2012 Report of the **Regional Bird Monitoring Program** for the Oil Sands

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Preface

The data contained in this report result from the collaborative effort of five industrial partners with support from the Government of Alberta Department of Environment and Sustainable Resource Development and the University of Alberta. Most of the data were collected by personnel employed by mining companies or their contractors. Some of the data contained in the report were collected by students and employees of the University of Alberta as part of a study of inter-observer variation in monitoring results. Personnel at the University of Alberta collated the data from all sources and requested additional information from industry to standardize data formatting and to support the summaries and syntheses in this report.

Drafts of the report were circulated by the authors on 20 February 2013 and 30 April 2013 and extensive comments on those drafts were provided by one or two representatives from each of the five participating oil sands operators, three provincial employees, and one participant from the federal government. Those comments are gratefully acknowledged below and a record of them indicating how they were used to modify the final report is available upon request to the authors.

Although the approach to report preparation and refinement was largely collaborative, the authors are responsible for the synthesis and interpretations presented here, including any errors or omissions that may remain. In addition to unintentional errors or omissions, there were some differences in opinion among operators and between operators and authors concerning both content and style of the final report. To accommodate these differences and to acknowledge the autonomy of individual operators, all industry partners have been invited by the Government of Alberta to provide additional interpretations of the results via letters submitted directly to Alberta Environment and Sustainable Resource Development with the final version of the report.

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Executive Summary

This report describes the second annual product of a standardized monitoring program that was initiated in 2011 in the oil sands region of Alberta to determine the number of birds coming in contact with and dying on the process-affected (hereafter PA) water ponds produced by the oil sands mining industry. The program is supported by collaborative effort from industry, government and academia stemming from circumstances associated with the mortality of 1 600 birds on a tailings pond in 2008. The program is guided by five objectives and progress toward each is described in this summary.

1. **Estimate bird contacts and mortalities on ponds containing process-affected waters.** Observers for five oil sands companies monitored 80 survey stations on 53 PA ponds daily between 16 April and 6 July (Spring) and between 25 July and 31 October (Fall) in 2012. Over 70 thousand birds of 152 unique species designations were detected as flying, landed, or heard during these monitoring sessions. Of this total, 20 540 were detected as landed birds belonging to foraging guilds targeted by the monitoring program because they potentially come in contact with process-affected water by dabbling, diving or wading for food. Extrapolating to the total area of ponds suggests that there were over 200 000 contacts (i.e., landings) of target birds with PA water.

   The number of landed birds from target guilds was much higher in the fall and divers were more prevalent than the other target guilds. Many species were detected almost exclusively in either Spring or Fall, demonstrating the need to monitor in both seasons. Across sites, detections of birds peaked in the hours after sunrise and declined through the rest of the day. Comparing simultaneous sessions by Industry and University (hereafter U of A) observers demonstrated high variation in the number of individuals and species recorded, suggesting that greater standardization of methods, particularly for distance estimation, is needed.

   In contrast to the high number of landed birds, only 139 mortalities were detected; 88 through scheduled searches comprised by almost 3 000 hours of boating, walking or driving, and 51 via reports following euthanasia or incidental detection.

2. **Estimate bird contacts on ponds containing fresh water.** Eight survey stations were monitored on six freshwater ponds (hereafter FW) to comprise a total survey area that was one tenth the size of that dedicated to PA ponds. Comparable numbers of individuals and species were detected suggesting that FW ponds attract five times as many birds as PA ponds. The greater density of birds at FW ponds might have occurred because they contain natural features and vegetation, which could provide food and shelter to birds, and / or because FW ponds lack bird deterrent systems.

3. **Develop a standardized monitoring program for all oil sands mine operations to provide comparable data across ponds, sites, seasons, and years.** Several observations during the 2012 season and discussion among industry, government and U of A on drafts of this report supported adjustments to the 2013 monitoring plan. In brief, these changes were to

  - **a.** increase the use of high-quality optical equipment for bird detection and distance estimation;
  - **b.** further standardize electronic data entry and conduct ongoing quality assurance and quality control during monitoring seasons;
  - **c.** decrease the frequency of mortality searches;
  - **d.** cease recording auditory detections of birds;
  - **e.** more formally designate the locations of survey stations and mortality searches;
  - **f.** refine criteria to narrow the incidental recording of live birds; and
  - **g.** increase preliminary reporting of data by the U of A to operators.

4. **Identify species at risk that have been affected through contact on ponds containing process-affected waters.** No confirmed sightings occurred at PA ponds of species designated under the federal Species at Risk Act. Several species with the lesser and informal provincial designation of sensitive were detected at PA ponds and some of them were abundant. Additional sensitive species were detected as part of the incidental records and at FW ponds, contributing to a comprehensive list of sensitive species for Oil Sands lease sites.

5. **Provide direction on adaptive management for long-term monitoring and bird deterrent programs.** Preliminary analyses of the characteristics of ponds that correlate with landed birds and mortalities indicated that birds are especially attracted to FW ponds and PA ponds with vegetation along the shore or as floating islands. Mortalities are more likely to be reported on large ponds with sloping beaches that contain bitumen. Deterrent density is weakly predictive of reduced mortalities, but there was no effect of pond or shore area below an 80 dB acoustic threshold. Synthesis of these results suggests that government and industry should revisit the goal of preventing birds from landing anywhere on PA ponds and instead increase efforts to segregate birds from bitumen. Because the 80 dB threshold of long range acoustic devices extends several km beyond pond perimeters, without preventing landing by target birds, this approach to bird deterrence should be further evaluated against existing alternative deterrent types with lesser economic, social, and ecological costs.

Introduction

Global declines in biodiversity result from human activities that remove or degrade natural habitat[1]. Measuring these negative effects is difficult, especially when they occur in remote locations, sporadically, indirectly, over large spatial scales and via multiple mechanisms and contributors[2]. Overcoming the difficulty of measuring these negative effects is necessary to identify mitigation that can reduce the rate of biodiversity loss, thus maintaining ecosystem health and preserving associated ecosystem services for people[3].

One context where it is both important and difficult to measure the effects of human activity on ecosystems is the oil sands region of northern Alberta, which is estimated to contain the third largest oil reserve on Earth[4]. The Government of Alberta estimates the oil sands deposit to underlie an area of 140 200 km^2, but only a small proportion of this deposit is accessible by surface mining. For the past 30 years, surface-accessible oil sands have been processed by excavating the sand from large, open-pit mines, separating the sand from the oil it contains using hot water, and depositing the by-products, including water, in tailings ponds[5]. Water is typically recycled from the larger ponds for subsequent use in the mining process. In 2012, there were over 50 ponds that contained process-affected water in the minable oil sands region. These ponds varied in both purpose and size from areas designed to collect surface drainage that were less than 1 ha in area to tailings ponds intended to capture all liquid tailings from the mine in water bodies as large as10 km^2. An estimated area of 715 km^2 is disturbed by current surface mines[6].

The tailings ponds produced by the oil sands industry are especially hazardous to migratory water birds because their northern extent lies just 150 km south of the Peace-Athabasca Delta, an internationally-important staging area for water birds that hosts as many as 1.5 million birds each spring and fall[7]. As the second-largest freshwater delta in the world, the area is especially important to waterfowl and it is the only region in North America that is believed to attract birds from all four of the continental flyways.[8] During that travel, birds may stop to rest and seek forage or mates on tailings ponds, particularly when those ponds are ice-free in the early spring owing to warm water effluent[9] or during storm events that can cause migrating birds to land abruptly[10].

Oil sands operators employ a variety of techniques to deter birds from landing[11]. Deterrents are typically comprised of both auditory and visual stimuli that are used in a variety of other industrial contexts, especially airports[12]. As part of their environmental approvals, oil sands operators are obliged to create and submit a *Waterfowl Protection Plan*, which specifies how they will monitor the number of birds coming in contact with their tailings ponds and how they will endeavor to minimize those contacts. A minimum standard of action is implied by the concept of due diligence via legislation described by the provincial *Environmental Protection and Enhancement Act*[13] and the federal *Migratory Birds Convention Act*[14]. Neither piece of legislation provides specific guidelines to identify an acceptable number of birds that may be killed via contact with ponds or the appropriate type, intensity, and distribution of deterrents.

The need for bird protection in the oil sands engaged sudden public attention when 1600 birds died in the spring of 2008 at a tailings pond where deterrents had not yet been placed for the season. Ultimately, the absence of due diligence was fundamental to the subsequent conviction stemming from this event (*R. vs. Syncrude*[15]), but it did not obviously apply to the landing of over 500 birds in the fall of 2010 on six ponds containing process-affected water, all of which contained functioning deterrents[16]. Both landing events highlighted the need for a standardized monitoring program that determines annually how many birds come in contact with process-affected water, how many die as a result of that contact, and how variation in landings and mortality are related to the specific deterrent practices that are applied to the dozens of ponds containing process-affected water. Only with specific and comparable information of this sort is it possible to identify rigorous and defensible standards for biodiversity protection in this and other contexts.

To support better bird protection in the oil sands, the provincial government department of *Alberta Environment* (now *Alberta Environment and Sustainable Resource Development*; hereafter *AESRD*) initiated the *Regional Bird Monitoring Program* in the spring of 2011[17]. Industry invited the University of Alberta (U of A) to receive and report on the data collected with the standardized program because of its associated research on bird protection stemming from funding awarded via a creative sentence from *R. vs. Syncrude.* These circumstances forged a novel collaboration among industry, government, and academia to develop, implement, and refine a standardized monitoring program. Regulators and biologists from both the provincial and federal governments have provided direction on standards of monitoring to meet regulatory approval, five industry operators have implemented the program annually and submitted their data, and a team of researchers at the U of A, which has supported the implementation and refinement of the monitoring plan and reported for the first time in 2012[18] on the data it produced.

Here we report on the second year of the *Regional Bird Monitoring Program.* This program provides the first standardized, comprehensive, rigorous, and public information on bird activity in the oil sands region in the 35-year history of this industry with potential application to many other industries and locations.

Goals and Objectives

The purpose of the Regional Bird Monitoring Program is to provide a robust and systematic monitoring program that documents bird interactions with liquid storage facilities at oil sands mining facilities. This program will ultimately provide site-specific guidance on bird deterrent strategies aimed at reducing bird contacts and mortalities. Specific objectives of the monitoring program are to:

1. Provide an estimate of bird contacts and mortalities on ponds containing process-affected waters.

2. Provide an estimate of bird contacts on ponds containing fresh water.

3. Develop a standardized monitoring program for all oil sands mine operations to provide comparable data across ponds, sites, seasons, and years.

4. Identify species at risk that have been affected through contact on ponds containing process-affected waters.

5. Provide direction on adaptive management for long-term monitoring and bird deterrent programs.

Methods

Throughout the report, we use terms that are specific to the oil sands region and we define these terms in accordance with common usage by the government and industry (Table 1). These methods summarize those contained in the complete protocol that was provided to all operators in April 2012 (Appendix A). Throughout the methods section, PA refers to ponds containing process-affected water and FW refers to those containing freshwater. We have used the industry abbreviations for our partners -- CNRL, Imperial, Shell, Suncor, and Syncrude -- that are commonly used on company websites and in the region (Table 1).

The minable oil sands region of Alberta begins approximately 15 km north of Fort McMurray and extends northwards to cover an area of approximately 4 800 km^2 (Figure 1)[19]. In 2012, there were five operators mining oil sands in the region, although one operator, Imperial Oil, was not yet producing separated bitumen. Within the leased areas for these five operators, there are currently 53 ponds designated as containing, or potentially containing PA water and another 6 ponds designated as containing only freshwater that has not been in contact with mine operations (Table 2). The PA ponds range in size from less than 0.1 ha to over 10 km^2.

Freshwater ponds pose no direct hazard to migratory birds and the degree of hazard posed by PA ponds is likely determined by several factors. We requested the following information from operators as descriptors of the ponds on their lease sites: pond characteristics (year of origin, likelihood of containing bitumen, water type, and area in ha), the locations of survey stations, the presence of attractants (including beach, vegetation, and islands), and the number and location of deterrents and deterrent systems.

We then used this information in ArcGIS[20] to calculate the area of survey stations that was comprised by water or shore and their sum, which we expressed in both ha and as a percent of total pond area. We also calculated the distance to the Athabasca River from each of the pond centroid and nearest edge. We estimated the capacity of bird deterrence for each pond in two ways. First, we simply summed the deterrent devices of all types that were described by operators as occurring on each pond and divided that sum by pond area to determine deterrent density. To accommodate the large range in sound power of different acoustic deterrent types, we designated 80 dB as an arbitrary, but biologically-relevant, threshold[21] of acoustic deterrence, calculated the spatial extent of each deterrent device based on manufacturer specifications of sound power 1 m from source (Appendix B), assumed sound attenuation with distance under ideal conditions of transmission, and used GIS to measure the area of each pond that was expected to fall below this acoustic standard. We measured the area within 200 m of shore separately from the remainder of ponds because other work suggests that bird mortalities are more likely to occur there.[22] Additional information on bird monitoring and deterrent programs for each lease site was supplied by operators and is listed verbatim in Appendix B.

In addition to these spatial attributes, there are several important temporal attributes. Birds are most prevalent in the region during spring and fall migration, but the annual production of young means that fall migration contains as many as 50% more individuals[23]. Weather patterns and diel (i.e., pertaining to a daily pattern) activity cycles additionally influence the probability of landing. Many birds, including most waterfowl and shorebirds, migrate at night and migrating birds are more likely to land abruptly during storm conditions[24]. Analysis of a landing event in 2010 suggests a combination of spatial and temporal factors might increase the likelihood that birds will land in bitumen. These include storm conditions at night with recent easterly winds, proximity of anthropogenic lights and the Athabasca River, ponds where deterrent intensity is relatively low, and downwind shores[25]. We did not attempt to measure or examine the effect of temporal variables beyond the effects of time of day and season on the prevalence of detections of live birds.

Monitoring Protocols

Pond inventories for live birds

The 2012 *Regional Bird Monitoring Plan* specified that operators would survey one station on small ponds (< 1.5 km^2), 2 stations on medium-small ponds (1 .5 km^2 – 5.0 km^2), three stations on medium-large ponds (5 km^2 – 10 km^2) and 4 stations on very large ponds (> 10 km^2).

At each survey station, observations were conducted by one, two, or more individuals, but typically by one person. Each survey station on a PA pond was visited once daily. If possible, observations were conducted in the morning and the order of visits was alternated among days to avoid systematic biases in detection frequency by pond.

Observations were conducted for 10 minutes at small ponds (< 1.5 km^2) and 30 minutes for each survey station at larger ponds. Observations were conducted by scanning the water surface and adjacent shorelines as well as the air above the survey area. When birds were detected, they were identified with as much specificity as possible and their position was recorded as a distance and bearing from the observer. Observers were encouraged to use binoculars, spotting scopes, compasses and range finders to support their observations. When possible, observers were to indicate whether landed birds contacted water, shore, or vegetation, but this information can often be assumed reliably from bird type.

In addition to observations of live birds, observers were to record for each survey the station identity and its geographic position (UTM), the start and end times, the date, and categorical weather variables describing precipitation, wind, cloud cover, cloud ceiling, visibility, and the pond characteristic of bitumen coverage.

In 2012, several methods of data recording were employed. Syncrude entered their data on tablets and uploaded them immediately to a cloud-based server via connection to the 3G cell phone network, whereas Imperial used tablets for data entry, but uploaded data after returning to their office. Shell began the season by recording their data on paper, entering into a spreadsheet, and submitting it electronically but later they adopted tablets with live uploading of data. CNRL and Suncor recorded data throughout 2012 with an independent method (paper or computer) and submitted electronic spreadsheets later. Operators that did not record their data via tablets submitted their data at least monthly and sometimes more frequently. Separate forms were used to describe site attributes (which were needed only once per survey) and bird observations.

Mortality Searches

Mortality searches were conducted for all ponds containing PA water twice weekly via systematic searches of pond surface and shorelines. Operators could conduct mortality searches by foot, truck, or boat according to pond size and their operational preferences. When birds were detected, they were to be attributed to a location, identified if possible, collected for examination by a biologist, and reported to ASRD. Operators were asked to record the time spent searching and the area covered so that survey effort could be compared to survey results. In addition to the mortalities detected via scheduled mortality searches, operators were obliged to complete incident reports for all birds (and other wildlife) that were found dead on their sites or euthanized because of contact with bitumen or other site hazards. These observations were also included in this report when available and either identified as coming from a specific pond or identified as being oiled. Mortalities reported in the database from any other cause (e.g., electrocution) were not included in the results below.

Species at risk

We identified in this report any species listed as sensitive or greater risk in the *Alberta Risk Status* using the *General Status Categories* of: at risk (of extinction), may be at risk, sensitive, or secure. We did not indicate a risk category for any species that was listed as undetermined, not assessed, exotic, extirpated, or accidental. We used the general status of species for our categorization because many of Alberta's species have not yet been evaluated under the more specific criteria used by the provincial ESCC[26] (Endangered Species Conservation Committee or the federal COSEWIC[27] (Committee on the Status of Endangered Wildlife in Canada) because many species have yet to be evaluated in detail. Both committees employ the detailed red list criteria recommended by the IUCN[28] (International Union for the Conservation of Nature) and are used by hundreds of other countries and conservation organizations. Species with a legal listing under provincial or federal committees are also identified in this report.

Inter-observer variation study

To assess the reasons for variation in the number and species of birds detected among ponds and operators, we initiated a study of inter-observer variation in the 2012 monitoring season. Two observers from the U of A accompanied industry observers on their daily monitoring rounds, ideally in the same truck with identical survey times and locations. The two sets of observers conducted their observations independently using their own observational equipment, but they were encouraged to discuss what they had seen after each survey was conducted.

Standardization of data and analysis

Substantial effort was applied to standardization of data after collection to create and maintain the master database that served as the basis for the tables and figures in this report. Data standardization included the correction of missing or erroneous information, consolidation of species, site, and observer names, reclassification of information attributed to one kind of observation that did not meet protocol criteria (e.g., birds observed outside of the specified time or distance limits in the standardized observations were reclassified as incidental observations), and removal of duplicate records.

The sources of the errors in data we detected typically stemmed from technical problems using tablets (e.g., inaccurate GPS readings), entry errors by observers (e.g., failing to record some variables), formatting inconsistencies when alternative methods of data entry were used (e.g., excel vs. tablet forms), transcription errors or double-entry from paper-based data collection, and coding inconsistencies stemming from inadequate instruction or restrictions on tablet forms. Examining these errors supported several specific adjustments to the 2013 monitoring plan, particularly in the training of observers and the programming of data forms, which should reduce the need for data standardization in future.

We summarized data from PA and FW ponds separately throughout the report. Mortality searches applied only to PA ponds. We compared metrics of birds observations for PA and FW ponds. At the request of industry and government, we also provided a preliminary comparison of live birds and mortalities among the 53 PA ponds and related these metrics to several other pond characteristics including deterrent systems (below). In all summaries of PA ponds, we included Imperial's External Tailings Area. Although that site was not yet in production in 2012 and the pond contained only freshwater, it had an active bird deterrent system throughout spring and fall migration seasons.

Summary information for birds typically describes either totals observed in a given time or space, or rates of detection of individuals for a standardized unit of time. Totals apply to both the number of individuals that were detected and the number of unique species designations. These designations do not always correspond to a specific species because of the ubiquity with which birds were recorded with a prefix of 'unknown' followed by another taxonomic designation. For example, the terms unknown scaup, unknown diver, unknown duck, and unknown waterfowl might all describe what was actually a Lesser Scaup. As for totals, rates may be applied to both the number of individuals and the number of species designations recorded.

We summarized information in a variety of ways to evaluate the effects on monitoring results of both temporal variables (such as time of day and season) and spatial variables (such as lease site or pond). We categorized birds by their primary means of foraging (hereafter foraging guilds) as dabbles (e.g., mallards), dives (e.g., loons and terns), flies (e.g., swallows), gleans (e.g., chickadees), pecks (e.g., grouse and sparrows), scavenges (e.g., crows, magpies), stoops (e.g., hawks, falcons, and owls), or wades (e.g., cranes and shorebirds). Birds targeted by the Regional Bird Monitoring Program are those that dabble, dive or wade because these species are more likely to come in contact with PA water. We used these foraging guilds as the primary means by which we categorized birds that were detected in the 2012 monitoring season (Table 3). Whenever species were listed in tables, we listed them first by foraging guild and then in taxonomic order as provided by the American Ornithologists' Union[29]

We collected no independent information on weather during the 2012 monitoring seasons, but summaries are available from other sources (Appendix C). Relative to the past 30 years, the spring, summer, and early fall of 2012 were warm with several days in excess of the 90th percentile of the long-term averages. Precipitation in the spring, summer and early fall 2012 was less frequent than average, producing a relatively warm, dry summer and a cooler, wetter fall.

Raw data from which the following results are derived are available in electronic form (Appendix D), currently from the authors, and later via a Government of Alberta website.

Results

Pond Characteristics and Survey Effort

A total of 53 ponds containing process-affected water (PA) were monitored for both live birds and mortalities in the 2012 season. Six ponds containing freshwater (FW) were monitored for live birds only. Several pond characteristics were provided by operators or measured by University of Alberta (U of A; Table 2).

The 53 PA ponds ranged in size from 0.1 to 929.6 ha (mean = 160.5 ha) whereas the six FW ponds varied in size from 5.9 ha to 77.3 ha (mean = 33.1. ha).

PA ponds were an average of 6.5 km or 5.9 km from the Athabasca River when measured from their centroids or nearest edges, respectively. Thirty-eight of the PA ponds were designated as likely to contain bitumen, 13 were designated as not likely to contain bitumen and no information was provided for 2 ponds. Using information from operators, U of A observers, and / or high resolution GIS imagery (with an opportunity for confirmation by operators), six of the 53 PA ponds were described as containing floating or shore-based vegetation and islands within the perimeter of the high-water mark. Thirty of the 53 PA ponds contained a sloping beach that could permit walking by birds; the other 23 were steep-sided.

For 48 of the 53 PA ponds, operators assigned the number of survey stations per pond that were specified in the 2011 Monitoring Plan (Table 2). Two stations were monitored on three ponds that required only 1 station and on two ponds that required 3 stations. Among both FW and PA ponds, operators surveyed a total of 88 stations on 59 ponds. Survey stations were sometimes highly clumped on ponds (e.g., CNRL's Tailings Pond and Syncrude's SW Sand Storage Pond) and were sometimes several hundred m from the nearest shore (e.g., Shell's Muskeg River In-pit and Syncrude's SW Sand Storage Pond; Figure 2). If survey stations were not accessible on a given day, some operators skipped the station on that day (e.g., CNRL) whereas other operators designated an alternative station (e.g., Syncrude).

According to the GPS positions collected during monitoring, observers concentrated their observations at designated monitoring stations for some ponds (e.g., Suncor's Crane Lake), but scattered their observations around the perimeter of other ponds (e.g., Syncrude's Southwest Sand Store; Figure 2). Some observation positions collected by Suncor and especially Syncrude appeared off-site or in the middle of ponds and obviously resulted from equipment failure. Because the cause of this inaccuracy and extent of occurrence could not be determined, it was not possible to eliminate only those records with equipment-caused error.

For both pond types, we calculated the area of water and adjacent shore area comprised by survey stations to calculate the percentage of pond area represented by surveys (Table 2). The average pond area covered by survey stations was 60% for PA ponds and 65% for FW ponds, but coverage of PA ponds was much larger, varying from 0 to 100%. With one exception, survey stations covered 100% of the ponds smaller than 10 ha (Table 2), but the proportion declined with increasing pond area to comprise only a few percent of the area of the largest ponds. In a few cases, observation stations were positioned so far from the pond perimeter that none of the pond area was effectively surveyed (Figure 2, Table 2).

Among the 80 survey stations on PA ponds, the total area surveyed for live birds was 860 ha, representing 10% of their total area (8 507 ha). By contrast, the 8 survey stations on FW ponds covered an area of 91.1 ha, representing 45% of their total area (198.4 ha; Table 2).

All operators conducted spring observations between 16 April and 6 July and fall observations between 25 July and 31 October as specified in the 2012 Monitoring Plan. Four operators also conducted observations throughout the summer period (7 July – 24 July), providing an unexpected opportunity to assess the additional information gained in this period along with other seasonal comparisons (below).

Process-affected water ponds

Observations of live birds

During designated survey periods and areas at 53 PA ponds, a total of 29 779 birds were detected as landed, 163 as heard, and 42 822 as flyovers, totaling 72 764 individuals (Table 4A). Of the nearly 30 000 birds that landed at PA ponds, 20 540 (70%) were of the foraging guilds targeted by the monitoring program because they dabble (n = 5 153), dive (n = 10 685), or wade (4 202).

Very few of the birds were detected by hearing; only 0.2% overall and less than 0.1% of the target birds. Among the remaining detections, there were substantial differences among lease sites in both the number of birds reported and the proportion of individuals recorded as landing vs. flying (Figure 3A).

Among the standardized observations of landed birds at PA ponds during spring and fall (n = 29 779 individuals), 152 unique species designations were reported, including 34 designations that began with the term UNK (unknown; Table 4A). The most abundant species designation was "unknown duck" (21%), followed by Snow Bunting (9%), and "unknown gull" (5%). The next 10 most abundant species each comprised between 2 and 4% of landed birds (spring and fall) and included 3 dabblers (American Wigeon, Mallard, Canada Goose), 3 divers (Bufflehead, Common Goldeneye, and Lesser Scaup), 2 waders (Least Sandpiper and Lesser Yellowlegs) and one scavenger (Common Raven).

Comparing the rate of observations (i.e., detections per 10 min) demonstrated large differences in guild prevalence as functions of both lease site and detection method (Figures 4A and B). When averaged across operators and seasons for landed birds only, detection rates were more similar among guilds (Figure 4C), but they were surprisingly high for birds that peck. Over 3 000 of these records were attributed to Snow Buntings, an irruptive, flocking, and land-based passerine species. Without Snow Buntings, diving birds represented almost 40% of all detections of landed birds, dabbling birds comprised 19%, and wading birds accounted for 17%. The remaining 25% of birds foraged primarily by scavenging (12%), pecking (7%) and the combination of flying, gleaning, stooping, or were of an unknown foraging guild (5%).

Among birds in the three target guilds that landed on PA water, all were more abundant in the fall (Table 5A) representing between 65 and 80% of all detections. Diving birds were detected twice as often in the fall as they were in the spring while dabblers increased by 3.5 times and waders by almost 5 times (Figure 5A). Because diving birds were more abundant (above) they were much more likely than the other two guilds to come in contact with PA water than the other birds, even in the fall (Figure 5B). Detections of target guilds in the two-week summer season (by those operators who continued to monitor then) comprised between 2 and 7% of the total records for each species, but records from this period had little effect on the complete list of species detected (Table 5A). A single species, Gray Jay, was detected only during the summer season and House Sparrows were prevalent then (50% of their total). Among the target guilds, only 13 species exhibited summer detections that were over 10% of their totals (Table 5A). Although none of these species would have been missed during spring and / or fall migration periods, their relatively higher abundance in the summer suggests that they were more likely to be breeding on or near PA ponds (Figure 5C).

Measured as detection rates (i.e., per 10 min) and for all bird guilds combined, there was substantial variation among operators in the diel pattern of bird detections (Figure 6A) at PA ponds. For example, at Suncor's Millennium site, detection rates peaked at midday and were lower in both morning and evening observation periods whereas a dramatic peak occurred in the 2 hours after sunrise at Imperial's Kearl site. However, when detection rates were averaged across all lease sites and seasons, the rate of bird detections peaked in the first two hours after sunrise and then declined for the remainder of the day (Figure 6B).

In addition to the nearly 30 thousand birds detected at PA ponds during standardized monitoring periods, another 30 thousand birds were detected as incidental records by operators while they visited or travelled among ponds. Included in incidental observations are those detections that were recorded as being outside of the temporal (30 min) or spatial (500 m) confines of the standardized monitoring visits. Again, approximately 70% of these were from the target guilds of dabblers, divers, and waders (Table 6A). In general, the relative abundance of species detected as incidental observations was similar to detections that occurred during the standardized surveys. Several sensitive or at risk species were detected during incidental reports that had not been detected during surveys (below).

Mortalities recorded via search, euthanasia and incidental reports

A total of 139 mortalities were reported by the 4 operators (CNRL, Shell, Suncor, and Syncrude) that were producing bitumen in 2012; 88 as the result of targeted searches and another 51 stemming from euthanasia or incidental discover y (Table 7). A total of 31 unique species designations (including unknown categories) were used but only three groups exhibited more than 5 mortalities each; UNK duck (39), Canada Goose (n = 17) and American Coot (n = 13). Four sensitive species were among the recorded mortalities including Northern Pintail (n = 3), Lesser Scaup (n = 3), Pied-billed Grebe (n = 1), and Horned Grebe (n = 1).

The amount of time devoted to mortality searches on the 53 PA ponds that were part of the standardized monitoring program totaled 3 953 hours via a combination of driving, walking, and boating (Table 2). Given that the monitoring plan specified that all ponds were to be searched twice weekly, there was a surprising amount of variation in the number of unique days for which mortality search data were associated with each pond (mean number of days on which mortality searches were recorded = 75, range = 50 – 168; Table 2).

Species at risk

Several species designated with some measure of risk under federal or provincial criteria were detected at PA ponds during the 2012 monitoring season. Only two records associated with PA ponds applied to species listed under the federal Species at Risk Act (SARA), and both records are believed to be erroneous. Two Whooping Cranes (SARA designation of endangered) were reported flying over as incidental observations (Table 6A) by observers at CNRL and one Ferruginous Hawk (SARA designation of threatened) was reported by Suncor as having landed during a standardized monitoring session (Table 4A). These sightings were unconfirmed by other observers. The crane sightings were later deemed to be highly unlikely by Environment Canada biologists because they were observed as a pair of juveniles, but no instance of twins was known to occur in the 2012 breeding season and juvenile Sandhill Cranes look similar to Whooping Cranes. Similarly, there have been no previous reports of Ferruginous Hawk, a prairie species, north of Edmonton and this identification was assumed by provincial experts to be erroneous.

As part of the standardized observations of live birds at PA ponds, several species with the lesser and informal designation of 'sensitive' in Alberta were detected. Categorized by foraging mode, these observations included two species of dabblers (Northern Pintail, Green-winged Teal), five divers (Lesser Scaup, Pied-billed Grebe, Horned Grebe, American White Pelican, Black Tern), and three waders (Great Blue Heron, Sandhill Crane, Upland Sandpiper). Other species categorized in Alberta as sensitive were less likely to come into immediate contact with PA water because of their foraging mode. These included diurnal raptors (6 species), owls (1 species), and aerial insectivores (4 species; Table 4A).

Incidental observations conducted by industry observers, which might have included the surface or vicinity of PA ponds, were responsible for detecting one additional species at risk, Peregrine Falcon (designated under SARA as Special Concern and by the ESCC in Alberta as Threatened), and several additional sensitive species that had not been observed during standardized surveys. These included one diver (Osprey), one wader (Sora), four species that catch prey on the wing and five perching birds that glean or peck (Table 6A). Because the incidental observations collected by U of A observers were potentially redundant with those collected by industry, they were tallied (Table 6B), but not separately discussed unless they added to the total species count detected by industry. Only one such detection occurred; a single Trumpeter Swan (designated under SARA designation as Not at Risk and under Alberta's ESCC as Threatened) was observed at the lease sites of Imperial and Shell.

Freshwater ponds

Each of the five operators monitored at least one pond on at least one lease site that contained fresh water and those observations were tallied separately from PA ponds. Comparable information on pond characteristics (Table 2) and observations of live birds (Panel B of Tables 4, 5, and 6) is provided for these ponds, but only those patterns that deviate from PA ponds are emphasized here.

A total of 27 743 birds were detected at freshwater ponds during designated monitoring periods in the spring and fall (Table 4B). Relative to PA ponds, a higher proportion of birds was detected by hearing (6%) but a similar proportion of the landed birds belonged to the three target foraging guilds (20 357 or 73%; Figure 3B and D). Suncor submitted approximately half of the birds recorded as landed on freshwater ponds (n = 14 056) which was between 5 and 30 times as many landed birds recorded by each of the other operators (Figure 3B). A total of 139 unique species designations were attributed to FW ponds.

When separated by foraging guild and expressed as detections per 10 minutes, FW ponds exhibited similar variation by operator to PA ponds (Figures 4D and E). There were dramatically more dabbling birds at Imperial's Kearl site in the spring relative to the fall, causing the average detection rate of dabblers at FW ponds to exceed those of divers, followed by scavengers and then waders (Figure 4F).

As was the case for PA ponds, detection frequency differed by migration season for many species on FW ponds (Table 5B). Two species (Blackpoll Warbler and Semipalmated Sandpiper) were detected only during the summer break and 25 additional species were recorded then for between 10 and 33% of their total detections. These relatively abundant summer detections included five sensitive species; Pied-billed Grebe, Great Blue Heron, Black Tern, Northern Harrier and Barn Swallow. Several additional species were biased heavily towards detections in the spring or fall. Thirty one species were recorded 90% or more often in the spring and 41 species were recorded 90% or more often in the fall.

As for PA ponds, FW ponds exhibited pronounced patterns of diel variation that varied among operators (Figure 6C) and averaged to exhibit a decline through the day (Figure 6D).

A total of 19 species with some risk designation were recorded at freshwater ponds (Table 4B). Two sensitive species, Western Grebe and Common Yellowthroat, were unique to freshwater ponds.

Comparison and extrapolation of bird observations

Comparing the number of bird observations in PA *vs.* FW ponds while correcting for differences in the total area surveyed provides some indication of the relative attraction to birds of the two pond types. Based on the total area surveyed for PA ponds, which was nearly 10 times larger than FW ponds (above), one would expect many more birds to have been recorded at PA ponds. However, the number of individuals in the three target guilds that landed within surveyed areas during the standardized monitoring sessions in either spring or fall was remarkably similar between pond types; 20 540 for PA ponds and 20 357 for FW ponds. In other words, there were almost 10 times as many (but see below) landed birds from the target guilds on FW ponds as would be expected from their surveyed area alone if PA and FW ponds were equally likely to attract birds.

A similar simplistic and area-based extrapolation can be used to estimate the total number of birds that may have landed on PA ponds in 2012. If 20 540 birds from target guilds landed in the survey area of 860 ha and a similar density occurred across the 90% of pond surfaces that was not surveyed, a total of 205 400 birds might have landed there during the designated monitoring periods in Spring and Fall 2012.

Information about the detectability of birds with which future estimates can be refined is provided by the study of inter-observer variation that was conducted collaboratively by U of A and Industry observers in the 2012 monitoring season. U of A observers made 3 visits to each of Syncrude, Shell, and Imperial in Spring and added CNRL with each operator receiving 6 visits in Fall. For Suncor, only Crane Lake, a FW pond, was visited by both U of A and Industry observers and visits were synchronized only in Fall.

At both PA and FW ponds, the number of birds detected from all guilds during paired observation sessions was highly variable (Table 7, Figure 7). Both sets of observers typically detected more birds as flyovers than as landings, but that pattern was reversed at the freshwater ponds for Imperial and Suncor (Figure 7). Shell observers detected the highest number of landed birds during paired observations at PA ponds with a mean over four times higher than the U of A observers.

When restricted to PA ponds and the three target guilds, there remained large differences in the mean number of individuals detected during paired observation sessions by Industry and U of A observers (Figure 8). As general patterns, more birds were detected by Industry at CNRL and Shell, more birds were detected by University (U of A) observers at Imperial, and similar numbers were recorded at Syncrude. Overall, both the average and variance was higher for the number of birds of target guilds detected as landed during paired observation sessions by Industry (mean = 4.9 ± 10.4 birds) than for U of A observers (2.9 ± 3.8 birds).

Comparisons of ponds

To complement a graphical presentation (below), we applied simple descriptive and univariate statistics to offer a preliminary exploration of the factors and correlates that might explain the substantial differences among ponds we observed in the number of landed birds and mortalities. For these analyses, we used only the 44 ponds that had at least one landed bird or mortality and sample sizes for the associated graphs sometimes differ. Analyses of landed birds are based on the sums of observations during the standardized monitoring periods for each pond and include only the three target guilds. Owing to small sample size (of ponds) and high variance, we interpreted statistical tests to be significant at $P < 0.10$. Wherever possible effects sizes between means and exact p-values are given.

Pond area. There was no effect of pond area on the number of landed birds (Figure 9A; r^2 = 0.001, df = 1,43 , P = 0.85) or number of unique species (Figure 9B; r^2 = 0.024, df = 1,43 , P = 0.31). Similarly, there was no effect of pond area on the number of days dedicated to mortality searches (Figure 10A; r^2 = 0.05, df = 1,43 , P = 0.15), but there was a positive correlation between pond area and the total number of hours dedicated to searching (Figure 10B; r^2 = 0.08, df = 1,43 , P = 0.07) and to the number of mortalities found (Figure 10C; r^2 = 0.15, df = 1,43 , P = 0.008). Interestingly, the relationship between pond area and the number of mortalities disappeared when only the 17 ponds with one or more mortalities was included (r^2 = 0.002, df = 1,16 , P = 0.85). In other words, although ponds with mortalities were over three times larger (mean = 375.1 ha ± 78.7) than ponds without mortalities (mean area = 103.7 ha ± 17.5; $t = 5.3$, df = 51, $P < 0.001$), there was no further effect of area among the ponds with mortalities.

Pond surfaces. Characteristics of pond surfaces were described with the binary information (presence / absence) for each of vegetation, islands, sloping beach, and bitumen that had been provided by operators (Table 2; Figure 11). The six PA ponds that contained islands and / or vegetation, had an average of 13.3 times more landed birds of the target guilds ($t = 3.0$, df = 43, $P = 0.005$), 3.6 times more species ($t = 3.6$, df = 43, $P = 0.001$), and 1.7 times as many mortalities ($t = 0.54$, df = 43, $P = 0.57$) as the 39 ponds without islands and vegetation. The 30 islands that contained a sloping beach had approximately twice as many, but not significantly more, landed birds (factor = 2.1; $t = 0.45$, df = 43, $P = 0.66$) and species (factors = 2.1 and 1.9, respectively; ($t = 1.03$, df = 43, $P = 0.27$) as the 23 ponds without sloping beaches. There were 8.6 times as many mortalities on the ponds with beaches, a highly significant difference ($t = 1.90$, df = 43, $P = 0.024$). There were significantly fewer, only 60% as many, landed birds ($t = 2.45$, df = 42, $P = 0.018$) and species ($t = 3.01$, df = 42, $P = 0.004$) on the 38 ponds containing bitumen relative to the 13 that did not and 2 that were unspecified. However, there were 10 times as many mortalities on the ponds with bitumen ($t = 1.98$, df = 42, $P = 0.005$).

Distance to River and Pond Origin. Again for the 44 ponds that had at least one landed bird or mortality, distance from the nearest pond edge to the Athabasca River was positively correlated with the number of landed birds (Figure 12A; $r^2 = 0.29$, df = 1,43 , $P < 0.001$) and the number of species (Figure 12B; $r^2 = 0.31$, df = 1,43 , $P < 0.001$), but not the number of mortalities (Figure 12C; $r^2 = 0.31$, df = 1,43 , $P < 0.001$). There was no linear relationship between pond origin and number of mortalities ($r^2 = 0.13$, df = 1,43 , $P = 0.233$.

Bird deterrence. We measured the effect of bird deterrents on the abundance of live birds for each pond with two measures: the density of deterrents (units / ha) of any sort and the area of each pond that was assumed to be below a threshold of 80 dB based on the type and configuration of audio deterrents, measuring entire pond surfaces, and the area within 200 m of shore separately (Table 2). Deterrent density did not affect the number of landed birds (Figure 13A; $r^2 = 0.01$, df = 1,43 , $P = 0.49$) but tended to decrease with species ($r^2 = 0.058$, df = 1,43 , $P = 0.11$), and had a weakly negative effect on the number of mortalities (Figure 13B; $r^2 = 0.063$, df = 1,43 , $P = 0.09$).

The area for each pond estimated to be exposed to less than 80 dB of acoustic deterrence had no significant effect on any of the dependent variables of landed birds, species, or mortalities, whether the acoustic threshold was applied to the entire pond area or only the area within 200 m of shore (Figure 14; $r^2 < 0.013$, df = 1,43 , $P > 0.45$ for each of the six regressions). Approximately three quarters of the 53 PA ponds in the region exhibited no area below the 80 dB threshold for acoustic deterrence, while the number of birds landing on these ponds varied from 0 to almost 10 000 (Figure 14A).

All four of the ponds at which more than 10 mortalities were recorded had lower than average deterrent densities, whereas they each had greater than average coverage when measured via the 80 dB acoustic standard (Table 2).

There was no relationship between the number of mortalities and the number of birds that landed from the three target guilds (Figure 15; $r^2 = 0.010$, df = 1,43 , $P = 0.52$. There were only three landed birds for the pond with the highest number of mortalities (Suncor's Pond 2/3) and none for the pond with the second-highest number of mortalities (Suncor's Sand Dump). The other two ponds with more than 10 mortalities reported over 100 landed birds each; 164 landed birds and 15 mortalities at Shell Jackpine's Mature Fine Tailings Pond and 266 landed birds with 13 mortalities at CNRL's Tailings Pond.

Discussion

Adjustments to the data contained in this report and the associated analyses were being requested and made up until the day its final draft was due. This circumstance resulted from the new ground that was being charted by every aspect of the program and by the tremendous attention given to previous drafts by industry and government representatives. That attention has supported rapid growth in program reporting, but it has left the authors without time to offer much synthesis of these results with the available literature. More such synthesis will occur in a subsequent publication, a draft of which will be circulated for review to industry and government representatives.

Temporal and spatial frequency of monitoring

With few exceptions, ponds were surveyed for live birds with the temporal and spatial frequency specified by the Monitoring Plan. Few monitoring sessions were skipped altogether, and these presumably resulted from operational constraints, but spatial clumping or large distances from adjacent shorelines characterized several survey stations, which would limit their representativeness of bird activity on ponds. For some ponds, changing water levels and unstable slopes would have imposed enduring safety limits on the proximity of survey stations, and future monitoring at these sites might be advanced with the use of automated monitoring instruments[30].

The monitoring protocol requested that observers record a UTM of their observation positions because variation in survey location could cause unintended variation in survey results. Unfortunately, the location accuracy of GPS-derived positions appeared to be variable, especially at Syncrude, where live data uploads relied on the 3G network for satellite information. We never determined the cause of this sporadic and localized GPS error, but variation in survey position, whether real or apparent, is expected to decline with changes that have already been adopted for the 2013 monitoring program. Those adjustments include more formally designating the locations of survey stations, marking them with signs or barcodes, and assigning alternative stations when necessary.

Monitoring results

Over 70 thousand birds were detected at process-affected (PA) ponds during designated monitoring sessions via the three detection methods (landed, flyover, and heard). Almost 30 thousand of these birds landed on the ponds and a majority of those birds (70%) belonged to the target guilds of dabblers, divers, and waders. Some of the most common species detected in the standardized observations are abundant throughout North America in suitable habitat (e.g., American Wigeon, Mallard, Canada Goose, Least Sandpiper) but one species designated as sensitive in Alberta, Lesser Scaup, was also among the 10 most abundant species.

Comparisons of monitoring results across seasons indicated that all of the target guilds were more abundant in the fall, presumably because of the increase in population sizes represented by the young of the year. Diving birds increased in fall more than the other two target guilds. There was no evidence that monitoring during the two week summer break designated by the Monitoring Plan (July 14 – 28) would produce qualitative changes in monitoring results. However, many species exhibited markedly different abundance in the spring and fall, underscoring the need to monitor comprehensively in both seasons.

Comparing detection rates by detection method and time of day suggest some changes for future monitoring efforts. First, although there was some variation in the diel patterns of bird detections among operators, there was a clear trend for bird detections to be highest in the two hours after sunrise and to decline through the rest of the day. Second, birds were seldom detected by hearing, particularly for the target guilds. Third, high variation in the rate with which birds were detected as flyovers suggests that criteria for recording flyovers were vague. Fourth, the information from incidental recording largely duplicates patterns from the standardized monitoring program. These four observations support several recommendations that have already been applied to the 2013 monitoring plan (Appendix E).

In 2012, almost 4 000 hours were dedicated to searching for mortalities on the perimeters of the 53 PA ponds via observers traveling by foot, truck and boat. Mortalities were also recorded as products of euthanasia or incidental reports. A total of 139 mortalities were found; 88 by searches and 51 by reports. From these data, it appears that very few birds die in PA ponds, despite the large numbers of birds that land. More information on the comprehensiveness of searches will support the generality of this result.

A total of 24 unique species with some risk designation under federal or provincial criteria were detected in the 2012 monitoring seasons. Although observers reported 3 birds listed under the federal Species at Risk Act (2 Whooping Cranes and 1 Ferruginous Hawk), these identifications were determined to be erroneous by government biologists. Many other species designated in Alberta as sensitive were prevalent in the monitoring results from PA ponds. These included two species of dabblers, five dabblers, three waders, and 11 species from other foraging guilds. Incidental records at PA ponds detected six additional species with some risk designation and two more unique species were detected at FW ponds. Together, these results indicate that species with lesser risk designations are abundant on lease sites and that a combination of monitoring via standardized and incidental reporting from both PA and FW ponds is needed to survey them comprehensively. To support the greater clarity about species at risk under federal and provincial designation systems, a table has been added to the 2013 monitoring plan (Appendix E) that identifies these species and summarizes the necessary reporting for them.

The high abundance of birds at FW ponds suggests that they serve as refuges for diverse species in the region. Based on survey area alone, FW ponds apparently attracted landed birds from the three target guilds at 10 times the rate of PA ponds with comparable species diversity. One pond in particular, Crane Lake on Suncor's lease, reported almost twice as many landed birds from the target guilds as the other FW ponds combined (Figure 3D).

We explored potential explanations for the high abundance of birds at Crane Lake. Although many factors may have been involved and have been discussed, none completely explained this result. Recently, we discovered that Crane Lake was surveyed much more often than the other FW sites. Whereas the 2012 monitoring protocol requested that FW ponds be monitored twice weekly, the six FW ponds were actually monitored for a total number of days varying from 64 (Syncrude's Mildred Lake Reservoir) to 223 (Suncor's Loon Lake). Crane Lake was visited on 203 days. The fact that we did not notice this difference sooner, despite the many hundred people-hours devoted to data standardization, speaks to the challenge of generating a truly standardized monitoring program.

A more accurate assessment of the relative attractiveness of FW ponds might compensate for the extra monitoring by Suncor, as a crude approximation, by deducting two thirds of the birds attributed to Suncor's two FW ponds from the total attributed to all FW ponds, making the new sum 11 080 landed birds from the target guilds, 54% of the number found on PA ponds. This value makes the abundance of landed birds from the target guilds on FW ponds 5.1 times higher than would be expected by their survey area alone, if the two pond types were equally attractive to birds. This difference might be attributed to the greater resources at FW ponds or their lack of deterrent systems. Some PA ponds are also highly attractive to target birds, presumably because they mimic some of their ecological characteristics (below).

At both PA and FW ponds, the number of birds detected during paired observations by Industry and U of A observers was surprisingly variable. Such high variation might be expected of flyover detections, which are necessarily fleeting and difficult to quantify, or the irruptive nature of some non-target species (e.g., snow buntings) that might be observed sporadically. There may also have been less attention to flyovers by some observers (e.g., Suncor did not report any flyovers for either pond type or any bird guild; Figure 3). However, variation in bird detections was high even among landed birds of the three target guilds. Greater effort to standardize the training of observers, the equipment they use, and the restriction of observations to designated periods and areas has been implemented in the 2013 monitoring season. In particular, greater use by industry of range finders and distance markers is expected to reduce variation owing to different search radii, which could explain why Industry observers sometimes detected more birds and sometimes fewer birds than U of A observers. The effect of distance on detectability, and hence monitoring results, is well known[31] and we will subsequently use the 2012 observations collected by U of A to create guild-specific, distance-based detectability functions, which can be applied to subsequent monitoring data.

In addition to the important effect of distance, several other factors likely affected the detectability, and hence recording, of birds in the 2012 Monitoring Program. Because they visited multiple lease sites, U of A observers witnessed several forms of variation in the way observations were conducted and recorded that would be harder to spot for any one operator. In brief, these issues concerned the standardization of training for observers, the optical quality and availability of equipment to observe birds and their locations relative to observers, consistent use and recording of the location of observation sessions and the consistency with which data were recorded for subsequent synthesis and analysis. Most of these have already been addressed in the 2013 monitoring plan (Appendix E) and they will not be discussed more here.

Comparisons among ponds

With the caveat that monitoring observations were assumed to be comparable among sites and dates, there were striking differences in bird abundance among ponds. Pond type was the most obvious difference with 53 PA ponds differing from 6 FW ponds in the kind of water they contained. After accounting for the area surveyed during standardized observation sessions as well as more frequent counting at some FW ponds (above), birds appeared to be five times more abundant at FW ponds. This attraction likely stemmed from a combination of greater resources at FW ponds and the lack of deterrent systems. But the heightened attraction of birds to FW ponds, and their ability to find them, is further emphasized by the 43-fold difference in surface area comprised on lease sites by the two pond types. Stated differently, birds of the target guilds were recorded as landed on FW ponds over 200 times more often than would have been predicted if they dropped randomly from the sky on any water surface with the average detection frequency measured at PA ponds. This suggests birds are extremely adept at finding and preferentially using the few FW refuges that exist in the area.

If the non-surveyed area of PA ponds attracted birds at the same rate as the surveyed area, over 200 000 contacts between birds from the target guilds and PA water would be expected to have occurred. A coarse estimate of this sort was requested by both industry and government representatives, but it is important to acknowledge the several simplifying assumptions it contains, both temporal and spatial. There is no acknowledgement in this estimate for the potential to count the same birds on successive days (leading to an overestimate in the number of unique individuals), but nor does it account for the small temporal window of sampling (30 minutes is 2% of each diel period) and the possibility that not all birds present within the 500 m radius of survey stations were detected by observers (both leading to underestimates). This extrapolation also assumes that birds detected near shorelines, where monitoring stations were invariably concentrated, is representative of the density of birds in open water. This assumption would certainly result in an overestimate for waders, and it is likely to overestimate dabblers. However, divers – which were the most abundant group on PA ponds -- might exhibit the opposite pattern, occurring at higher densities farther from shore.

Among the 44 ponds at which at least one bird from a target guild landed or mortality was recorded, there was no relationship between pond area and the number of individuals landed or species detected. The significantly positive relationship between pond area and the number of mortalities could have resulted from the fact that search effort, when measured in hours, also increased with pond area. Without more information about search routes, it is impossible to know whether large ponds actually had more mortalities, or simply experienced greater search effort. Changes to the 2013 monitoring plan are expected to resolve this issue.

Among the same 44 ponds, there were significant effects of pond surface characteristics which differed for landed birds vs. mortalities. Whereas the six ponds with residual vegetation in the form of floating islands were strongly predictive of attraction to landed birds, it was not demonstrably important to the frequency of mortalities. Presence of a sloping beach, by contrast, did not significantly predict landed birds, but it those ponds had significantly more mortalities. As for the effect of pond area on mortalities, it is impossible to know whether this relationship occurred because more birds died on ponds with beaches, where bitumen might more easily collect, or because mortalities were more likely to be discovered when there were sloping beaches. The presence of bitumen was predictive of both measures when restricted to this subset of 44 ponds; there were fewer birds and species on the ponds with bitumen, but they had an average of 10 times as many mortalities.

The increase between landed birds with distance to the Athabasca River was surprising because of the river's known role as a migratory corridor. However, birds that migrate at night, as most ducks and shorebirds do, are not well represented by observations of birds based entirely on daytime monitoring and with variable attention to birds in flight. Accurate and timely information about the relative abundance of migrating birds through the oil sands region could be advantageous to deterrence programs. A better method for obtaining this information might be to refine and calibrate the detection of birds via radar, which is a component of deterrent systems at the lease sites of all five operators. Calibrating the output of radar to standardize these measures would be a substantial undertaking because several factors influence the detection of radar targets and their software-assisted translation to counts of birds[32]. But with this effort, radar is likely to be both accurate and comparable in this application, potentially more accurate than it is in the current application of identifying targets for deterrence. This is because migrating birds typically maintain high elevations and relatively constant flight trajectories, which are easily detected and interpreted by radar, whereas resident and prospecting birds fly at lower elevations and with less predictable trajectories, which increases the likelihood of interference by surrounding vegetation and water and errors of interpretation by software.

Until recently, bird protection in the Oil Sands Region relied primarily on small visual and acoustic deterrents scattered throughout pond surfaces and shorelines. In the last five years, new oil sands mine sites have addressed bird protection with fewer deterrents that produce much greater sound intensity. To initiate an assessment of these two approaches on bird protection, we compared the density of deterrent devices and the spatial extent of pond surfaces below a 80 dB threshold to the number of landed birds and mortalities. Our univariate analyses suggested that bird mortalities decreased with increasing deterrent density, but were unaffected by the area below an 80 dB sound threshold, whether that was measured for whole ponds or only the area within 200 m of shore.

In addition to the several spatial influences on birds described above, temporal effects also occur. Beyond daylight, weather is the most obvious temporal contributor to migratory behaviour in birds. At the latitude of the Oil Sands, weather is highly variable and it undoubtedly and constantly affects the number of birds in the vicinity of lease sites, particularly in early spring and late fall. Although we did not explore correlates between monitoring results and weather in this report, other work has demonstrated such links. Operators might make more use of the known effects of weather on migratory birds as part of their deterrent strategies. For example, the attraction birds already exhibit to FW ponds on lease sites might be enhanced in advance of severe weather events when they are predicted in early spring or late fall by the provision of aerators that create open water or decoys which could signal safe landing sites to birds in flight. Because severe weather appears to interact with anthropogenic light to cause bird mortality at many industrial sites, the distribution of lights should also be measured and potentially manipulated in future.

Conclusions

Results of the 2012 season of the Regional Bird Monitoring Program documented the landing on PA water ponds of almost 30 thousand birds, mostly dabbling ducks, diving birds, and wading birds. Extrapolating from surveyed area suggests that more than 200 000 contacts between target birds (dabbling, diving and wading species) and PA ponds likely occurred. There was large variation in the number of birds detected by Industry and University observers during simultaneous monitoring sessions, indicating that more work is needed to standardize observation and recording methodologies.

Despite the high number of birds that landed and almost 3 000 hours of dedicated search effort, only 139 mortalities were recorded in association with PA ponds. Comparing the ratios of landed birds to mortalities suggests that fewer than 1% of the birds that land on the PA ponds die as a result.

Comparisons of live bird counts at freshwater and PA ponds indicated that FW ponds are five times more attractive to birds than are PA ponds, an effect that is magnified by the 40-fold greater surface area available on PA ponds. The attractiveness of PA ponds increased with their area and, especially, with the presence of vegetation or islands. Among the 44 ponds with at least one landed bird or mortality, the presence of bitumen predicted fewer landed birds, but 10 times more mortalities.

Mortalities were also more prevalent on large ponds, but this relationship may have resulted partly from the greater search intensity on those ponds. Among ponds, mortalities increased as deterrent density declined, but there was no evidence that increased intensity of audio deterrence, measured as pond or shore area beneath an 80 dB threshold, reduced the number of landed birds or mortalities.

Recommendations

The section below contains two sets of recommendations; a synthesis of those presented in a draft version of this report on 20 Februrary 2013, many of which have already been implemented in the 2013 *Oil Sands Bird Monitoring Program*, and a set of recommendations that apply the key findings of this report to the broader goals of bird protection in the oil sands region.

2013 Monitoring Plan

- Standardize training for bird monitors and provide specific training for data recording, bird identification, and data submission; support and evaluate training with continued study of inter-observer variation.
- Streamline data collection to eliminate information that is redundant, inefficient, or of little value by

    - eliminating the recording of birds detected by hearing and during the summer break;
    - reducing the recording of incidental birds (to novel species, species with any risk designation, and unusual species or behaviours) and the frequency of mortality searches;
    - increasing use of optical equipment for bird identification and distance estimation and the use of tablets and web-based forms for data submission;
    - designating and more consistently using survey stations and specific routes for mortality searches; and
    - refining the design of electronic data forms with greater use of drop-down menus to reduce variation in submitted data.
- Increase data standardization and preliminary reporting during monitoring seasons by
    - accepting data only on tablets or web-based forms;
    - identifying errors and discrepancies sooner and requiring their resolution; and
    - providing weekly reports to operators of collated data; and
    - building data query and presentation templates to support annual reports.
- Protect data for future use by
    - organizing and storing data to support additional analyses by others; and
    - ensuring data and reports are available to the public.

Bird Protection in the Oil Sands Region

Core findings of the 2012 Regional Bird Monitoring Program indicate that contacts between target birds and PA water are very common. Yet, assuming mortality searches were comprehensive, fewer than 1% of the live birds we detected died as a result of that contact. The resulting inference, that brief landings on PA water are not harmful to birds, is consistent with toxicological measures following repeated exposure of captive ducks to PA water[33]. Although comprehensive application of an acoustic deterrent did not seem to reduce the number of landed birds or mortalities, mortalities were weakly and negatively related to the density of deterrent devices. The single strongest predictor of bird mortalities is the presence of bitumen.

Together, these results invite caution for the continued use and expansion of long range acoustic devices, which impose noise pollution that exceeds the 80 dB deterrent standard for several km beyond pond perimeters. An alternative approach to bird protection with greater economic, environmental, and social benefits, might be to dedicate more effort to segregating birds from bitumen. Such segregation might be achieved with the use of booming and skimming technology, which have been used by the industry for decades and comprise the standard means of protecting birds from oil at sea. If bitumen were contained, deterrent efforts could be more concentrated in space and time, which would be expected to increase their efficacy while reducing the exposure of workers and surrounding ecosystems to the known detrimental effects of chronic noise pollution.

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Tables and Figures

Table 1 Definitions of Terms

Adaptive Management	A style of resource management that uses an iterative cycle of innovation, monitoring, and adjustment to learn how natural systems function while identifying the best practices to optimize long-term management outcomes
CNRL	Canadian Natural Resources Limited
Contact	The presence of a bird on a pond or shore area that comes in contact with process-affected (PA) water at any time of the year; includes birds landed on the pond, diving under the water surface, on vegetation on the pond surface, or on the adjacent shore; equivalent to 'landed birds'
Deterrent	An instrument stationed beside or on a tailings pond to deter birds; in the oil sands these include both audio deterrents (e.g. propane cannons, phoenix wailers, speaker systems associated with visual deterrents (e.g., Peregrine Systems), and Long Range Acoustic Devices [LRAD]) and visual deterrents (e.g. human effigies, peregrine effigies, lasers)

Flyover	One or more birds flying over a pond during an observation period; includes migrating flocks or individuals
Freshwater pond	Abbreviated after the first mention in each section of the report as FW; ponds without bird deterrent systems that not involved (in the past, present, or future) in the waste of the bitumen mining process; includes reservoirs, compensation ponds, and natural lakes; used in the standardized monitoring for comparison with process-affected (abbreviated as PA) ponds
Imperial	Imperial Oil Ltd.
Landed birds	As for “contact” above; includes birds that land on pond surfaces or on vegetation on the pond surface or on the adjacent shore
Lease site	An area of publicly-owned land that is leased to private interests for a specified period of time for specified purposes and subject to regulatory approval
Mortality	A dead bird found in association with a process-affected tailings pond either by dedicated search or via incidental reporting
Process-affected water	Abbreviated after the first mention in each section of the report as PA; water that has been used in any part of the mining process; includes tailings, recycled water, and run-off water; some process-affected water contains bitumen, which can sit like a mat on the water where it may be blown around by the wind; under most conditions, bitumen is heavier than water, but adhesion to gases and temperature differentials can cause it to rise to or remain on the surface of the water
Shell	Shell Canada Ltd.
Suncor	Suncor Energy Ltd.
Syncrude	Syncrude Canada Ltd.

Table Titles

Table titles are provided here for reference, but the tables themselves are provided in a separate document owing to their large sizes.

Table 2 Pond attributes

Attributes of 59 ponds that were surveyed in 2012 as part of the Regional Bird Monitoring Program (RBMP) for the Oil Sands. The first 53 ponds contained process-affected water and the last 6 ponds contained freshwater. Eleven additional ponds were monitored for mortalities by Suncor and they are listed here, but they were not otherwise described as part of the RBMP.

For the 59 ponds in the monitoring program, listed attributes include operator and pond name, pond characteristics (year of origin, likelihood of containing bitumen, water type, and area in ha), number and area of survey stations (comprised by water or shore and their sum, expressed in ha and as a percent of total pond area), distance to the Athabasca River (from the pond centroid and nearest edge), presence of attractants (including beach, vegetation, and islands), deterrent characteristics (including the number and density of audio and visual deterrents, both floating and land-based, the area (ha) and percent area calculated to be below an 80 dB acoustic threshold [see methods]), the number of individuals and species that landed (including only the three target guilds and standardized monitoring periods), mortalities (dead birds detected via search, incidental report and total), and mortality search effort (measured in days or hours devoted to boating, walking, driving and their sum).

Table 3 Species attributes

List of species detected as part of the Regional Bird Monitoring Program in 2012. Species are organized hierarchically according to whether or not they are targeted by the monitoring program, which was, in turn, dictated by their primary foraging method (targeted birds dabble, dive or wade), and then by taxonomic order. Within each foraging guild, species are listed with common family and species names, followed by Latin name, and Alberta provincial risk status. Alberta Risk Status corresponds to the legal listing if the species has been evaluated by the Endangered Species Conservation Committee; otherwise the General Status of Alberta Wildlife (2010) is given. Federal listing under the Committee on the Status of Endangered Wildlife (COSEWIC) is also provided. Birds detected at process-affected and freshwater ponds are combined. In this and the following tables, red type corresponds to species designated as being at risk by federal or provincial committees, green corresponds to species that may be at risk, and blue corresponds to species that have not yet been evaluated by either committee but are listed as sensitive on the general list.

Table 4 Bird observations by operator, season, and detection mode

Number of birds detected by five operators during standardized daily visits to survey stations. Detections are separated by monitoring season (Spring and Fall) and detection mode (fly-over, heard, and landed). Only birds detected within survey station areas (up to 500 m), and designated survey times (up to 30 min) are included. Detections are listed by species or species group, within foraging guilds, and then in taxonomic order. Results are tallied separately for process-affected water ponds (Panel A) and freshwater ponds (Panel B) and text colours designate the risk status applied in Table 3.

Table 5 Effect of season on detection of landed birds

Number of birds detected landing and flying over ponds monitored during standardized daily visits to survey stations in the spring, summer break, and fall monitoring periods of 2012. Detections are listed by species or species group, within foraging guilds, and then in taxonomic order. Results are tallied separately for process-affected water ponds (Panel A) and freshwater ponds (Panel B) and text colours designate the risk status applied in Table 3.

Table 6 Incidental live observations

Number of birds detected by any method (flying over, heard, landed) on lease sits as incidental records that were reported outside of the standardized daily visits to survey stations for five operators. Detections are listed by species or species group, within foraging guilds, and then in taxonomic order. Results are tallied separately for observations collected by industry (Panel A) and university observers (Panel B). Because Panel B observations were presumed to be redundant with those in Panel A (i.e., they were collected during paired observations) or they were collected off of operator lease sites, they were not included in the text descriptions of incidental detections. Text colours designate the risk status applied in Table 3.

Table 7 Summary of mortalities by species

Number of mortalities detected by species at process-affected water ponds during standardized mortality searches (search) and via incidental reports of mortalities (report) by five operators. Detections are listed by species or species group, within foraging guilds, and then in taxonomic order. Text colours designate the risk status applied in Table 3.

Table 8 Inter-observer variation in detection of live birds by operator

Number of birds detected landing or flying over independently by Industry and U of A observers during paired visits to ponds managed by five operators. Detections are listed by species or species group, within foraging guilds, and then in taxonomic order. Results are tallied separately for process-affected water ponds (Panel A) and freshwater ponds (Panel B).

Figure 1 Regional Map

Locations of ponds (both process-affected and freshwater) for each of 5 operators and 7 lease sites in the Oil Sands Region of Alberta.

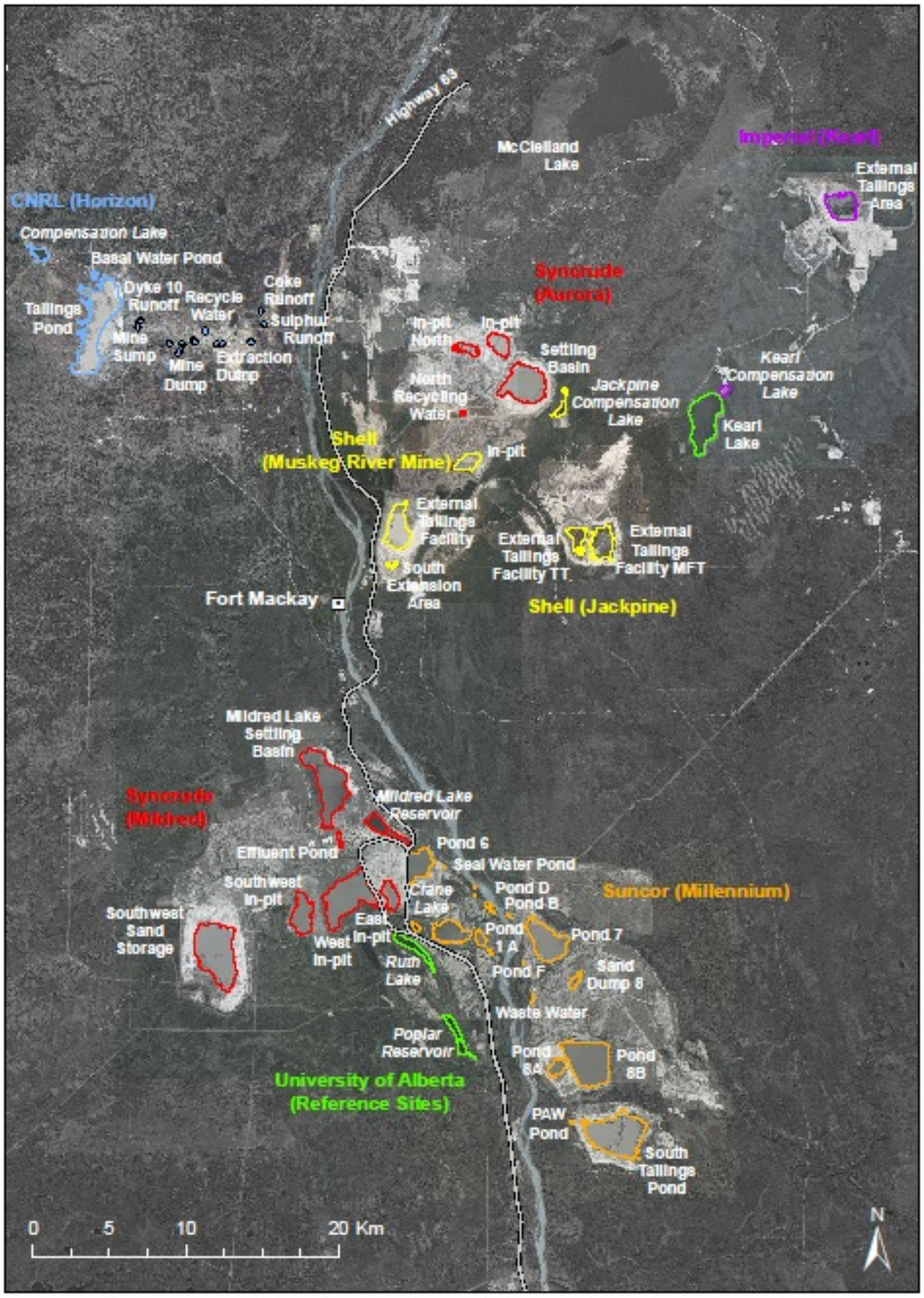


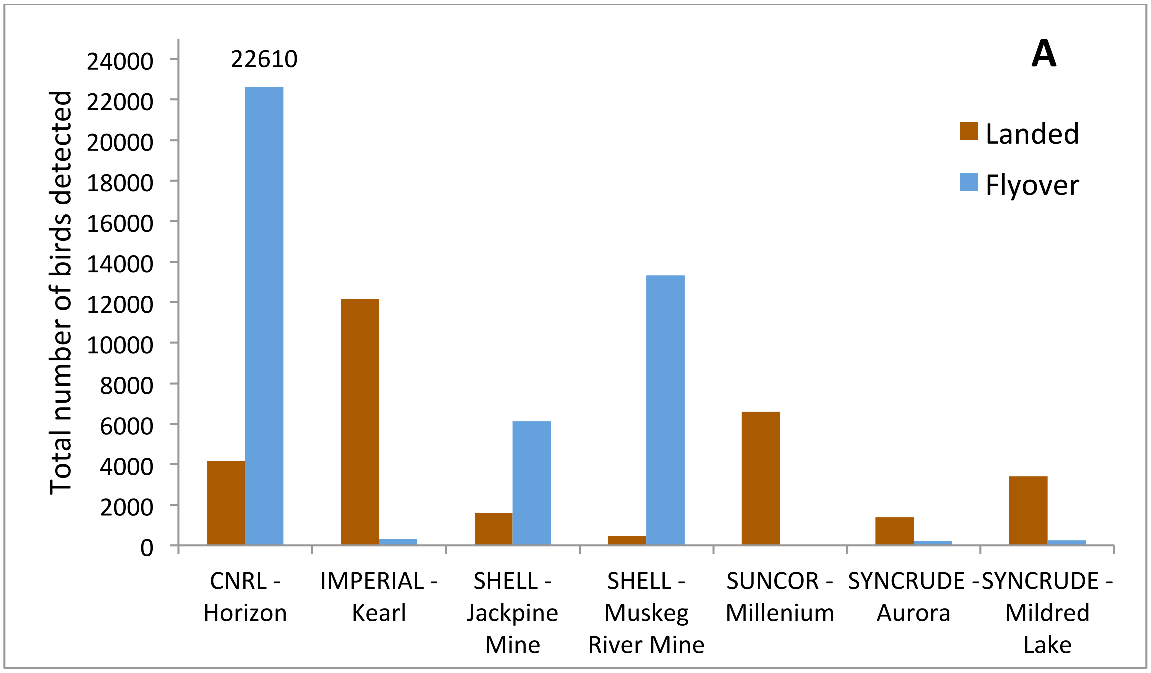
Figure 2 Operator Maps

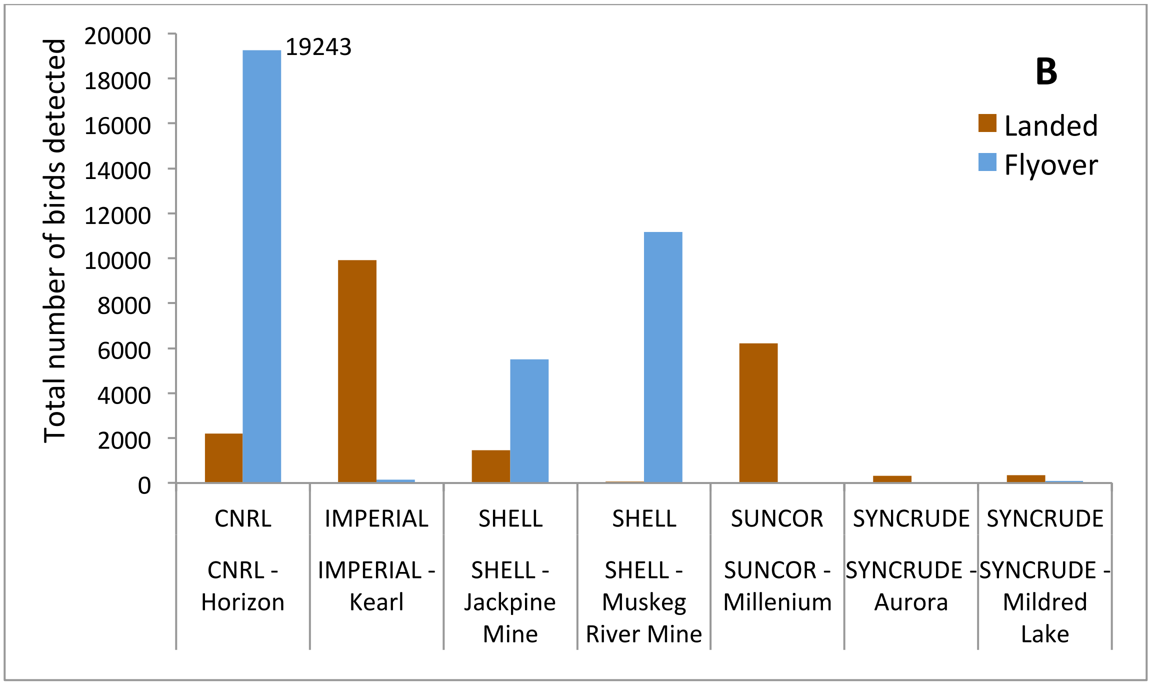
Locations of survey stations, survey samples, and deterrents for ponds containing both process-affected and freshwater for each of the 5 operators in the Oil Sands Region of Alberta. Each panel describes an individual lease site or portion thereof labeled with the name of the Operator that holds the lease. Symbols describe the locations of designated monitoring stations, actual monitoring locations, deterrents (visual, acoustic, and combined), radar units used to detect birds, and containment booms (when indicated by operators). Translucent buffers demark the 500 m radius of observation stations in which live birds were recorded, the radius for acoustic deterrents expected to meet or exceed a sound intensity of 80 dB (see methods), and the 200 m adjacent to shorelines from which the shore-based monitoring area was calculated (Table 2).

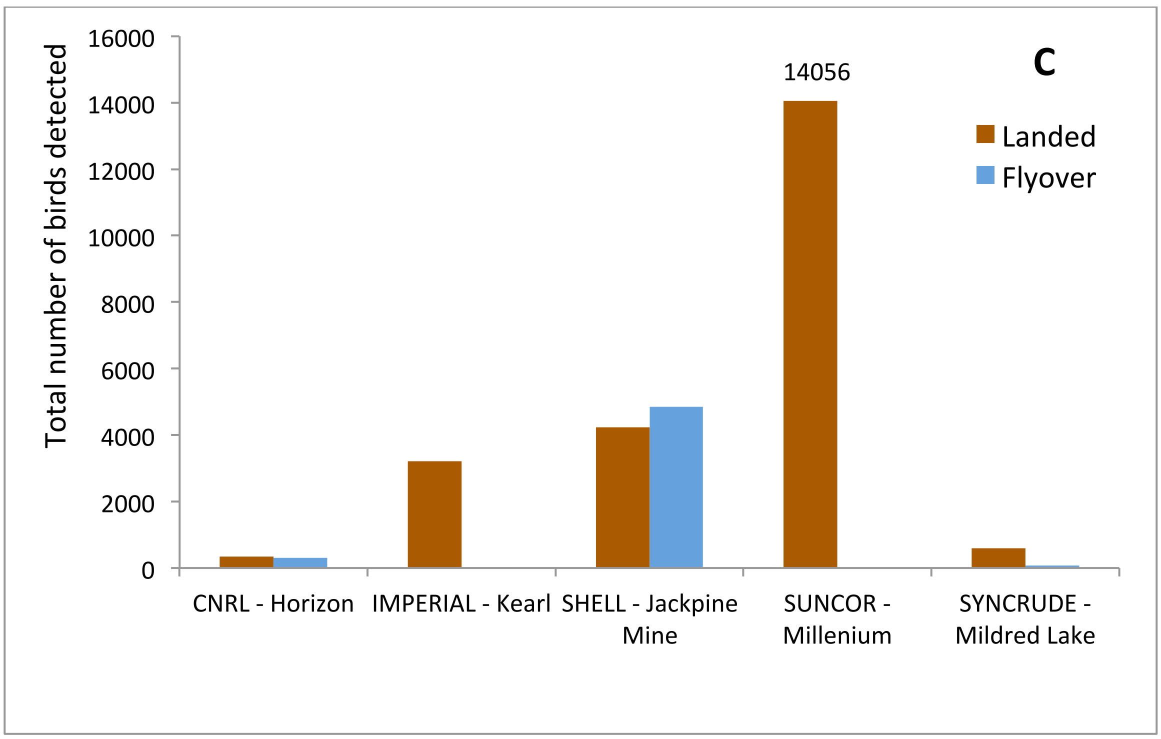
Owing to their large size, Operator Maps are contained in a separate document.

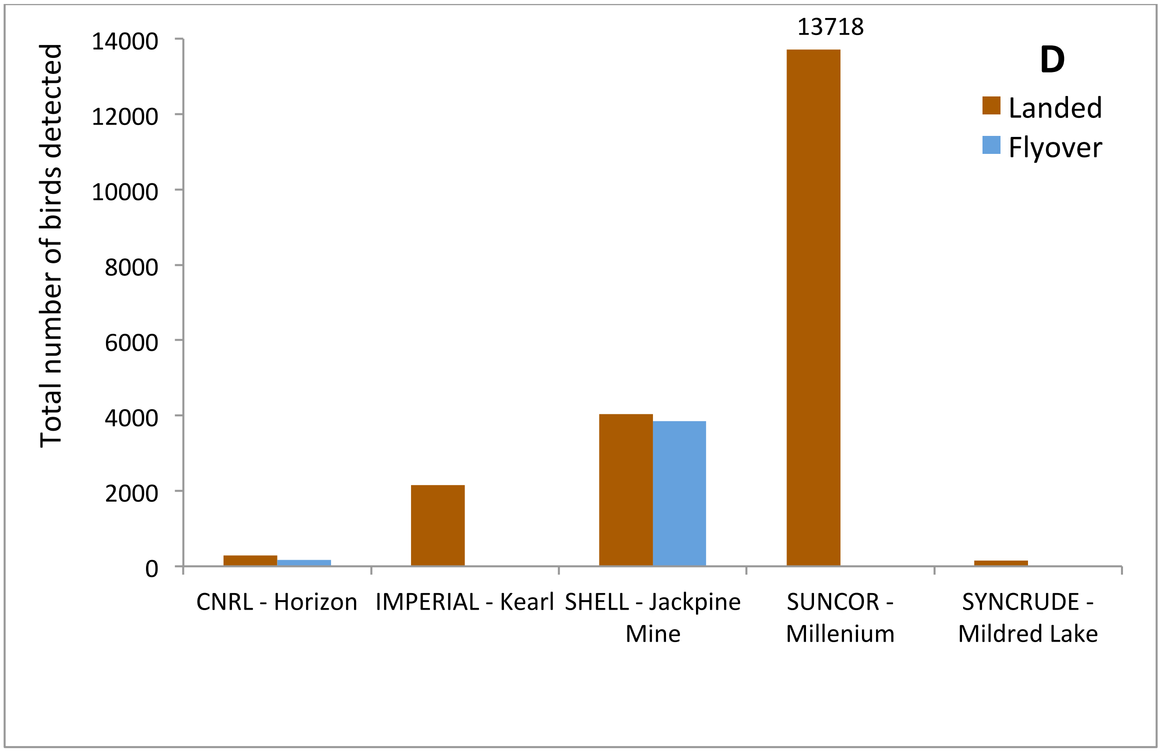
Figure 3 Number of birds flying over *vs.* landed

Total number of birds detected flying over *vs.* landed for each operator. Results are tallied separately for process-affected water ponds (Panels A and B) and for freshwater ponds (Panels C and D) and for all guilds (Panels A and C) and for only those in the three foraging guilds targeted by the monitoring program (i.e., birds that dabble, dive, or wade; Panels B and D).




B
Landed
Flyover
Total number of birds detected
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
19243
CNRL
CNRL - Horizon
IMPERIAL
IMPERIAL - Kearl
SHELL
SHELL - Jackpine Mine
SHELL
SHELL - Muskeg River Mine
SUNCOR
SUNCOR - Millenium
SYNCRUDE
SYNCRUDE - Aurora
SYNCRUDE
SYNCRUDE - Mildred Lake

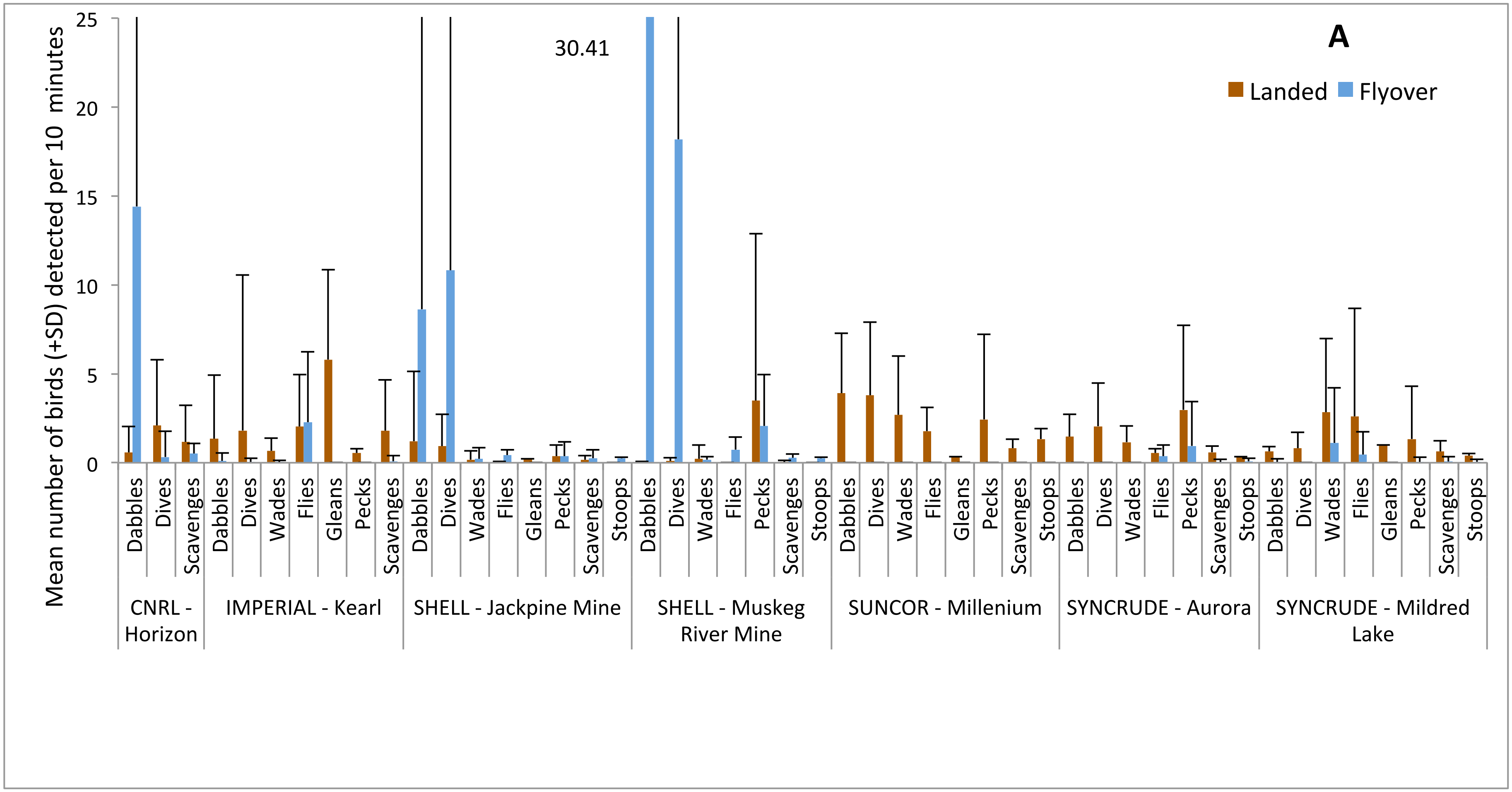

C
Landed
Flyover
Total number of birds detected
16000
14000
12000
10000
8000
6000
4000
2000
0
14056
CNRL - Horizon
IMPERIAL - Kearl
SHELL - Jackpine Mine
SUNCOR - Millenium
SYNCRUDE - Mildred Lake

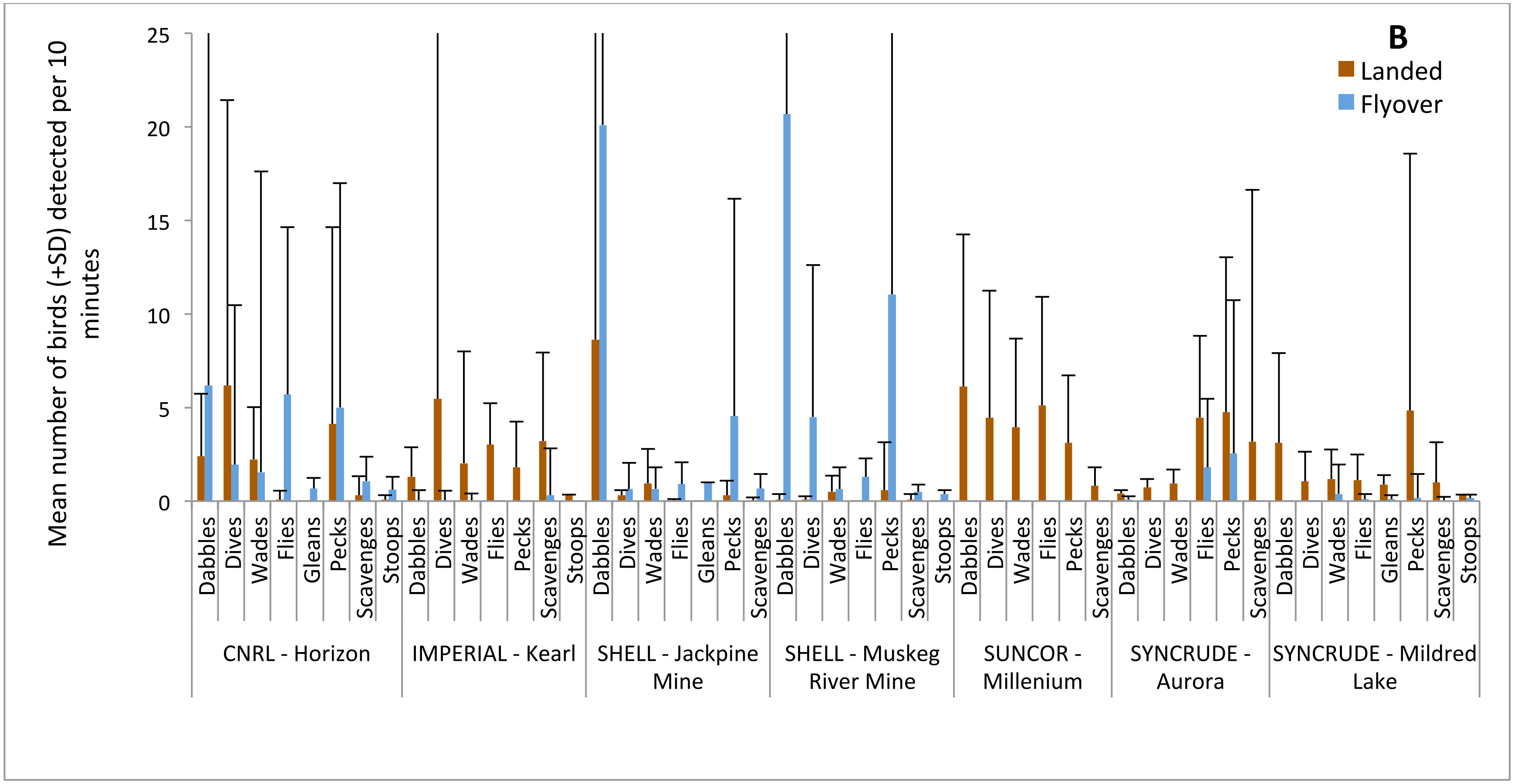


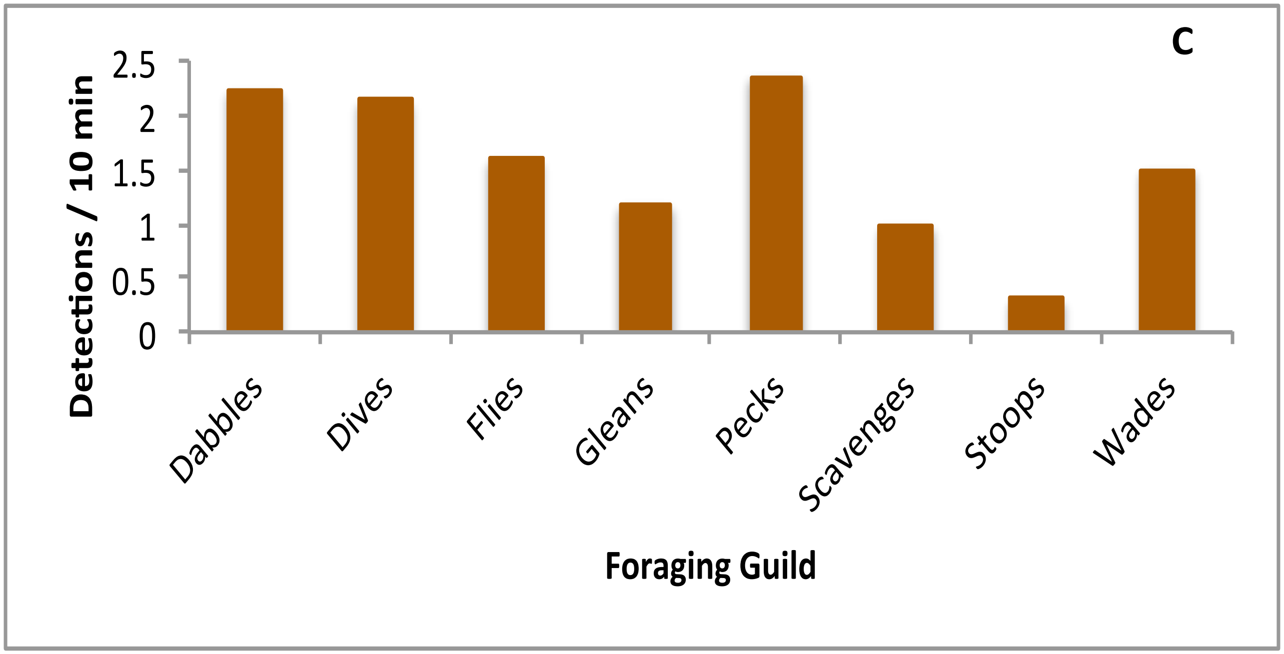
D
Landed
Flyover
Total number of birds detected
14000
12000
10000
8000
6000
4000
2000
0
13718
CNRL - Horizon
IMPERIAL - Kearl
SHELL - Jackpine Mine
SUNCOR - Millenium
SYNCRUDE - Mildred Lake

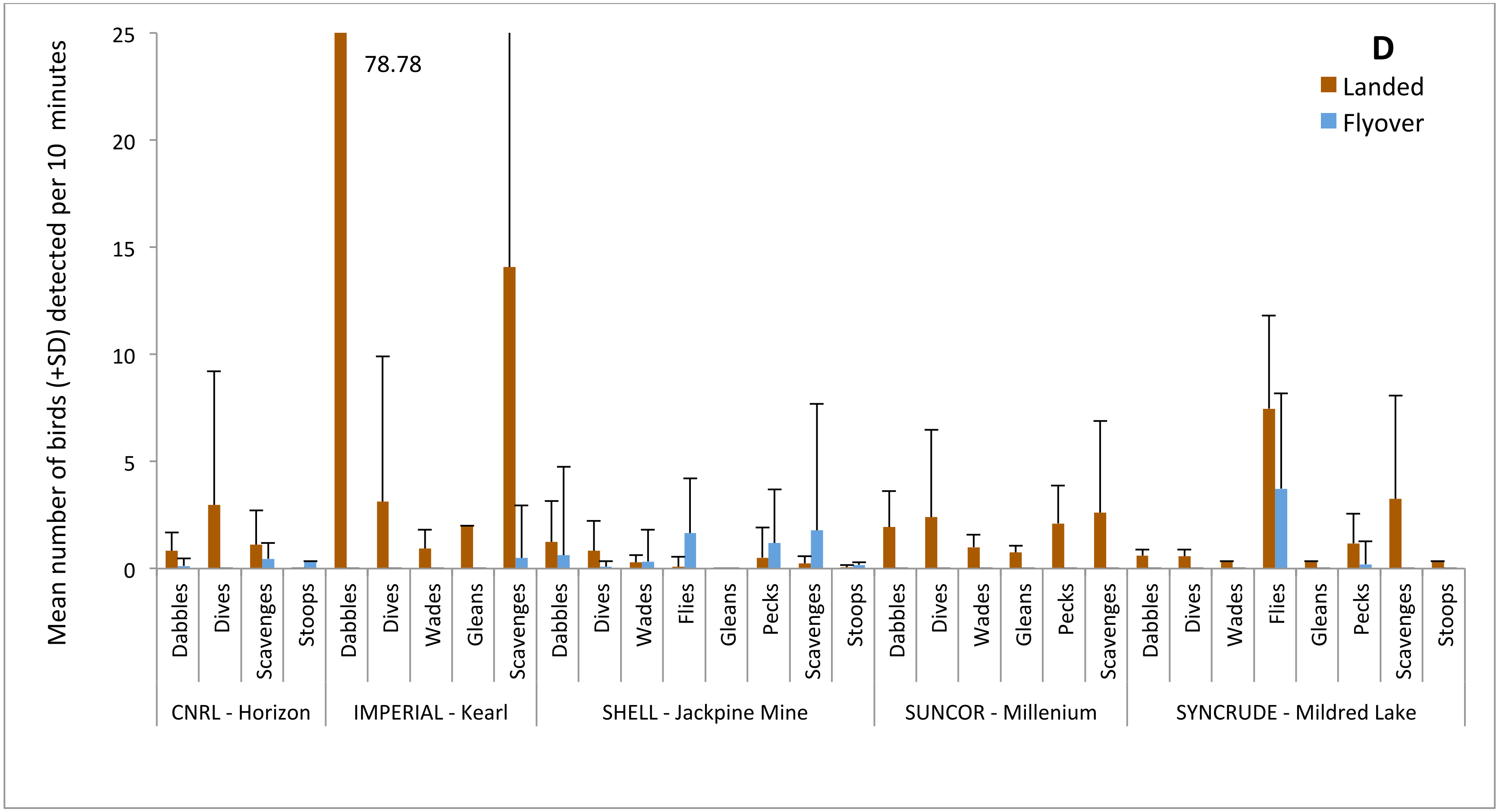
Figure 4 Bird detections by foraging mode

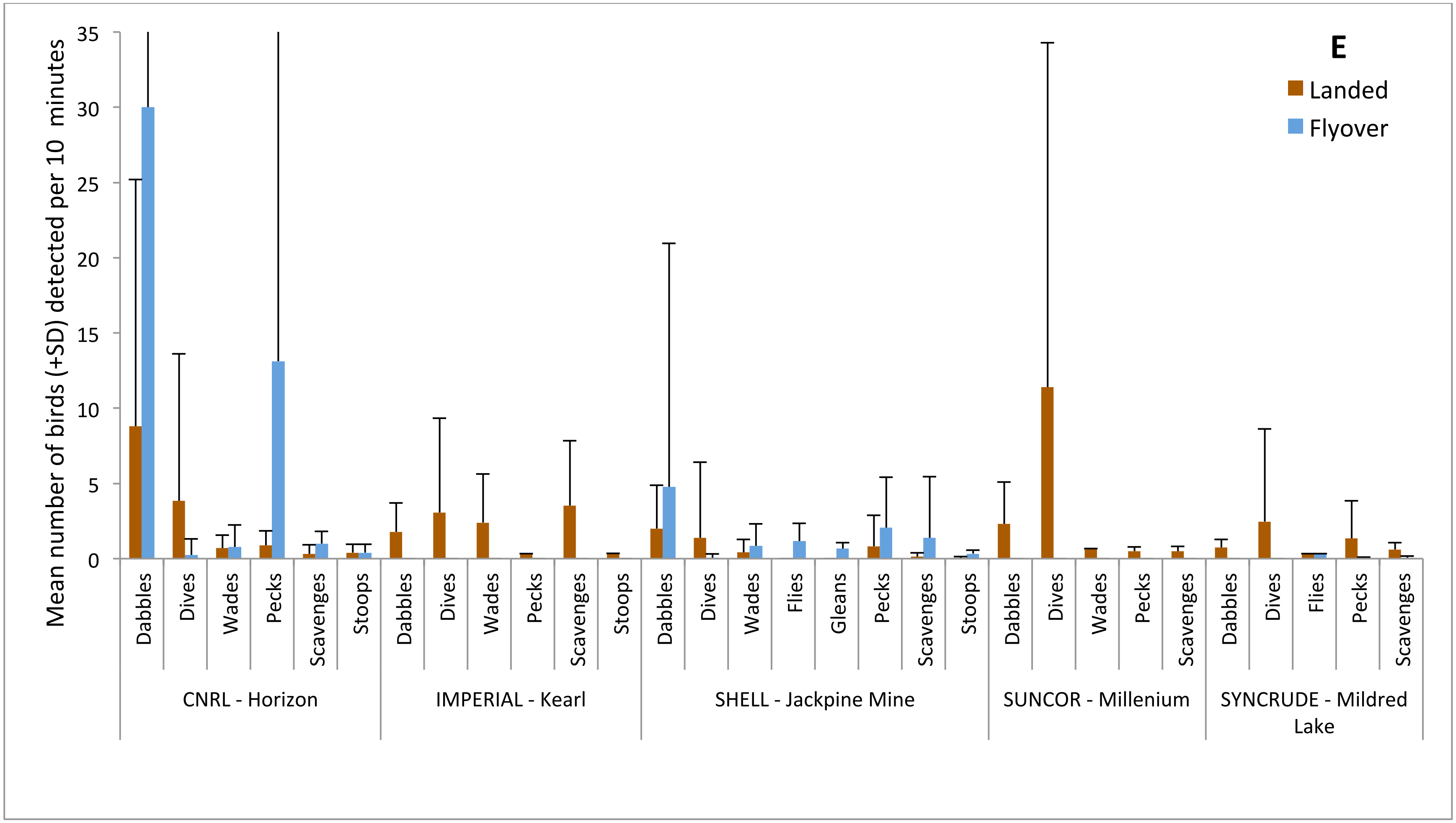
Mean number of birds (+ SD) detected per 10 minutes for birds categorized by their primary mode of foraging during standardized monitoring sessions for each of process-affected ponds (Panels A and B) and freshwater ponds (Panels C and D) and for each of spring (Panels A and C) and fall (Panels B and D). The average detection rate of birds across all operators for both seasons is shown for each guild separately for process-affected ponds (Panel E) and freshwater ponds (Panel F).




B
Landed
Flyover
Mean number of birds (+SD) detected per 10 minutes
25
20
15
10
5
0
Dabbles
Dives
Wades
Flies
Gleans
Pecks
Scavenges
Stoops
CNRL - Horizon
IMPERIAL - Kearl
SHELL - Jackpine Mine
SHELL - Muskeg River Mine
SUNCOR - Millenium
SYNCRUDE - Aurora
SYNCRUDE - Mildred Lake


C
Detections / 10 min
2.5
2
1.5
1
0.5
0
Dabbles
Dives
Flies
Gleans
Pecks
Scavenges
Stoops
Wades
Foraging Guild


D
Landed
Flyover
Mean number of birds (+SD) detected per 10 minutes
25
20
15
10
5
0
78.78
Dabbles
Dives
Scavenges
Stoops
Dabbles
Dives
Wades
Gleans
Scavenges
Dabbles
Dives
Wades
Flies
Gleans
Pecks
Scavenges
Stoops
Dabbles
Dives
Wades
Gleans
Pecks
Scavenges
Dabbles
Dives
Wades
Flies
Gleans
Pecks
Scavenges
Stoops
CNRL - Horizon
IMPERIAL - Kearl
SHELL - Jackpine Mine
SUNCOR - Millenium
SYNCRUDE - Mildred Lake


E
Landed
Flyover
Mean number of birds (+SD) detected per 10 minutes
35
30
25
20
15
10
5
0
Dabbles
Dives
Wades
Pecks
Scavenges
Stoops
Dabbles
Dives
Wades
Pecks
Scavenges
Stoops
Dabbles
Dives
Wades
Flies
Gleans
Pecks
Scavenges
Stoops
Dabbles
Dives
Wades
Pecks
Scavenges
Dabbles
Dives
Flies
Pecks
Scavenges
CNRL - Horizon
IMPERIAL - Kearl
SHELL - Jackpine Mine
SUNCOR - Millenium
SYNCRUDE - Mildred Lake

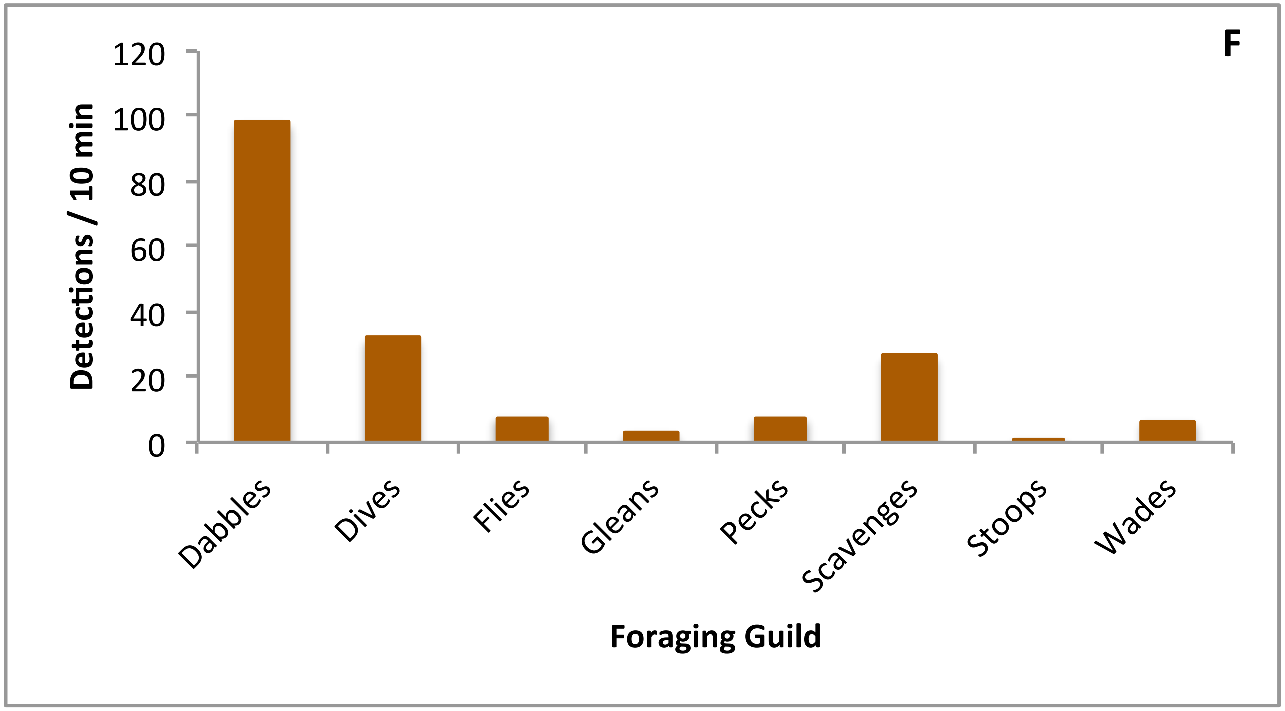

F
Detections / 10 min
120
100
80
60
40
20
0
Dabbles
Dives
Flies
Gleans
Pecks
Scavenges
Stoops
Wades
Foraging Guild

Figure 5 Bird detections by season for target guilds

Detections of landed birds by season at process-affected ponds for the target foraging guilds birds that dabble, dive, or wade expressed as a percentage of total (Panel A), total number o detections (Panel B) and the number of detections for 13 species in target guilds that had the highest proportion of detections in summer (Panel C), which might indicate these species ar more likely to breed in the area.

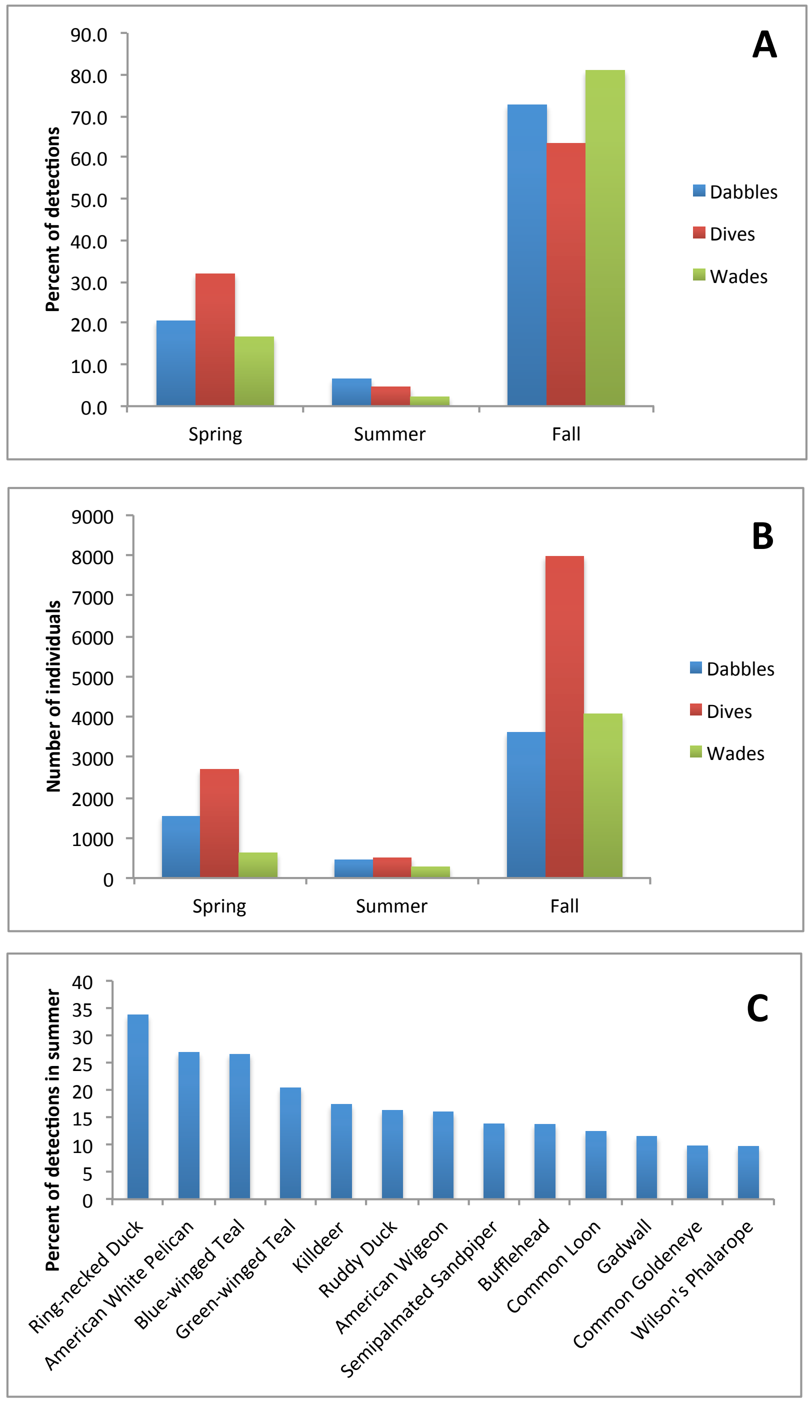
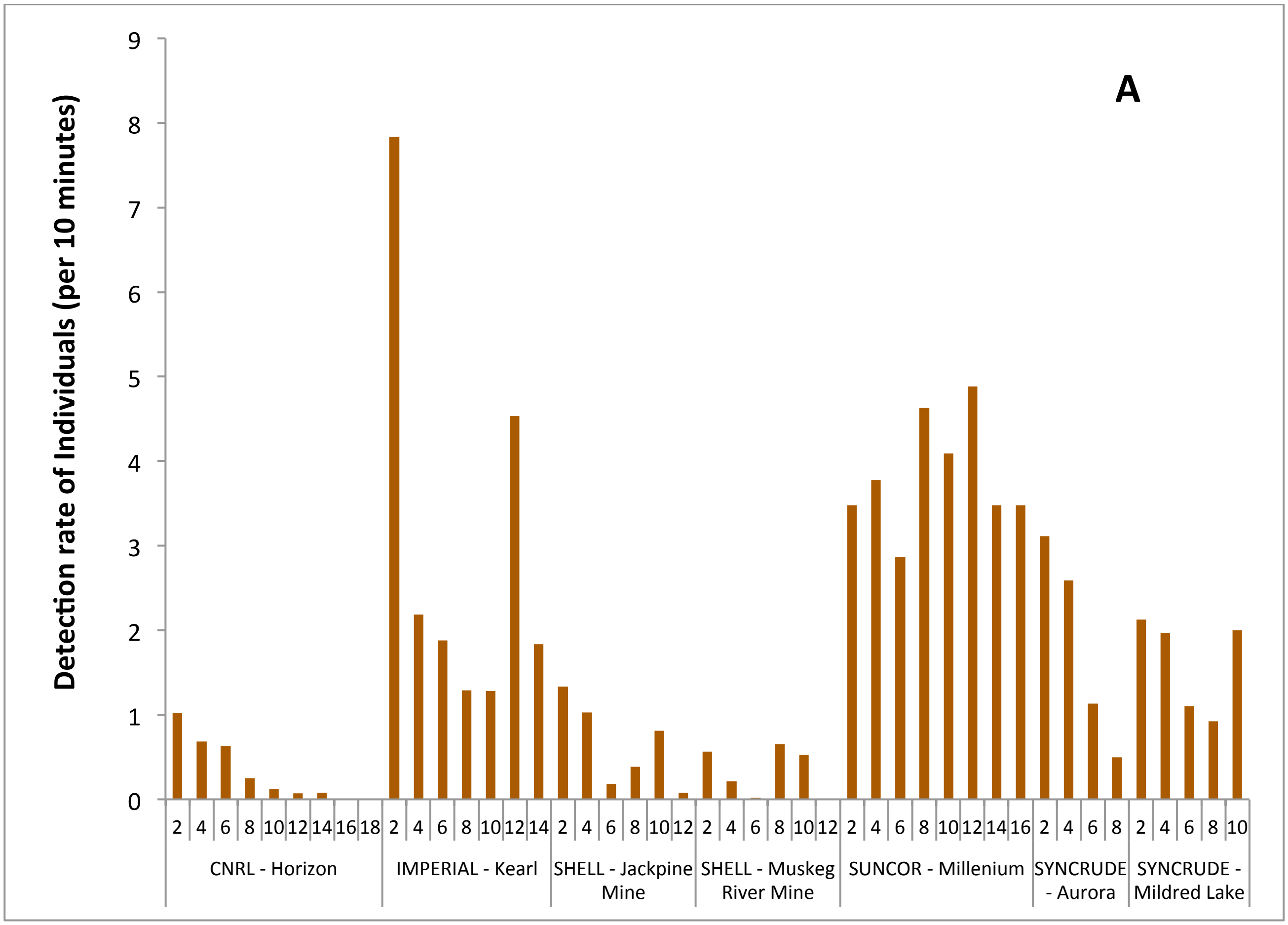
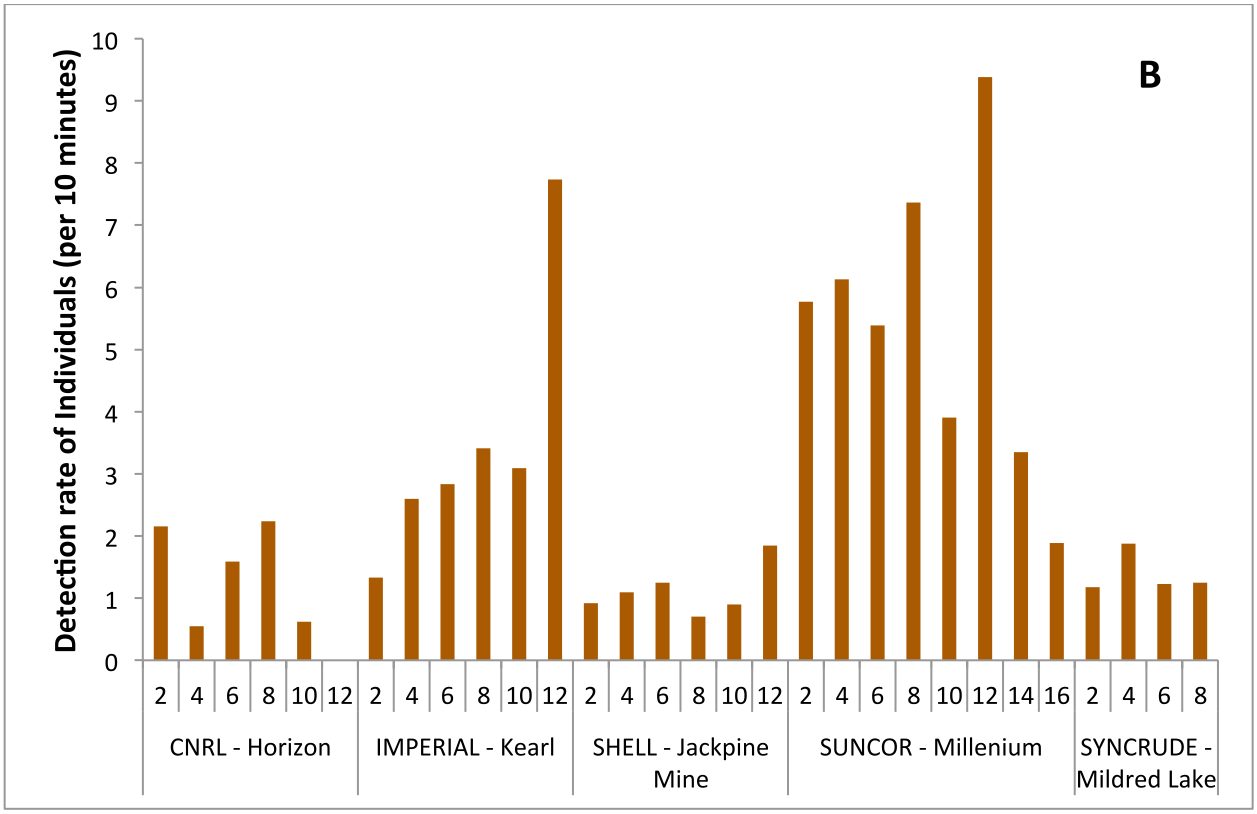
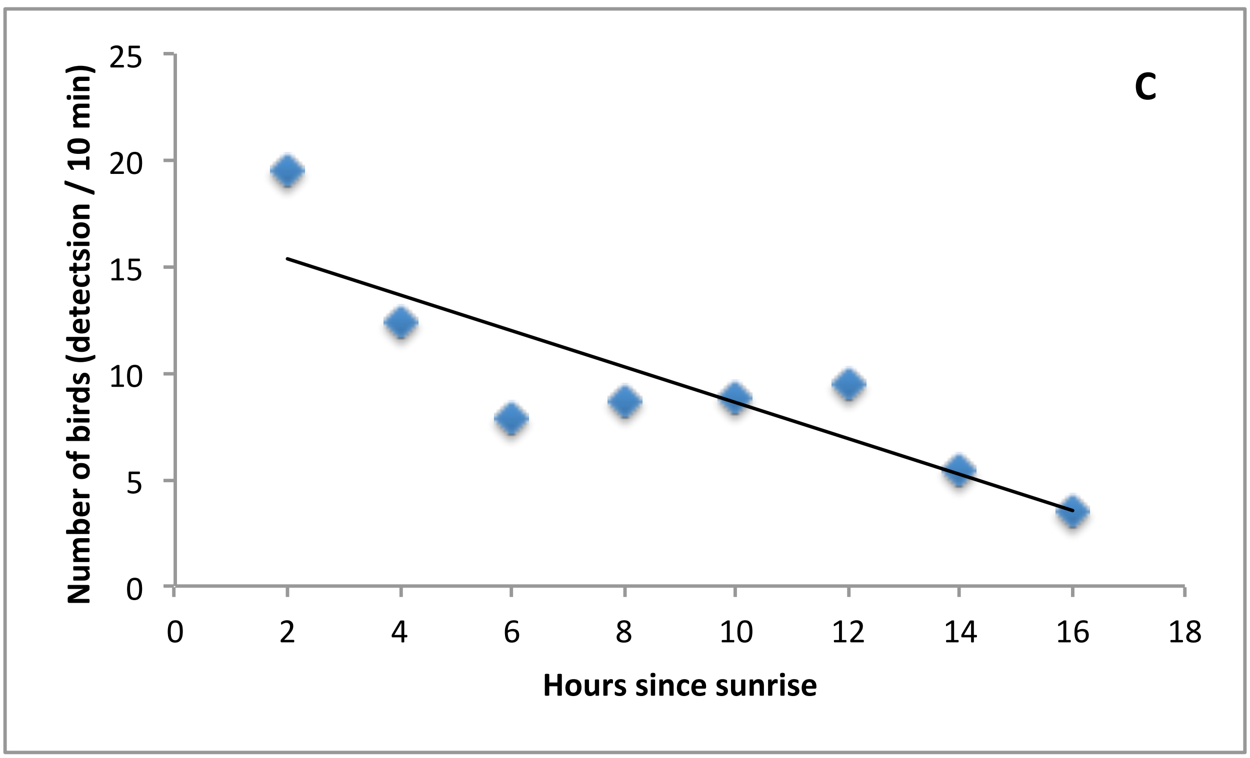


Figure 6 Bird detections by operator and hour since sunrise

Rate of bird detections (standardized to 10 minute observation sessions) for ponds containing process-affected water (Panel A) and freshwater (Panel B). Average detection rates by time block and the best-fit trend line (via linear least-squares regression) are given separately for process-affected ponds (Panel C) and freshwater ponds (Panel D). All bird guilds are included.




B
Detection rate of Individuals (per 10 minutes)
10
9
8
7
6
5
4
3
2
1
0
2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 14 16 2 4 6 8
CNRL - Horizon
IMPERIAL - Kearl
SHELL - Jackpine Mine
SUNCOR - Millenium
SYNCRUDE - Mildred Lake


C
Number of birds (detectsion / 10 min)
25
20
15
10
5
0
0 2 4 6 8 10 12 14 16 18
Hours since sunrise

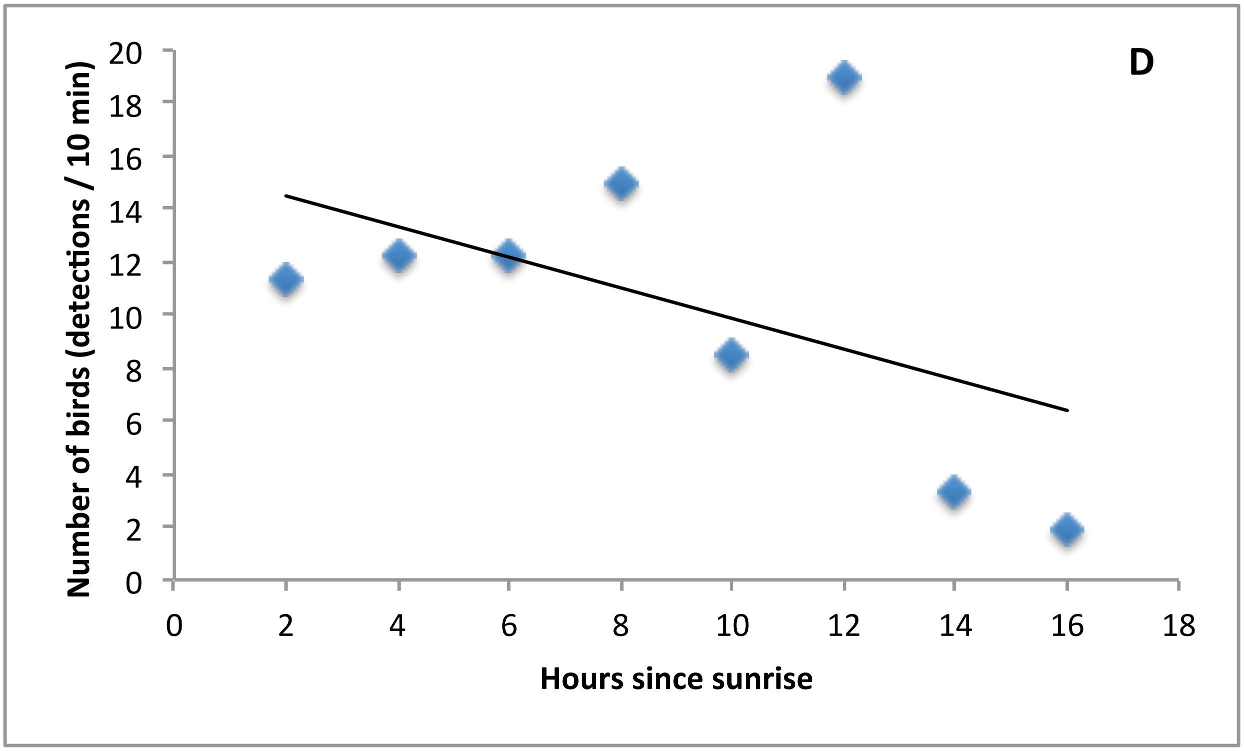
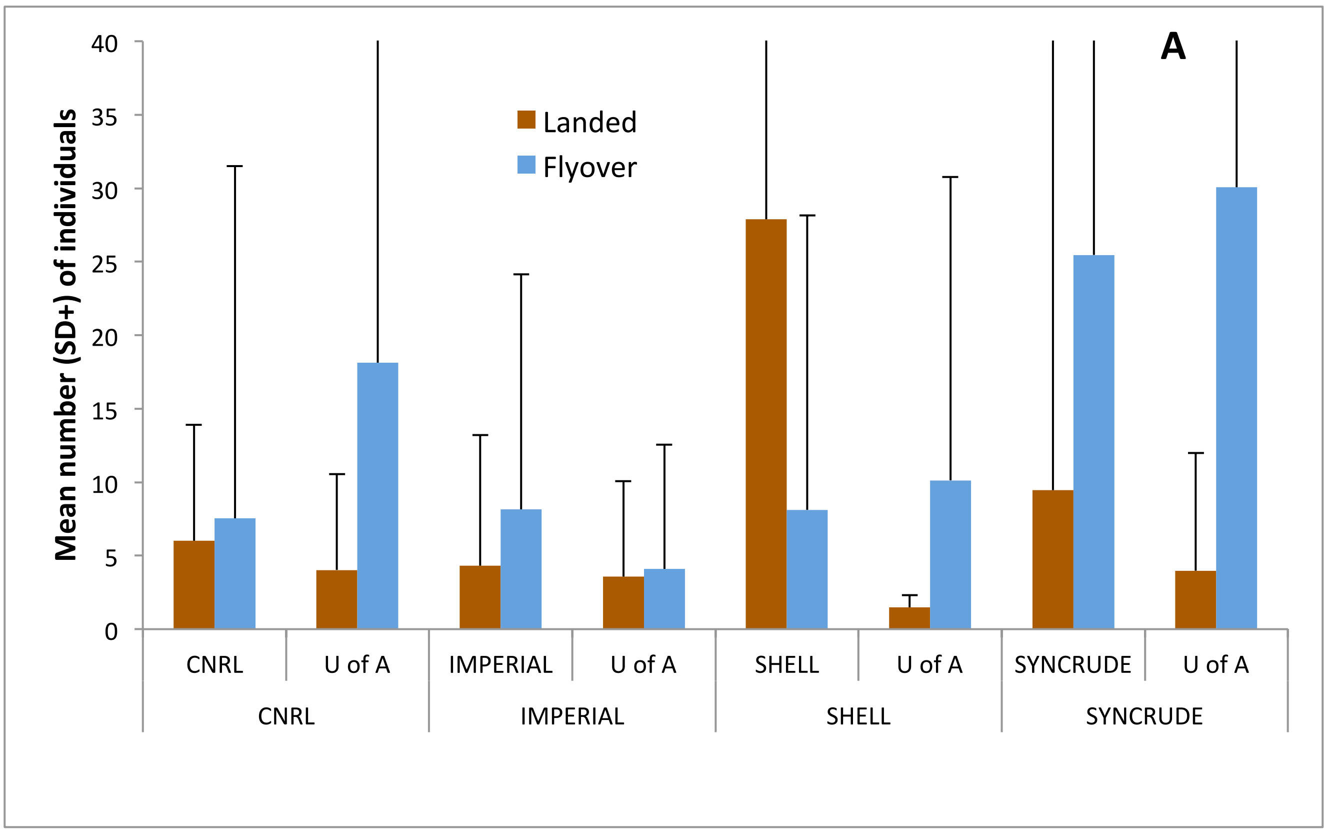

D
Number of birds (detections / 10 min)
0
2
4
6
8
10
12
14
16
18
20
0
2
4
6
8
10
12
14
16
18
Hours since sunrise

Figure 7 Detections per session for industry vs. U of A observers

Mean number of birds from all guilds recorded per observation session for spring and fall seasons combined during simultaneous observation sessions by each of industry and U of A observers. Results are tallied separately for landings (brown bars) and flyovers (blue bars) and for process-affected water ponds (Panel A) and freshwater ponds (Panel B). Only one pond, freshwater Crane Lake, was visited at Suncor with synchronized visits occurring there only in Fall.



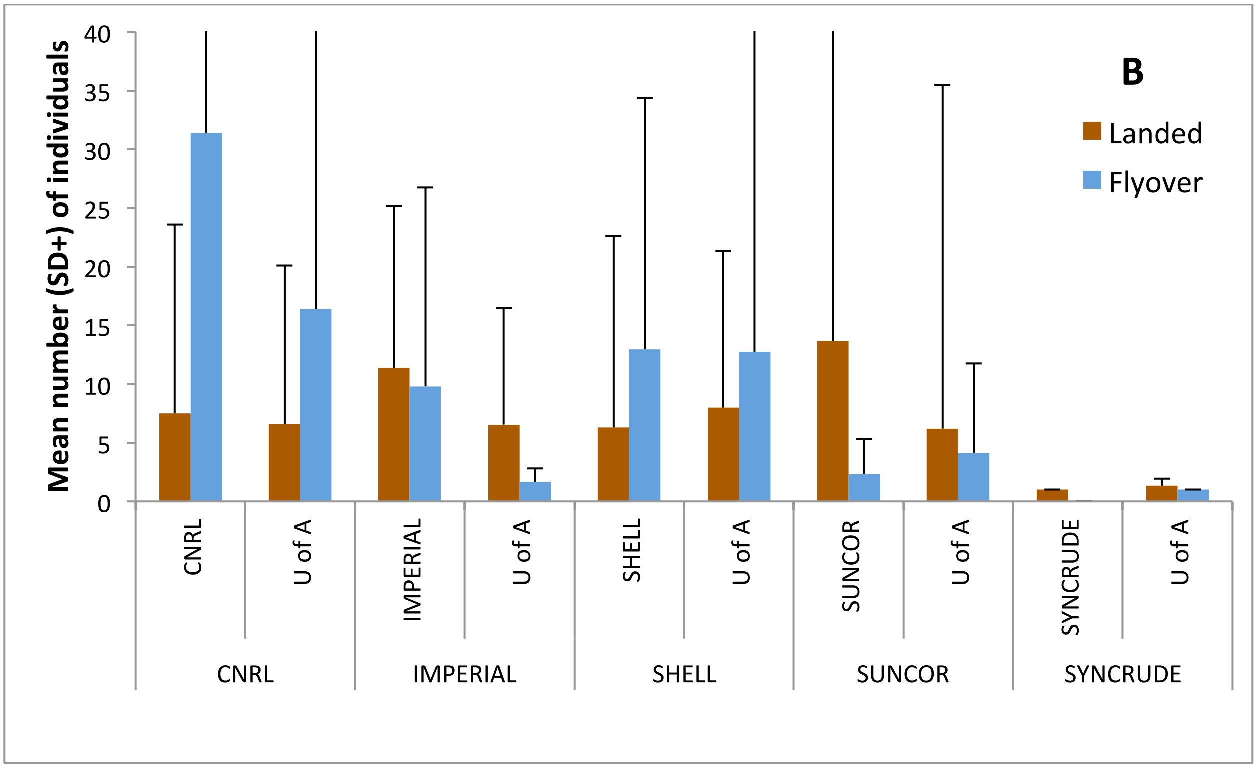
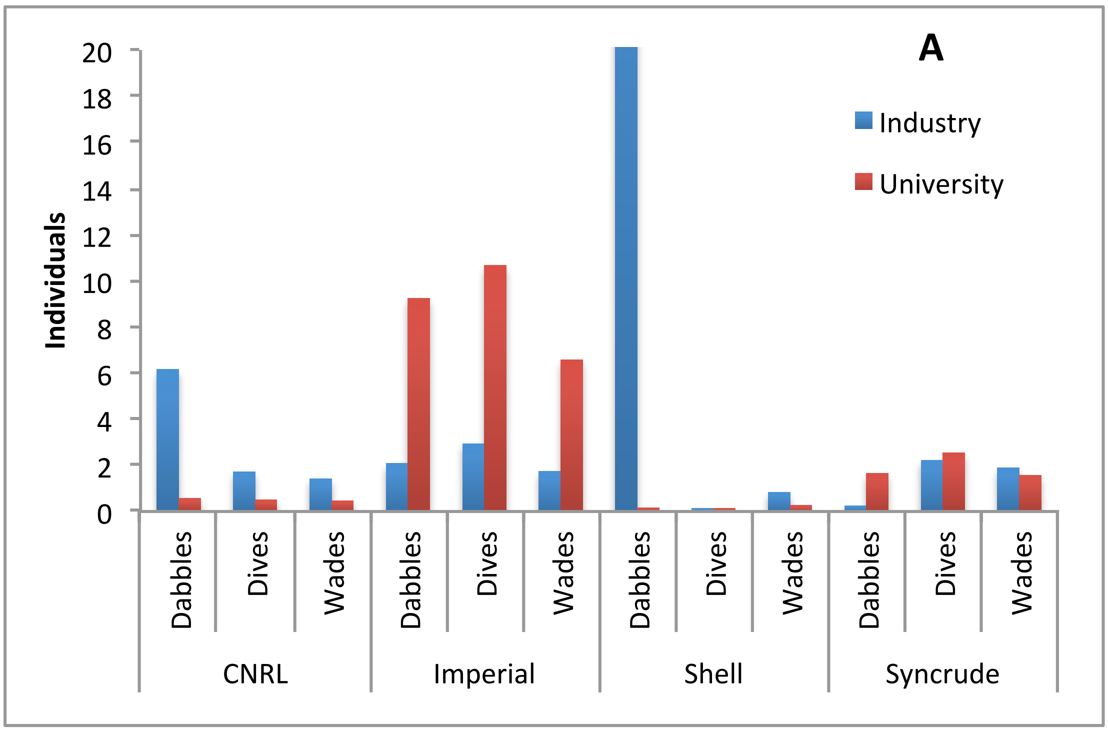
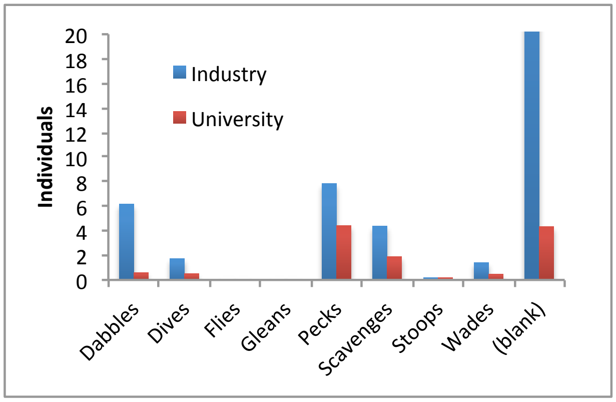

B
Landed
Flyover
Mean number (SD+) of individuals
40
35
30
25
20
15
10
5
0
CNRL
U of A
IMPERIAL
U of A
SHELL
U of A
SUNCOR
U of A
SYNCRUDE
U of A
CNRL
IMPERIAL
SHELL
SUNCOR
SYNCRUDE

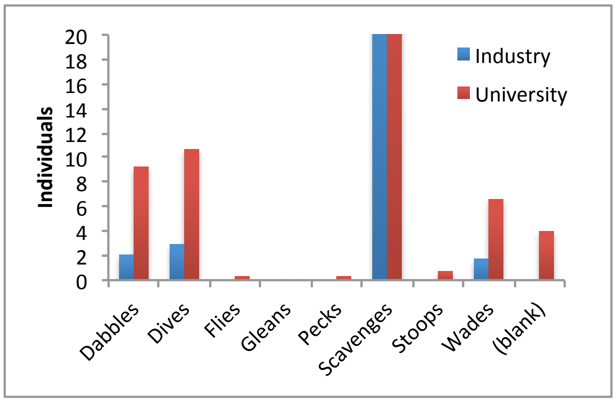
Figure 8 Counts by guild for industry vs. U of A observers at process-affected ponds

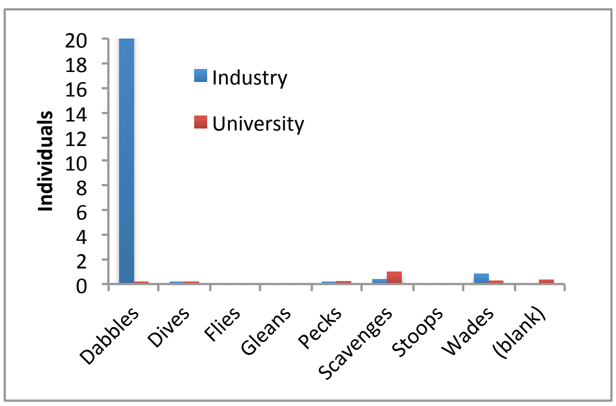
Mean number of birds recorded as landed by guild during paired observation sessions at process-affected ponds for spring and fall seasons combined by each of industry (blue bars) and U of A (red bars) observers. The number of visits for each operator is provided in the text. Results are presented for the three target guilds and four operators combined (Panel A) and for each operator and all guilds (Panel B; from top to bottom, CNRL, Imperial, Shell, Syncrude). For all panels, the total number of individuals is truncated at 20 individuals; actual numbers are provided in Table 8.



B


20
18
16
14
12
10
8
6
4
2
0
Individuals
Industry
University
Dabbles
Dives
Flies
Gleans
Pecks
Scavenges
Stoops
Wades
(blank)


20
18
16
14
12
10
8
6
4
2
0
Individuals
Industry
University
Dabbles
Dives
Flies
Gleans
Pecks
Scavenges
Stoops
Wades
(blank)


20
18
16
14
12
10
8
6
4
2
0
Individuals
Industry
University
Dabbles
Dives
Flies
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Scavenges
Stoops
Wades
(blank)

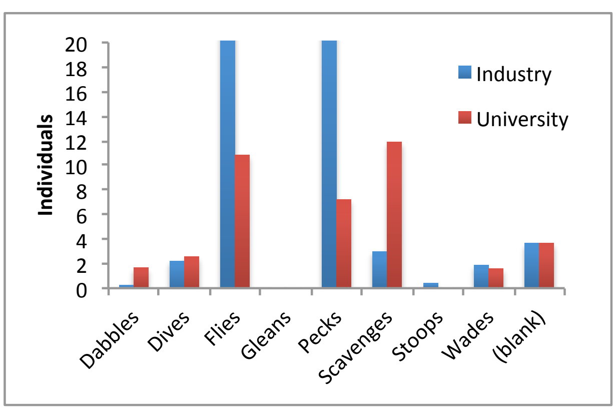
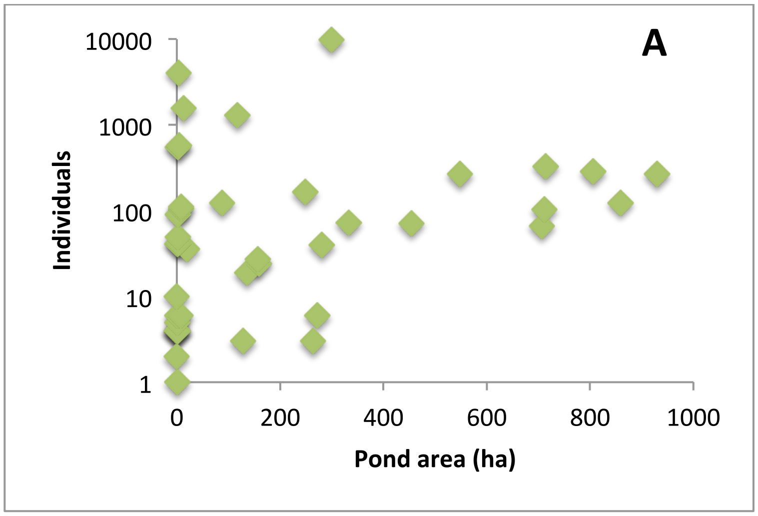

20
18
16
14
12
10
8
6
4
2
0
Individuals
Industry
University
Dabbles
Dives
Flies
Gleans
Pecks
Scavenges
Stoops
Wades
(blank)

Figure 9 Effect of pond area on individuals and species

Effect of pond area on number of individuals (Panel A) and number of species (Panel B) at 40 process-affected water ponds at which one or more birds landed. Number of individuals and species includes only birds of the three target guilds that were recorded as landing during designated monitoring periods in the spring and fall and is plotted on a $\log_{10}$ scale.



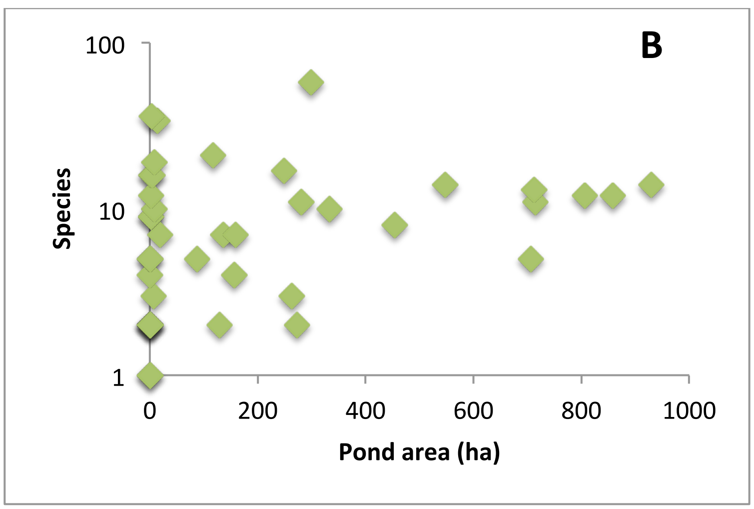


Figure 10 Effect of pond area on search effort and mortalities

Effect of pond area on number of days (Panel A) or hours (Panel B) spent in mortality searches and number of mortalities reported (Panel C) at 53 process-affected water ponds. Number of search hours includes all transportation modes (walking, driving, boating). The number of mortalities sums those detected via standardized searches, euthanasia, and incidental reports.

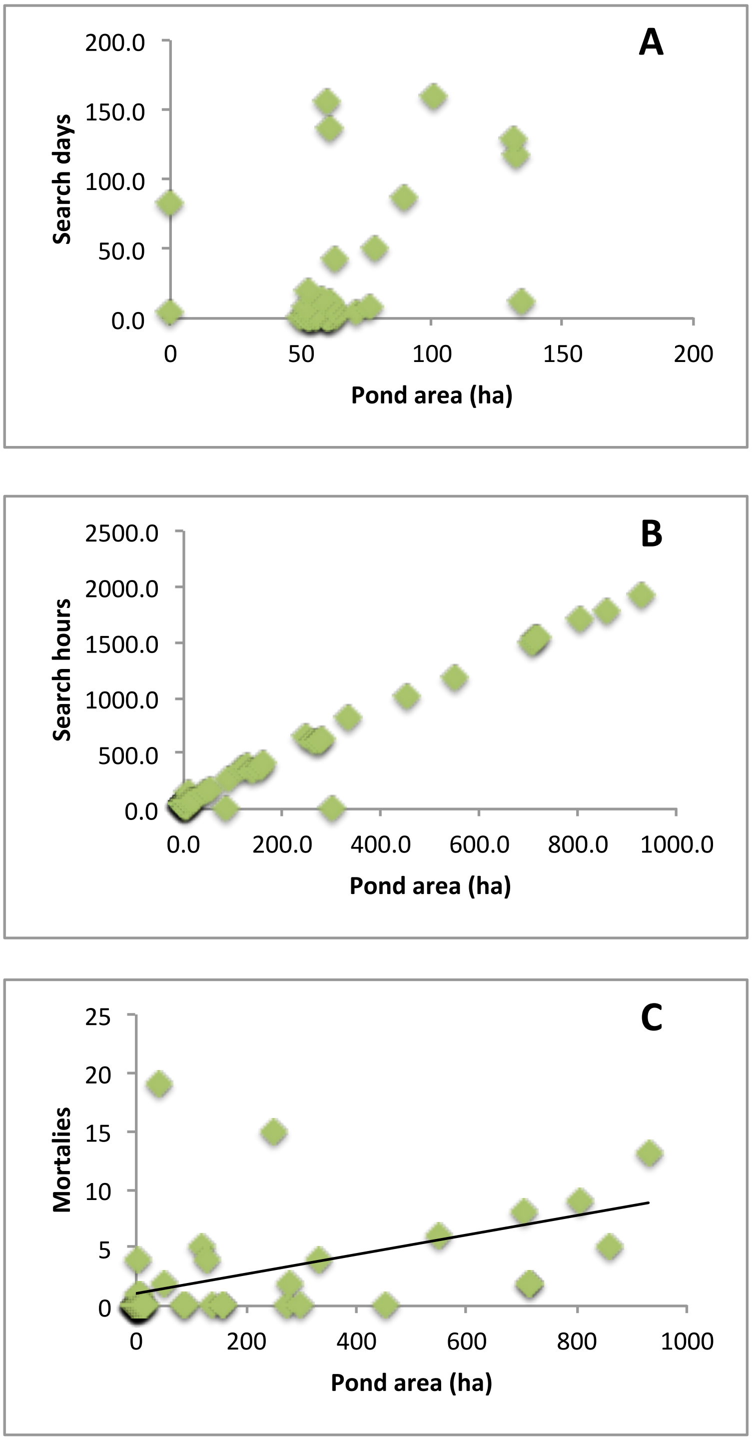


Figure 11 Effects of beach, vegetation, islands, and bitumen

Effect of the presence (orange bars) or absence (green bars) of beach, vegetation, islands and bitumen on the number of landed individuals (Panel A), number of species (Panel B), and mortalities (Panel C) at 53 process-affected water ponds. For each dependent variable, totals per pond were averaged. The number of mortalities includes all species detected via standardized searches, following euthanasia, or from incidental reports. Landed birds and species include only the three target guilds recorded during designated monitoring periods.

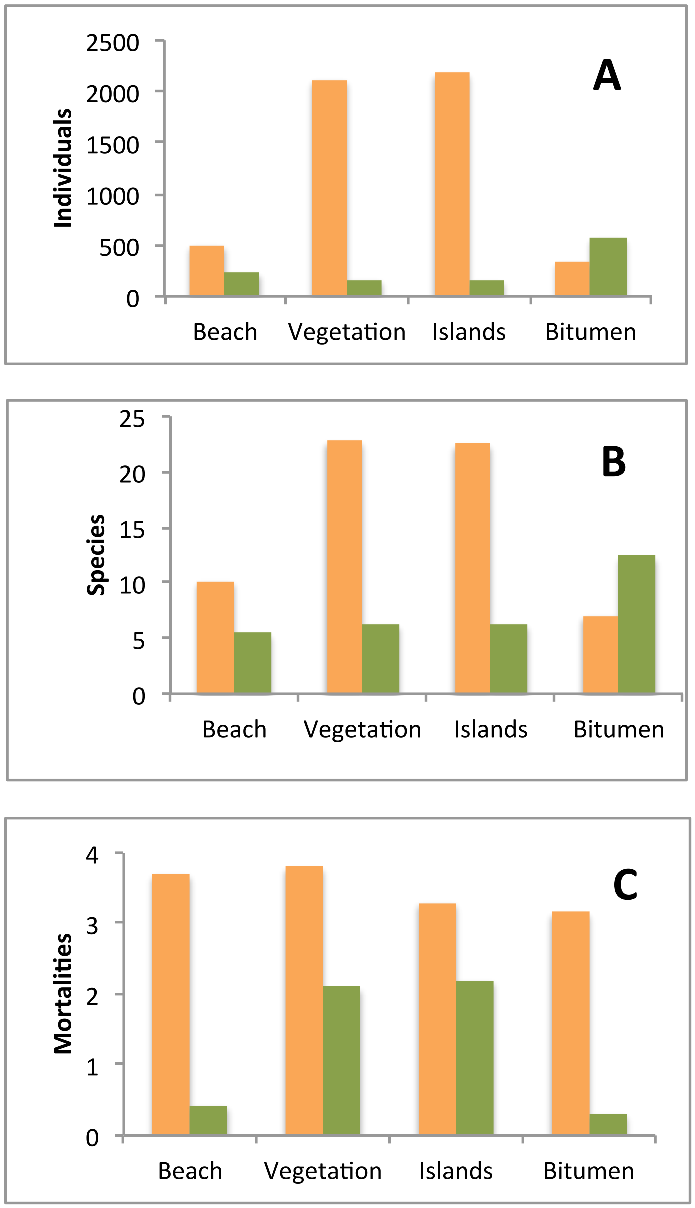
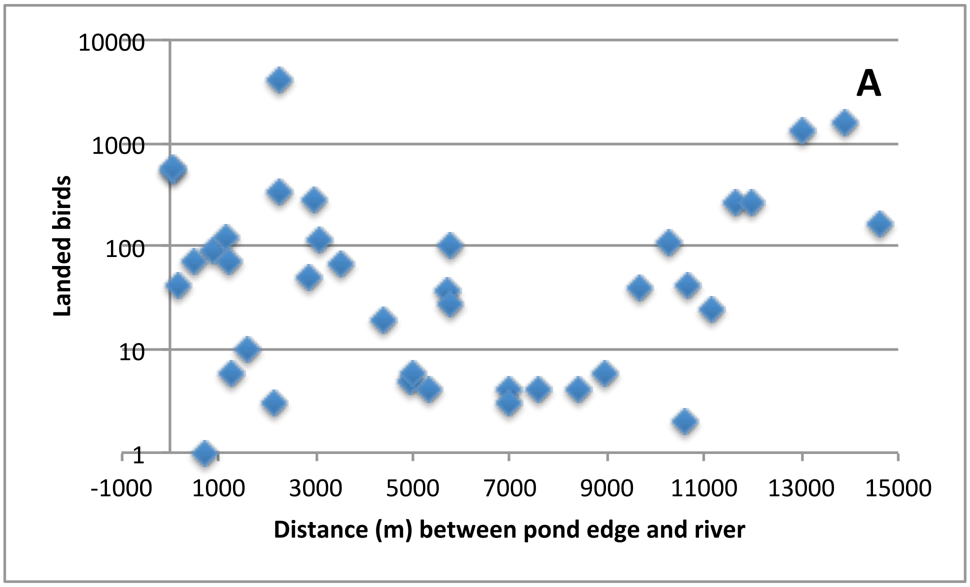


Figure 12 Effects on landings of distance to river

Effect of the distance between the Athabasca River and the nearest pond edge on the number of individuals (Panel A) and species (Panel B) of target guilds that landed on 53 process-affected ponds during designated monitoring periods.



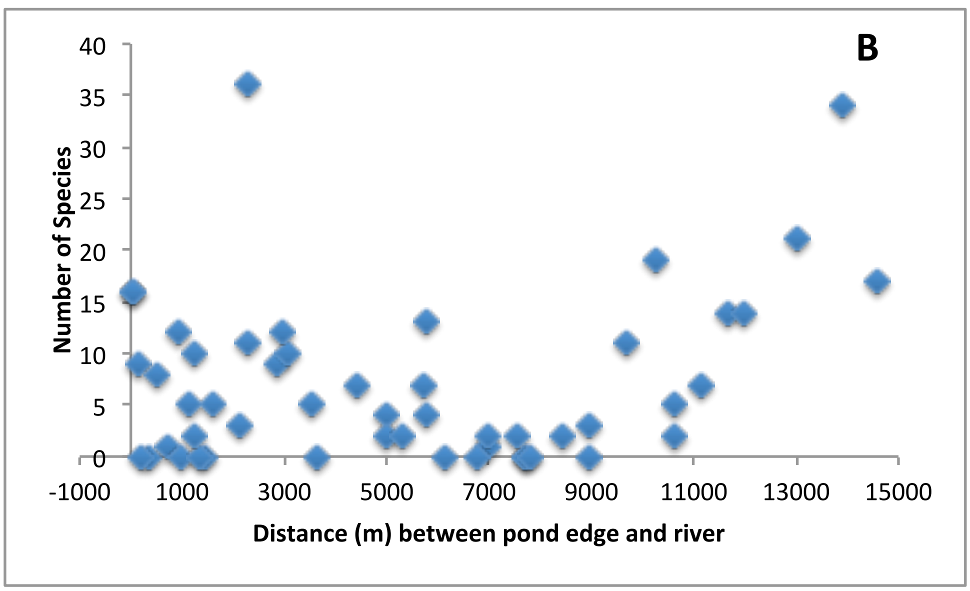


Figure 13 Effect of deterrent density on landed birds and mortalities

Effect of the density of audio, visual, and combined deterrents on the number of landed birds (Panel A) and mortalities (Panel B) for 53 PA ponds. Only birds from the three target guilds counted during standardized monitoring periods and only those ponds with one or more landed birds or mortalities were included. Mortalities were counted from all guilds and from detections stemming from systematic searches, euthanasia, and incidental reports that were attributed to a specific pond.

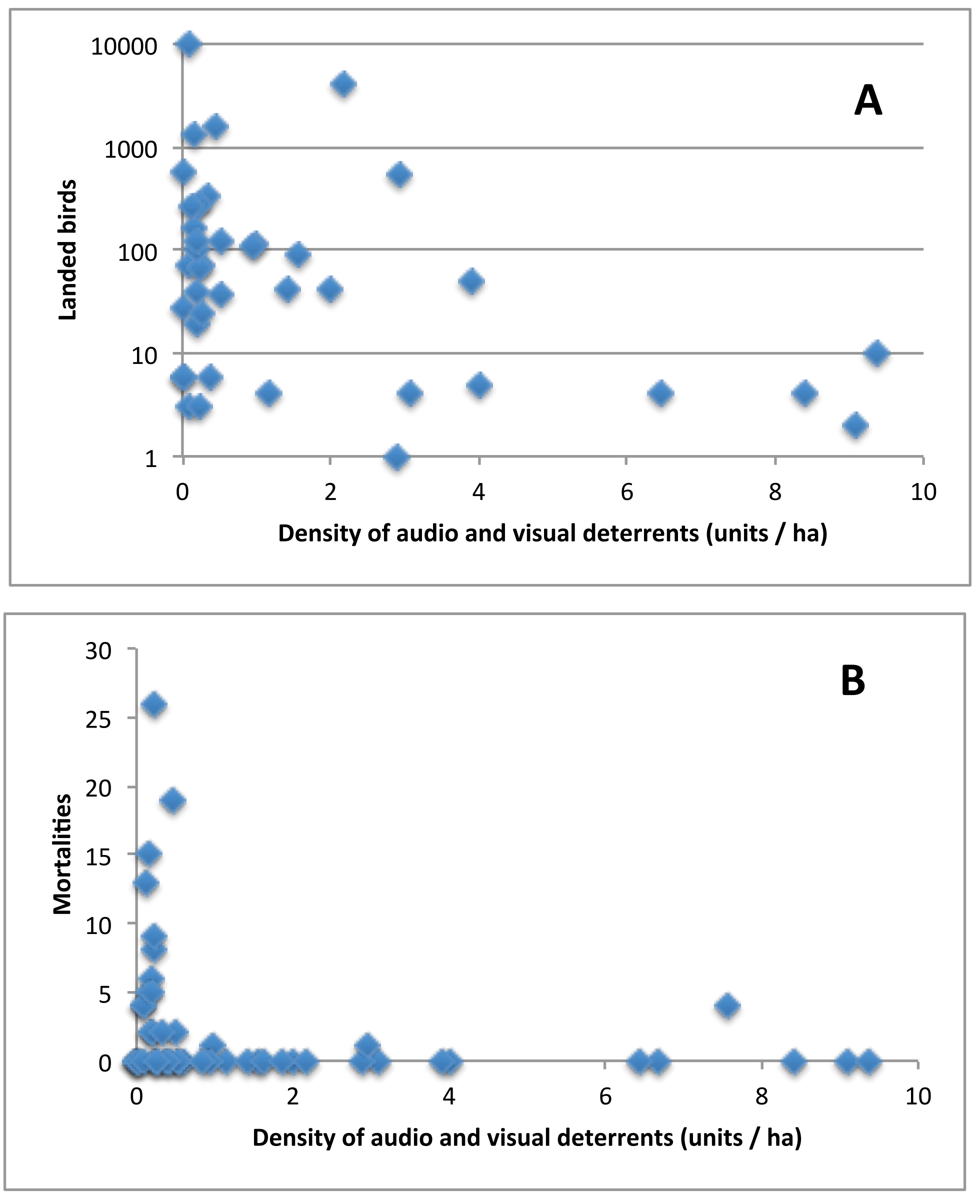


Figure 14 Effect of 80 dB acoustic coverage on landed birds and mortalities

Effect of the area within 200 m of shore calculated to be below an 80 dB threshold of acoustic deterrence on the number of landed birds (Panel A) and the number of mortalities (Panel B) at 53 PA ponds.

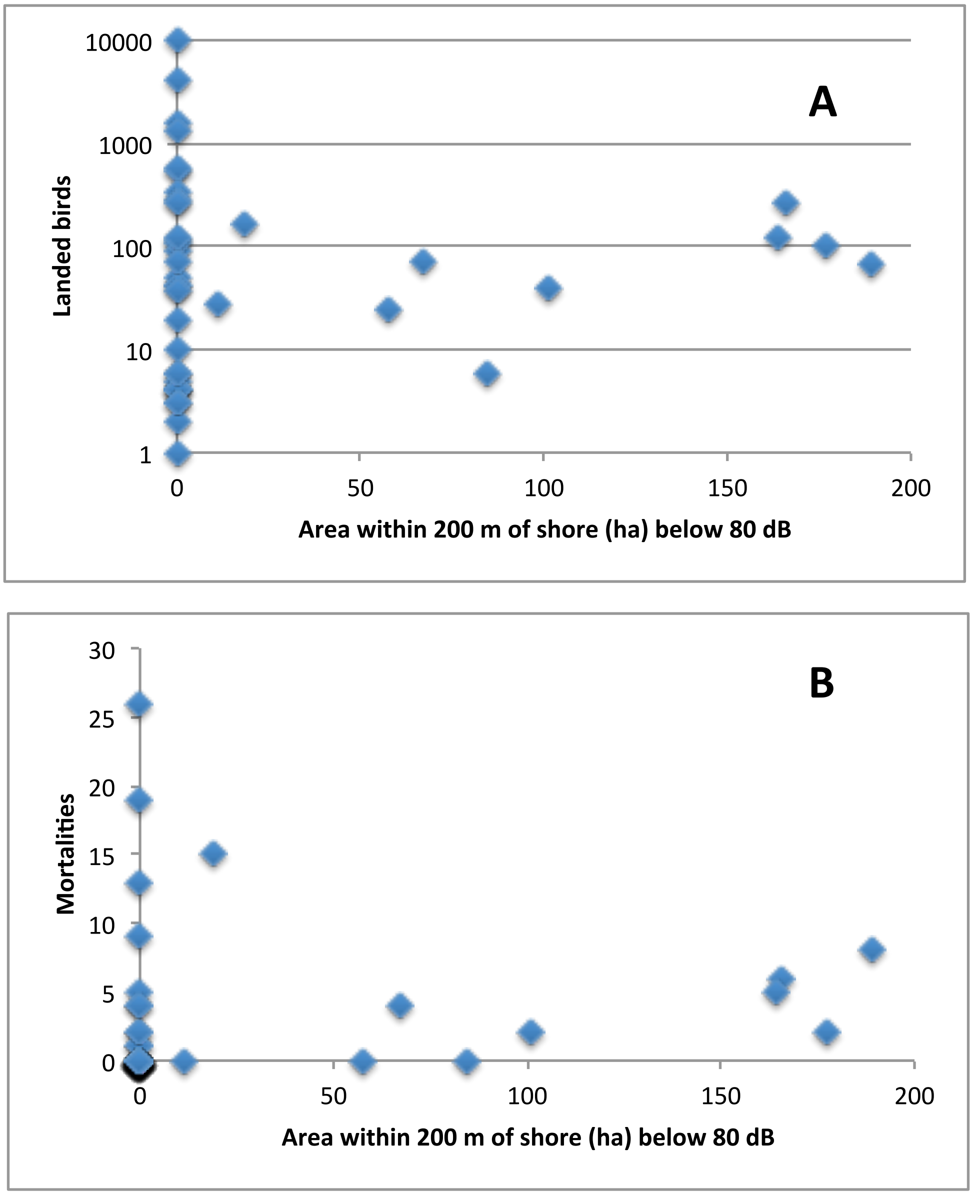
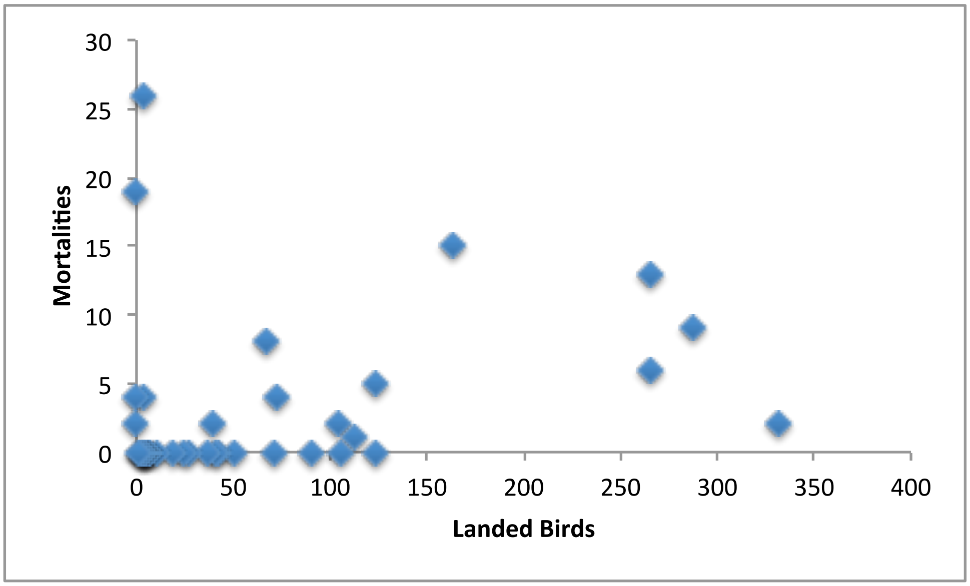


Figure 15 Relationship between landed birds and mortalities

Effect of the number of landed birds on the number of mortalities reported from each of 44 PA ponds at which at least one mortality or landed bird was recorded. The x-axis is truncated at 400, which excludes 4 records in which more than 500 birds landed and zero to a few mortalities (0, 0, 5, 1) were reported (Table 2). Landed birds include only those from the three target guilds and mortalities is the sum reported from search, euthanasia, and incidental reports.



List of Appendices

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Appendix C -- Summary of Weather Data

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