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Effectiveness of Observers in Visually Detecting Dead Seabirds on the Open Ocean

Efficacité avec laquelle les observateurs détectent visuellement les oiseaux marins morts en pleine mer

March 2017

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Effectiveness of Observers in Visually Detecting Dead Seabirds on the Open Ocean

Final Report
205

Wildlife Research Division
Environment and Climate Change Canada
St. John’s, Newfoundland

March 2017

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1 Executive Summary

Assessing the environmental effects and impacts of oil spills is challenging, even when assessing impacts on highly visible top predators such as marine birds. The number of methods to assess the effects and impacts on marine birds from oil spills are limited, and require many assumptions, especially when pre-spill data are not available. In offshore environments the methods become even more constrained, because beached bird carcass surveys are not possible.

The purpose of this study was to assess whether seabird carcasses can be detected during standardized vessel-based seabird surveys that are more typically conducted to estimate densities of live birds. The approach was to conduct an experiment at-sea, by deploying a known number of seabird carcasses in an area, and subsequently surveying through the area to estimate densities of carcasses on the water.

Before conducting the experiment, a means to track the drift of carcasses was needed to ensure that the vessel could be directed to the area where the bird carcasses actually were. In November 2013, 2 seabird carcasses and 2 drift blocks were instrumented with satellite transmitters and released five nautical miles east of Witless Bay, Newfoundland and Labrador. Positions were received from the ARGOS satellite system within 70 minutes of deployment, and subsequently received on average every 34 minutes. The carcasses and drift blocks drifted similarly, suggesting the blocks could also serve as useful proxies for the carcasses. These results indicated that the choice of attachment methods and satellite transmitters would serve to track the overall drift of carcasses during the main experiment.

The main experiment was conducted onboard the M/V Burin Sea, an 82 m offshore oil and gas industry supply vessel, and started about 20 nautical miles east of Bay Bulls, Newfoundland and Labrador. The experiment ran for approximately 48 hours, starting on the evening of 26 November 2016, with a deployment of 680 marine bird carcasses (obtained from a variety of mortality events) and 312 drift blocks; of which 7 gulls, 8 murres, 7 dovekies and 8 drift blocks were equipped with satellite transmitters. The next morning a line transect survey based on the position of the telemetered targets was developed and observers used standard pelagic seabird survey protocols (incorporating Distance Sampling) to record carcasses and blocks as the vessel steamed along the survey route. Two experienced observers conducted observations throughout the daylight period of 27 and 28 November, along with two members of the ship's crew, who served as trained, but inexperienced, observers.

Over 15.3 hours of observation time, experienced observers detected 65 carcasses and 24 blocks, while inexperienced observers detected 42 and 32, respectively. Based on distance sampling, experienced observers saw 53% of carcasses and blocks within survey transects (within 300 m of the vessel). Density of carcasses and blocks estimated from data from experienced observers was 1.80 (95% CI: 1.06-3.06) objects/km (corrected densities could not be calculated for inexperienced observers because they did not employ distance sampling). To determine the area where objects were drifting at the time of the surveys, we used minimum convex polygons based on positions of telemetered and observed blocks and carcasses. Based on that area (364 km^2), the total abundance 95% confidence intervals for blocks and gull carcasses included the true number deployed. However, this was not the case for alcids (murres, dovekies, puffins and razorbills), where the estimated total abundance (and 95% confidence interval) was less than the number of carcasses released.

In general, the blocks and carcasses drifted together over the 48 hours, in spite of high winds (45 knots) on the first day of the survey. Industry inexperienced observers generally performed well during the survey, and were able to employ distance sampling by the second day of the survey.

Overall, the experiment was successful. Our results suggest that observers can detect seabird carcasses on the open ocean, providing another potential tool to assess marine bird mortality in the case of on offshore oil spill. Further work could include understanding the relationship between the drift properties of seabird carcasses and oil itself, and more work to determine if the apparent low detections rates of alcids is pervasive under a range of survey conditions.

Sommaire

Il est difficile d’évaluer les effets et les impacts environnementaux des déversements de pétrole, même lorsqu’on évalue les impacts sur des prédateurs alpha très visibles comme les oiseaux marins. Le nombre de méthodes pour évaluer les effets et les impacts des déversements de pétrole sur les oiseaux marins est limité, et ces méthodes exigent de nombreuses présomptions, en particulier lorsqu’aucune donnée sur la situation avant le déversement n’est disponible. Dans les environnements extracôtiers, les méthodes sont encore plus restreintes, parce qu’il est impossible d’étudier des carcasses d’oiseau échouées.

Cette étude avait pour objet d’évaluer si les carcasses d’oiseaux marins peuvent être détectées pendant les levés normalisés par navire qui sont généralement réalisés pour estimer les densités d’oiseaux vivants. L’approche consistant à réaliser une expérience en mer en déployant un nombre connu de carcasses d’oiseaux de mer dans un secteur, puis d’effectuer un levé dans ce secteur pour estimer la densité des carcasses dans l’eau.

Avant de réaliser l’expérience, on avait besoin d’un moyen de suivre la dérive des carcasses pour garantir que le navire pouvait être dirigé vers le secteur où se trouvent réellement les carcasses. En novembre 2013, deux carcasses d’oiseaux marins et deux blocs dérivants ont été munis de transmetteurs satellite et mis à l’eau à cinq milles nautiques à l’est de Witless Bay, Terre-Neuve-et-Labrador. Le système satellite ARGOS a reçu des positions dans les 70 minutes suivant le déploiement, puis en moyenne toutes les 34 minutes par la suite. Les carcasses et les blocs dérivants ont dérivé de manière semblable, ce qui laisse croire que les blocs pourraient également servir de substitut utile aux carcasses. Ces résultats ont indiqué que le choix de méthode de fixation et de transmetteur satellite permettrait de suivre la dérive générale des carcasses pendant l’expérience principale.

L’expérience principale a été réalisée à bord du M/V Burin Sea, un navire de ravitaillement de 82 m. de l’industrie du pétrole et du gaz extracôtiers, et a commencé à environ 20 milles nautiques à l’est de Bay Bulls, Terre-Neuve-et-Labrador. L’expérience, d’une durée d’environ 48 heures, a commencé dans la soirée du 26 novembre 2016 par le déploiement de 680 carcasses d’oiseaux marins (issues de divers événements de mortalité) et de 312 blocs dérivants; de ces nombres, 7 mouettes, 8 guillemots, 7 mergules nains et 8 blocs dérivants ont été munis de transmetteurs satellite. Le matin suivant, un levé par recoupement fondé sur la position des cibles suivies par télémétrie a été réalisé et les observateurs ont utilisé des protocoles standard de levés pélagiques des oiseaux marins (y compris l’échantillonnage par distance) pour consigner les carcasses et les blocs trouvés à mesure que le navire suivait l’itinéraire du levé. Deux observateurs d’expérience ont réalisé les observations pendant les périodes de clarté du 27 et du 28 novembre, avec deux membres de l’équipage du navire faisant office d’observateurs formés, mais sans expérience.

Sur 15,3 heures de temps d’observation, les observateurs expérimentés ont détecté 65 carcasses et 24 blocs, alors que les observateurs sans expérience en ont détecté 42 et 32, respectivement. En fonction de l’échantillonnage par distance, les observateurs expérimentés ont vu 53 % des carcasses et des blocs dans le transect du levé (dans un rayon de 300 m du navire). La densité des carcasses et des blocs, estimée à partir des données des observateurs expérimentés, était de 1,80 (95 %, IC : 1,06-3,06) objet/km (on n’a pas pu calculer de densité corrigée pour les observateurs sans expérience parce qu’ils n’ont pas utilisé l’échantillonnage par distance). Afin de déterminer le secteur dans lequel les objets dérivaient au moment des levés, on a utilisé des polygones convexes minimum en fonction des positions des carcasses et des blocs suivis par télémétrie et observés. D’après ce secteur (364 km^2), les intervalles de confiance de 95 % pour l’abondance totale des carcasses de mouettes et des blocs correspondait au nombre véritable de carcasses et de blocs déployés. Ce n’était toutefois pas le cas pour les alcidés (guillemots, mergules nains, macareux et petits pingouins), pour lesquels l’abondance totale (et l’intervalle de confiance de 95 %) était inférieur au nombre de carcasses déployées.

En général, les carcasses et les blocs ont dérivé ensemble sur les 48 heures, malgré de forts vents (45 nœuds) le premier jour du levé. Les observateurs de l’industrie sans expérience ont généralement offert un bon rendement pendant le levé et ont pu utiliser l’échantillonnage par distance le second jour du levé.

Dans l’ensemble, l’expérience a été couronnée de succès. Nos résultats laissent croire que les observateurs peuvent détecter les carcasses d’oiseaux marins morts en pleine mer, ce qui offre un autre outil potentiel pour évaluer la mortalité des oiseaux marins en cas de déversement de pétrole extracôtier. On pourrait, dans le cadre d’autres travaux, tenter de comprendre la relation entre les propriétés de dérive des carcasses d’oiseaux marins et du pétrole lui-même de même que déterminer si les taux de détection apparemment bas pour les alcidés sont les mêmes dans un éventail de conditions de levés.

2 Introduction

The western North Atlantic ocean is an important breeding area and wintering site for millions of marine birds (Fifield et al. 2009, 2016). They nest in well-known globally significant seabird colonies throughout the western North Atlantic (Tuck 1961, Montevecchi and Tuck 1987, Gaston et al. 2012), but the global significance of these cold productive waters of for non-breeding birds is only beginning to be understood. For example, tracking studies are showing massive movements of birds from northern European colonies to western North Atlantic waters for the non-breeding period (Frederiksen et al. 2012, 2016; Fort et al. 2013, Jessop et al. 2013).

Marine birds using the western North Atlantic face a variety of threats and pressures, notably risks of incidental capture in industrial fisheries (Hedd et al. 2015), legal harvests in Canada and Greenland (Merkel and Barry 2008), and exposure to chronic, ship-source oil pollution (Wiese and Robertson 2004). Significant shifts in the western North Atlantic ecosystem have also occurred, effecting the primary prey of many seabirds (Buren et al. 2014).

Specific to oil pollution, the numbers of seabirds killed from chronic ship-source oil pollution has declined dramatically in recent years (Wilhelm et al. 2009, Robertson et al. 2014). However, the risk of accidental catastrophic spills remains, and these events are responsible for the mortality of thousands of seabirds every year (Page et al. 1990, Piatt et al. 1990, Piatt and Ford 1996, Camphuysen 1998, Cadiou et al. 2004, Robertson et al. 2006, Castege et al. 2007, Munilla et al. 2011). Although rare, accidental releases from oil exploration and production platforms do occur and place a further pressure on seabird populations (Wilhelm et al. 2007, Haney et al. 2014).

A major part of any oil spill damage assessment is estimating the numbers of animals, including seabirds, directly killed by the incident. Beached bird surveys have historically been the most common method used to assess the amount of seabird mortality during an oil spill event (Page et al. 1990, Van Pelt and Piatt 1995, Flint et al. 1999, Wiese 2003, Wiese and Robertson 2004, Ford 2006, Castege et al. 2007). However, actual mortality rates are often underestimated (Castege et al. 2007) due to scavenging from other animals (Van Pelt and Piatt 1995), inaccessibility of coastal sites (Flint et al. 1999), poor searcher effort and efficiency (Ford 2006), and the change in frequency and speed of onshore winds (Flint and Fowler 1998, Wiese and Ryan 2003).

In the offshore environment (or near shore environments where the probability of beach-cast birds is reduced by strong currents or offshore winds), seabird mortality can be estimated from a baseline density of seabirds in the area of an oil slick over the duration of the spill (Wilhelm et al. 2007, Haney et al. 2014). When season-specific at-sea seabird density data are lacking or outdated (Wilhelm et al. 2007) mortality can be estimated by conducting ship-based and aerial seabird surveys (Piatt et al. 1990, Hyrenbach et al. 2001). During marine surveys, seabird detectability is critical for accurately assessing at-sea densities and in turn, robust population estimates. Seabirds can be difficult to detect for a variety of reasons, including relative body size, aggregation of foraging groups, sea state and weather, the relative experience of observers, and the type of vessel used for observations (Tasker et al. 1984, Hyrenbach et al. 2007, Ronconi and Burger 2009). Further complications arise for accurate assessments when the seabirds are dead or moribund, as they are potentially darkened with oil and not conspicuous. Seabird carcases also lose buoyancy over time and therefore will sink and become undetected after several days. The increased loss of buoyancy is exacerbated when the carcasses are scavenged by other animals (Wiese 2003).

Distance sampling, which corrects for the probability of detecting seabirds within survey transects, can resolve some of these issues (Buckland et al. 2001, Fifield et al. 2009, Gjerdrum et al. 2012). Correction factors that account for imperfect detectability are obtained with these methods, and would further advance the accuracy of impact assessments of marine oiling events.

Several experimental approaches have been used previously to assess the detection rates of oiled seabirds. Drift blocks, as a proxy for oiled and dead seabirds, have been released at sea and beach, aerial, or ship surveys, along with drift modelling applications (or a combination thereof) have been used successfully, but with limitations (Hlady and Burger 1993, Flint and Fowler 1998, Wiese and Jones 2001, Munilla et al. 2011). Using actual seabird carcasses for drift experiments has also been used in combination with mark-recapture (Castege et al. 2007) and drift modeling (Munilla et al. 2011). The limitation with these previous experiments is that drift blocks and/or carcasses were only detected when they were found on beaches and provided very limited information on drift trajectory.

The original concept for this study was to determine what proportions of seabirds were visible from a support vessel under various conditions. However, as the project unfolded, it became apparent that distance sampling could improve on that concept and should be applied during surveys at the time of any release. Therefore, the study scope was broadened to assess the validity of distance sampling to quantify the proportion of dead birds detected and allow for the corrected densities of dead seabirds on the water to be estimated at the time of an actual spill.

3 Objectives

As stated in the MOU, the objective of this study was to design and conduct an experiment to determine the number of dead seabird carcasses and drift blocks that are visually detectable in the open ocean by both experienced and inexperienced observers in relation to a known number of these objects previously deployed in the same area.

3.1 Phase I Objectives

1. Determine how long satellite transmitters on deployed objects will effectively transmit;

2. Determine if drift blocks and seabird carcasses drift together.

3.2 Phase II Objectives

1. Determine the proportion of objects detectable by visual observation from a known number that were released;

2. Evaluate the Eastern Canada Seabird At Sea (ECSAS) protocol (which employs Distance Sampling) for dead seabirds, as it previously has only been used to gather density data on live seabirds;

3. Compare the number of objects detected by experienced observers using the ECSAS protocol compared to the inexperienced observers using the Oil Spill Response plan protocol;

4. Develop a correction factor that depends on influences of detectability that can be applied to estimating the mortality rate of seabirds during an oil spill;

5. Use telemetry data to determine drift characteristics (dispersal rate, trajectories) of tagged drift blocks and seabird carcasses that would provide valuable information to government and industry for future response and planning.

As indicated above, objective 4 of phase 3.2 was broadened over the course of the study to develop and test a method of obtaining these correction factors at the time of an incident.

4 Phase I: Proof of Concept

Before conducting the full scale experiment, it was important to ensure that any telemetry deployed would be effective, providing accurate and timely positions so that a survey grid could be developed while at sea. The details of that experiment are presented in Appendix A, and are briefly summarized here.

On 23 November 2013, 2 murre carcasses and 2 drift blocks were outfitted with a satellite transmitter from KiwiSat, and deployed about 5 miles east of Witless Bay, Newfoundland and Labrador. Positions were first received 70 minutes after deployment, and continued to be received every 34 minutes, on average. The quality of the locations transmitted (accurate to within 350 m) was sufficient to effectively track the drift of the 2 carcasses and 2 drift blocks. Given the success of this trial, we proceeded to use these transmitters and attachment methods for the main experiment.

5 Phase II: Full Experiment

5.1 Methods

5.1.1 Study Area and Vessel

The experiment was conducted onboard the *M/V Burin Sea*, an 82 metre offshore oil and gas industry supply vessel (supplied by Suncor). The experiment started about 20 nautical miles east of Bay Bulls, Newfoundland and Labrador (Figure 1) and ran for approximately 48 hours, starting on the evening of 26 November 2016.

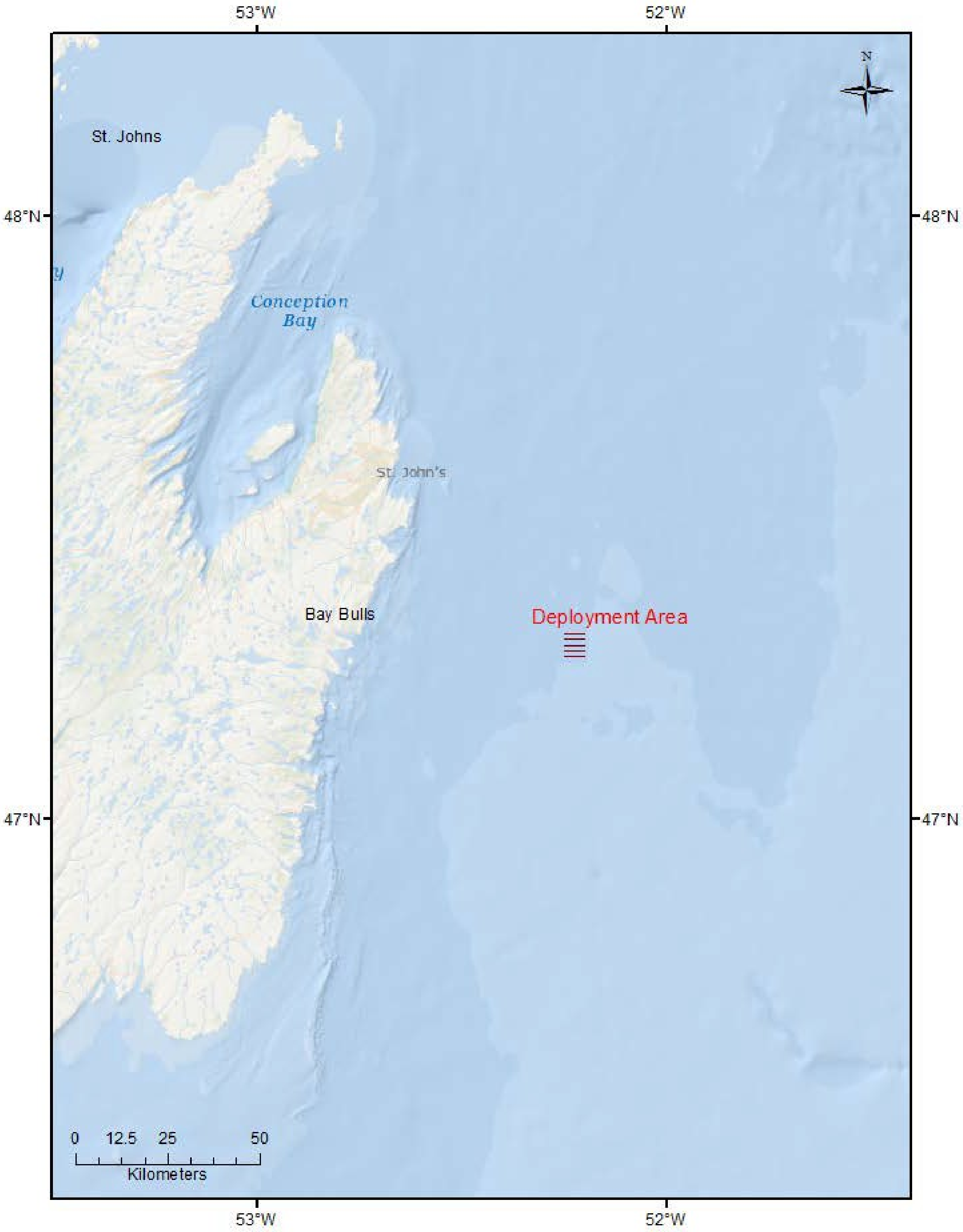


Figure 1. Phase II study area showing deployment area for seabird carcasses and drift blocks.

5.1.2 Drift Block and Seabird Carcass Deployment

A total of 680 bird carcasses (Table 1) and 312 drift blocks (weighted so that they would float like dead seabirds; Wiese and Jones 2001), were deployed along five lines on a 6 km x 6 km grid between 18:19 and 19:56 NST on 26 November 2016 (Figure 2; Figure 3). These were deployed so that the gulls, alcids, and blocks were distributed evenly along each line at a rate of roughly one every 10 s as the vessel proceeded at a speed of roughly 10.5 kn. The size of the deployment area was chosen, based on the drift rate and spacing between objects during the Phase I trial, so that the objects would likely be neither too clumped nor too spread out on the following morning to allow for adequate survey coverage. The drift blocks included an information plate that contained the block identification number and contact information, in case the block was found on a beach subsequent to deployment.

Table 1. Numbers of carcasses deployed by species.

Species	Scientific name	Number
Alcids		
murres	*Uria spp.*	66
razorbill	*Alca torda*	27
Atlantic puffin	*Fratercula arctica*	86
dovekie	*Alle alle*	98
Sub-total		277
Gulls		
herring gull	*Larus argentatus*	283
great black-backed gull	*Larus marinus*	88
glaucous gull	*Larus hyperboreus*	4
Iceland gull	*Larus glaucoides*	14
black-legged kittiwake	*Rissa tridactyla*	14
Sub-total		403
Total		680

Seabird carcasses used in this experiment were obtained from a variety of mortality events and were kept frozen until they were needed for this experiment (in accordance with the Canadian Wildlife Service permit (SS2803) issued under section 19 of the Migratory Birds Regulations for obtaining dead migratory birds for research purposes).

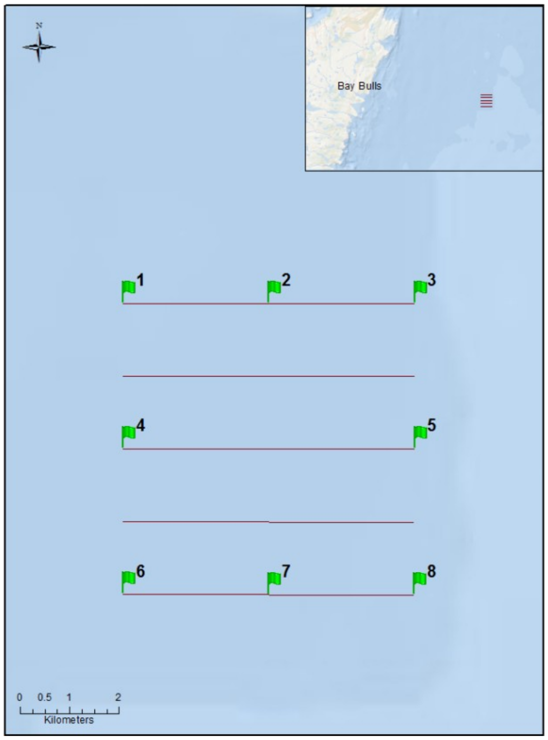


Figure 2. Deployment lines (on 6 km x 6 km grid) where 680 seabird carcasses and 312 drift blocks were deployment on 26 November 2017. Coordinates of NW corner of grid (flag marked "1") are 47.308° N, 52.250° W.

Figure 3. Drift blocks and carcasses being deployed with the help of the crew on the *M/V Burin Sea* on 26 November 2016 (*Photo: Jeannine Winkel*).

5.1.3 Satellite Transmitters

In order to define the "search area of interest" (i.e., the slick) for this mock oil-spill experiment, we deployed SirTrack KiwiSat 202 satellite transmitters (see Figure A-7 in Appendix A) on 30 objects (7 herring gulls, 8 common murres, 7 dovekies and 8 drift blocks) to track their movement. These were deployed around the perimeter of the deployment area at the locations marked “1” through “8” in Figure 2, with one object of each type at each location (except location #2 which only had 1 drift block and 1 common murre).

Satellite transmitters were programmed to transmit once every minute. The actual number and timing of satellite tag locations received was dependent upon the timing and geometry of satellite over-passes.

5.1.4 Observation Experiment

5.1.4.1 Line Transect Survey and Route

Before dawn on the morning of 27 November 2016, a line transect survey based on the most recent positions of the satellite-tagged objects was developed using Distance 6.2 Release 1 (Thomas et al. 2010). This consisted of a series of parallel North-South survey line transects separated by 600 meters. The survey layout was designed to cover the rectangular bounding box surrounding the satellite tag locations plus a buffer of 10% of the longest dimension of the bounding box.

5.1.4.2 Observers and Survey Protocol

Both experienced and inexperienced observers simultaneously conducted observations throughout the daylight period of 27 and 28 November. Four experienced observers who took approximately 2-hour shifts during the two day period (2 observers on duty at a time) were positioned indoors on the port and starboard rear bridge wings. These observers used line-transect methods (Buckland et al. 2001), which uses Distance Sampling to assign each observation to one of four perpendicular distance classes within 300 m (Fifield et al. 2009). This information is subsequently used to correct for imperfect detection (see Results). This protocol (Gjerdrum et al. 2012; Appendix B) is regularly used for Environment and Climate Change Canada’s Eastern Canada Seabirds at Sea (ECSAS) monitoring program and these observers had extensive experience using this protocol.

Figure 4. Experienced observer positioned on the port bridge wing aboard M/V Burin Sea (*Photo: Megan Boucher*).

There were 6 inexperienced observers who took shifts during the two day period typically with 1 or 2 positioned on each side indoors and forward on the port and starboard sides of the bridge. Inexperienced observers were members of the ship's crew and had various levels of familiarization with seabirds (e.g., hunters, novice). All were trained using Suncor's oil spill response protocol for surveying pelagic seabirds (Appendix C), which uses a strip-transect method to count all birds detected within 300 m. Strip-transect methods assume that all birds within the survey strip are detected with certainty and cannot correct for imperfect detection. On the second day of observation, inexperienced observers categorized observations into the same perpendicular distance classes that were used by experienced observers.

An additional experienced seabird observer, who was not actively collecting observations, was also on the bridge to liaise with the captain and inexperienced observers, provide protocol and seabird identification guidance, and confirm data collection quality.

All data were recorded into the ECSAS database (version 3.51) directly by the experienced observers, and were recorded on survey sheets (Appendix B) by inexperienced observers, which were later transcribed to the ECSAS database.

5.1.5 Statistical and Spatial Analyses

The number of detections of drift blocks and carcasses (separated into alcids and gulls) were tabulated for experienced and inexperienced observers. Chi-square tests (or Fisher's Exact Test when cell counts were small) compared the relative proportion of detected blocks, alcids, and gulls versus expectation (based on the number deployed), and for differences between experienced and inexperienced observers. Data manipulation analysis was conducted using R 3.3.2 (R Core Team 2016).

Distance sampling analysis of data collected by experienced observers was used to estimate object detection probability by fitting candidate detection function models using the R Distance 0.9.6 package (Miller 2016). See Buckland et al. (2001) and Fifield et al. (2016) for an explanation of fitting detection functions. Inexperienced observers used a strip-transect method (with no distance sampling) so detection probability was assumed to be 1. Candidate detection function models were compared and a best model was chosen using Akaike information criterion (AIC). Overall goodness of fit of the detection function model was judged by χ^2 goodness-of-fit tests and visual inspection of detection function fit to the histogram of observed distances (Buckland et al. 2001). Daily and overall density estimates for drift blocks, alcids and gulls were then computed with the R package mrds 2.1.17 (Laake et al. 2016) using the chosen best detection function model for experienced observer data and assuming perfect detection for inexperienced observers. Abundance estimates for each object type and observer experience level were computed by multiplying the appropriate density estimate with the approximate area covered by the drift blocks and carcasses.

For drift blocks subsequently found on beaches by members of the public, the number, location and date were recorded. Maps of survey routes, object detections, tracks of satellite-tagged objects, and locations of beach-cast un-tagged blocks were produced using ArcGIS 10.2.2.

5.2 Results

Pre-dawn satellite telemetry on the morning of 27 November 2016 (hereafter "day 1") indicated that the satellite-tagged objects were clustered in an area to the southwest of the deployment zone covering an area similar to that in which they were deployed (Figure 5). Based on this telemetry, a survey grid was created and surveys began at 07:38 NST with blocks and carcasses being detected almost immediately (Figure 6). The wind speed increased steadily throughout the day from the southeast and east reaching more than 45 kn by the end of the survey period and requiring slower vessel speeds as the day progressed. This caused fewer and fewer birds to be available for detection on the south-east portion of the survey grid with the last detection occurring at 11:16 NST (Figure 6). After finishing the initial survey grid, we attempted to re-find the deployed objects by downloading updated satellite tag positions and designing a new survey grid. We ran the first pass through this grid in an east-west direction but detected no birds (Figure 6). Subsequently, we continued searching an east-west direction in an attempt to catch up with the fast-moving wind-driven birds until discontinuing surveys at 16:00 NST having covered 96.2 km of survey track at a mean survey speed of 7.6 kn (range: 5.8 – 10.5 kn). At this point, the satellite-tagged objects ranged from roughly 10 km to 25 km from their start locations that morning (Figure 5).

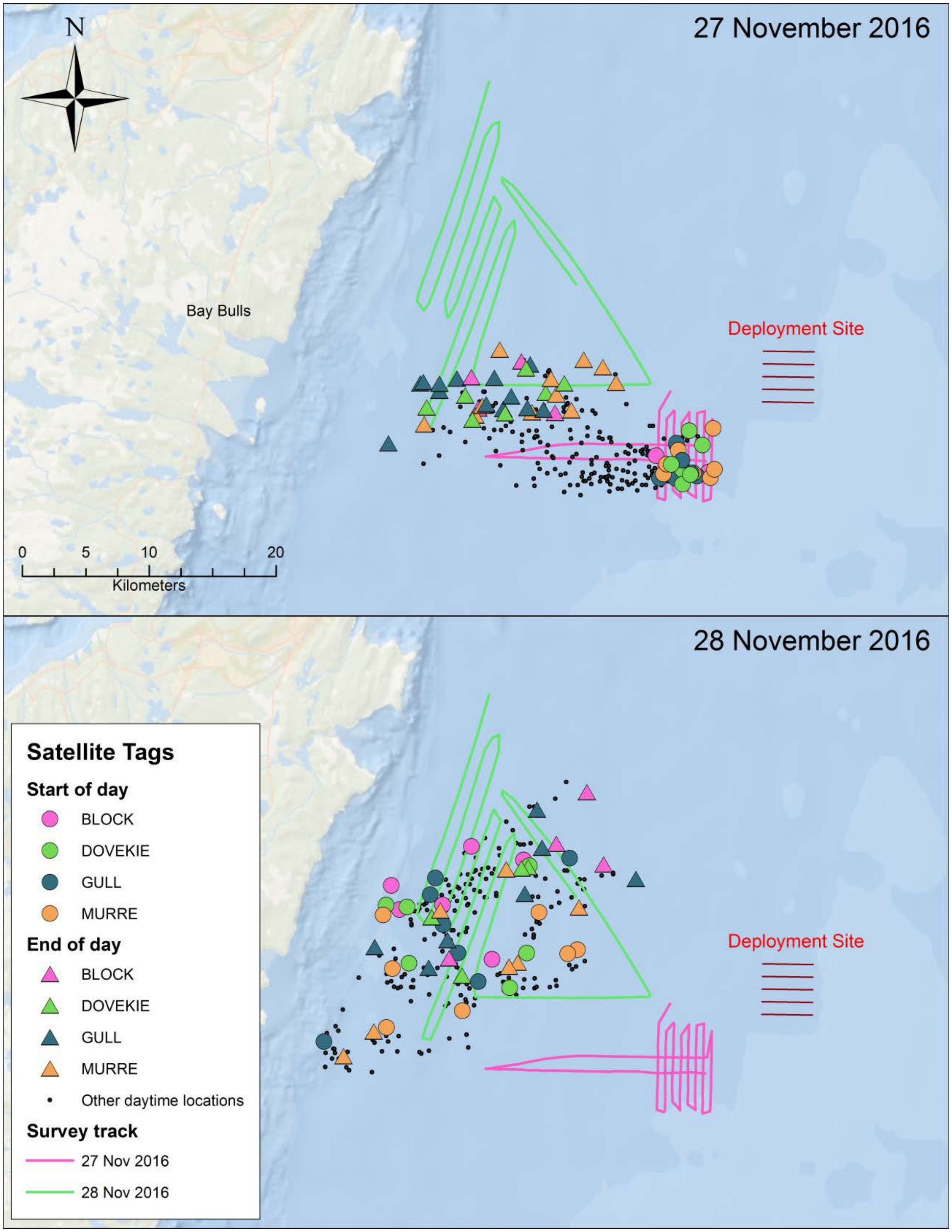


Figure 5. Daily start and end locations of satellite tracked carcasses and blocks and daily vessel survey track.

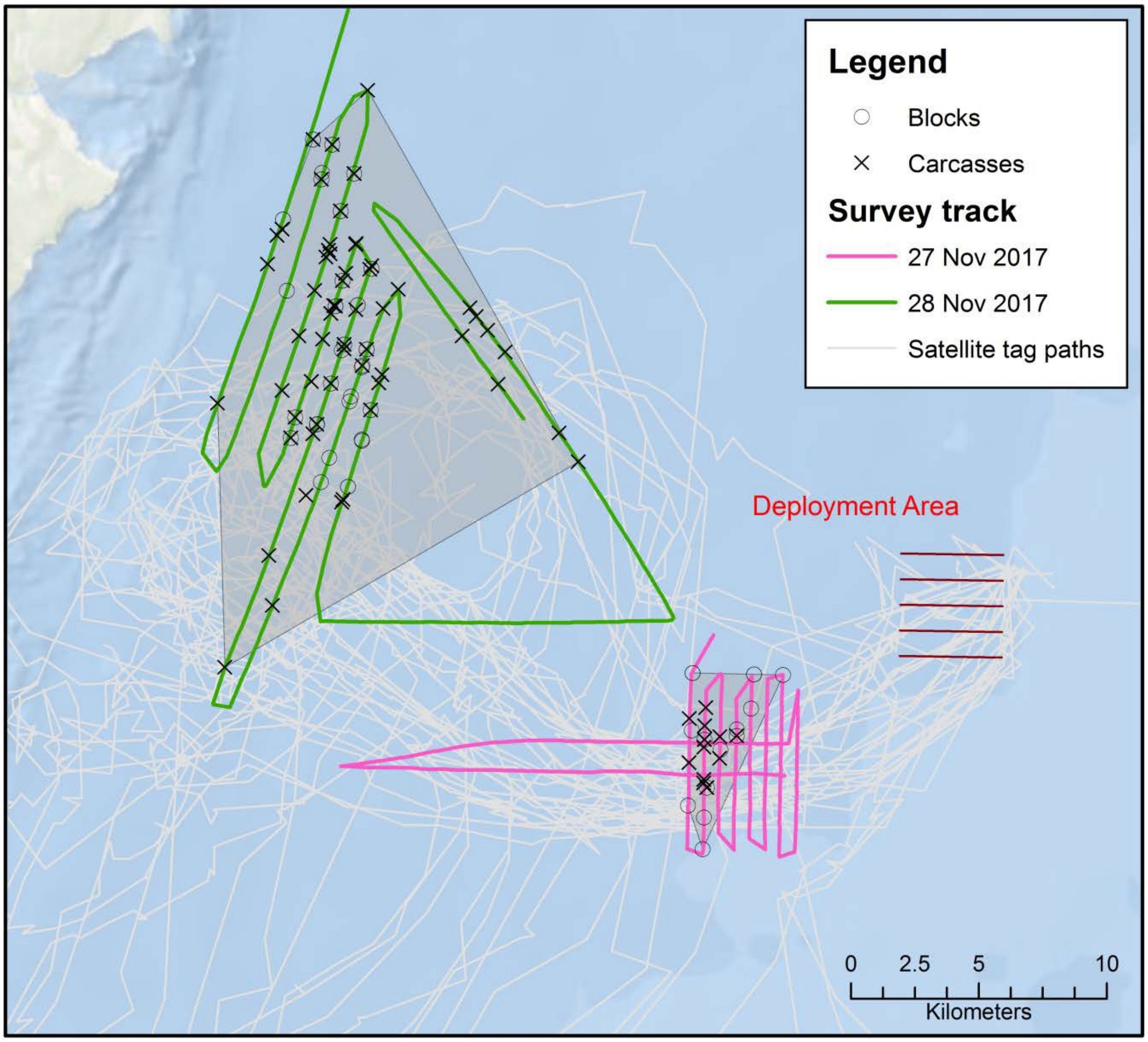


Figure 6. Observations of drift blocks (open circles) and carcasses (crosses) on survey tracks on 27 (pink) and 28 (green) November 2016. Grey polygons delimit survey effort used for density estimation (see Section 5.2.2.2). White lines show the path of satellite-tagged birds and blocks.

On the evening of day 1 we discussed with the captain the likely location that the drift blocks and carcasses might drift to by the next morning given the current and forecasted winds, and planned to be in that general vicinity by morning. The captain and crew took it upon themselves to search with spot lights throughout the night and were able to find drift blocks and carcasses starting around midnight. They then kept the ship with the floating objects until daylight thereby providing an excellent position from which to start surveys the next morning.

By the morning of day 2 the drift blocks and carcasses had spread out over a much larger area than the previous day (Figure 5). By this time the wind had subsided to around 25 kn and further decreased to around 20 kn by the end of the day. Once new satellite telemetry was received, we began surveys at 06:58 NST and attempted to delineate the eastern and southern boundary of the objects and then conducted survey transects systematically through the occupied area for the rest of the day, finishing at 16:50 NST having covered 123.8 km at a mean speed of 8.4 kn (range: 6.5 – 12.3 kn).

5.2.1 Object Detections

Experienced observers detected 89 objects (65 carcasses and 24 drift blocks; Figure 7), while inexperienced observers detected 74 objects (42 carcasses and 32 drift blocks; Figure 6; Table 2). There was weak evidence for a difference in the proportion of carcasses versus drift blocks detected by experienced versus inexperienced observers ($\chi 2 = 4.05$, df = 1, $P = 0.04$). However there was no strong evidence that this proportion differed from deployment proportions for either experienced ($\chi 2 = 0.57$, df = 1, $P = 0.45$) or inexperienced ($\chi 2 = 3.86$, df = 1, $P = 0.05$) observers. Likewise, there was no evidence for a difference between experienced and inexperienced observers in the number of alcids versus gulls detected (Fisher's exact: $p = 0.53$). However, the observed proportion of detected alcids versus gulls was less than deployed proportions for both experienced ($\chi 2 = 19.11$, df = 1, $P < 0.0001$) and inexperienced ($\chi 2 = 15.58$, df = 1, $P < 0.0001$) observers.

Figure 7. Detected drift block (top) and herring gull (*Larus argentatus*, bottom; *Photo: Jeannine Winkel*).

Table 2. Numbers of drift blocks and carcasses deployed and detected by observer experience and species group.

	Deployed	Observed	
		Inexperienced	Experienced
Drift Blocks	312	32	24
Carcasses			
Alcids	277	3	8
Gulls	403	36	57
Carcass sub-total	680	42[1]	65
Total	992	74	89[2]

[1] Includes 3 observations of unidentified birds.

[2] One detection was beyond the edge of the 300 m transect and was not included in detection function fitting.

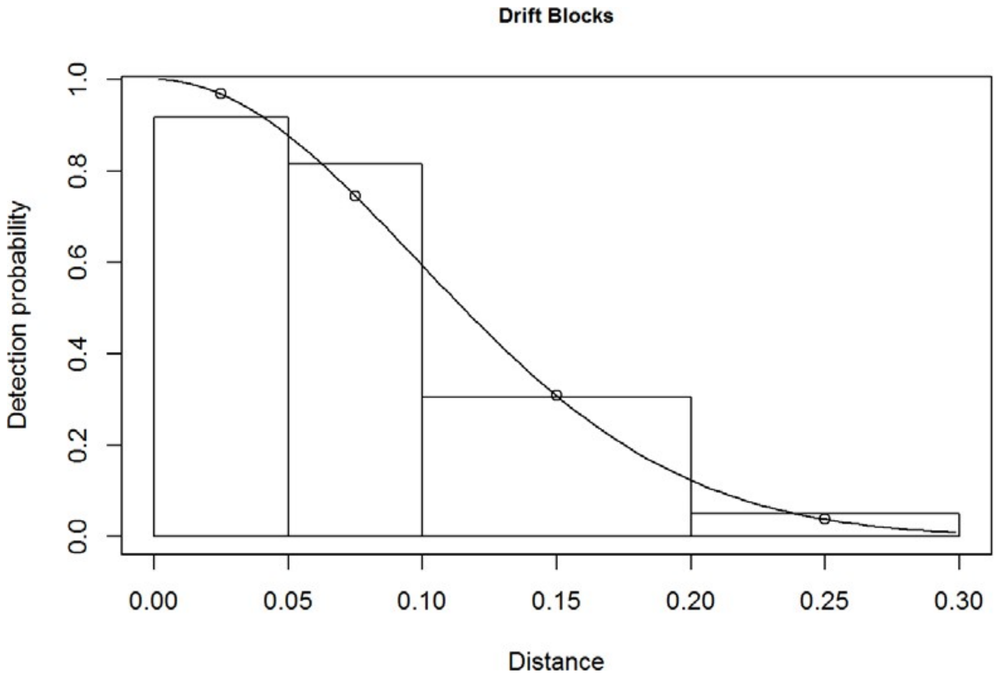
5.2.2 Detection Probability, Density and Abundance

5.2.2.1 Detection Probability

The ability to include numerous covariates thought to affect object detection probability in detection function models was limited by the relatively small number of detections of each object type (alcids, gulls, and drift blocks; Table 2). The list of candidate detection function models was therefore restricted to 1) a uniform key function with cosine adjustment terms, and

2) both half-normal and hazard-rate key functions with a covariate for "object type" (carcasses vs drift blocks; Marques et al. 2007) thus accounting for the difference in detectability between these two object types. There was not enough data to fit models that accounted for differing detection probabilities between alcids and gulls due to the small number of alcid detections (n = 8). Likewise, models including covariates for wind speed and wave height failed to fit.

The model with a half-normal key function and covariate for object type (birds versus blocks) was chosen as the best model of detection probability (Figure 8). For both carcasses and drift blocks, the probability of detection decreased with increasing distance of the object from the observer. The overall average object detection probability was 0.53 (Coefficient of variation: 9.2%) for all objects combined indicating that failure to use a distance sampling-based protocol would have underestimated the number of objects by nearly half. For drift blocks, detection probability decreased more quickly with distance from the observer than for the carcasses (Figure 8), with point estimates for average detection probability of 0.41 and 0.60, respectively. Other candidate models not chosen as the “best” model had similar average detection probabilities indicating that choice among candidate models was not critical.



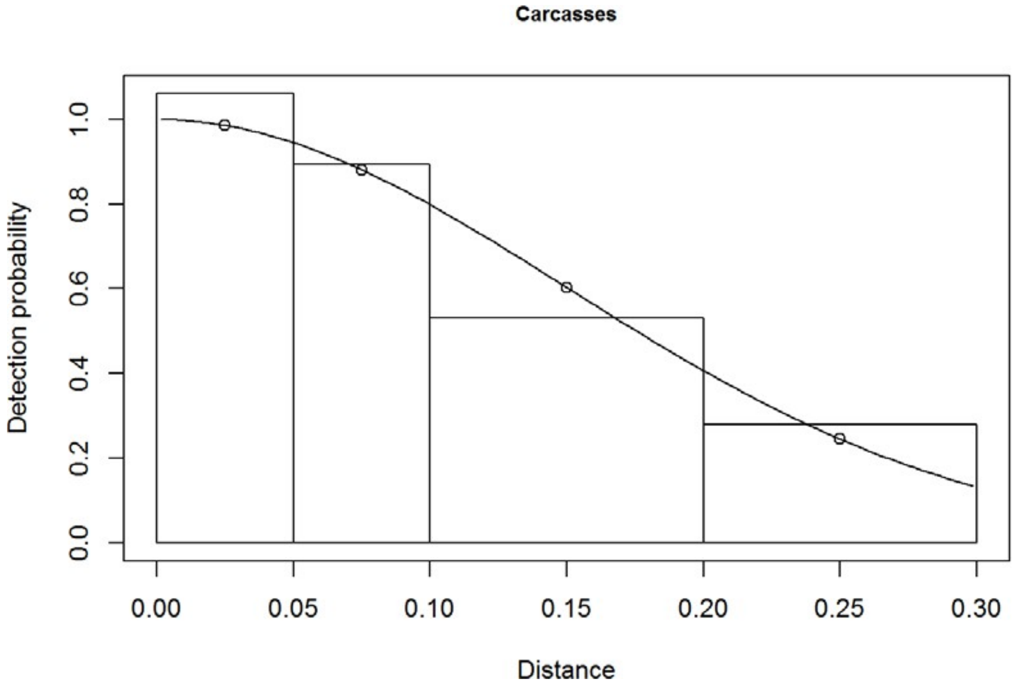


Figure 8. Histogram of perpendicular distances (km) to detected blocks and carcasses and fitted detection probability curves based on a half-normal key function showing decreasing detection probability with distance from the observer.

5.2.2.2 Density Estimates

High winds, particularly on day 1, made it difficult to complete the survey grid before drift blocks and carcasses had blown out of the area. This resulted in sections of survey effort where no drift blocks or carcasses were detected because they were not available for detection (Figure 6). These areas were considered "unsuitable habitat" and including survey effort there for the purpose of density estimation would artificially bias density estimates low. Therefore, only survey effort expended within the daily polygons surrounding observations of blocks and carcases (Figure 6) was included for density estimation giving survey effort of 29.1 km and 123.8 km on day 1 and day 2 respectively.

Density estimates (Table 3) were higher on day 1 than on day 2 reflecting the fact that detections on day 1 occurred when objects were still fairly tightly clumped compared to day 2 when the objects had spread out over a larger area. Overall density estimates for both days combined (average of daily estimates weighted by daily survey effort) were 0.63 blocks·km^{-2}, 0.14 alcid carcasses·km^{-2}, and 1.04 gull carcasses·km^{-2}, giving a total object density of 1.80 objects·km^{-2}.

Table 3. Density estimates (95% CI) by object type and day for distance sampling data collected by experienced observers. Overall estimates are an average of day 1 and day 2 estimates weighted by survey effort on each day (29.1 km and 123.8 km, respectively).

		Day 1	Day 2	Overall
Experienced Observers				
Blocks		0.70 (0.33 - 1.51)	0.63 (0.33 - 1.20)	0.63 (0.33 - 1.20)
Carcasses				
	Alcids	0.19 (0.05 - 0.67)	0.14 (0.05 - 0.34)	0.14 (0.05 - 0.34)
	Gulls	0.96 (0.33 – 2.79)	1.04 (0.48 – 2.23)	1.04 (0.48 – 2.23)
Combined		1.85 (0.84 - 4.10)	1.80 (1.10 – 3.10)	1.80 (1.06 – 3.06)
Inexperienced Observers				
Blocks		0.68 (0.37 – 1.27)	0.27 (0.15 – 0.47)	0.35 (0.25 – 0.53)
Carcasses				
	Alcids	0.06 (0.01 – 0.45)	0.03 (0.00 – 0.19)	0.03 (0.01 – 0.13)
	Gulls	0.23 (0.03 – 1.53)	0.43 (0.19 – 0.98)	0.39 (0.20 – 0.78)
Combined		0.97 (0.53 – 1.79)	0.77 (0.47 – 1.26)	0.80 (0.56 – 1.18)

5.2.2.3 Abundance Estimates

Abundance estimates computed as the product of densities in Table 3 and the affected “spill area” are presented in Table 4. The spill area was estimated to be 364 km^2, which was the area encompassing all satellite tag and visual observations on day 2. It was not possible to choose an appropriate area over which to apply density estimates on day 1 (see Discussion). With the exception of the alcids, the point estimates of object abundance were broadly similar to the corresponding number of deployed objects (especially for gulls), and the 95% confidence interval included the number deployed for the gulls, blocks and for the overall object total (Table 4).

Note that the abundance estimates for inexperienced observers were lower than those for experienced observers since the observation protocol used by inexperienced observers did not allow for the application of distance sampling to correct for imperfect detection.

Table 4. Numbers of objects deployed and estimated object abundances (95% CI) by object type and observer experience using densities from day 2 (see Table 3) and an affected area of 364 km^2.

		Abundance (experienced observers)	Abundance (inexperienced observers	Objects Deployed
Blocks		228 (120 - 436)	98 (56 – 173)	312
Carcasses				
	Alcids	49 (19 - 125)	10 (1 – 69)	277
	Gulls	378 (176 - 813)	157 (69 – 356)	403
Total		656 (386 - 1115)	279 (170 – 458)	992

5.2.3 Drift Block and Carcass Movement and Satellite Tracking

During the two days of surveys, drift blocks and carcasses with and without satellite tags drifted in a similar fashion (Figure 5).

Satellite tags continued to function for an average of 16 days, (range: 0 – 37 days). Tagged drift blocks and carcasses drifted south along the east coast of the Avalon Peninsula and then westward (Figure 9). The paths of tags diverged when they reached the vicinity of the NE Green Bank: the more southerly of the tags continued south and then southeast along the southern Grand Bank while the more northerly tags drifted into Placentia and St. Mary's Bays. There was no discernible difference in movement path and final locations between each type of tagged object indicating that all bird species and drift blocks moved in a similar fashion.

Four satellite-tagged objects (two gulls and two drift blocks) eventually became stranded on beaches in Placentia Bay and St. Mary's Bay between 16 December 2016 and 4 January 2017 (Figure 9). The gull near Argentia was subsequently recovered by ECCC staff. Likewise, 14 untagged blocks from this experiment were picked up by members of the public between 20 December 2016 and 1 April 2017 on beaches around the southern Avalon and Placentia Bay (Figure 9). The overlap in the location of these drift blocks with the locations of satellite-tagged carcasses and drift blocks indicates that the untagged drift blocks continued to drift similarly to the satellite-tagged carcasses and drift blocks more than a month after deployment.

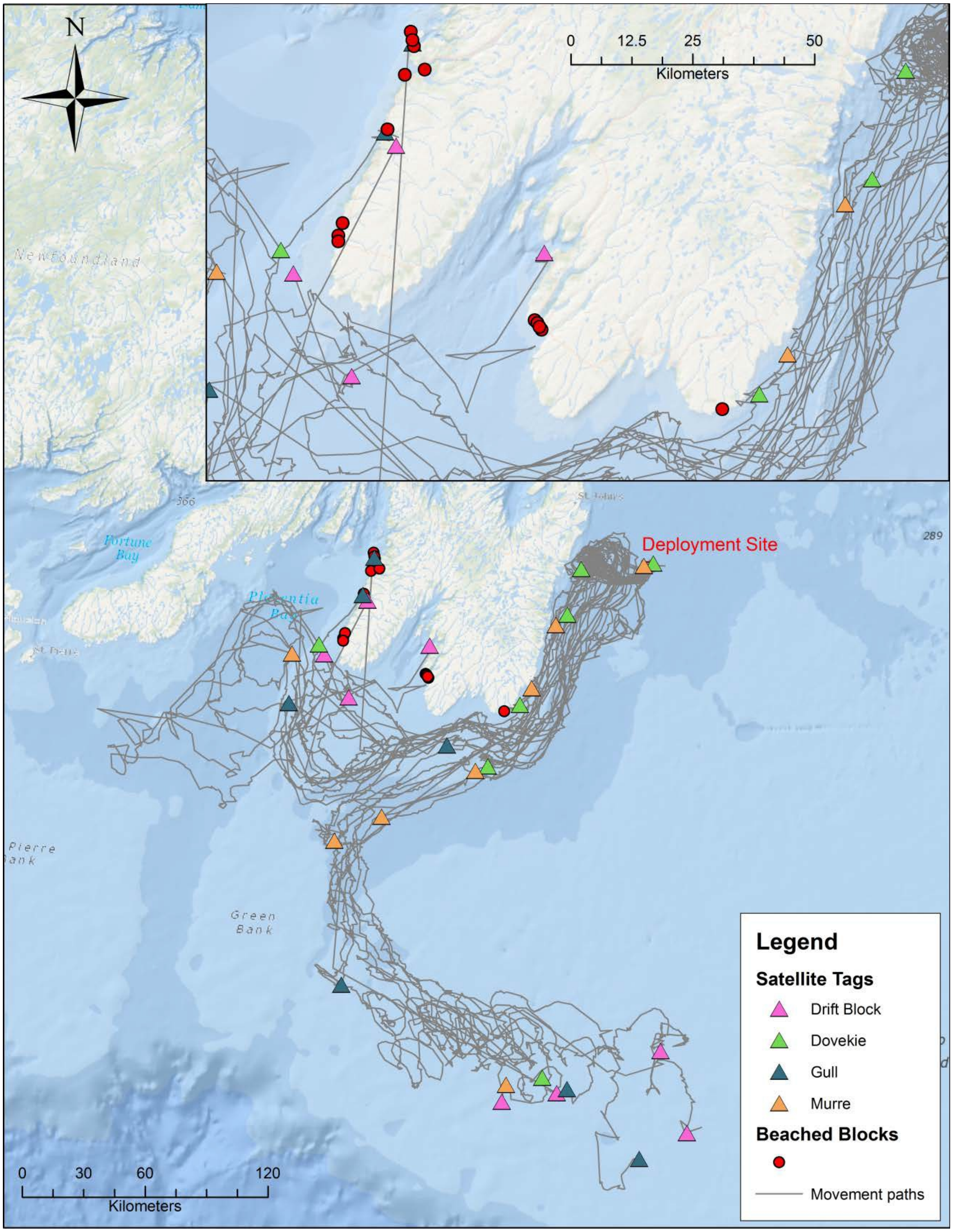


Figure 9. Movement paths of satellite-tagged carcasses and drift blocks showing final transmitted locations, 26 Nov 2016 to 3 Jan 2017, and locations of beached blocks reported by members of the public 20 Dec 2016 to 1 Apr 2017.

6 Discussion

The experiment was successful in simulating a mock oil spill event involving a large number (hundreds) of dead seabirds. The experiment was carried out under challenging weather conditions, with winds sometimes exceeding 45 knots, but conditions that could easily be encountered in a real spill event in the Grand Banks production area. Our results suggest that observers, both inexperienced and experienced, can effectively detect seabird carcasses on the open ocean. The experimental design was successful in producing detection data from which scientifically defensible density estimates of dead seabirds can be produced, and provides another tool to assess marine bird mortality in the case of an offshore oil spill. Although not the focus of our experiment, our results also corroborate the effectiveness of the Wiese and Jones (2001) drift block in mimicking the drift of seabird carcasses.

6.1 Object Detectability, Density and Abundance

6.1.1 Object Detection

The experiment was successful in producing enough detections of objects (with accompanying distance measurements) within the 300 m transect (n = 88) to estimate a detection function and thus density and abundance. A typical rule of thumb in distance sampling is that a study should aim to have at least a minimum of 70 detections (but preferably many more) to estimate a detection function (Buckland et al. 2001). Given this, the large number of carcasses and drift blocks deployed in this experiment was certainly warranted and was probably a minimum given the conditions. The overall object detection probability was 0.53, indicating that failure to use distance methods would have underestimated abundance by nearly half. It is important to note that the 53% detection probability is situation-dependent and cannot simply be applied to future situations. This is because detection probability depends on a number of factors including weather conditions, differing observer skill/fatigue, visibility offered by the survey vessel, height of the observer above the water surface, among other unmeasured/unmeasurable variables (Buckland et al. 2001). However, when distance sampling is employed, these factors are accounted for and a defensible detection probability is the result. Therefore it is extremely important that any attempt to estimate seabird mortality during a real spill event should include distance sampling methodology. Failing to do so could vastly underestimate seabird mortality.

Raw detection results (uncorrected for imperfect detection) indicated that experienced and inexperienced observers generally did not differ in rates of detection of the various types of objects although there was weak evidence that inexperienced observers may have detected more drift blocks. Inexperienced observers were placed on each side of the bridge at the front of the vessel with a full view of the oncoming ocean surface from the ship centreline to the far edge of the survey transect. Experienced observers were placed further back on overhanging bridge wings where the superstructure of the vessel obscured their view towards the centreline of the vessel (Figure 4). Therefore the inexperienced observers transect extended from the vessel centerline to 300 m, whereas the experienced observers transect started at the starboard import edges of the vessel thereby giving inexperienced observers a larger search area in which to identify objects (although the difference was likely small, around 8 m given the beam of the Burin Sea is 16 m). Also, inexperienced observers typically worked in teams of two (although not always) and had assistance from the officer of the watch stationed in the center of the vessel who enthusiastically assisted with object detection. Nonetheless, these differences did not result in a greater number of carcasses being detected by inexperienced observers and are likely negligible. These results indicate that supply vessel crews are a valuable resource for estimating seabird mortality during a spill event and their ongoing preparedness training for such an event is strongly recommended.

6.1.2 Density

The overall observation rate and estimated density (Table 2, Table 3) of alcids was lower than expected given the relative number of alcids deployed. Several factors likely contributed to this low estimated alcid density.

Firstly, alcids are generally smaller and more darkly colored than the gulls so it might be expected that fewer of them would be detected in comparison with gulls. However, because of the small number of alcids detected, it was not possible to estimate separate detection probabilities for gulls and alcids; thus, an overall detection probability of 0.60 was applied to all carcass observations despite this number being more influenced by gull detections. In previous analyses of at-sea survey data (Fifield et al. 2009), detection probabilities of live alcids floating on the surface was 0.44 (95% CI: 0.34 – 0.57, D. Fifield unpub.). Detection probabilities of dead carcasses would almost certainly be lower than this.

Secondly, given the small size of the alcids (particularly dovekies which made up more than a third of the alcids deployed), it is possible that many of them sank before being detected because of the rough sea conditions experienced during the experiment. For example, Wiese (2003) estimated that murre carcasses would float for 10-14 days. However, that experiment was conducted under calm conditions in a floating wooden pen alongside a sheltered wharf. The sinking rate for alcids exposed to rough sea conditions is unknown. It is possible that water-logged alcids got close to neutral buoyancy resulting in them sitting flush with the water surface making them more difficult to detect; or that freezing the carcasses (prior to the experiment) had an effect on the body tissues and influenced their floating time.

Thirdly, although distance sampling can account for imperfect detection, one of the assumptions of the methodology requires that all objects available for detection at perpendicular distance zero (essentially on the survey line) must be detected. It is possible that some alcids (particularly dovekies) were missed at distance zero. Failure to meet this assumption results in density estimates that are biased low by an amount equal to the proportion of birds that were missed at distance zero.

6.1.3 Abundance

The estimated densities in Table 3 are applicable to the area within the 300 m wide survey transect, after taking detection probability into account. To convert these into abundance estimates over a larger area it is necessary to multiply the densities by the appropriate area to which they apply (Buckland et al. 2001). Thus the estimated size of the impacted "spill area" critically affects the mortality estimate. In a real spill situation this would be the area covered by the slick. In this experiment we used the location of satellite tagged objects and ship-based observations to approximate the "spill area" in order to calculate abundance.

During high winds on day 1, the objects moved quickly and spread over an increasingly larger area. However, we were only able to survey a portion of this area before all objects moved out of the area. All detections of objects occurred during the first two-thirds of the day when the objects were still relatively tightly clumped. Therefore it is difficult to know what area the day 1 densities should be applied to in order to calculate abundance since applying the computed density estimates to the large area swept by the tags (or, more conservatively, the area covered by the tags at the end of the day) would result in an overestimate of abundance. This highlights the need for secondary information to estimate the impacted area, typically obtained by aerial reconnaissance.

On day 2, satellite tracking indicated that the positions of the objects were relatively stable even though the wind remained at 20 - 25 kn, with start and end locations highly interspersed (Figure 5). Although there was extensive overlap in the locations of satellite tags with object detections throughout the day, the overlap was not perfect and some observations were made outside the area encompassed by satellite tags. Therefore, we estimated the spill area for the purpose of abundance estimation (364 km^2) to be the smallest convex polygon (convex hull) encompassing all satellite tag and observation locations on day 2.

Using data from experienced observers, estimated abundances for gulls and drift blocks were comparable to the numbers deployed and in all cases (except alcids) the true number of deployed objects was included within the 95% confidence interval.

Abundance estimates for inexperienced observers were considerably lower, but not because of their experience. Analyses of the relative number of raw object detections did not differ between experienced and inexperienced observers. Rather, inexperienced observers did not use distance sampling in their strip-transect protocol, precluding the ability to correct for imperfect object detection. This underscores the need to use methodologies which can account for imperfect detection in order to generate defensible estimates of marine bird mortality in the case of a real spill.

6.2 Carcass and Drift Block Movement and Satellite Tracking

The drift behaviour of all satellite-tagged objects was similar, and appeared to mimic the drift properties of bird carcasses. This is an encouraging result, as tests of the drift properties of carcasses and drift blocks are limited (Wiese and Jones 2001, Munilla et al. 2011). Our preliminary tests in Phase I suggested that telemetered carcasses and drift blocks would drift in a similar fashion and our larger release during the main experiment confirmed that expectation. It was not known, however, whether telemetered bird carcasses and drift blocks would drift in a way similar to normal bird carcasses. Wiese and Jones (2001) showed that weighted drift blocks outperformed unweighted drift blocks, in terms of showing drift trajectories most similar to bird carcasses, but that study was conducted over only a few hours and in relatively calm and sheltered conditions (see also Munilla et al. 2011). Our results show that the drift blocks we deployed (Wiese and Jones 2001) fairly mimic bird carcass drift on the order of days to weeks, and in all types of weather. We had some concern that telemetered bird carcasses would drift differently than normal carcasses, due to the rather bulky (but necessary) attachment package we developed (Appendix A). Our results show satellite positions interspersed with direct observations of carcasses and drift blocks, suggesting that our telemetered carcasses drifted similarly to the other objects we deployed.

Beyond the time-frame of the experiment (48 hours), telemetered blocks and bird carcasses continued to show similar trajectories. All targets eventually moved south along the eastern coast of Newfoundland, turning west once past Cape Race. About half of the targets moved towards Cape St. Mary's, and entered currents circulating on Placentia Bay. The other half of the targets moved offshore, following currents moving southwesterly, then southeasterly to the southwest Grand Bank. Encouragingly, a mix of drift blocks and telemetered bird carcasses of the various species followed these 2 main paths, indicating the drift patterns were comparable for extended periods. Also encouraging was the fact that 14 un-telemetered blocks were found on beaches in the same area that a mix of telemetered blocks and telemetered carcasses eventually became beached. This result strengthens our conclusion that the drift blocks move similarly to marine bird carcasses over the long-term; and further bolsters the validity of mortality estimates by Wiese and Robertson (2004).

The south coast of the Avalon Peninsula, Newfoundland, and especially the Cape Shore (southeastern Placentia Bay), are areas where oiled bird carcasses are commonly found (Wiese and Ryan 2003, Wilhelm et al. 2009). Our results show that currents bring some objects from the east coast of the Avalon into Placentia Bay. But of the 680 un-telemetered carcasses deployed in this experiment, not one was recovered, although both telemetered drift blocks and carcasses, and un-telemetered drift blocks were found on the beaches of the southern Avalon and Cape Shore. Wiese (2003) showed that marine bird carcasses remain floating on the surface for about 10-14 days maximum. Our results support the assertion made in Wiese and Robertson (2004) that, despite favourable currents, birds oiled and killed on the east coast of the Avalon Peninsula would not reach Placentia Bay before sinking.

6.3 Summary

A lack of tested and validated methods for assessing the number of seabirds killed during a major oil spill has led to much debate and discussion over previous estimates of seabird morality during high-profile events (*Exxon Valdez*, Piatt and Ford 1996, *Prestige*, Munilla et al. 2011), and still continues with the Deepwater Horizon release (Haney et al. 2014, Sackmann and Decker 2015). These debates potentially undermine the credibility of scientists, regulators and industry, and lead to uncertainty and possibly even public distrust. In developing and improving methods before a major oil spill, responders will be better positioned to assess the impact using methods with known strengths, weaknesses, biases and assumptions. Using tested methods will lead to estimates of impact that will still have some level of uncertainty, but are scientifically credible, and gives responders, the responsible party, regulators and the public a clear and consistent message throughout the response and during the aftermath of the event.

Our results indicate that Distance Sampling to directly estimate densities of dead seabird carcasses from industry supply vessel is possible and provides another potential tool to assess impact and damages to marine birds in the event of an offshore hydrocarbon release.

7 Recommendations

7.1 Deployment with Oil Spill Tracking Buoy

Due to the short notice for the vessel deployment and logistical constraints of getting all the bird carcasses and drift blocks ready, there was not enough time to access and deploy an Oil Spill Tracking Buoy (OSTB). An OSTB is equipped with a GPS tracking system and is designed to accurately track oil spills by utilizing the ocean's current to estimate the oil spill trajectory. Given that the dead seabirds and drift blocks disperse at relatively the same speed and trajectory, **we recommend an experiment be conducted to determine whether an OSTB will drift together with drift blocks.** Such a deployment should occur during moderate to high winds in order to assess differential effects of wind on the OSTB and drift blocks.

7.2 Challenges to overcome in future experiments

Two logistical challenges emerged as part of this study, which would need to be considered for similar experiments in the future. The first challenge was obtaining access to a supply vessel. A variety of mechanisms were considered to procure the services of a supply vessel for the 2 days needed for the experiment, including directly contracting a vessel for the work. Unfortunately that method did not work (no bids were received), and as a result, one of the oil companies made available the use of a vessel. It took a number of years to assemble the observers, carcasses, drift blocks, and satellite tags at a time when a vessel was available. **For future studies and experiments, we recommend flexibility and patience to ensure all parties involved are coordinated and logistical challenges are minimized**.

The second challenge was the long-term storage of several hundred seabird carcasses. Commercial freezer space was not an option due to the nature of the frozen material (not food-grade). This challenge was met by the generous loan of freezer space at Animal Health Division (Government of Newfoundland and Labrador), and the timely purchase of some chest freezers. **We recommend the securement of long-term freezer space with the capacity to hold a large number of carcasses, and a contingency plan in place to manage the mobilization and**

demobilization of carcasses when the experiment does not proceed to plan (which happened twice in this experiment).

7.3 Oil spill response planning

We recommend an inventory of drift blocks be maintained and be ready to deploy in the case on offshore hydrocarbon release. Drift blocks were detectable from the supply vessel, had similar drift properties as seabird carcasses, and could be used to help track the potential drift patterns of oiled birds and increase the number of detections available for Distance Sampling. A sample of blocks should have transmitters attached to help determine the likely location of dead carcasses and establish appropriate survey grids.

Industry observers performed well, and were able to employ distance sampling methods with some additional guidance and training. **We therefore recommend that industry protocols include Distance Sampling as part of their methods.** This will ensure the data collected can be used to provide more precise estimates of density and abundance. **In the event of a release, we recommend that an experienced observer be deployed to the spill area as soon as it is possible, to develop appropriate survey grids and to ensure protocols are followed.**

7.4 Future work

Seabird carcasses and drift blocks appeared to share similar drift properties, but it is not currently known how those drift patterns would relate to the drift of oil itself. **We recommend computer modeling to compare drift properties of block/carcasses to oil.** The simultaneous deployment of an oil spill tracker buoy and telemetered drift blocks would also help to determine the relationships between oil and carcass drift.

The number of detections of alcids was quite low, when compared to drift blocks and gulls, and suggests that detecting dead alcids on the water is more difficult. **We recommend further work to determine the detectability and detection functions for dead alcid carcasses to ensure Distance Sampling methods for these highly oil-vulnerable seabirds are valid, and whether obtaining a sufficient number of detections is feasible during an actual response.**

Additionally, ECCC is developing and implementing aerial surveys for live seabirds in Atlantic Canada. **The extent to which dead seabird carcasses and drift blocks can be detected during an aerial survey is unknown and we recommend this be investigated.**

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Appendix A Phase I: Proof of Concept Experiment

A.1 Methods

A.1.1 Deployment Preparation

Two drift blocks and two seabird carcasses (dead murres that were recently thawed) were equipped with satellite transmitters, released at sea, and monitored for (1) 24 hours and (2) until devices stopped transmitting. Transmitters were encased in a pouch made of durable nylon fabric, with antennae emerging from a small hole in the fabric. Fabric was attached directly to drift blocks using screws. For carcasses, transmitters were encased alongside buoyant styrofoam and attached using zip ties running through channels at the top and bottom of the fabric (Figure A-1). Satellite transmitters for drift blocks and carcasses were ground-truthed.

A.1.2 Release

On 15 November 2013 (16:27 UTC) four experimental targets (2 bird carcasses, Platforms 131900, 131901; and 2 drift blocks, Platforms 131902, 131903; Figure A-2) were released 5 miles offshore from Witless Bay, Newfoundland and Labrador (N 47°12.452’, W 52°40.420’; Figure A-3). Witless Bay was chosen for three reasons: (1) the current in this area was expected to take the targets southwards and away from shore, (2) offshore oil and gas industry support vessels regularly use the facilities in Bay Bulls, and (3) given the large seabird colonies in the area, some drift block and carcass drift data from this region could prove useful in the event of a future release in this sensitive area.

The Phase II experiment is expected to relocate targets within 24 hours, therefore data is summarized in two parts: (1) for the first 24 hours only, and (2) for ongoing remote monitoring of targets through the Argos website. Due to battery limitations and continuous transmission time, it is expected they will stop transmitting around 15 December 2013.

A.1.3 Processing

Transmissions were filtered in ESRI ArcMap 10.1 to display only accurate point detections (class 2, 150-350m accuracy; class 3, <150m accuracy). All calculations and maps include only accurate detections. Distances between locations that matched in time (±5 min) were calculated in ESRI ArcMap (10.1), using Data Management Tools toolbox.

Figure A-1. Drift block and bird carcass satellite attachment methods

Figure A-2. Drift block and bird carcass deployments outside Witless Bay, Newfoundland and Labrador, for Phase I proof of concept.

A.2 Results and Discussion

A.2.1 Transmissions

A.2.1.1 First 24 hours

Both drift blocks and only one of the bird carcasses successfully transmitted data starting the day of release (15 November 2013, 16:27 UTC; Figure A-3). Accurate locations (class 2, 150-

350m accuracy; class 3, <150m accuracy) were obtained within 1h 10 min of release, and were subsequently received every 34 minutes (on average; maximum gap in transmission = 1 h 37 m; Table A-1). Transmissions were more frequent between 22:00 and 00:00 (UTC; Figure A-4) and were unavailable at 11:00 (UTC). Winds were generally light (<20 km/h) southerlies and south westerlies over this period.

A.2.1.2 Over 10 days

The second bird carcass began transmitting nine days post-release (on 24 November 2013). Similar to what was observed in the first 24-hour period, accurate locations over the 9-day period were received every 40 minutes (on average), but the maximum gap was greater (3 h 20 m; Table A-2). As well, transmissions continued to be more frequent between 23:00 and 0:00, but also between 07:00 and 09:00 (UTC; Figure A-4). Over this longer period, there were no data gaps in the daily 24-hour period; however, detections were most infrequent at 03:00. Winds remained light westerly to southerly (<30 km/h) until 20 November. From 20-30 November, winds increased (20-50 km/h) as a number of systems moved through the region.

A.2.2 Drift Patterns

A.2.2.1 First 24 hours

The three platforms (two drift blocks and one bird carcass) travelled at 1.2 km/h and drifted 25 km in 24 hours (Table A-1). All three transmitters stayed on the same trajectory (Figure A-3) and remained within 417 ± 37 m of each other over 24 hours (Table A-2). Drift blocks stayed closer to each other (220.6 m) than the bird carcass did to the drift blocks (514.2 m; Table A-2, Figure A-5).

A.2.2.2 Over 10 days

As time progressed past 24 hours, the drift between the experimental targets increased (Figure A-6, Figure A-7) and was clearly influenced by wind and current patterns (see also Wiese and Jones 2001). Drift blocks drifted up to 35 km apart on 20 November, but then regrouped to within 15 km by 22 November and all three transmitters were still within 30 km of each other after 10 days (Figure A-6, Figure A-7). Knowledge of currents in the study area (cf. Wu and Tang 2011) of Phase II will be essential in planning the survey grid. However, the similar drift trajectories between bird carcass and drift blocks are encouraging, both during the initial 24 hours and nine days later when the second bird carcass began transmitting (Figure A-7). This suggests that using both drift blocks and bird carcasses will be useful in carrying out Phase II objectives.

Table A-1. Details on satellite transmissions from three PTT platforms (one bird carcass, two drift blocks) one day post-release, from 15 - 16 November 2013 (upper section) and for the two blocks from 16 – 25 November 2013 (9-day period; lower section). Distance is calculated along all points in each individual trip and includes trip sinuosity. Platform 131901 (seabird carcass) stopped transmitting after 24 hours.

Interval	Platform	Type	Total hours (hh:mm:ss)	Total detections	Average Detections per hour	Average interval	Min interval	Max interval	Average Speed (km h^{-1})	Distance travelled (km)
24 hours	131901	Bird	22:19:36	39	1.75	0:36:12	0:00:03	1:37:30	1.14	25.45
	131902	Block	22:27:24	41	1.83	0:33:41	0:00:13	1:37:27	1.26	22.23
	131903	Block	22:20:42	40	1.79	0:34:23	0:00:31	1:36:59	1.26	28.03
		24-hour Average			*1.79*	*0:34:45*	*0:00:16*	*1:37:19*	*1.22*	*25.24*
9 days	131902	Block	213:35	314	1.48	0:40:46	0:00:41	3:26:39	1.45	309.80
	131903	Block	213:36	328	1.53	0:39:45	0:00:14	3:14:44	1.24	263.79
		9-day Average			*1.50*	*0:40:15*	*0:00:28*	*3:20:41*	*1.34*	*286.78*

Table A-2. Average distance (m) between satellite platforms over a 24-hour period (since deployment), including between bird carcass and drift blocks, between drift blocks, and overall. See also Figure A-5.

Average Distance Between Platforms (m)

Detection	Time of Day (UTC)	Bird-Block	Block-Block	Overall
1	17:07	285.09	231.06	267.08
2	17:32	240.01	88.92	189.65
3	18:46	387.35	418.13	397.61
4	19:00	305.22	476.90	362.45
5	20:28	414.65	160.92	330.07
6	21:11	390.26	211.55	330.69
7	22:17	481.02	495.22	485.75
8	22:48	442.40	147.43	344.08
9	22:53	225.65	183.28	211.53
10	23:52	421.60	88.97	310.72
11	0:30	200.40	202.52	201.11
12	1:35	235.45	242.77	237.89
13	2:09	260.75	439.06	320.19
14	5:21	245.36	67.93	186.22
15	6:54	185.45	142.35	171.08
16	7:03	870.50	202.48	647.82
17	7:28	671.85	221.44	521.71
18	8:35	834.30	211.98	626.86
19	8:36	709.12	211.98	543.40
20	9:11	859.29	405.94	708.18
21	10:14	699.32	161.11	519.92
22	12:09	585.93	61.79	411.22
23	12:43	821.51	181.62	608.21
24	13:05	927.03	na	927.03
25	13:56	1239.62	57.47	845.57
26	14:25	702.41	369.70	591.50
27	14:39	624.42	228.90	492.58
28	15:14	511.67	114.93	379.42
29	15:27	339.10	150.67	276.29
Average		*514.15 ± 50*	*220.61 ± 23*	*417.45 ± 37*

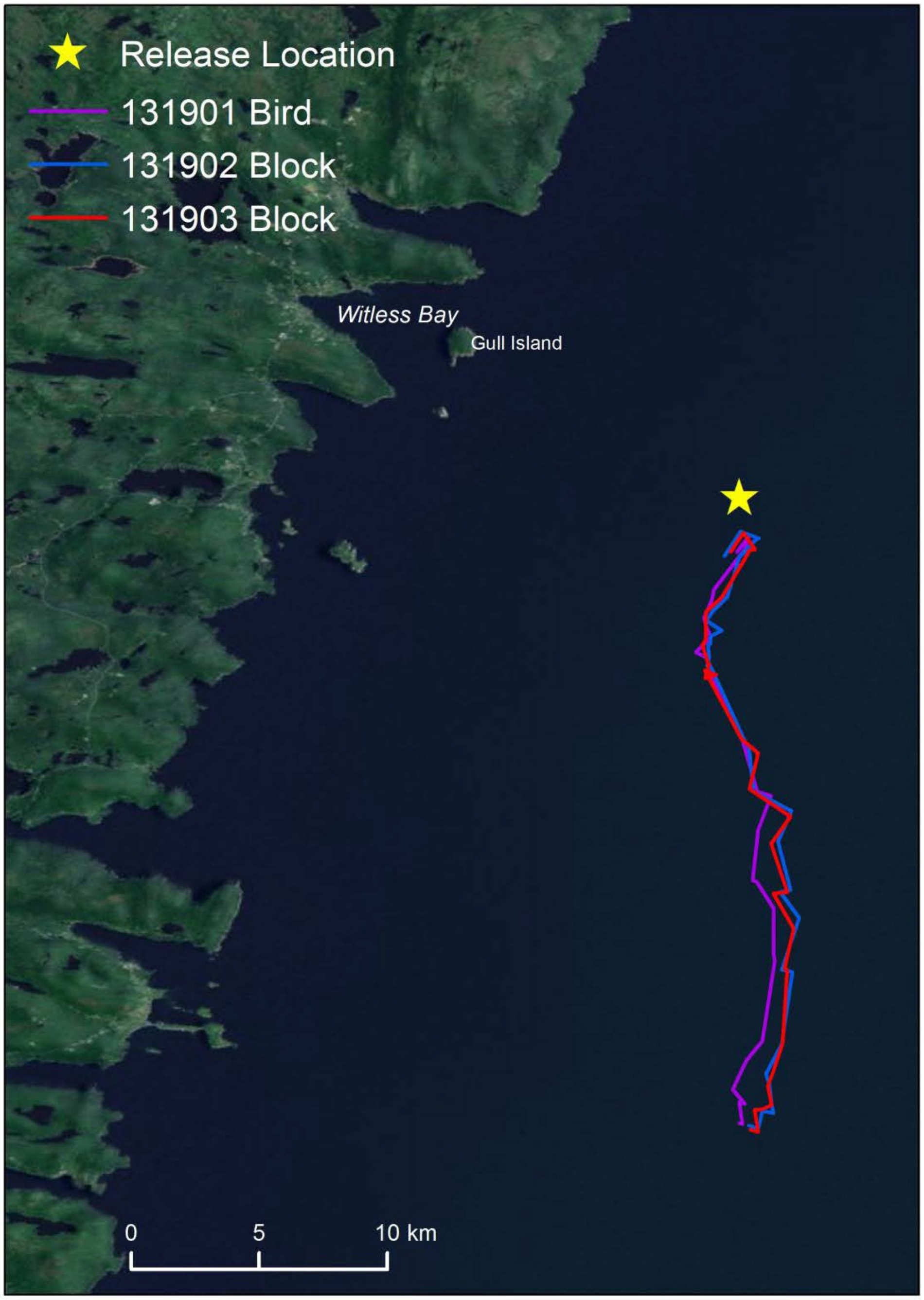

Figure A-3. Three platform drift trajectories over a 24-hour period.

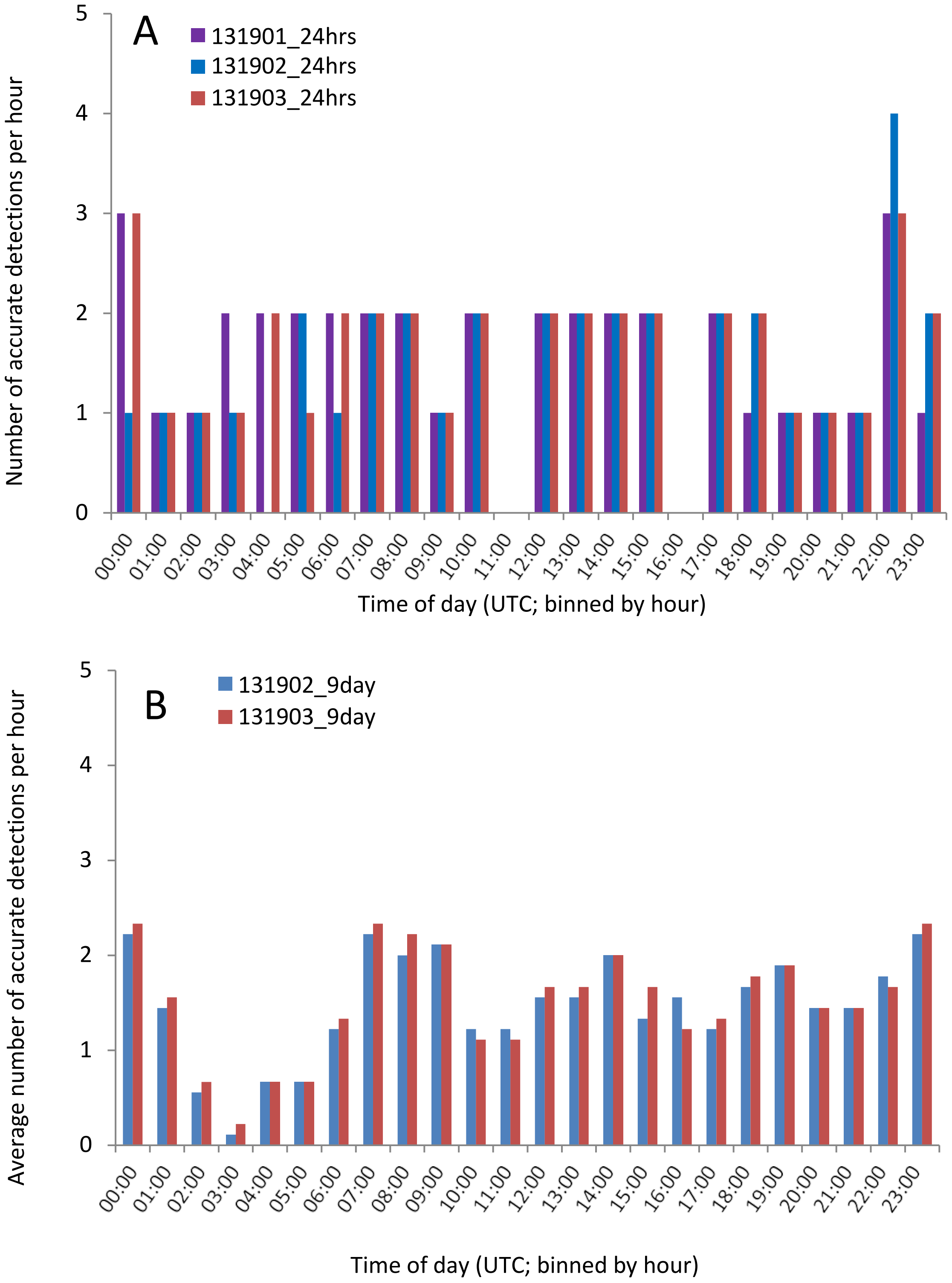

Figure A-4. Starting from the time of deployment, (a) the number of accurate detections for each platform (class 2, class 3) per hour (UTC), across a 22-hour period; and (b) the average number of accurate detections for each platform per hour (UTC) over 9 days post-deployment.

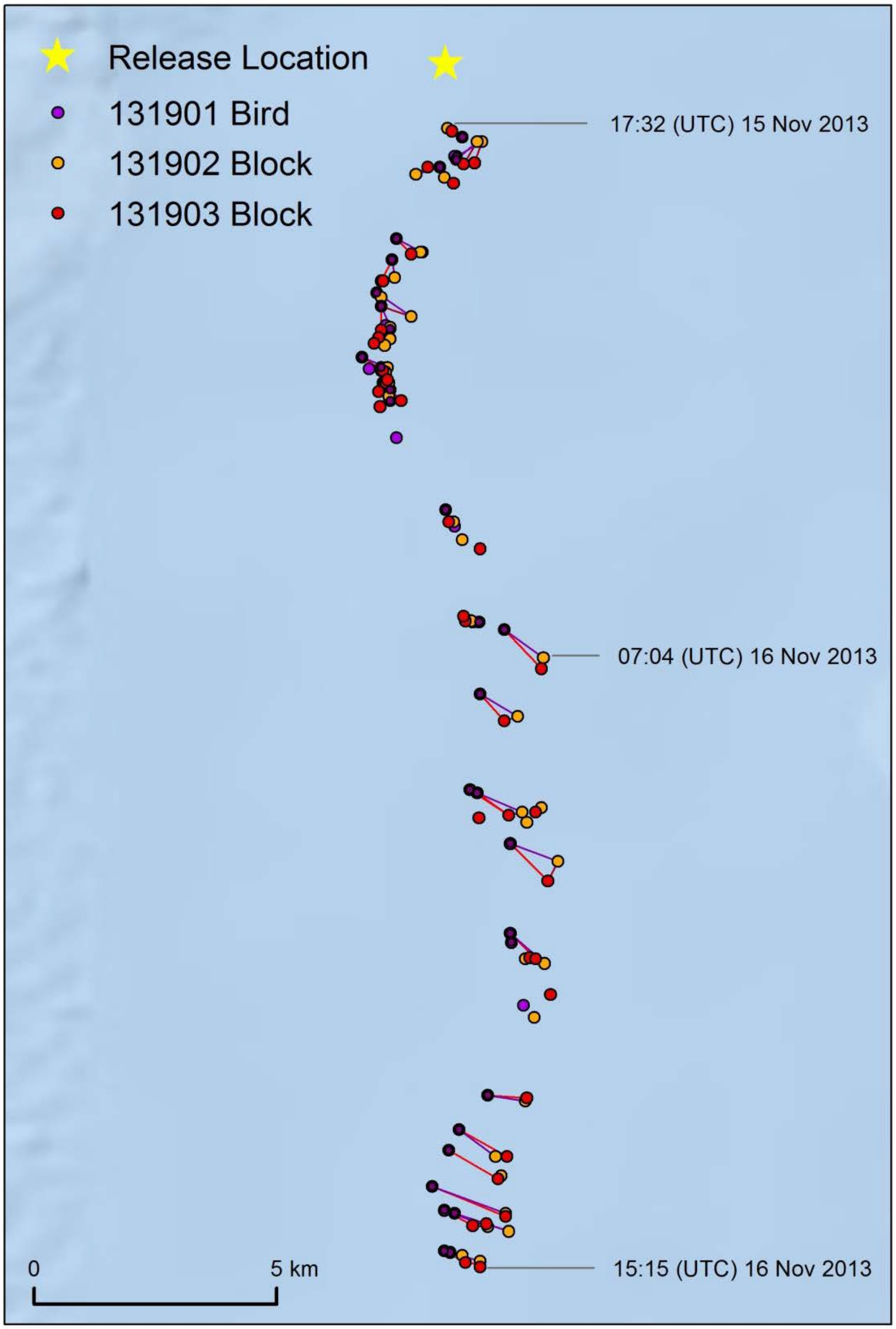

Figure A-5. Detailed transmitter paths over a 24-hour period. Colors represent detections for individual transmitters and lines indicate distances between platforms when transmission times matched.

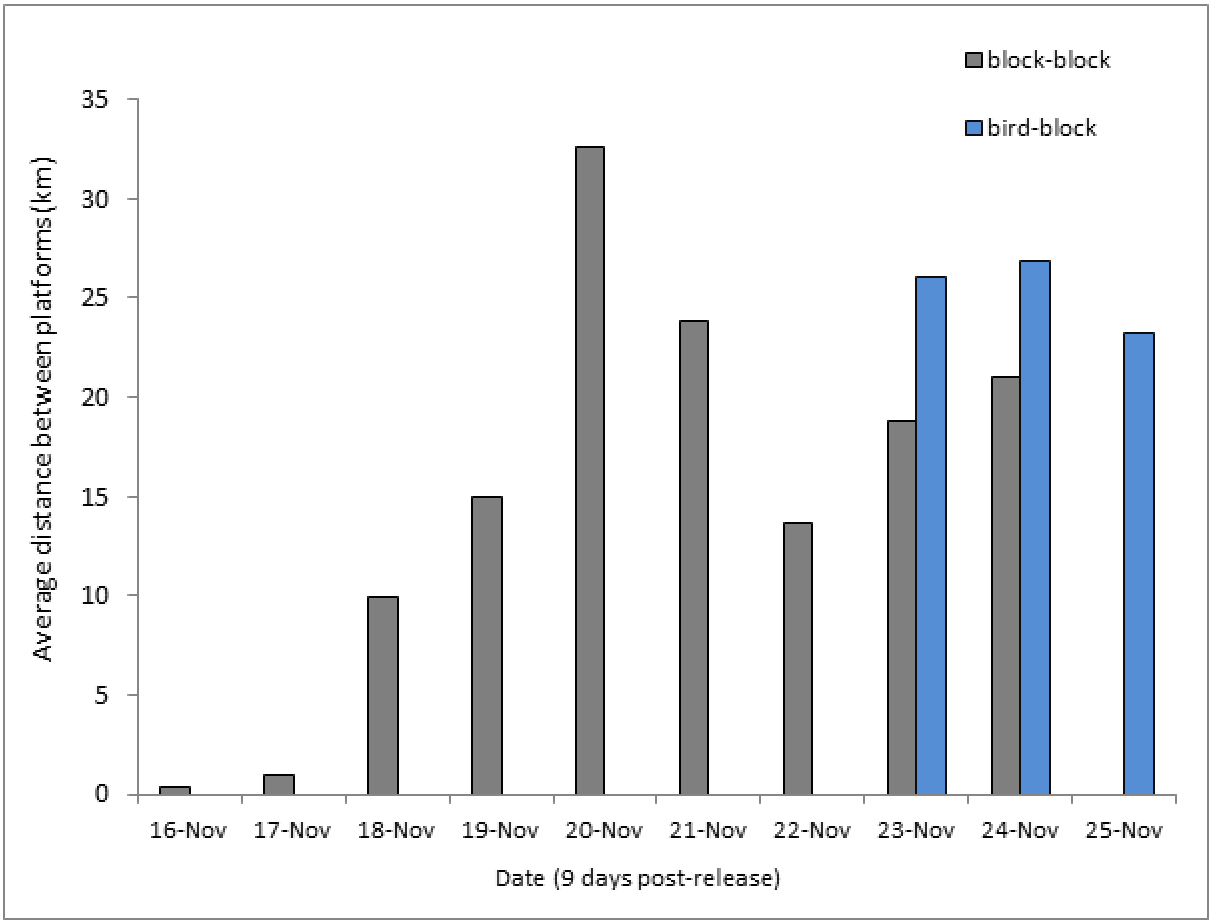

Figure A-6. Distance between drift blocks (131902, 131903) for 9 days post-release, and average distance between bird (131900) and blocks (131902, 131903) once bird began transmitting on Nov 22. Distances increased dramatically once blocks passed the southern point of the Avalon Peninsula; see also Figure A-7.

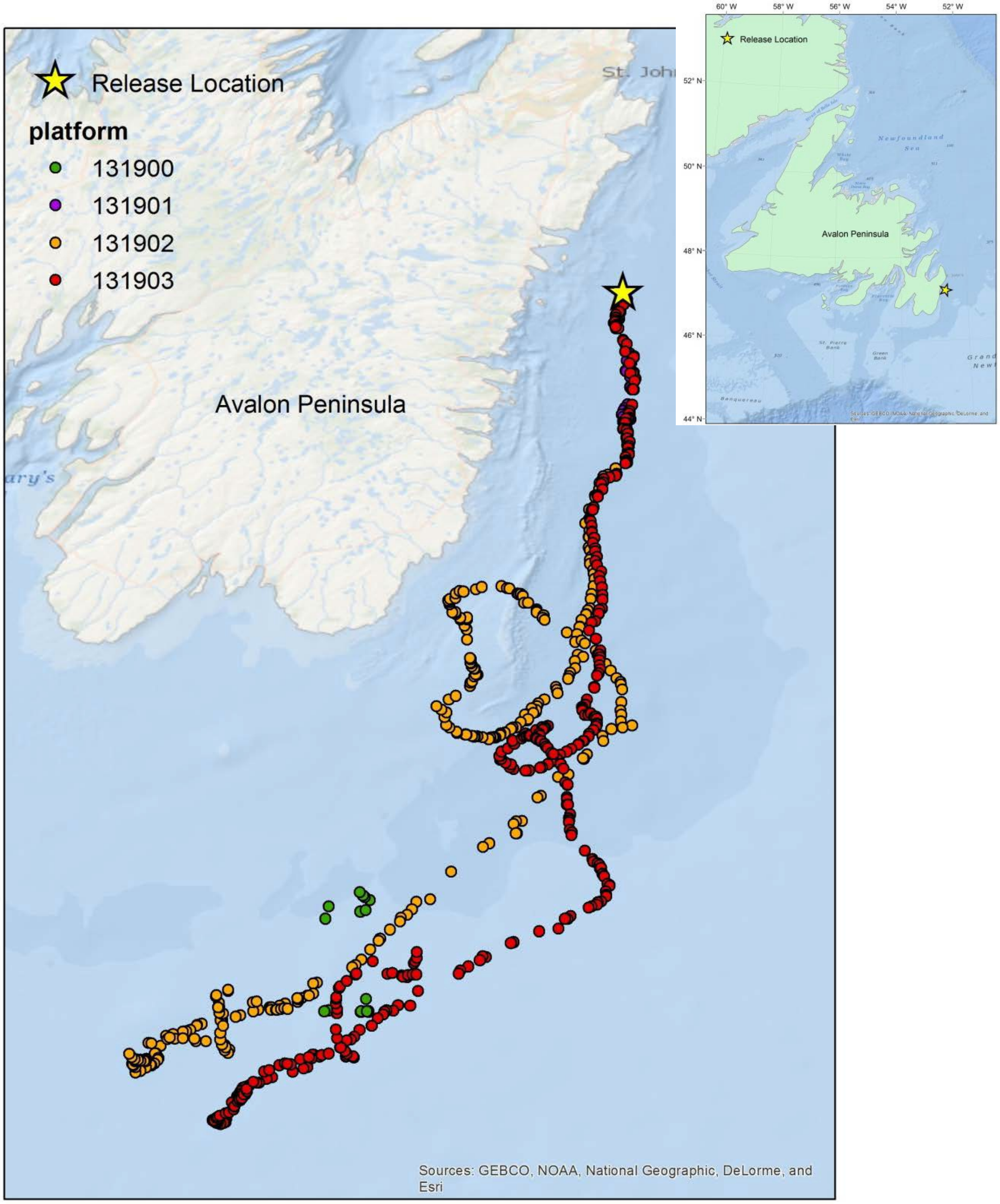

Figure A-7. Satellite deployment study area and trajectories over 10 days.

A.3 Recommendations

Given the success of the Proof of Concept, including the rapid upload of satellite data, attaching the devices to a bird carcass and the close trajectories of the carcass and blocks, we recommended going forward with Phase II of this experiment using the KiwiSat 172A PTTs as the telemetry solution.

With the data from the proof of concept experiment, the expected spread in the data could be less than 1 km after 24 hours. This will likely allow a distance between transect (w) of 600m, allowing for 100% coverage of the survey area (with 2 experienced observers) and a relatively small transect length (*t*) of 3 km. Based on Table 2, only 21 km are required to transit this area, which could allow us to repeat the search grid within the allotted time of 5 hours or more at 5 or more knots. This search grid could be run perpendicular to the target area to model the effect of working at 90° to the current or with/against the current. It is expected that the spread will be smaller than predicted, however exact details will be worked out with the real-time telemetry on the day the survey is planned.

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Appendix B Experienced Observer Protocol

Environment Canada Environnement Canada

Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms

Carina Gjerdrum, David A. Fifield, and Sabina I. Wilhelm

Atlantic Region

Canadian Wildlife Service
Technical Report Series Number 515

Canada

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EASTERN CANADA SEABIRDS AT SEA (ECSAS) STANDARDIZED PROTOCOL FOR PELAGIC SEABIRD SURVEYS FROM MOVING AND STATIONARY PLATFORMS

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ABSTRACT

Marine birds play an important role in marine ecosystems and their responses to oceanographic variability can be used to monitor changes in the marine environment. To understand their roles and to identify and minimize human impacts on birds at sea, data on their offshore distributions and abundance are required. Numerous methods are employed throughout the world's oceans to study seabirds at sea from ships, but for studies to be comparable, methods have to be standardized. In Atlantic Canada, data were collected between 1966 and 1992 under PIROP (Programme intégré de recherches sur les oiseaux pélagiques), but there was no systematic monitoring of birds at sea after the mid-1980s. In 2005, the Canadian Wildlife Service of Environment Canada re-initiated the pelagic seabird monitoring program in eastern Canada (Eastern Canada Seabirds at Sea; ECSAS) and developed a survey protocol based on those used elsewhere in the Atlantic. We record birds observed along a line transect, scanning a 90^o arc to one side of the ship, and follow the recommended snapshot approach for flying birds (Tasker et al. 1984). Distance sampling methods are incorporated to address the variation in bird detectability. This method allows the estimation of seabird densities. In this report we describe the general methods we use to conduct seabird surveys at sea, and then provide detailed instructions on how to fill out each data field. We also provide worked examples for surveys from moving and stationary platforms. It is our hope that this report will serve as a guide for other such studies in the Atlantic and beyond so that comparisons of seabird communities can be made among regions and between research organizations.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 History of pelagic seabird surveys in eastern Canada

Gathering systematic information on the pelagic distribution of seabirds in eastern Canadian waters was pioneered by R.G.B. Brown (Canadian Wildlife Service; CWS) through PIROP (Programme intégré de recherches sur les oiseaux pélagiques), a joint initiative between the Canadian Wildlife Service and P. Germaine at l’Université de Moncton. Data collection under PIROP occurred from the late 1960s until the early 1990s, with the bulk of the data collected during the 1970s. In addition to doing much of the field work, R.G.B. Brown published extensively on the oceanographic factors that influence seabird distribution (e.g., Brown 1970, 1976, 1979, 1985), and produced a series of atlases summarizing the seasonal distribution and abundance of seabirds in the northwest Atlantic (Brown et al. 1975, Brown 1977, 1986). In the early 1990s, A.R. Lock (CWS) organized the PIROP data into one database and published a Gazetteer, which re-mapped the pelagic distribution of seabirds throughout the northwest Atlantic, with special emphasis on abundance and distribution of seabirds vulnerable to marine oil pollution (Lock et al. 1994). The PIROP database has since been used to examine seabird migration, seasonal moult, and the abiotic factors that influence seabird distribution (Huettmann 2000, Huettmann and Diamond 2000, 2001a,b, 2006).

The PIROP database continued to be relied on heavily well after data collection had ceased, particularly as it related to environmental assessments and impact statements associated with increasing offshore oil and gas activities and the high chronic oiling rates of seabirds reported along the east coast (Wiese and Ryan 2003, Lucas and MacGregor 2006). By the early 2000s, it became evident that current data were required to fill substantial spatial and temporal gaps in the database, and that a revival of a pelagic seabird survey program was necessary. An important step toward this implementation was to develop a standardized survey protocol.

1.2 Development of the standardized protocol

Early PIROP surveys were based on 10 min observation periods during which all birds observed were recorded, regardless of their distance from the moving vessel. These surveys were designed to gather information on the relative abundance and distribution of seabirds, and the short recording periods allowed observations to be related to the variable oceanographic conditions of the area (Brown et al. 1975). Following a review of survey methods by Tasker et al. (1984), PIROP surveys after 1984 recorded birds observed within a 300 m band transect, scanning a 90° arc to one side of the ship. This change in protocol allowed the estimation of densities (i.e., birds per square kilometer) but the protocol did not adopt the recommended snapshot approach for flying birds, which often move faster than the ship and thus inflate estimates of local density (Tasker et al. 1984, Gaston et al. 1987). During the re-vitalization of the pelagic seabird survey program for the Canadian east coast in the early 2000s, A.R. Lock recommended that CWS seek pan-Atlantic coordination and develop survey protocols based on those used by the European Seabirds At Sea (ESAS) group. This was successfully established with the help of K. Camphuysen, past chair of the ESAS group, who generously provided materials and at-sea training on current seabird survey practices in the North Sea.

Standardised data collection among institutes of various countries bordering the North Sea began in the early 1980s, with the establishment of the ESAS database. Early surveys focused on assessing the vulnerability of certain areas to surface pollutants and were therefore designed to collect data that allowed the mapping of relative abundance and distribution of seabirds at sea (see Camphuysen 1996 for review). More recently, surveys in the North Sea have evolved to include the collection of detailed behavioural data, with considerable interest in foraging behaviour of individuals (Camphuysen and Garthe 2004). The methods require extensive training and practice for an observer to gain proficiency in identifying and recording the 92 codes for behaviour and association, in addition to the flight direction data, and were deemed too detailed for the proposed pelagic seabird survey program in eastern Canada. Therefore, a selection of behavioural and association codes taken from the ESAS protocol have been implemented along with the general methods used by European observers, to develop the standardized protocol presented in this report. This protocol will allow for direct comparison with data collected currently in the northeast Atlantic.

We developed a standardized protocol for surveys conducted from two types of observation platform, moving (e.g., oceanographic research or platform supply vessels) and stationary (e.g., oil production rig or supply vessel on stand-by). The protocol for surveys conducted aboard moving platforms was modelled after Tasker et al. (1984), and the protocol for stationary platforms was adapted from methods described in Tasker et al. (1986) and Baillie et al. (2005). Distance sampling methods were included to address variation in bird detectability and to allow for calculation of correction factors to account for missed birds (Buckland et al. 2001). We also reduced the observation period length from 10 min to 5 min in order to obtain more precise spatial information for each bird sighting. This change does not, however, affect our ability to compare seabird densities to those surveys that use longer observation periods. The Eastern Canada Seabirds at Sea (ECSAS) program has used this survey protocol, with minor modifications, in eastern Canada since 2006 (Gjerdrum et al. 2008, Fifield et al. 2009), during which time almost 80,000 km of transect have been surveyed and 144,000 birds counted. In this report, we describe the general methods we use to conduct surveys, and then describe each data field in detail. A series of appendices provide distance estimation equations, data field coding details, example surveys and blank datasheets.

2. GENERAL REQUIREMENTS FOR SEABIRD OBSERVERS

Seabird observers collecting data on pelagic seabird occurrence and behaviour for the ECSAS program are required to use this standardized protocol. It is also strongly recommended (and may be required) that each observer participate in a training workshop. The workshop includes instruction on boat safety, survey methods, distance sampling, and seabird identification. Instruction takes place in a classroom, although students will also be expected to train with an experienced observer at sea. Students will be evaluated in their understanding of the recording methods and seabird identification. As trips can last anywhere between three days and six weeks and travel in a variety of environmental conditions, observers can expect to stand for long periods of time, often under arduous conditions. Limited space on board the vessels may also require observers to share living areas. To ensure the highest quality of data is collected, observers should have the following:

- Experience working with seabirds and a strong knowledge of their behaviour and ecology
- Ability to rapidly identify Atlantic seabirds in all plumages, in various lighting conditions, reduced visibilities, and in rough ocean conditions

- Ability to follow the ECSAS protocol for surveying seabirds at sea
- Ability to accurately record data on data sheets (or electronically) according to protocol, including information on vessel, weather conditions, and birds
- Ability to work independently
- Experience travelling in boats and an ability to work in rough sea conditions without getting seasick
- Good communication skills and the ability to live and work closely with ship's crew and staff for extended periods of time

3. DISTANCE SAMPLING: THE IMPORTANCE OF RECORDINGDISTANCES TO BIRDS

3.1 Introduction to Distance Sampling

A crucial question to address in any survey program is that of detection probability. It is well known that some birds will be missed by even the best observer due to sea and weather conditions, vessel characteristics, observer fatigue, etc. (Buckland et al. 2001). The question is, how many? If we do not account for detectability we are forced to assume that all animals within the survey transect are detected, which will underestimate abundance, perhaps drastically. In that case, all we can produce are (likely biased) indices of relative abundance. Relative abundance indices are difficult to compare between surveys, years, observers, etc. when variation in detectability is not assessed (i.e., failure of the assumption of constant proportionality) (Norvell et al. 2003).

Distance sampling is a powerful technique that allows us to estimate the proportion of birds present that are actually detected (i.e., detection probability) and to automatically factor this into abundance calculations (Buckland et al. 2001). Distance sampling is based on the premise that the likelihood of detecting a bird decreases the further away it is from the observer. Likewise, detectability varies by species and environmental conditions.

The subsequent data analysis involves the use of specialized software called Distance (Thomas et al. 2010). The software works by comparing the number of birds actually observed within each distance class (Figure 1) with the number that would have been counted if every bird had been detected. If all birds present were detected, then on average there should be equal numbers of birds in each equal-size distance class[†]. This is the same as saying that birds in all distance classes have equal detection probability (Figure 2a). In reality, this never happens. Bird detectability and thus the number in each distance class decreases with distance from the observer. This can readily be seen by simply plotting the number of birds actually observed in each distance class as a histogram. The histogram in Figure 2b shows a typical data set where detection probability decreases with distance. The smooth dark line is a curve that has been fit to the histogram. A correction factor, called the detection probability, is computed by dividing the area under the curve by the area of the entire dashed rectangle. The distance sampling software does this and thus computes abundance, taking birds that were missed into account. Note that detectability will also be affected by other factors including the identity and behaviour of the species, weather conditions, sea state, and observer, all of which the software factors into the analysis (Thomas et al. 2010).

[†] Distance automatically adjusts for distance classes of unequal width.

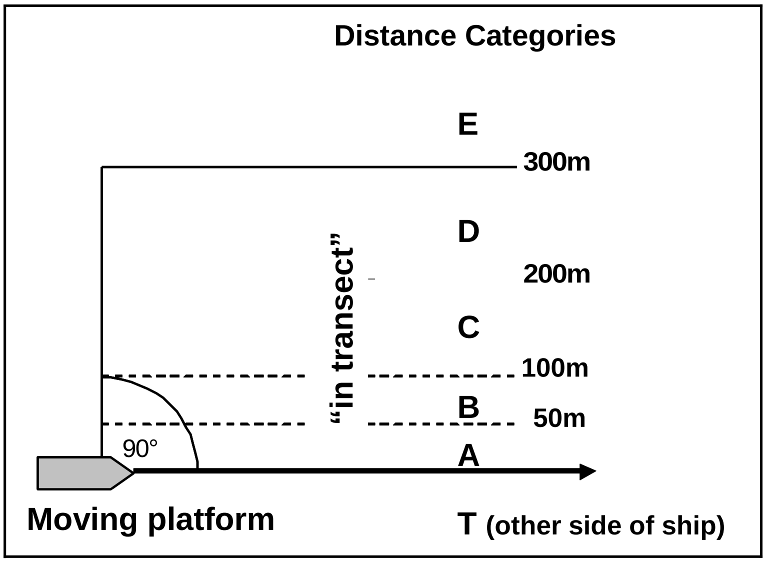
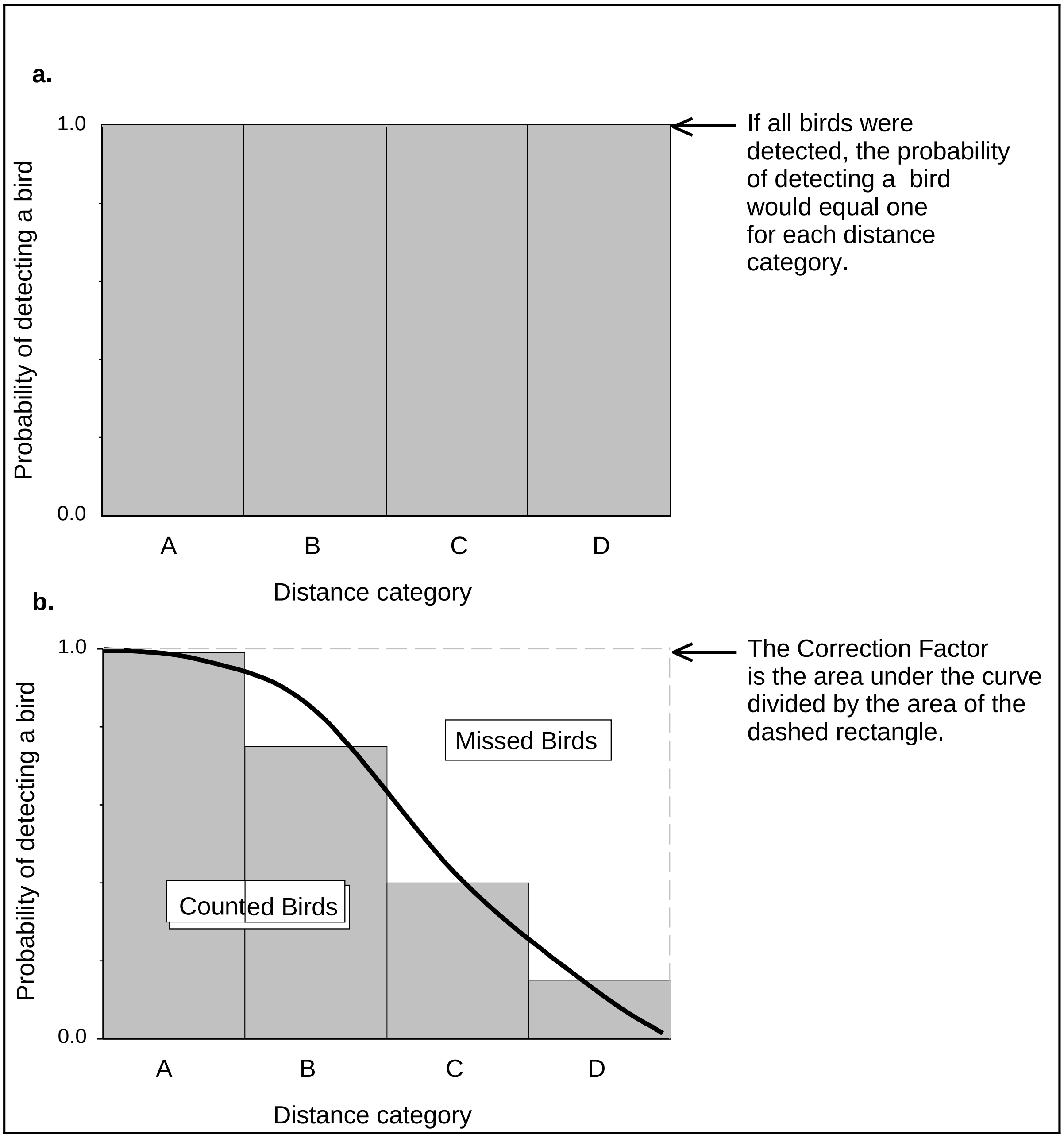


Figure 1. Illustration of a survey using a 90º scan, covering a 300 m transect from a moving platform. All birds observed within this transect, whether flying or on the water, are recorded. The perpendicular distance from the line to birds detected on the water or in flight is estimated. Birds observed outside the transect are normally also recorded if this does not affect observations within the transect. Distance categories "E" and "T" are both considered not in transect.

For distance sampling to work, all the observer has to do is estimate the distance to each flock of birds, which we do in distance classes or "bins" (Figure 1). Note that the mathematical framework requires that the observer records the *perpendicular* distance from the ship's track line to each flock (Figure 1). Imagine extending a 300 m long "yardstick" perpendicular to the ship, counting each flock and estimating its distance as it passes under the stick. In this way, a 300 m wide rectangular swath of ocean is surveyed as the ship proceeds. In reality, it is often necessary to estimate the perpendicular distance before the ship reaches a flock of birds because they are in flight or to ensure that birds on the water are not displaced by the ship (see section 4.1).

3.2 Analysis assumptions

Distance sampling produces unbiased density estimates while depending on only a small set of assumptions (Thomas et al. 2010). These include: 1) all birds on the line (i.e., within the first distance class) are detected, 2) birds are neither attracted to nor displaced by the survey platform before being detected (requires looking well ahead of the vessel for some species) and 3) distances are measured accurately. The first assumption is due to the internal mathematics used by the software to compare the relative numbers of birds in each distance class. If many birds in distance class "A" are missed, then the computed probability of detection will be artificially high, resulting in an underestimate of abundance. It is therefore extremely important to ensure that all birds in the first bin are detected. However, a balance of effort is required so that observers are not concentrating so much on birds that are close to the vessel that they will miss other more distant birds. In order to avoid violating the third assumption, observers are also required to look well ahead of a moving platform to detect birds before they dive or fly away.



If all birds were detected, the probability of detecting a bird would equal one for each distance category.

The Correction Factor is the area under the curve divided by the area of the dashed rectangle.

Figure 2. Typical example showing how the histogram would look if (a) all birds were detected, and (b) detectability of birds decreasing with increasing distance. The correction factor is computed as the area under the curve divided by the area of the entire dashed rectangle.

4. GENERAL METHODS FOR SEABIRD SURVEYS

4.1 Surveys from moving platforms

Surveys are conducted while looking forward from the moving survey platform, scanning at a 90° angle from either the port or starboard side and limiting observations to a transect band 300 m wide from the observer (Figure 1). The transect is continuously surveyed by eye to count and identify birds present in air or on water. Binoculars are used to confirm species identification, and other details, such as age, moult, and behaviour. Observers scan ahead regularly (e.g., every minute) to detect birds that may dive as the ship approaches. If large concentrations of birds in the transect fly off as the ship approaches, binoculars can be used to help count individuals, and these birds are recorded as being on water. Priority is given to birds observed in transect (Figure 1). Birds not in transect are also important and are recorded if these observations do not interfere with observations of birds in transect.

A survey consists of a series of 5 min observation periods, which are exclusively dedicated to detecting birds. As many consecutive 5 min observation periods are conducted as possible, regardless if birds are present or not, and consistent coverage throughout the day is encouraged. The transition between observation periods may take one or two minutes, in order to record the vessel's position and any conditions that may have changed since the last 5 min observation period (see Section 5.1 on recording observation period information). Transits longer than two hours may need to be broken up to avoid observer fatigue.

Surveys are best conducted when the platform is travelling at a minimum speed of 4 knots (7.4 km/h) and a maximum of 19 knots (35.2 km/h). Surveys can be done when the ship is travelling less than 4 knots, but birds are often attracted to slow moving or stationary vessels. If birds are clearly gathering around the vessel and settling on the water when the ship is moving at decreased speeds (i.e., less than 2 knots), cease your observations. If the ship is no longer moving at all, switch to the protocol used for stationary surveys (section 4.2). When visibility is poor due to rain or fog and the entire width of the 300 m transect is not visible, surveys from moving platforms can still be conducted, however, observers must record the width of the transect that is visible during the survey (e.g., 200 m) in the "Notes" section of the record sheet (see Appendix X for blank record sheets). When no birds are detected during a 5 min period, it is important to record "No birds observed" on the datasheet. If vessel speed or direction changes significantly during an observation period, record the time and location of termination and begin a new observation period.

Observers should practice estimating the locations of the various distance bands. This is best accomplished with a distance gauge made from a transparent plastic ruler (see Appendix I). This gauge should be kept close at hand to quickly verify bird distances.

4.1.1. Detecting and recording bird sightings

One of the primary goals of pelagic surveys is to quantify bird distribution and abundance. To do this, we need estimates of density, which is the number of birds occupying a prescribed area of ocean surface at any given instant in time. During a 5 min observation period, a 300 m wide rectangular area of ocean will be covered (see Figure 1, Appendix VII), the length of which is determined by ship speed. For example, for a ship traveling at 10 knots, the rectangle will be 300 m wide and approximately 1500 m long. To compute bird density, it would be ideal to be able to count all birds that occur within this rectangle *at a single instant in time,* before they swim or fly away, giving a measure of birds/km^2. Since we do not have the ability to see the entire area simultaneously, birds must be counted as the ship approaches them.

4.1.2. Recording birds on the water

All birds observed on the sea surface are continuously recorded throughout the 5 min period and their perpendicular distance from the observer is estimated (Figure 1). If a bird appears to have been flushed off the water, it is counted as a bird on water and not subsequently counted as a flying bird during a snapshot – see below. Observers scan ahead regularly (e.g., every minute) to detect birds that may dive as the ship approaches.

4.1.3. Recording birds in flight

During the observation period, more birds will fly through the survey area than were present in that area at a single instant in time (Tasker et al. 1984). The faster the birds fly relative to the ship's speed, the greater the number of birds will pass through the transect area during a 5 min period. If these flying birds are counted continuously as they are encountered, their density will be overestimated by an amount that is proportional to the relative speeds of the bird and observer (Tasker et al. 1984, Spear et al. 1992). Therefore, flying birds are recorded using a series of instantaneous counts, or snapshots, at regular intervals along the transect (see Appendix VII for an example). The time interval between snapshots depends on the speed of the ship and is chosen so that the ship moves roughly 300 m between snapshots (Table 1). For example, if the platform is moving at a speed of 10 knots, snapshots will occur every minute for the duration of the 5 min observation period. At the time of the snapshot, all flying birds within the transect and up to 300 m ahead of the observer are counted (Figure 1, Appendix VII). In this way, the entire survey transect is covered by a series of instantaneous snapshots. During each snapshot, flying birds are recorded as in transect only if they are within 300 m to the side and 300 m ahead of the vessel (Figure 1). All other flying birds that are seen beyond 300 m OR between snapshot intervals are recorded as not in transect. Birds recorded not in transect (or not in semi-circle for stationary surveys) provide important information on distribution, timing of occurrence, and behaviour, and effort should be made to record them if at all possible. Nothing is recorded if no birds are observed during the snapshot. *It is important to remember that all 5 min observation periods begin with a snapshot of flying birds.*

Table 1. Intervals at which instantaneous snapshot counts of flying birds are conducted from a moving platform.

Platform Speed (knots)	Interval between counts (min)
< 4.5	2.5
4.5 - 5.5	2
5.5 - 8.5	1.5
8.5 - 12.5	1
12.5 - 19	0.5

4.1.4. Lines of flying birds

Some species (e.g., murres (*Uria* spp.), Northern Gannets (*Morus bassanus*)) may fly in long lines across the survey area. At the time of the snapshot, the number of birds in the flock is counted and the distance class is assigned according to the location of the centre of the flock. All the birds are recorded as in transect if the centre of the flock is within the 300 m transect. If the centre of the group is beyond 300 m, they are recorded as not in transect, despite some individuals being within 300 m (see Appendix VII).

4.1.5. Large numbers of birds

When very large numbers of birds are encountered that overwhelm the observer's ability to count and measure the distance to individual flocks (this does not include typical ship-followers circling the ship), snapshots (of all birds whether in flight or on water) are conducted rather than continuous counts. Snapshot intervals are the same as those used to count flying birds (Table 1). At the time of the snapshot, all the birds that occur within 300 m of the observer (perpendicular to, as well as ahead of the observer) are counted, but the flying birds are not separated from those on the water. Another count does not occur until the next snapshot interval when the ship has travelled another 300 m. Although it is not practical to estimate distance to each bird, you should indicate whether the birds were observed within 300 m (see Section 5.2). If the majority of the birds are in the air, they can be recorded as flying. However, if they appear to be flushing off the surface of the water as the ship approaches, or continuously moving between the water and air, they are recorded as on the water. When such large flocks are recorded in this way, it is important to indicate the change in protocol in the notes. This scenario is a relatively rare occurrence. Most of the time, distance estimates can be made and flying birds can be separated from those observed on the water.

4.1.6. Birds that follow the ship

After recording a flying bird, it is not subsequently recorded again if it is following the ship. The same bird is not recorded on subsequent snapshots, even if it leaves and then re-enters the survey area. When dozens or more birds are following the vessel, it will be impossible to determine which individuals have already been recorded and which have recently joined the ship. For example, Northern Fulmars (*Fulmarus glacialis*) at times circle the ship in large numbers and as far out as the edge of the transect and beyond. In this case, the number of birds following the ship is estimated at regular intervals (i.e., once an hour) and their association as ship followers (code 18; Appendix VI) is recorded. The ship followers are ignored at intervals between counts. If it can be determined that new individuals are joining the flock, these are recorded and their distance from the observer is estimated.

4.2. Surveys from stationary platforms

Observations from stationary platforms (including ships stopped on station or on standby) are conducted using instantaneous counts, or snapshots, of birds within an area that is scanned at regular intervals throughout the day. These surveys will usually last only a few seconds. The survey is conducted from a position outdoors whenever possible, as close to the edge of the platform as permitted. A position near the edge will increase the detection rates of birds, especially for birds that use the waters at the base of the platform. If surveys are being conducted from a stationary platform such as an oil drilling rig, observers should scan from the same location each time in order to increase the comparability among scans.

Surveys are conducted by scanning a 180º arc, giving priority to birds within a 300 m semi-circle (Figure 3). Observers should practice estimating the locations of the various distance bands prior to beginning observations. This is best accomplished with a distance gauge made from a transparent plastic ruler (see Appendix I). This gauge should be kept close at hand to quickly verify bird distances. The area is visually swept only once per scan, from one side to the other, and all birds on the water and in flight are systematically recorded at that time. The distance to birds from the observer is estimated and recorded for all birds (Figure 3). Binoculars and spotting scopes can be used to confirm species identification and other details as necessary.

The same area is surveyed once every hour during the day, regardless if birds are present or not. When the entire width of the 300 m semi-circle is not visible, the observer indicates the limit of visibility on the data sheet. When no birds are detected during a scan, it is important to record "No birds observed" on the record sheet.

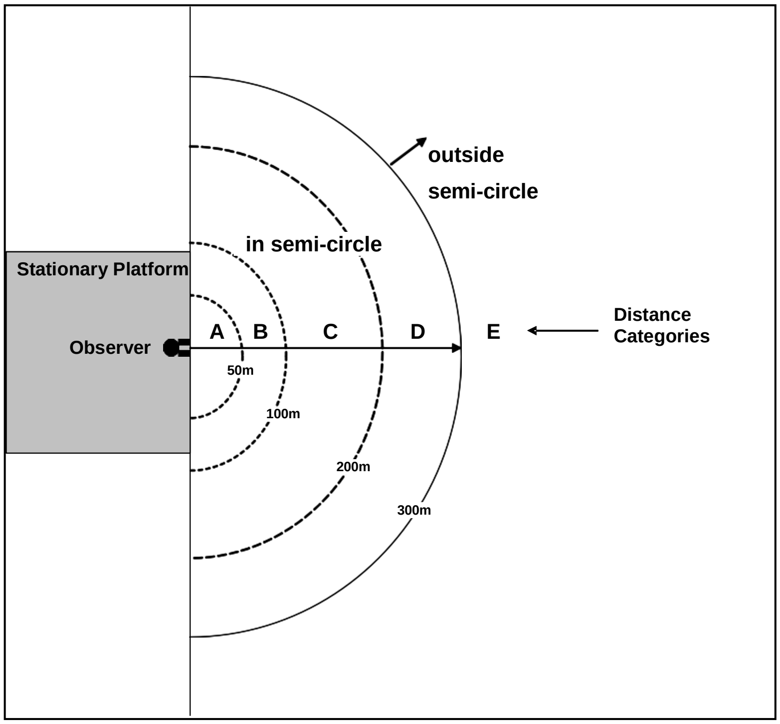


Figure 3. Illustration of survey using a 180º scan, surveying an area 300 m from a stationary observer. All birds observed within this area, whether flying or on the water, are recorded. Birds visible beyond 300 m are also important and are recorded, if at all possible. The distances to all birds are estimated. Birds observed outside the 300 m semi-circle are recorded as not in semi-circle.

5. DATA RECORDING

This section provides detailed information on recording information during each observation period. See Appendix X for example data sheets. Section 5.1 describes the data fields that must be filled in for each 5-minute observation period. Section 5.2 describes the fields recorded for each bird sighting.

5.1 Observation Period Information

It is important to fill in all the fields under the heading “Observation period information” for moving platform surveys, or “Scan information” for stationary surveys at the beginning of each survey. The information collected here may affect which birds are observed and therefore will be important to incorporate into any subsequent analyses.

Company/agency: Seabird observers may be volunteers or contracted through private industry or government agency. Indicate the company, agency or organisation that has requested the surveys (e.g., Canadian Wildlife Service, ExxonMobil, Memorial University).

Platform name and type: Platform type may include seismic ship, offshore supply vessel, fishing boat, research ship, ferry, etc.

Observer(s): Indicate the first and last name of the primary observer. Also record the name of any additional observers assisting with the survey.

Date: Record the date that the survey took place. Use format DD-MMM-YYYY (e.g. 12-Apr-2008) to avoid ambiguity.

Time at start / Time at end: Record the time (using 24 h notation) at the start and end of the observation period. Use Universal Time (UTC) to standardize across regions. Note that the conversion from local time to UTC will be influenced by daylight savings time.

Latitude and longitude at the start and end of the observation period: Indicate position of platform in either decimal degrees (e.g. 47.5185) or degrees and decimal minutes (e.g. 47˚ 31.11´) depending on which format is available to you.

Platform activity: Platform activity may influence observations and should therefore be noted. Activities could include steaming, seismic array active, drilling, off-loading at drilling rig, etc.

Scan type (for stationary platforms only): Conduct a 180˚ scan for all stationary surveys. If part of the survey area is obstructed, indicate the scan angle used.

Scan direction (for stationary platforms only): Indicate the true (not magnetic) bearing when looking straight ahead, at centre of semi-circle.

Visibility: Measure visibility by determining the greatest distance at which you can distinguish objects, ideally black, against the horizon sky with the unaided eye. Under normal atmospheric conditions, visibility depends only on the height above the sea surface from which it is observed (visibility in kilometres = 3.84 * sqrt(height in meters)). For example, on a clear day on a vessel 12 m above the surface, maximum visibility will be 13 km. Visibility will be considerably less during foggy conditions.

Weather conditions: Record the general weather conditions at the time of the survey according to codes in Appendix II. Record the most prominent conditions within the survey area. For example, if there are distant fog patches that do not directly affect the survey conditions, the weather code will be 0 or 1. Alternatively, if there is < 50% cloud cover but you are travelling through fog patches, the weather code will be 2.

Glare conditions: Light reflecting off the surface of the water can often influence bird detection. Record the glare conditions at the time of the survey according to codes in Appendix II.

Sea state code: Sea state codes give an approximate description of current conditions on the surface of the water. Use codes from Appendix III.

Wave height: Estimate wave height (m) from the highest point of a wave (peak) to the lowest point (trough).

Wind speed or force: Indicate wind speed in knots. If observations are from a moving platform, be sure to record the TRUE wind speed, as this takes into account the ‘apparent’ wind generated from the forward momentum of the vessel. If relative wind speed is the only measurement available, indicate that you are recording relative wind speed so that appropriate adjustments can be made later. If no measurements are available, estimate wind speed using Beaufort codes from Appendix III.

Wind direction: Wind direction is the direction from which a wind originates. If observations are from a moving platform, be sure to record the TRUE wind direction, as this takes into account the ‘apparent’ wind generated from the forward momentum of the vessel. If relative wind direction is the only measurement available, indicate that you are recording relative wind direction so that appropriate adjustments can be made later. Use ***ND*** (No Direction) if the wind direction is variable or too light to indicate a particular direction.

Ice Type and Concentration: If ice is present during the survey, indicate the type and concentration using codes from Appendix IV. Indicate in the notes if the ice is present only beyond the transect limits.

Platform speed and direction (for moving platforms only): Record the platform speed in knots and the true (NOT magnetic) platform direction. If the platform speed or direction changes significantly during an observation period, terminate the observation period and record the time and position of termination. Start a new observation period, recording the new speed and/or direction.

Observation side (for moving platforms only): Circle whether you are surveying from ***Starboard*** or ***Port***.

Height of eye (meters): Indicate height of observer's eye above the water in meters. This measurement is important to calibrate distance categories (Appendix I) and may need to be measured with a measuring tape or rope.

Outdoors or Indoors: Circle ***Out*** when conducting observations from a position outdoors and ***In*** for indoor observations.

With snapshot? (for moving platforms only): Indicate if snapshot method is being used for birds in flight by circling ***Y*** or ***N***. Under normal circumstances, snapshots should always be used for birds in flight.

Notes: Make note of disturbances or relevant activities in the area, especially if there are large vessels or fishing activities nearby, or if your vessel is sounding the fog horn.

5.2 Bird Information

At a minimum, the species (which can be unknown), count, fly or water, and in transect (or in semi-circle, if doing stationary surveys) fields MUST be filled in for each sighting. Note that some fields are only appropriate for certain species. For example, age and sex will only be recorded for species where this can be determined (e.g., ageing gulls or sexing waterfowl). Priority is given to birds that are in transect, since these are the only birds that are used in density estimates. Birds recorded not in transect or not in semi-circle give us important information on distribution, timing of occurrence, and behaviour, and effort should be made to record them if time permits.

Species: Identify each individual bird seen to species. If this is not possible, identify to genus or family. Record all unknowns, even if they are identified only as "unknown gull" or "unknown bird". See Appendix V for a list of commonly used species codes. See Section 5.2.1 for information on recording mixed species/age flocks. When garbage is encountered within the survey area, it should be recorded as GARB. Marine mammals, fish and sharks should also be recorded if possible.

Count: Record the number of birds in each sighting in the count field. Record homogenous flocks on a single line. For example, a group of 10 Common Murres (*Uria aalge*) close together on the water is recorded in a single row as a flock of 10 and not as 10 individual rows. If large numbers are present, estimate the number as accurately as possible.

Fly or Water?: Indicate whether the bird(s) observed is in flight (***F***) or on the water (***W***). Occasionally you will have a songbird that may land on the ship. We record these as on the ship (***S***). When surveying close to land, birds sitting on land may be recorded as ***L***.

In transect or semi-circle?: Indicate if bird observed is in (***Y***) or out (***N***) of the transect (moving) or semi-circle (stationary). See Section 5.2.2 for more details. Give priority to birds that are in the transect or semi-circle. Record birds seen outside the transect if activity levels permit.

Association and Behaviour: Record one or more association and/or behaviour codes with each bird when appropriate (see Appendix VI for association and behaviour codes, and refer to Camphuysen and Garthe (2004) for further information).

Distance: Record the distance to each bird or flock. This information is used to assess detectability and account for missed birds (see Section 3). For all birds, estimate the perpendicular distance between the bird(s) and the observer (Figure 1). Distance categories are as follows: ***A*** = 0-50 m, ***B*** = 51-100 m, ***C*** = 101-200 m, ***D*** = 201-300 m, and ***E*** = > 300 m. Record flocks of birds as a single unit by recording the distance to the ***centre*** of the flock. For example, if a group is straddling the 300 m boundary with the flock centre located in ***D*** (with some individuals inside and some individuals outside the transect) record **the entire flock** as being in ***D*.** If the flock centre is outside the transect, record the entire flock as distance class ***E***. It is very important to record distance to birds within the 300 m strip, but if this is not possible (i.e., too busy), you may use ***3*** = within 300 m but no distance recorded. Distance ***T*** is used to indicate that the bird or flock was observed on the opposite side of the vessel.

Flight direction: Indicate true heading direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, ***or NW)*** for birds in flight if they are not associated with the platform. If birds are flying erratically such that no one direction is appropriate, record them as ***ND*** **(no direction)**. Note that *ND* is not the same as not recording flight direction. For example, if the data field is left blank, flight direction information was not collected for that sighting. However, if *ND* was recorded for the sighting, that particular bird(s) was flying erratically, in circles, etc.

Age: Record age based on plumage, where ***J***(uvenile) = first coat of true feathers acquired before leaving the nest; ***I***(mmature) = the first fall or winter plumage that replaces the juvenile plumage and may be worn for several years (across multiple moults) until reaching adulthood; and ***A***(dult) = all subsequent plumages.

Plumage: Adult plumage can be further categorized as ***B***(reeding) = spring and summer plumage, or ***NB*** (non-breeding) = fall and winter plumage. ***M*** is used to indicate a bird with flight feathers moulting.

Notes: Record other pertinent information such as color phase, unusual behaviours, etc.

5.2.1 Recording mixed groups of birds

Sometimes flocks of birds will contain multiple species or age classes and will require multiple rows on the datasheet (e.g., a flock containing both Great and Sooty Shearwaters (*Puffinus gravis* and *P. griseus*), or a flock of Black-legged Kittiwakes (*Rissa tridactyla*) containing both adult and immature birds). Subsets of the group that share the same morphological and behavioural characteristics are recorded in the same row (e.g., all adult kittiwakes in breeding plumage flying in the same direction). Other individuals from the group that have different characteristics (e.g., juveniles) are recorded in subsequent rows. Draw an arc linking all rows from the group to indicate that they were together (see example in Appendix VII).

5.2.2 For moving platforms, when are birds recorded as in transect?

Whether birds are in transect or not depends on whether they are on the water or in flight. Birds on the surface of the water within 300 m perpendicular distance from the observer are always considered in transect (Figure 1). When visibility is good, birds on the water may be seen up ahead of the platform, perhaps as far as 400 m or 500 m ahead, but still within the 300 m transect. Because these individuals may dive or fly away as a result of the approaching vessel, they should be counted as in transect and their perpendicular distance recorded when they are first detected (unless the observation period will end before the ship reaches them, in which case they are recorded in the next period). Flying birds are only considered in transect if they are observed during a snapshot AND they are physically within the snapshot block (within 300 m to the side and 300 m ahead of the vessel) (Figure 1, Appendix VII).

6. CONCLUSION

The Eastern Canada Seabirds at Sea (ECSAS) monitoring program uses this protocol to collect distribution and abundance information for birds at sea in Atlantic Canada. The protocol follows recommendations for standardized recording techniques (Tasker et al. 1984) that are used in the North Sea and northeastern Atlantic with modifications to allow for the estimation of bird detectability (Buckland et al. 2001). Although we are far from achieving a global standardization of methods, it is our hope that this report will serve as a guide for others conducting pelagic bird surveys in our region and elsewhere so that comparisons among seabird communities can be made. It is our recommendation that before any surveys are conducted, observers have the skills necessary to identify the seabirds in their survey area, and participate in a training program that includes specific instruction on implementing the protocol. Future modifications of the protocol will be necessary as methods are tested and techniques developed, and we encourage any feedback that will improve upon our current survey approach.

7. ACKNOWLEDGEMENTS

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APPENDIX I. Estimating distance categories

The various distance categories can be estimated using the following equation[1]:

$$d_h = 1000 \frac{(ah3838\ \sqrt{h}) - ahd}{h^2 + 3838d\sqrt{h}}$$

e.g. if $a = 0.730$ m, $h = 12.5$ m, and $d = 300$ m

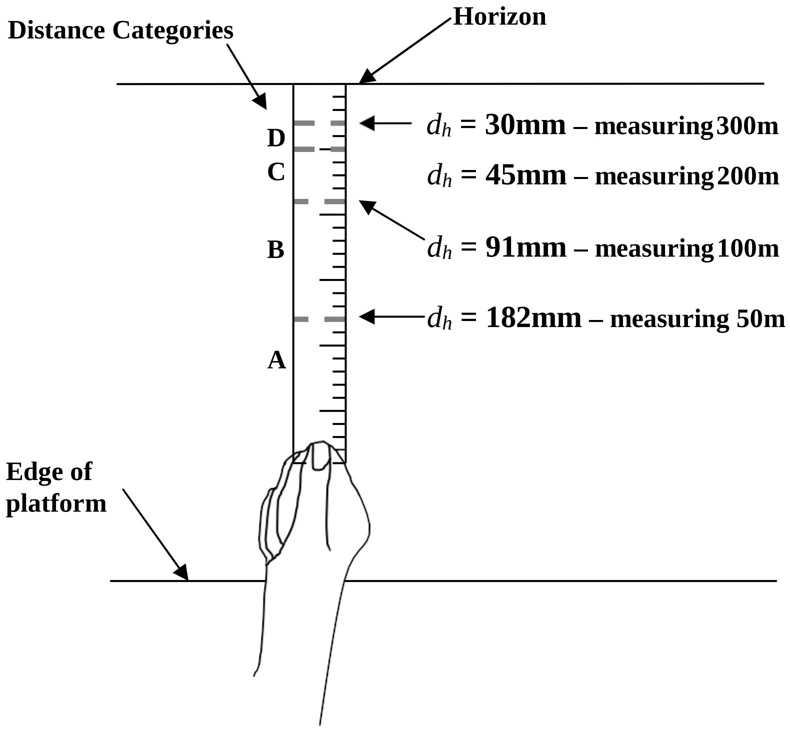
then $d_h = 30.0$ mm

where:

d_h = distance below horizon (mm)
a = distance between the observer's eye and the ruler when observer's arm is fully out-stretched (m)
h = height of the observer's eye above the water at the observation point (m)
d = distance to be estimated (m; a separate calculation is required for each of 50, 100, 200, 300)

Distances are easily estimated using a gauge made from a transparent plastic ruler. A different ruler will be required for each combination of observer arm length (a) and platform height (h). Calculate d_h for the boundary of each distance class (A, B, C, D) and mark them on the ruler (dashed lines in figure). To use the gauge, extend the arm fully and keep the top end of the ruler aligned with the horizon. The dashed lines now demark the distance class boundaries on the ocean surface. Keep the gauge nearby during surveys to quickly verify bird distances.

Measurements for an observer with a = 73 cm and h = 12.5 m:



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[1] Formula derived by J. Chardine, based on Heinemann 1981. A spreadsheet is available from the corresponding author to perform this calculation.

APPENDIX II. Codes for general weather conditions and glare

Code	Description	Explanation
Weather conditions		
0		< 50% cloud cover (with no fog, rain, or snow)
1		> 50% cloud cover (with no fog, rain, or snow)
2		patchy fog
3		solid fog
4		mist/light rain
5		medium to heavy rain
6		fog and rain
7		snow
Glare conditions		
0		none
1		slight/grey
2		bright on the observer's side of vessel
3		bright and forward of vessel

APPENDIX III. Codes for sea state and Beaufort wind force

Wind Speed (knots)	Sea state code and description	Beaufort wind force and description
0	**0** Calm, mirror-like	**0** calm
01 – 03	**0** Ripples with appearance of scales but crests do not foam	**1** light air
04 – 06	**1** Small wavelets, short but pronounced; crests do not break	**2** light breeze
07 – 10	**2** Large wavelets, crests begin to break; foam of glassy appearance; perhaps scattered white caps	**3** gentle breeze
11 – 16	**3** Small waves, becoming longer; fairly frequent white caps	**4** moderate breeze
17 – 21	**4** Moderate waves with more pronounced form; many white caps; chance of some spray	**5** fresh breeze
22 – 27	**5** Large waves formed; white foam crests more extensive; probably some spray	**6** strong breeze
28 – 33	**6** Sea heaps up; white foam from breaking waves blows in streaks in direction of wind	**7** near gale
34 – 40	**6** Moderately high long waves; edge crests break into spindrift; foam blown in well-marked streaks in direction of wind	**8** gale
41 – 47	**6** High waves; dense streaks of foam in direction of wind; crests of waves topple and roll over; spray may affect visibility	**9** strong gale
48 – 55	**7** Very high waves with long overhanging crests; dense foam streaks blown in direction of wind; surface of sea has a white appearance; tumbling of sea is heavy; visibility affected	**10** storm
56 - 63	**8** Exceptionally high waves; sea is completely covered with white patches of foam blown in direction of wind; edges blown into froth; visibility affected	**11** violent storm
64 +	**9** Air filled with foam and spray; sea completely white with driving spray; visibility seriously affected	**12** hurricane

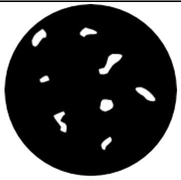
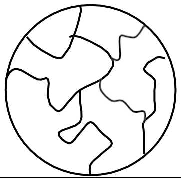
APPENDIX IV. Codes for ice conditions

Adapted from NOAA: Observers Guide to Sea Ice

Sea Ice Forms

Code	Name	Description
0	New	small, thin, newly formed, dinner plate-sized pieces
1	Pancake	rounded floes 30 cm - 3 m across with ridged rims
2	Brash	broken pieces < 2 m across
3	Ice Cake	level piece 2 - 20 m across
4	Small Floe	level piece 20 - 100 m across
5	Medium Floe	level piece 100 -500 m across
6	Big Floe	level, continuous piece 500 m - 2 km across
7	Vast Floe	level, continuous piece 2 - 10 km across
8	Giant Floe	level, continuous piece > 10 km across
9	Strip	a linear accumulation of sea ice < 1 km wide
10	Belt	a linear accumulation of sea ice from 1 km to over 100 km wide
11	Beach Ice or Stamakhas	irregular, sediment-laden blocks that are grounded on tidelands, repeatedly submerged, and floated free by spring tides
12	Fast Ice	ice formed and remaining attached to shore

Sea Ice Concentration

Code	Concentration	Description	
0	< one tenth	"open water"	
1	two-three tenths	"very open drift"	
2	four tenths	"open drift"	
3	five tenths	"open drift"	
4	six tenths	"open drift"	
5	seven to eight tenths	"close pack"	
6	nine tenths	"very close pack"	
7	ten tenths	"compact"	

APPENDIX V. Species codes for birds seen in Eastern Canada

Common name	Species code	Latin name
COMMON, REGULAR OR FREQUENTLY SEEN SPECIES		
Northern Fulmar	NOFU	*Fulmarus glacialis*
Great Shearwater	GRSH	*Puffinus gravis*
Manx Shearwater	MASH	*Puffinus puffinus*
Sooty Shearwater	SOSH	*Puffinus griseus*
Wilson’s Storm-Petrel	WISP	*Oceanites oceanicus*
Leach‘s Storm-Petrel	LESP	*Oceanodroma leucorhoa*
Northern Gannet	NOGA	*Morus bassanus*
Red Phalarope	REPH	*Phalaropus fulicaria*
Red-necked Phalarope	RNPH	*Phalaropus lobatus*
Long-tailed Jaeger	LTJA	*Stercorarius longicaudus*
Parasitic Jaeger	PAJA	*Stercorarius parasiticus*
Pomarine Jaeger	POJA	*Stercorarius pomarinus*
Great Skua	GRSK	*Stercorarius skua*
Herring Gull	HERG	*Larus argentatus*
Iceland Gull	ICGU	*Larus glaucoides*
Glaucous Gull	GLGU	*Larus hyperboreus*
Great Black-backed Gull	GBBG	*Larus marinus*
Black-legged Kittiwake	BLKI	*Rissa tridactyla*
Common Murre	COMU	*Uria aalge*
Thick-billed Murre	TBMU	*Uria lomvia*
Razorbill	RAZO	*Alca torda*
Dovekie	DOVE	*Alle alle*
Atlantic Puffin	ATPU	*Fratercula arctica*
SPECIES MORE COMMONLY SEEN INSHORE		
Common Loon	COLO	*Gavia immer*
Red-throated Loon	RTLO	*Gavia stellata*
Red-necked Grebe	RNGR	*Podiceps grisegena*
Horned Grebe	HOGR	*Podiceps auritus*
Great Cormorant	GRCO	*Phalacrocorax carbo*
Double-crested Cormorant	DCCO	*Phalacrocorax auritus*
Greater Scaup	GRSC	*Aytha marila*
Common Eider	COEI	*Somateria mollissima*
Harlequin Duck	HARD	*Histrionicus histrionicus*
Long-tailed Duck	LTDU	*Clangula hyemalis*
Surf Scoter	SUSC	*Melanitta perspicillata*
Black Scoter	BLSC	*Melanitta nigra*
White-winged Scoter	WWSC	*Melanitta fusca*
Red-breasted Merganser	RBME	*Mergus serrator*
Black Guillemot	BLGU	*Cepphus grylle*

Common name	**Species code**	**Latin name**
INFREQUENTLY OR RARELY SEEN SPECIES		
Cory’s Shearwater	COSH	*Calonectris diomedea*
Audubon’s Shearwater	AUSH	*Puffinus lherminieri*
Lesser Scaup	LESC	*Aythya affinis*
King Eider	KIEI	*Somateria spectabilis*
South Polar Skua	SPSK	*Stercorarius maccormicki*
Bonaparte's Gull	BOGU	*Larus philadelphia*
Ivory Gull	IVGU	*Pagophila eburnea*
Black-headed Gull	BHGU	*Larus ridibundus*
Laughing Gull	LAGU	*Larus articilla*
Ring-billed Gull	RBGU	*Larus delawarensis*
Lesser Black-backed Gull	LBBG	*Larus fuscus*
Sabine’s Gull	SAGU	*Xema sabini*
Common Tern	COTE	*Sterna hirundo*
Arctic Tern	ARTE	*Sterna paradisaea*
Roseate Tern	ROTE	*Sterna dougallii*
CODES FOR BIRDS IDENTIFIED TO FAMILY OR GENUS		
Unknown Bird	UNKN	
Unknown Shearwater	UNSH	*Puffinus* or *Calonectris*
Unknown Storm-Petrel	UNSP	Hydrobatidae
Unknown Duck	UNDU	Anatidae
Unknown Eider	UNEI	*Somateria*
Unknown Phalarope	UNPH	*Phalaropus*
Unknown Jaeger	UNJA	*Stercorarius*
Unknown Skua	UNSK	*Stercorarius*
Unknown Gull	UNGU	Laridae
Unknown Tern	UNTE	*Sternidae*
Unknown Alcid	ALCI	Alcidae
Unknown Murre or Razorbill	MURA	*Uria* or *Alca*
Unknown Murre	UNMU	*Uria*

APPENDIX VI. Codes for associations and behaviours

From Camphuysen and Garthe (2004). Choose one or more as applicable.

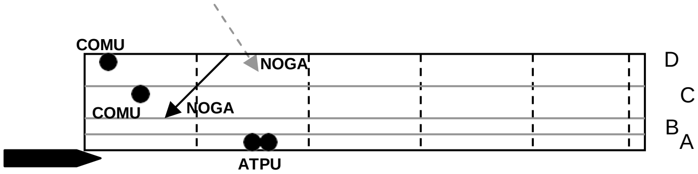
Code	Description
Association	
10	Associated with fish shoal
11	Associated with cetaceans
13	Associated with front (often indicated by distinct lines separating two water masses or concentrations of flotsam)
14	Sitting on or near floating wood
15	Associated with floating litter (includes plastic bags, balloons, or any garbage from human source)
16	Associated with oil slick
17	Associated with sea weed
18	Associated with observation platform
19	Sitting on observation platform
20	Approaching observation platform
21	Associated with other vessel (excluding fishing vessel; see code 26)
22	Associated with or on a buoy
23	Associated with offshore platform
24	Sitting on offshore platform
26	Associated with fishing vessel
27	Associated with or on sea ice
28	Associated with land (e.g., colony)
50	Associated with other species feeding in same location

Code	Description	Explanation
Foraging behaviour		
30	Holding or carrying fish	carrying fish towards colony
32	Feeding young at sea	adult presenting prey to attended chicks (e.g., auks) or juveniles (e.g., terns)
33	Feeding	method unspecified (see behaviour codes 39,40,41,45)
36	Aerial pursuit	kleptoparisitizing in the air
39	Pattering	low flight over the water, tapping the surface with feet while still airborne (e.g., storm-petrels)
40	Scavenging	swimming at the surface, handling carrion
41	Scavenging at fishing vessel	foraging at fishing vessel, deploying any method to obtain discarded fish and offal; storm-petrels in the wake of trawlers picking up small morsels should be excluded
44	Surface pecking	swimming birds pecking at small prey (e.g., fulmar, phalaropes, skuas, gulls)
45	Deep plunging	aerial seabirds diving under water (e.g., gannets, terns, shearwaters)
49	Actively searching	persistently circling aerial seairds (usually peering down), or swimming birds frequently peering (and undisturbed by observation platform) underwater for prey
General behaviour		
60	Resting or apparently sleeping	reserved for sleeping seabirds at sea
64	Carrying nest material	flying with seaweed or other material; not to be confused with entangled birds
65	Guarding chick	reserved for auks attending recently fledged chicks at sea
66	Preening or bathing	birds actively preening feathers or bathing
Distress or mortality		
71	Escape from ship (by flying)	escaping from approaching observation platform
90	Under attack by kleptoparasite	bird under attack by kleptoparasite in an aerial pursuit, or when handling prey at the surface
93	Escape from ship (by diving)	escaping from approaching observation platform
95	Injured	birds with clear injuries such as broken wings or bleeding wounds
96	Entangled in fishing gear or rope	birds entangled with rope, line, netting or other material (even if still able to fly or swim)
97	Oiled	birds contaminated with oil
98	Sick/unwell	weakened individuals not behaving as normal, healthy birds, but without obvious injuries
99	Dead	bird is dead

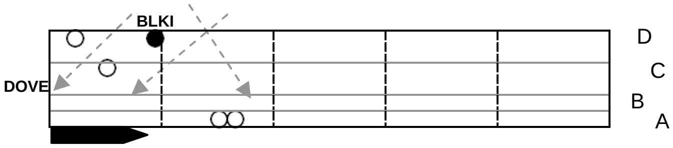
APPENDIX VII. Example 5 min survey from a moving platform[†]

See associated datasheet on pg. 30: We are on a ship travelling east at 10 knots, so in 5 minutes we will travel a distance of approximately 1.5 km. Based on the speed of the vessel, we will conduct a snapshot for flying birds every minute (see Table 1), or 5 times during the survey, and record flying birds detected between snapshots as NOT in transect. In the diagrams that follow, birds on water are represented by dots and flying birds by arrows (birds are at the position of the arrowhead). The vertical dashed lines in the diagrams indicate the boundaries of the 300 m snapshot blocks. Remember, we record the perpendicular distance to all birds.

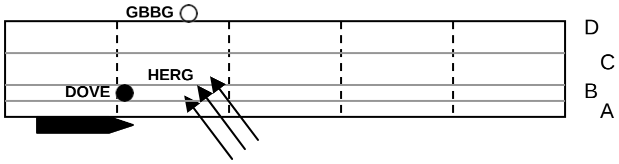
a) We begin the observation period at 11:00 with a snapshot of the flying birds and a count of the birds we see on the water. We see 2 separate adult Northern Gannets flying, although we only count one as in transect, at distance C, as the other is more than 300 m in front of the vessel (at distance D). We also see 2 Common Murres on the water to the port side of the vessel, at distances C and D. These are recorded as in transect. We can also see 2 puffins together on the water, more than 300 m in front of the vessel. We will also count these as in transect, although we will be careful not to count them again as we get closer.



b) Now we are about 30 seconds into the 5 min observation period, **in between snapshot counts**. We have already counted the 2 murres and 2 puffins on the water (shown in the figure as open circles), but an adult Black-legged Kittiwake has appeared on the water at distance D, and we add this to our list as in transect. Despite the appearance of a flying Dovekie within 300 m of the vessel at distance C, we do not count it as in transect because we are between snapshots. We add the Dovekie to our list but indicate that it is NOT in transect.

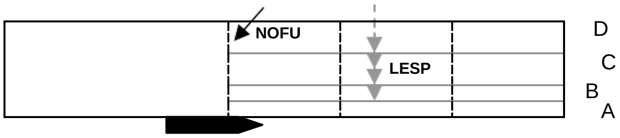


c) At minute 1, we take another snapshot count of flying birds. A flock of 3 Herring Gulls is seen traveling NW. The centre of the flock is at distance B. We also see one Dovekie on the water at distance B, and one Great Black-backed Gull outside 300 m (distance category E). These are all in transect except for the gull at distance E.

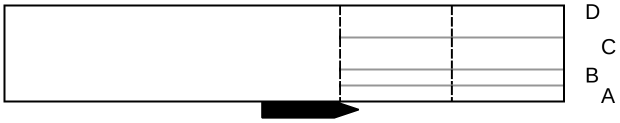


[†] Adapted from Tasker et al. 1984.

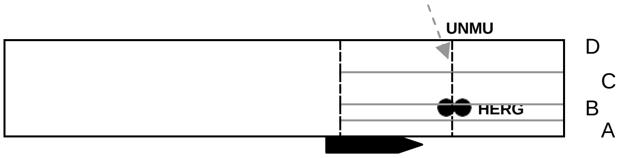
d) At minute 2, we perform another snapshot and count one flying Northern Fulmar in transect at distance D travelling SW. We record the flock of 4 Leach's Storm-Petrels flying south ahead of the vessel (at distance C) but do NOT count them as in transect as they are beyond 300 m.



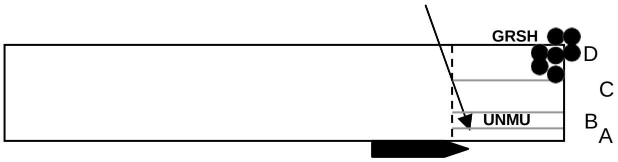
e) At minute 3 we conduct another snapshot. No new birds are observed, so nothing new is written on our data sheet.



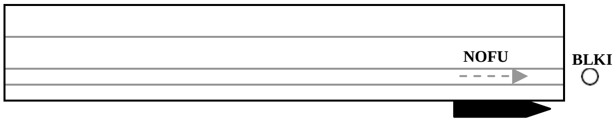
f) At 3:42, a murre of unknown species is observed flying but we DO NOT count it as in-transect because we are **between snapshots**. We will record it as NOT in transect. We record the 2 Herring Gulls feeding (behaviour code 44) up ahead on the water, both in transect at distance B. Because one is a juvenile and one is an adult, we enter them on separate datasheet rows, linking the two with an arc in the left margin.



g) At minute 4, our next snapshot takes place and we note that the unknown murre that we saw flying earlier (see frame f) can now be recorded as in transect at distance B, as it is within 300 m of the vessel AND observed during the snapshot. If we know for certain that this is the same individual we previously recorded as NOT in transect (frame f), we can cross the previous observation out. If we are not certain that this is the same individual we do not cross anything out. There is also a large flock of 200 Great Shearwaters on the water near the edge of the 300 m transect. Since the centre of the group is within the transect, at distance D, we count ALL the shearwaters as being at distance D. If the centre of the group had been beyond 300 m, we would have recorded them as outside the transect at distance E, despite some individuals being in the transect.



h) As we approach the end of the 5 min observation period, we record a Northern Fulmar that is following us (at distance B), but has not been previously recorded. We record it as NOT in transect since we are not at a snapshot point. Remember, you must record ship-followers as “associated with platform” (code 18). We do not include the kittiwake we can see ahead of the vessel, because by the time we reach it, the 5 min observation period will be over. This bird will be counted in the next period.



Example datasheet of a 5 min survey from a moving platform

Observation Period Information:

Company/agency	**CWS**		Sea state code	**3**
Platform name and type	**Hudson, DFO Research**		Wave height (m)	**1**
Observer (s)	**Carina Gjerdrum**		True wind speed [✓ (knots)] **OR** Beaufort code	**12**
Date (DD/MMM/YYYY	**24 May 2007**		True wind direction (deg)	**93°**
Time at start (UTC)	**11:00**		Ice type code	**0**
Time at end (UTC)	**11:05**		Ice concentration code	**0**
Latitude at start / end	**42°46.307**	**42°45.803**	True platform speed (knots)	**10.0**
Longitude at start / end	**-61°59.156**	**-61°58.233**	True platform direction (deg)	**191°**
Platform activity	**Steaming**		Observation side	Starboard [✓ Port]
Visibility (km)	**13.5**		Height of eye (m)	**12.3**
Weather code	**0**		Outdoors or Indoors	Out or [✓ In]
Glare conditions code	**1**		Snapshot used?	[✓ Yes] or No

Notes:

Bird Information: *this field <u>must</u> be completed for each record

	* Species	* Count	* Fly or Water?	* In transect?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments
a)	NOGA	1	F	Y	C			SW	A			
	NOGA	1	F	N	D			SE	A			
	COMU	1	W	Y	C							
	COMU	1	W	Y	D							
	ATPU	2	W	Y	A							
b)	BLKI	1	W	Y	D				A			
	DOVE	1	F	N	C			SW				
c)	HERG	3	F	Y	B			NW				
	DOVE	1	W	Y	B							
	GBBG	1	W	N	E							
d)	NOFU	1	F	Y	D			SW				
	LESP	4	F	N	C			S				
f)	UNMU	1	F	N	D			SE				
	HERG	1	W	Y	B		44		A			
	HERG	1	W	Y	B		44		J			
g)	UNMU	1	F	Y	B			SE				
	GRSH	200	W	Y	D							
h)	NOFU	1	F	N	B	18						

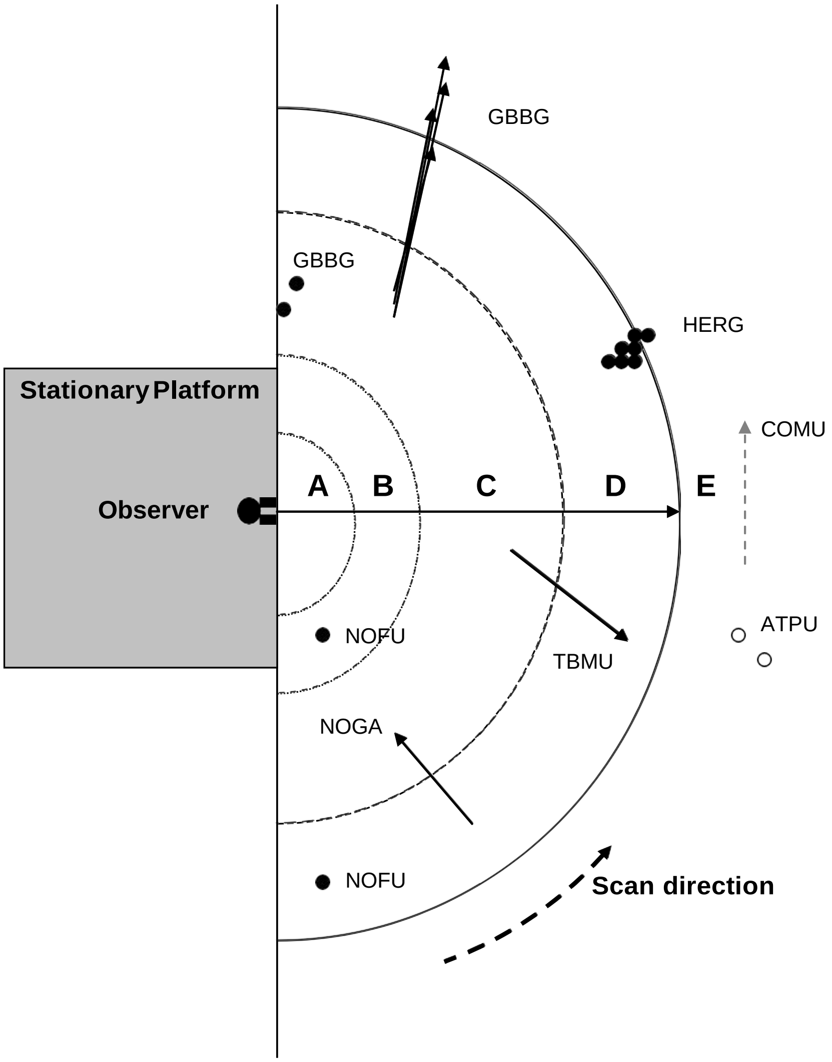
[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.

[2] Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction

[3] ***J***(uvenile), ***I***(mmature), or ***A***(dult); [4] ***B***(reeding), ***NB***(non-breeding), ***M***(oult)

APPENDIX VIII. Example survey from a stationary platform

See associated datasheet on pg. 33: Before we begin the scan, we record the required Scan Information at the top of the datasheet. We are facing east and about to conduct our first survey of the day from an offshore oil platform. We have estimated the distance from where we are standing out to 50 m, 100 m, 200 m, and 300 m using our ruler gauge created with the formula outlined in Appendix I. We will now visually scan a 180° arc, counting all birds observed and estimating their distance from the platform. Before we begin the scan, we record the required Observation Period Information at the top of the datasheet. The survey begins on the right hand side of the semi-circle. In the diagram that follows, birds on water are represented by dots and flying birds by arrows (birds are at the position of the arrowhead).



a) A Northern Fulmar sits on the water approximately 250 m away from us. Another sits within 100 m of us. We add both of these as separate entries on the datasheet.

b) An adult Northern Gannet is flying towards us at distance C and we record it as in semi-circle.

c) We observe a flying Thick-billed Murre travelling southeast, and we record it as in semi-circle at distance D.

d) We can see 2 Atlantic Puffins beyond 300 m sitting on the water. We record them on the datasheet in distance E but note that they are NOT in the semi-circle.

e) We also see a Common Murre flying north beyond 300 m and record it as NOT in semi-circle at distance E.

f) A flock of 7 Herring Gulls is observed at the edge of the 300 m semi-circle. Because the centre of the group is within the semi-circle, at distance D, we count ALL the gulls as being at distance D. If the centre of the group had been beyond 300 m, we would have recorded them as outside the semi-circle at distance E, despite some individuals being in the semi-circle.

g) Four Great Black-backed Gulls are flying north, away from the platform. Since the centre of the flock is outside the semi-circle, these individuals are recorded as outside the semi-circle at distance E (see Section 4.1.4, ***Lines of Flying Birds***)

h) Two additional Great Black-backed Gulls are sitting in the water feeding at distance C. The code for feeding behaviour is '33' (see Appendix VI). Because one is an immature and one is an adult, we enter them in two datasheet rows, linking the two with an arc in the left margin.

Example datasheet for a survey from a stationary platform

Scan Information:

Company/agency	**CWS**	Weather code	**1**
Platform name and type	**Terra Nova FPSO**	Glare conditions code	**0**
Observer (s)	**Carina Gjerdrum**	Sea state code	**3**
Date (DD/MMM/YYYY)	**13 April 2007**	Wave height (m)	**1**
Time at start (UTC)	**0800**	True wind speed (knots) **OR** Beaufort code	**12**
Latitude	**46°45.000**	True wind direction (deg)	**93°**
Longitude	**-48°46.799**	Ice type code	**0**
Platform activity	**Anchored offshore**	Ice concentration code	**0**
Scan type	**[✓ 180°] or other (specify:)**	Height of eye (m)	**33 m**
Scan direction	**East**	Outdoors or Indoors	Out or [✓ In]
Visibility (km)	**10 km**		

Notes:

Bird Information: *this field must be completed for each record

	* Species	* Count	* Fly or Water?	* In semi-circle?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments
a)	NOFU	1	W	Y	D							
	NOFU	1	W	Y	B							
b)	NOGA	1	F	Y	C			NW	A			
c)	TBMU	1	F	Y	D			SE				
d)	ATPU	2	W	N	E							
e)	COMU	1	F	N	E			N				
f)	HERG	7	W	Y	D							
g)	GBBG	4	F	N	E			N				
h)	GBBG	1	W	Y	C		33		I			
	GBBG	1	W	Y	C		33		A			

[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.

[2] Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction

[3] ***J***(uvenile), ***I***(mmature), or ***A***(dult); [4] ***B***(reeding), ***NB***(non-breeding), ***M***(oult)

APPENDIX IX. Check-list of materials required while conducting seabird surveys

☐ Multiple pens or sharp pencils **(required)**

☐ Multiple copies of blank recording sheets and clipboard **(required)**

☐ Binoculars **(required)**

☐ Watch or clock **(required)** - with countdown timer that can beep on snapshot intervals

☐ Global Positioning System (GPS) to determine vessel position, speed and direction plus extra batteries **(required)**

☐ Compass or GPS to determine flight direction of birds **(required)**

☐ Copy of protocol (**required**)

☐ Seabird identification guide (**required**)

☐ Transparent ruler to determine distances (**required**)

☐ Steel toed boots (**required** for most vessels)

☐ Security and medical certificates (**required** for most vessels)

☐ Notebook (recommended)

☐ Warm and waterproof clothing (recommended)

☐ Calculator or Excel spreadsheet[†] for equation in Appendix I to determine observation distances (recommended)

☐ Laptop for data entry (recommended). Software is available for data entry from corresponding author.

[†] An Excel spreadsheet that automatically performs these calculations is available from the corresponding author.

APPENDIX X. Blank record sheets for moving and stationary platforms

Record sheet for a moving platform survey

Observation Period Information:

Company/agency			Sea state code	
Platform name and type			Wave height (m)	
Observer (s)			True wind speed (knots) **OR** Beaufort code	
Date (DD/MMM/YYYY)			True wind direction (deg)	
Time at start (UTC)			Ice type code	
Time at end (UTC)			Ice concentration code	
Latitude at start / end			True platform speed (knots)	
Longitude at start / end			True platform direction (deg)	
Platform activity			Observation side	Starboard Port
Visibility (km)			Height of eye (m)	
Weather code			Outdoors or Indoors	Out or In
Glare conditions code			Snapshot used?	Yes or No

Notes:

Bird Information: *this field must be completed for each record

* Species	* Count	* Fly or Water?	* In transect?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments

[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.

[2] Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction

[3] ***J***(uvenile), ***I***(mmature), or ***A***(dult); [4] ***B***(reeding), ***NB***(non-breeding), ***M***(oult)

Record sheet for a stationary platform survey

Scan Information:

Company/agency		Weather code	
Platform name and type		Glare conditions code	
Observer (s)		Sea state code	
Date (DD/MMM/YYYY)		Wave height (m)	
Time at start (UTC)		True wind speed (knots) **OR** Beaufort code	
Latitude		True wind direction (deg)	
Longitude		Ice type code	
Platform activity		Ice concentration code	
Scan type	180° or other (specify:)	Height of eye (m)	
Scan direction		Outdoors or Indoors	Out or In
Visibility (km)			

Notes:

Bird Information: *this field <u>must</u> be completed for each record

* Species	* Count	* Fly or Water?	* In semi-circle?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments

[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.

[2] Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction

[3] ***J***(uvenile), ***I***(mmature), or ***A***(dult); [4] ***B***(reeding), ***NB***(non-breeding), ***M***(oult)

www.ec.gc.ca

Additional information can be obtained at:

Environment Canada
Inquiry Centre
10 Wellington Street, 23rd Floor
Gatineau QC KIA OH 3
Telephone: 1-800-668-6767 (in Canada only) or 819-997-2800
Fax:819-994-1412
TTY: 819-994-0736
Email: enviroinfo@ec.gc.ca

Appendix C Inexperienced Observer Protocol

A. ENVIRONMENTAL DATA SHEET (OSRP - 05)

To be completed at beginning of each observation period.
Please note any changes that occur during observation period.

Date			Vessel		
Time Start			Time End		
Lat/Long Start			Lat/Long End		
Visibility			Sea State		
Vessel Speed (kts)			Vessel Direction (°T)		
Band Width (m)			Observation Ht. (m)		

Time Zone: NST ☐ NDT ☐ UTC ☐

Watch side if in transect is 90º – Port ☐, Starboard ☐

if in transect is 180º – Ahead ☐

Environmental Conditions at Time of Observation					
Wind Speed:		kph or kts	Wind Direction:		°T (from)
Current Speed		kph or kts	Current Direction		°T (to)
Seastate (Hs):		m	Visibility:		nm
Water Temp:		°C	Salinity:		ppt

Notes:

Updated April 26, 2011

SUNCOR
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B. SEABIRDS AT SEA RECORD SHEET (OSRP - 06)

Date:____________________ **Observer:**________________________________ **Vessel:** _____________________________________

Time	Lat	Long	Species or Description	Number Sighted	In Transit	Flying	On Water	Age	Notes

Updated April 26, 2011

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