

FINAL REPORT

**THE NEARSHORE DISTRIBUTION OF TERNS AND OTHER SEABIRDS IN
RELATION TO INDUSTRIAL PROJECT DEVELOPMENTS IN
STORMONT BAY, NOVA SCOTIA**

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1. ABSTRACT

The tern colony located on Country Island in Guysborough County, Nova Scotia, represents one of only two major nesting locations for endangered Roseate Terns (*Sterna dougallii*) in Canada. Within 10 km of Country Island, three industrial projects have been proposed including a liquefied natural gas (LNG) terminal, a petrochemical facility including a marginal wharf, and a natural gas pipeline. Although critical breeding habitat for Roseate Terns has been identified on Country Island and Environment Canada has an ongoing project designed to mitigate the impacts of predator populations on the tern colony, little is known about the foraging distribution of terns throughout the breeding season in the waters around Country Island. We used a combination of land and boat-based surveys to monitor tern foraging throughout the breeding season to establish baseline conditions in advance of industrial development activities and to better understand the temporal and spatial use of habitat by terns. We also monitored other species of waterbirds detected during surveys. Although we had limited success detecting Roseate Terns during land and boat-based surveys (n = 5 and 9 for land and boat surveys, respectively), we found similar patterns of habitat use compared to a radio-telemetry study conducted in 2003 and 2004. Common Terns and unidentified terns were seen near the site of the proposed petrochemical facility and marginal wharf during two surveys conducted in early and mid-June, but terns were rarely present in the area on subsequent surveys. Roseate Terns were never identified in the region of proposed development, however the majority of terns in the development area were unidentified (89%) resulting in very high levels of uncertainty regarding the occurrence of Roseate Terns in this area. Land and boat-based surveys throughout the study area reveal the foraging distribution of terns shifted across the season possibly due to changes in foraging strategies associated with the stage of reproduction or to seasonal changes in prey availability.

Keywords: Roseate Terns, *Sterna dougallii*, Common Terns, *Sterna hirundo*, Arctic Terns, *Sterna paradisaea*, seabirds, nearshore surveys, foraging distribution, oil and gas development

2. PROJECT ORGANIZATION

This report includes data collected from a single season of land-based and at-sea surveys for terns and other seabirds conducted by Bird Studies Canada personnel from May to August 2008. Although we determined the foraging distribution of all species of waterbirds, the focus of this report is on terns with particular emphasis on the distribution of Roseate Terns (*Sterna dougallii*). The need for a better understanding of the critical habitat requirements of Roseate Terns in the region relate to their classification as endangered under Schedule 1 of the *Species at Risk Act* (SARA) and to the close proximity of industrial development projects in relation to the Country Island tern colony.

The three industrial development projects in the Isaac's Harbour area include: a liquefied natural gas (LNG) terminal proposed by MapleLNG, a petrochemical facility and marginal wharf proposed by Keltic Petrochemicals Inc., and a pipeline proposed by EnCana Corporation as part of their Deep Panuke Offshore Energy Project. All projects entail construction activities on the shore near Isaac's Harbour and Betty's Cove, as well as some activity (pipelaying and/or a small increase in boat traffic) in the approaches to Isaac's Harbour (Fig 1).

As part of the Adaptive Management Plan (AMP) outlined in the joint Comprehensive Study Report (CSR) for the developments proposed by MapleLNG and Keltic Petrochemicals, Environment Canada and the Nova Scotia Department of Natural Resources required a program for monitoring tern foraging activities be implemented prior to construction of the marginal wharf and LNG receiving terminal. Furthermore, this monitoring was to entail land and boat-based surveys of the area throughout the breeding season (May 1 to August 31) so as to enhance current understanding of the spatial and temporal patterns of tern use of foraging habitats. Additionally, EnCana Corporation was committed to surveying Roseate Terns at all islands in the Country Island complex prior to commencement of Deep Panuke pipelaying activities and to coordinate their surveys with the tern monitoring program of the adjacent Keltic/Maple projects. Thus, to meet some of the requirements outlined in their respective Comprehensive Study Reports, proponents of these projects (Keltic/Maple/EnCana) provided funding to Bird Studies Canada to monitor the distribution of foraging terns

prior to construction of these industrial developments. This report details the findings of these survey activities.

The Canadian Wildlife Service (CWS), with support from the Nova Scotia Department of Natural Resources and Dalhousie University, is collecting data on the reproductive success and diets of terns on Country Island as part of the long-term Country Island Tern Restoration Plan. We have integrated some of the invaluable information CWS personnel collected in 2008 into this report in order to aid in the interpretation of distributional data. Specifically, we use colony monitoring data to infer the timeline of reproductive activities of terns to better understand the factors underlying the seasonal changes in foraging habitat observed in the present study.

3. INTRODUCTION

The Roseate Tern (*Sterna dougallii*) is a colonially nesting seabird with a scattered distribution throughout the subtropical and temperate regions of the Atlantic, Pacific and Indian Oceans (del Hoyo et al. 1996, Gochfeld et al. 1998). Roseate Terns are endangered in Canada under Schedule 1 of the *Species at Risk Act* (SARA), endangered in the United States, and at risk worldwide. In Canada, Roseate Terns nest almost exclusively at two locations: The Brothers Island in Yarmouth County and Country Island in Guysborough County (Environment Canada 2006).

Prerequisites for successful reproduction in seabirds include secure nesting habitat and a reliable food supply to meet the energetic demands of adults and their offspring. In 1998, the Canadian Wildlife Service in conjunction with Nova Scotia Department of Natural Resources, Dalhousie University, and the Canadian Roseate Tern Recovery Team, initiated the Country Island Tern Restoration Plan. The project was launched to mitigate the high levels of predation on terns by gulls and corvids observed in 1996 and 1997 (Whittam and Leonard 1999). The restoration plan is an ongoing project designed to reduce predator impacts on Roseate Terns and to increase Roseate Tern productivity (Toms et al. 2007). Because Roseate Terns nest sympatrically with Common (*S. hirundo*) and Arctic Terns (*S. paradisaea*), resilience of the Roseate Tern population is necessarily dependent on continued prosperity of Common and Arctic Terns on Country Island. The restoration plan has been effective in managing predator impacts on all three species (see Toms et al. 2007) however, effective management of nutritional resources for terns is a more challenging prospect given our limited understanding of their foraging distribution.

Within 10 km of Country Island, three industrial projects have been proposed including a liquefied natural gas (LNG) terminal, a petrochemical facility including a marginal wharf, and a pipeline (Fig 1). The environmental assessments completed for the respective projects concluded that following the implementation of mitigation measures, the projects were unlikely to result in significant adverse environmental effects on terns from the Country Island colony. However, the foraging distribution of Country Island terns (including Roseate, Common, and Arctic Terns) is not well delineated and the

ecological factors that shape their distribution are not well understood. Rock et al. (2007a, 2007b) utilized radio-telemetry to study the foraging distribution of adult Roseate, Common, and Arctic Terns from the Country Island colony during late incubation and chick-rearing in 2003 and 2004. Radio-tagged Common and Roseate Terns utilized near-shore shallow water habitat which suggest these populations may be vulnerable to coastal development activities that could disturb their foraging activities or alter the abundance and/or distribution of their prey populations. In contrast, Arctic Terns utilized offshore resources to a greater extent (Rock et al. 2007b).

Studies of Roseate Tern populations in the Northeastern United States indicate that they have relatively narrow foraging habitat requirements characterized by shallow sandy shoals (Gochfeld et al. 1998) which may make them particularly vulnerable to foraging habitat degradation. Thus, effective management of Roseate Tern populations in Canada requires the identification and conservation of critical foraging habitat. Because the resilience of Roseate Tern populations is dependent upon the breeding success of sympatric nesting Common and Arctic Terns, additional knowledge regarding the foraging distribution of these species will also be important to effectively manage the Roseate Tern population. In an effort to better understand the distribution of terns within the nearshore environment and to identify mitigative measures to minimize anthropogenic impacts on this population, the proponents of the aforementioned development projects agreed to support a study of the at-sea distribution of Roseate Terns breeding at the Country Island colony.

In this study we investigated the spatial distribution of terns along the shoreline of islands and mainland within 25km of the Country Island tern colony during 2008. Given the small size of the Roseate Tern population at Country Island (twenty-one pairs in 2007: Toms et al. 2007) and the potential negative impacts of telemetry on breeding seabirds (reviewed in Burger and Shaffer 2008), it was ultimately decided that land-based and at-sea surveys would provide the most information while ensuring that research methods would not compromise the study population. The project was designed to provide a better understanding of the distribution of terns at different times of the breeding season which is vital to assess the potential impacts of and develop mitigative measures for industrial project developments. Survey efforts were restricted to the

shoreline areas of Goose and Harbour Islands and to the mainland of Nova Scotia because Rock et al. (2007a) found that Roseate Terns from Country Island foraged close to the shoreline primarily in regions where water depth was <5m. We also monitored the distribution of other species of waterbirds to provide quantitative data that could be used to examine possible impacts of the industrial developments on non-tern species. Additionally, this data will provide a baseline for future studies designed to investigate temporal trends in these species.

4. STUDY GOALS AND OBJECTIVES

The overarching goal of this project was to monitor tern foraging throughout the breeding season to establish baseline conditions in advance of industrial development activities and to better understand the temporal and spatial use of habitat by terns. In order to achieve this goal, the following specific objectives were set:

1. Map positions of foraging terns along the coast, identified to species, throughout the breeding season.
2. Time the above activities in relation to project timelines, in such a way that baseline conditions are captured in advance of construction to identify mitigative measures and to allow project effects, if any, to be detected.

We purposely biased our sampling effort towards nearshore regions where Roseate Terns are known to forage (Rock et al. 2007a) and where development impacts are likely to be most pronounced. Given the limited resources available, we felt that this approach would be more useful in providing managers with the information needed to identify potential mitigative measures. However, this approach may fail to identify critical habitat requirements of Roseate Terns outside of survey areas and will be of only limited use in understanding the distribution of Arctic Terns, a species that is known to utilize more offshore areas (Rock et al. 2007b).

Although the original objectives outlined in the proposal were restricted to monitoring the distribution of terns, we also collected data on other species of waterbirds

because doing so required little additional effort and little information is available on these species in this region.

5. METHODS

5.1 Study Area

We investigated the foraging distribution of terns and other seabirds along the Eastern Shore of Nova Scotia between Wine Harbour (45° 4' N, 61° 50' W) and Tor Bay Provincial Park (45° 11' N, 61° 21' W; Fig 1). Surveys were designed to cover the shoreline within 20-25km of the Country Island tern colony, including the shoreline of Goose and Harbour Islands. Rock (2007a) found Roseate Terns foraged primarily within 7km of the colony with a maximum foraging distance of 24km, similar to the maximum foraging range of Roseate Terns in the United States (25km; reviewed in Nisbet and Spendelov 1999). Between 2000 and 2008, Country Island had an average of 1139 pairs of breeding terns (range: 811-1495 pairs; Toms et al. 2008). In that same time period, the number of Roseate Terns breeding on Country Island has varied between 1 and 53 pairs (mean 32 pairs; Toms et al. 2008). Nest counts from 1996-2008 are shown in Fig 2.

5.2 At-Sea Surveys

All surveys were conducted using 35 foot Cape Islander lobster fishing boats with paired observers seated on the bow, each scanning from directly ahead to 90° abeam (Fig 3). Vessel speed was between 10-12 km/h with the exception of surveys conducted between Port Bickerton and Wine Harbour or between New Harbour and Little Harbour where vessel speed was 15 km/h. The platform height upon which observers were seated was approximately 1.5m above the water surface and observers had an unobstructed field of vision from directly ahead to approximately 140° abeam; observer view from 140° abeam to directly aft was obscured by the vessel cabin. Observers used distance sampling protocols (Buckland et al. 1993) recording bird clusters (individual birds or groups of birds of the same species), angle and distance to clusters, and behaviour of the bird(s) at first detection. Terns were considered to be part of the same group if they were within 5m of one another or somewhat farther apart but engaged in the same behaviour (i.e., all diving, all flying in the same direction).

Observers were trained at estimating distances by determining distance to land, emergent rocks, and buoys using digital range-finders. Range finders were periodically used throughout surveys to determine the distance to land, aiding in estimates of distances to bird clusters. Angles to birds were determined to the nearest 5° using a protractor. The survey-vessel position and direction of travel was determined every two seconds using a global positioning system (GPS) receiver. The position of terns was then determined using spherical trigonometry based on the position and heading of the vessel as determined using the GPS receiver and the estimated angle and distance to bird clusters.

Whenever possible, the species of tern detected was recorded. However, the three tern species found in this study are similar in appearance and the ability of observers to distinguish between species can be affected by a variety of factors including distance to bird, sea state, and light conditions. Thus, the majority of birds detected were recorded as “unidentified terns”. Due to obvious ID features (i.e. the presence of significant red/orange bill colouration not found in Roseate Terns), observers could often determine that a bird was not a Roseate Tern but were unable to discern whether it was a Common or Arctic Tern, in which case the species was recorded as a “non-Roseate Tern”. If not all members of a cluster could be identified to species, terns were recorded as two separate clusters at the same location (i.e. one cluster identified to species and one cluster of unidentified birds).

We used the same distance sampling protocol to record detections of other species of waterbirds during at-sea surveys. Shorebirds and large gulls (Herring gulls [*Larus argentatus*] and Greater Black-backed Gulls [*Larus marinus*]) were not recorded during at-sea surveys. Large gulls were excluded because they routinely engaged in ship-following behaviour, making estimations of their abundance impossible. Although some studies record birds that engaged in ship following behaviour (e.g. Hyrenbach et al. 2007), we found that gulls often ‘leap-frogged’ the survey vessel making it impossible to prevent recounting individuals. Additionally, large gulls were very abundant and we were concerned that counting gulls might detract from efforts to locate terns. Shorebirds were excluded because they were more difficult to rapidly identify to species at a distance.

Survey conditions were recorded at the beginning of each survey and were updated periodically as conditions changed. We recorded sea state using the Beaufort scale (Bowditch 1966), estimated wind direction and velocity, cloud cover as a percentage, and estimated visibility. Maximum visibility was assumed to be 2000m as birds beyond this distance could rarely be identified even under ideal conditions. Surveys were halted if visibility fell to less than 500m or if sea state exceeded a Beaufort of 5. We attempted to conduct surveys when sea state was ≤ 3 , but this was not always possible. Visibility fell below 2000m on only two surveys.

All surveys tracked the coastline at a distance of approximately 300m whenever this distance could be safely maintained. The number of times each section was surveyed (hereafter referred to as survey effort) is shown in Fig 4. Survey effort was highest surrounding the nearshore waters of Goose and Harbour Islands because these areas are known to be important foraging grounds for terns (Rock et al. 2007a, 2007b) and cannot be accessed for land-based surveys (see below).

5.3 Land-Based Surveys

We conducted land-based surveys for terns from 20 coastal point locations distributed between Wine Harbour and Tor Bay Provincial Park (Fig 4). We selected survey locations that were at varying distances from sites of coastal development. We also restricted our land-based survey efforts to sites that were easily accessible by road and provided a relatively wide view.

Land-based surveys were designed to be instantaneous scans of all birds that could be detected using a spotting scope. Because it is not possible to instantaneously count all terns, observers would begin by initially identifying and counting all birds located in close proximity to the survey point that could be readily detected using binoculars and/or the naked eye. Once that count was complete, observers would make a scan of the horizon (either left to right or right to left) using a 20-60x spotting scope and being careful not to count birds twice. Only terns were counted beyond 500m. The spotting scope was set at 20x for all scans and the zoom was only used to aid in species identification. Birds that entered regions of the survey area after that region had already been scanned were ignored to ensure that scanning time did not affect the number of

birds counted. We also counted all waterbirds (including gulls and shorebirds) located within 500m of land-based survey points. This scan was also designed to be instantaneous although it did not always occur at the same time as the tern scan; when the number of terns in a region was high, observers would complete the tern scan and then do a second scan for other waterbirds. Any terns that entered the observation area during this secondary waterbird scan were ignored.

Distance sampling techniques were used for all land surveys. For each detection (individual bird or cluster of birds), the observer would record the species, number, and behaviour of birds in the group. Angle to the bird or group of birds was calculated using a protractor with a map of the location. Concentric circles surrounding the survey point were displayed on the maps to facilitate estimating distance to individual birds or to the center of a group of birds (examples shown in Figs 5 and 6). In order to estimate distance accurately at sites where terns could be seen foraging along the perimeter of islands, multiple maps of varying scale were used (example shown in Fig 6)

At some survey locations it was possible that detected birds could be seen from a second survey location. In order to prevent duplication in survey regions between adjacent sites with overlapping views, we created ‘observation boundaries’ at such sites beyond which birds would not be recorded (see example in Fig 5). These survey boundaries ensured that no overlap occurred within 500m of survey points. However, survey overlap still occurred because terns could be detected for several kilometres from land-based survey sites. This is especially true for land based sites from where terns could be seen foraging along the perimeters of islands. There was little to no overlap of survey areas within 1000m of survey points but our ability to classify terns to species was greatly reduced beyond 500m. Additionally, during land-based surveys visibility of observers beyond 2000m was often reduced by fog and some surveys took place with only 1000m visibility. Therefore, we present data on terns located within 500m of survey points.

5.4 Mapping

Survey routes and calculated locations for birds were plotted in a geographic information system (GIS; Arcview 3.2, ESRI, Redlands, CA). Digital map layers of land

(1:10000) were obtained from the Nova Scotia topographic database (www.nsgc.gov.ns.ca). All survey point locations and at-sea transects were imported from GPS receivers using the program DNR Garmin (version 5.4, Minnesota Department of Natural Resources 2008), a freeware extension for ArcView.

6. RESULTS

6.1 Timeline of Reproductive Events

We initiated land-based surveys on 13 May 2008 (Julian day 134). On 16 May, approximately 100 terns were spotted by CWS personnel on Country Island (CWS pers. comm.) but the first day terns were observed during land surveys was 23 May, 2008 (Julian day 144). We conducted our first at-sea surveys for terns that same day (23 May) and detected low numbers of terns during the Goose Island survey (see section 6.3.3 below). The first tern egg was seen at the Country Island colony on 28 May 2008 (day 149) and the first tern chick was seen on 19 June 2008 (day 162). We first detected terns carrying fish in their bills (indicative of nestling provisioning) on 29 June (Julian day 181) for land surveys and on 25 June (day 177) for at-sea surveys. Assuming chicks fledge at 23 days (Cramp 1983), tern chicks would have commenced fledging on 12 July (day 194), although peak fledge would have likely been 7-10 days later (Arnold et al. 2004). We first sighted hatch-year terns (recently fledged young) at-sea on 1 August (Julian day 214) for land surveys and on 31 July for boat-based surveys. However, we only sighted 27 and 6 hatch-year terns during land and boat-based surveys, respectively. Overall, CWS personnel counted 1495 tern nests, including 23 Roseate Tern nests, during the 2008 breeding census on Country Island (Toms et al. 2008). Thus, Roseate Terns made up approximately 1.5% of the tern population nesting on Country Island in 2008.

6.2 At-Sea Surveys

6.2.1 All Regions

We conducted at-sea surveys for seabirds on 19 days from 23 May to 9 August along a 94 km route that included 1) the shoreline of the mainland of Nova Scotia between Wine Harbour and Little Harbour, 2) the perimeter of Goose and Harbour Islands, and 3) short transects running from the mainland to Goose Island and from

Goose Island to Harbour Island (Fig 4). Additionally, some opportunistic surveys were conducted during transit to our standard survey routes. All areas were surveyed between 3-12 times. Overall, cloud cover and sea state conditions ranged from 0% to 100% and from Beaufort 1 to 5, respectively. At-sea surveys were limited by weather, sea state and availability of lobster boats. Boats became more available after the lobster season ended on June 20, but dense fog throughout the month of July made it impossible to conduct as many surveys as planned.

In total, we detected 1776 clusters of terns comprised of 2943 individuals (Figs 7 and 8). In the majority of clusters (56%), terns were not identifiable to species; 65% of all terns were classified as unidentified. Additionally, 294 clusters (17%) comprised of 403 individuals (14%) were classified as “non-Roseate Terns” (i.e. either Arctic or Common Terns). Most of the identified clusters were comprised of Common Terns (434 groups [24% of all terns] comprised of 556 individuals [19%]); 39 clusters (2%) comprised of 46 individuals (2%) were identified as Arctic Terns and 9 clusters (0.5%) comprised of 13 individuals (0.4%) were identified as Roseate Terns. Roseate Terns made up 1.1% of the clusters (1.3% of individuals) that could be identified to species (including non-Roseate Terns); the locations of the 9 clusters of Roseate Terns detected during at-sea surveys are shown in Fig 9. Five of the nine detections consisted of a single Roseate Tern and the remaining four detections involved a pair of Roseate Terns. Across all species, group size of terns was small with 77% of clusters comprised of a single tern and 97% of clusters comprised of five or less terns (Table 1). Less than 1% of clusters were comprised of >10 terns and none of these clusters were observed after June 26th (Julian day 178). Only three clusters occurred with greater than 20 terns.

The ability of observers to identify terns to species clearly deteriorated with distance of the terns to the survey line (Figs 7 and 8). Although the number of terns detected was related to survey effort (Fig 8), it is apparent that terns were not uniformly distributed throughout the survey region and that the distribution of terns changed over time irrespective of survey effort (see below).

6.2.2 Development Areas

Survey transects that covered the proposed industrial development area are shown in Fig 10. The total number of terns and the number of tern groups detected in the nearshore waters surrounding the development area were higher in June compared to July. No terns were detected in close proximity to the development sites during the two at-sea surveys conducted in August. During the survey conducted on 4 June 2008, a large group of approximately 60 unidentified terns was detected in the nearshore waters at the proposed Keltic and Maple facilities site. Only 10 of the 176 terns detected in this area were identified to species (8 Commons and 2 Arctics); an additional 10 birds were identified as non-Roseate Terns (i.e. either Commons or Arctics).

6.2.3 Goose Island

Results from at-sea surveys circumnavigating Goose Island are shown in Fig 11. The number of terns detected during this transect peaked during late June but remained high through mid-July declining in late July/early August. Although Goose Island was not circumnavigated after August 5, land sites confirmed that very few terns were foraging along the northern edge of the island after this date (data not shown). Surveys conducted on consecutive days suggest factors other than season/breeding stage are important. For example, 51 terns were detected on 23 May whereas only eight terns were detected during a survey on 24 May even though these surveys occurred at the same time of day and during similar tidal states. Terns were often seen flying over Goose Island, particularly at the southern tip and across the narrow band of land that occurs towards the middle of the island. Roseate Terns were sighted during two of the Goose Island surveys; in both cases the sighting involved a single tern.

6.2.4 Harbour Island

Results from at-sea surveys circumnavigating Harbour Island are shown in Fig 12. A fog bank on 8 July prevented a complete survey transect. The number of tern groups seen in the nearshore waters of Harbour Island was much lower in late May and early June (the incubation period) compared to late June/early July (the chick-rearing period). Only three terns (one Arctic and two unidentified) were detected on 9 August, the final date an at-sea survey was conducted. Roseate Terns were detected along the northern

edge of Harbour Island during three of the surveys that occurred in July (chick-rearing period) and off the southern tip of the island on 9 June. In all cases, Roseate Terns were either alone or in groups of two.

6.2.5 Bickerton Lighthouse to Drum Head

Four surveys were conducted from Bickerton Lighthouse to Drum Head and results are presented in Fig 13. The distribution of terns appeared to change seasonally with a disproportionate number of terns detected at the entrance to Isaac's Harbour during the two June surveys (the incubation period). Additionally, the region directly to the west of Bickerton Lighthouse was being used extensively by foraging terns on 17 June (late incubation) and 13 July (chick-rearing). Roseate Terns were not identified during these surveys.

6.2.6 Wine Harbour to Bickerton Lighthouse

Three at-sea surveys were conducted between Wine Harbour and Bickerton Lighthouse and results are shown in Fig 14. The number of terns detected during these surveys was low throughout the season which was consistent with results from land surveys (see below). Roseate Terns were not identified in this region.

6.2.7 Drum Head to Little Harbour

A clear seasonal pattern was evident in the seven at-sea surveys running parallel to the shoreline west of Drum Head towards New Harbour and Little Harbour (Fig 15). Overall, relatively few terns were detected east of Seal Harbour during surveys conducted in May and June (the incubation period). However, a large number of terns were present throughout July (chick-rearing) and individuals were still found in this region during the 5 August survey (the post-fledging period). Roseate Terns were seen on two of the ten surveys between Drum Head and Seal Harbour. On May 24th, two Roseate Terns were detected near the mouth of Seal Harbour; these terns were observed separately but were only ~400m apart. The third Roseate Tern was spotted in this same area on July 5th; it had a fish in its bill and was flying in the direction of the Country Island colony.

6.2.8 Overall Pattern

When all of these survey areas are combined a general seasonal pattern emerges. Overall, the density of terns detected surrounding Goose and Harbour Islands was high throughout the breeding season but was lower during May when many terns had likely not yet begun egg-laying and during August by which time most chicks had fledged. Between June and July there was a clear seasonal shift in the foraging distribution of terns along the mainland shores (Fig 16). In June, the incubation period, a large number of terns were detected at the entrance to Isaac's Harbour and in close proximity to the proposed industrial development sites. In July, the chick-rearing period, the distribution of terns shifted east as birds were detected along the shoreline between Seal Harbour and Little Harbour. Although there was high day to day variability in the density of terns (see Figs 11 and 12) and the number of at-sea surveys was limited by fog, the distributional shifts detected on at-sea surveys were consistent with the results of land-based surveys (see below).

6.3 Land-Based Surveys

6.3.1 All Regions

The twenty land-based sites were each surveyed between 23 and 28 times from May to August. Tor Bay Provincial Park was surveyed the least and had the largest gap in surveys (19 days) due to persistent fog in the region. Across all land surveys, we detected 2639 terns including 1845 unidentified, 415 non-Roseate, 284 Common, 89 Arctic, and 6 Roseate Terns (Fig 17). Our ability to determine species identification deteriorated with distance to birds. When results are restricted to terns located within 500m of the survey point, we detected 801 terns, comprised of 264 unidentified, 223 non-Roseate, 230 Common, 83 Arctic, and four Roseate Terns. Thus, Roseate Terns made up only 0.4% of the terns that could be identified to species (including those identified as non-Roseate Terns).

Within 500m of land sites and across all species, group size was generally small with 38% of clusters comprised of a single tern and 86% of groups comprised of five terns or less (Table 2). In total, only 15 groups (6%) were comprised of more than ten

terns with six groups (3%) having more than twenty terns. Five of the six groups with more than twenty terns were detected on or before 3 June (Julian day 155). A group comprised of 27 Arctic Terns was detected on 6 August. The number of large groups rapidly increases when birds beyond 500m are included as observers have greater difficulty in estimating distances between individuals at distances >1km and separate groups were combined into a single group (data not shown).

6.3.2 Development Areas

Overall, few terns were seen in close proximity (within 500m) to land based survey sites in Isaac's Harbour (sites 12 and 13; Fig. 18). However, a large group of 29 unidentified terns was detected in Isaac's Harbour near site 12 on June 2nd (Julian day 154). This site is not in close proximity to the development area although this group must have transited within 1km of the proposed Keltic and Maple facilities to enter Isaac's Harbour (Fig. 1). Few terns were detected at survey site 14 in Betty's Cove, the closest survey location to the proposed development projects. Roseate Terns were not identified at any of these sites but a high proportion of unidentified terns results in uncertainty regarding the occurrence of Roseate Terns in this area.

6.3.3 Bickerton Lighthouse to Country Harbour Ferry

This region includes land survey sites 9 (Bickerton Lighthouse), 10 (Fisherman's Harbour), and 11 (Ferry) and results are shown in Fig 19. No clear seasonal pattern is apparent at sites 9 or 10. At site 11, terns were never sighted prior to Julian day 180 (the incubation period), but were consistently present in low numbers (1-2 terns) during the chick-rearing period. Roseate Terns were never identified at any of these locations.

6.4.4 Wine Harbour to Bickerton Lighthouse

Few terns were detected at the three most southerly sites (sites 1-3) in the study area with the exception of a survey on Julian Day 189 when 13 Common and 6 unidentified terns were observed at site 3 (Fig. 20). The survey site located near Hilford (site 4) also had low numbers of terns although Arctic Terns apparently utilized this area during the post-fledging period (Fig. 21). Terns were rarely detected at sites 5 and 6 prior

to the chick-rearing period, but were routinely detected at these locations after this date, albeit in low numbers (Fig. 21). Similarly, terns were never present at Bickerton (sites 7 and 8) prior to Julian day 180, but were routinely sighted after this date (Fig. 22). Roseate Terns were never detected at any of the eight land survey sites (sites 1-8) located in this region.

6.3.5 Drum Head to Seal Harbour

The highest densities of terns located in close proximity to the mainland during land-based surveys occurred between Drum Head and Seal Harbour (sites 15-17; Fig. 23). These three sites are also the closest sites to the Country Island tern colony; all are located within 6.5km of the colony. During the incubation period (prior to Julian day 180), large groups of terns (>30 individuals) were occasionally observed at these three sites. In contrast, during the chick-rearing period, the number of terns observed at these sites was generally lower but more consistent. During the post-fledging period, terns were rarely observed within 500m of these locations. Roseate Terns were observed at sites 15 (Drum Head) and 17 (Seal Harbour). A single Roseate Tern was observed foraging on the north side of Harbour Island from the Drum Head survey site on July 27th. A pair of Roseate Terns were observed in Seal Harbour on July 8th and a single Roseate Tern was observed at this site on July 16th. Note that not all Roseate Terns appear in Figs 23 and 24 because they were sometimes detected at distances >500m.

6.3.6 Coddles to Tor Bay Provincial Park

Coddles Harbour (site 18), New Harbour (site 19), and Tor Bay Provincial Park (site 20) were the only three land sites located north of Seal Harbour because of the limited road access in this portion of the study area. The occurrence of terns at these sites is shown in Fig 24. Terns were never sighted within 500m of the Coddles Harbour survey location (site 18) during the pre-lay and incubation periods. However, terns (primarily Commons) were consistently sighted after Julian day 180 (i.e. during chick-rearing). Similarly, terns were rarely sighted at sites 19 and 20 during pre-lay and incubation but were consistently sighted during the chick-rearing period. Roseate Terns were sighted at site 18 (Coddles Harbour) on July 8th (a single foraging tern) and July 16th (two birds).

Arctic Terns were sighted regularly towards the end of the season at Tor Bay Provincial Park and were seen feeding fledged young nearby (CTW pers. obs).

6.3.7 Overall Pattern

Overall, the number of terns in close proximity to land was highest at sites 15-17 (Drum Head to Seal Harbour). This result is not surprising given these sites are closest to the Country Island tern colony and adjacent to Harbour and Goose Islands which had high densities of foraging terns in their nearshore waters (see section 6.3). At nine of the 20 survey sites, there appears to be a seasonal pattern in tern abundance with almost no terns observed during the incubation period but consistent low numbers of terns observed during chick-rearing (i.e. after Julian day 180). This result is consistent with the seasonal shift in tern distribution observed in boat-based surveys. The number of terns observed at Betty's Cove (the closest land-site to the proposed development areas) was low throughout the season and no Roseate Terns were identified in this region (Fig 18).

6.4 Distribution of Fish-Carrying Adult and Hatch-Year Terns

During at-sea surveys, a total of 85 terns were seen carrying fish in their bills including 18 unidentified terns, 22 non-Roseate Terns, 41 Common Terns, four Arctic Terns, and one Roseate Tern. During land-based surveys, a total of 13 terns were seen carrying food in their bills including four unidentified, one non-Roseate, five Common, and three Arctic Terns. Two of the three Arctic Terns sighted with fish in their bills during land-surveys were either suspected or confirmed to be feeding fledged young. The distribution of terns exhibiting fish carrying behaviour is shown in Fig 25.

The distribution of hatch-year terns sighted during land and boat based surveys is shown in Fig 26. During at-sea surveys we sighted a total of 6 hatch-year terns. Three of the six were unidentified and three were identified only as non-Roseate Terns. During land-based surveys we sighted 16 tern groups that included a total of 27 hatch-year terns. These hatch-year terns included seven unidentified, four non-Roseates, seven Commons, and nine Arctics. Hatch-year Roseate Terns were never sighted during land or at-sea surveys.

6.5 Non-Tern Species

Results of at-sea surveys for non-tern species in close proximity to the proposed development areas are shown in Fig 27. Overall, the development areas did not appear to be used extensively by any non-tern species. The most abundant species in this area was the Double-crested Cormorant (*Phalacrocorax auritus*), however, the density of cormorants in this region appeared to be equal to or lower than other areas surveyed in the region (data not shown). Repeated nearshore surveys of Goose and Harbour Islands revealed strong seasonal patterns in the abundance of the three major non-tern species: Double-crested Cormorants, Common Eiders (*Somateria mollissima*), and Surf Scoters (*Melanitta perspicillata*; Table 3).

There was also high variability in the abundance of non-tern species between land survey sites and these patterns changed across the season. For example, land site 1 (Wine Harbour) was an exceptionally high use area for Common Eiders during May and June, but numbers dropped off substantially in July (Fig. 28). Additionally, land sites 4 (Hilford) and 12 (Isaac's Harbour) were used extensively by scoters during the month of June (Fig. 29).

7. DISCUSSION

7.1 Roseate Tern Foraging Distribution

Despite 73 hours of boat surveys and 23-28 observations from each of our 20 land based sites we had only 14 detections in which Roseate Terns were positively identified. We located Roseate Terns along the northern edge of Harbour Island on four occasions (three times during boat surveys and once during shore-based surveys) and between the northern edge of Coddles Island and the mainland on two occasions (both during shore-based surveys). Both of these regions were previously identified as high use areas by Roseate Terns in the study of Rock et al. (2007a). However, it is notable that we did not detect terns of any species within 500m of our Coddles Harbour land-based survey point (site 18) prior to June 28th (Julian day 180). This suggests that this region was not utilized extensively by Common Terns during the incubation period. Because of the small size of the Roseate Tern population at Country Island, we cannot determine whether Roseate Terns used this area in the early season and we simply did not observe them.

Alternatively, they may have been responding to the same cues as the Common Terns and only used this area later in the year.

Rock et al. (2007a) also found that Roseate Terns foraged in the nearshore region directly to the east of Bickerton lighthouse (site 9), yet we did not identify any Roseate Terns foraging in this region during land or at-sea surveys. However, boat surveys indicate that this region was used extensively by Common and unidentified terns (see Fig 13). Terns within 500m of land site 9 were primarily identified as either Common or non-Roseate, but our ability to identify terns to species rapidly deteriorated beyond 500m and it is possible that Roseate Terns utilized this region but were never identified. Alternatively the difference between this study and that of Rock et al. (2007a) may reflect annual variability in the foraging distribution of Roseate Terns. Data suggest that Seal Harbour may also be utilised extensively by Roseate Terns; we detected Roseate Terns in this area on 5 occasions (two sightings during land-based surveys and three during boat surveys). This site was not previously identified by Rock et al. (2007a).

7.2 Roseate Tern Group Size

In all cases, Roseate Terns were observed alone or in groups of two. Whether this pattern is typical is difficult to ascertain given the low numbers of Roseate Terns breeding on Country Island (23 pairs in 2008; CWS unpub. data). It is possible that we missed Roseate Terns if they were foraging in mixed-species flocks, particularly during the early season (pre-lay and incubation) when large groups of unidentified terns were occasionally seen. Roseate Terns are known to forage extensively in mixed flocks (Ramos 2000), although foraging with other species apparently reduces their capture efficiency due to interference competition (Shealer and Burger 1993). Nisbet and Spendelov (1999) suggest that Common Terns outcompete Roseates when they forage in mixed flocks and for this reason breeding Roseate Terns in the Northwestern Atlantic are reliant on feeding over shoals where they are not subject to such competition. This may explain the much greater importance of sandlance (*Ammodytes* spp.) in the diet of Roseate Terns compared to Common and Arctic Terns at the Country Island colony (Rock 2005). However, given our limited information on the diet and distribution of

Roseate Terns prior to chick-rearing, it is possible that they are reliant on other prey types and engage in different foraging behaviours during this period.

7.3 Seasonal Changes in Foraging Distribution

Information furnished from land and boat-based surveys indicate a seasonal shift in the foraging distribution of terns occurred during the summer of 2008. Large numbers of terns were detected at the entrance to Isaac's Harbour in the early season but later in the summer they were more dispersed and located along the mainland shoreline northeast of Goose Island. Terns were sighted regularly during surveys at a number of land-sites after 28 June (Julian day 180) but had never been sighted in these locales prior to that date. Furthermore, anecdotal sightings of terns by observers occurred in some inshore bays/estuaries in July where they had not previously been seen. The factors underlying this seasonal shift in distribution are unknown but may reflect changes in prey availability and/or an intrinsic shift in foraging strategies associated with the stage of reproduction. Stage-dependent foraging strategies in seabirds may arise due to the sudden need to meet the nutritional and energetic requirements of growing offspring. The foraging range of seabirds may also be reduced following incubation because of increased time constraints imposed by parental duties (Shaffer et al. 2003). Furthermore, central-place foraging theory predicts that for species that do not regurgitate food to their young, adults should maximize the rate of energy provided to their offspring and minimize the cost of chick-provisioning by selecting large, high-quality prey items to feed their nestlings (Orians and Pearson 1979). However, when feeding for self-maintenance, adults may increase their rate of energy intake by selecting smaller prey items that occur in highly predictable and dense aggregations (Baird 1991; Mehlum 2001). Thus, the foraging behaviour, distribution, and diet of seabirds may be affected by stage-dependent foraging strategies (e.g. Humphreys et al. 2006, Williams et al. 2008).

The seasonal change in foraging distribution appeared to coincide with the shift from incubation to chick-rearing. However, breeding in seabirds is also thought to be timed such that the most energetically demanding period (chick-rearing) coincides with the seasonal influx in prey populations into nearshore areas. Piatt (1990) found that seasonal changes in seabird foraging distribution can result from changes in prey

availability. Thus, it is not possible to determine which factor (reproductive or prey availability) is driving the observed distributional shifts. Regardless of the ultimate cause of such shifts in foraging distribution, our results indicate that researchers should be careful not to extrapolate beyond the observation period used in a particular study. For example, Rock (2007a, 2007b) determined the foraging distribution of Common, Arctic, and Roseate Terns using radio-telemetry, but only during late incubation and chick-rearing. Identification of critical foraging habitat should be done throughout the summer (from pre-lay to post-fledging) to ensure adequate protection of resources. For example, we found some use of inshore habitat by Arctic Terns during the post-fledging period (at Hilford and Tor Bay Provincial Park) suggesting nearshore areas might be more important for this species than previously assumed.

7.4 Other Tern Colonies

We found no evidence of additional tern breeding colonies between Wine Harbour and Tor Bay Provincial Park. Local fishermen and citizens report that a small tern colony has been present on the spit at Fisherman's harbour in prior years (Whittam 1997). During 2008, small numbers of Common Terns were sometimes spotted in close proximity to and standing on this spit, but we saw no evidence of breeding activity. A large numbers of gulls associated with fishing vessels are often present at the harbour. Additionally, this spit is physically attached to the mainland at low tide and thus accessible to terrestrial predators. For these reasons this site likely represents poor nesting habitat for terns.

7.5 Terns and Development Areas

A large number of unidentified and Common Terns, including a single group of ~40 terns, were located foraging in close proximity to the site of the proposed Keltic and Maple facilities on 4 and 17 June. However, few terns were located in this region on subsequent surveys. In contrast, few terns were detected foraging in the vicinity of the proposed EnCana pipeline throughout the summer of 2008. We found no evidence that either of the development areas were used by Roseate Terns during the breeding season, although our confidence in their absence is limited by our difficulties in identifying terns

to species. Based on the present study and the telemetry study of Rock (2005, 2007a), the closest high-use area for Roseate Terns is the northern edge of Harbour Island located approximately 3.7 km from the proposed petrochemical and LNG facilities and 2.3 km from the EnCana pipeline landfall.

The Environmental Assessments for the industrial projects in Stormont Bay indicated that there was unlikely to be any impact of development on Roseate Terns. Our results generally support this conclusion although as indicated earlier some unidentified terns in the development area may have been Roseate Terns. In addition, large flocks of terns seen in the development area in June including a single flock of more than 60 terns suggest that mitigative measures should be implemented in the month of June to decrease potential disturbances. Because the in-water activities associated with the EnCana pipeline laying period does not overlap with the tern breeding season there is unlikely to be an impact on Roseate Terns.

7.6 Future Research Directions

The primary limitations of the current study were the difficulties associated with the identification of terns, the high occurrence of fog during the month of July, and our limited access to survey vessels during the lobster fishing season (May-June). Because we identified relatively few Roseate Terns we still have a great deal of uncertainty regarding their foraging habitat, particularly during the incubation period when sightings were rare. Areas identified as foraging habitat for Roseate Terns in our study overlapped with high-use areas from the radio-telemetry study of Rock et al. (2007a) and could be studied in more detail in future years to determine when and how often they are used by Roseate Terns, and what species of forage fish are caught there. Any future studies on Roseate Tern foraging distribution should weigh the potential negative impacts of radio-transmitters (reviewed in Burger and Shaffer 2008) on the small Country Island population of Roseate Terns with the potential benefits of gathering more detailed information. Gulls tend to be far less affected by the attachment of tracking devices and Rock et al. (2007a, 2007b) found no evidence for negative effects on Roseate, Common, or Arctic Terns, although their sample size was relatively small. The recent development of GPS tags sufficiently light to be deployed on small gulls also holds promise for the

future. Given the small population size and the difficulty in identifying terns at a distance, it will be difficult to obtain more precise results using boat and/or land surveys alone. It is also important that any radio-tracking study be done throughout the breeding season to account for seasonal shifts in foraging distribution as shown in this study.

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Table 1. The size of groups detected during boat-based surveys for each species (or grouping) of tern.

<i>Group Size</i>	<i>Unidentified tern</i>	<i>Non-Roseate tern</i>	<i>Common tern</i>	<i>Arctic tern</i>	<i>Roseate tern</i>
1	699	245	379	33	5
2-5	249	50	48	6	4
6-10	30	1	6	0	0
11-20	12	1	1	0	0
>20	3	0	0	0	0

Table 2. The size of groups detected during land-based surveys for each species (or grouping) of tern. Data are only from terns detected within 500m of the 20 land-based sites.

<i>Group Size</i>	<i>Unidentified tern</i>	<i>Non-Roseate tern</i>	<i>Common tern</i>	<i>Arctic tern</i>	<i>Roseate tern</i>
1	26	15	33	12	2
2-5	24	24	38	12	2
6-10	6	5	5	0	0
11-20	1	4	3	1	0
>20	4	1	0	1	0

Table 3. Summary of the three predominant non-tern and non-gull bird species counts from boat-based surveys circumnavigating Goose and Harbour Islands in May-August 2008.

Julian Date	Goose Island Transect			Harbour Island Transect		
	Common Eider	Double-Crested Cormorant	Surf Scoter	Common Eider	Double-Crested Cormorant	Surf Scoter
144	226	39	44	-	-	-
145	131	36	28	108	46	0
149	141	25	26	73	26	0
161	181	36	0	30	17	0
168	275	36	0	72	54	0
177	50	63	18	-	-	-
178	102	27	0	40	19	0
187	169	97	0	20	42	0
190	34	60	0	85	125	0
194	65	66	0	89	40	0
195	82	41	0	34	25	0
213	60	59	0	43	62	0
218	22	152	0	0	54	0
222	-	-	-	0	90	0

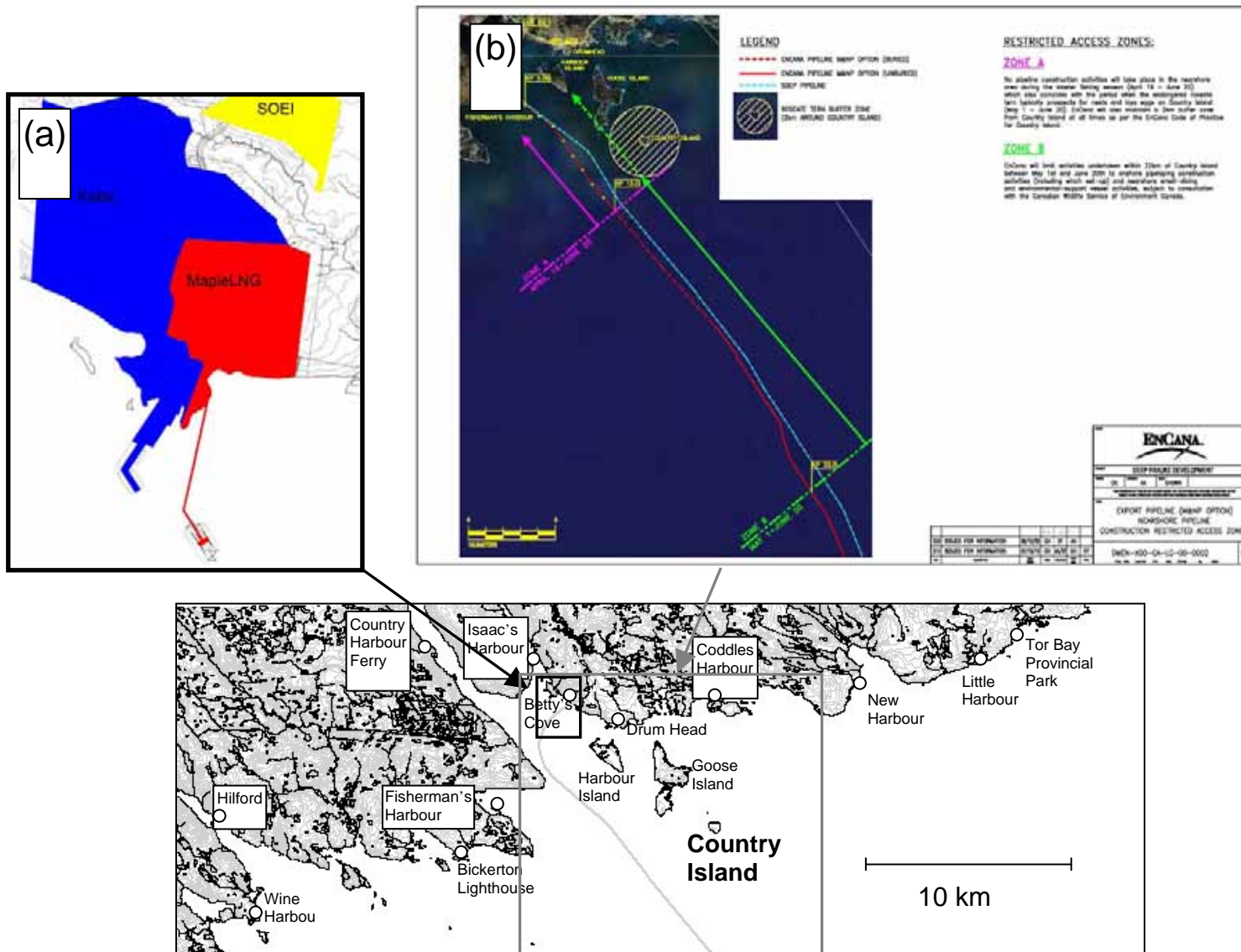


Fig 1. Map depicting the study region and the location of the tern colony (Country Island) in relation to industrial development projects: (a) Keltic Petrochemical and MapleLNG facilities, (b) EnCana pipeline. Names of villages, islands, and harbours referenced throughout the report are also shown. The grey line in the bottom map indicates the route of the proposed EnCana pipeline.

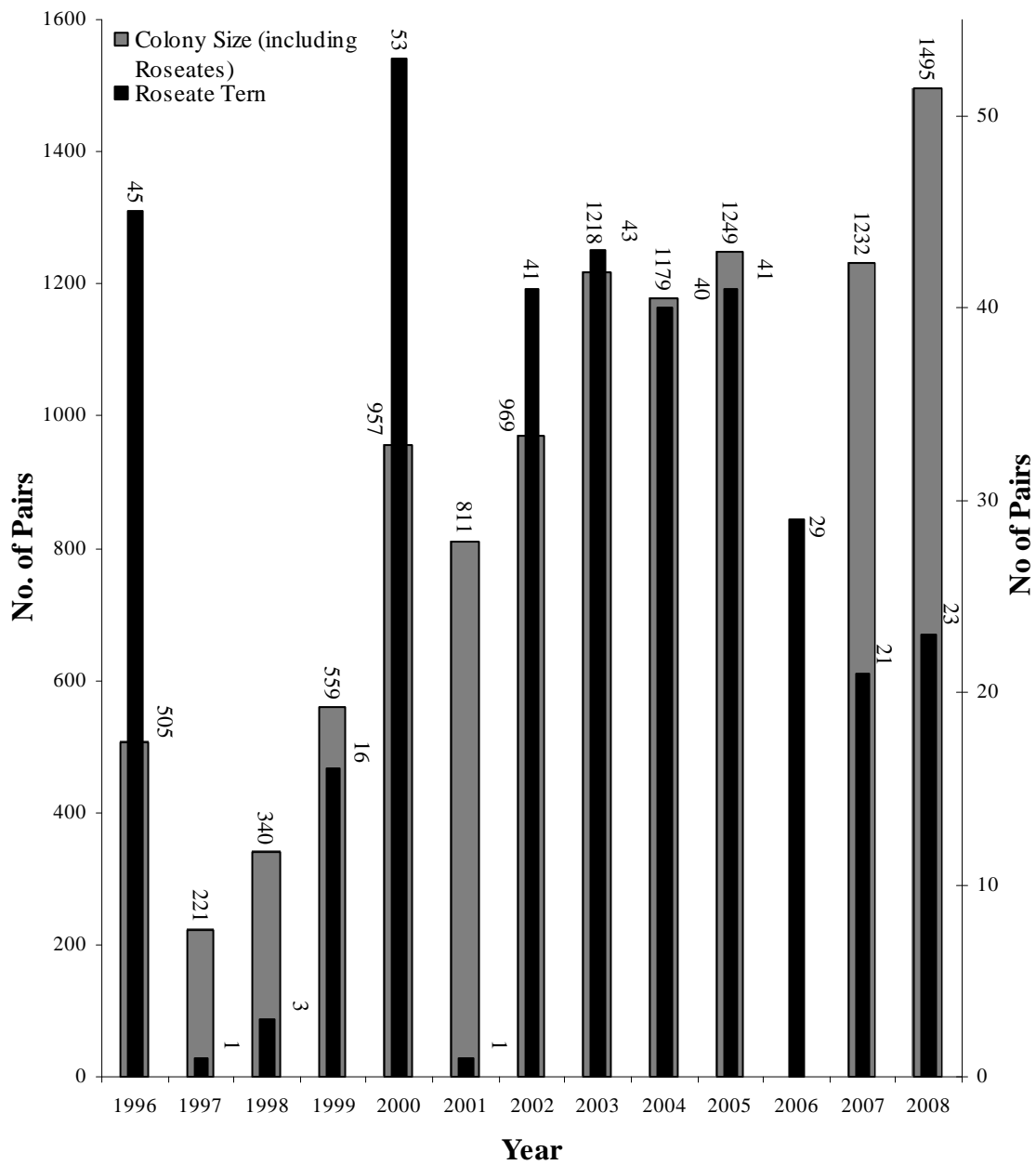


Fig 2. Number of nests of all tern species and of Roseate Terns counted during the census on Country Island, 1996-2008. The 2006 census was incomplete. Reproduced from Toms et al. 2008.

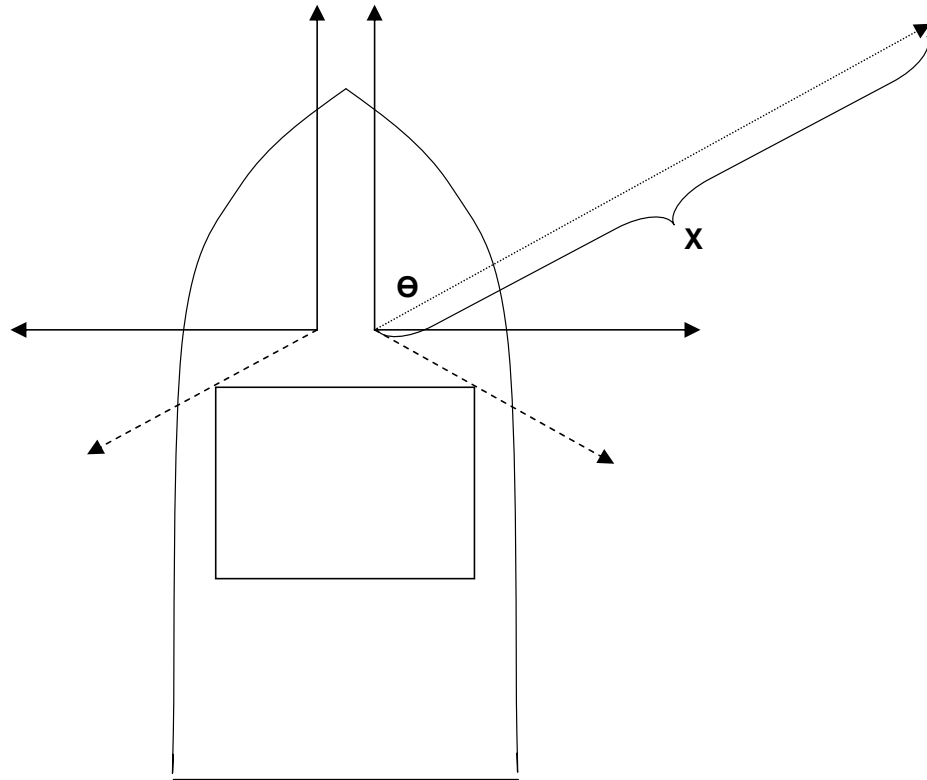


Fig 3. Schematic diagram illustrating the at-sea survey sampling protocol. Boat surveys involved paired observers seated on the bow scanning for birds from directly ahead to 90° abeam (solid arrows). Whenever a single bird or group of birds was detected, the observer recorded the angle to the bird relative to the current direction of the boat (θ) and the estimated distance to the bird in metres (X). Distance to shore was checked periodically using laser range finders and the position and direction of travel were determined using a GPS receiver. The observers' range of view was limited by the cabin (broken arrows).

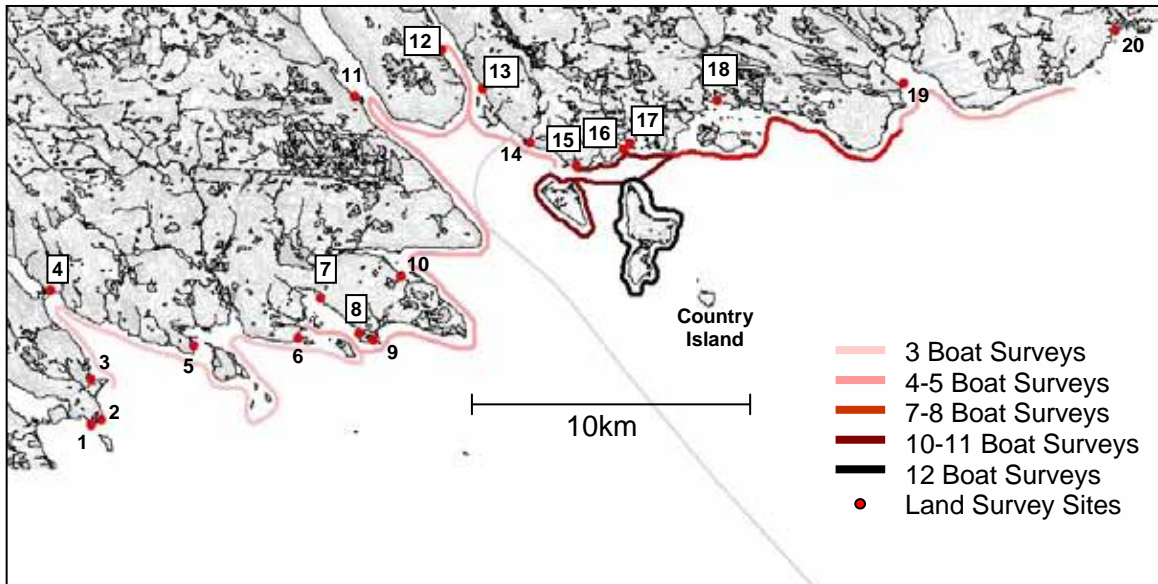


Fig 4. Map depicting the study area surrounding the tern colony on Country Island and survey effort from May to August 2008. Lines depict boat-based transects conducted in nearshore waters. Twenty-three to twenty-eight surveys were conducted at each of the land-based survey sites (sites 1-20; red circles) during the study period. The grey line depicts the proposed EnCana pipeline.

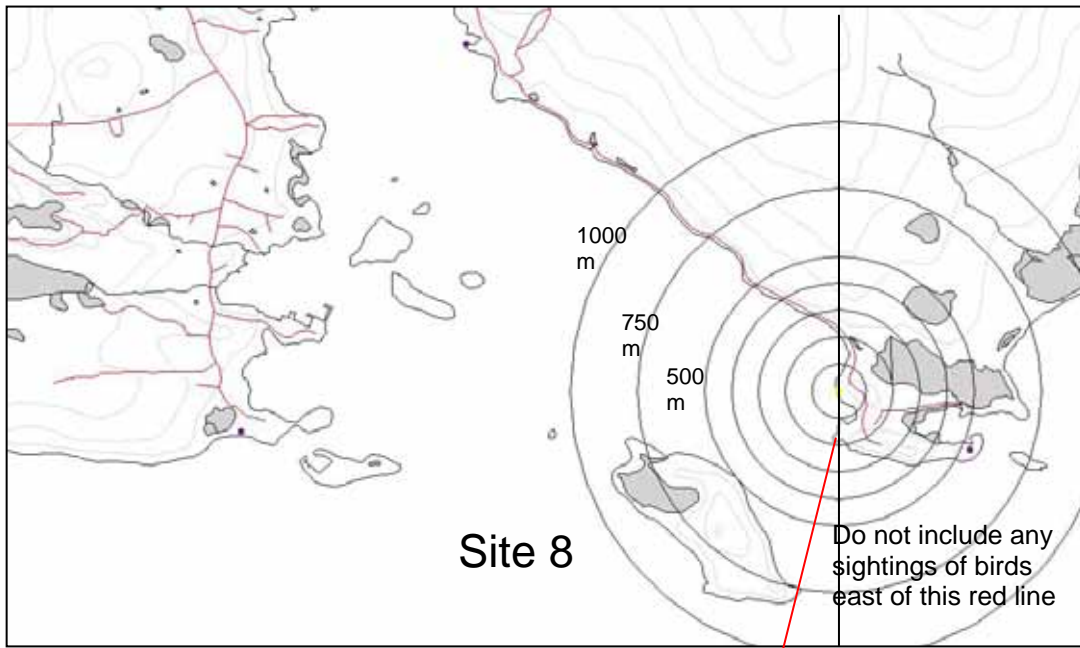


Fig 5. Example of a mapsheet used to estimate distances to birds from a land-based survey point. Surveyors were initially trained to estimate distance using the mapsheet with laser range finders to verify distances to landmarks on the map. Angle to each bird was estimated by placing a protractor on the mapsheet and lining the mapsheet up with a landmark. Birds detected east of the red line on the mapsheet were not recorded to prevent overlap with a nearby land site.

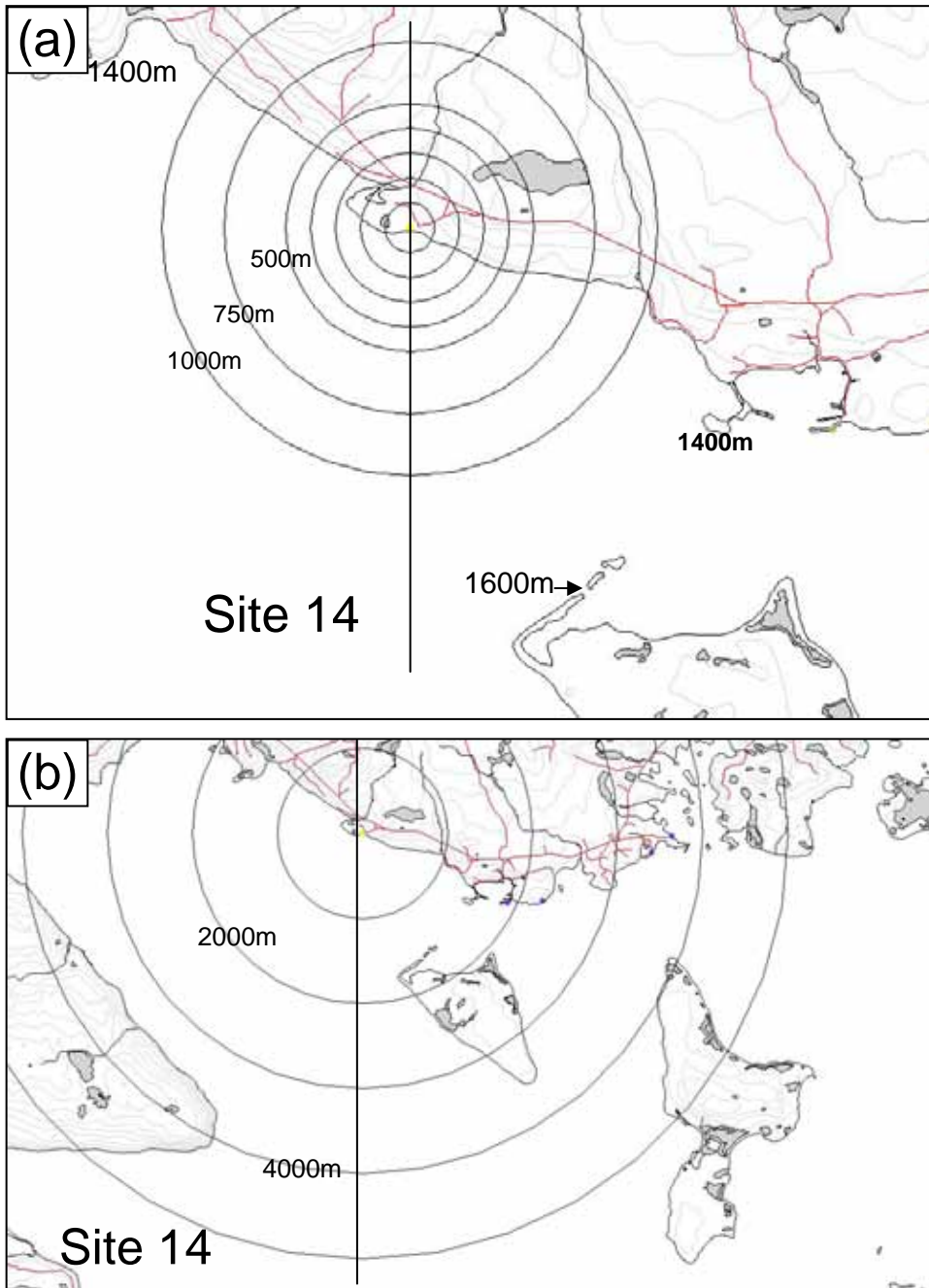


Fig 6. Example of two mapsheets used to estimate distances to birds from a land-based survey point. Multiple mapsheets were used so that distance to birds could be estimated for terns foraging along the shorelines of islands. Observers recorded all waterbirds located within 500m of the survey point and all terns that were detected when scanning with a 20x spotting scope.

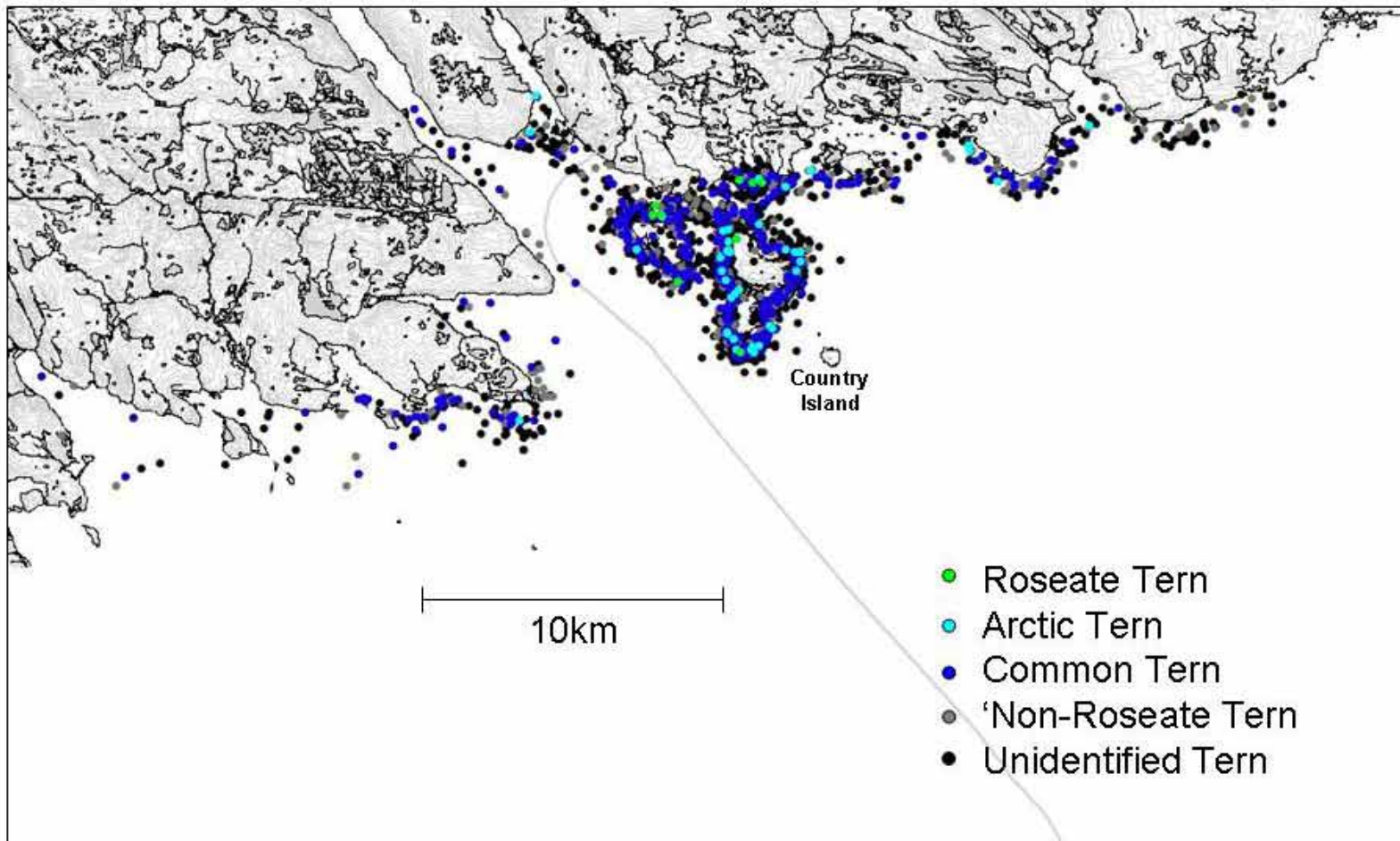


Fig 7. Results of boat-based surveys conducted between from May to August 2008. Each point represents a detection of an individual tern or group of terns. The distribution of tern sightings reflects a combination of survey effort and tern distribution. The grey line depicts the proposed EnCana pipeline.

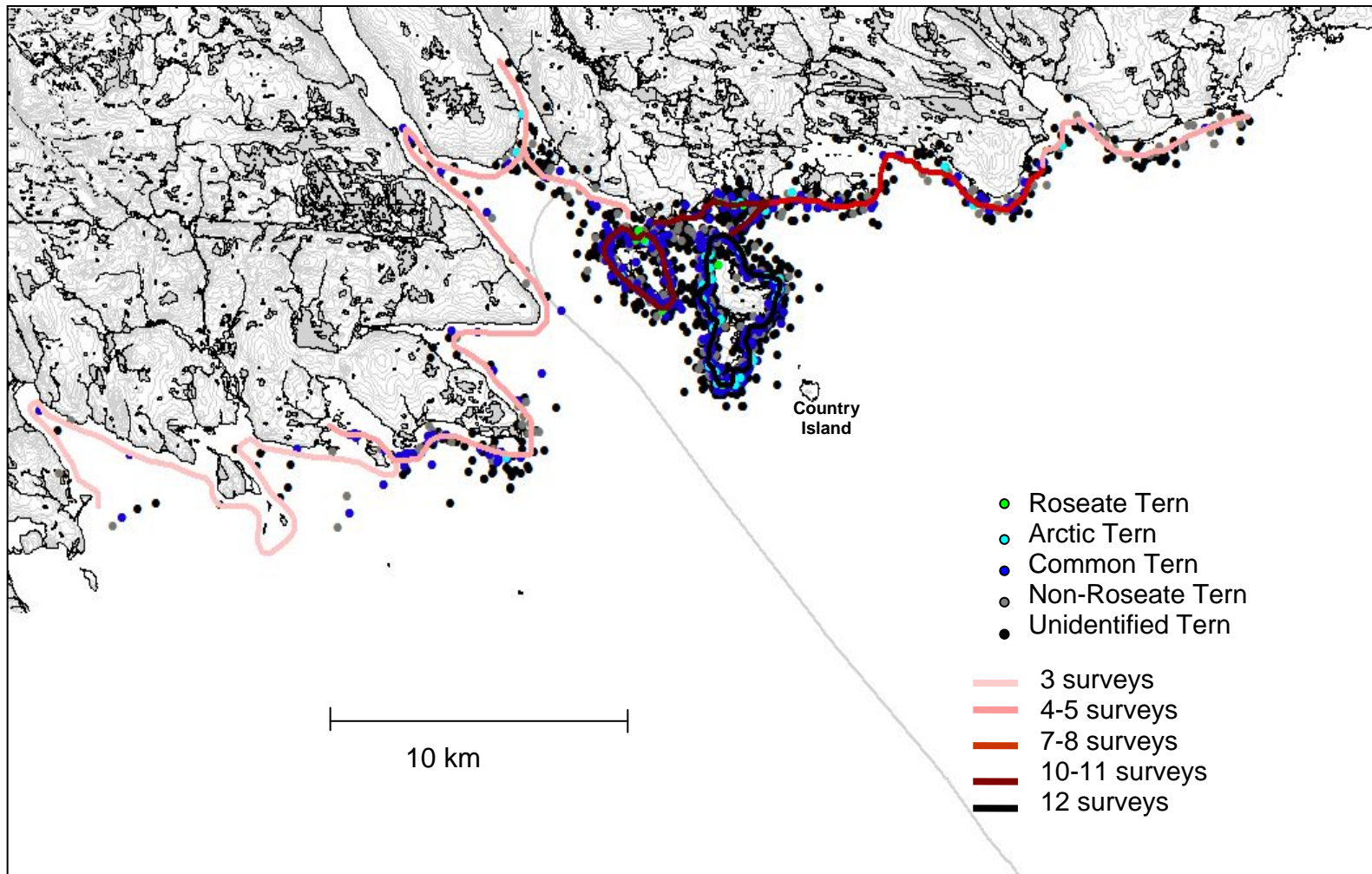


Fig 8. Results of boat-based surveys conducted from May to August 2008. Line colors indicate the survey effort (number of surveys conducted) throughout the summer. The ability of survey personnel to identify terns to species deteriorated rapidly with distance to detected tern from the survey vessel. Other factors such as wind speed, sea state, and tern density also affected the ability of survey personnel to identify terns to species. The grey line depicts the proposed EnCana pipeline.

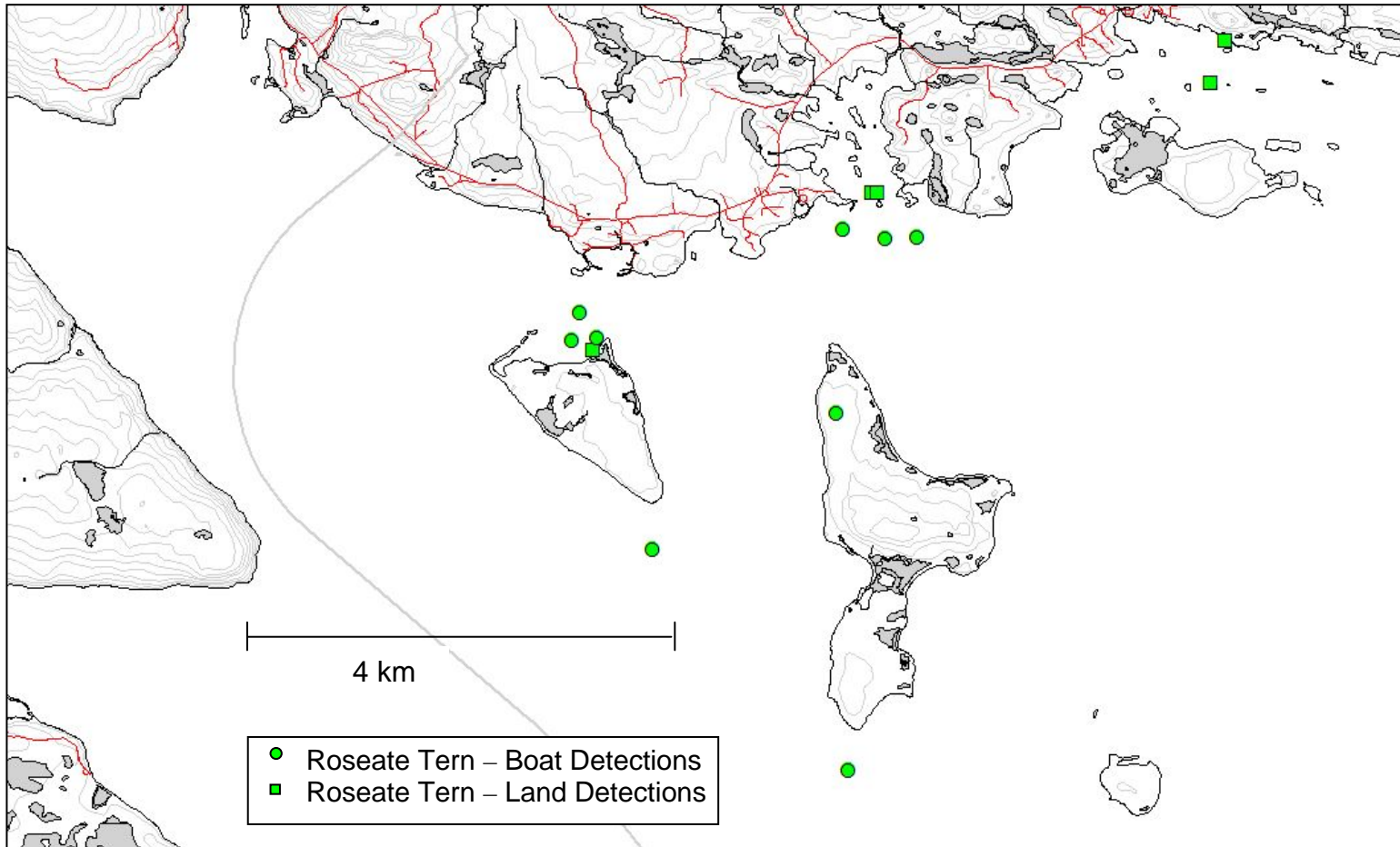


Fig 9. Locations of Roseate Terns detected at-sea during boat and land-based surveys conducted from May to August 2008. In all cases, Roseate Terns were seen as lone individuals or in groups of two birds. The tern that appears to be on land was actually over water within a few metres of the shore and only appears on land due to error in distance and angle estimates. The grey line depicts the EnCana pipeline.

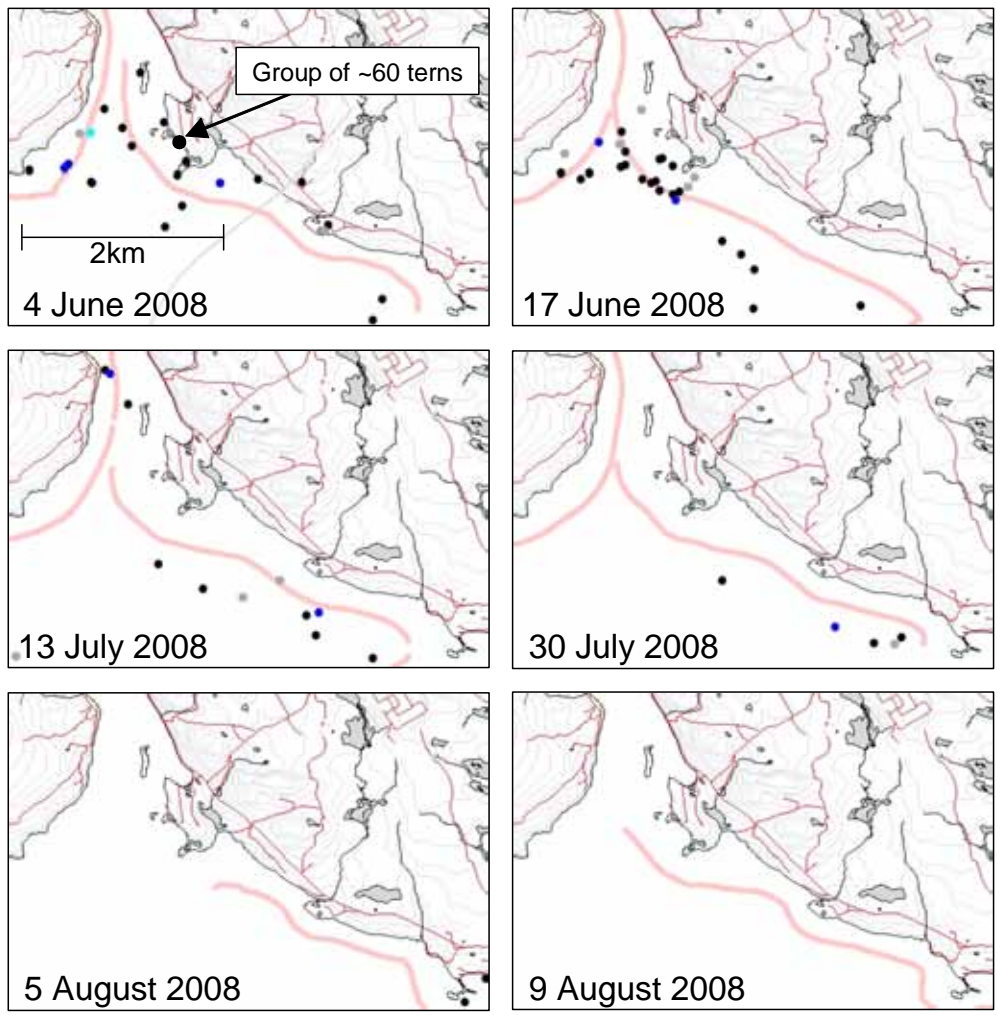


Fig 10. Tern detections during boat-based surveys in the vicinity of the proposed development area from early-June to early-August 2008. Approximate locations of the development sites are indicated by the large red circles. The pink line indicates the route of the survey vessel. Development sites are shown in Figure 1. See Figures 7 and 8 for tern species legend. The grey line in the upper left panel depicts the EnCana pipeline.

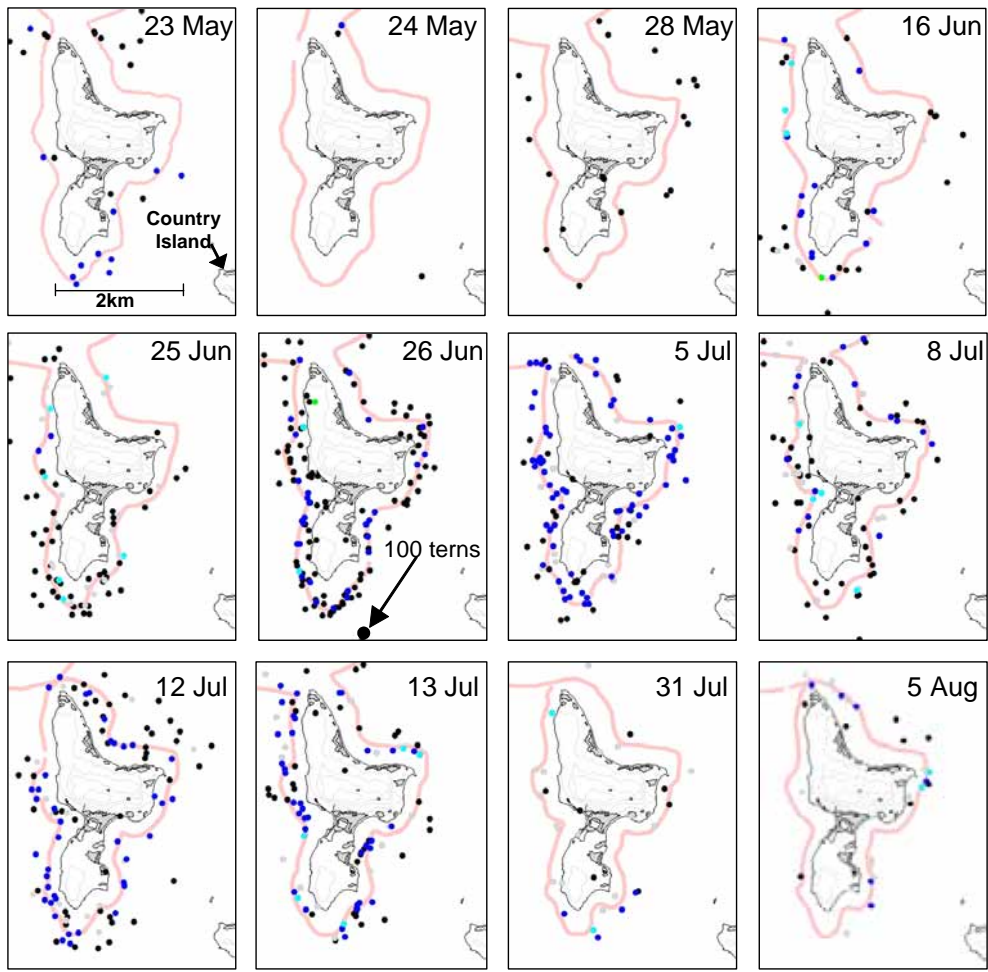


Fig 11. Tern detections during boat-based surveys circumnavigating Goose Island from May to August, 2008. Each point represents an individual tern or group of terns. A clear seasonal pattern in tern densities emerges with the number of detections being higher between mid-June and mid-July. See Figures 7 and 8 for tern species legend.

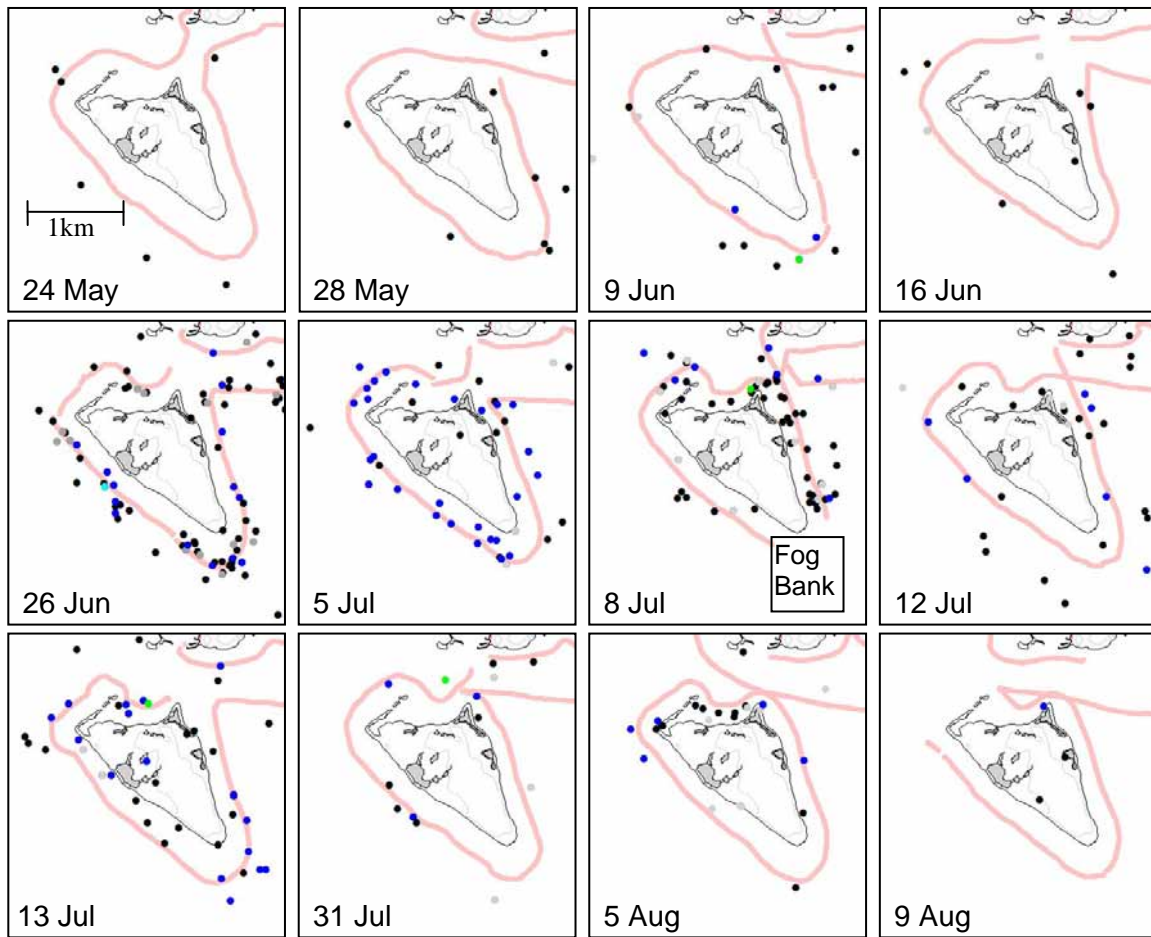


Fig 12. Tern detections during boat-based surveys circumnavigating Harbour Island from May to August, 2008. Each point represents an individual tern or group of terns. A clear seasonal pattern in tern densities emerges with the number of detections being higher between late-June and mid-July. See Figures 7 and 8 for tern species legend.

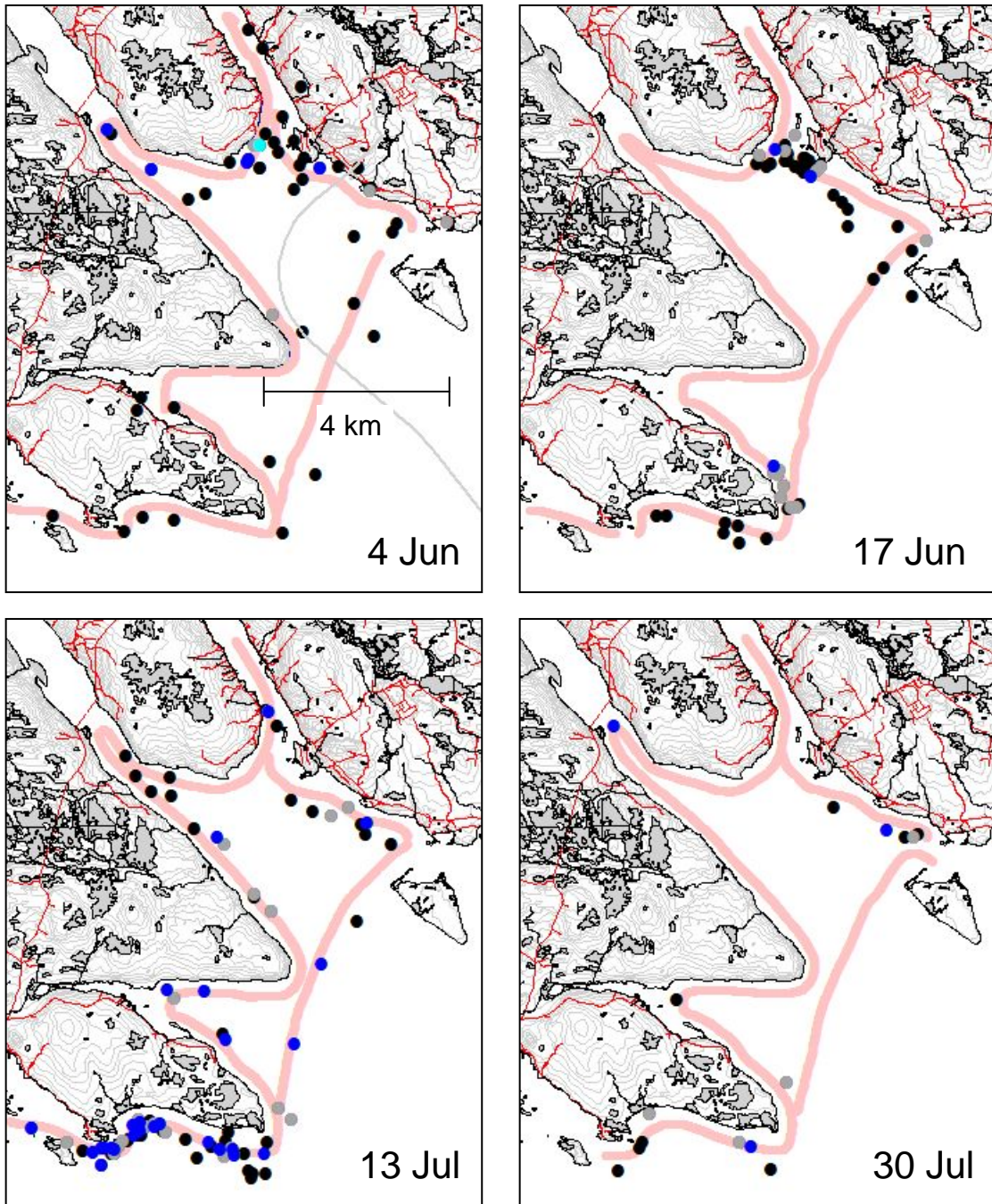


Fig 13. Tern detections during boat-based surveys east of Bickerton Lighthouse to Drum Harbour between early June and late July, 2008. This figure includes the survey area shown in figure 9 of the development area. See Figures 7 and 8 for tern species legend. The EnCana pipeline is depicted in the upper left panel.

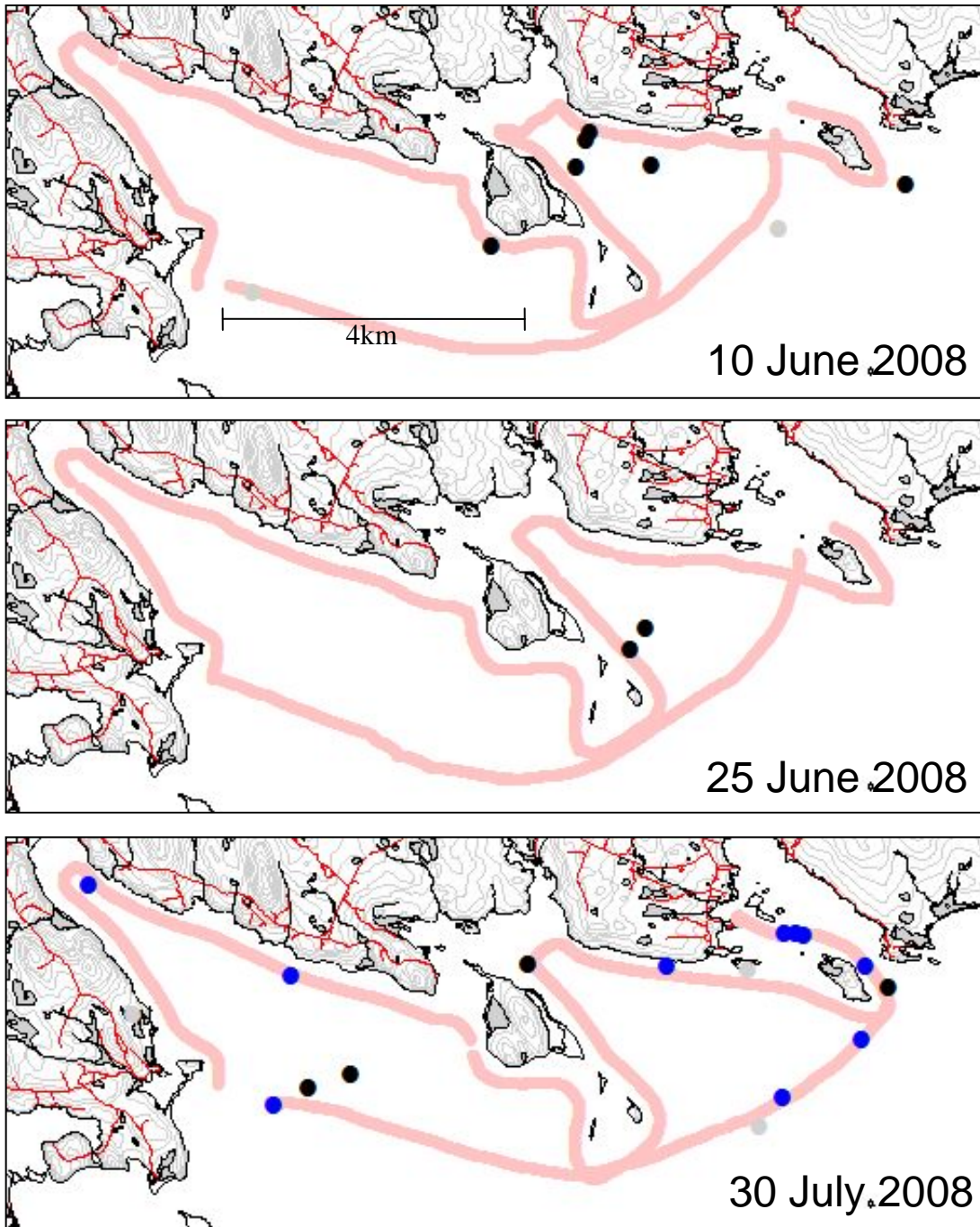


Fig 14. Tern detections during boat-based surveys west of Bickerton Lighthouse between early June and late July, 2008. Few terns were detected during these surveys throughout the year (2-19 groups/survey detected; 13-33 terns/terns detected). We found no evidence for breeding colonies other than Country Island in our surveys despite prior evidence of terns breeding at the lighthouse spit (Whittam 1997). See Figures 7 and 8 for tern species legend.

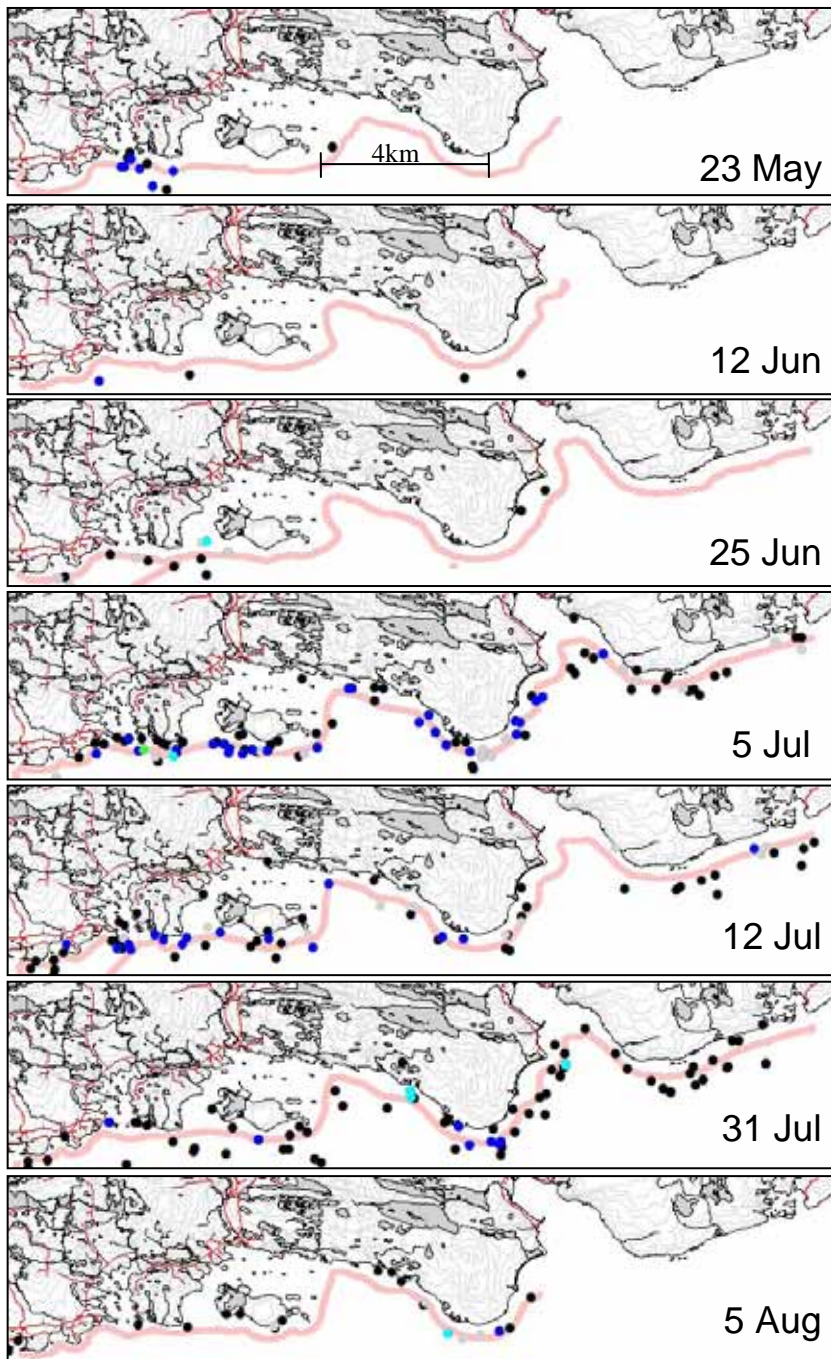


Fig 15. Tern detections during boat-based surveys east of Drum Harbour from May to August, 2008. The numbers of detections were low throughout May and June but increased during the month of July. This increase during July coincided with a decrease in terns detected in close vicinity to the proposed development sites. See Figures 7 and 8 for tern species legend.

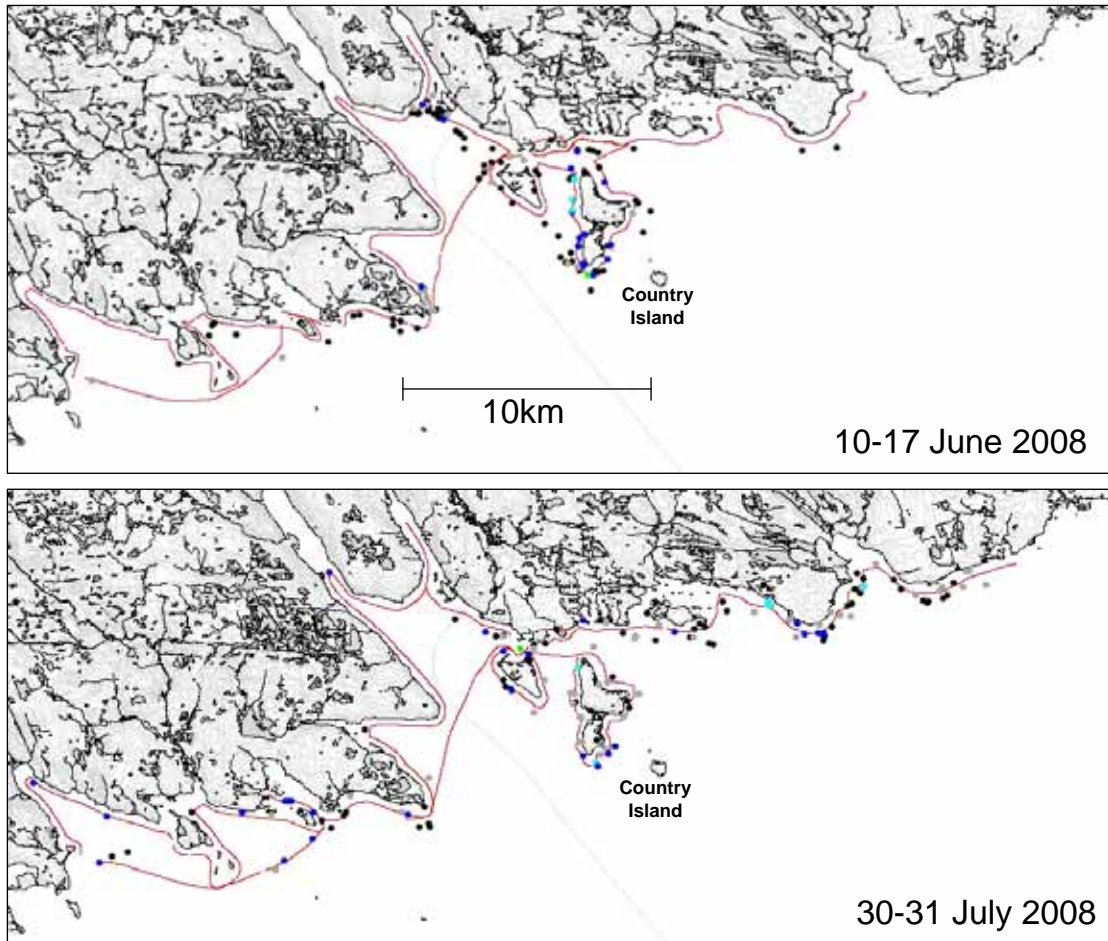


Fig 16. Tern detections during boat-based surveys covering the entire survey area between (a) 10-17 June and (b) 30-31 July, 2008. The survey route on 30-31 July extended somewhat further to the east. The distribution of terns shifted during this time period with higher numbers detected in the vicinity of the proposed Keltic and Maple facilities in June compared to July. In July, terns were detected in higher numbers North-East of Country Island along the mainland (compared to June). See Figures 7 and 8 for tern species legend. The grey line depicts the EnCana pipeline.

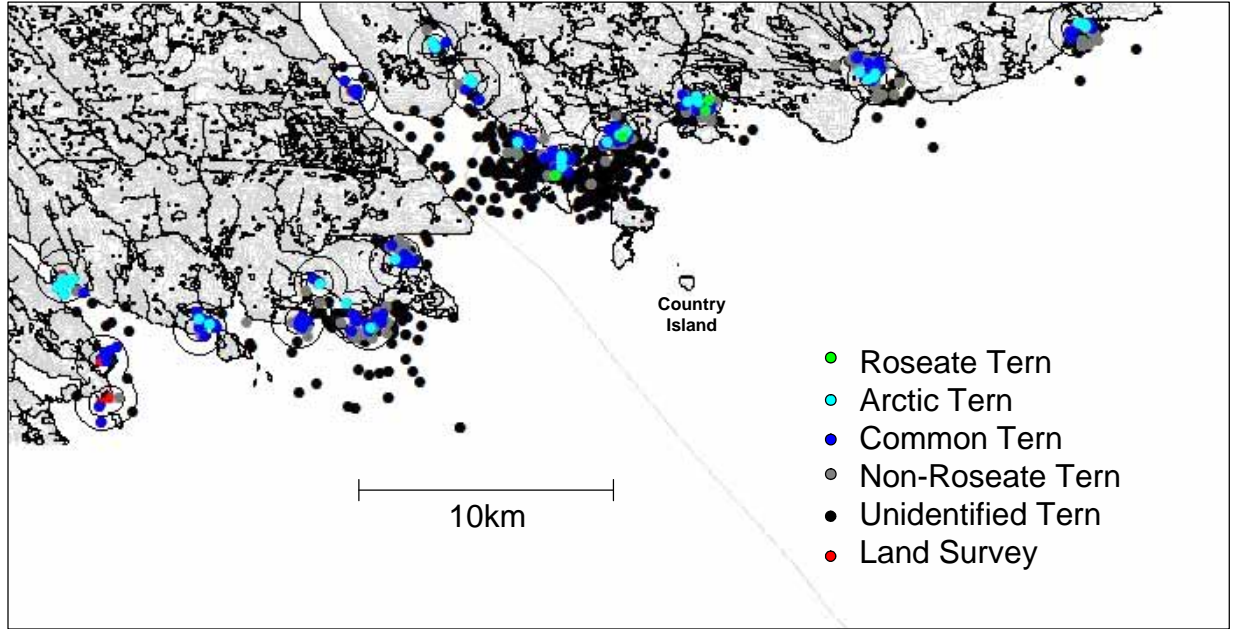


Fig 17. Results of land-based surveys conducted from May to August 2008. Each point represents a detection of an individual tern or group of terns. The two concentric rings represent a 500m and 1000m buffer around each survey point. Survey locations are shown in red, although most are obscured by the bird points (see Fig. 4 for survey points). The ability of observers to identify terns deteriorated with distance from the survey point and weather conditions. The grey line depicts the EnCana pipeline.

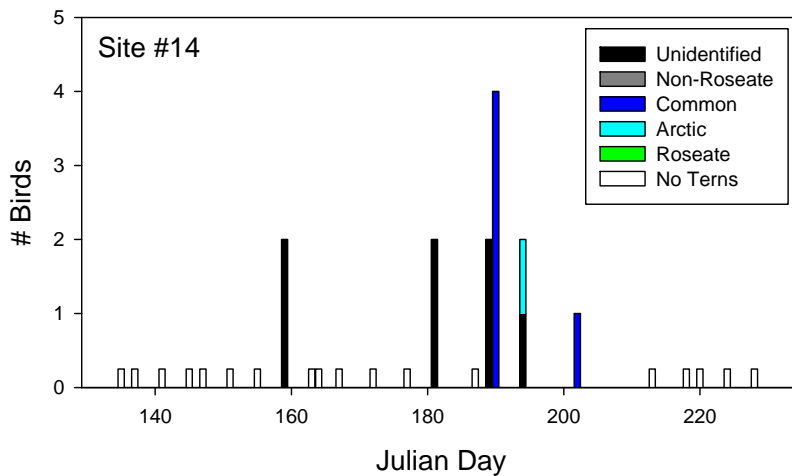
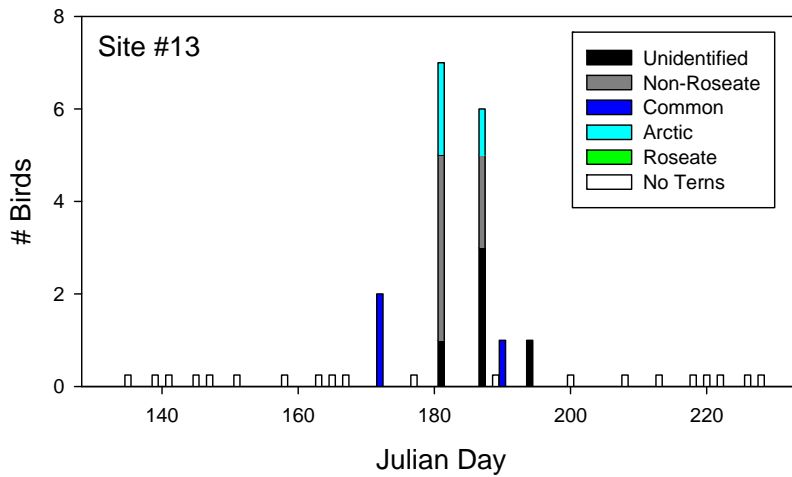
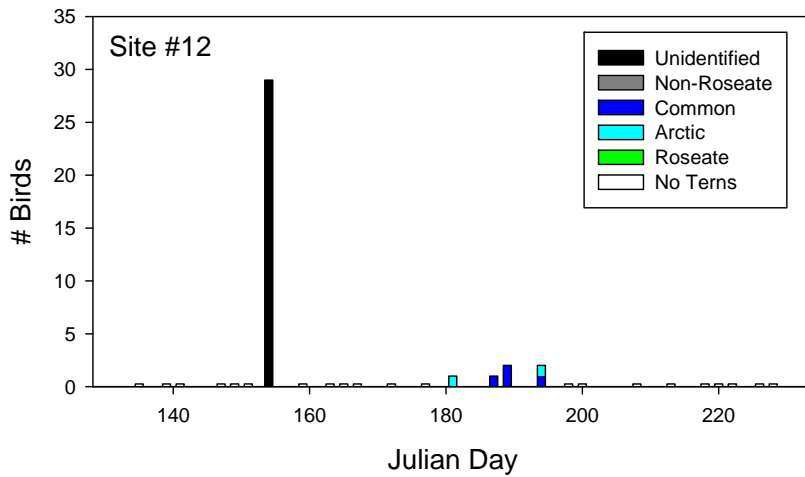


Fig 18. The number of terns detected within 500m of sites 12, 13, and 14 which are located 13, 10.5, and 8.5 km from Country Island, respectively. A single group comprised of 29 unidentified terns was seen in Isaac’s Harbour at site 12 on day 154. Few terns were observed at site 14, the closest observation point to the industrial development areas. See Figure 4 for the locations of survey points.

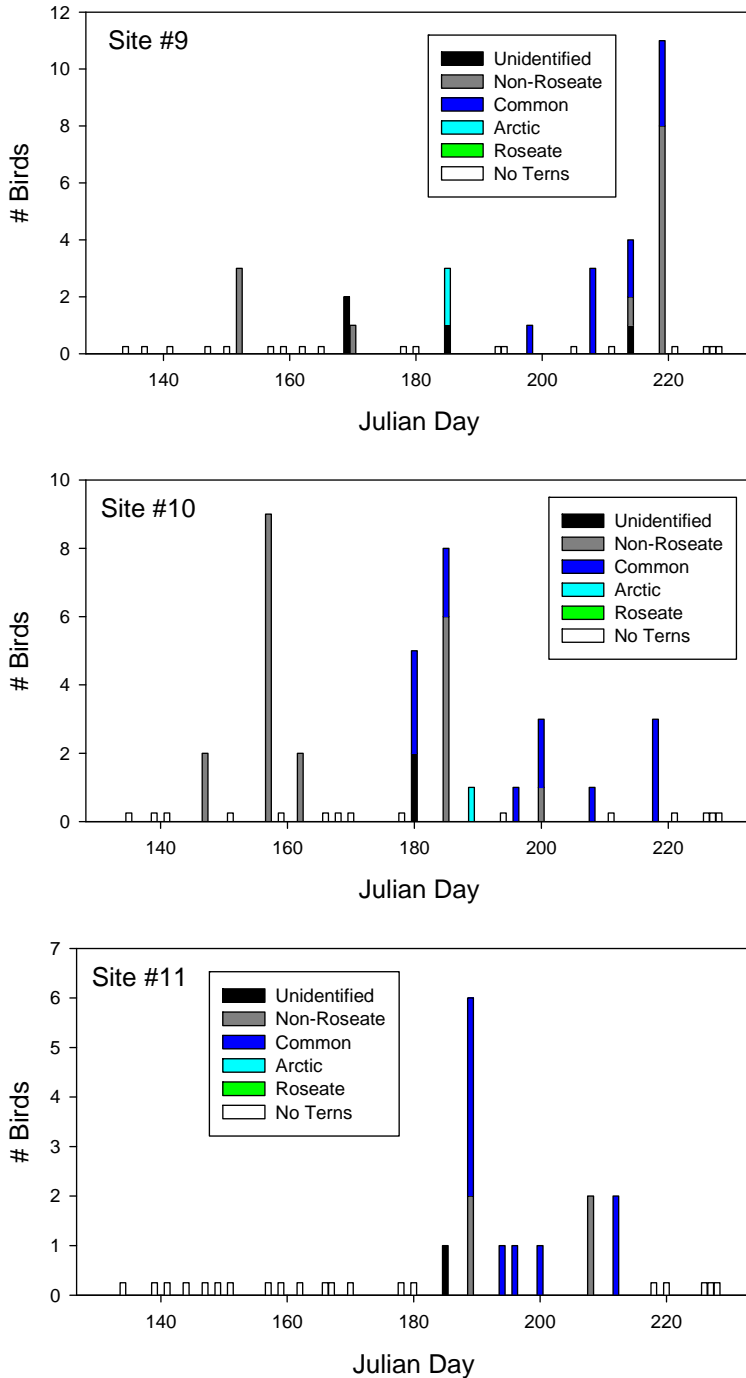


Fig 19. The number of terns detected at sites 9, 10 and 11 which are located near Bickerton Lighthouse, Fisherman’s Harbour, and the ferry terminal, respectively. Sites 9, 10, and 11 are located 11.5, 10.5 and 14.5 km from the Country Island tern colony. There was no obvious seasonal pattern in the number of terns detected at Bickerton Lighthouse or Fisherman’s Harbour. Terns were never sighted at the ferry terminal prior to Julian Day 180, but were sighted on seven consecutive surveys after this date. See Figure 4 for the locations of survey points.

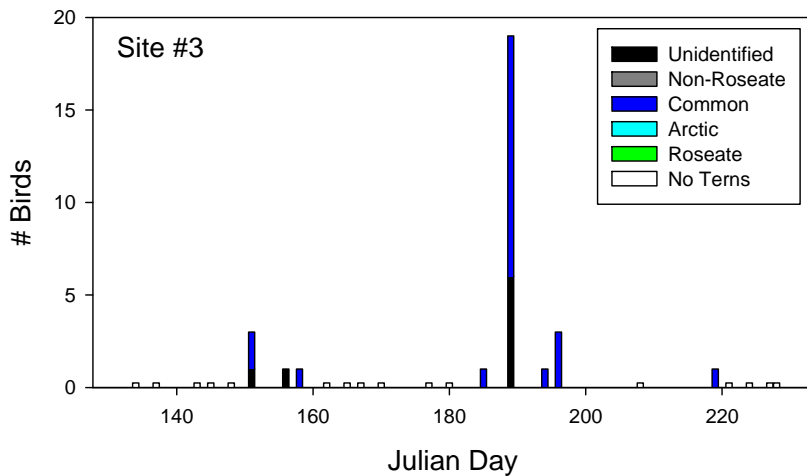
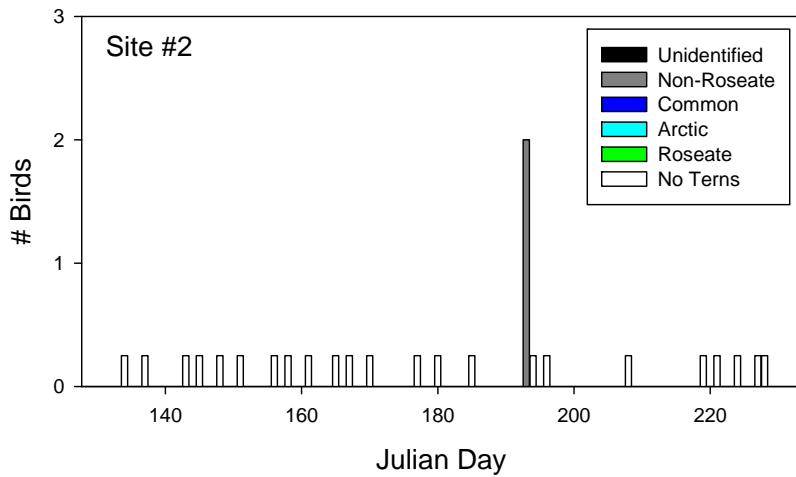
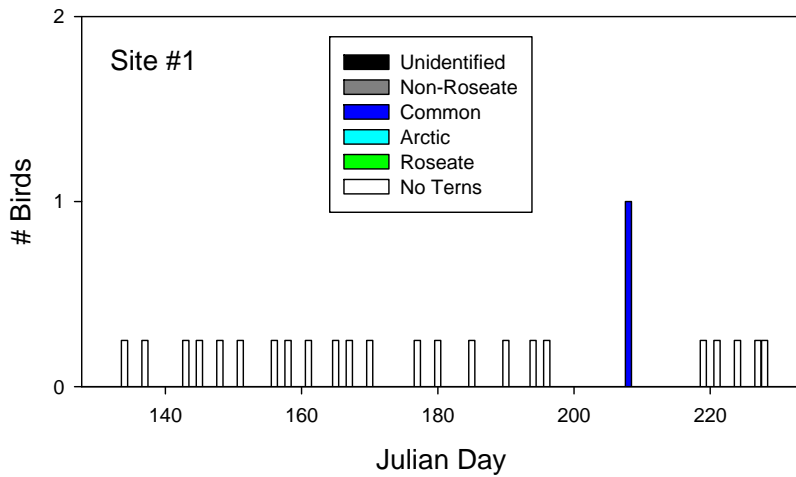


Fig 20. The number of terns detected within 500m of three land survey sites located within 1.5km of Wine Harbour. Sites 1, 2, and 3 are all located between 22 and 23km from the Country Island tern colony. Few terns were observed at these sites with the exception of a single survey at Site #3 during which 13 Common terns and 6 unidentified terns were detected. See Figure 4 for the locations of survey points.

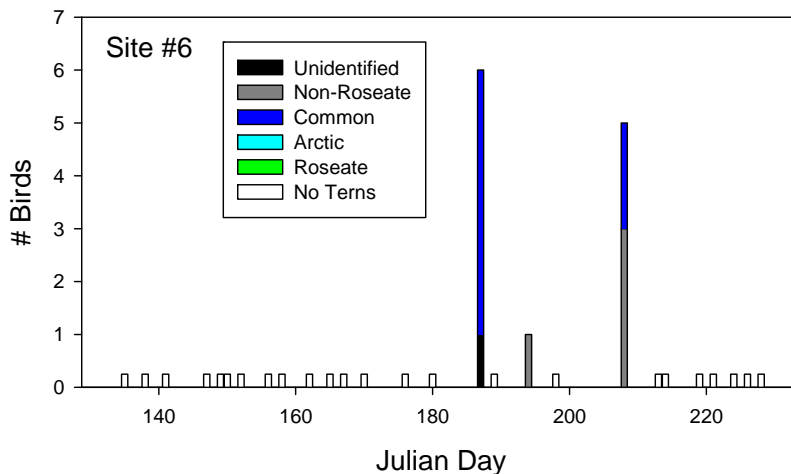
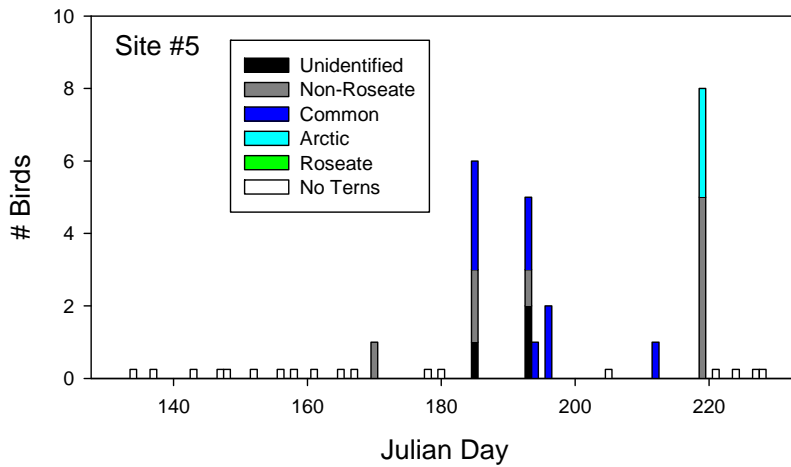
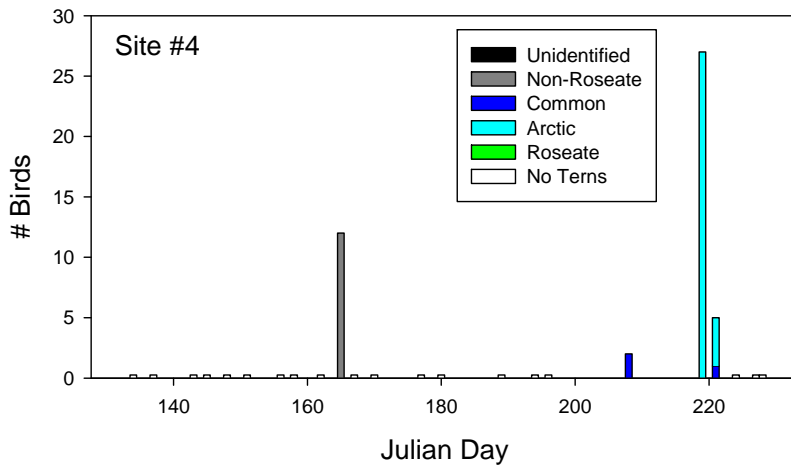


Fig 21. The number of terns detected within 500m of sites 4, 5, and 6 which are located 23.5, 18.5, and 14.5 km from Country Island, respectively. Terns were rarely detected at site 4 although a fairly large group of Arctic Terns were sighted at this location late in the season, presumably after chicks had fledged. Terns were sighted with a higher degree of regularity at sites 5 and 6 after Julian day 180 compared to earlier in the season. See Figure 4 for the locations of survey points.

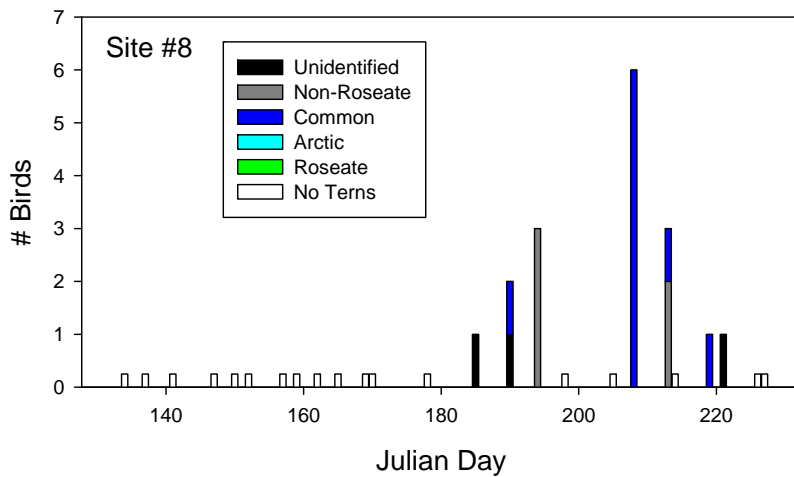
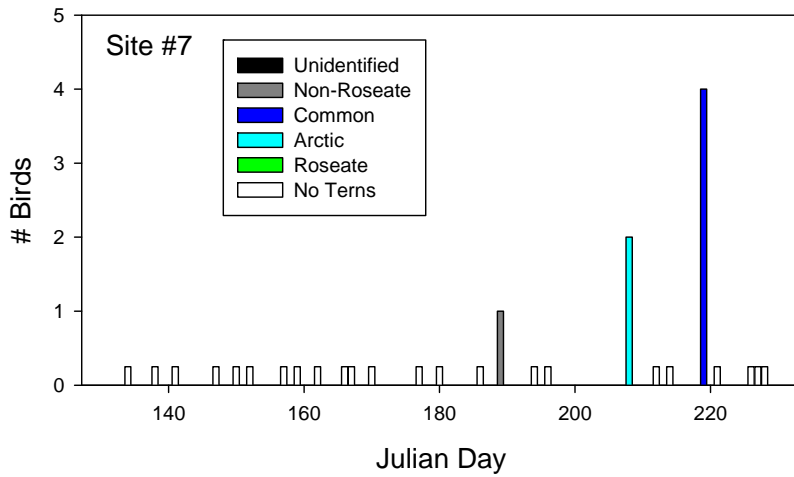


Fig 22. The number of terns detected within 500m of sites 7 and 8 which are located 14 and 12 km from the Country Island tern colony, respectively. Terns were never sighted prior to day 180 but were seen on 53% of surveys between days 180 and 220 at these sites. See Figure 4 for the locations of survey points.

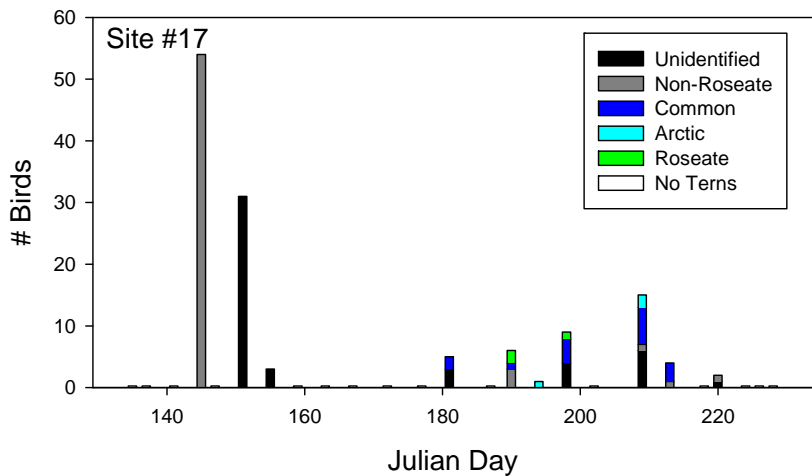
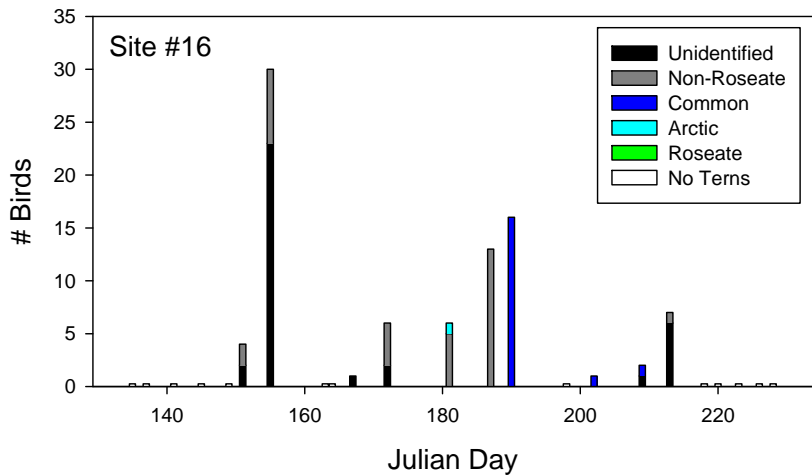
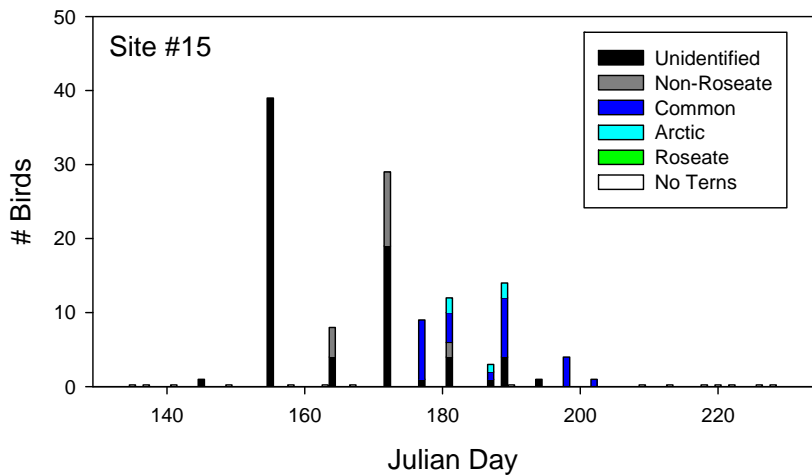


Fig 23. The number of terns detected within 500m of sites 15, 16, and 17 which are all located within 6.5 km of the Country Island tern colony. Unlike other sites, large groups of terns were detected at these sites between day 140 and 160 (prior to egg-laying and/or incubation). See Figure 4 for the locations of survey points.

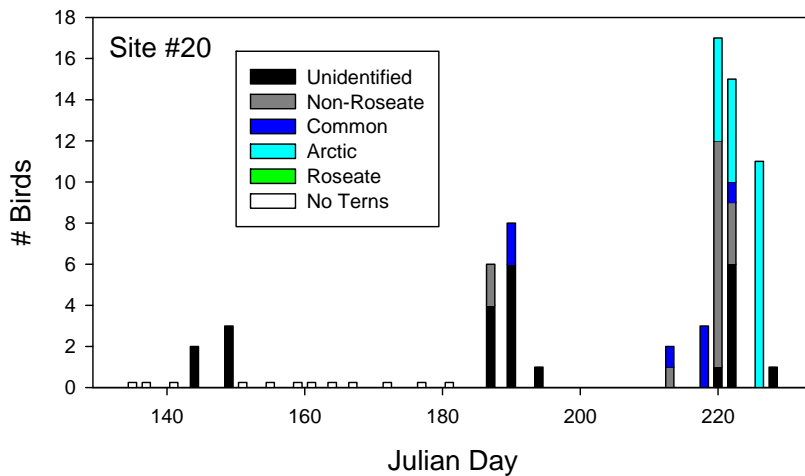
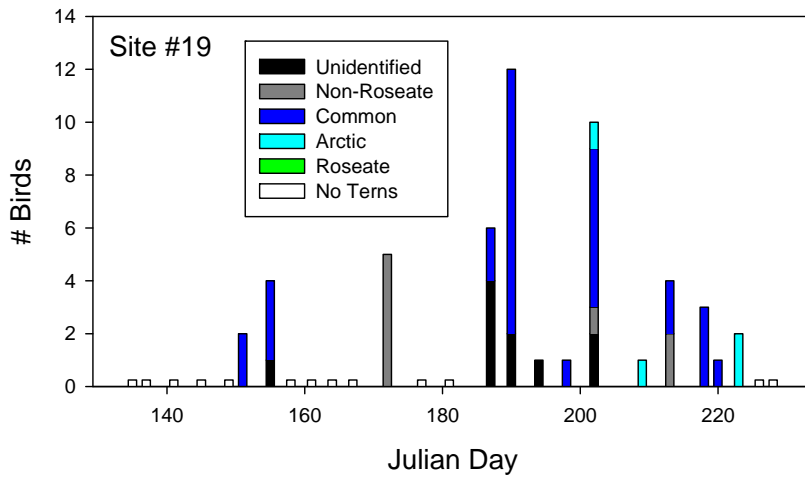
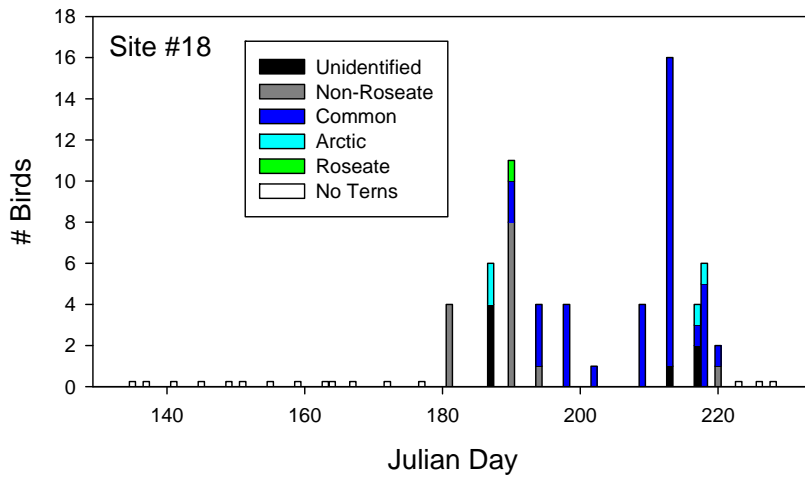


Fig 24. The number of terns detected within 500m of sites 18, 19, and 20 located 6.5, 10.5, and 17.5 km North-East of the Country Island tern colony, respectively. Terns were detected at these locations far more after day 180 than they were before day 180. Arctic terns were detected at site #20 (Tor Bay Provincial Park) late in the year. See Figure 4 for the locations of survey points.

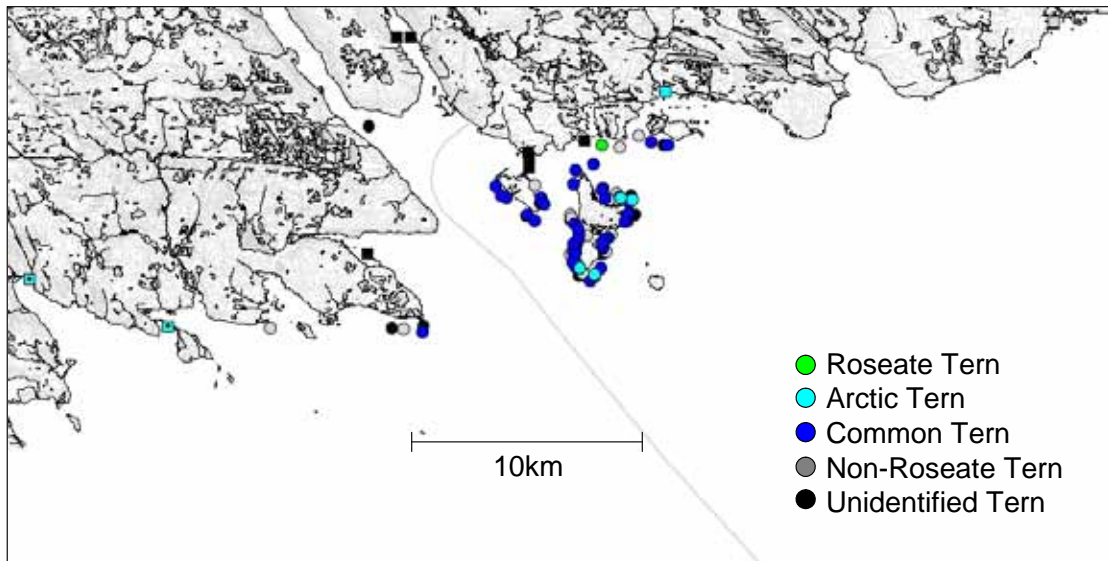


Fig 25. The locations of terns sighted carrying food in their bills during land-based surveys (squares) and boat based surveys (circles). Symbols with a dot in the center indicate birds that were either suspected of or confirmed to be feeding fledged young. The grey line depicts the EnCana pipeline.

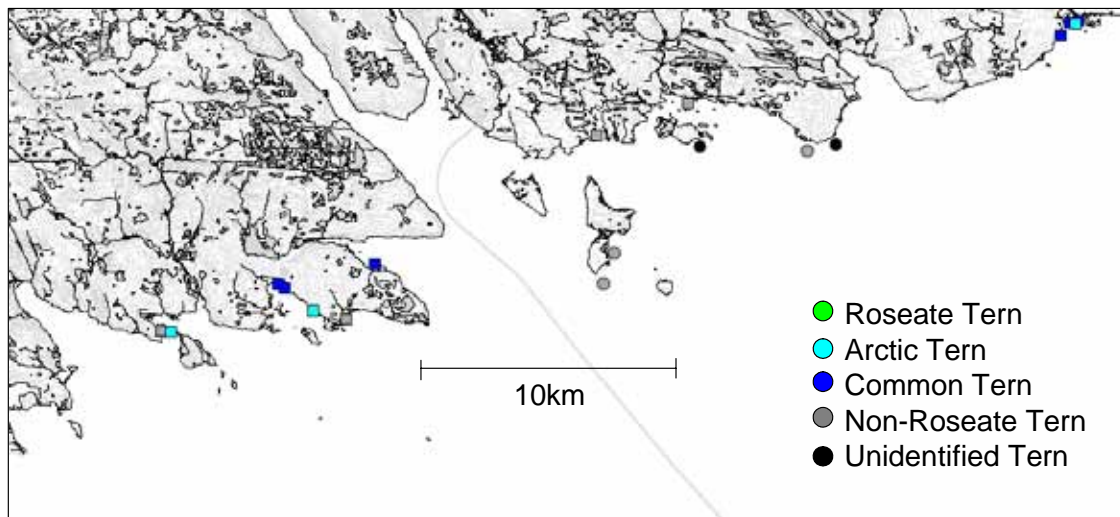


Fig 26. The locations of hatch-year terns detected during land-based surveys (squares) and boat based surveys (circles). The grey line depicts the EnCana pipeline.

- Double-Crested Cormorant
- Common Eider
- Common Loon
- Black Guillemot
- Red-Breasted Merganser
- Great-Blue Heron

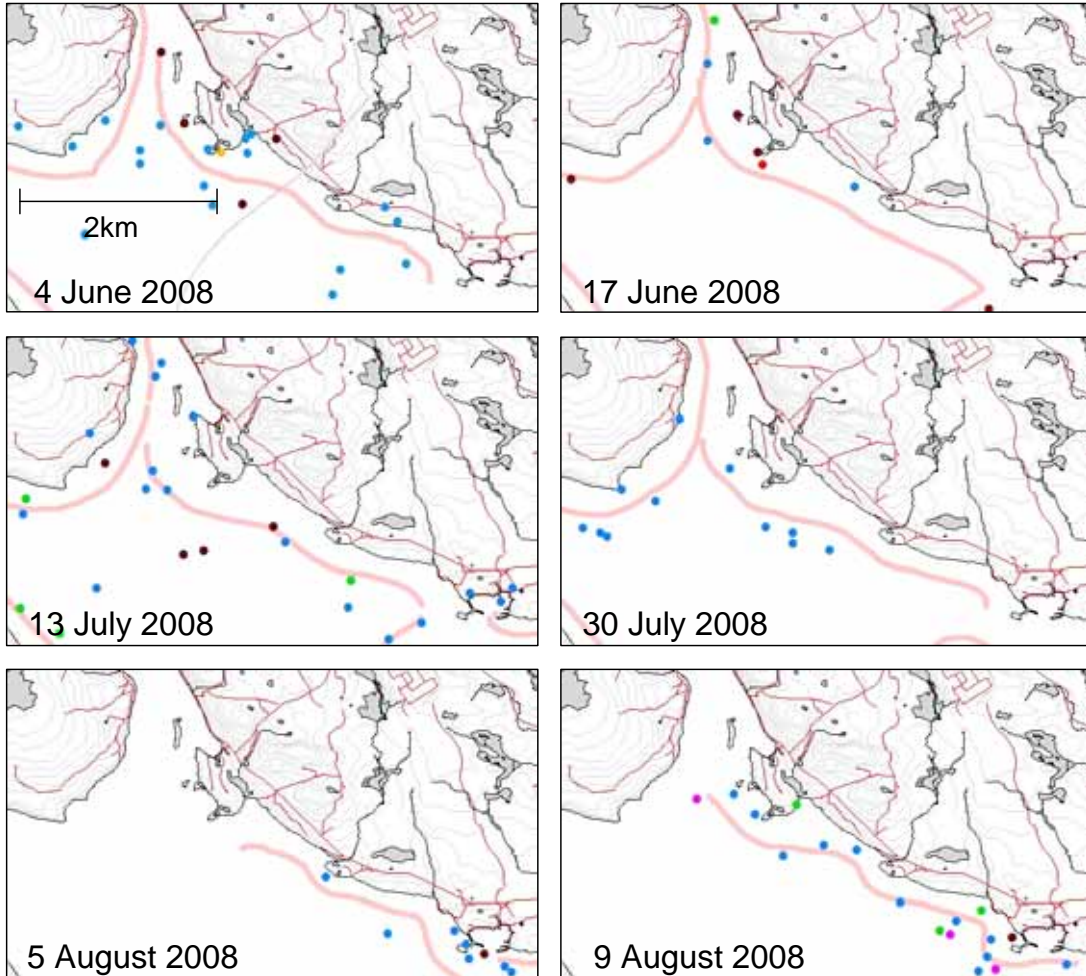


Fig 27. Detections of non-tern species during boat-based surveys in the vicinity of the proposed development area between early-June and early-August 2008. The pink line indicates the route of the survey vessel. The grey line in the upper left panel depicts the EnCana pipeline.

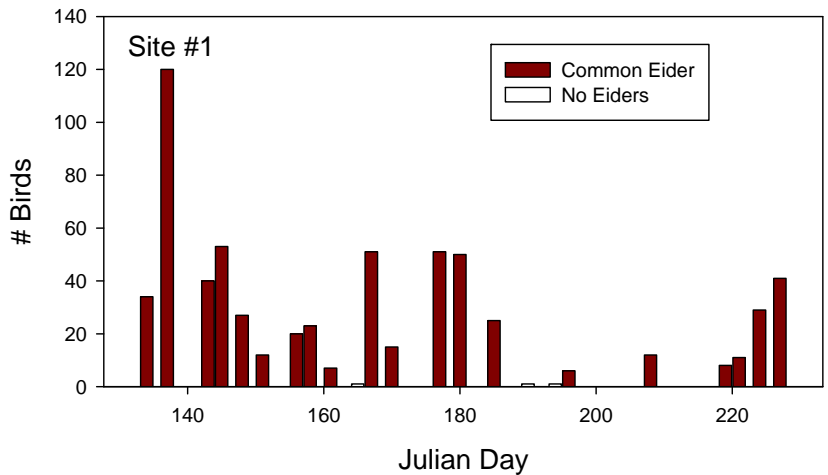


Fig 28. The number of Common eiders detected within 500m of site 1 which is located near the village of Wine Harbour.

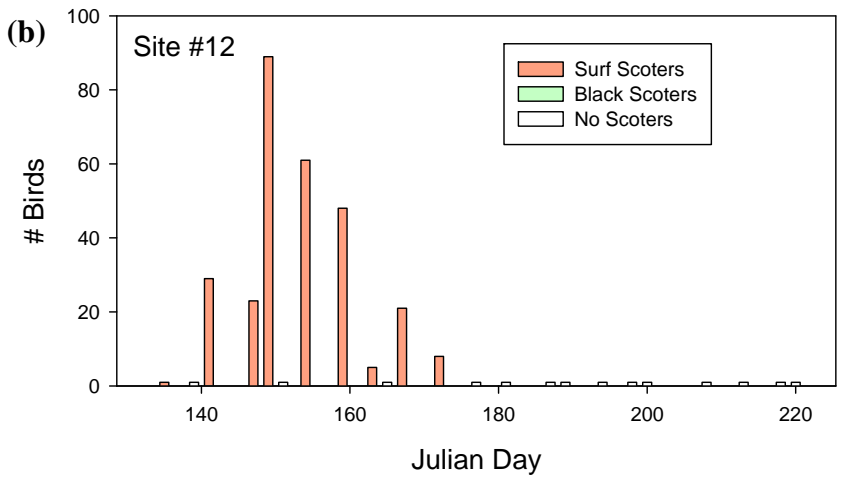
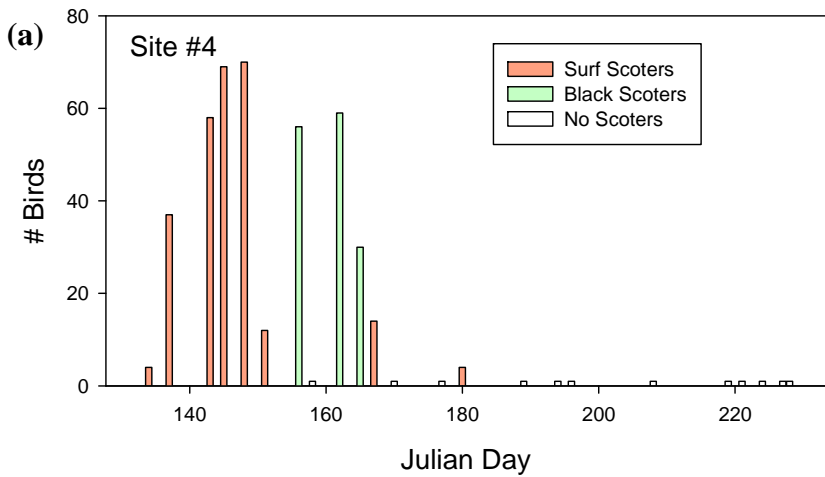


Fig 29. The number of scoters detected within 500m of (a) site 4 and (b) site 12 which are located near the town of Hilford and in Isaac’s Harbour, respectively.