Study of Seabird Attraction to the Hebron Production Platform

A Proposed Study Approach

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For

Hebron Project
ExxonMobil Canada Properties
Atlantic Place, Suite 701
St. John's, NL

Project No. SA1190

17 March 2017

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Introduction

This report presents a proposed research program that has been developed to satisfy a commitment made by the Hebron Project in its Comprehensive Study Report (Hebron 2011) to develop and implement a seabird monitoring program at the Hebron field location. The overall purpose of this research study is to examine potential interactions between pelagic seabirds and the Hebron Platform. The specific objectives of the study were developed in consultation with Environment Canada (EC, now ECCC), the Canadian Wildlife Service (CWS), and the public.

The Hebron Project through its operator EMCP engaged LGL Limited for assistance in developing this seabird research program. Early discussions with EC and CWS suggested that these interactions could be studied by utilizing either vessel or platform-based field observers or perhaps by using specially designed Platform-based avian radar to observe seabird behaviour. Initially the avian radar approach was favored; however, subsequent work led to the conclusion that due to technical problems and design issues, a radar-based approach on the platform will not provide the information required to assess the bird attractions.

The present document outlines an approach for assessing the bird attractions of the Hebron platform using a real-time visual approach to address questions raised by EC, CWS and the public.

Seabirds occasionally strand during the night on well-lit ships at sea or in coastal communities. In offshore Newfoundland waters this behaviour is most commonly exhibited by the Leach's Storm-Petrel (*Oceanodroma leucorhoa*), a species that nests on islands around Newfoundland. Such strandings are of concern to CWS because many involve negative impacts such as mortality to this and other species protected by the *Migratory Birds Convention Act*.

All seabirds will be considered in the study but the focus will be on the Leach's Storm-Petrel because recent studies by Canadian Wildlife Service have indicated that the numbers of nesting storm-petrels have declined. It has been suggested that the declines may be due to several factors with the offshore hydrocarbon industry being a possible contributing factor. It should be noted, however, that data from the existing platforms do not indicate that large numbers of storm-petrels are regularly killed on the platforms. The existing data from the offshore platforms are examined later in this proposal.

Objectives of the Monitoring Study

Consultations with the agencies and the public identified five key areas of research regarding potential interactions between pelagic seabirds and the Hebron Platform area. It is important to ensure that the objectives of the resulting study are clear and that they conform to the expectations of the responsible authorities. The proposed research program is intended to address: 1) attraction of birds to the general vicinity of the production platform; 2) attraction of birds to the actual platform itself; 3) behaviour of birds around the platform; 4) bird strandings on the platform, and 5) bird interactions with the flare.

1) **General attraction to the Platform Area.** Will seabirds be attracted to the general vicinity of the Hebron production platform?
   This question will be addressed by evaluating quantitative data on seabird species composition and densities that have been gathered during many industry and government shipboard surveys near existing platforms and away from them in the region. [See later section in this report discussing the available data.] There are many factors to be considered in the comparisons including location, proximity to shelf break, annual variability, seasonality, type of survey, etc. It should be noted that the presence of existing drilling and production platforms can be used as surrogates for the Hebron platform. Until the analyses of existing data are completed, it is not known whether it would be necessary to conduct targeted surveys to supplement the existing data.

2) **Attraction to the Platform Itself.** This component involves documenting the numbers and species of birds in the vicinity of the platform both during the day and at night and comparing them to the general distribution of birds offshore or prior to placement of the Platform offshore. [Component is closely related with the following component.]

3) **Behaviour of Birds near the Platform.** The behaviour of birds near the platform during the day and at night will be documented. This component includes documenting whether birds are flying toward the platform with the apparent intention of landing there. Recent studies have shown that at least some species of gulls are attracted to platforms at certain times of the year for resting and feeding.

4) **Bird Strandings on the Platform.** The vessel-based approach can document whether birds approach and perhaps land on the platform but it cannot determine whether the birds become stranded on the platform. Data on strandings and release of stranded birds are required to be collected by staff on the platform. These data will be used in the proposed study. [See elsewhere in this document for a discussion of those data.]

5) **Bird Interactions with the Flare.** Birds flying toward the flare and either turning away or flying into it will be documented using a combination of regular binoculars (with shaded glasses to protect the eyes) near the well-lit platform and very bright flare. Away from the heat of the flare, FLIR (infrared binoculars) would be used. Because the main species of concern is the small Leach's Storm-Petrel, it will be necessary to have the supply vessel close to the flare (<100 m or so). A complicating factor is that the storm-petrels are thought to be more prone to stranding on foggy/rainy nights when visibility is restricted.

Study Methods

The more detailed methods to be used to address the objectives listed above are discussed here.

Objective 1 - General Attraction of the Platform Area

The potential attraction of seabirds to the Hebron platform can be assessed by investigating the attraction of existing platforms. For an examination of whether seabird density is higher in the immediate vicinity of the existing production platforms (GBS/FPSOs) than away from the platforms, the daytime seabird strip-transect surveys conducted before the incorporation of the distance sampling technique provide the best source of data. Over 1000 such 10-minute counts have been conducted in the eight 15′ W x 30′ N squares around the existing production platforms (Hebron Comprehensive Study Report: Figure 9-4). The number of surveys conducted using distance sampling since that time is a small fraction of that number. Because such an analysis would be a relative comparison of surveys from the vicinity of platforms with the areas away from the platforms, rather than a documentation of absolute densities, there is no need for the more accurate densities provided by the distance sampling technique. [See section of this document discussing available bird survey data.]

An additional approach for determining whether the Hebron GBS will attract birds is to examine bird numbers in that location before the platform is present and compare those to the numbers of birds present after the platform is operating. This would be a before-and-after-control impact study (BACI). Only 65 10-minute strip-transect seabird counts were carried out up to 2008 in the 15′ W x 30′ N square in which the Hebron field is located (Comprehensive Study Report). The number of counts conducted by industry and ECSAS since that time is probably on the order of tens, suggesting that there may be an insufficient sample size for comparison with surveys conducted after installation. However, a data request to CWS would be necessary to determine the exact number of counts already conducted. Because of this small number of counts it may therefore be necessary to conduct additional counts on the Hebron field prior to the GBS installation to provide sufficient seabird density data from the pre-installation period for this comparison.

Objectives 2 and 3 - Attraction to, and Behaviour around, the Platform

Analysis of the attraction of birds to, and their behaviour around, the Hebron platform will be assessed using visual and infrared techniques. The infrared techniques were developed and tested during the recent study conducted by LGL Limited for Petroleum Research Newfoundland and Labrador (PRNL).

These studies involved the use of standardized, quantitative surveys during the day using high quality binoculars. In addition, regular surveys will be conducted using the latest techniques approved by the Canadian Wildlife Service to increase the available data for comparison with data from other parts of the Grand Banks. [See later section “Documentation of Available Information on Seabird Density” for discussion of survey techniques that have been used offshore in Atlantic Canada.] Numbers and behaviour at night will be documented using a forward looking infrared bi-ocular (FLIR). Quantitative survey techniques developed in the previous study conducted by LGL Limited for PRNL will be used.

The frequency of the various surveys within each season will depend upon whether one or two observers are present on the supply vessels with two observers necessary during the key periods of summer and fall when surveys would need to be more frequent.

Objective 4 - Strandings on the Platform

Strandings of birds on the platform will be addressed using infrared and visual observation techniques. Strandings will be approximated by watching birds that approach the platform and by assessing their behaviour near the platform. This information will be compared to data routinely collected on the platform by the designated staff person. The effort by the staff person will be upgraded to a dedicated, structured daily survey during the period of the two months of September and October, which is the period when Leach's Storm-Petrels are most likely to become stranded. Ship-based observations may not be as effective on foggy nights and the best source of information may come from the platform-based observer. [See later section 'Strandings on Existing Platforms on the Grand Banks".] Additional information on potential stranding will be gathered as part of the study of interactions with the flare in Objective 5.

There is a concern about the possibility of major stranding events that occur on a less than annual basis. This concern requires a different study approach that is discussed later in this proposal. Presently, all stranding events are reported to CWS in the annual salvage reporting requirements on the seabird handling permit.

Objective 5 - Interactions with the Flare

Bird interactions with the flare will be assessed using a combination of visual and infrared techniques. The question of whether birds fly into the gas flare from an offshore production platform remains largely unanswered even after decades of gas flaring activity around the world. There are two general sources of birds that could potentially interact with a flare primarily during the hours of darkness. These are (1) landbirds migrating at night during spring and fall and (2) seabirds active at night.

The location of the oil production structures on the eastern Grand Banks is outside of known or expected routes of night-time migrating land birds. A few landbirds are known to land on ships and the oil platforms on the Grand Banks. These are generally considered to be birds that are off course and would have perished had they not landed on a platform. In summary, migrating landbirds are not expected to be a significant issue in the area of the Hebron platform.

Seabirds can be attracted to the lights of oil production platforms and ships at sea. Gulls and shearwaters are known to actively feed at night on fish attracted to the surface by lights. Other species, notably the Leach's Storm-Petrel, are attracted to the lights of vessels and oil platforms. They frequently become disoriented, resulting in an unplanned or crash landing on the vessel. Once on the deck they do not return to sea for reasons that are unclear. Leach's Storm-Petrels are known to fly directly into a light at night. They are regularly found on the ground around lighthouses on land after flying into the glass around the turning light.

There remains the unanswered question: do Leach's Storm-Petrels fly into the flare on oil production platforms off Newfoundland? An important part of this study is to document possible storm-petrel mortality at the flare. LGL Limited is conducting a recently approved pilot study of storm-petrels near existing flares on the Grand Banks for Petroleum Research Newfoundland and Labrador (PRNL). That study is using the methodology discussed in the Detailed Methods section below.

Detailed Methods

Observations of birds around the Hebron platform will be from supply vessels and will require different methods during day and night. It is important to document bird abundance and activity in the general area and adjacent to the Hebron during daytime. This provides information on abundance and distribution of birds that could occur at night-time when strandings and flare interactions are most likely.

***Daytime Survey Methodology*:** The protocols for conducting seabird censuses from Stationary Platforms outlined by Environment Canada's *Eastern Canadian Seabirds at Sea* standardized protocols (Gjerdrum et al. 2012) will be used with modifications. The supply ships attending production platforms are typically stationary or moving very slowly. A survey will consist of a snapshot scan of a 180° arc from a point on the vessel with a good view. Each scan will take a few seconds and will document all birds present within 500 m of the observer. All birds observed during the scan will be recorded with priority given to the birds within 500 m. The distance of birds from the observer will be recorded by dividing the survey area into distance bands of 50, 100, 200, 300, 500 and > 500 m. A distance gauge using tick marks on a clear plastic ruler and a mathematical equation outlined in Gjerdrum et al. (2012) will be used to determine the distance of a bird from the observer. The surveys will occur once every ten minutes during an observation period of two hours. Two hour observation periods could occur up to three times per day depending on ship's activity and the demand on observer with night-time observations.

Observation period information recorded for each survey such as time, position of ship, environmental conditions, etc., will follow the protocol outlined in (Gjerdrum et al. 2012). In addition, the distance and direction of the Hebron platform from the supply ship will be noted. The bird information recorded with each observation will include species, number, activity, distance, flight direction and other headings as outlined in Gjerdrum et al. (2012). A data sheet will be devised with the appropriate headings for efficient recording of information and later entry into a digital data base.

Night-time Survey Methodology: To be able to see small species such as Leach's Storm-Petrel the observer on the supply vessel will need to be stationary at a distance of no more than 100 m from the Hebron structure for continuous periods of up to two hours. It is recognized that a supply vessel inside the 500 m safety zone around Hebron will require the use of special safety protocols. These are the protocols that are routinely used when the supply vessels approach the platforms to unload cargo, etc.

The ship should be positioned a little off to the side from the location of the flare so that the observer can see around the area of the flame looking up on an angle of < 45°. This will reduce neck strain on the observer and still be near enough to the flame to see small birds through optics.

Ideally, on nights with observations there should be three two-hour survey periods per night. Logistically this will rarely be possible due to other duties of the supply vessel.

The observer will use infra-red FLIR optics equipped with a 65 mm lens as the primary tool to search for birds. Every two minutes the observer will make two circular scans around the flame. The first will be a 360° scan as tight around the flame as possible while avoiding potential damage to the eyes. The second scan will be just outside the diameter of the first scan. It may be possible to insert a third scan (see next paragraph). Each orbital scan of the flame should take about 20 seconds. If birds are detected they would be followed to observe their activity in relation to the flame and GBS structure.

It is not clear how close to the flare that the FLIR optics can be used without interference from the heat of the flare. It may be practical to use standard high quality binoculars to conduct the scan closest to the flare where the light from the flare would allow detection of close-in birds. Care must be taken to protect eyesight during observations close to the flare. There will need to be some experimentation to determine the best protocol to use on these orbital surveys. In between orbital scans of the flare, there will be a visual scan with binoculars to look for birds around the visible part of the platform and the water around the base of the platform. Good quality binoculars would be used in observing birds within the lighted areas close to the rig. Binoculars can be used to identify birds to species but the infra-red optics are of limited use for identification of birds beyond the family group. The latter limitation is not too important for the Hebron Study because there will be very limited species diversity in the vicinity of the platform.

Information recorded on a field data sheet would include environmental conditions, distance of observer from the platform plus the number and species of birds if any observed. Behavioural observations of birds such as approaching the platform, colliding with the platform, falling onto a horizontal surface or into flare, erratic flight among components of platform, circling the platform or flare (known as “nocturnal circulation” or “holding effect”), hovering at platform or flare; loafing, preening, sleeping would also be recorded and entered into a digital database.

Timing of Surveys

The timing of surveys is designed to cover a full year of avian activity. This would be achieved by conducting six weeks of surveys within each of three (winter, spring and summer) of the four seasons of the year. During the fall, eight weeks of surveys would be conducted. The extra time in the fall is because that is the period with the highest likelihood of attraction and strandings by recently-fledged young birds. The surveys during each season would be broken into several small trips. The proposed 26 week survey schedule would give a good representation of the bird activity over the year and would adequately account for seasonal patterns.

It is anticipated that a single year of surveys would be sufficient to typify the extent of regular attraction of seabirds to the Hebron platform. The possible need for additional coverage at certain seasons would be determined after evaluation of the first year’s data.

Rare Major Stranding Events

One of the concerns about the attraction of storm-petrels to the lighted platform is the possibility of a major event where hundreds of birds might strand on the platform. Because these would be very rare events, it is difficult to design a study that would actually be on site for such less than annual events. In fact, there is no evidence of any such major events having occurred on the existing platforms offshore Newfoundland. The stranding reports from the offshore platforms are summarized in a later section "*Strandings on Existing Platforms on the Grand Banks*". Various platforms were present for all or part of 60 platform-years from 2003 to 2014. Depending on the definition of a major event, there were no major strandings recorded on these platforms.

To ensure that major strandings are documented, EMCP has developed an approach summarized here:

1. **Seabird awareness training –** Platform personnel's daily duties will take them to all areas of the Platform, so all personnel will receive orientation on seabird awareness. This orientation will emphasize the importance of reporting seabird strandings as part of their daily duties. The training will include general awareness of the risks to seabirds and of the requirements to report stranded seabirds to the SSHE Lead. The SSHE Lead will have additional training focused on additional seabird handling permit requirements. Since there is an SSHE Lead on all shifts, this ensures there will be a designated person with extensive training who is responsible for the tracking, addressing concerns, and ensuring relevant bird-handling protocols are followed at all times.

2. **Daily Observation Checklist –** The SSHE Lead will conduct SSHE observations around the platform (SSHE walkabout) on a daily basis. During this walkabout bird observations will be documented as required by the CWS bird-handling permit. Areas covered are largely determined by the locations where workers are active, but areas where no work is taking place are also covered. When the vessel-based study is active (i.e., in field), a bird observation checklist will be used during the daily walkabout to record the presence or absence of stranded seabirds. The bird observation checklist will serve to document the areas covered and where stranded seabirds are identified. Relevant details will then be carried forward into the standard reporting protocols identified in the CWS bird-handling permit.

3. **SSHE Weekly Platform-Wide Inspection –** The SSHE weekly inspection will cover the entire platform and will typically involve people from all platform disciplines (management and workers) divided into groups of two to three. One of the topics that will be covered and included on the checklist is observing and cataloguing stranded seabirds.

To more fully document the circumstances associated with any large stranding event, data on weather and the presence of fog sources should be routinely collected and retained for a few weeks. Information on the size of the flare would also be useful to determine whether light from the platform was higher than usual. This data collection would enable the retrieving and saving of data from around the stranding event that could be examined for conditions correlating with major stranding events.

Meetings with Technical Experts and CWS

The Board requested that there be a meeting with Dr. Phil Taylor of Acadia University. Dr. Taylor is a recognized expert at studying bird movements in both terrestrial and marine environments. He examined bird attraction to the Deep Panuke platform operated by Encana Corporation offshore of Nova Scotia. His broad experience was valuable in evaluating potential methods to be used in the proposed study at Hebron.

A preliminary telephone meeting was held on 1 June 2015 attended by Dr. Taylor, Dr. Rolph Davis of LGL Limited, and James O'Reilly, Rob Dunphy and Michael Teasdale of EMCP. An in-person meeting was held at Dr. Taylor's office at Acadia University in Wolfville, NS on 18 August 2015 with Dr. Taylor, Dr. Davis, and Rob Dunphy and Michael Teasdale. A follow-up telephone meeting between Dr. W. John Richardson, LGL's radar expert, and Dr. Taylor was held in the morning of 1 September 2015. During the course of the meetings, Dr. Taylor made many useful suggestions on possible approaches to be considered. Some of his ideas would be most appropriate for region-wide studies of the bird attraction to offshore facilities issue. These are not discussed here because the focus of the present study is the Hebron platform.

A subsequent meeting with Canadian Wildlife Service in St. John's to review the present proposal is recommended but has not yet occurred. This would be a technical meeting involving Dr. Davis and staff of LGL Limited and appropriate CWS personnel.

Radar

The Public Review Commissioner for the Hebron Project made the following recommendation regarding seabirds.

Recommendation 5.11:

The Commissioner recommends that the Proponent, given the data and information collection and communications technology to be incorporated on the platform, evaluate the use of real-time visual imaging to supplement and provide a means of validation of the radar data concerning bird attraction, and to provide a back-up if the radar method proves unsuccessful.

The recommendation contemplates the use of a back-up approach if the radar method proves unsuccessful. In fact, that is the case that is being addressed in the present study.

The Hebron project carefully evaluated the use of radar on the platform to examine the attraction of birds. For a variety of reasons, the use of on-platform radar has proved to be unfeasible. There are two types of problems. First, the radars on the Platform look outward to avoid structures on the platform and thus, the beam close to the rig is very narrow and not very useful at documenting birds on or near the Platform. In addition, the radars would be high above the water and would miss most of the birds near the rig unless they were focused downward, where they would be degraded by significant wave clutter. The second concern is the lack of ability to maintain the radars and their data processing facilities on the platform because of bedspace limitations and competing work priorities. Therefore, the present approach of observing the platform from the supply vessel assigned the safety role has been devised.

Discussions with Dr. Phil Taylor identified the possibility of using the marine radar on the supply vessel to monitor birds flying near the platform. There are many problems associated with this approach the most obvious being that the pitch and roll of the vessel is problematic for interpreting the data from the radar beams. In addition, the signal processing that makes the radar signals usable by the vessel eliminate the data of interest to this study. Dr. Taylor thought that intercepting and copying and saving the raw radar signals would be feasible. The data could then be subjected to currently available software to determine whether any useful information could be obtained. It may be possible that this low cost research initiative could be conducted, but it has not yet been confirmed if the new Hebron supply vessels will be capable of recording radar data.

Existing Information Relevant to this Proposal

A variety of information was reviewed and analyzed in the preparation of this proposal. Some of that information is summarized in the following sections. The information was used to assist in the design of the proposed study. The data will also be useful in the interpretation of the data collected during the proposed study.

Relevant Species

Many of the individual birds attracted to offshore vessels and platforms are nesting adults or recently fledged young. In Newfoundland waters, this is true for the two species most commonly stranding around artificial light, Leach's Storm-Petrel and Atlantic Puffin (Wilhelm et al. 2013). However, migrating, wintering, and non-breeding summering birds may also interact with the Hebron platform. Large numbers of Great Shearwaters (*Puffinus gravis*) and Sooty Shearwaters (*P. griseus*) nesting in the South Atlantic migrate to the Grand Banks, the Labrador Shelf, and their shelf slopes to spend the austral winter (Lock et al. 1994; Hedd et al. 2012). Other major migrants on the outer Grand Banks consist of Arctic-nesting species: Northern Fulmar (*Fulmarus glacialis*), Black-legged Kittiwake (*Rissa tridactyla*), Arctic Tern (*Sterna paradisaea*), Common Murre (*Uria aalge*), Thick-billed Murre (*Uria lomvia*), Dovekie (*Alle alle*), and jaegers and skuas (*Stercorarius* spp.) (Lock et al. 1994; González-Solís et al. 2011; Fort et al. 2013). Although seabird migration is apparent during daylight, the proportion of total seabird migration that is diurnal is unknown (Stienen et al. 2007). Seabird migration usually occurs within 25 m of the surface of the sea, infrequently up to 50 m, but seldom at greater altitudes (Krüger and Garthe 2001). For many individuals of the Arctic-nesting species, the outer Grand Banks and the shelf slope are the final destination of their fall migration; these areas host large numbers of these species during winter (McFarlane Tranquilla et al. 2013b, 2014).

Many landbird species migrate primarily at night. Their migratory flights take place at a wide range of altitudes, from just above the surface to altitudes of 3,000–5,000 ft, and occasionally higher. Most of the passerine migration to and from Newfoundland is on a northeast–southwest axis over land or close to shore, well to the west of Hebron. A small number of individuals of these species may reach platforms on the Grand Banks, well to the east of their normal migration routes, but these individuals will mainly be disoriented vagrants—mostly young-of-the-year birds that would die if they did not land on a platform.

Migration by many species of shorebirds (Charadriidae and Scolopacidae) includes long-distance round-the-clock trans-oceanic flights. Most shorebirds migrating in Atlantic Canada travel between breeding grounds on the Arctic tundra and wintering grounds in South America. Some of these flights occur over the ocean but generally west of the Hebron location. Shorebirds are very rare on the existing offshore platforms on the Grand Banks.

General Information on Attraction of Offshore Platforms

Artificial lighting on ships at sea, offshore oil/gas drilling and production structures, coastal communities, and oceanic island communities has often been implicated in the stranding of nocturnally-active seabirds and nocturnally-migrating land- and water-birds, sometimes in large numbers (Montevecchi et al. 1999; Gauthreaux and Belser 2006; Montevecchi 2006). Birds may be attracted to artificial lighting from a distance of up to 5 km in the case of offshore oil/gas installations with 30 kW of lighting (Poot et al. 2008). This interaction with artificial lighting can result in bird mortality. Mortality may arise from collisions with non-illuminated structures near the lights that the birds cannot see, or more rarely, with the lights themselves (Dick and Donaldson 1978; Telfer et al. 1987; Black 2005; Russell 2005; Poot et al. 2008; Rodríguez and Rodríguez 2009; Bocetti 2011). In many cases seabirds strand on the vessel/platform deck or ground and are unwilling or unable to take flight and return to the sea. In offshore Newfoundland, stranded seabirds are usually found in partially enclosed decks, so stranding may be due to the birds' inability to find their way back out to sea. Once stranded, these birds eventually succumb to dehydration, starvation, or predation (when on land). Some die from hypothermia or drowning when coming into contact with hydraulic fluid or other hydrocarbons in water-filled tanks or drip-trays.

Attraction to artificial lighting and attendant grounding appears to be widespread among procellariiform seabird species, i.e., petrels, shearwaters, and prions (Procellariidae), storm-petrels (Hydrobatidae), and diving-petrels (Pelecanoididae) (but not albatrosses Diomedeidae), having been observed in more than 20 species (Imber 1975; Reed et al. 1985; Telfer et al. 1987; Le Corre et al. 2002; Black 2005; Montevecchi 2006; Abgrall et al. 2008b; Rodríguez and Rodríguez 2009; Miles et al. 2010). Light attraction has also been reported in the Atlantic Puffin (*Fratercula arctica*) in coastal areas near nesting colonies in both Scotland and Newfoundland (Miles et al. 2010; Wilhelm et al. 2013).

The stranding of seabirds at artificial lighting occurs at all times of the year, but tends to be more common at the end of the nesting season (Telfer et al. 1987; Le Corre et al. 2002; Miles et al. 2010). In studies in which the age of the grounded seabirds has been determined, the majority of individuals have been newly fledged young, particularly in strandings near seabird nesting colonies (Imber 1975; Telfer et al. 1987; Rodríguez and Rodríguez 2009; Miles et al. 2010).

Stranding at artificial lighting appears to be associated with certain environmental conditions. Greater numbers of birds strand around artificial lighting when there is a low cloud ceiling, particularly when accompanied by fog or rain (Hope Jones 1980; Wallis 1981; Telfer et al. 1987; Black 2005; Russell 2005; Abgrall et al. 2008a,b; Poot et al. 2008). Seabird strandings also appear to peak when moonlight levels are lowest, i.e., around the time of the new moon (Telfer et al. 1987; Rodríguez and Rodríguez 2009; Miles et al. 2010; Wilhelm et al. 2013). Species prone to stranding may be more active on darker nights. For example, the arrival and departure of small procellariiform species at active nests occurs primarily at night, presumably to reduce predation on the eggs, nestlings and adults. This activity is lowest around the time of the full moon (Imber 1975; Bretagnolle 1990), so a preference among seabirds to be active on dark nights may be a mechanism for avoiding nocturnal predators (Watanuki 1986; Mougeot and Bretagnolle 2000; Oro et al. 2005).

At oil production installations gas flaring is another bright source of light. As a result, some researchers suggest that flaring, like electric lighting, attracts nocturnally-active birds. In addition to potentially colliding with platform structures or stranding on the platform, these researchers suggest that some of the birds attracted by gas flaring at night may be incinerated (Russell 2005; Montevecchi 2006). Systematic visual monitoring of North Sea gas flares has detected no incineration (Hope Jones 1980; Wallis 1981). Such monitoring has not been conducted in the Gulf of Mexico, but two burned songbirds were found in a study of the use of offshore oil platforms by migrating land birds (Russell 2005). Bird mortality at an onshore flare stack in Alberta has been documented (Bjorge 1987). However, necropsies of 56 of the birds revealed equivocal evidence of collisions and no evidence of burning. The injuries observed were instead consistent with hydrogen sulfide poisoning. In September 2013 news media reported 7,500 nocturnally-migrating songbirds dying at a gas flare at the Canaport liquid natural gas plant in Saint John, New Brunswick (CBC News 2013). Atmospheric conditions included fog and overcast sky. Many of the birds were burned, but many showed no external injuries. Environment Canada initiated an investigation.

Bird attraction to artificial lighting at sea may be mitigated in a variety of ways. Recovering grounded seabirds and returning them to sea when their plumage has dried greatly reduces mortality (Telfer et al. 1987; Le Corre et al. 2002; Abgrall et al. 2008b; Rodríguez and Rodríguez 2009; Williams and Chardine, n.d.). Reducing, shielding or eliminating skyward radiation from artificial lighting also appears to reduce the number of birds grounded (Reed et al. 1985; Rodríguez and Rodríguez 2009; Miles et al. 2010). A preliminary study of the effect of replacing white and red lights on an offshore natural gas production platform with green lights suggested that there was a reduction in the number of nocturnally-migrating birds attracted to the green artificial lighting (Poot et al. 2008).

Strandings on Existing Platforms on the Grand Banks

Strandings on offshore platforms of those bird species protected under the federal *Migratory Birds Convention Act Regulations* are documented on the platforms and reported in the bird salvage logs submitted to Environment Canada. The salvage permits issued by that agency require that the bird handling protocol detailed in “The Leach’s Storm-Petrel: General Information and Handling Instructions” (Williams and Chardine, n.d.) be followed. That document recommends that, on nights when storm-petrels are stranding, the crew patrol the decks of the platform or vessel as frequently as is necessary to ensure that as many birds as possible are returned to the sea in good health. The document details the capture, handling, and release procedures, and the procedure for birds whose plumage has been contaminated with oil. The salvage permit is issued for a single calendar year and requires that a written report detailing the numbers of all birds salvaged, those released, and those that died be submitted by the following 31 January.

There is variability among the platforms in the ability of the observers to survey all potential areas on the platform where storm-petrels could be trapped. Also, the observers have other duties and there is some variability in the rigour and frequency with which they can search for stranded birds. These caveats should be kept in mind when reading the following sections that discuss strandings on the various platforms, as indicated by the reports filed with Environment Canada.

A total of 2,048 birds of 31 species have been recorded in the bird salvage logs of the offshore production facilities and mobile offshore drilling units (MODUs) from 2003 to 2014. Of those birds, 1,986 were seabirds consisting of eleven species and the remainder were landbirds or shorebirds (20 species). Of the seabirds, 86% (1,706 individuals) were identified as Leach's Storm-Petrels or unknown storm-petrel, consistent with the view that this bird group is the group most strongly attracted to artificial lighting in offshore Newfoundland. The remainder of the seabirds consisted of species that strand on offshore facilities only when their plumage is oiled or when they collide with the structures in poor visibility (46 individuals of puffins, murres, Dovekies and shearwaters), or due to illness (various gull species; 208 individuals were associated with an avian cholera outbreak in 2007).

Leach's Storm-Petrel

The storm-petrel strandings occurred on the floating production, storage and offloading vessels (FPSOs), the *Hibernia* gravity-based structure (GBS), and the MODUs. These facilities varied in their amount of time on-site (Table 1). Of these facilities, the *Sea Rose* accounted for the most strandings, despite being present in Jeanne d'Arc Basin only since late 2005 (Figure 1). The other two production facilities, *Hibernia* and *Terra Nova*, had fewer strandings. Two of the MODUs (*GSF Grand Banks* and *Henry Goodrich*) had numbers of strandings that were similar to *Hibernia* and *Terra Nova* despite the *GSF Grand Banks* being on-site for three fewer years than the production facilities. The other three MODUs were on-site for one to two years. The reasons for the differences among individual offshore facilities in the number of storm-petrels stranded are unknown. However, potential causes include geographic location, proximity to the shelf break where the storm-petrels feed, structural and lighting characteristics of those facilities, weather, and differences in application of storm-petrel survey protocols on the platforms.

Overall, there was an annual average of 142 storm-petrel strandings recorded on the offshore platforms over the 12 year period. The average was spread over a variable number of platforms in each year.

Table 1. Numbers of years of stranding data (number of years on-site in the period 2003 to 2014) from each of the GBS, FPSOs, and MODUs.

Platform	Facility Type	No. of Years of Data
Eric Raude	MODU	2
GSF Grand Banks	MODU	9
Henry Goodrich	MODU	12
Hibernia	GBS	12
Sea Rose	FPSO	10
Stena Caron	MODU	2
Terra Nova	FPSO	12
West Aquarius	MODU	1

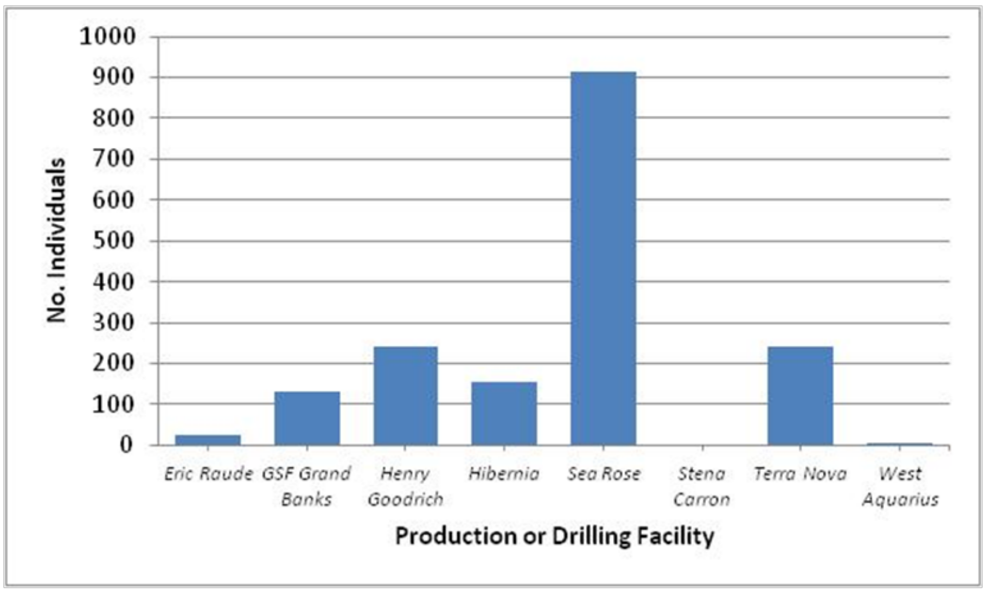

Figure 1. The number of storm-petrels stranded from 2003 to 2014 on production facilities and mobile offshore drilling units. *Sea Rose* and *Terra Nova*: FPSOs; *Hibernia*: GBS; *Eric Raude, GSF Grand Banks, Henry Goodrich, Stena Caron*, and *West Aquarius*: MODUs.

Variability in Strandings

To examine variability in storm-petrel strandings only the production facilities were considered because they were on-site for consistently longer periods of time than the MODUs. The strandings on the production facilities showed large annual variation. The number of storm-petrels stranded annually varied from five to 781 (Figure 2). Sixty percent of all birds stranded during the period 2003 to 2014 were recorded during 2006. The reason for this variation is not clear but may have been related to abnormal water temperature patterns that occurred in 2006 (Colbourne et al. 2007).

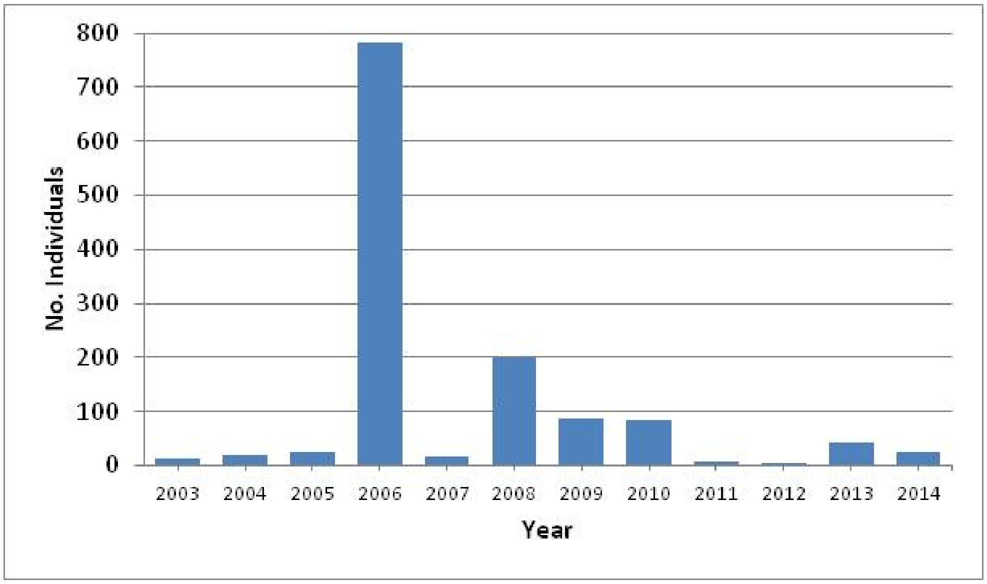

Figure 2. The number of storm-petrels stranded on production facilities by year from 2003 to 2014. Data are from *Hibernia* GBS and *Sea Rose* and *Terra Nova* FPSOs.

The strandings also show strong seasonality. The vast majority of strandings occurred during September and October (Figure 3). Even when data from 2006 are excluded, 95% of strandings occurred during these two months. This correlates with the period during which juvenile storm-petrels fledge from the nesting colonies in Newfoundland and begin their southward migration (Huntington et al. 1996). During this period, strandings peaked from 10 September to 13 October (Figure 4). The beginning of the peak period corresponds to the earliest recorded date of fledging at Great Island in Witless Bay, Newfoundland, i.e., 10 September (Huntington et al. 1996).

The number of strandings per day varied greatly, from 0 to 122 individuals. The days with the five largest numbers of birds stranding are presented in Table 2; all were in 2006. Three of these days occurred in mid-September and two were at the beginning of October. Most of the birds stranding on these five days were found on the *Sea Rose* (Table 2). The largest exception was 83 birds found on *Hibernia* on 2 October.

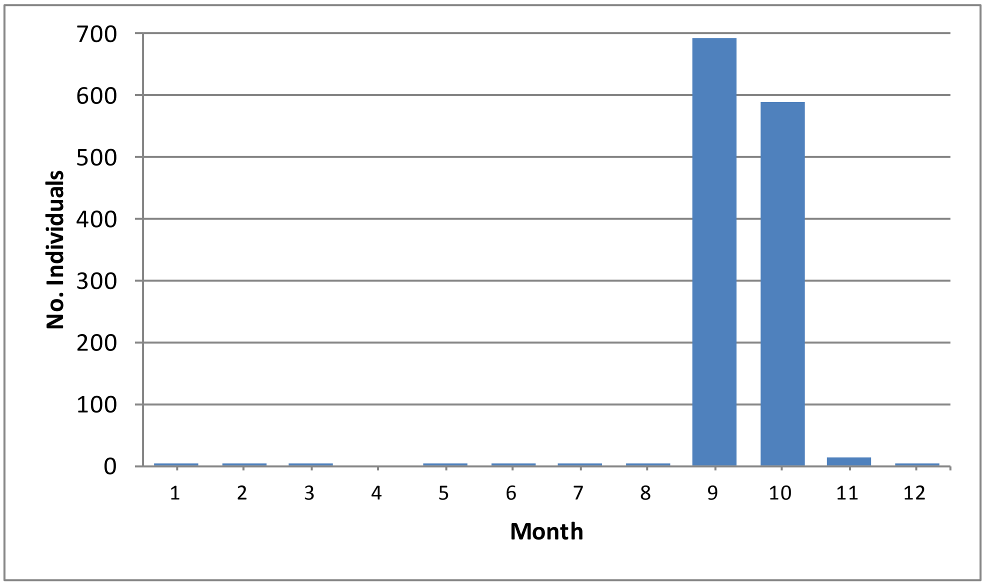

Figure 3. Number of storm-petrels stranded on production facilities by month from 2003 to 2014. Data are from *Hibernia* GBS and *Sea Rose* and *Terra Nova* FPSOs.

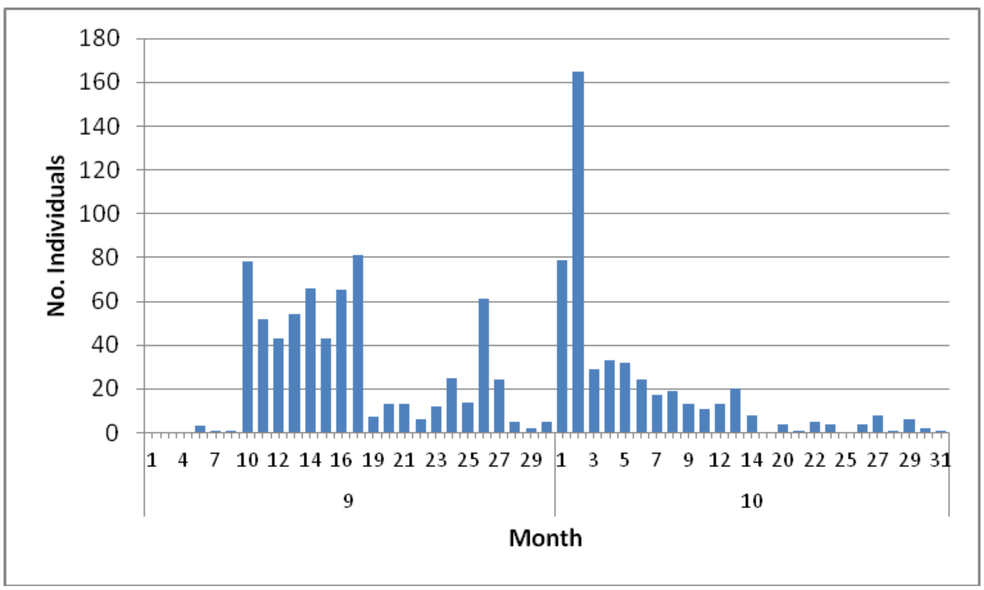

Figure 4. The Number of storm-petrels stranded on production facilities from 2003 to 2014 by date during September and October. Data are from *Hibernia* GBS and *Sea Rose* and *Terra Nova* FPSOs.

Table 2. Days with the largest numbers of stranded storm-petrels from 2003 to 2014. Data are from *Hibernia* GBS and *Sea Rose* and *Terra Nova* FPSOs.

Day	Month	Year	# of Individuals	% on *Sea Rose*
2	Oct	2006	122	26
1	Oct	2006	75	99
10	Sep	2006	75	100
14	Sep	2006	66	100
16	Sep	2006	65	100

Strandings on Offshore Industry Vessels

Monitoring of marine mammals and seabirds stranding at night on board seismic vessels and industry supply vessels off Newfoundland and Labrador has been conducted by LGL biologists from 2004 through 2014. Among the duties of the LGL observers was searching for and rescuing any stranded birds found aboard the vessels. Up to date protocols developed by Environment Canada were followed when handling and releasing stranded birds.

During the eleven year time frame there were 38 voyages with a grand total of 2,197 days spent at sea, all within the period May to November (Table 3). Seismic programs were initiated as early as 7 May and terminated as late as 26 November; however, most were conducted during some portion of the months of June through September. During that time a total of 1,029 birds were found stranded on the ships. Of this number 1,012 were seabirds, of which 994 individuals or 98% were Leach's Storm-Petrel *Oceanodroma leucorhoa* (Table 4). This species breeds in large numbers at nesting colonies in eastern Newfoundland that include the largest colony in the world, i.e., Baccalieu Island (estimated 3.3 million pairs) at the northeastern tip of Conception Bay.

Table 3. Types of ships and numbers of days monitored for stranded birds and the numbers of stranded Leach's Storm-Petrels found from 2004-2014.

Survey Area	Ship Type	# of Trips	# of Days	# of Stranded Storm-Petrels
All areas off Newfoundland and Labrador		38	2,179	994
	seismic[1]	25	1,955	987
	supply[2]	13	224	7

[1] A seismic ship is typically built with an open ended stern for towing seismic cables and compressed-air guns.

[2] Supply ships are used for carrying cargo and other duties around stationary offshore platforms.

Table 4. Numbers and species of birds found stranded on 38 seismic exploration and offshore supply vessels from 2004 to 2014.

Species	**# Found Stranded**
Seabirds	
Northern Fulmar *Fulmarus glacialis*	2
Great Shearwater *Ardenna gravis*	11
Sooty Shearwater *Ardenna griseus*	2
Wilson's Storm-Petrel *Oceanites oceanicus*	2
Leach's Storm-Petrel *Oceanodroma leucorhoa*	994
Dovekie *Alle alle*	2
Black-legged Kittiwake *Rissa tridactyla*	1
Landbirds	
Eastern Wood-Pewee *Contopus virens*	1
Cliff Swallow *Petrochelidon pyrrhonota*	2
Snow Bunting *Plectrophenax nivalis*	10
Warbler sp. *Parulidae*	1
Lincoln's Sparrow *Melospiza lincolnii*	1
Sparrow sp. *Emberizidae*	2

The focus on the following analyses is the Jeanne d'Arc Basin on the northern Grand Banks where oil production is taking place. LGL personnel conducted 22 trips totalling 859 days in the Jeanne d'Arc Basin area within the study period 2004 and 2014 (Table 5). The peak of survey effort occurred from June to August with 580 (67.5%) of the survey days and 141 (35.9%) of the stranded storm-petrels (Figure 5). The peak of strandings occurred in September and October with 249 (63.5%) of the stranded storm-petrels found on 153 (17.8%) of the survey days (Figure 5). The average number of stranded Leach's Storm-Petrels per ten-day period showed a strong peak from 21 September to 10 October (Figure 6). The average daily number of stranded birds for the periods of 21-30 September and 1-10 October were five and seven times higher respectively than the next highest average during 11-20 August. All monitoring days (n=2179) combined for Newfoundland and Labrador waters showed a peak of strandings during the same period from 21 September and 10 October (Figure 7).

Table 5. Ship type, number of trips, number of days and number of stranded Leach's Storm-Petrels.

Survey Area	**Ship Type**	**# of Trips**	**# of Days**	**# of Stranded Storm-Petrels**
Jeanne d'Arc Basin		22	859	392
	Seismic ship	9	635	385
	Supply ship	13	224	7
Newfoundland and Labrador excluding Jeanne d'Arc Basin		16	1,320	602
	Seismic ship	16	1,320	602
	Supply ship	0	0	0

Among the factors causing Leach's Storm-Petrels to strand on ships are the intensity of the lights present on the ship, structure of the ship, and weather conditions. Presently it is not possible and probably never will be to predict when or how many storm-petrels will strand on any particular ship on a given date or location. It is generally agreed, but not quantified, that storm-petrels are more prone to stranding on foggy nights. We do not have accurate enough weather data throughout the nights from the survey vessels to correlate weather with storm-petrel strandings. LGL observers found some stranded Leach's Storm-Petrels after clear nights but the largest strandings occurred during foggy nights. However, there were many foggy nights when there were no strandings even on the ships that were prone to large strandings. The largest single night strandings occurred during late September and early October but significant strandings were not restricted to that time period (Figure 8). Strandings of ten or more individuals occurred on 21 dates from late June to mid-October (Table 6). The earliest date of storm-petrel stranding was 21 May. This was the only Leach's Storm-Petrel found stranded on 83 survey days in May. The latest date for finding a stranded Leach's Storm-Petrel was 24 November and this was one of only two found after the first week of that month.

No two ships are created equal when it comes to attracting and stranding Leach's Storm-Petrels. The type of ships from which monitoring was conducted can be broken down into two main types 1) dedicated seismic exploration ships and 2) offshore supply ships. The offshore supply ships in the Jeanne d'Arc Basin accounted for 26.1% days at sea but only 1.8% of the total number of stranded storm-petrels. It is suspected that the open air back decks of supply ships allows for unrestricted movement of any storm-petrels attracted to the ship's lights, which permits the storm-petrels to fly back out to sea. In contrast, seismic survey ships typically have two or three of the back decks that are open at the stern (e.g., streamer deck, gun deck). It was on these decks that most Leach's Storm-Petrels have been found stranded in this study. It is thought the birds were attracted to the lights at the stern and were lured inside by the lighted decks. Once inside these decks they were unable to find their way back to the outside and ended up on the deck.

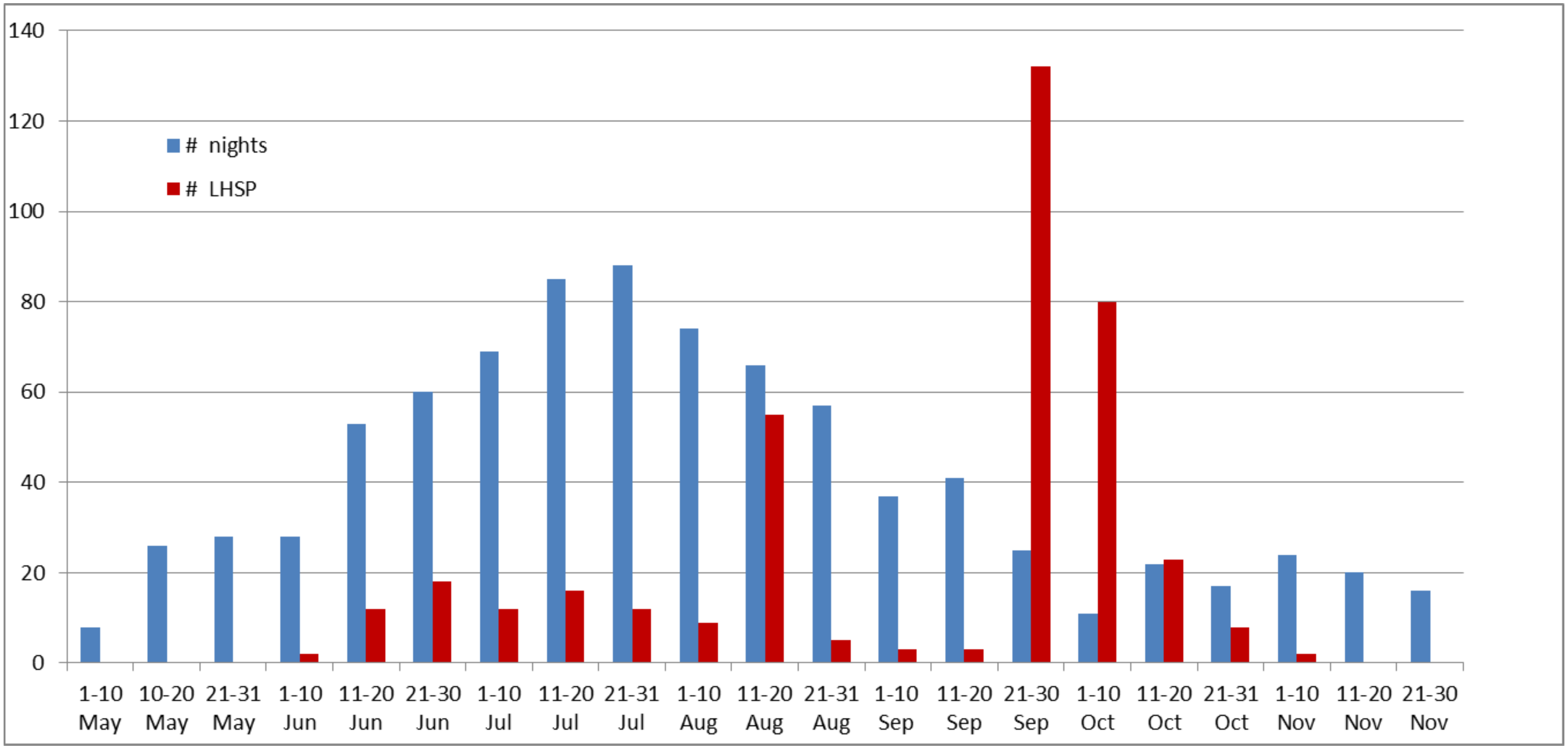

Figure 5. Number of survey nights and stranded Leach's Storm-Petrels (LHSP) found by ten-day periods from May to November 2004-2014 on seismic vessels and offshore supply vessels in the Jeanne d'Arc Basin.

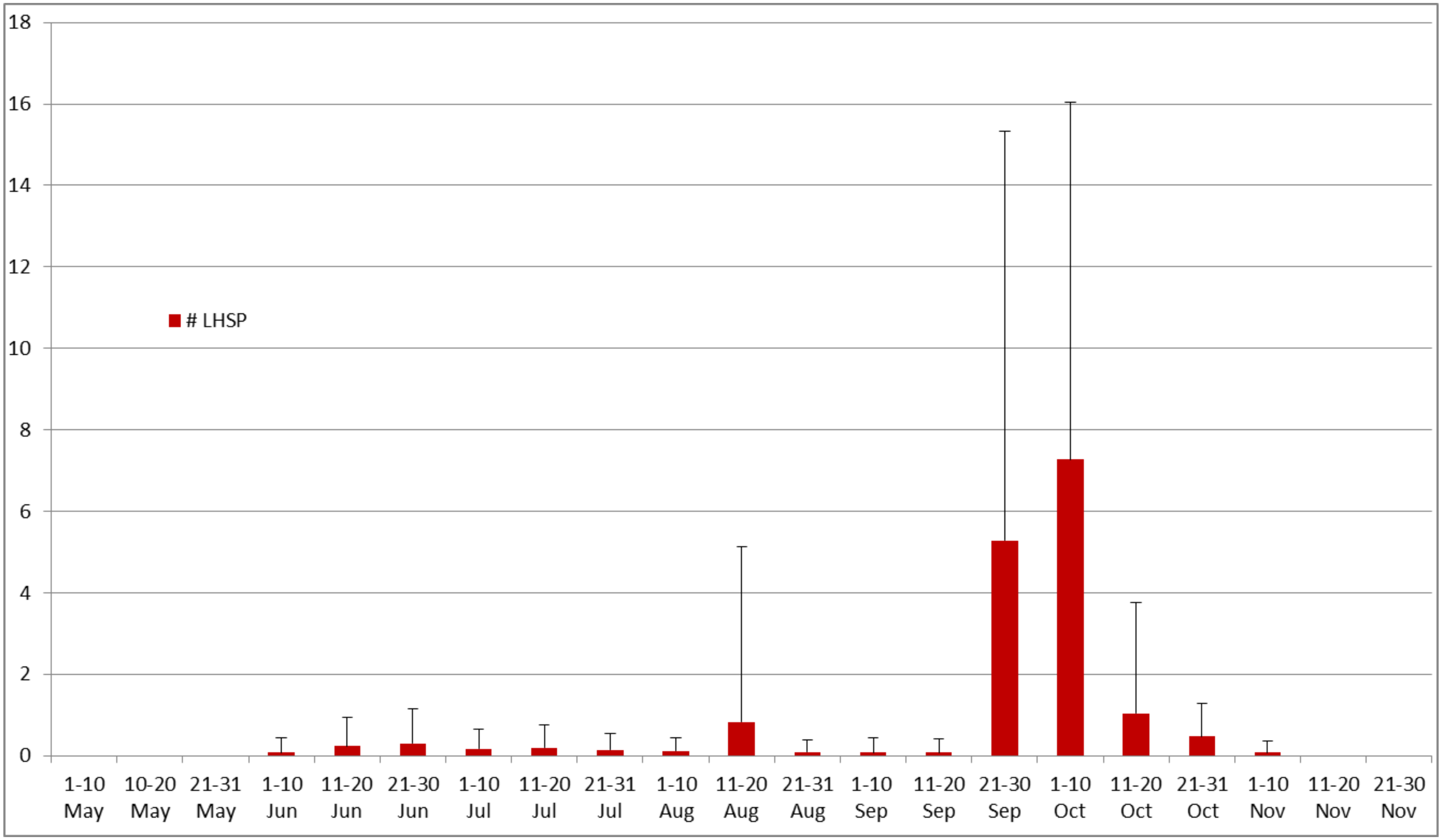

Figure 6. Average number of stranded Leach's Storm-Petrels (LHSP) found per day during ten-day periods from May to November 2004 to 2014 on selected seismic vessels and offshore supply vessels in the Jeanne d'Arc Basin.

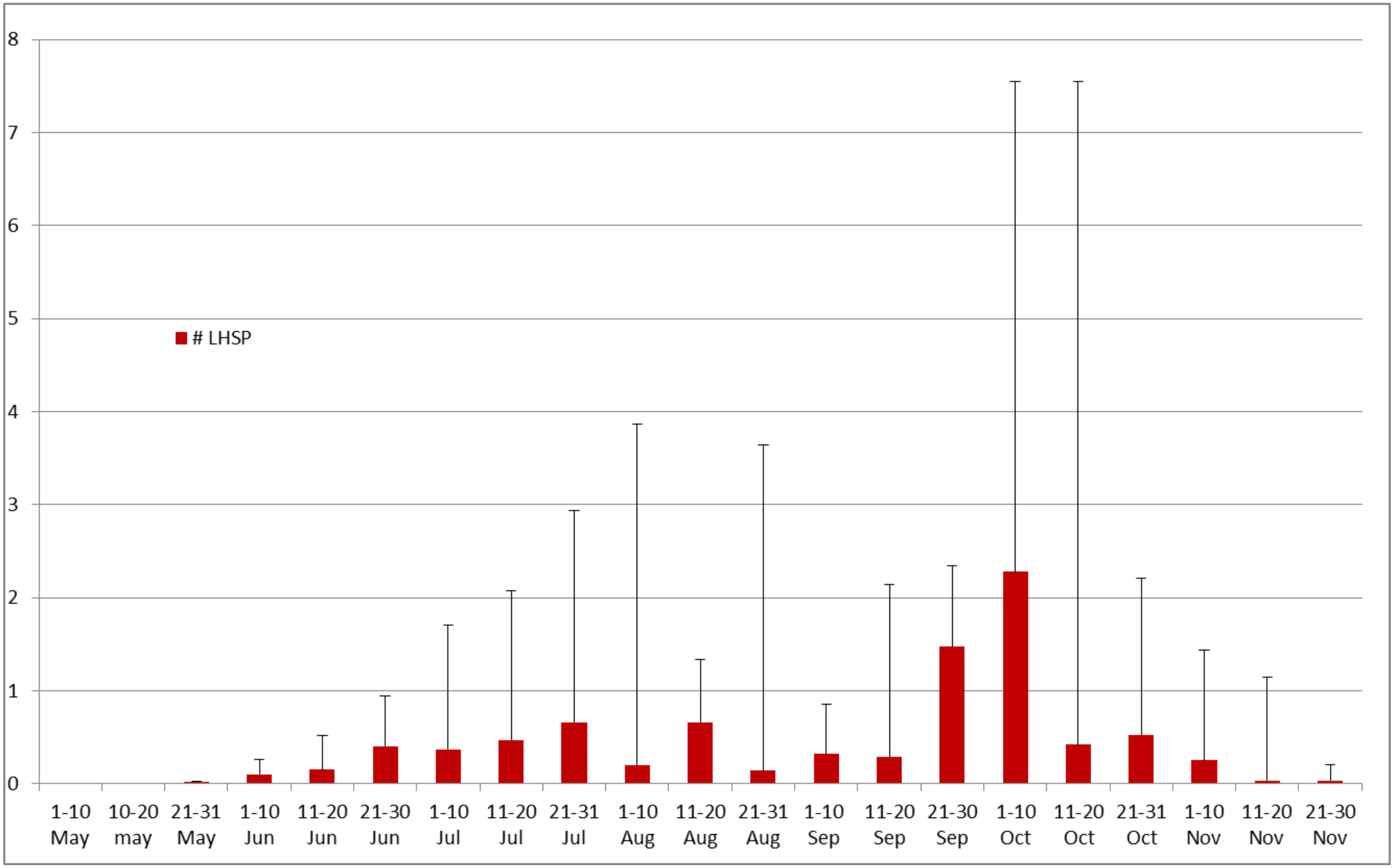

Figure 7. Average numbers of stranded Leach's Storm-Petrels found per day during ten-day periods from May to November 2004 to 2014 on selected seismic vessels and offshore supply vessels in all Newfoundland and Labrador waters.

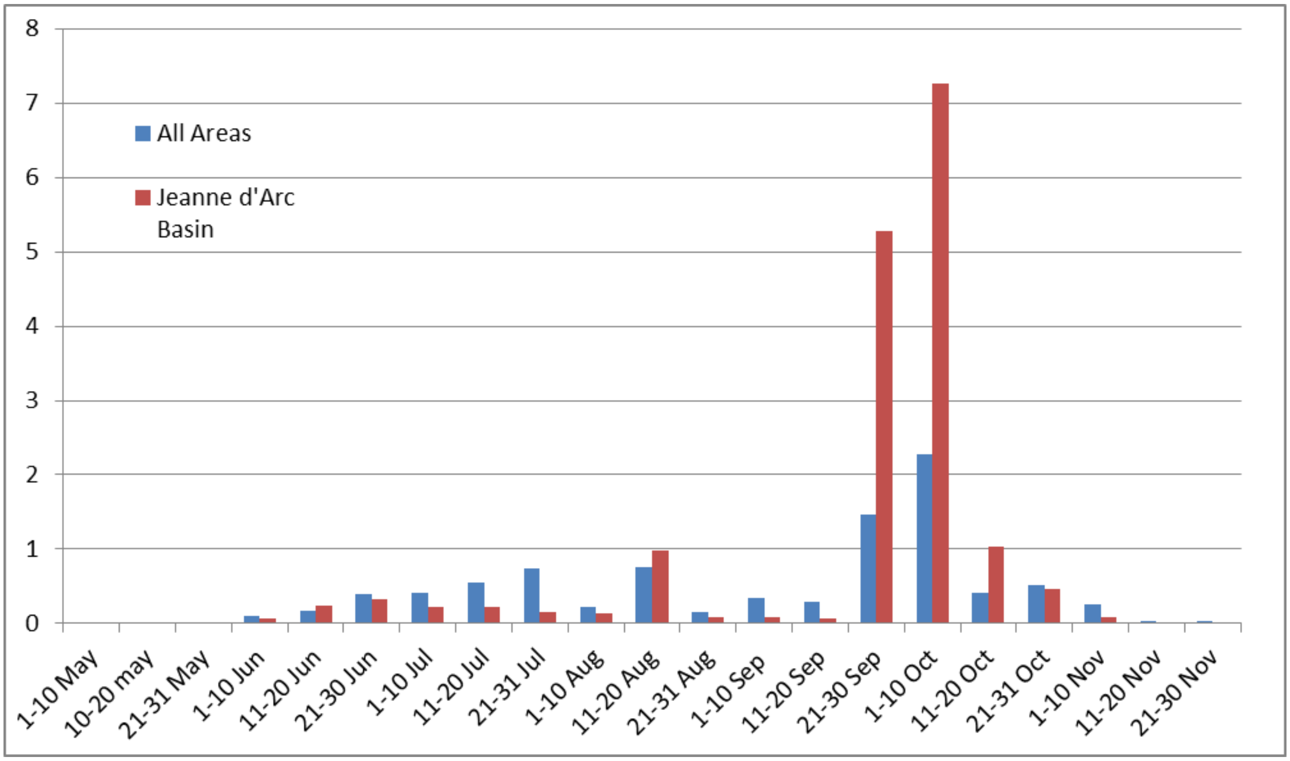

Figure 8. Average number of stranded Leach's Storm-Petrels found per day during ten-day period from May to November 2004 to 2014 on selected seismic vessels and offshore supply vessels in all Newfoundland and Labrador waters compared to Jeanne D'Arc Basin.

Some seismic vessels have more bird strandings than others for reasons unknown. It is possible vessels with more obstructions over the open ends of the streamer and gun deck, such as parts of the ship's superstructure and various pieces of equipment help deflect Leach's Storm-Petrels from flying inside the decks. On the other hand, the controlled-source electro-magnetic vessel *Siem Molle* was notable for the large number of storm-petrel strandings. A unique situation was created when an accommodation module was mounted on the back deck forming a long but narrow gap between the module and the bulwarks, which were about 4 metres high. The storm-petrels were colliding the wall of the module, then falling into the gap between the module and bulwarks, and landing on the deck below. During the 76 day voyage of the *Siem Molle* on the Orphan Basin from 3 June to 16 August 2009, the ship caught 183 Leach's Storm-Petrels including a total of 128 on five dates in July (Table 6).

In summary, the Leach's Storm-Petrel was the most numerous species of bird found stranded on oil industry ships on the Jeanne d'Arc Basin and other offshore regions of Newfoundland and Labrador. Overall there was an average of 0.5 storm-petrels stranded per survey day during the entire survey period. However, the distribution of strandings was not uniform over the May to November study period. There was only one bird found stranded during the month of May and 16 found in November. There was a distinct spike in the number of strandings in the period of 21 September to 10 October. The numbers of strandings varied by the ship involved. Offshore supply vessels attracted < 1% as many Leach's Storm-Petrels as did ships with open end sterns built specifically for seismic exploration.

Table 6. All dates when ten or more Leach's Storm-Petrels were found stranded on monitored ships in Newfoundland and Labrador waters from 2004 to 2014.

Date	# of Leach's Storm-Petrels stranded	Ship Name	Location
May	None more than 10		
June			
June 29, 2009	11	Siem Molle	Orphan Basin
July			
July 4, 2005	18	Western Neptune	Laurentian Sub-basin
July 16, 2009	28	Siem Molle	Orphan Basin
July 23, 2009	38	Siem Molle	Orphan Basin
July 27, 2009	11	Siem Molle	Orphan Basin
July 28, 2009	33	Siem Molle	Orphan Basin
August			
August 11, 2012	32	Geo Caribbean	Flemish Pass/NE Grand Banks
August 12, 2012	14	Geo Caribbean	Flemish Pass/NE Grand Banks
September			
September 1, 2005	10	Western Neptune	Laurentian Sub-basin
September 1, 2005	19	Geco Diamond	Orphan Basin
September 24, 2008	26	Veritas Vantage	Jeanne d'Arc Basin
September 27, 2008	28	Veritas Vantage	Jeanne d'Arc Basin
September 28, 2008	32	Veritas Vantage	Jeanne d'Arc Basin
September 29, 2008	18	Veritas Vantage	Jeanne d'Arc Basin
September 30, 2008	16	Veritas Vantage	Jeanne d'Arc Basin
October			
October 1, 2005	16	Western Neptune	Jeanne d'Arc Basin
October 2, 2005	11	Western Neptune	Jeanne d'Arc Basin
October 8, 2005	46	Western Neptune	Jeanne d'Arc Basin
October 9, 2005	28	Western Neptune	Jeanne d'Arc Basin
October 10, 2005	11	Western Neptune	Jeanne d'Arc Basin
October 11, 2005	12	Western Neptune	Jeanne d'Arc Basin

Fate of Stranded Leach's Storm-Petrels

There were 994 Leach's Storm-Petrels found stranded by LGL personal on seismic and supply ships in Newfoundland waters from 2004 to 2014. Of the 994, 157 (15.7%) were found dead or died during rehabilitation and 84.3% were released unharmed. The unique configuration of each vessel affects the number of Leach's Storm-Petrel that are found stranded and the percentage of birds that are found dead or which died during rehabilitation. For example, the vessels *Western Neptune* and *Siem Molle* each caught unusually high numbers of Leach's Storm-Petrels. The *Western Neptune* accounted for 24.9% of all Leach's Storm-Petrels found stranded on all trips combined but only 6.7% of the total nights at sea. The *Siem Molle* accounted for 18.3% of all Leach's Storm-Petrels found stranded but only 3.4% of the total nights as sea. Together the *Western Neptune* and *Siem Molle* caught 43.2% of all Leach's Storm-Petrels but represented only 10.1% of the total nights at sea).

The percentage of birds that died varied from ship to ship as well. For example, the percentage of the Leach's Storm-Petrels found stranded that were found dead or died in rehabilitation was 40.1% on the *Western Neptune* but only 14.0% on the *Siem Molle*. The common cause of death was related to a wet, oily deck. A minute amount of lubrication or hydraulic fluid in the water on the deck was often enough to cause the birds to get wet through to the skin. Birds were found dead that were wet only on the belly. Other birds found in drip trays beneath the large winches that hold the seismic cables sometimes contained both water and small quantities of hydraulic fluid. Rarely was there enough liquid in one of the various drip trays to drown a bird.

Available Information on Seabird Density

The available data on seabird density on the Grand Banks will be analyzed to determine whether there is any relationship between seabird densities and existing production and exploration platforms. The available sources of data are summarized here. They include CWS Atlases, the results of the ESRF study, and seabird density data collected on the many seismic surveys conducted by LGL Limited and other consultants.

The Programme Intégré de Recherches sur les Oiseaux Pélagiques (PIROP) data were collected initially solely from oceanographic research vessels and later also by Canadian Wildlife Service (CWS) and onboard ships of opportunity (see Table 7). As a result, effort was not concentrated in oil production and exploration areas. The technique in use at the time did not sample within a strip of defined width, so the density of seabirds recorded cannot be calculated. Consequently, the abundance values have to be regarded as relative rather than absolute.

When CWS developed the Eastern Canadian Seabirds at Sea (ECSAS) program and when MUN researchers surveyed from offshore oil industry supply boats they used a refined technique. Seabirds were counted within a 300 m wide strip-transect. This allows the calculation of bird density, e.g., number of birds per square kilometre (Table 7). However, later research showed that counting all of the birds flying through the strip-transect resulted in overestimation of their number relative to the number of birds on the sea surface (Tasker et al. 1984). This was because some seabirds tended to follow moving ships. As a result, these data are now considered to represent relative abundance (Fifield et al. 2009).

A method to prevent the overestimation of the density of flying birds was later incorporated into seabird surveys conducted by ECSAS and by seabird observers on board industry seismic and controlled-source electro-magnetic (CSEM) exploration vessels (Table 7). Data collected on board the latter vessels was summarized into reports submitted by industry to the C-NLOPB. Industry submitted raw data to C-NLOPB for incorporation into the ECSAS computerized database by CWS.

Data were also collected by weather observers on production and exploratory drilling platforms (Baillie et al. 2005) (Table 7). Seabirds were counted within a semi-circular plot of defined size. However, the observers did not have extensive experience in bird identification, so the utility of the data is limited.

Table 7. Seabird abundance and distribution data sources for offshore Newfoundland and Labrador oil production and exploration areas.

Program	Dates	Method	Data Type	Shortcomings	Geographic Coverage	Source
PIROP [1]	1969-1973	Line transect Unlimited distance	Relative abundance (no. birds/linear km)	Qualitative due to unlimited sampling area	Atlantic Canada	Brown et al. (1975)
PIROP	1969-1983	Line transect Unlimited distance	Relative abundance (no. birds/linear km)	Qualitative due to unlimited sampling area	Atlantic Canada	Brown (1986)
PIROP	1986-1992	Line transect Unlimited distance	Relative abundance (no. birds/linear km)	Qualitative due to unlimited sampling area	Atlantic Canada	Lock et al. (1994)
ECCC-CWS [2]	1992-1995	Strip transect	Relative abundance (no. birds/linear km)	Qualitative due to: Overestimation of flying birds Underestimation of distant birds	Atlantic Canada	CWS; unpublished
MUN [3]	1999	Strip transect	Relative abundance (no. birds/linear km)	Qualitative due to: Overestimation of flying birds Underestimation of distant birds	Newfoundland oil rig supply routes	Wiese and Montevecchi (1999)
Industry: oil platforms	1999-2002	Semi-circular plot	Density (no. birds/km^2)	Non-specialist observers Underestimation of distant birds	Newfoundland oil production fields	Baillie et al. (2005)
Industry: seismic/ CSEM [4] ships	2004-09	Strip transect Correction for overestimation of flying birds	Density (no. birds/km^2)	No correction for underestimation of distant birds	Newfoundland & Labrador exploration & production areas	Reports & data submitted to C-NLOPB, to be forwarded to ECCC-CWS
ECSAS [5]	2006-present	Strip transect Correction for overestimation of flying birds Correction for underestimation of distant birds (distance sampling)	Density (no. birds/km^2)		Atlantic Canada esp. production areas and supply routes	CWS [3]; Fifield et al. (2009)

Table 7. Concluded.

Program	Dates	Method	Data Type	Shortcomings	Geographic Coverage	Source
Industry: seismic/ CSEM ships	2010-present	Strip transect Correction for overestimation of flying birds Correction for underestimation of distant birds	Density (no. birds/km^2)		Newfoundland and Labrador	Reports submitted to C-NLOPB; data submitted to CWS
ECSAS	2009-present	Strip transect Correction for overestimation of flying birds Correction for underestimation of distant birds	Density (no. birds/km^2)		Labrador	Fifield et al. in prep.; CWS

[1] PIROP: Programme Intégré de Recherches sur les Oiseaux Pélagiques
[2] ECCC- CWS: Environment and Climate Change Canada Canadian Wildlife Service
[3] MUN: Memorial University of Newfoundland
[4] CSEM: Controlled-Source Electro-Magnetic
[5] ECSAS: Eastern Canadian Seabirds at Sea (program of ECCC-CWS)

After a hiatus, CWS resumed the ECSAS surveys in 2006 and incorporated a method to compensate for the underestimation of the number of distant birds (distance sampling) (Table 7). The first summary of the data generated by this improved method was partially funded by ESRF and published in 2009 (Fifield et al. 2009). In 2010, CWS directed industry to use the improved method in their surveys from seismic/CSEM vessels. The new ECSAS surveys included a concentration of effort in the offshore oil production areas and the Flemish Pass/Sackville Spur exploration leases, and to a lesser extent, the exploration leases in Orphan Basin. Industry continues to submit reports of seabird surveys and raw data from their exploration vessels to C-NLOPB.

A summary of data more recently incorporated into the ECSAS database is currently being prepared for the Labrador offshore area (McFarlane Tranquilla et al. 2013b).

Principal Sources of Bird Mortality in Canada

Appendix 1 summarizes the results of a special issue of the peer-reviewed, ornithological science journal *Avian Conservation and Ecology* that presented a series of papers evaluating the sources and extent of human-related mortality to birds in Canada. There are extremely wide confidence limits associated with various estimates but the scale of the human effects is staggering. Overall, the median of the estimates is over 185 million birds killed per year with domestic and feral cats topping the list. The lowest of the 28 categories identified was the offshore oil and gas industry with an estimated 584 seabirds per year. This estimate was for routine operations and excluded the accidental and intentional releases of oil and oil products to the water surface by the transportation industry.

Acknowledgements

We thank Dr. Phil Taylor of Acadia University for several interesting discussions on bird monitoring techniques and his experience with the Deep Panuke project off Nova Scotia. Dr. W. John Richardson, LGL's radar ornithology expert had a productive telephone meeting with Dr. Taylor about the possibility of using the supply ship's marine radar in the proposed study. We thank Michael Teasdale, Robert Dunphy and James O'Reilly of EMCP for providing information for this study.

Anne Wright at LGL Limited produced the report.

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Appendix 1. Human-related Avian Mortality in Canada

In 2013, the Society of Canadian Ornithologists and Bird Studies Canada published a special issue of *Avian Conservation and Ecology* devoted entirely to estimates of the human caused mortality to birds in Canada. A series of papers (see list at end of this discussion) attempted to estimate the total annual bird mortality associated with various human factors and activities. Of course, the estimates are very imprecise with very wide confidence limits and some estimates are little more than guesses. Nonetheless, the numbers of birds dying every year are staggering.

Calvert et al. (2013) synthesized the data presented in the nine other reports on the issue. They prepared a summary table that is included here. They described the contents of the table as follows:

> Median annual estimates of human-related mortality in Canada across the five major species groups, based on a stochastic model that converted stage-specific mortality to potential adult breeders, ranked in descending order according to total estimated mortality across all bird groups. Note that species-group totals do not sum exactly to the 'all birds' value because uncertainty in species composition was explicitly modeled and the "all birds" value was modeled independently of each species group's total. In cases where mortality was not fully extrapolated to all regions and taxa, e.g., where it was only estimated for a given region or set of focal species, the taxonomic or regional scope of the estimate is indicated; impacts estimated Canada-wide and across taxa are indicated as 'all' in the Scope column.

The table is arranged from the largest annual sources of bird mortality to the smallest. Occupying the position of smallest source of mortality is "Oil and Gas – Marine" (median 584). This excludes chronic ship sources of oil discharge which is the highest source of mortality for seabirds (median 282,700). The overall total for all sources for all birds is 186,429,533 per year in Canada.

Source	Scope	Landbirds	Seabirds	Shorebirds	Waterbirds	Waterfowl	All Birds	References
Cats - Feral	All	78,600,000			293,400	380,500	79,600,000	1,2
Cats – Domestic	All	54,150,000			199,300	258,300	54,880,000	1,2
Power - Transmission line collisions	All	574,700		2,548,000	5,170,000	8,459,000	16,810,000	2,9
Buildings – Houses	All	16,390,000					16,390,000	2,3
Transportation - Road vehicle collisions	All	8,743,000		197,000	187,200	218,500	9,814,000	2,6,7
Agriculture – Pesticides	All	1,898,000		19,230	19,430	19,130	1,998,000	7,14
Harvest - Migratory game birds	All	235	55,520	24,770	8773	1,691,000	1,786,000	16,17,18,19

Source	Scope	Landbirds	Seabirds	Shorebirds	Waterbirds	Waterfowl	All Birds	References
Buildings - Low- and mid-rise	All	1,132,000		26,310	23,870	32,190	1,283,000	2,4
Harvest - Non-migratory game birds	All	1,031,000					1,031,000	20
Forestry – Commercial	Landbirds	887,835					887,835	21
Transportation - Chronic ship-source oil	All		282,700				282,700	11,12
Power – Electrocutions	All	178,200		1715	1854	2275	184,300	2,8
Agriculture – Haying and mowing	5 species	135,400					135,400	22
Power - Line maintenance	All	70,140		4474		33,030	116,000	10
Communication - Tower collisions	All	101,500		965	1050	1278	101,500	2,8
Power - Hydro reservoirs	Québec	31,260		490	1571	158	35,770	6,7
Buildings – Tall	All	32,000		388	339	501	34,130	2,3,5,6,7
Fisheries - Marine gill nets	All		19,790				19,790	7,13
Power - Wind energy	All	13,060					13,060	2,7
Oil and Gas - Well sites	Landbirds	9815					9815	23
Mining - Pits and quarries	All	5169		39	168		5637	6,7
Oil and Gas – Pipelines	Landbirds	4687					4687	23
Mining - Metals and minerals	All	2798					2798	24
Oil and Gas - Oil sands	All	2193					2193	23
Oil and Gas - Seismic exploration	Landbirds	1966					1966	23
Fisheries - Marine longlines and trawls	All		1843				1843	7,13
Transportation - Road maintenance	6 species	1103		71		324	1545	15
Oil and Gas – Marine	All		584				584	11,12,13
Total		**163,980,226**	**360,437**	**2,848,252**	**5,931,455**	**11,124,386**	**186,429,553**	

1 – Blancher 2013; 2 – Canadian Migration Monitoring Network data from western Canada; 3 – Machtans et al. 2013; 4 – range between tall buildings and houses, no source; 5 – Fatal Light Awareness Program (www.flap.org; see Machtans et al. 2013); 6 – no data, wide distribution assigned; 7 – vague prior, no source; 8 – Longcore et al. 2012 (note that communication tower values were used for seasonal and species-composition of electrocutions); 9 – Rioux et al. unpublished manuscript, 10 – no data, assumed same distribution as road maintenance (Abraham et al. 2010; Appendix 1); 11 – Wiese et al. 2004; 12 – Fraser et al. 2006; 13 – Ellis et al. 2013; 14 – Mineau 2010 (Appendix 1);15 – Abraham et al. 2010 (Appendix 1); 16 – National Harvest Survey data, 2000-2011(http://www.cwsscf.ec.gc.ca/harvest-prises/def_e.cfm); 17 – snipe and woodcock data from National Harvest Survey (2000-2011); 18 – Elliot 1991; 19 – Gaston and Robertson 2010 (band recovery data); 20 – provincial and territorial government web sites; 21 – Hobson et al. 2013; 22 – Tews et al. 2013; 23 – van Wilgenburg et al. 2013; 24 – J. Williams 2010.

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