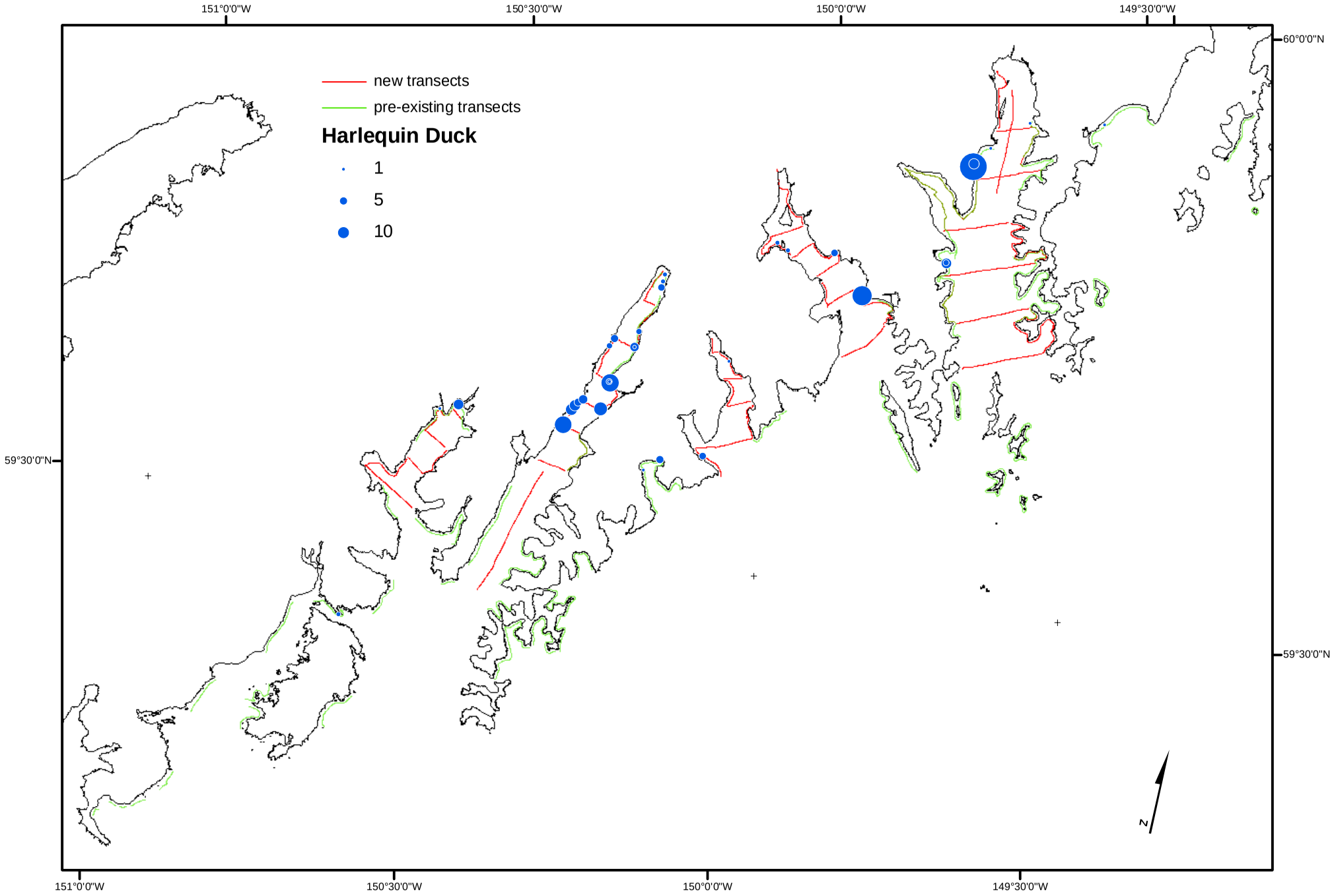
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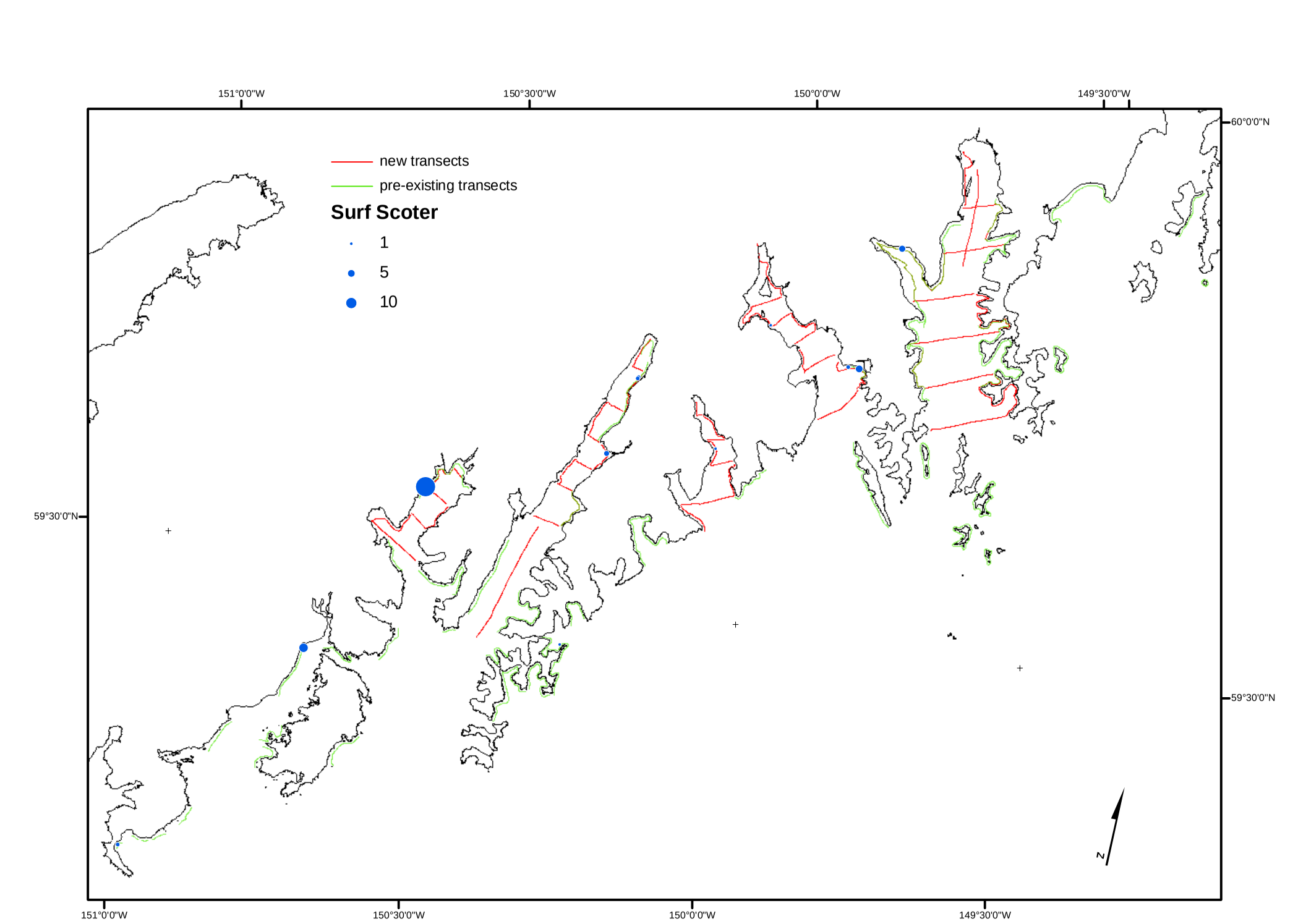
Harlequin Duck
1
5
10
N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Surf Scoter
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5
10
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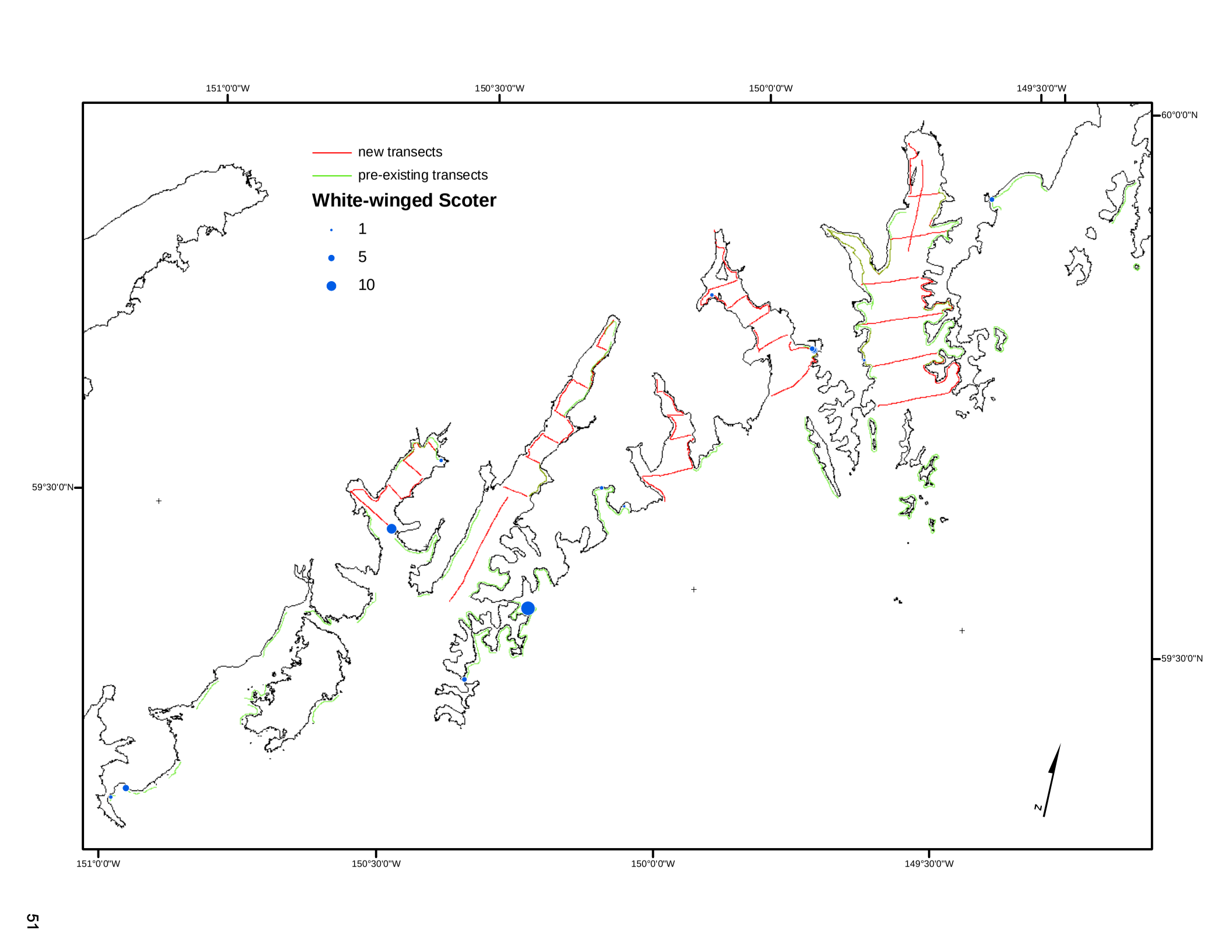
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10
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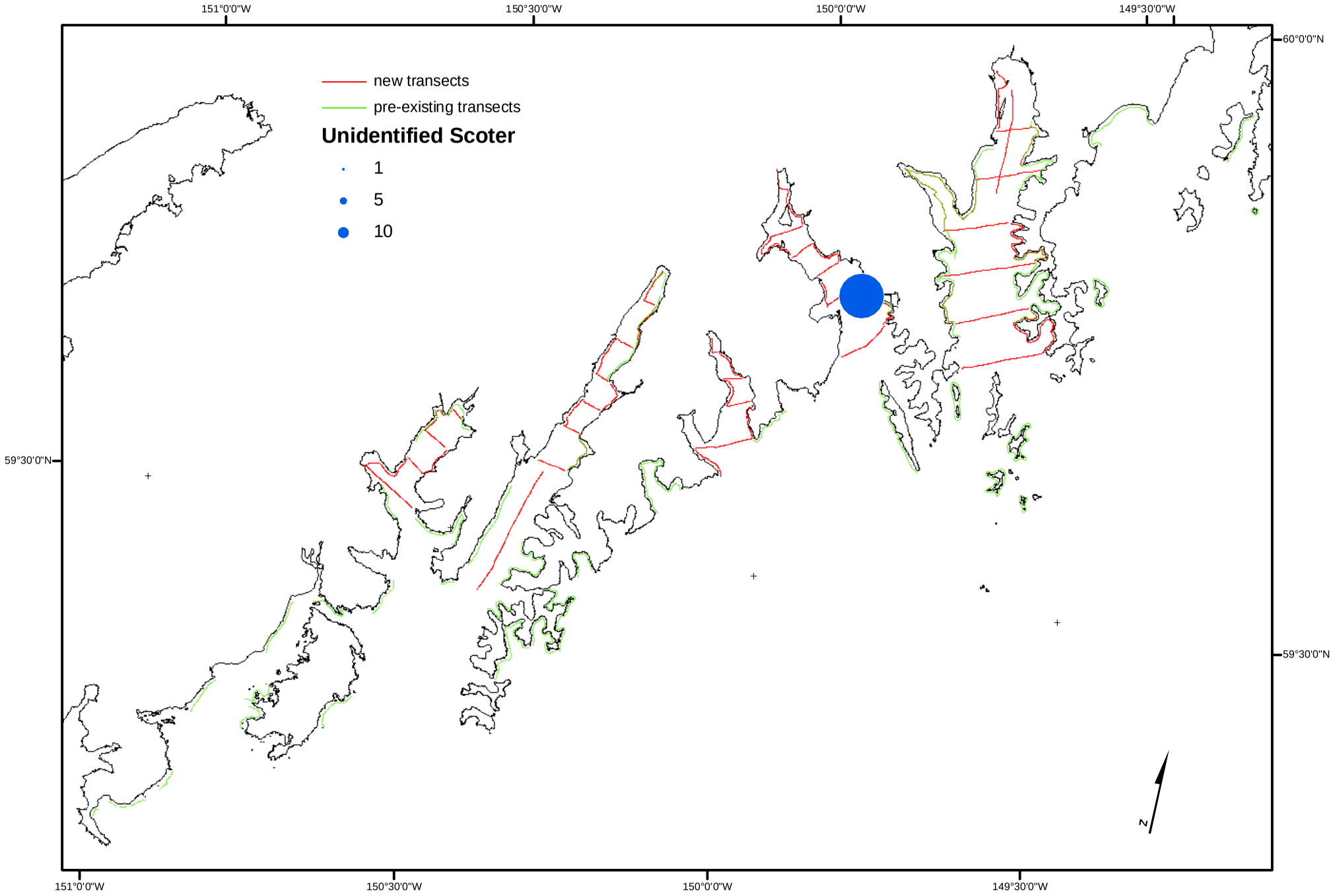
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Unidentified Scoter
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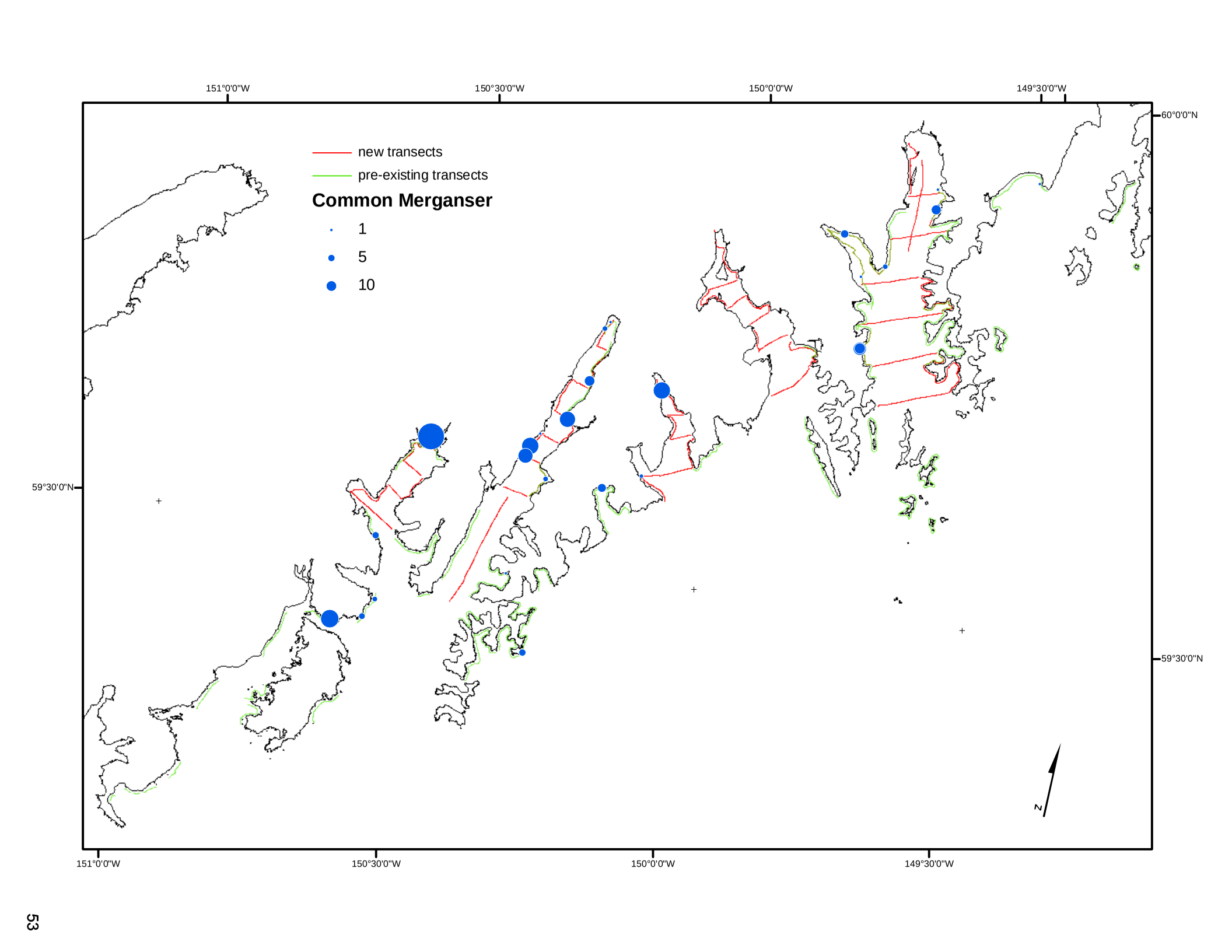
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pre-existing transcects
Common Merganser
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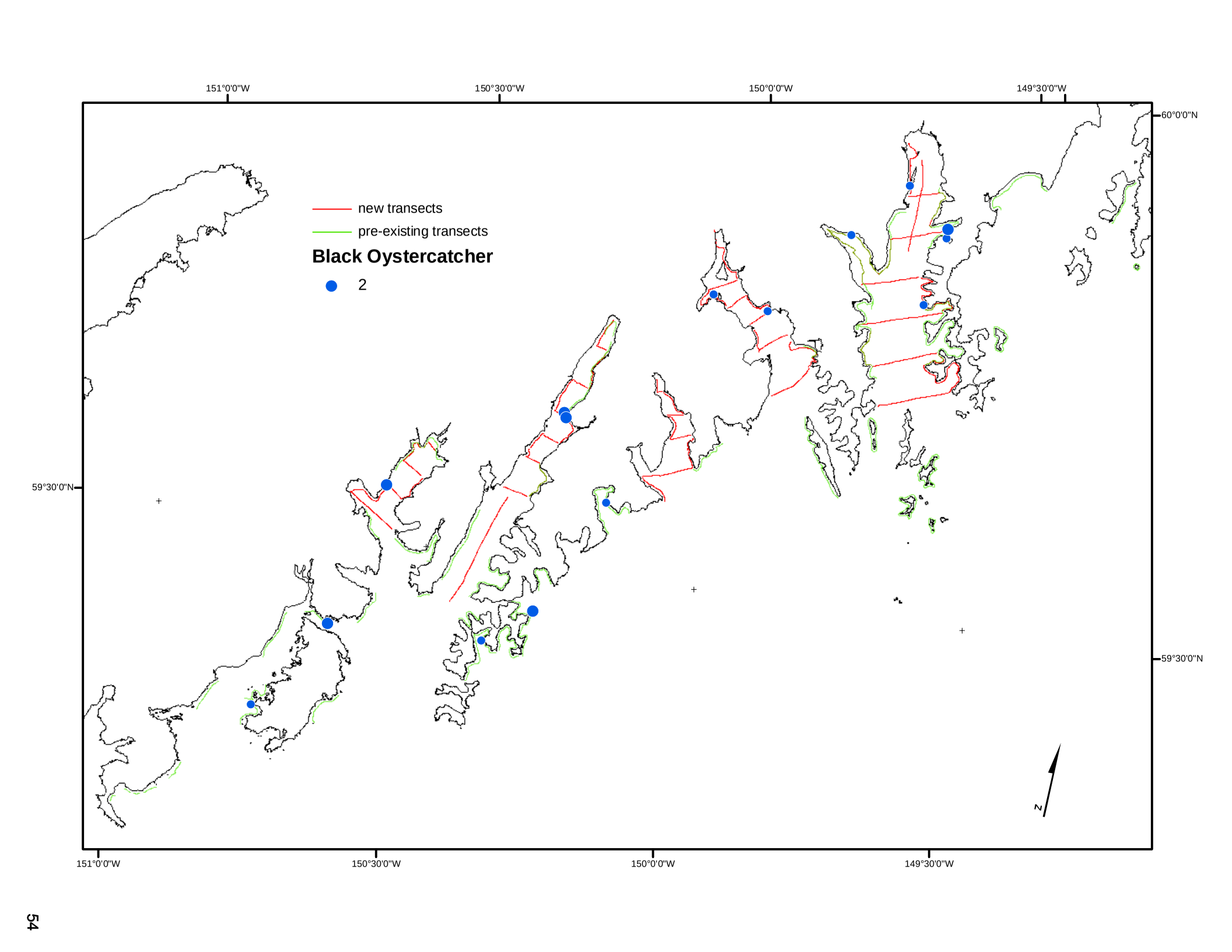
5
10
N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Black Oystercatcher
2
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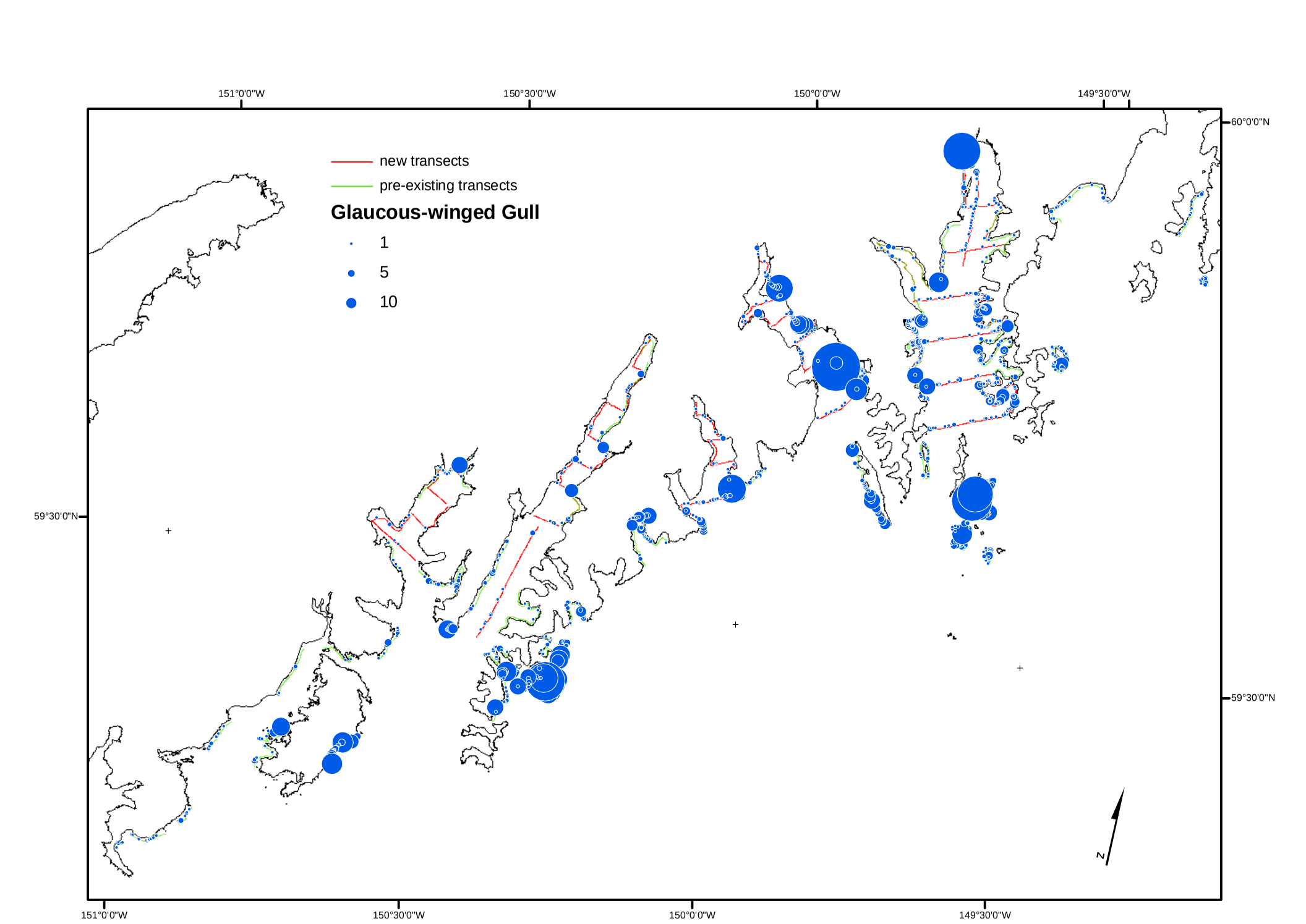
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pre-existing transcects
Glaucous-winged Gull
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10
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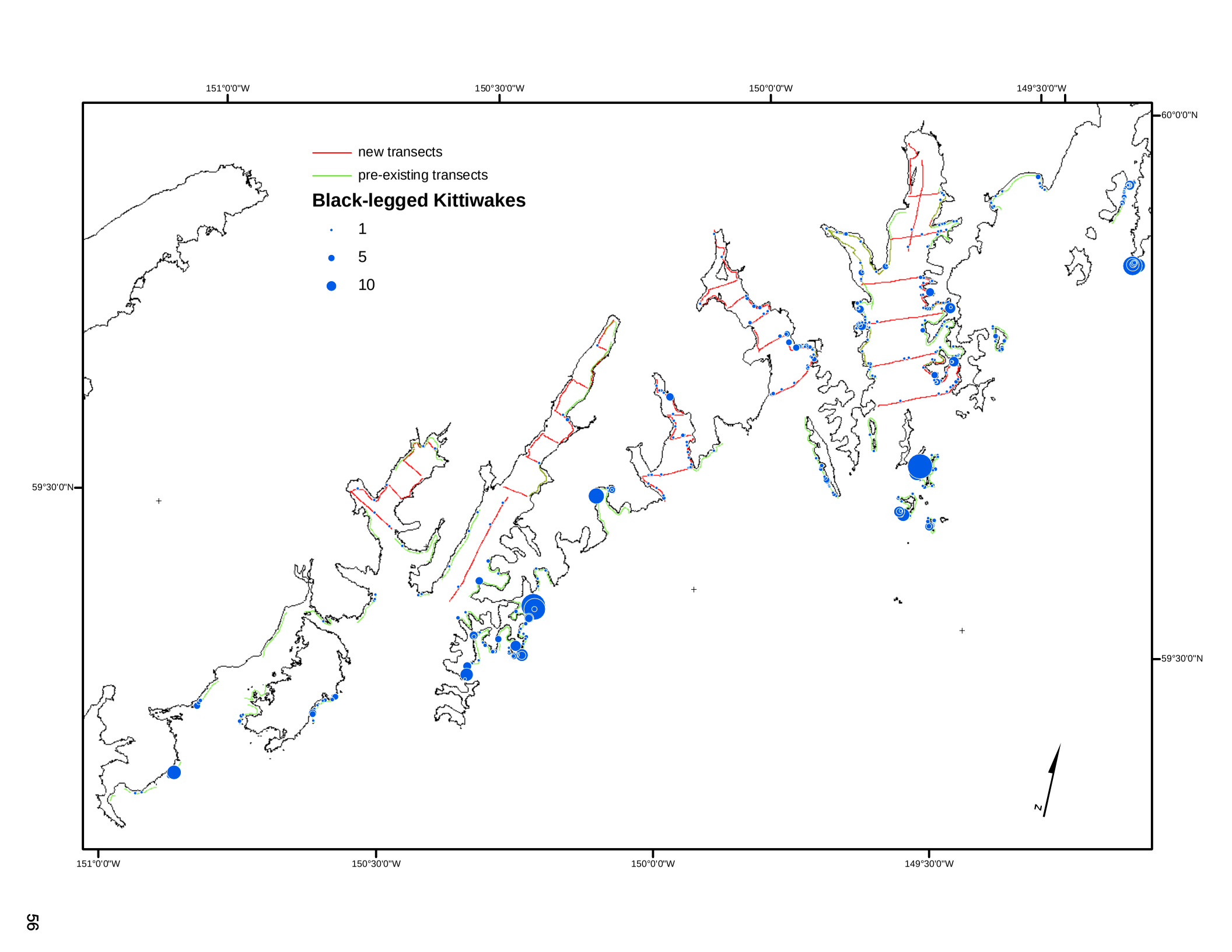
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Black-legged Kittiwakes
1
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10
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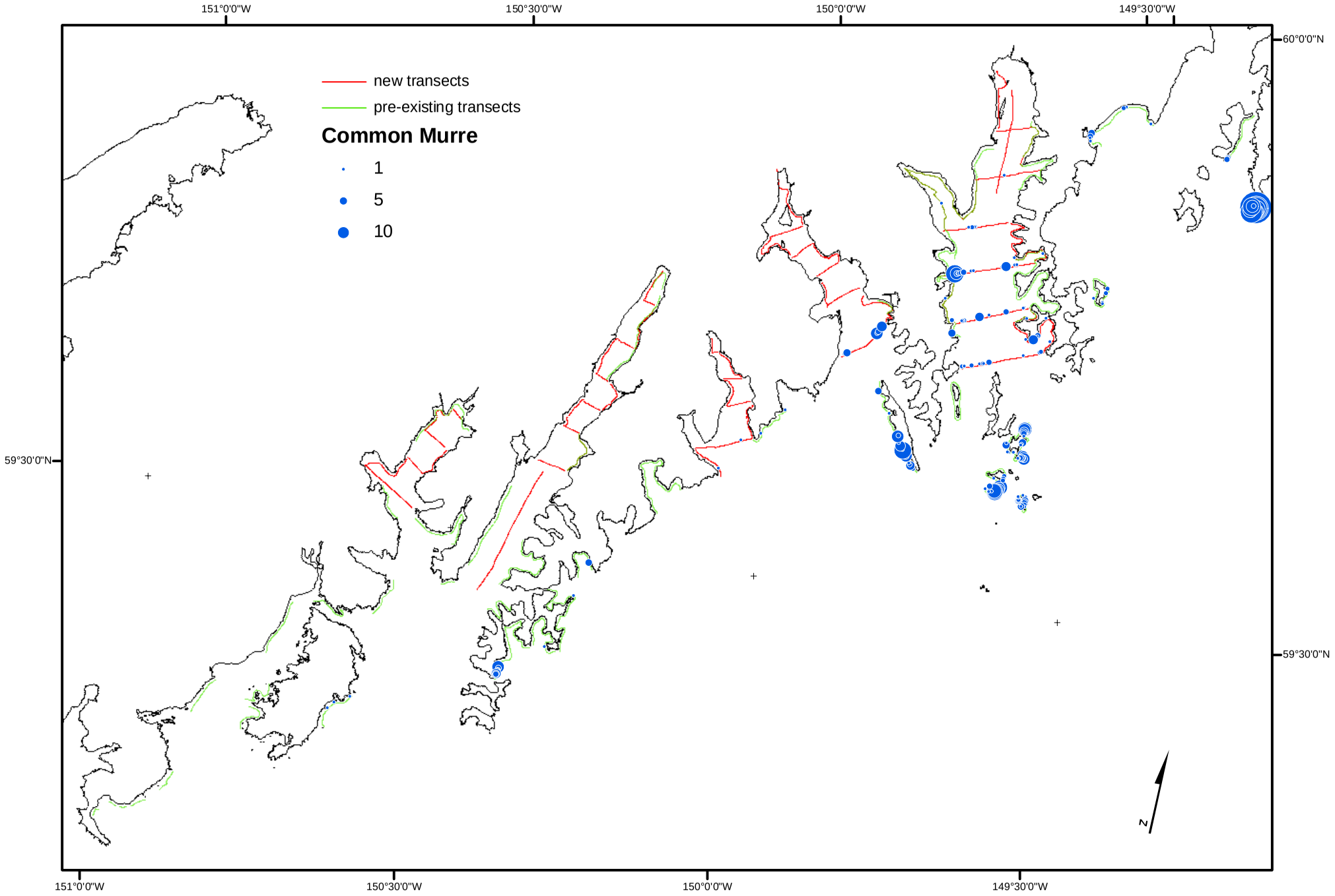
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Common Murre
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10
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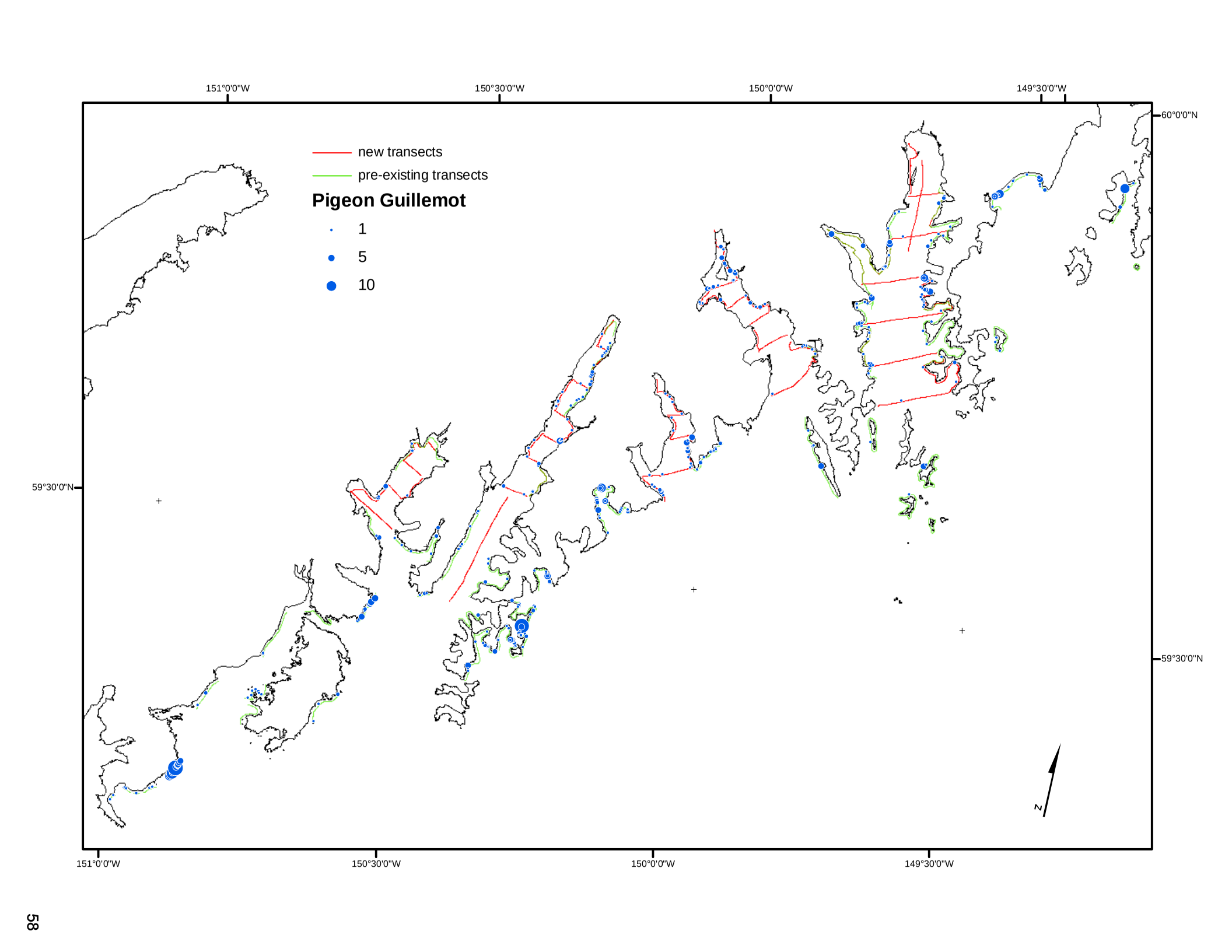
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Pigeon Guillemot
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10
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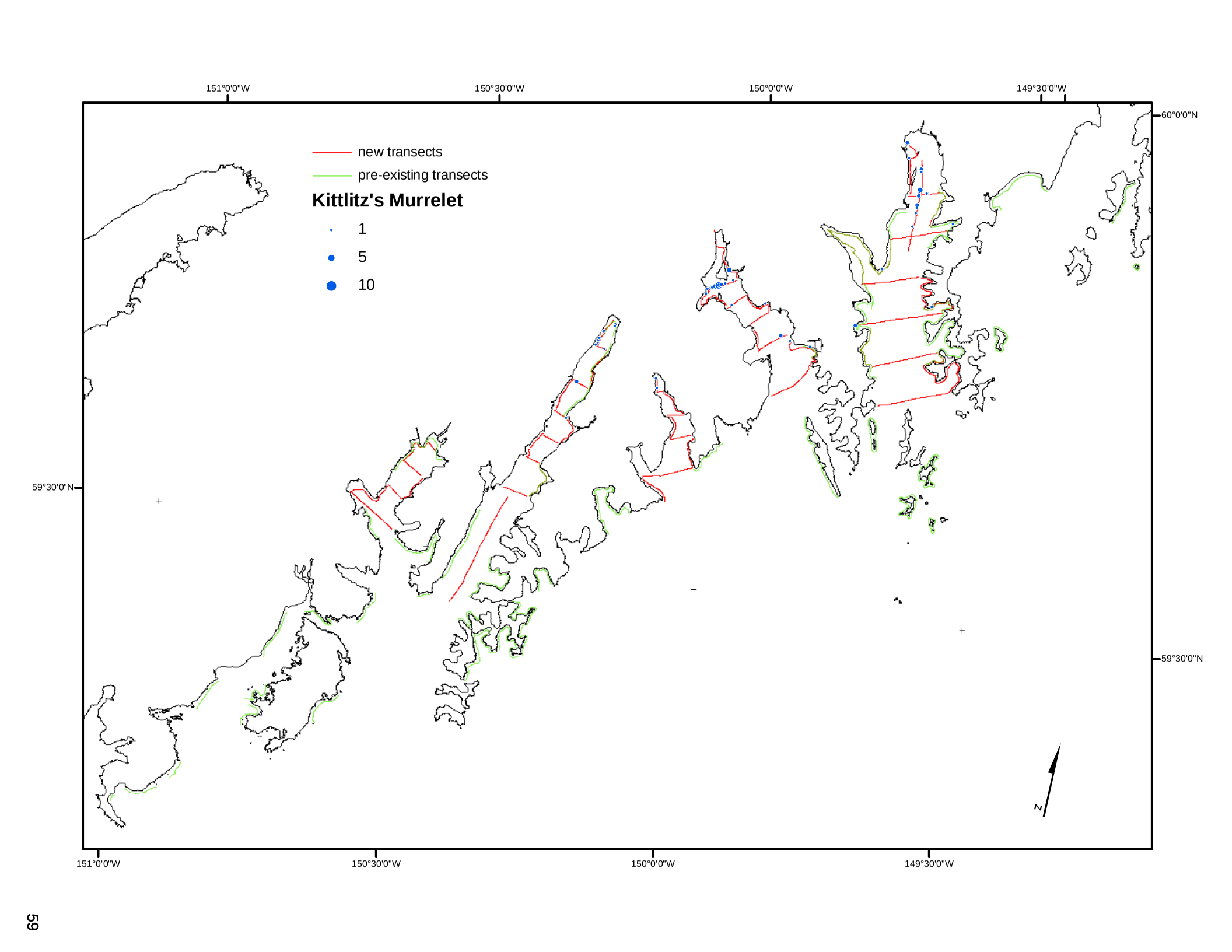
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10
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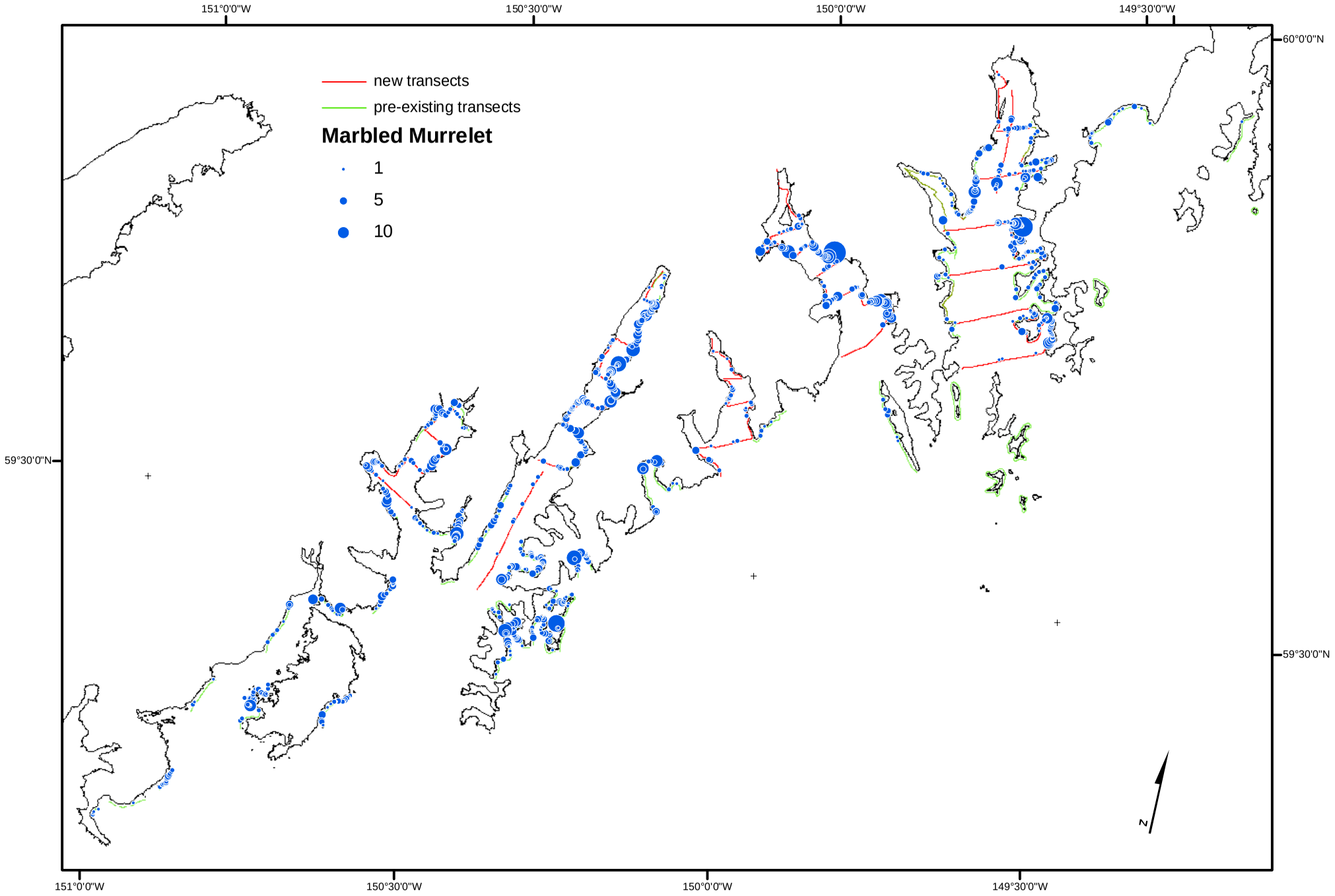
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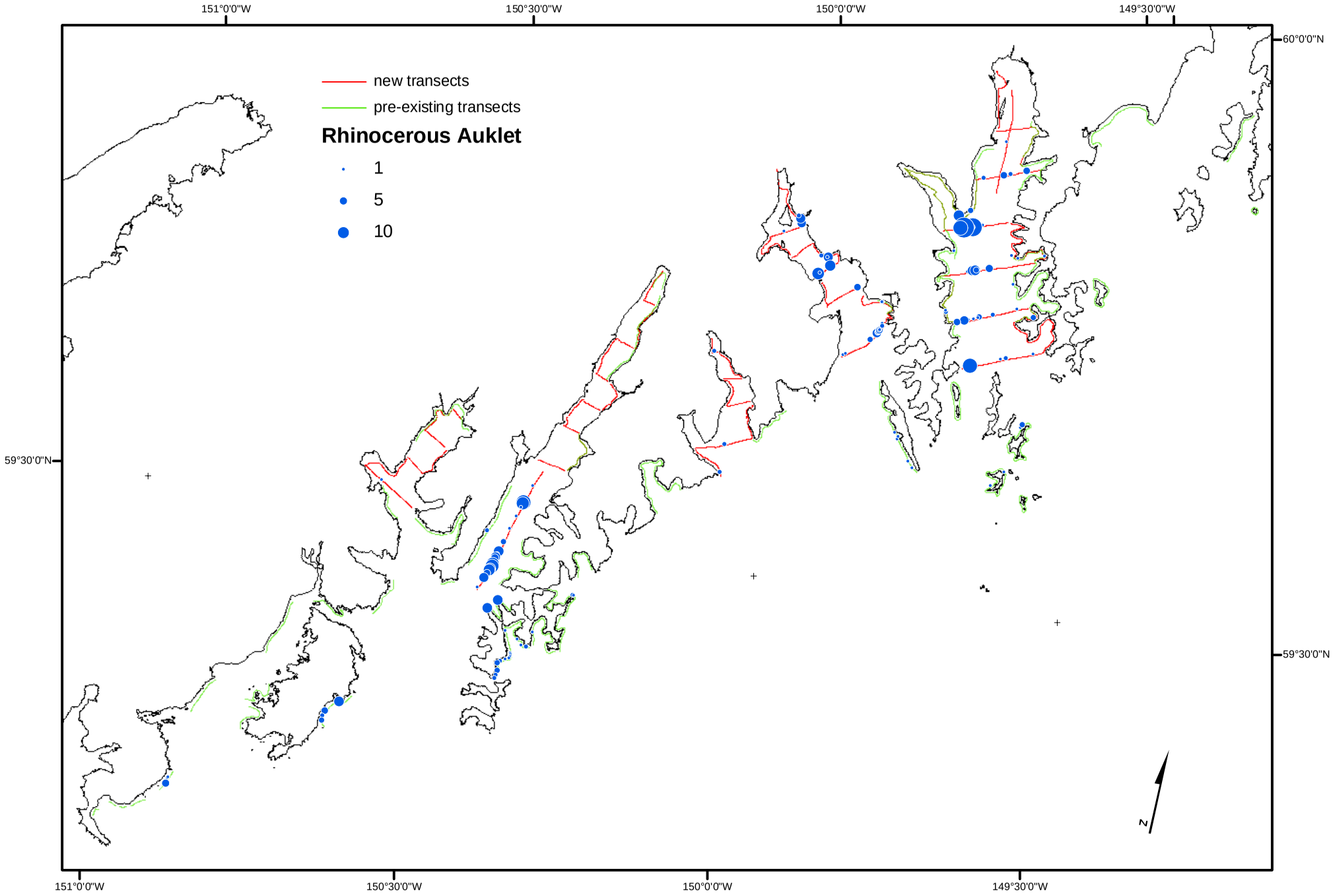
Marbled Murrelet
1
5
10
N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1
5
10
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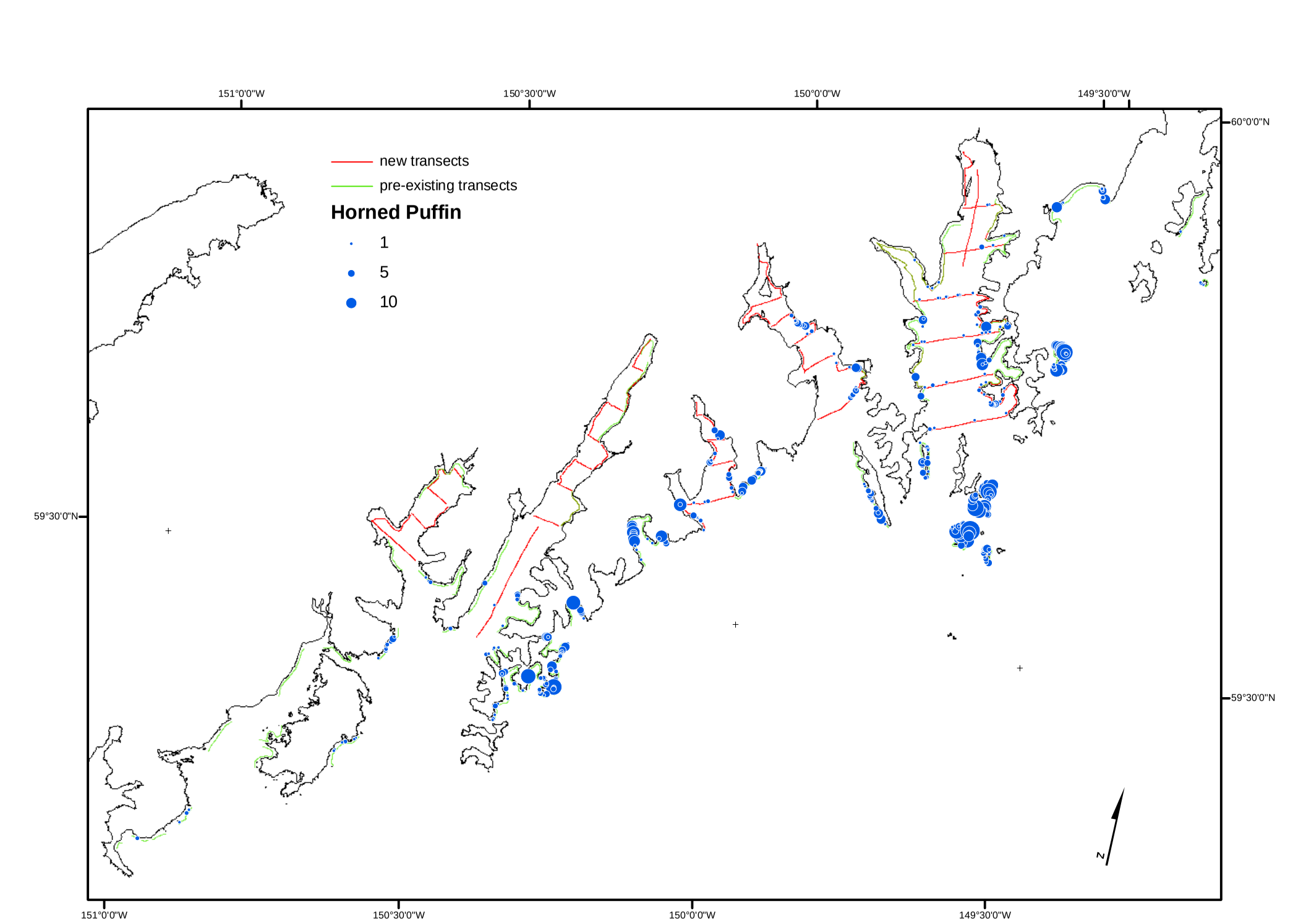
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Horned Puffin
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10
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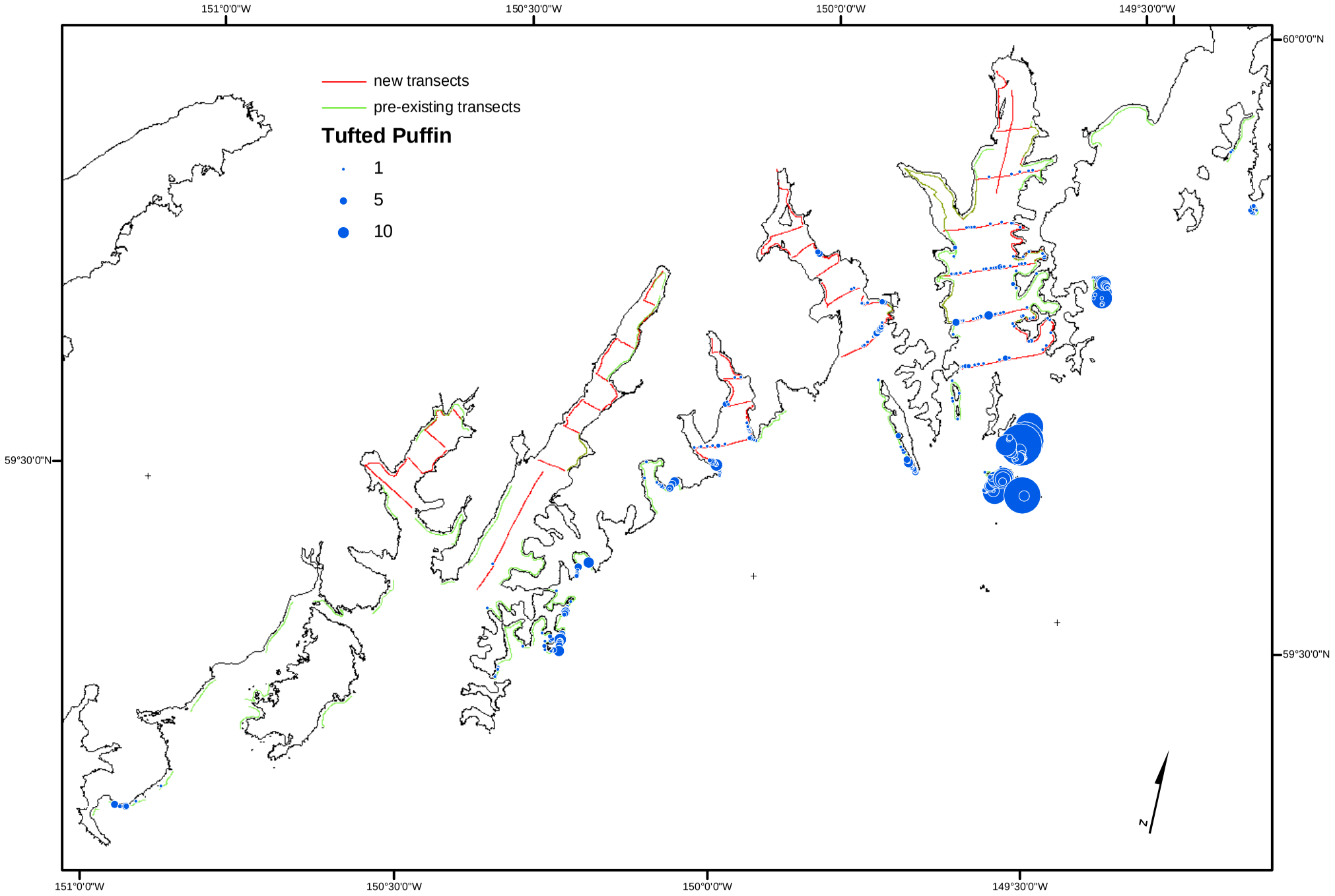
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Tufted Puffin
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10
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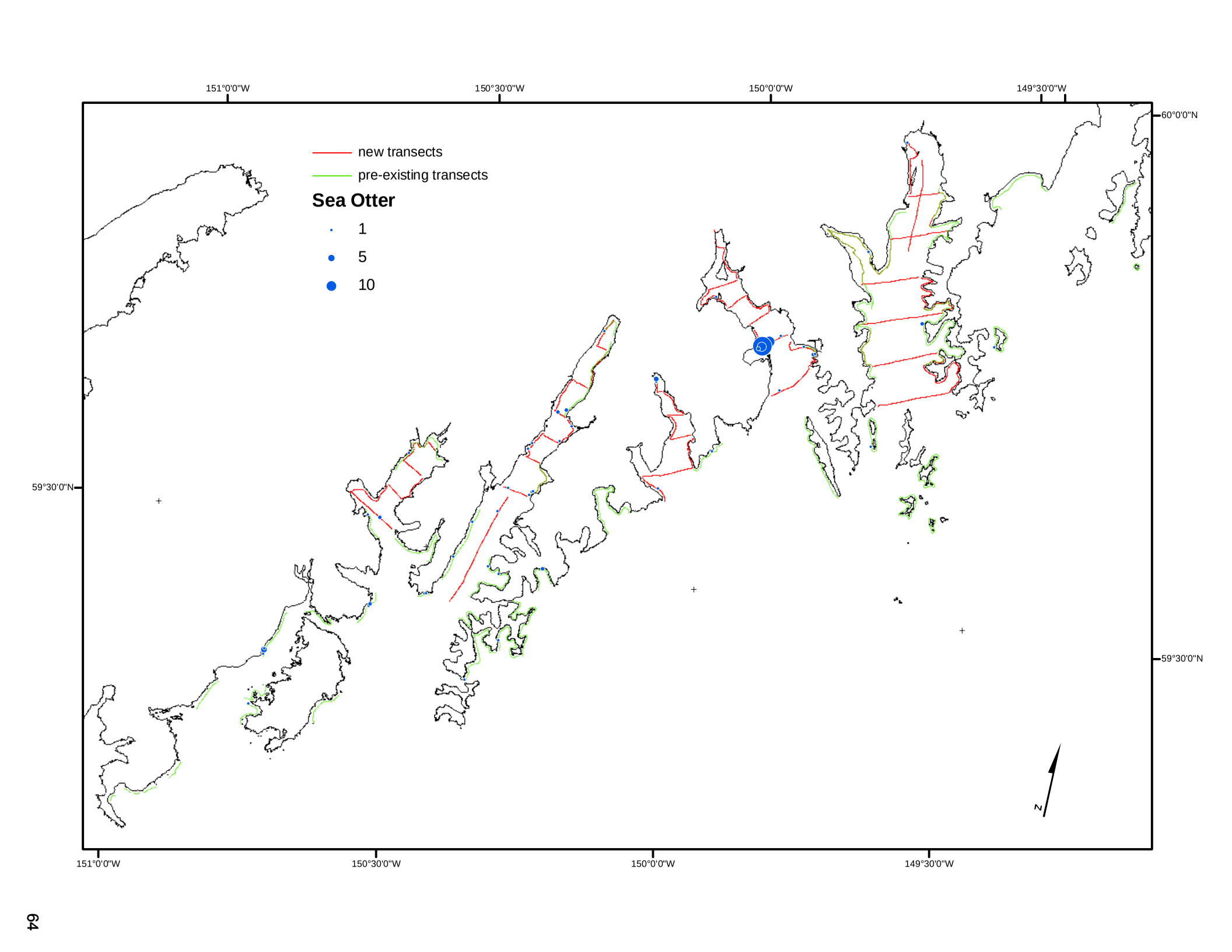
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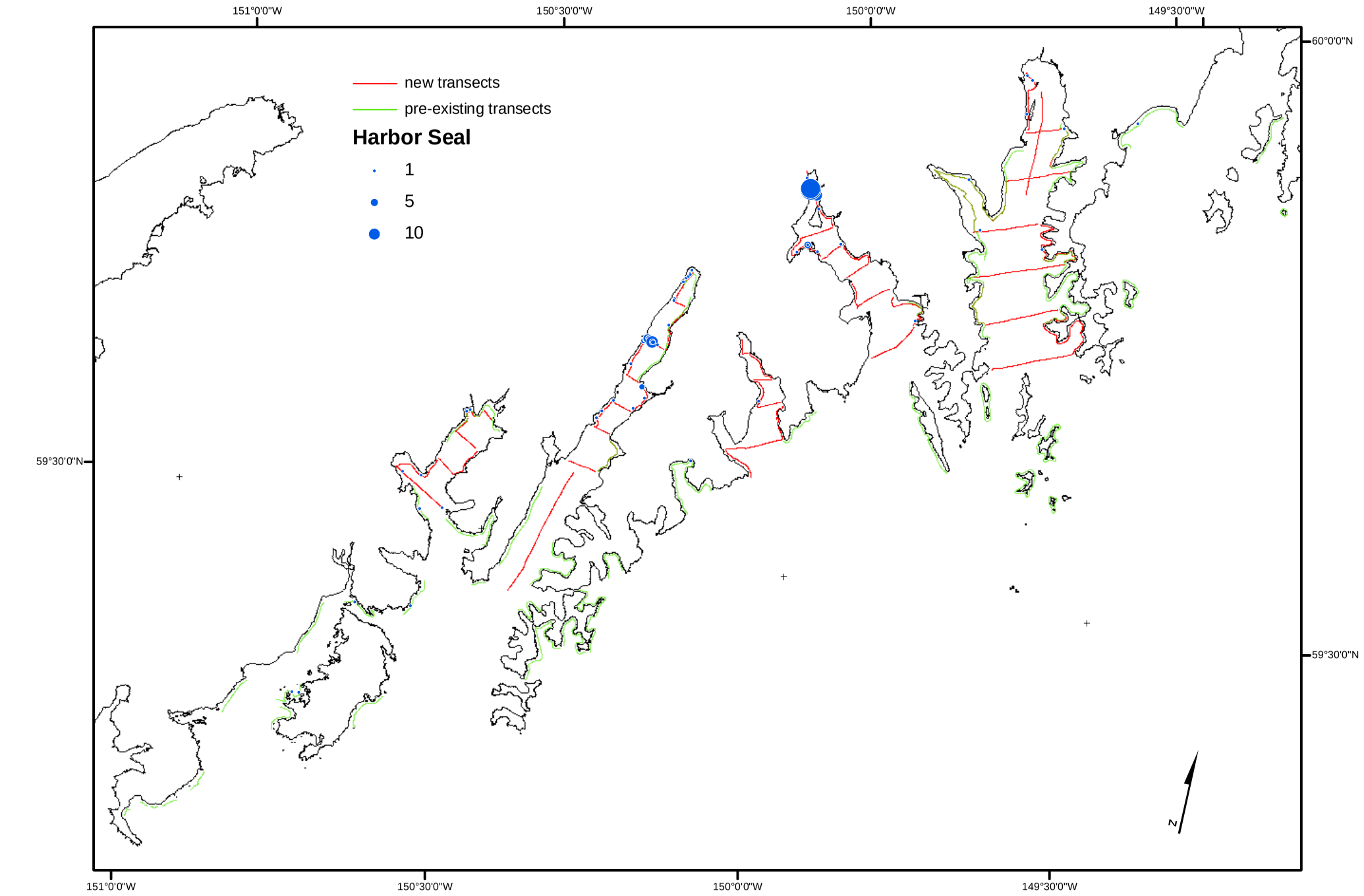
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pre-existing transcects
Harbor Seal
1
5
10
N