Marine Seabirds Monitoring Program

Tidal Energy Demonstration Site – Minas Passage, 2016-2017

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Fundy Ocean Research Center for Energy (FORCE)
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Executive Summary

The Fundy Ocean Research Center for Energy (FORCE) developed and operates a tidal energy demonstration site and support facility along the north shore of Minas Passage in Nova Scotia's Bay of Fundy. As a condition of its regulatory approvals to operate at the site, FORCE has been required to carry out an environmental effects monitoring program (EEMP) to provide information on the marine ecosystem, including seabirds and marine mammals, before and after installation of tidal energy devices, to verify predictions that these organisms are not likely to be impacted by tidal energy development activities. FORCE conducted vessel- and shore-based observational surveys for seabirds and marine mammals beginning in 2009 and extending until 2012 as part of ongoing Environmental Effects Monitoring Program (EEMP) activities at the site.

The latest phase of the EEMP extends from 2016-2021 and includes year-round shore-based monitoring of marine seabirds. The first year of shore-based surveys under the present EEMP covers the period from May 6, 2016 to May 1, 2017, conducted from the FORCE Visitor Center on the north shore of Minas Passage, near Parrsboro, Nova Scotia, and covering a period both before and during the operation of a grid-connected tidal turbine which was installed in early November, 2016, and which operated through the end of the survey period.

Surveys targeted the occurrence, abundance, local distribution, and annual pattern of composition and abundance of seabirds and water-associated birds (loons, cormorants, waterfowl, gulls, alcids), in coastal waters of Minas Passage, which included the zone designated for deployment of tidal energy devices (the 'Crown Lease' area) and adjacent waters both inshore and offshore and on Black Rock, an island at the site. Thirty-two (32) species of water-associated birds and shorebirds, and three marine mammal species (Harbour Porpoise, Harbour Seal and Harp Seal) seen incidentally at the site, were observed during the year. The most common and abundant bird species included gulls (Great Black-backed Gull and Herring Gull, present in 88 and 100% of surveys respectively), Common and Red-throated Loon, Common Eider, Black Guillemot, Black Scoter, Double-crested Cormorant and Great Cormorant. Least common species included shorebirds (Lesser Yellowlegs, Purple Sandpiper and Spotted Sandpiper), as well as Northern Gannet, Red-necked Grebe, Razorbill, Common Murre, Blue-winged Teal, Arctic Loon and Snow Goose, which were each observed on single surveys. An estimated four pairs of Black Guillemot and several Great Black-backed Gull were nesting on Black Rock, but there was no indication of nesting by Herring Gull, Double-crested Cormorant, or Great Cormorant on the island during the year.

Abundance of water-associated birds (loons, cormorants, waterfowl, gulls, alcids) at the Minas Passage site showed seasonal peaks corresponding to migratory movements (March-April and October-November); a late spring to early summer occupation of the area by local resident breeders such as Black Guillemot and Common Eider; and a low summer abundance when migrants are not present and individuals of local breeding species such as gulls and cormorants move out of the area. Number of species observed per survey ranged from a low of five species in early September and early December 2016; to a high of 17 species per survey in mid-April 2017. Abundance ranged from a low of 1.8 birds per half-hour on October 17, 2016 to a high of 267.8 birds per 30-minute period on April 17, 2017.

Fewer species of seabirds and water-associated birds visited the site than in the surveys conducted at the site in 2010-2012, both in total numbers observed (32 versus 45) and average number per survey. Common and abundant species in 2016-2017 were the same ones as in the earlier surveys, with the exception of Northern Gannet which was nearly absent this year, occurring in only one survey. Abundance was similar to earlier surveys but the peak abundance during the spring 2017 migration

(April 17, 2017) was the highest of any observed at the site, when high numbers of Red-throated Loon and Black Scoter, concurrently with high numbers of Double-crested Cormorant, visited the area.

Birds showed moderate and about equal utilization of survey subareas including the 'Crown Lease' and areas east of it around Black Rock. Black Rock was a focal point for bird activity, with birds typically roosting on and otherwise using it as a stopover for longer flights; for nesting (e.g. Black Guillemot); or as a base for local feeding in the adjacent waters at various times. During migration peaks, however, birds moving through the area over the water dominated numbers using Black Rock.

Since environmental monitoring at the Minas Passage site began in 2009, 50 species of water-associated birds and shorebirds have been seen in the vicinity of the Tidal Energy Demonstration Site (Minas Basin, Minas Passage & Minas Channel), the majority in Minas Passage specifically at the demonstration site, as the result of shore-based surveys.

Three species of marine mammal, the Harbour Porpoise (*Phocoena phocoena),* Harbour Seal (*Phoca vitulina*) and Harp Seal (*Pagophilus groenlandicus)* were observed during the year. Seal sightings were rare with three Harbour Seal noted on two surveys and a single Harp Seal on the January 2017 survey. Harbour Porpoise (*Phocoena phocoena)* occurred occasionally. Twenty-one Harbour Porpoise were seen at the site, principally from early summer to early fall, with highest numbers detected in September-October, and individuals most commonly observed in the tidal stream outside Black Rock and the Crown Lease area, south and southwest of Black Rock. Porpoise typically moved with the tidal current, westerly with the ebb tide (out-going) and easterly with the incoming tide, typically in the tidal stream outside Black Rock and extending through the Crown Lease and inshore areas in the direction of the tidal stream.

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1 Introduction

The Fundy Ocean Research Center for Energy (FORCE) operates a marine tidal energy demonstration site and testing facility in Minas Passage, near Parrsboro, Nova Scotia. The site is important both for the high energy potential of the tidal currents which occur there, and as a biologically significant part of the Bay of Fundy—supporting a unique marine ecosystem and habitat for many important marine species, as well as providing a migration route through the Bay of Fundy and a gateway into Minas Basin, the biologically productive bay located at its eastern end.

As a condition of its regulatory approvals to operate the Minas Passage tidal energy demonstration site, FORCE has, from the inception of the project, been required by the Province of Nova Scotia to carry out environmental effects monitoring (EEM) to provide information to verify impact predictions made in the environmental impact assessment for the project. FORCE undertook various studies as part of its initial Environmental Effects Monitoring Program (EEMP) activities (FORCE 2011, 2014), which included a three-year project to determine the occurrence, abundance, species composition and seasonality of seabirds and marine mammals which were important components of the marine ecosystem at the site (Envirosphere Consultants Limited 2011; 2012; 2013; FORCE 2011; 2014). The studies provided information to verify predictions that these groups were not likely to be impacted by tidal energy development activities. The shore- and vessel-based surveys in 2010-2012 as part of the EEMP, added basic knowledge concerning these species at the site—an essential component of any environmental monitoring program—against which changes potentially arising from the project could be assessed.

Seabirds and other water-associated birds are among the most important organisms in the marine ecosystem of the Bay of Fundy, Minas Passage and Minas Basin. They are generally less numerous than other organisms in the ecosystem; have protected status and are managed under Canadian and international law; are often of higher importance and concern to the general public; and in the context of tidal power development, are among the organisms which have the potential to interact physically as well as indirectly (e.g. through the food chain), with tidal energy devices and activities. Studies of seabirds and incidental occurrence of marine mammals from shore- and vessel-based observations from carried out in FORCE's EEMP from 2009-2012, revealed some 45 species of seabirds and water-associated birds as well as several marine mammal species, including Harbour Porpoise, Grey Seal and Harbour Seal which occur occasionally at the Minas Passage site (Envirosphere Consultants Limited, 2010-2012).

Potential for impacts of tidal energy activities and equipment on seabirds and other water-associated birds is a major concern and has been assessed at various stages of the development of the FORCE site, including reviews conducted as part of the environmental assessment process (JWEL 2008; AECOM 2009); and evaluation of information arising from baseline and environmental studies carried out through the course of the development of the site (e.g. FORCE 2011, DFO (2016)). FORCE has been allowed to proceed by regulatory agencies with various conditions, including a requirement to conduct environmental monitoring, most recently to conduct an operational phase Environmental Effects Monitoring Program (EEMP) in 2016-2021 to gather information on key environmental features as activity and use of the site by tidal energy developers increases[1] (FORCE 2016).

This latest phase of Environmental Effects Monitoring (EEM) extends from 2016-2021 and includes shore-based monitoring of seabirds (FORCE 2016). Since early May 2016, observations of seabirds and harbour porpoise, have been made as part of this monitoring program through a series of half day,

[1] The Cape Sharp Tidal Development Inc. installed an Open Hydro turbine on November 7, 2016.

monthly to semi-monthly surveys conducted from the FORCE Visitor Center facility, located on West Bay Road, Black Rock, Nova Scotia. The monitoring study focused on determining local distribution, abundance and seasonality of seabirds in subareas of the nearshore marine environment at the FORCE test site, including areas designated for deployment of tidal turbines and Black Rock—a prominent island at the site. The results of the monitoring study, extending from May 2016 to May 2017 are presented in this report.

2 Methods

2.1 Study Area

The Fundy Ocean Research Center for Energy (FORCE) tidal energy demonstration site is located on the northern shore of Minas Passage, a narrow (5 km) strait which connects the Bay of Fundy and the Atlantic Ocean to Minas Basin, a shallow estuarine and macrotidal bay at its eastern end. The site consists of an area of seabed and waters above it allocated by the Province of Nova Scotia (a 1 x 1.5 km box ("Crown Lease") located approximately 1 km from the northern shore of Minas Passage (Figure 1)); submarine electricity transmission cables for present and future tidal installations; instrumentation platforms and supporting power and data cabling; and onshore infrastructure, including an operations and interpretive center (FORCE Visitor Center), a high-voltage transformer substation, and a high voltage transmission line connecting the offshore tidal energy devices to the Nova Scotia electricity grid. Observations were made from the deck of the FORCE Visitor Center, an onshore operations center (45° 22.21' N 64° 24.22' W, 22 m above mean high water) used in baseline monitoring surveys in 2011 & 2012. The site has an unobstructed view of about 5 km across Minas Passage and a panoramic view of Minas Channel including nearby Cape Split from due south to west (coastal features obstruct views to the southeast) (Figures 2-4). Vantage points from both indoors and outdoors were available; the front windows of the Visitor Center are positioned about 10 m landward of the outer edge of the deck, and the indoor and outdoor fields of view are nearly identical. Surveys in winter and in inclement weather were done indoors.

Sixteen shore-based surveys were carried out at the site between May 6, 2016 and May 1, 2017 (Table 1). Field activities were arranged to take place on days when high tide occurred near mid-day, and to continue during the approximately 6-hour period of the outgoing tide. This approach was consistent with the earlier 2010-2012 surveys, and also allowed us to monitor a consistent time of day and tidal phase to help reduce statistical variability inherent in seabird observations. Dominant environmental factors expected to affect bird abundance, include tide phase; time of day; day length, weather, etc. The observer team typically arrived on site at approximately high tide and observations were made from that time until low tide. On several occasions in 2016-2017, however, weather and scheduling resulted in the observations being conducted on the rising tide, although the time of day was preserved for all surveys.

The first survey included an orientation in which the entire field team participated, during which the data recording methods were finalized and standardized among observers and field assistants. Two visits were made by one member of the team (Stewart) for obtaining 'landscape' photographs of the waters at the site to provide a visual reference for the locations of the study sub-areas, which included, coordination of a support vessel to occupy the four corners of the Crown Lease to record the positions on photographs to be used in subsequent surveys.

Surveys used a geographic grid system to locate the observations in space and in relation to the Crown Lease area, following standard practice in monitoring of seabirds in general, and in particular in

monitoring studies used in monitoring tidal energy development sites in the United Kingdom (e.g. Jackson and Whitfield 2011; Robbins 2012). The subareas in the grid were assigned to be relevant to analysis in terms of a statistical design for environmental effects monitoring, in particular Before-After Control Impact (Green 1979). The areas included the 'Crown Lease' (CL), the 1.5 x 1 km box assigned for deployment of tidal energy devices; two areas inshore of the CL, "Inside Black Rock 1" (IB1) and "Inside Black Rock 2" (IB2) (Figure 2); three areas outside the CL, "Outside Black Rock 1-3" (OB1-OB3); and three sites ("Farfield 1-3 'Reference' sites). Because of low numbers of birds at the "Farfield" sites, counts were grouped under the "FF" category in data analysis and interpretation. Positions of grid areas on the water as they appear from the FORCE Visitor Center are shown in Figure 4.

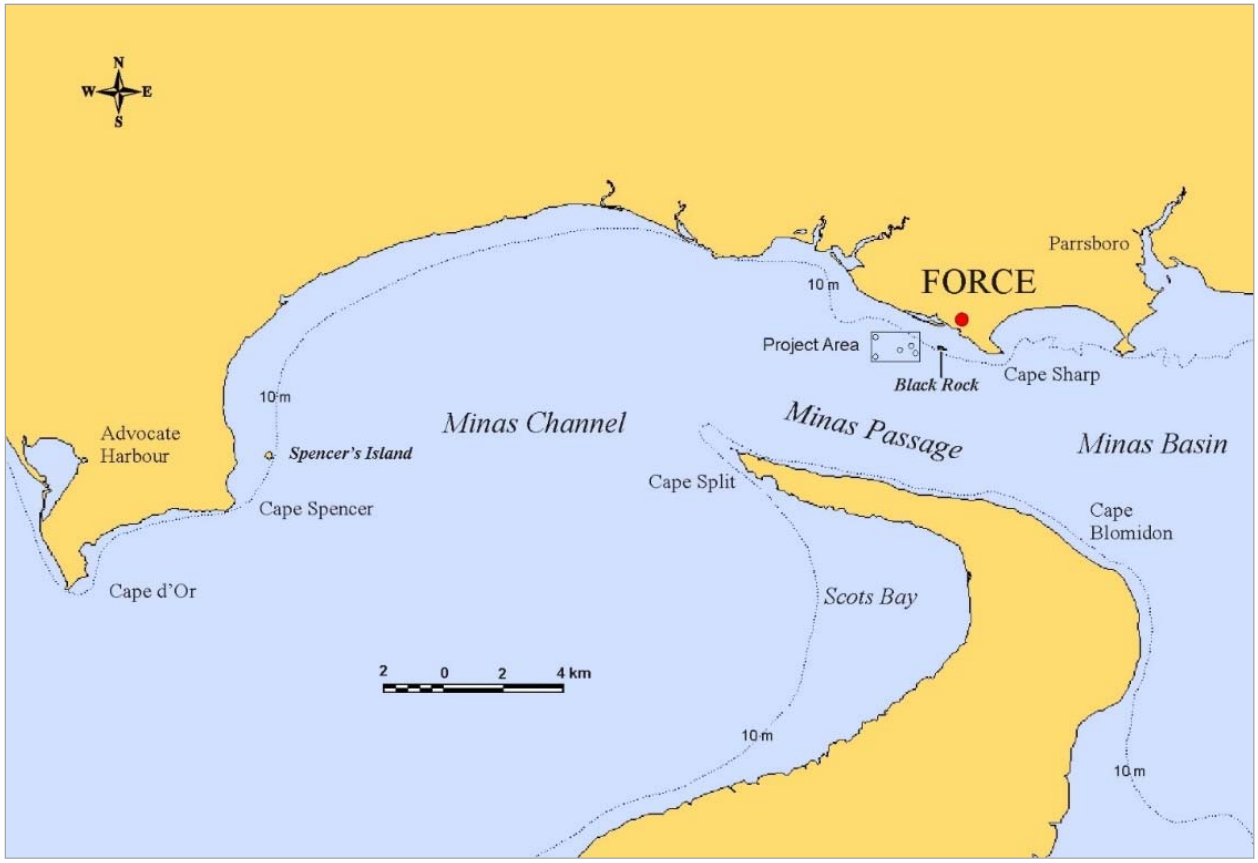

Figure 1. Study area for vessel surveys, showing project location and major subdivisions.

Information from the seabird reporting form was entered directly into a MicroSoft Excel spreadsheet with columns corresponding to those on the form, and all the surveys were compiled as they were completed. At the completion of the Year-One activities, the annual data was transferred into a MicroSoft Access database where it was combined with the data from the earlier (2010-2012) shore-based surveys. Statistics compiled included: total and average number of species per survey and subarea; and average abundance of birds overall and by species per survey and subarea.

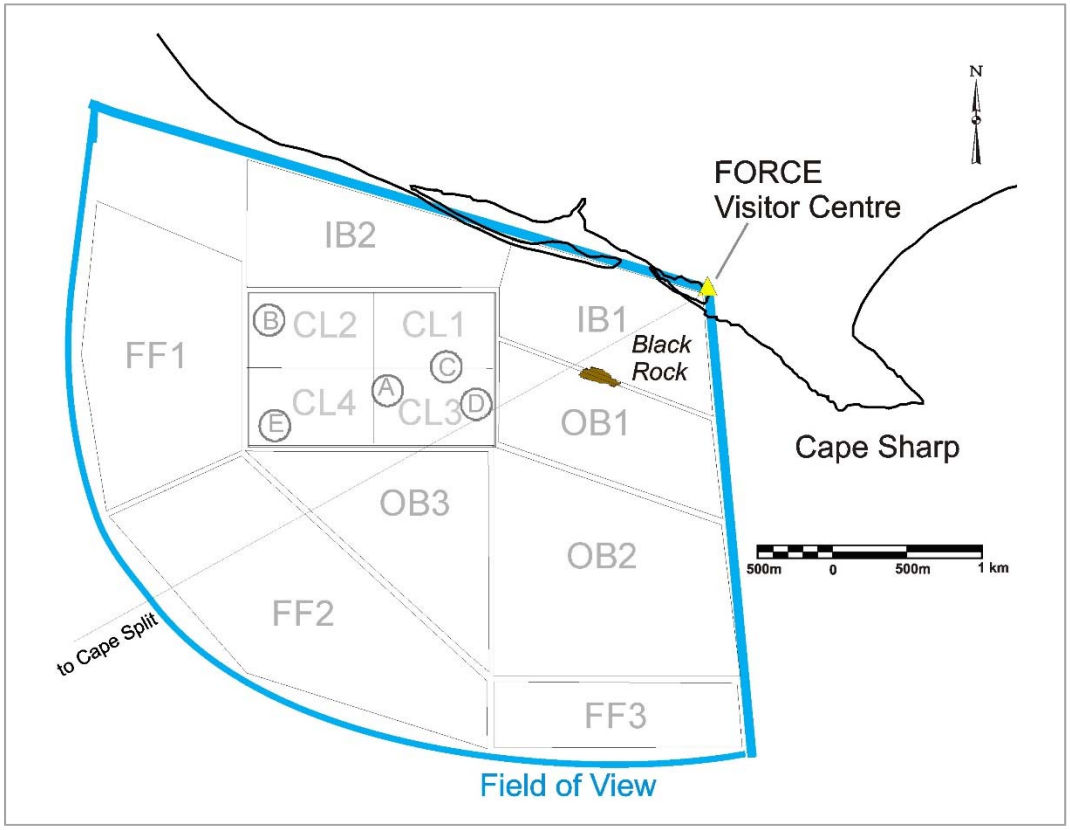

Figure 2. Spatial grid showing subareas used in seabird survey. Berths currently assigned to FORCE berth holders are shown as circles in Crown Lease (CL) area.

Figure 3. Bird Observer, Fulton Lavender, counting bird occurrences using a 22x Bushnell spotting scope. June 2, 2016.

Figure 4. Photograph of the view from the observation point at the FORCE Visitor Center, showing subareas used in survey, including Black Rock. Red lines show reference directions to assist in locating subareas.

3 Results and Discussion

3.1 Seabirds and Other Water-Associated Birds

A wide variety of seabirds and other water-associated birds utilize the waters of Minas Passage off the FORCE site throughout the year. These include seabirds—oceanic species such as shearwaters and petrels, which spend their lives wholly at sea, except for breeding on land; and species such as some gulls, cormorants, and other species whose life cycle spans a spectrum of oceanic and coastal environments—waterfowl such as ducks, geese, and loons, which may occupy the full range of marine, freshwater and estuarine environments during their life cycle; shorebirds which are often found seasonally in intertidal areas; and other species which from time to time occur.

The FORCE marine seabirds monitoring program includes the waters of Minas Passage and locations where tidal energy devices will typically be installed. Dynamics of birds there are influenced by various factors, in particular proximity to shore, exposure to spatially- and temporarily-varying tidal currents, presence of Black Rock, the small coastal island at the site etc., and also by the presence in the general vicinity of coastal features including a major nearby point of land (Cape Sharp), a coastal salt marsh, a sand spit and lagoon system, and nearby shoreline and tidal flats—all of which may attract seabirds and other water-associated birds of many different kinds to the area. Black Rock in particular, is an exceedingly important feature of the site, influencing occurrences and abundance seabirds and other water-associated birds in the adjacent waters by attracting birds to the site from throughout the region for roosting, resting, and nesting, and as a base for active feeding in the adjacent waters.

Table 1. Tide times and heights for seabird surveys at the Fundy Tidal Power Demonstration Site (FORCE Visitor Center) during 2016 - 2017.

SURVEY DATE	START/ END TIME	TIME & HEIGHT FOR HIGH & LOW TIDE		NUMBER OF PERIODS
		Time	Meters (above MLW)	
May 6, 2016	12:38 – 18:12 (ADT)	13:03	13.3	11
		19:13	0.2	
June 2, 2016	12:00 – 18:15	10:56	12.5	12
		17:08	0.9	
July 2, 2016	11:50 – 17:20	11:29	12.5	12
		17:40	0.9	
August 2, 2016	13:00 – 19:00	12:56	12.7	12
		19:09	0.9	
September 1, 2016	13:15 – 19:15	13:23	12.6	12
		19:38	0.9	
October 1, 2016	11:30 – 17:35	13:41	12.5	12
		19:56	1.1	
October 17, 2016	11:45 – 17:45	14:10	13.8	12
		20:23	0.2	
November 3, 2016	12:15 – 18:15	09:37	2.1	12
		15:48	11.8	
November 17, 2016	12:00 – 17:30 (AST)	08:13	0.3	11
		14:25	13.6	
December 1, 2016	12:30 – 17:00	13:41	12.1	9
		19:55	1.5	
January 16, 2017	12:15 – 16:45	09:16	1	10
		15:25	12.8	
February 21, 2017	12:00 – 18:00	08:23	10.6	12
		14:43	3.1	
March 13, 2017	12:15 – 18:15 (ADT)	14:09	13	12
		20:24	0.6	
April 3, 2017	12:15 – 18:15	12:33	1	12
		18:50	12.1	
April 17, 2017	11:50 – 18:20	11:43	2.5	13
		17:59	10.7	
May 1, 2017	12:00 – 18:00	11:17	0.5	12
		17:32	12.6	

3.1.1 Seabird Community – Species Diversity

Thirty-two (32) species of water-associated birds and shorebirds were observed at the FORCE site during year (Tables 2 and 3; Figure 5). Table 2 contains a list of all bird species that were observed during the year-long survey. Seasonal occurrence of the number of observed species by survey date is displayed in Table 3.

The most common and abundant species included Herring and Great Black-backed Gull, Red-throated Loon, Common Loon, Common Eider, Black Scoter and both Double-crested and Great Cormorant, all of

which occurred on at least 50 % of the 16 surveys. Various species were observed on single surveys only, including three shorebird species (Lesser Yellowlegs, Purple Sandpiper and Spotted Sandpiper), as well as Northern Gannet, Red-necked Grebe, Common Merganser, Blue-winged Teal, Wilson's Storm Petrel and Snow Goose (Table 3). A vagrant or accidental Arctic Loon, a species with a range encompassing Arctic and east and northern Pacific waters, was a significant sighting on November 17, 2016 (Table 3). Frequency of species sightings, defined as the percentage of surveys a bird species was observed, are displayed in Figure 6.

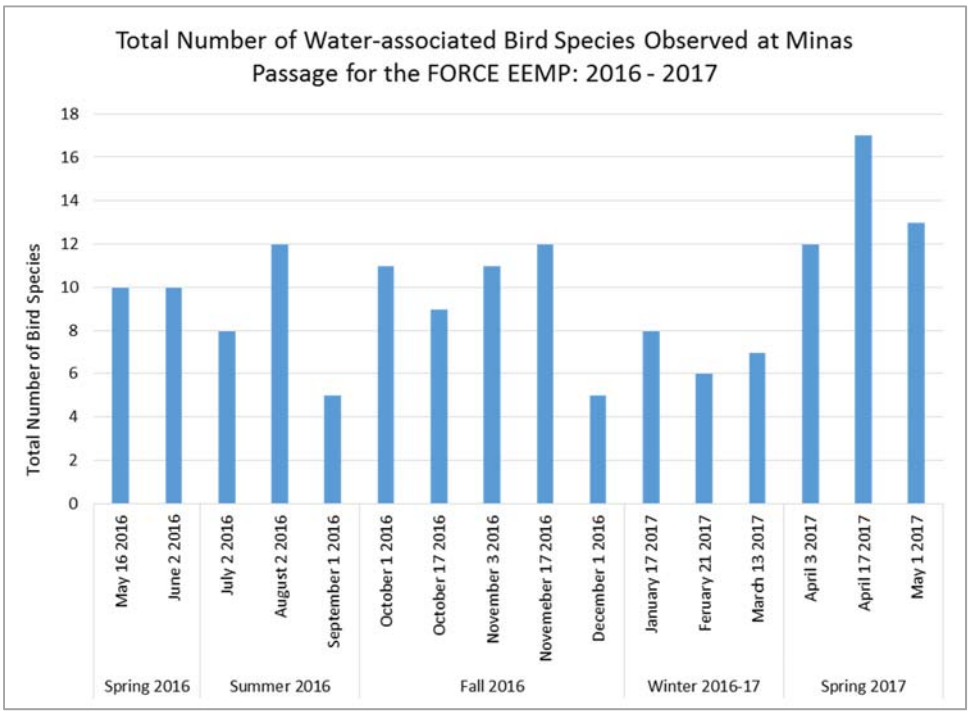

Figure 5. Total number of water-associated bird species observed during Year-One (May 2016 – May 2017) of the Shore-Based Seabird Survey – Tidal Energy Demonstration Site, Fundy Ocean Research Center for Energy. Parrsboro, Nova Scotia.

Number of species observed per survey (an indicator of the overall diversity of birds at the site) was higher during the spring-early summer nesting and migration season seasons (April to June) (10 – 17 species); and the fall migration period (October to November)(9 – 12 species). Species richness ranged from a low of five species in early September and early December 2016; to a high of 17 species per survey in mid-April 2017 (Figure 8). The number of species present was made up of several resident and locally breeding species, which were usually present; and the remainder by migrants of various types, as well as seasonal visitors (e.g. Atlantic Puffin, Razorbill, Red-throated Loon). Species composition and relative abundance in survey subareas is presented in Figures 7-9 and 14-25.

The majority of seabirds and other water-associated birds seen at the site were common and not of particular conservation concern, with the exception of Harlequin Duck and Red-Necked Phalarope[2]. Conservation status of other birds occurring at the site are shown in Appendix C, Tables C1 & C2).

[2] Harlequin Duck is a species of *Special Concern* under both the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the federal *Species at Risk Act* (SARA) and *Endangered* under the Nova Scotia *Species at Risk Act.* Red-Necked Phalarope is rated *Special Concern* by COSEWIC.

Table 2. Seabirds and other water-associated bird species observed at the Fundy Tidal Power Demonstration Site (FORCE Visitor Center) during the 2016 - 2017 shore-based survey year. A total of 32 species were observed and documented.

Species Code	*Common Name*	*Scientific Name*
WATERFOWL, LOONS, GREBES		
COLO	Common Loon	*Gavia immer*
RTLO	Red-throated Loon	*Gavia stellata*
ARLO	Arctic Loon	*Gavia arctica*
RNGR	Red-necked Grebe	*Podiceps grisegena*
ABDU	American Black Duck	*Anas rubripes*
SNGO	Snow Goose	*Chen canagica*
CAGO	Canada Goose	*Branta canadensis*
COGO	Common Goldeneye	*Bucephala clangula*
RBME	Red-breasted Merganser	*Mergus serrator*
COME	Common Merganser	*Mergus merganser*
BWTE	Blue-winged Teal	*Anas cyanoptera*
SEABIRDS & SEA DUCKS		
ATPU	Atlantic Puffin	*Fratercula arctica*
BLGU	Black Guillemot	*Cepphus grylle*
COMU	Common Murre	*Uria aalge*
RAZO	Razorbill	*Alca torda*
DCCO	Double-crested Cormorant	*Phalacrocorax auritus*
GRCO	Great Cormorant	*Phalacrocorax carbo*
GBBG	Great Black-backed Gull	*Larus marinus*
HEGU	Herring Gull	*Larus argentatus*
ICGU	Iceland Gull	*Larus glaucoides*
LBBG	Lesser Black-backed Gull	*Larus fuscus*
RBGU	Ring-billed Gull	*Larus delawarensis*
NOGA	Northern Gannet	*Morus bassanus*
WISP	Wilson's Storm Petrel	*Oceanites oceanicus*
COEI	Common Eider	*Somateria mollissima*
LTDU	Long-tailed Duck	*Clangula hyemalis*
BLSC	Black Scoter	*Melanitta americana*
SUSC	Surf Scoter	*Melanitta perspicillata*
WWSC	White-winged Scoter	*Melanitta deglandi*
SHOREBIRDS		
LEYE	Lesser Yellowlegs	*Tringa flavipes*
PUSA	Purple Sandpiper	*Calidris maritima*
SPSA	Spotted Sandpiper	*Actitis macularius*

Table 3. Water-associated bird species presence (p) for each survey conducted for the Shore-Based Seabird Survey – Tidal Energy Demonstration Site, Fundy Ocean Research Center for Energy. Parrsboro, Nova Scotia.

DATE	Spring		Summer			Fall					Winter			Spring			Total # of Surveys Observed	% of surveys
	06-May-16	02-Jun-16	02-Jul-16	02-Aug-16	01-Sep-16	01-Oct-16	17-Oct-16	03-Nov-16	17-Nov-16	01-Dec-16	16-Jan-17	21-Feb-17	13-Mar-17	03-Apr-17	17-Apr-17	01-May-17		
LOONS (GAVIIDAE)																		
COLO	p	p	p	p		p	p	p	p		p	p	p		p		12	75.0
RTLO	p	p	p			p		p	p			p	p	p	p	p	11	68.8
ARLO									p								1	6.3
WATERFOWL (ANATIDAE)																		
ABDU						p				p	p		p	p			5	31.3
SNGO														p			1	6.3
CAGO						p								p			2	12.5
COEI	p	p	p	p			p	p	p		p		p	p	p	p	12	75.0
COGO											p	p		p			3	18.8
RBME						p								p	p	p	4	25.0
COME										p							1	6.3
LTDU								p	p					p	p	p	5	31.3
BLSC	p			p		p	p	p	p					p	p	p	9	56.3
SUSC								p							p	p	3	18.8
WWSC							p								p		2	12.5
BWTE																p	1	6.3
AUKS, MURRES & PUFFINS (ALCIDAE)																		
ATPU								p	p						p		3	18.8
BLGU	p	p	p	p										p	p	p	7	43.8
COMU									p		p						2	12.5
RAZO								p	p								2	12.5
CORMORANTS (PHALACROCORACIDAE)																		
DCCO	p	p	p	p	p	p	p								p	p	9	56.3
GRCO	p	p	p	p	p	p	p					p	p		p	p	11	68.8
GULLS (LARIDAE)																		
GBBG	p	p	p	p		p	p	p		p	p	p	p	p	p	p	14	87.5
HEGU	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	16	100.0
ICGU								p			p				p		3	18.8
LBBG	p	p		p												p	4	25.0
RBGU		p		p	p	p	p		p	p					p		8	50.0
NORTHERN GANNET (SULIDAE)																		
NOGA															p		1	6.3
RED-NECKED GREBE (PODICIPEDIDAE)																		
RNGR									p								1	6.3
WILSON'S STORM PETREL (PROCELLARIIDAE)																		
WISP					p												1	6.3
SHOREBIRDS (SCOLOPACIDAE)																		
LEYE				p													1	6.3
PUSA														p			1	6.3
SPSA				p													1	6.3

Resident species at the site, including gulls (Great Black-backed Gull, Herring Gull, and Ring-billed Gull), Double-crested Cormorant and Great Cormorant, Black Guillemot, and Common Eider, frequently occupy Black Rock, either for resting or nesting (Black Guillemot), often in large numbers. Birds on Black Rock formed the largest proportion of total birds on most surveys, occurring prominently in late spring, early summer, summer and winter. Birds typically seen over water were often those species moving to and from Black Rock, but the most abundant were mainly migrants, in particular Red-throated Loon, sea ducks including Black Scoter, Surf Scoter and White-winged Scoter, Long-tailed Duck, Red-breasted Merganser and Common Merganser. During peak migration, numbers of birds were often exceedingly high in the water areas of the site.

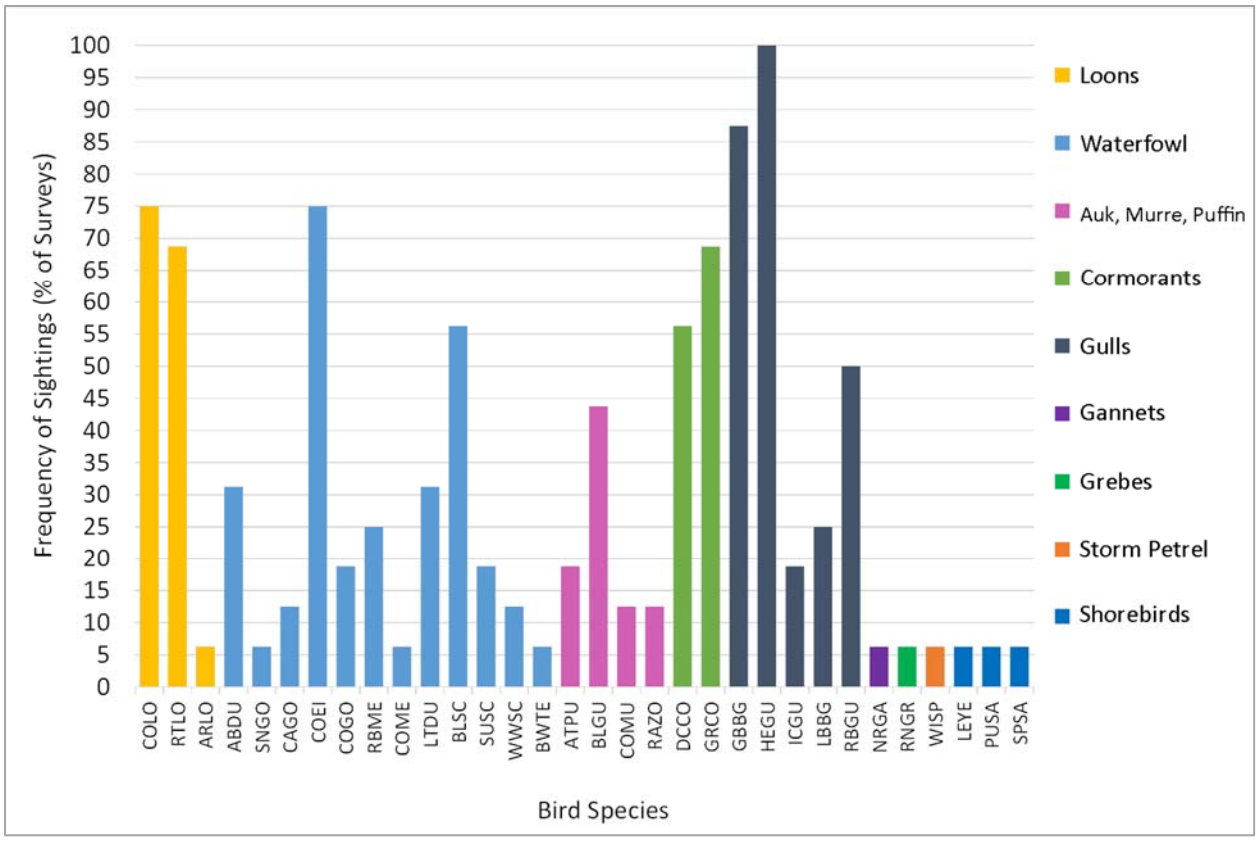

Figure 6. Frequency of surveys (%) in which a species occurred out of 16 surveys conducted for the Shore-Based Seabird Survey – Tidal Energy Demonstration Site, Fundy Ocean Research Center for Energy. Parrsboro, Nova Scotia.

3.1.2 Abundance of Seabirds and Other Water-Associated Birds

Overall, the abundance of seabirds and water-associated birds at the FORCE site is low compared with other coastal areas of the Bay of Fundy and Atlantic Canada (Envirosphere Consultants Limited 2012). This conclusion was based on a comparison of the abundances determined in vessel-based surveys for the site, which used a methodology comparable to the ECSAS surveys (Gjerdrum et al 2012). The present survey approach does not make absolute or quantitative assessments of bird abundance which can be related to other areas; and there are no similar studies (i.e. a full annual study of bird abundances in Atlantic Canada) to which the abundances can be compared. The present approach allows, however, comparisons within the site, as in looking at differences before and after activities, such as the installation of tidal energy devices, which is the objective of monitoring at the site.

Black Rock

The relative abundance of birds on Black Rock (Table 4, Figure 10) is an important indicator of activity for species such as Black Guillemot, which nest on the island, since it reflects breeding activity and success, as well as use of adjacent waters for feeding. Abundance of other birds on Black Rock including Herring Gull, Double-crested Cormorant and Great Cormorant, and Common Eider, are not breeding on the island and their occurrence and abundance there reflects the local population abundance (i.e. in the system encompassing the outer Minas Basin, Minas Passage, and Minas Channel) of these species. Great Black-backed Gull are thought to have nested on Black Rock this year. Number of birds occurring over water at the site reflects overall abundance and also preferences for particular sub-areas, and in the context of monitoring for interactions with tidal installations, are most important direct indicators of the potential for tidal interactions.

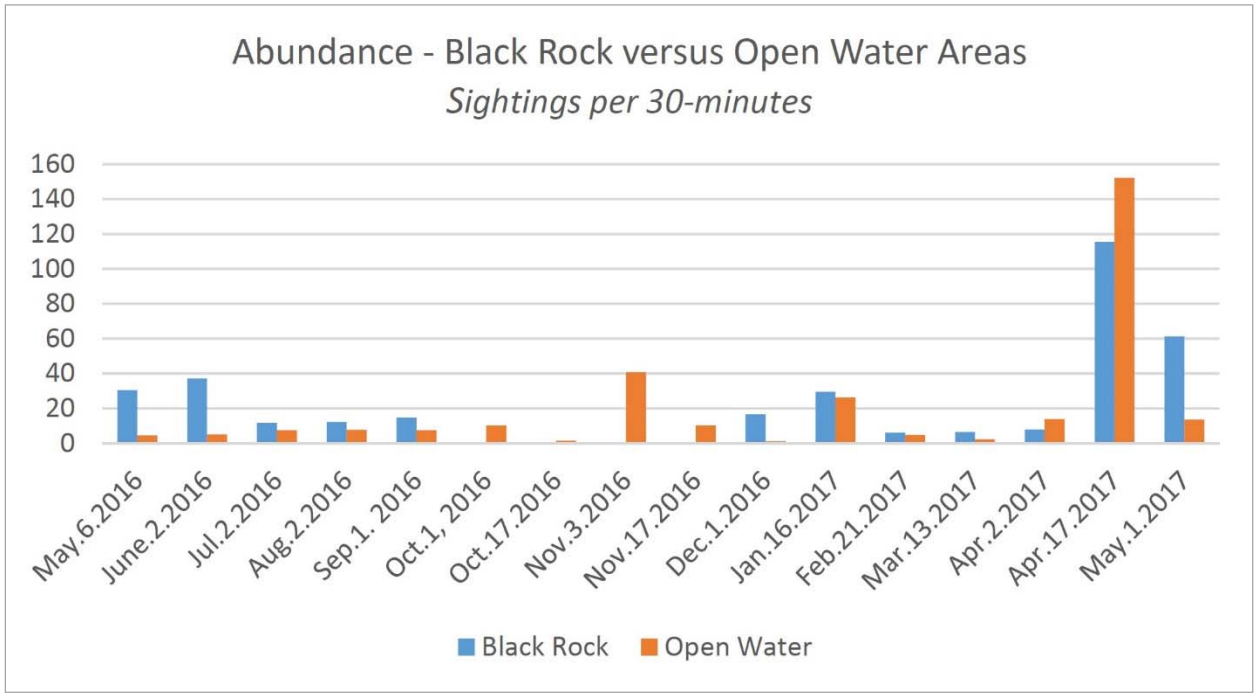

Figure 7. Average abundance of seabirds and water-associated birds (Black Rock versus open water) during the Shore-Based Seabird Survey – Tidal Energy Demonstration Site, Fundy Ocean Research Center for Energy. Parrsboro, Nova Scotia.

Peak abundance of birds on Black Rock occurred in the late spring to early-summer (with a peak in mid-April 2017), and winter to early spring. Peak abundances for the survey of 115.5 and 61.4 individuals per 30 minutes were observed on April 17th 2017 and May 1st 2017 respectively. This peak was dominated by Double-crested Cormorant, which made up about 50% of numbers; and Great Black-backed Gull and Herring Gull most of the remainder (Figure 11). These two gulls were also important in the early summer from mid-May to early June 2016; and were the most abundant birds on Black Rock over the winter to early spring. Summer abundance of gulls on Black Rock was low, indicating a general absence from the area, and low importance on Black Rock in summer. Ring-billed Gull which had been relatively abundant in the earlier (2010-2012) baseline surveys occurred occasionally and in small numbers in the summer and in the December survey (Figure 9). Common Eider was present in moderate numbers in the late spring through the summer, and was most abundant in the early summer (June and July, 2016) surveys, when 3.4 and 2.3 birds per 30 minutes were observed, and in the April 3rd and April 17th 2017 surveys (6.3 and 4.7 sightings per 30 minutes respectively). Double-crested Cormorant were present in

moderate numbers chiefly from late spring to early October with highest numbers observed on Black Rock on April 17th and May 1st 2017 (61.2 and 28.1 birds per 30-minute period respectively). Black Guillemot is an important species which nests on the island, but which was observed in less than 50% of surveys. Surveys confirmed Black Guillemot, possibly four pairs, nest on Black Rock but were seen most frequently on the water adjacent to it during individual surveys, and their low abundance reflects the short period during which they land on Black Rock to access nesting crevices.

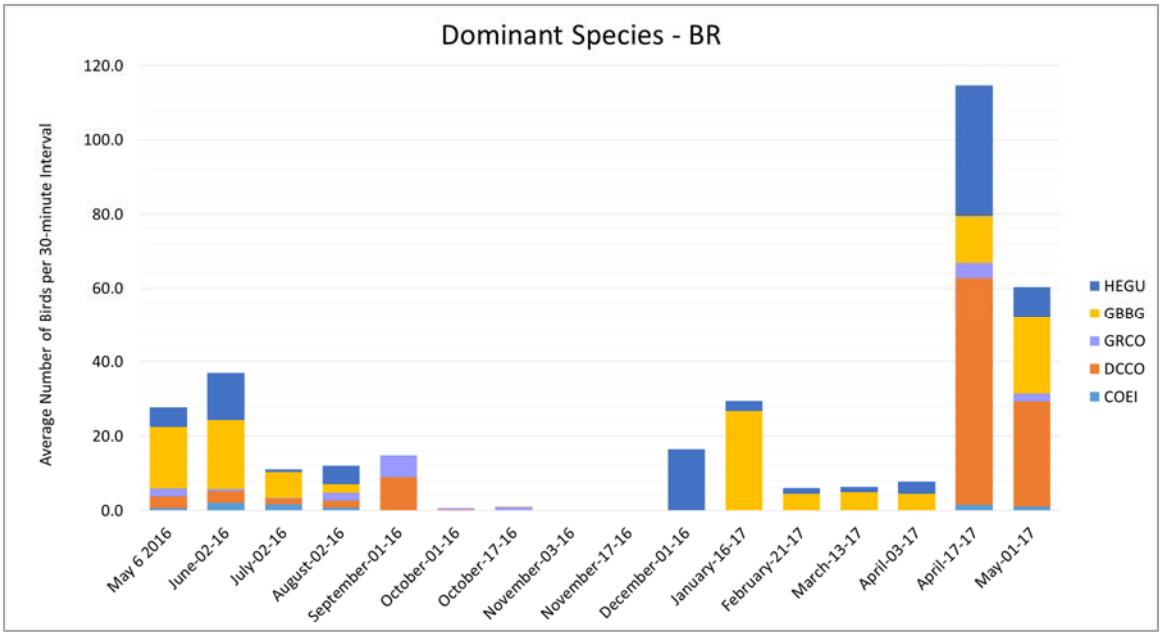

Figure 8. Average abundance of dominant bird species per 30-minute interval on subarea BR (Black Rock).

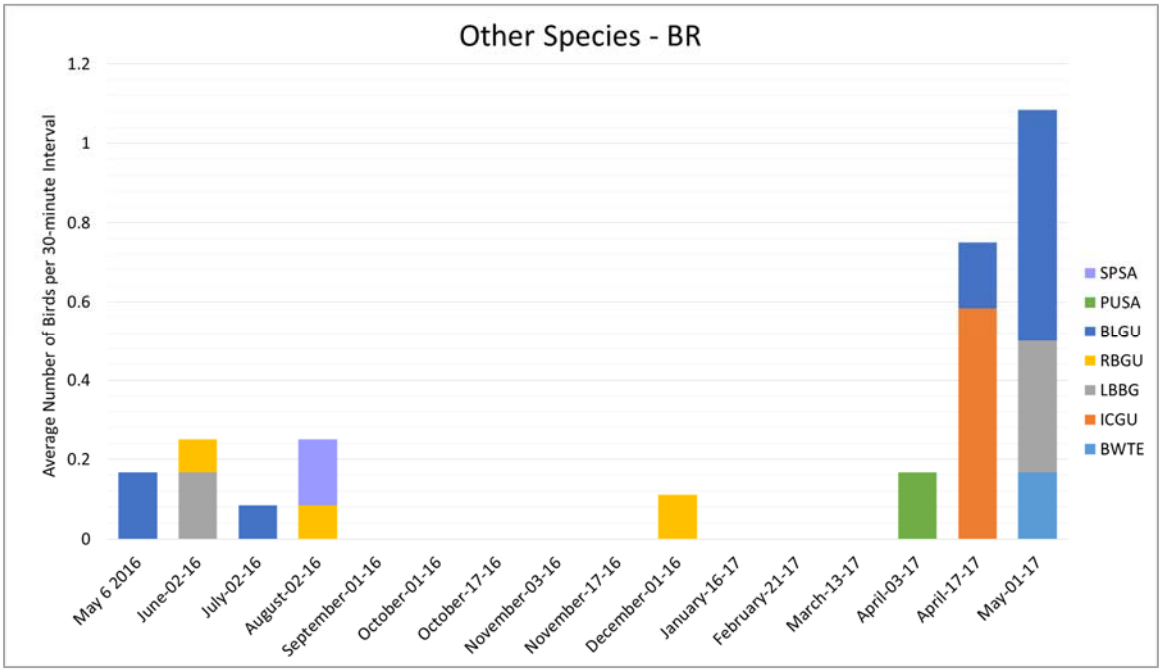

Figure 9. Average abundance of other bird species per 30-minute interval on subarea BR (Black Rock).

Various bird species were observed landing on or flying over Black Rock which are not typically aquatic, including terrestrial and coastal species such as American Crow, American Bald Eagle, Peregrine Falcon, and various songbirds, as well as shorebirds, the latter which are considered aquatic and are included in the analysis. Bald Eagle occurred at the site during several surveys, flying through the area close to shore or landing on the island. Bald Eagles landing on the Black Rock can drive normal resident species away temporarily. Presence of a Bald Eagle on April 17th 2017 appeared to drive gulls and cormorants off Black Rock, as flocks of more than 100 Double-crested Cormorant and Herrings Gull abruptly flew off the island and landed on the water in OB1 when the eagle arrived. An individual male Peregrine Falcon was seen flying parallel to shore in IB1 during the October 1st 2016 survey. This threatened species nests on cliffs in the area, in particular at Cape Sharp located east of the site (AECOM 2009) and commonly feeds on small birds such as shorebirds. The species has been seen on other occasions in the vicinity of the FORCE Visitor Center although not during our surveys and occurrences were not documented.

Purple Sandpiper, a shorebird, landed on Black Rock in early April 2017; and a Spotted Sandpiper was recorded in early August 2016, coincident with the expected southerly shorebird migration through the area. Several individual Iceland Gull and Lesser Black-backed Gull, as well as a Blue-winged Teal, were observed on Black Rock in early May 2017 (Figure 9).

Abundance in Open Water Areas

Use of open water (i.e. areas other than coastal features, flats and islands) by seabirds and other water-associated birds at the FORCE site provides background information useful in assessing trends in distribution and abundance of birds, particularly in areas primarily occupied by tidal energy devices, but also in assessing patterns useful in interpreting observations in later, operational phases of the tidal energy demonstration site. Various factors can influence local distribution of birds overall including closeness to food sources and food abundance, availability of islands and other protection from predators, presence of geographic features such as passages and points which can direct a bird's movements and lead to concentrations, and proximity to colonies and breeding areas, among others.

For the year as a whole, highest average numbers of birds were observed in open water subareas IB1, OB1, and CL (Figure 10). Black Rock is in the middle of areas IB1 and OB1 and the numbers in these areas in part reflect birds landing on or flying from Black Rock. Flocks of scoters and other migratory species, such as Red-throated Loon also travel through these sub areas en route to West Bay and other areas in Minas Basin and outer parts of the Bay of Fundy beyond Minas Passage. For most of the year except during migration, most birds in open water areas at the FORCE site were detected in the IB1 (Inside Black Rock) sub-area (Figures 11-13)[3]. Birds seen here included those which were coming and going from Black Rock but many birds also used the IB1 area in their coastal movements through the area. IB1 had the highest number of birds through the summer and early fall (Figure 11) (from July 2nd to October 1st 2016); and through the winter (Figure 13). IB1 also supported significant numbers of birds during the migration periods of November and April-early May, when overall numbers of birds were seasonally highest; numbers in the nearby CL (Crown Lease) area were also high, and comparable to those in IB1.

[3] Survey subareas are shown in Figure 2.

Abundance of birds in the CL ("Crown Lease") area was usually a close second to IB1 in the late spring to fall period (beginning May 6, 2016 and extending to October 17th, 2016 (Figure 14) and also figured prominently although at low numbers during the winter (Figure 12)). Numbers in the CL area were highest of all areas in surveys during migration in the November 2016 and April 2017 (Figure 13) when large numbers of scoters moved through the FORCE site. The CL area is immediately 'upstream' or 'downstream' in the tidal currents passing Black Rock depending on tidal stage, and birds on the water in either area frequently drift with the current, before flying upstream to maintain an overall position relative to Black Rock. Most of our surveys were conducted on the ebb tide, with currents flowing from Black rock to the CL area.

The remaining survey areas supported lower numbers of birds than the IB1, OB1 and CL subareas, in particular with lowest abundances in the more removed sites (i.e. the "Farfield" (FF) sites FF1, FF2 & FF3) (which have been grouped together in the analysis). Significant, though low, numbers of birds at the FF sites were observed only in the summer (May 6, 2016) and during migration (November 3, 2016) surveys. This finding suggests that the inner parts of the study area such as IB1, CL and the OB1 to OB3 sites are more attractive to birds than the distant sites, and in particular the complexity of the local environment—which includes the presence of Black Rock as well as other features at the site, such as proximity to the coast, a point of land, a coastal marsh, a sand spit system, and nearby shoreline and tidal flats—may attract seabirds to the area. We don't think that this observation of is due to 'distance effects' (i.e. that some observations in the furthest sites will be missed, due to increasing difficulty in accounting for all birds with distance from the observation site)(Buckland et al 2001; Gjerdrum et. al. 2012); although some birds at the furthest locations are most certainly missed in our survey protocol, the contribution of this effect is thought to be small, although the assumption wasn't evaluated in the current study. The IB2 site, situated west along the coast from Black Rock, and the OB ("Outside Black Rock") sites OB2 and OB3 usually supported lower numbers of birds than IB1, OB1 and CL, although both subareas had higher numbers in the May 6, 2016 survey. The OB3 site, which is near the CL site and is also close to Black Rock, also supported comparable numbers of birds to the other sites on occasion. OB1 had the highest number of birds on the April 17, 2017 survey when all the sub-areas around Black Rock and the CL area, and including OB3 supported significant numbers of migrating birds (Figure 13). Species occurring in these subareas, and their relative abundance, are summarized in Figures 17-28 and Table 4.

Table 4. Average abundance of seabirds and water-associated birds (number per 30-minutes) at the FORCE Tidal Energy Demonstration Site, Black Rock, Nova Scotia, 2016-2017. Number in brackets is standard deviation.

Total Bird Abundance								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016	0.33 (0.78)	0.33 (0.89)	0.92 (1.24)	0.67 (0.98)	1.17 (1.47)	0.17 (0.39)	1.42 (2.31)	28.75 (11.29)
June.2.2016	1.83 (2.55)	2 (2.37)	0.33 (0.89)	0.75 (0.97)	0.33 (0.89)			37.25 (10.14)
Jul.2.2016	1.58 (2.35)	3.83 (2.17)		0.5 (0.67)		0.25 (0.45)	0.08 (0.29)	11.67 (2.53)
Aug.2.2016	1.75 (1.71)	3.75 (2.42)		1 (1.35)		0.42 (1)	0.17 (0.58)	12.33 (6.47)
Sep.1. 2016	3.33 (5.35)	3.58 (2.75)		0.17 (0.39)		0.08 (0.29)		14.75 (5.89)
Oct.1, 2016	0.67 (0.78)	5.17 (6.62)		0.58 (1.24)		0.92 (2.11)	0.58 (0.9)	0.67 (0.98)
Oct.17.2016	0.33 (0.49)	1.83 (2.21)		0.58 (1)		0.25 (0.45)		1.08 (1)
Nov.3.2016	25.83 (57.24)	1.42 (2.87)		3.17 (6.39)		1.83 (4.88)	6.25 (21.65)	
Nov.17.2016	6 (10.48)	1 (1.6)		0.25 (0.45)		0.5 (1.45)	0.25 (0.62)	
Dec.1.2016	0.08 (0.29)	0.83 (1.53)						12.5 (43.3)
Jan.16.2017	0.5 (1.17)	20.58 (59.78)		0.75 (2.6)			0.08 (0.29)	24.58 (41.45)
Feb.21.2017	0.42 (0.9)	2.5 (2.47)		0.17 (0.58)				6.08 (15.44)
Mar.13.2017	0.33 (0.49)	0.92 (1.44)		0.17 (0.39)				6.5 (5.99)
Apr.2.2017	1.75 (4.52)	7.83 (22.77)	0.58 (2.02)	1.92 (5.73)		0.92 (2.61)		7.92 (11.1)
Apr.17.2017	46.83 (62.76)	26.25 (51)	0.5 (1.73)	60.75 (58.35)	0.58 (2.02)	16.67 (57.74)		115.5 (63.43)
May.1.2017	5.67 (8.82)	3.5 (2.84)		4.33 (6.51)	0.5 (1.73)			61.42 (15.31)
Black Guillemot								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016			0.09 (0.3)	0.27 (0.65)				0.18 (0.4)
June.2.2016	0.08 (0.29)	0.5 (1)		0.25 (0.45)				
Jul.2.2016	0.08 (0.29)	1.08 (1)			0.17 (0.39)			0.17 (0.39)
Aug.2.2016	0.42 (0.67)	0.58 (1.44)				0.17 (0.58)		
Apr.2.2017	0.08 (0.29)	0.08 (0.29)				0.08 (0.29)		
Apr.17.2017				0.08 (0.29)				0.17 (0.58)
May.1.2017		0.75 (1.14)		0.08 (0.29)				0.58 (0.79)
Black Scoter								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016	0.18 (0.6)		0.09 (0.3)					
Aug.2.2016				0.08 (0.29)				
Oct.1, 2016				0.17 (0.58)	0.75 (2.6)			
Oct.17.2016		0.5 (1.73)						
Nov.3.2016	21.42 (56.72)			2.58 (6.47)	1 (3.46)	1.42 (4.91)	6.25 (21.65)	
Apr.2.2017	0.42 (1.44)	0.33 (1.15)						
Apr.17.2017	10.17 (17.72)	8.58 (27.31)		32.33 (37.4)				
May.1.2017				0.92 (1.78)				

Table 4. Average abundance of seabirds and water-associated birds (number per 30-minutes) at the FORCE Tidal Energy Demonstration Site, Black Rock, Nova Scotia, 2016-2017. Number in brackets is standard deviation.

Common Loon								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016			0.09 (0.3)					
June.2.2016	0.25 (0.45)	0.08 (0.29)		0.08 (0.29)				
Aug.2.2016				0.08 (0.29)				
Oct.1, 2016	0.08 (0.29)	0.92 (0.29)						
Oct.17.2016				0.08 (0.29)				
Nov.3.2016		0.08 (0.29)						
Nov.17.2016	0.09 (0.3)							
Jan.16.2017	0.2 (0.42)	0.1 (0.32)						
Mar.13.2017		0.08 (0.29)						
Apr.17.2017	0.08 (0.29)			1.92 (3.12)				
Common Eider								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016			0.64 (1.21)					0.82 (0.98)
June.2.2016	1.17 (1.75)	0.25 (0.45)						2.17 (2.66)
Jul.2.2016	1.08 (2.02)	0.50 (1.17)						1.25 (1.29)
Aug.2.2016		0.58 (1.00)						0.83 (0.83)
Oct.17.2016		0.75 (0.97)						
Nov.3.2016		0.08 (0.29)						
Nov.17.2016		0.64 (1.57)						
Jan.16.2017	0.40 (1.26)							
Mar.13.2017		0.42 (1.44)						
Apr.2.2017		6.25 (21.65)						
Apr.17.2017		0.33 (0.65)		2.42 (5.65)				1.58 (1.44)
May.1.2017	1.17 (2.76)							1.17 (1.64)
American Black Duck								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
Oct.1, 2016		0.33 (1.15)						
Dec.1.2016		0.22 (0.67)						
Jan.16.2017		0.30 (0.95)						
Mar.13.2017		0.42 (1.44)						
Apr.2.2017		0.08 (0.29)	0.58 (2.02)					
White-winged Scoter								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
Oct.17.2016		0.08 (0.29)						

Table 4. Average abundance of seabirds and water-associated birds (number per 30-minutes) at the FORCE Tidal Energy Demonstration Site, Black Rock, Nova Scotia, 2016-2017. Number in brackets is standard deviation.

Apr.17.2017				0.58 (1.08)				
Surf Scoter								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
Nov.3.2016					1 (3.46)			
Apr.17.2017	11.83 (40.37)	0.42 (1.44)		15.42 (48.78)				
May.1.2017	0.5 (1.73)			2.42 (6.11)				
Red-throated Loon								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016		0.09 (0.3)				0.09 (0.3)	0.73 (1.56)	
June.2.2016	0.08 (0.29)	0.08 (0.29)						
Jul.2.2016							0.08 (0.29)	
Oct.1, 2016	0.08 (0.29)							
Nov.3.2016	0.17 (0.39)			0.17 (0.58)	0.25 (0.45)	0.42 (1)		
Nov.17.2016	4 (11.05)	0.18 (0.4)		0.09 (0.3)	1.27 (2.65)	0.45 (1.21)	0.09 (0.3)	
Feb.21.2017	0.08 (0.29)				0.08 (0.29)			
Mar.13.2017	0.17 (0.39)							
Apr.2.2017	0.33 (1.15)							
Apr.17.2017	4.83 (6.06)	1 (2.66)		1.67 (3.58)	0.25 (0.87)	8.33 (28.87)		
May.1.2017	0.17 (0.39)	0.33 (1.15)		0.42 (0.67)	0.08 (0.29)			
Common Merganser								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
Nov.17.2016		0.56 (1.67)						
Red-breasted Merganser								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
Oct.1, 2016	0.08 (0.29)							
Apr.2.2017		0.08 (0.29)						
Apr.17.2017		0.58 (1.24)						
May.1.2017	0.08 (0.29)			0.17 (0.58)				
Ring-billed Gull								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
June.2.2016								0.08 (0.29)
Aug.2.2016	0.67 (1.37)	0.92 (1.16)		0.75 (1.22)	0.5 (0.67)		0.08 (0.29)	0.08 (0.29)
Sep.1. 2016	1.5 (3.32)	0.5 (0.8)		0.08 (0.29)	0.08 (0.29)			
Oct.1, 2016	0.25 (0.62)	0.17 (0.39)		0.08 (0.29)			0.17 (0.39)	
Oct.17.2016					0.08 (0.29)			
Nov.17.2016		0.09 (0.3)		0.18 (0.4)	0.18 (0.6)			

Table 4. Average abundance of seabirds and water-associated birds (number per 30-minutes) at the FORCE Tidal Energy Demonstration Site, Black Rock, Nova Scotia, 2016-2017. Number in brackets is standard deviation.

Dec.1.2016								0.11 (0.33)
Apr.17.2017		0.33 (1.15)						
Double-crested Cormorant								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016		0.18 (0.6)	0.27 (0.9)	0.18 (0.4)				3.27 (1.85)
June.2.2016	0.33 (0.78)	0.58 (1.24)	0.25 (0.87)					3.08 (2.23)
Jul.2.2016		0.08 (0.29)			0.08 (0.29)			2 (1.21)
Aug.2.2016	0.08 (0.29)	0.33 (0.49)						1.83 (1.19)
Sep.1. 2016	0.08 (0.29)	1.58 (1.93)		0.08 (0.29)				8.92 (2.5)
Oct.1, 2016	2.67 (7.7)	0.58 (0.79)						0.25 (0.62)
Oct.17.2016								0.08 (0.29)
Apr.17.2017		10.67 (23.89)		1.17 (3.01)	0.5 (1.73)			61.17 (38.61)
May.1.2017		0.83 (1.19)		0.17 (0.39)	0 (0)			28.08 (10.15)
Great Cormorant								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016								2.36 (2.66)
June.2.2016	0.08 (0.29)	0.17 (0.39)						0.5 (0.67)
Jul.2.2016								0.17 (0.58)
Aug.2.2016	0.08 (0.29)			0.08 (0.29)				2.17 (1.03)
Sep.1. 2016	0.17 (0.39)							5.75 (6.48)
Oct.1, 2016		0.42 (0.67)		0.17 (0.58)				0.42 (0.51)
Oct.17.2016				0.08 (0.29)				1 (0.95)
Feb.21.2017	0.25 (0.87)							
Mar.13.2017				0.08 (0.29)				0.08 (0.29)
Apr.17.2017								4.17 (3.83)
May.1.2017								2.25 (1.76)
Great Black-backed Gull								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016	0.09 (0.3)	0.09 (0.3)		0.27 (0.9)		0.09 (0.3)	0.09 (0.3)	18.91 (3.88)
June.2.2016		0.17 (0.39)		0.58 (0.79)	0.08 (0.29)			18.5 (4.83)
Jul.2.2016	0.08 (0.29)	0.5 (0.67)		0.5 (0.67)				7.08 (1.44)
Aug.2.2016		0.08 (0.29)						2.25 (0.87)
Oct.1, 2016		0.08 (0.29)						
Oct.17.2016	0.08 (0.29)							0.08 (0.29)
Nov.3.2016								0.08 (0.29)
Dec.1.2016	0.11 (0.33)							0.11 (0.33)
Jan.16.2017		0.6 (1.58)		0.2 (0.63)				26.7 (39.1)

Table 4. Average abundance of seabirds and water-associated birds (number per 30-minutes) at the FORCE Tidal Energy Demonstration Site, Black Rock, Nova Scotia, 2016-2017. Number in brackets is standard deviation.

Feb.21.2017					0.25 (0.87)			4.58 (12.03)
Mar.13.2017								4.92 (2.19)
Apr.2.2017		0.08 (0.29)	0.08 (0.29)			0.33 (1.15)		4.5 (4.7)
Apr.17.2017			0.08 (0.29)		0.08 (0.29)	4.17 (14.43)		12.67 (6.18)
May.1.2017		0.25 (0.45)		0.25 (0.62)				20.42 (8.12)
Herring Gull								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
May.6.2016	0.09 (0.3)				0.09 (0.3)		0.45 (0.82)	5.82 (2.93)
June.2.2016		0.17 (0.39)	0.08 (0.29)					12.75 (6.97)
Jul.2.2016	0.33 (0.65)	1.67 (2.1)			1 (1.41)	0.25 (0.45)		1 (1.04)
Aug.2.2016	0.33 (0.78)	1.25 (1.86)		0.08 (0.29)	0.17 (0.39)		0.08 (0.29)	5 (5.98)
Sep.1. 2016	1.25 (2.01)	1.5 (1.57)			0.17 (0.39)	0.08 (0.29)		0.08 (0.29)
Oct.1, 2016	0.17 (0.39)	2.67 (6.85)		0.08 (0.29)	0.17 (0.39)	0.92 (2.11)	0.42 (0.9)	
Oct.17.2016	0.25 (0.45)	0.5 (1.24)		0.42 (1)	0.33 (1.15)	0.25 (0.45)		
Nov.3.2016	3.58 (11.5)	1.25 (2.9)		0.42 (0.51)	0.08 (0.29)			
Nov.17.2016	0.64 (0.67)	0.27 (0.9)			0.09 (0.3)		0.18 (0.4)	
Dec.1.2016		0.33 (0.71)						16.44 (49.33)
Jan.16.2017	0.1 (0.32)	21.5 (66.24)		0.7 (2.21)			0.1 (0.32)	2.8 (5.9)
Feb.21.2017		0.33 (0.65)		0.17 (0.58)	1.42 (4.91)			1.5 (3.45)
Mar.13.2017	0.17 (0.39)	0.92 (1.44)		0.08 (0.29)				1.5 (4.3)
Apr.2.2017	0.08 (0.29)	0.33 (0.65)		0.25 (0.62)	0.75 (2.6)	0.5 (1.24)		3.25 (6.88)
Apr.17.2017	4.17 (14.43)	0.25 (0.45)	0.42 (1.44)	0.08 (0.29)	0.25 (0.87)	4.17 (14.43)		35.17 (41.56)
May.1.2017	0.58 (1)	1 (1.13)						8.42 (4.14)
Long-tailed Duck								
SUBAREA	CL	IB1	IB2	OB1	OB2	OB3	FF	BR
Nov.3.2016	0.42 (1.44)							
Nov.17.2016	0.27 (0.9)							
Apr.17.2017	15.25 (40.02)	3.33 (11.55)		4.92 (13.66)				
May.1.2017	0.5 (1.45)							

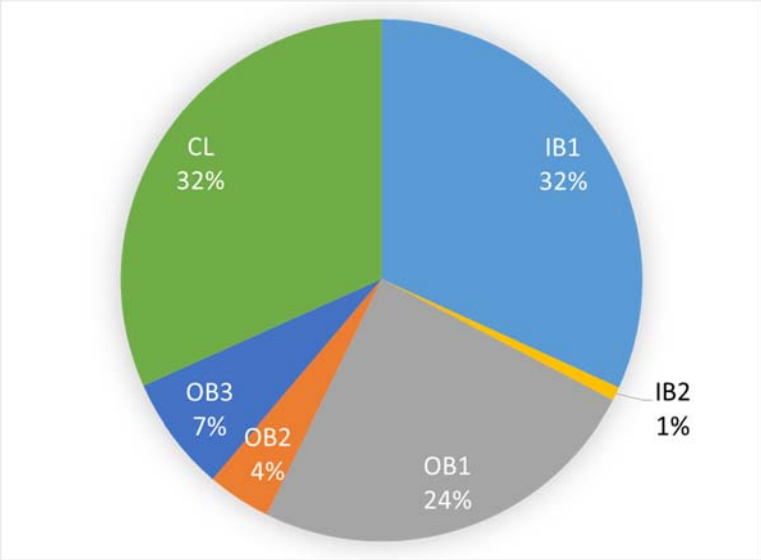

Figure 10. Average abundance of birds by subarea, as a proportion of the total for Year-One of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017). Total includes birds flying or on the water; and sitting on or in the water immediately adjacent to Black Rock (BR).

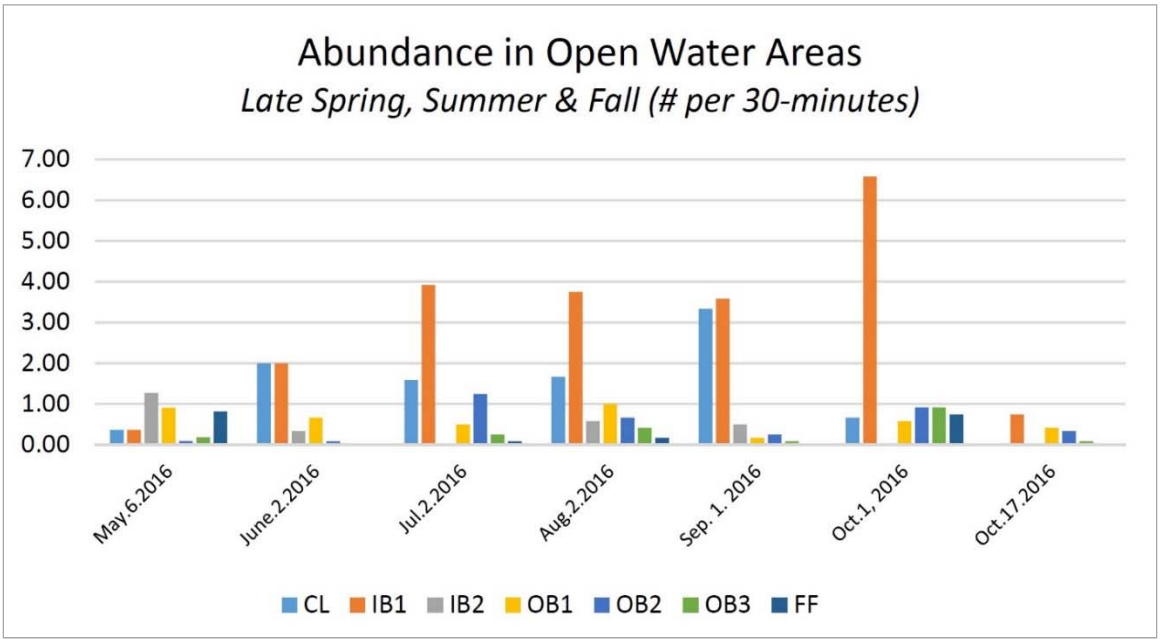

Figure 11. Utilization by seabirds of sub-areas of the FORCE site in late spring, summer and fall.

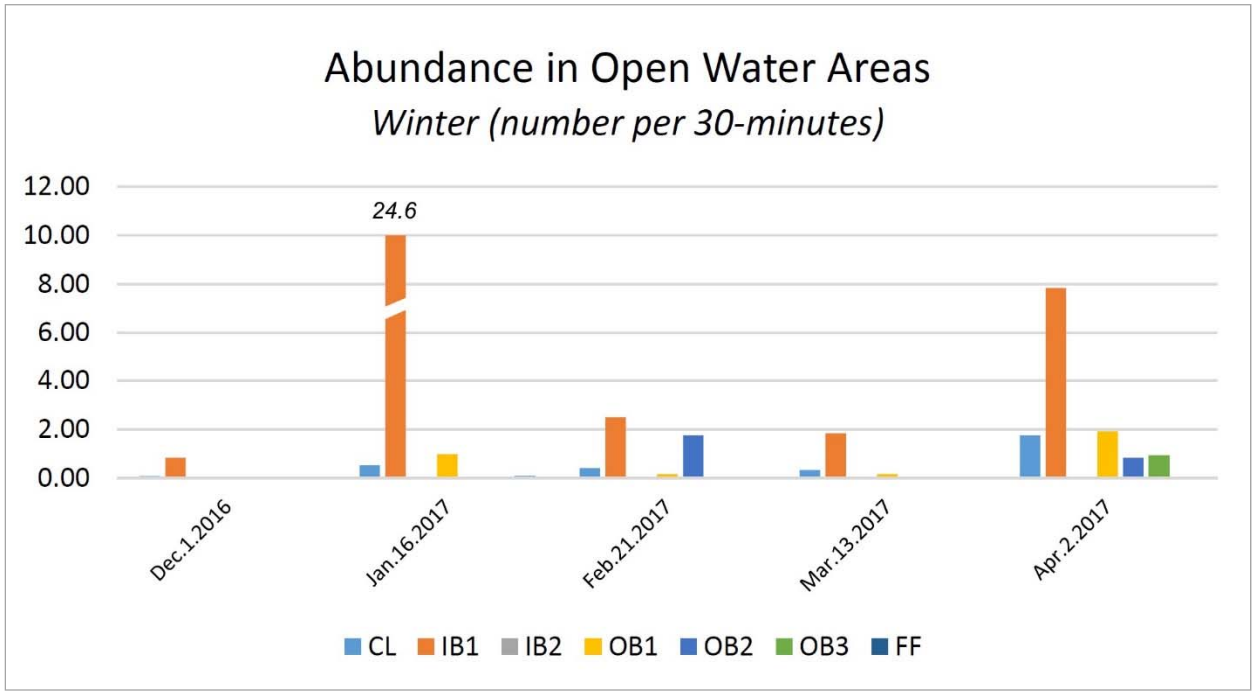

Figure 12. Utilization by seabirds of sub-areas of the FORCE site in winter to early spring.

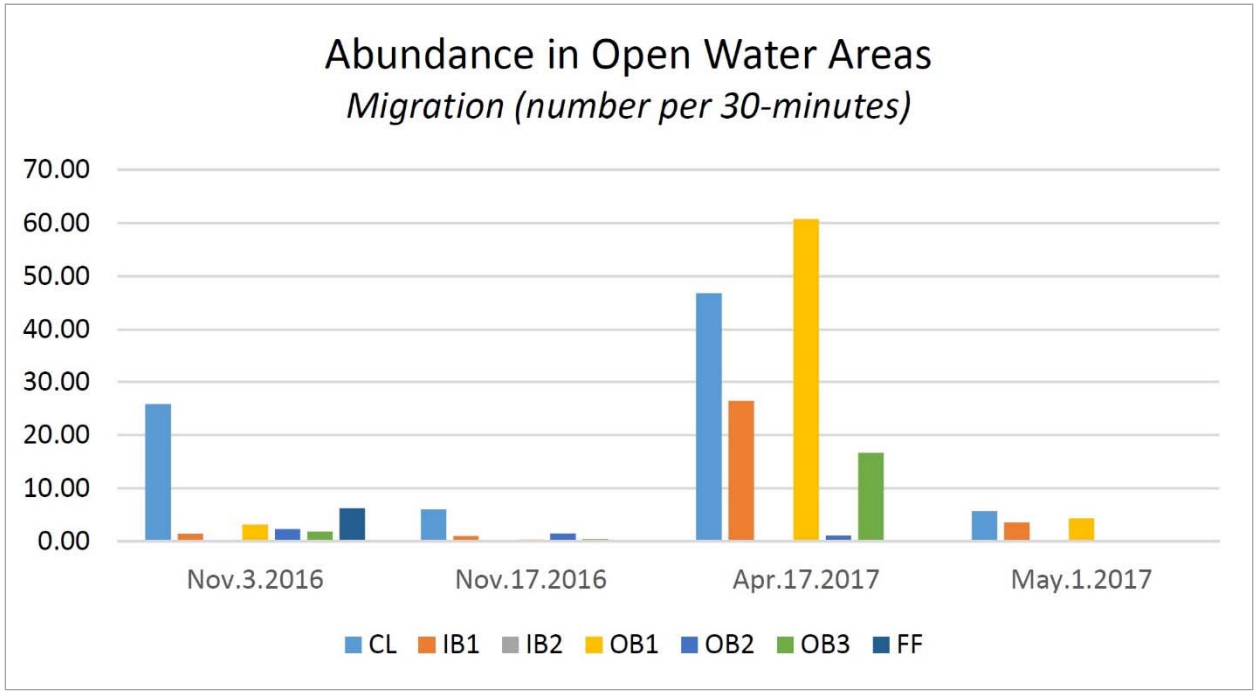

Figure 13. Utilization by seabirds of sub-areas of the FORCE site in migration periods.

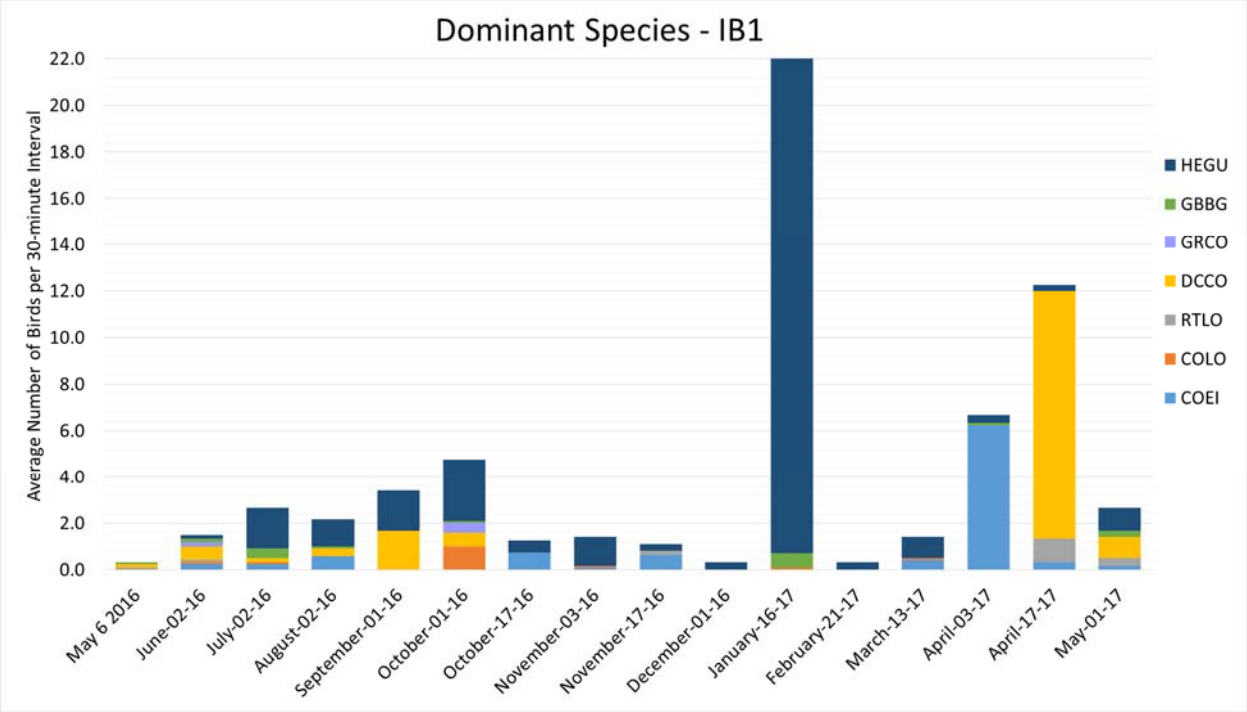

Figure 14. Average abundance of dominant birds per 30-minute interval in subarea IB1.

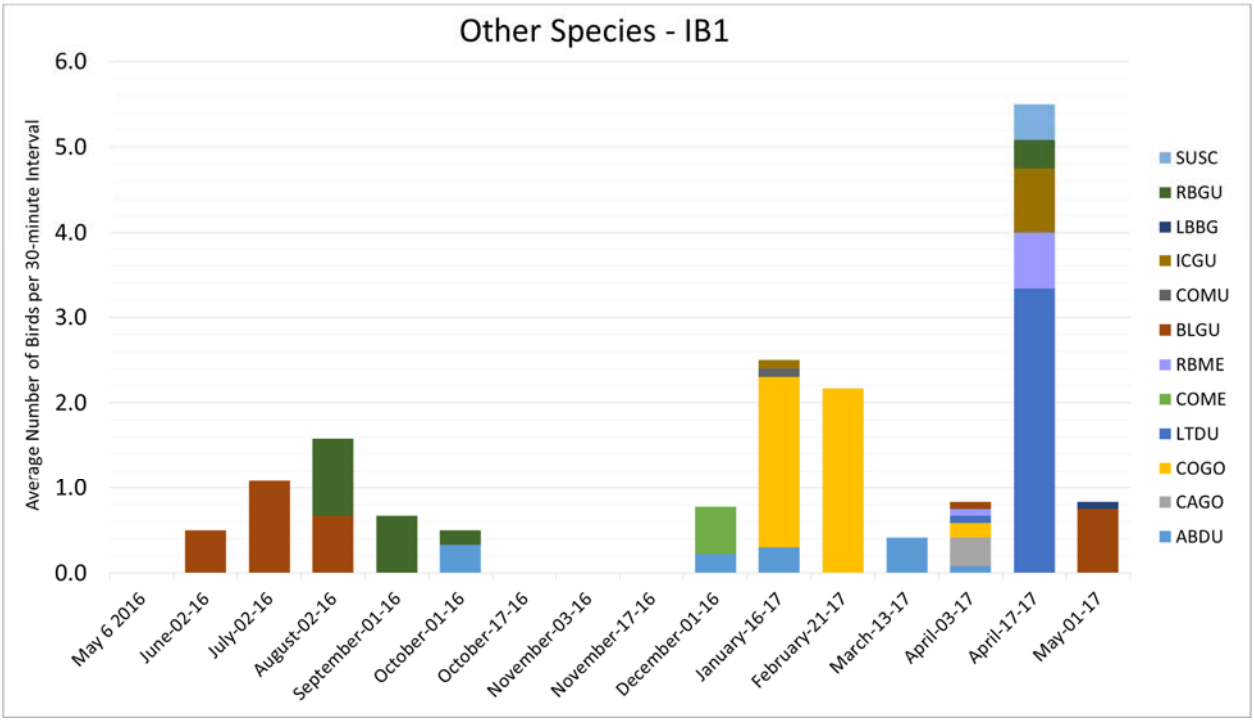

Figure 15. Average abundance of other birds per 30-minute interval in subarea IB1.

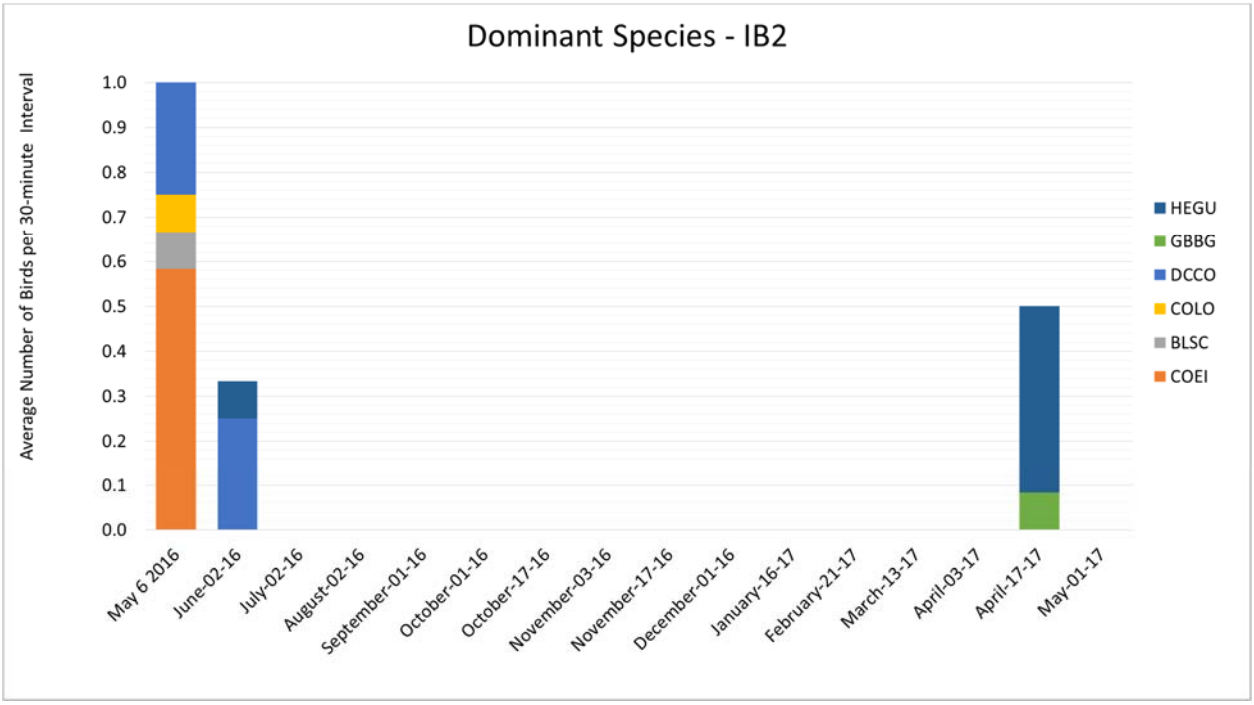

Figure 16. Average abundance of dominant birds per 30-minute interval in subarea IB2.

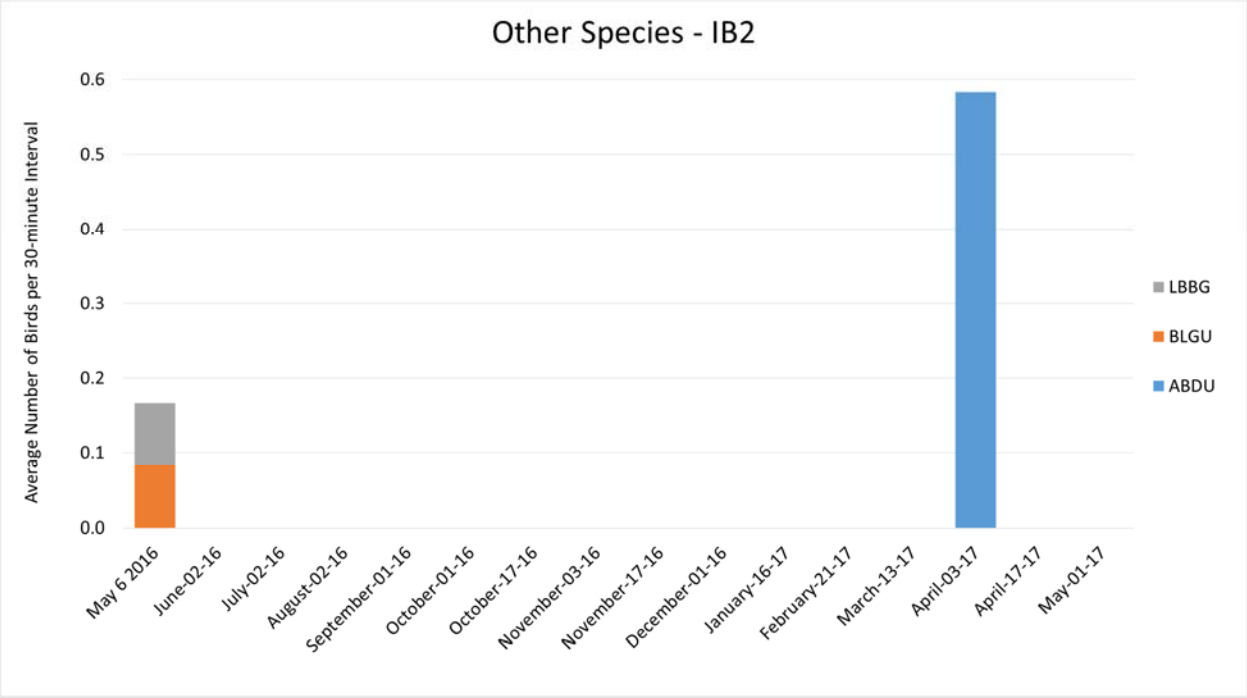

Figure 17. Average abundance of other birds per 30-minute interval in subarea IB2.

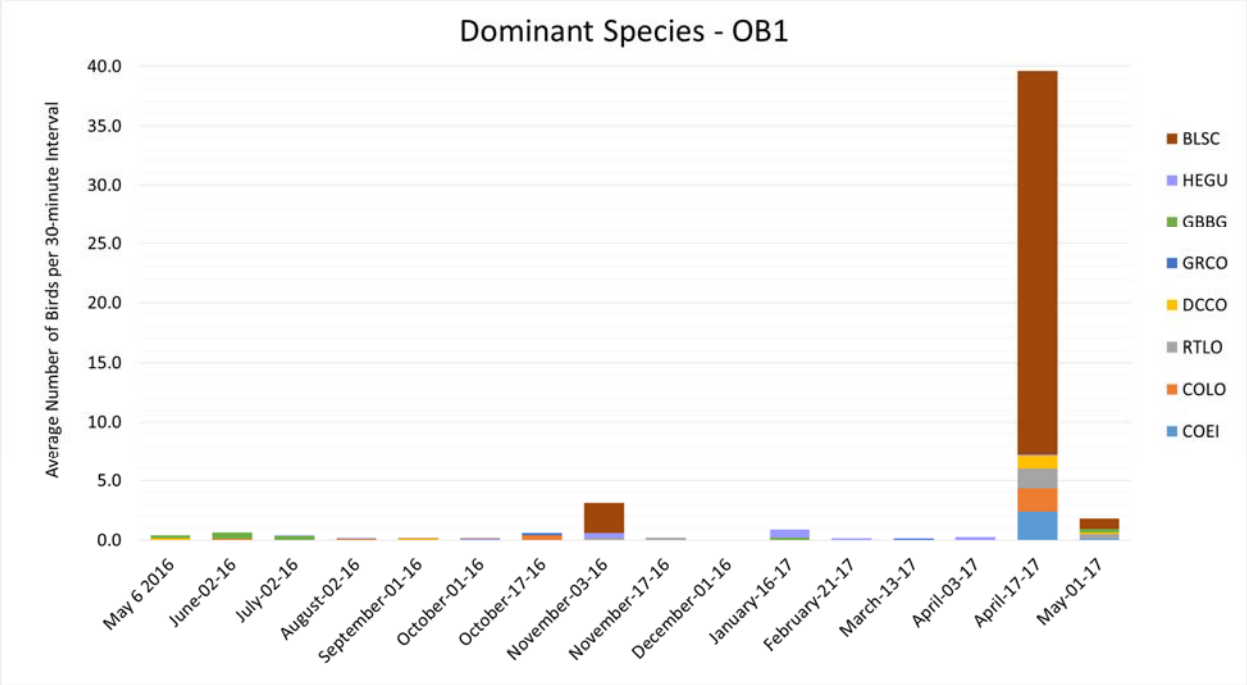

Figure 18. Average abundance of dominant birds per 30-minute interval in subarea OB1.

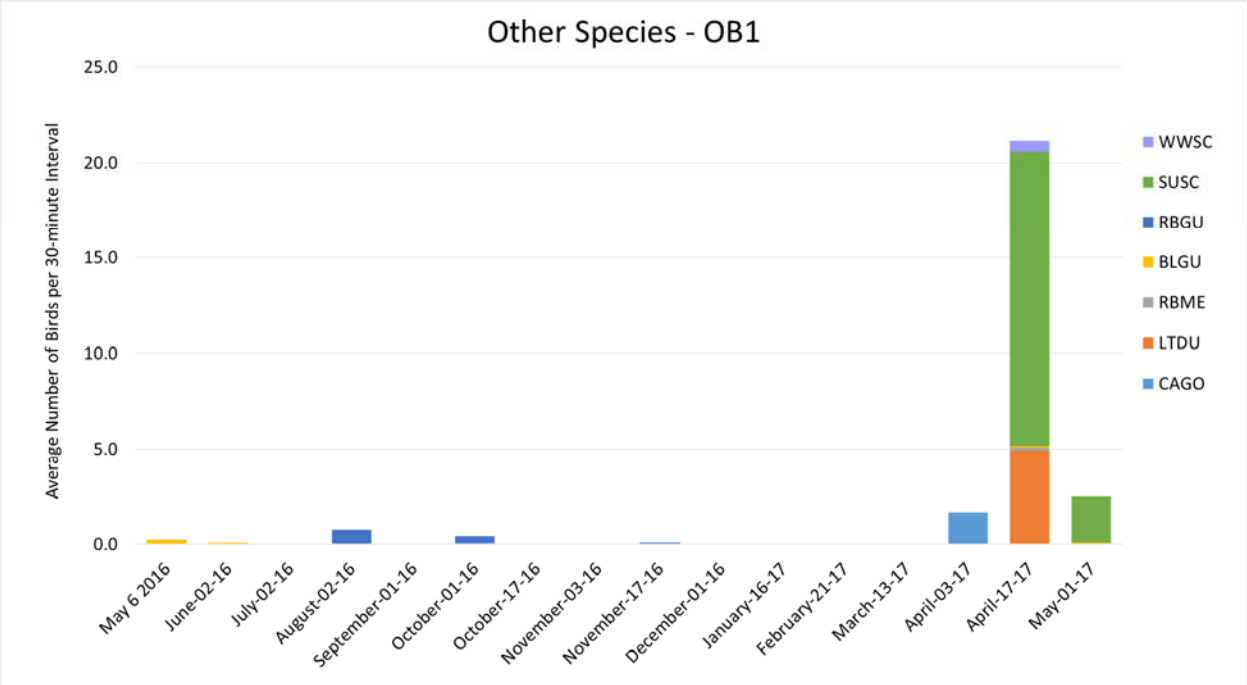

Figure 19. Average abundance of other birds per 30-minute interval in subarea OB1.

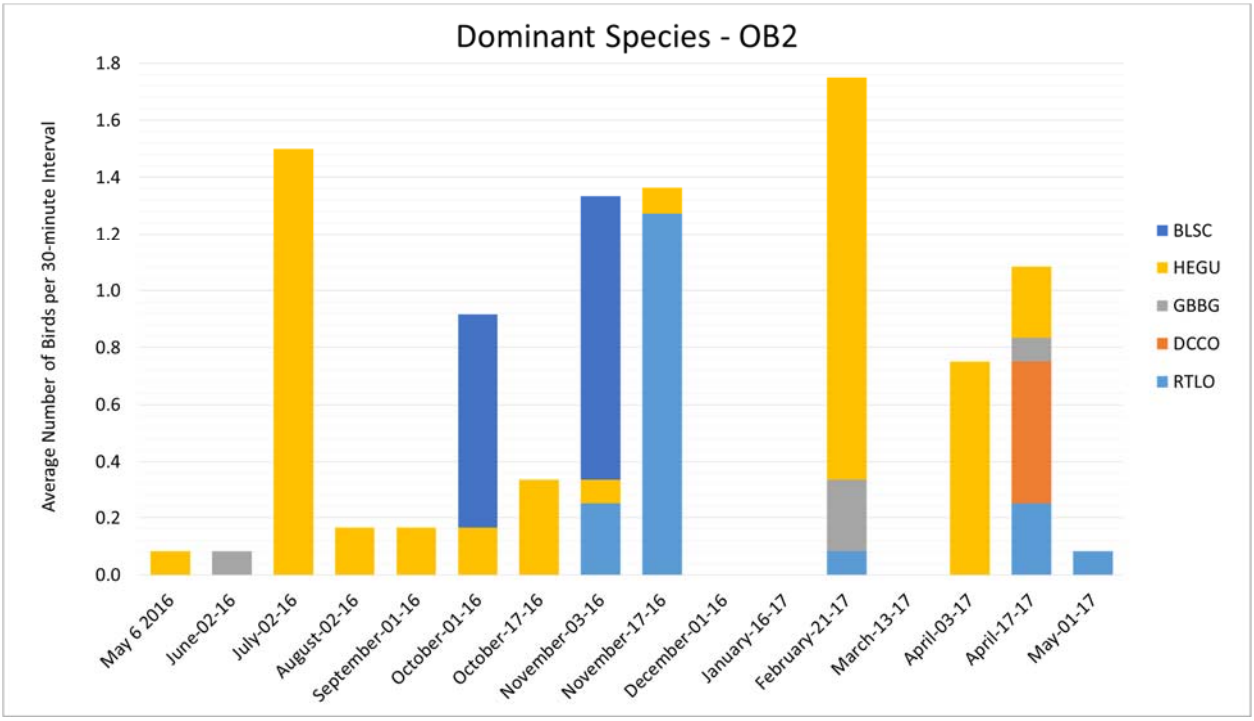

Figure 20. Average abundance of dominant birds per 30-minute interval in subarea OB2.

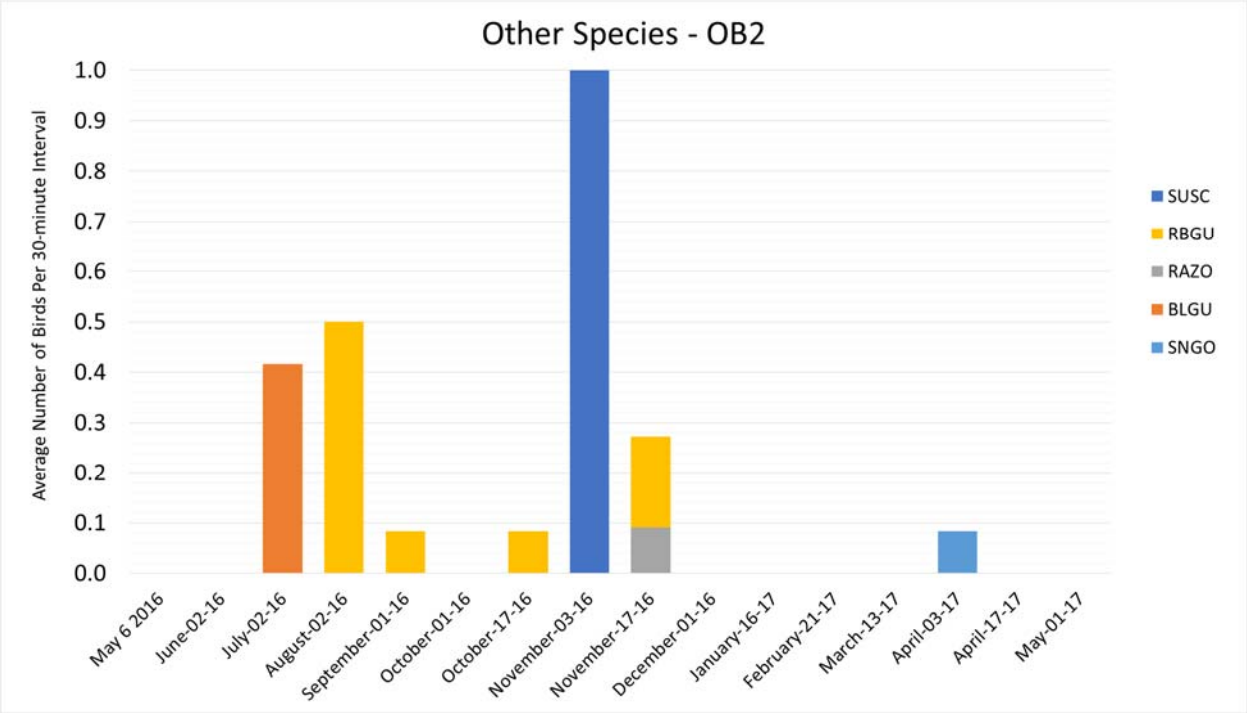

Figure 21. Average abundance of other birds per 30-minute interval in subarea OB2.

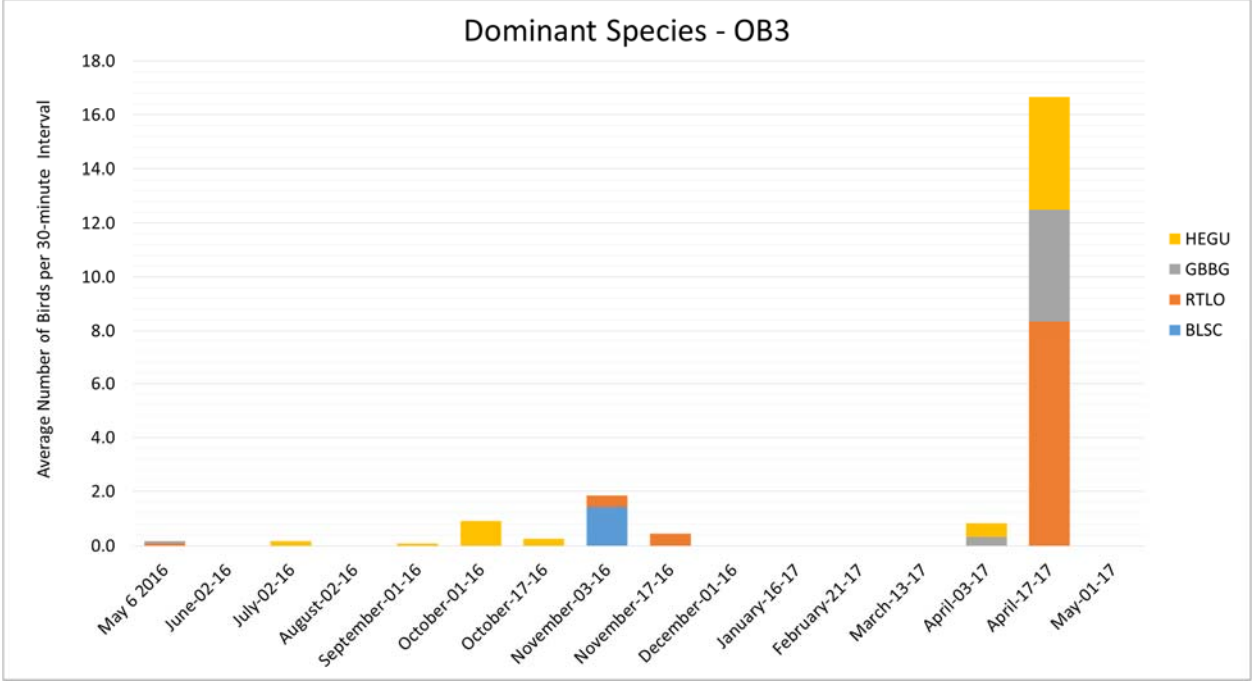

Figure 22. Average abundance of dominant birds per 30-minute interval in subarea OB3.

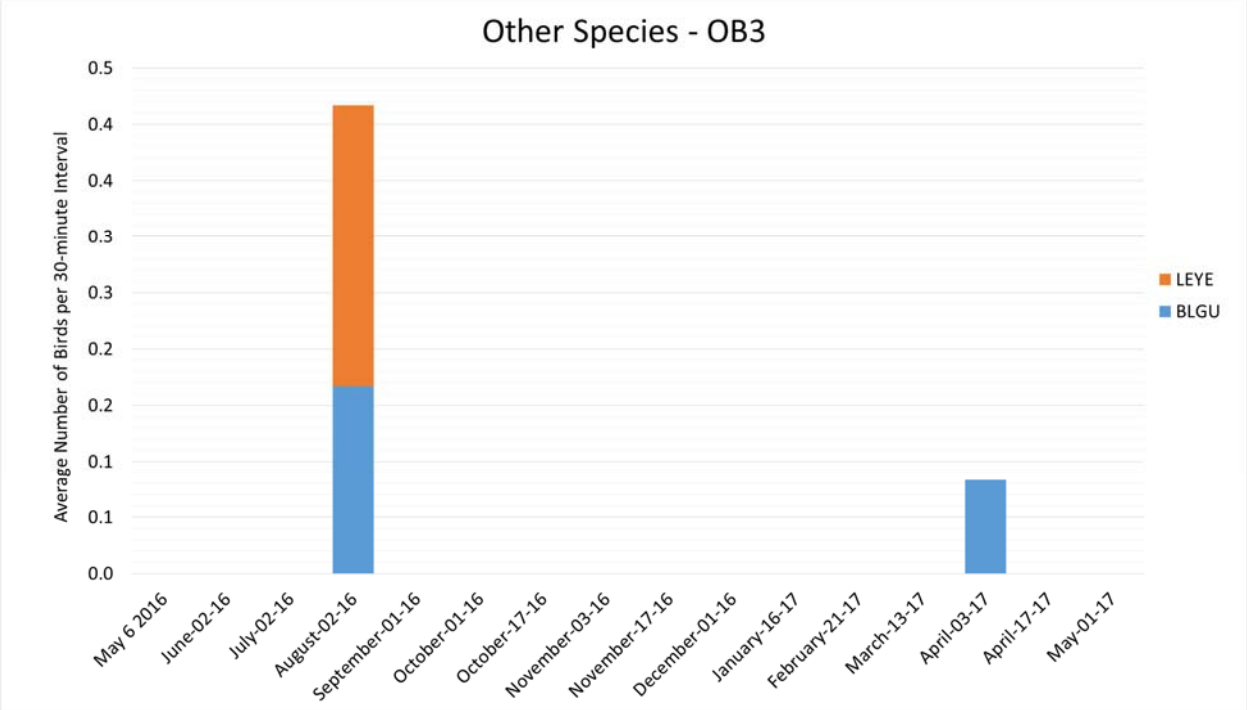

Figure 23. Average abundance of other birds per 30-minute interval in subarea OB3.

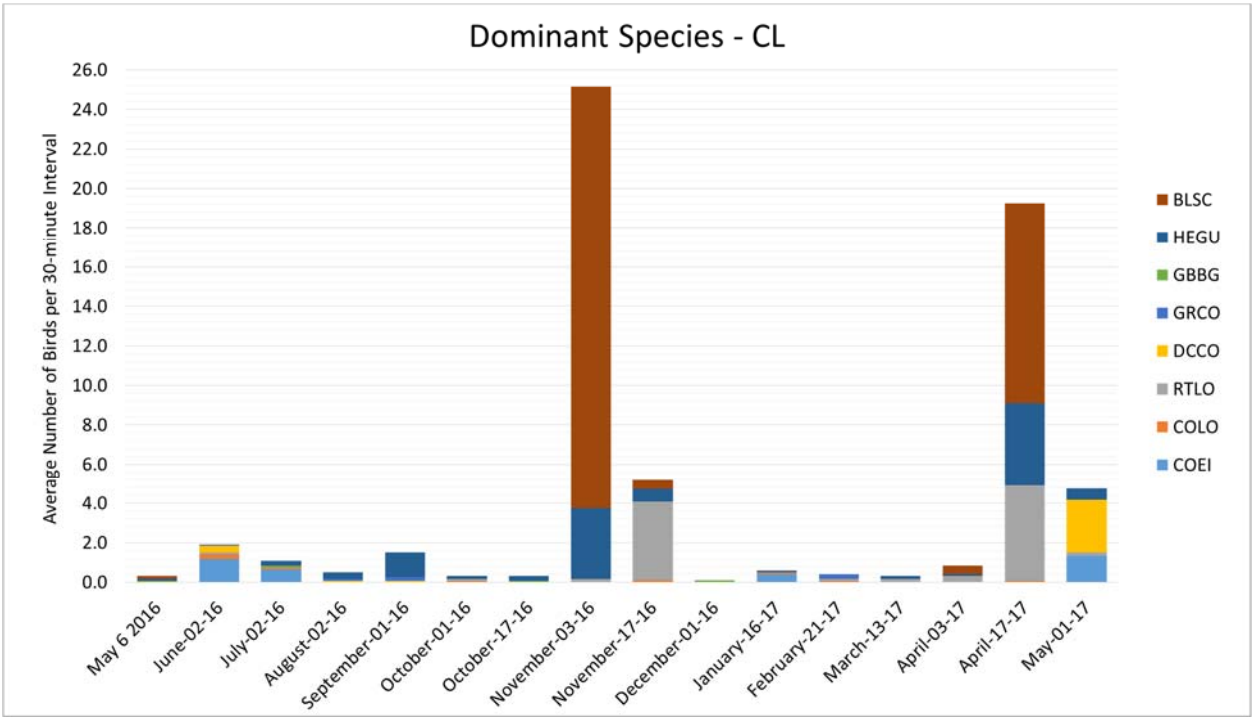

Figure 24. Average abundance of dominant birds per 30-minute interval in subarea CL.

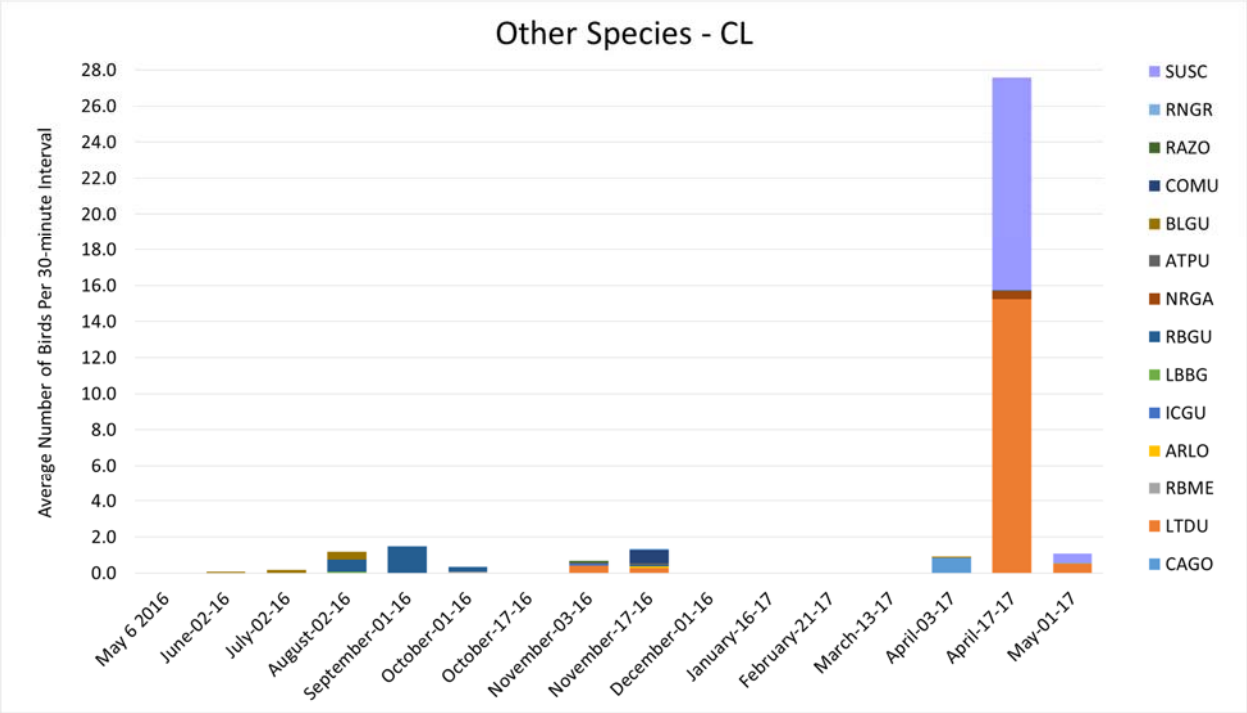

Figure 25. Average abundance of other birds per 30-minute interval in subarea CL.

3.1.3 Species Composition Based on Seasonality

3.1.3.1 Dominant Species

Dominant bird species [4] included Black Scoter, Common Eider, Common and Red-throated Loon, Double-crested Cormorant and Great Cormorant, as well as Herring Gull and Great Black-backed Gull (Figures 26 and 27). Common Eider, both cormorants, and both dominant gulls, are common seasonal residents and breeders in Atlantic Canada and the Bay of Fundy. Common Loon breed on lakes and are commonly seen in Atlantic coastal waters in summer, and overwinter in coastal areas. Black Scoter and Red-throated Loon are migratory species which pass through the Bay of Fundy at certain times of year, although individuals can often be found year-round.

Common Eider – Common Eider is a diving duck species and a common breeder on islands and shorelines of the Bay of Fundy. The species feeds in shallow water and occasionally deeper to reach shellfish and other aquatic organisms. Common Eider was observed on consecutive surveys during the breeding season (May 6 – August 2, 2016; March 13 – May 1, 2017) and intermittently during the fall and early winter (Figure 26). Overall, densities were low with small numbers including both males and females, observed on the water in IB1, close to and on Black Rock or near shore. Average abundance was highest on April 3rd 2017 (6.3 birds per 30-minute interval) and lowest on November 3rd 2016 (0.1 birds per 30-minute interval) (Figure 27).

Double-crested and Great Cormorant –Double-crested and Great Cormorant are colonial resident species in the area, nesting and breeding in the inner Bay of Fundy and migrating through the study site during spring and fall, but also found at other times of year. Cormorants feed primarily on fish which they catch through diving. Great Cormorant is the least abundant of the two and is known to dive deeper and feed farther offshore than other cormorant species.

Both species were observed at the site through the year, when they were commonly seen resting on Black Rock. Overall, Double-crested Cormorant was the most abundant cormorant observed. Abundances were relatively low for both species during the 2016 spring and early fall surveys, (May 6th to October 17th 2016) (Figure 26), with highest abundance for both species recorded on September 1st 2016 (Double-crested Cormorant – 10.5 birds per 30-minute interval; Great Cormorant – 5.9 birds per 30-minute interval) (Figure 30). Peak abundances for the year for Double-crested Cormorant were recorded on April 17th and May 1st 2017. (79.8 and 31.8 birds per 30-minute interval, respectively); while Great Cormorant abundances on those surveys were similar to those in the other surveys (4.2 and 2.3 birds per 30-minute interval, respectively) (Figure 27). Both species occurred through the winter, and, in particular, a group of three Great Cormorants were observed on February 21st flying east through CL. Groups of Double-crested Cormorants were occasionally observed taking flight from Black Rock and landing on the water upstream in relation to the tide, in particular in CL on the incoming tide, to feed while drifting eastward towards and then returning to Black Rock.

Common Loon and Red-throated Loon – Common Loon and Red-throated Loon were observed occasionally throughout the survey (Figure 26). Individual Common Loon were most commonly seen flying eastward through CL and IB1, and occasionally through OB1. Individuals were also frequently seen on the water, feeding and/or drifting in IB1. Highest average abundance for Common Loon occurred on

[4] Dominant species are defined as those which were observed on at least 50% of the surveys.

April 17th, 2017 (2.0 birds per 30-minute interval) (Figure 27). Common Loon is a year-round resident, frequently found in coastal areas, but habitat also includes freshwater lakes, in particular during its spring and summer breeding season.

Red-throated Loon was the most abundant loon, occurring throughout the year, but peaking in abundance in the spring and during fall during migration (October 1st, November 3rd and 17th 2017) (Figures 29 and 30), during which the species returns from Arctic breeding sites to US northeast Atlantic coastal areas to overwinter. Peak abundance was observed during the spring migration on April 17th, 2017 when large flocks of Red-throated Loon were observed at the site, and birds were frequently seen on the water, feeding and drifting with the tidal stream, generally in CL and OB1.

Black Scoter – Black Scoter are large sea ducks which feed by diving in shallow waters where they feed on shellfish and other bottom-dwelling organisms. The species is a regular migrant, passing through the Bay of Fundy in spring and fall, commonly accompanied by Surf Scoters and White-winged Scoters, with individuals also seen occasionally throughout the year. Black Scoter were observed on consecutive surveys, typically in large flocks, during the fall and spring migration (Figures 26 & 27). Peak abundances of Black Scoter occurred during two surveys; November 3rd, 2016 and April 17th, 2017. An average of 33 birds per 30-minute interval were observed on November 3rd, including a flock of over 100 birds. Black Scoter were typically seen flying east into West Bay, or on the water drifting. A peak of 51 birds per 30-minute interval occurred on April 17th, including flocks of over 100 birds (Figure 30) seen on the water in CL. Like the cormorants, many scoters used the tidal current, drifting with the tide until close to Black Rock, and then flew back to the outer boundary of CL, landed, and drifted east again. As the tide shifted to ebb stage, during the last hour of the survey, the birds drifted west with the current before returning to the water near Black Rock.

3.1.3.2 Gulls (Lariidae)

Herring and Great Black-backed Gull are both common, annual breeders, nesting on islands and seacliffs year-round in the Bay of Fundy region, and both species were dominant sat the site. Herring Gull were observed year-round, during all surveys; and Great Black-backed Gull on all but two surveys late in the year (September 1st and November 17th 2016). Other gulls—Iceland Gull, Ring-billed Gull, and Lesser Black-backed Gull—also occurred at the site, but less frequently and in lower abundances. Gulls in coastal areas feed mainly by scavenging along shores and at the water surface, and as well can prey on juveniles of other bird species.

Herring Gull – Herring Gull was the most common gull species, observed during all surveys, often sitting on Black Rock, flying in and out of the study area, and circling above the subareas searching for food. During several surveys, Herring Gull abundance dramatically increased during the last hour or less of observations, nearing dusk, as the gulls flew in from the south and southwest and landed on Black Rock presumably to roost (i.e. December 1st 2016; January 16th 2017; April 17th 2017). Abundance was generally consistent throughout the year, with peak abundances on January 16th (25.3 birds per 30-minute interval—attributed to birds flying to Black Rock to roost), and April 17th 2017 (44.5 birds per 30-minute interval) (Table 4, Figures 28 and 29).

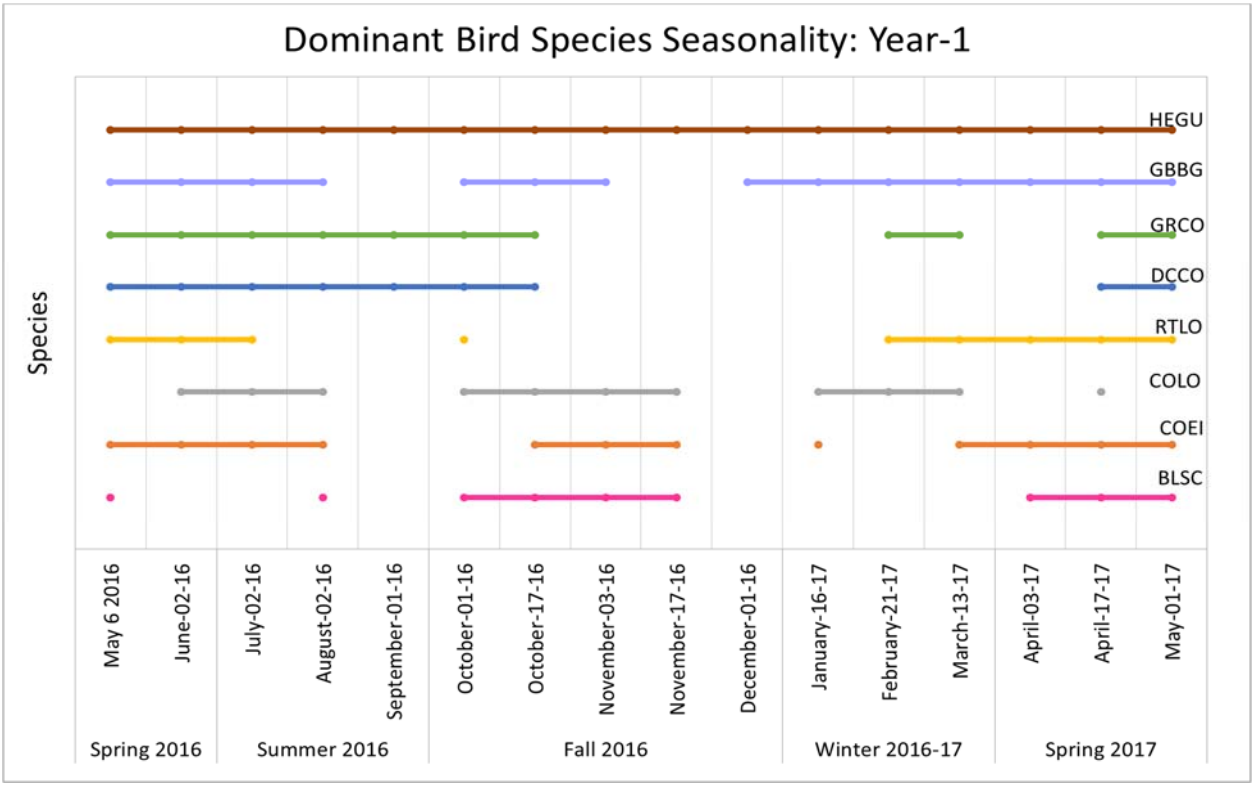

Figure 26. Seasonal occurrence of dominant bird species based on season for Year-One (16 surveys) of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017).

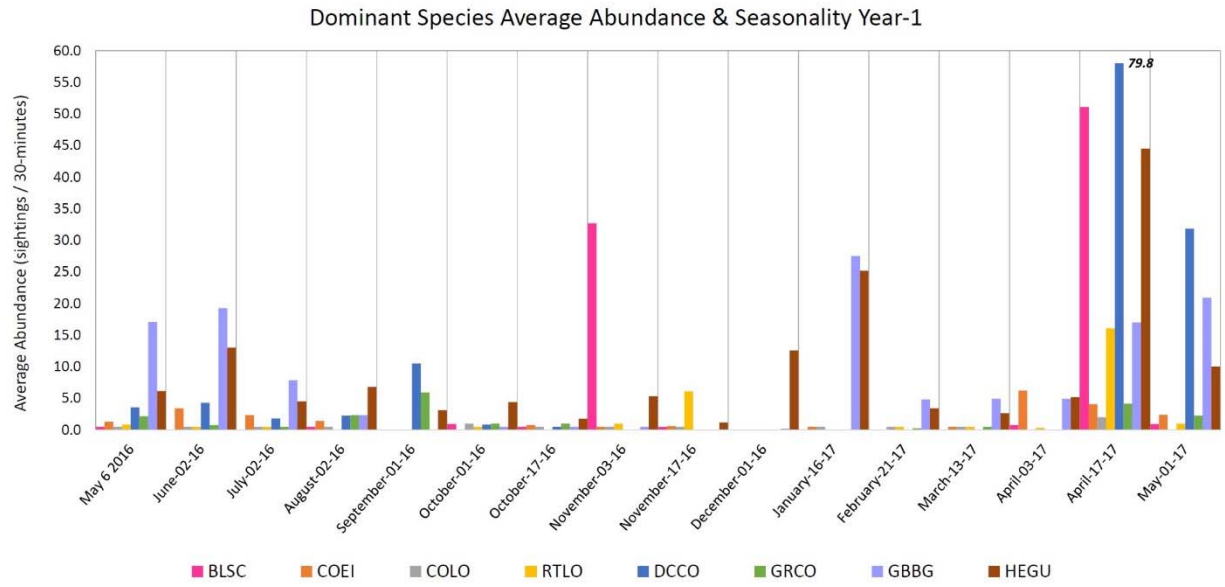

Figure 27. Average abundance and seasonal occurrence of dominant bird species for Year-One (16 surveys) of FORCE tidal energy demonstration site, 2016-2017.

Great Black-Backed Gull – Great Black-Backed Gull was the second most frequently occurring bird species at the site. It was usually observed sitting on Black Rock, but also was seen flying through and circling

above searching for food in all subareas. Based on our observations of 4-5 juveniles, 2-3 pairs of Great Black-backed gull probably nested on Black Rock in 2016. Average abundance fluctuated from survey to survey and peaked during late spring and early summer, but the highest abundance occurred on January 16th, 2017 with an average of 27.5 birds per 30-minute interval, the highest abundance for all surveys, a similar pattern to Herring Gull with the movement of large flocks to Black Rock to roost. Abundances were lowest on October 1st and November 3rd 2016, with 0.1 birds per 30-minute interval on both days (Figures 28 and 29).

Ring-Billed Gull – Ring-Billed Gull is a common annual late summer migrant and occasional summer resident of the area but individuals can frequently found year-round. The species breeds inland near freshwater in central North America including the Great Lakes region, and moves to Atlantic coastal areas post-breeding in late summer. They feed on insects, crustaceans, molluscs and other invertebrates along the shore, as well as in agricultural and urban areas, and sometimes pirate food from other species. Ring-billed Gulls were observed on 50% of the surveys, in low abundance, during spring 2016 and 2017, and summer and fall surveys in 2016, generally seen flying through subareas OB1, IB1 and CL. Highest abundance was observed on August 2nd 2016 (3.0 birds per 30-minute interval)(Figures 28 and 29).

Iceland Gull – Iceland Gull overwinters in Nova Scotian coastal areas, including the Bay of Fundy region. Low numbers were observed on three occasions from fall 2016 to early spring 2017 (November 3rd 2016, January 16th and April 17th, 2017). Although two of the sightings were of a single bird flying or circling over water, a group of 12 gulls were seen sitting on Black Rock on April 17th (Figures 28 and 29).

Lesser Black-backed Gull – Lesser Black-backed Gull shares a similar habitat preference as Herring Gull, and was seen on four occasions in the spring and summer (May 6th, June 2nd August 2nd, 2016; and May 1st, 2017) all recorded on Black Rock. Highest average abundance for Lesser Black-backed Gull occurred on May 1st 2017 (0.4 birds per 30-minute interval) (Figures 28 and 29).

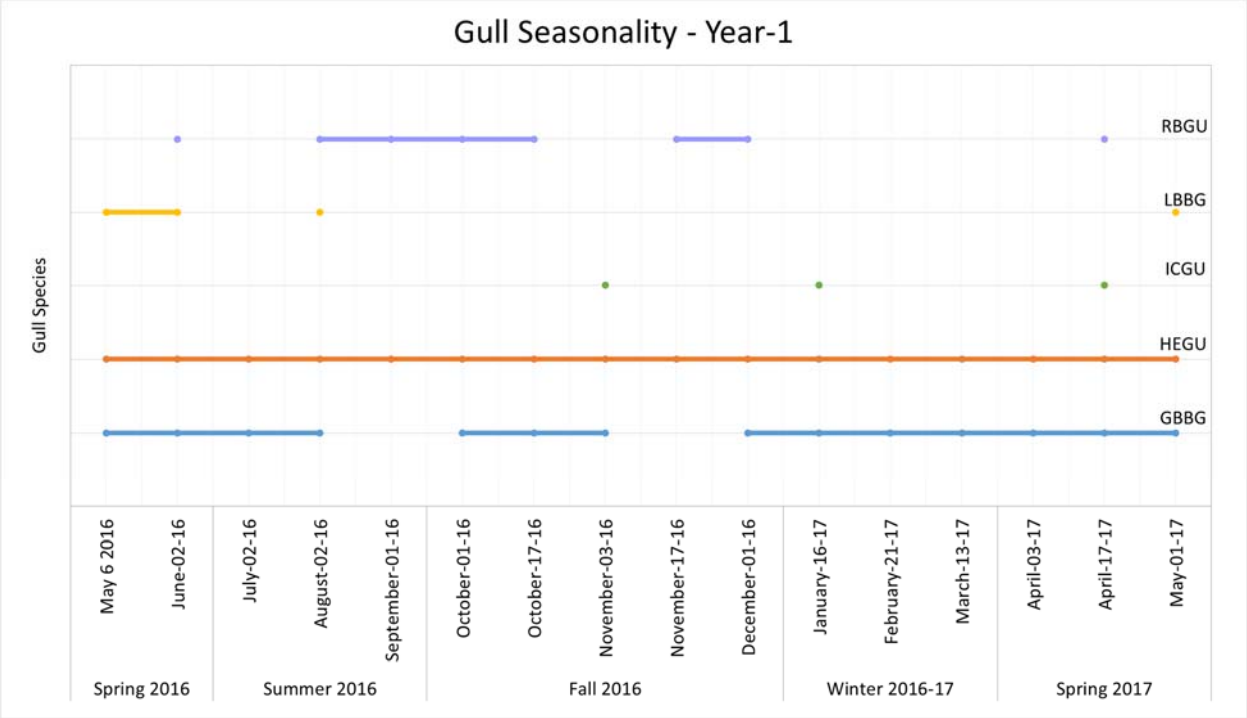

Figure 28. Presence of gull species based on season for Year-One (16 surveys) of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017).

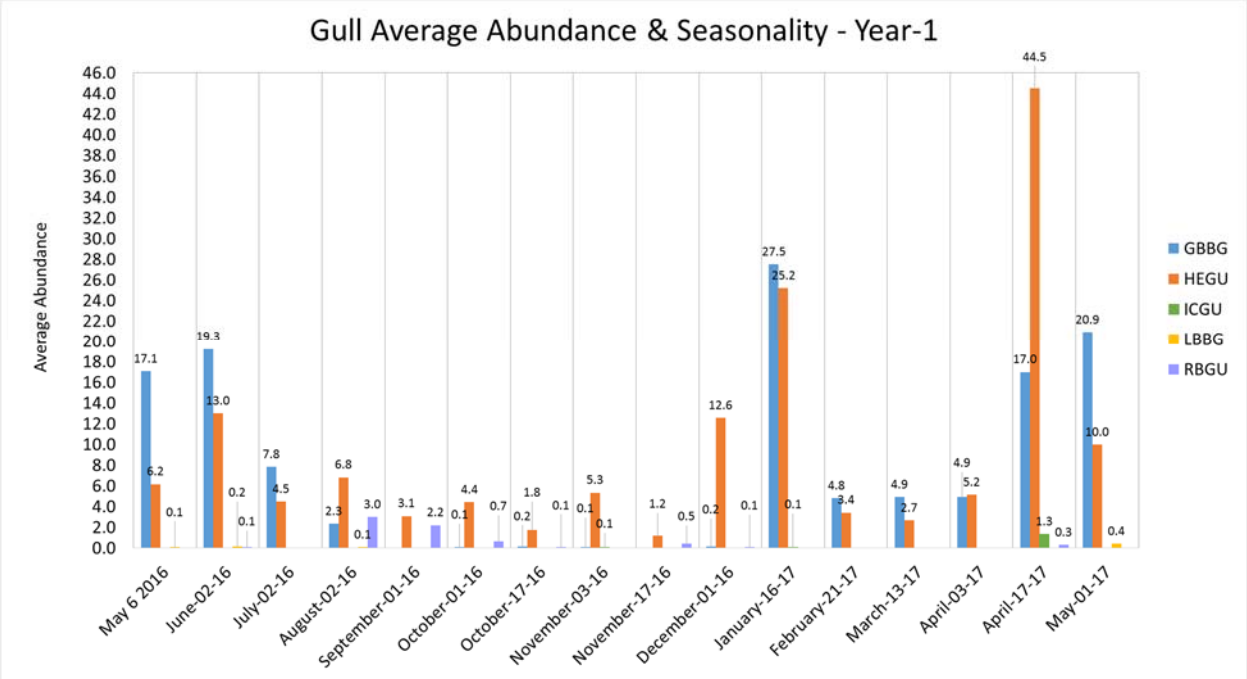

Figure 29. Average abundance and seasonal presence of gull species for Year-One (16 surveys) of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017).

3.1.3.3 Occasional Seabirds and Sea Ducks

Several seabirds and sea ducks were observed regularly during the survey, although less frequently and generally at lower abundance than dominant species. These included four alcid species (Atlantic Puffin, Common Murre, Razorbill, and Black Guillemot), sea ducks including Long-tailed Duck, Surf Scoter and White-winged Scoter, Northern Gannet, and Wilson's Storm Petrel.

Alcids – Alcids (Family Alcidae) are a family of stocky, diving and predominantly fish-eating birds, which nest in colonies on cliffs and islands in cold northern waters, including the Bay of Fundy for some species. Black Guillemot is a resident species of alcid in the area, and occurred regularly during the breeding season and occasionally at other times of year. The species nests on Black Rock and breeding pairs were observed in the waters around the island during spring and summer 2016, and spring 2017. Birds could be seen moving between nests in rock crevices and the water, diving and feeding. Between one and four pairs of birds were documented during spring and summer 2016 surveys (May 6th to August 2, 2016). During spring 2017 surveys (April 3rd, April 17th, and May 1, 2017) up to two pairs were observed. Highest average abundance of Black Guillemot occurred on July 2, 2016 (1.8 birds per 30-minute interval) (Figures 30 and 31).

Individual Atlantic Puffin were seen on three occasions –November 3rd and 17th 2016, and April 17th 2017, all flying west through CL. The species is commonly seen in coastal waters year-round. Summer distribution is along the eastern Canadian coastlines and Greenland where it nests in colonies along the coast (Figures 30 and 31).

Common Murre were seen in two surveys in late-fall, early-winter, eight on November 17th 2016 and an individual on January 16th 2017. The species nests on coastal cliffs and ledges of eastern Canada from Newfoundland to the eastern Arctic and Greenland (Figures 30 and 31) and disperses along the Canadian East Coast post-breeding.

A single Razorbill was observed on the water in CL on November 3rd 2016 and again on November 17th 2016 flying west and landing on the water in OB2, with an average abundance of 0.1 birds per 30-minute interval each day. Razorbill nests on rocky offshore islands and disperses to coastal waters along eastern Canada and the United States (Figures 30 and 31). Occurrences of Razorbill and Atlantic Puffin are consistent with use of the outer Bay of Fundy, Gulf of Maine and offshore areas by overwintering birds from East Coast colonies and for other alcids from winter offshore dispersal from coastal and generally more northerly nesting areas.

Long-tailed Duck – Long-tailed Duck was observed on four surveys during fall 2016 and spring 2017 migration (Figure 30). Fall sightings included five individuals seen on November 3rd on the water in CL, and three on November 17th flying east through CL. Highest numbers were observed on April 17th 2017 during a migratory movement. Birds were typically observed in flocks, the largest with 90 birds and others consisting of 20-50 individuals, as well as scattered birds either flying through the site or drifting with the tide in IB1, OB1 and CL. Average abundance on April 17th 2017 was 23.5 birds per 30-minute interval (Figure 31).

Northern Gannet—Two Northern Gannet were observed during one survey on April 17th 2017 (Figure 30) flying southwest through CL towards the outer bay (0.4 birds per 30-minute interval) (Figure 31). This species normally migrates through the area to colonies on the Gulf of St. Lawrence at this time of year,

but the Inner Bay of Fundy also support immatures and late migrants at other times. The species feeds by diving from great heights for fish.

Wilson's Storm Petrel – Storm Petrels are primarily pelagic, spending most of their lives at sea feeding on plankton, crustaceans, and small fish, except when nesting in colonies on coastal islands and sea coasts. They are a highly migratory species, but are seen regularly in Atlantic Coastal waters and can be occasionally seen from shore. Two Wilson's Storm Petrel were observed on September 1st 2016 feeding in CL during one survey interval (15:15 – 15:45) (Figures 30 and 31).

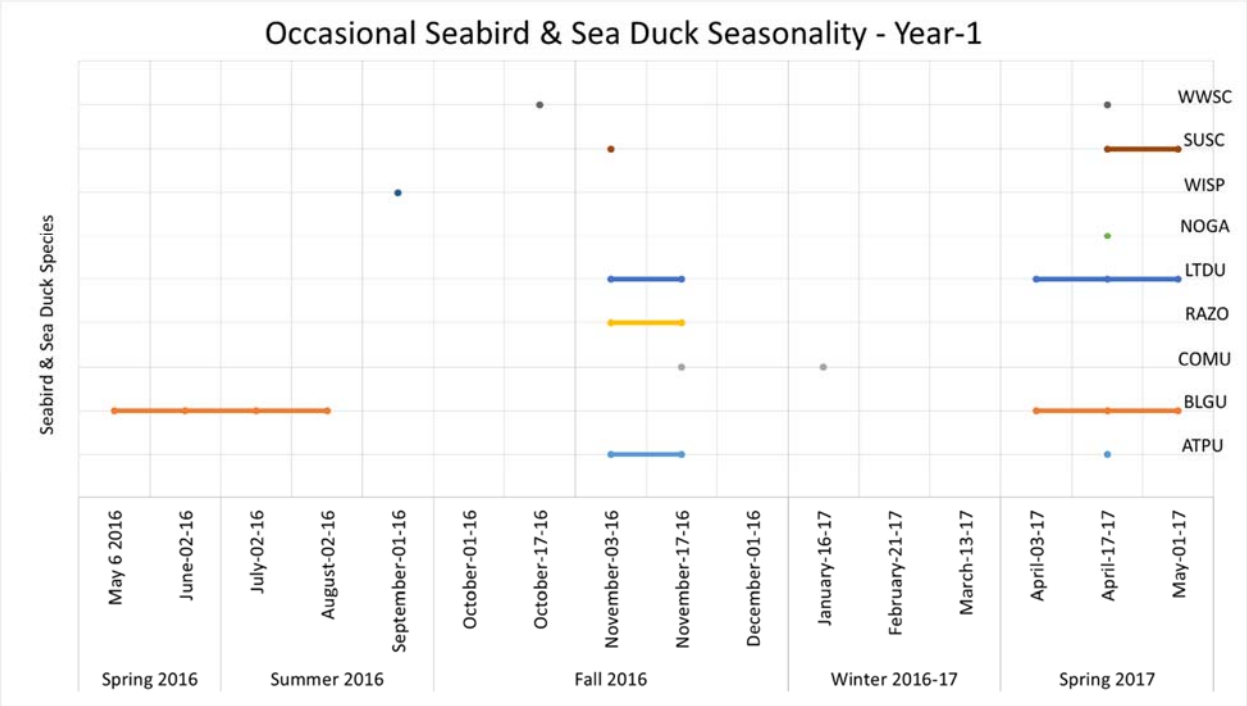

Figure 30. Presence of occasional seabird and sea duck species based on season for Year-One (16 surveys) of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017).

Surf Scoter and White-winged Scoter – Surf Scoter and White-winged Scoter are large sea ducks, having similar biology and behaviour to Black Scoters (one of the dominants bird species at the site, discussed in Section 3.2.4.1). These species are regular migrants through Nova Scotian coastal waters including the Bay of Fundy in spring and fall, frequently migrating together, and individuals may occur casually year-round. Both Surf Scoter and White-winged Scoter were less common and abundant than Black Scoter at the FORCE site. White-winged Scoter was least abundant, observed in fall (a single individual flying easterly through IB1 on October 17th 2016); and seven White-winged Scoters were observed in spring on April 17th 2017 (0.58 birds per 30-minutes) during a major passage of birds at the site (Figures 30 and 31, Table 4). Surf Scoters also occurred infrequently— observed on three surveys—but in higher abundance compared to White-winged Scoters. Twelve were observed November 3rd 2016, drifting on the water in OB2. During spring 2017 surveys, Surf Scoters were observed on April 17th and May 1st. Large flocks were observed during the April 17th survey, the largest consisting of140 Surf Scoters on the water drifting from

CL to OB1, but other groups or flocks of from 2 to 120 Surf Scoters also occurred, leading to an average for that survey of 27.7 birds per 30-minute interval, among the highest of any species in the monitoring program Generally, the birds were on the water, drifting with the tidal stream between OB1 and CL. Smaller numbers observed on May 1, 2017 included a flock of approximately 20 birds flying through the site and a daily average of 2.9 birds per 30-minutes (Figure 31, Table 4). Observations of both Scoter species in the fall and spring correspond to migratory periods as the birds move through Minas Passage.

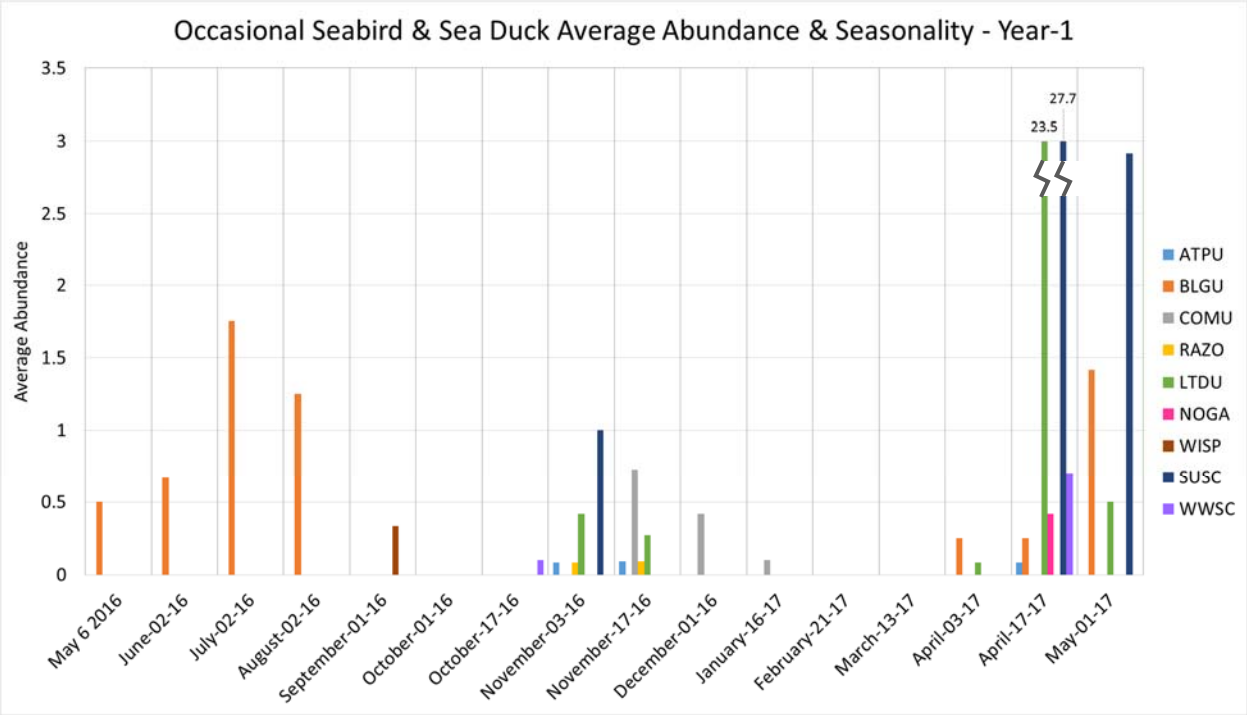

Figure 31. Average abundance and seasonal presence of occasional seabird and sea duck species for Year-One (16 surveys) of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017).

3.1.3.4 Other Waterfowl

In addition to Red-throated Loon and Common Loon which were dominants at the site (see Section 3.2.4.1), waterfowl species recorded at the site included nine species which occurred in lower frequency and abundance overall. These included two species of Merganser (Red-breasted and Common Merganser), two species of geese (Canada Goose and Snow Goose), American Black Duck, Blue-winged Teal, Common Goldeneye, Red-necked Grebe and a single occurrence of a vagrant or accidental Arctic Loon.

Red-breasted and Common Merganser – Mergansers migrate regularly through the inner Bay of Fundy in spring and fall and Red-breasted Merganser can overwinter in the area. They feed by diving for fish in shallow water. A single Red-Breasted Merganser was present during one survey in the fall (October 1st 2016) observed on the water in CL. The species was present during all three spring 2017 surveys, in similar abundance, with highest abundance on April 17th 2017 of 0.8 birds per 30-minute interval. Common

Merganser were observed during the December 1st 2016 survey only, when a small group of five birds (average abundance of 0.4 birds per 30-minute interval) were seen flying east through IB1 (Figures 32 and 33, Table 4).

Canada Goose and Snow Goose – Although more typically found in terrestrial and freshwater settings, both species can be found in marine coastal waters, saltmarshes and eelgrass beds feeding on grasses, seeds, aquatic plants and shellfish. Canada Goose were observed on October 1st 2016 and April 3rd 2017, during fall and spring migration periods, but the species is a year-round resident in Nova Scotia, found in both coastal and inland areas. The single Canada Goose observed on October 1st was on the water in OB1, while flocks of 10 and 20 birds were observed on April 3rd (2.8 birds per 30-minute interval), generally on the water and in the outer areas of the study site (OB1, IB1 and CL) (Figures 32 and 33).

Sightings of Snow Geese are an uncommon but regular occurrence in the Bay of Fundy region. A single Snow Goose was seen flying west in OB2 on April 3rd 2017 (Figures 32 and 33). Snow Geese overwinter in western, midcontinent, and eastern regions of the United States and migrate to northern Canada during the summer breeding season. Migratory patterns of the species are roughly parallel to the lines of longitude for wintering grounds, and they typically congregate and migrate in large flocks. The eastern population of Snow Goose overwinters along the Atlantic Coast from New Jersey to North Carolina.

American Black Duck – American Black Duck is a common duck species in the Atlantic Region, found in a range of habitats including freshwater lakes, ponds and marshes, as well as bays and estuaries. The species is present year-round in Nova Scotia, often found in large concentrations in marine coastal areas including the Bay of Fundy in winter. The species feeds on aquatic plants, seeds, insects and other aquatic invertebrates. Low abundances of birds, typically in small (i.e. IB1 & IB2) groups near shore, were observed during five surveys between fall 2016 and spring 2017 (October 1st, December 1st 2016; January 16th, March 13th and April 3rd 2017) (Figures 32 & 33, Table 4). Two pairs were observed on October 1st 2016 flying through IB1; one pair on December 1st 2016; and a group of three on January 16th 2017 seen flying through IB1. A group of five birds was seen flying northwest in IB1 on March 13th and a group of seven were observed flying into IB2 on April 3rd (0.7 individuals per 30-minutes) and landing on the water nearshore.

Blue-winged Teal – A single occurrence of Blue-winged Teal in the study site occurred on May 1st 2017 (Figures 32 and 33). A male/female pair were observed on Black Rock during the first half hour of the survey, and then flew from the front of the rock to the opposite side and out of view. Blue-winged Teal are a dabbling duck species usually found in freshwater habitats as well as mudflats.

Common Goldeneye – Common Goldeneye is a duck species typically found in lakes and coastal bays and estuaries during winter, and forested lakes during the reminder of the year. It feeds by diving for aquatic plants and animals as well as marine invertebrates in shallow coastal areas. Common Goldeneye were observed on three occasions, January 16th, February 21st, and April 3rd 2017 (Figure 32), when they were relatively abundant, averaging two per 30-minutes on January 16th and 2.2 per 30-minutes on February 21st (Figure 33), usually observed in small groups of eight or less on the water near the shoreline in IB1. On April 3rd a pair were observed flying east through IB1.

Red-necked Grebe – A single Red-necked Grebe was observed flying west in CL on November 17th 2016 (Figures 32 and 33). Grebes feed by diving for small fish and other aquatic life. Red-necked Grebe are found in freshwater habitat year-round, and also in coastal areas during winter.

Arctic Loon – Arctic Loon are extremely rare on the Atlantic Coast and the sighting of a single Arctic Loon on November 17th was the first for the FORCE site. The bird, briefly landed on the water in CL and then flew off in a westerly direction (Figures 32 and 33). Arctic Loon is a migratory species found during winter on the coasts of the northeast Atlantic and eastern and western Pacific, as far south as the Mediterranean, Black Sea, Caspian Sea, China, Japan and southern Alaska. During the breeding season, Arctic Loon is found on large, inland, freshwater lakes in Russia, Scandinavia, and Alaska.

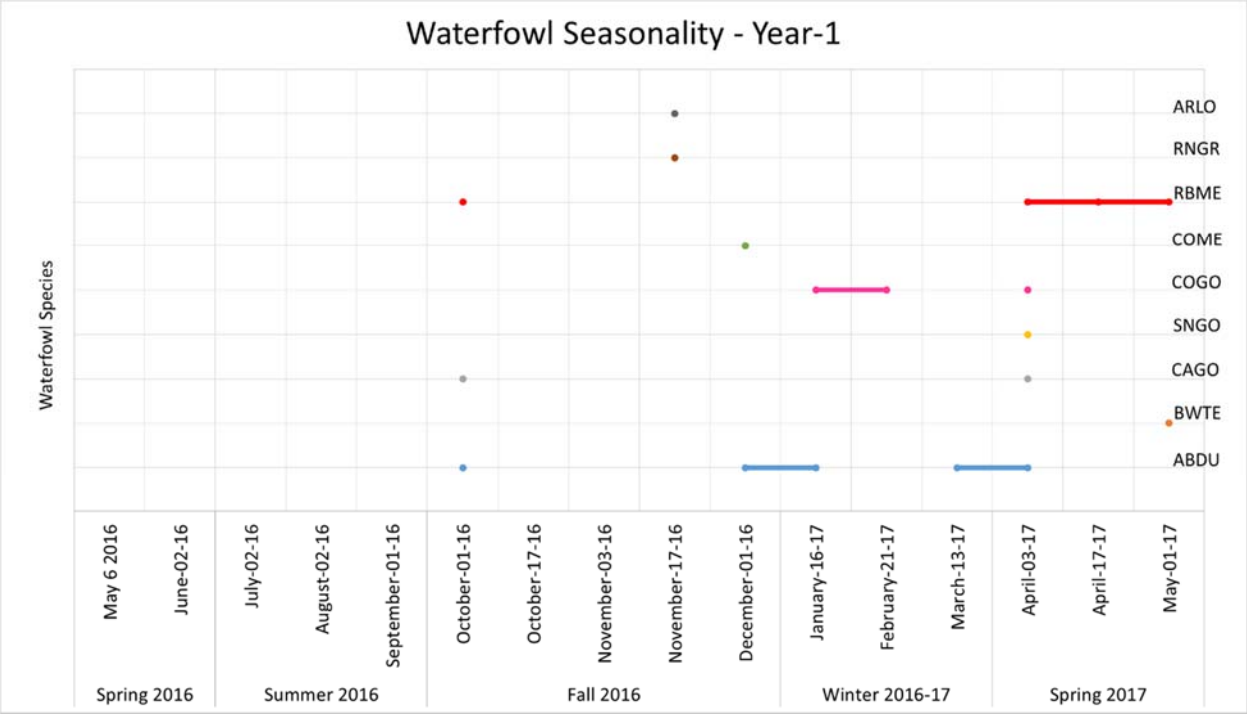

Figure 32. Presence of waterfowl species based on season for Year-One (16 surveys) of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017).

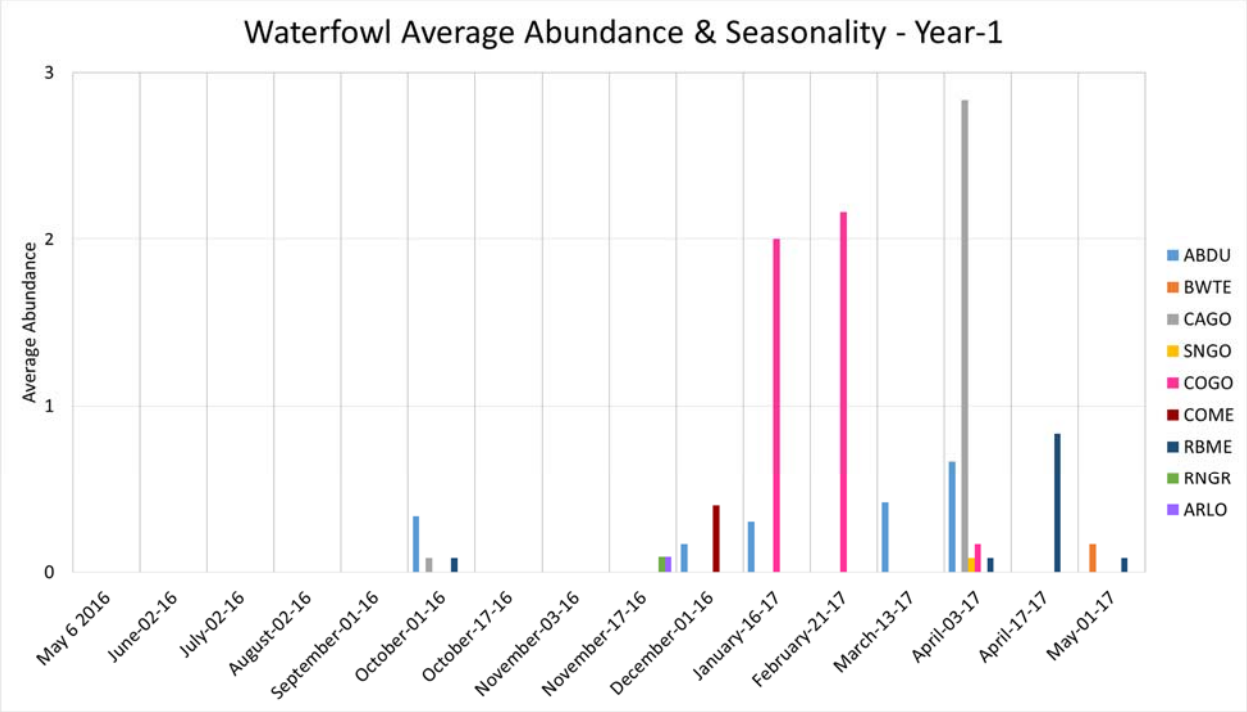

Figure 33. Average abundance and seasonal presence of seabird and sea duck species for Year-One (16 surveys) of FORCE shore-based seabird survey. FORCE Visitor Center, Parrsboro, Nova Scotia. (May 2016 – May 2017).

3.1.4 Comparison with Earlier Surveys

3.1.4.1 Species Composition

Fewer species were observed overall at the site in the 2016-2017 survey compared to the number seen in the first surveys (2010 – 2012) (Figure 34, Table 5). The difference on an annual basis was statistically significant (Kruskal-Wallace One-Way Analysis of Variance, $p<0.001$, $n=14$) [5]. The overall lower number of species in 2016-2017 versus the earlier surveys (32 versus 45) was largely due to the absence of oceanic species such as shearwaters and some rare and casual species. All of the common and abundant resident species were present this year including Great Black-backed Gull, Herring Gull, Double-crested Cormorant, Great Cormorant, Common Eider, and Common Loon, and Black Guillemot, as well as common migrants (Red-throated Loon, Ring-billed Gull, Northern Gannet, Black Scoter, Surf Scoter, White-winged Scoter and Long-tailed Duck) and seasonally important species (American Black Duck, Red-breasted Merganser and Common Merganser).

Several new species were recorded this year, including birds occurring well outside their normal range, such as Snow Goose and Arctic Loon and oceanic/coastal species (Wilson's Storm Petrel) (this species had previously been recorded in vessel-based surveys at the FORCE site). Species from earlier surveys not seen this year included Pacific Loon, King Eider, Horned Grebe and Red-necked Grebe, Thick-billed Murre, gulls (Laughing Gull, Mew Gull, and Black-legged Kittiwake), shearwaters (Cory's Shearwater, Greater Shearwater, and Sooty Shearwater), Black Tern, ducks (Northern Shoveler, Mallard and

[5] Number of species and total abundance were compared for fourteen surveys on corresponding dates from the baseline (2010-2012) surveys and Year-One surveys (2016-2017)(Table 5).

Harlequin Duck), and several shorebirds (Red Phalarope, Red-necked Phalarope, Ruddy Turnstone, Sanderling, and Semipalmated Sandpiper).

3.1.4.2 Species Diversity & Seasonality

Diversity of species as expressed by number of species (species richness) at the site in 2016-2017 was uniform throughout the year with a small peak in spring migration in April to early May 2017. Earlier baseline surveys had shown peaks in both fall and spring (Figure 34, Table 5). The 2016-2017 survey had the lowest number of species per survey (5) of all surveys done at the FORCE site—observed during two surveys on September 1 and December 1, 2016 (Figure 34, Table 5). In surveys through the spring and summer completed in 2016, number of species per survey was comparable to that observed during the baseline surveys; the later surveys in the Year-One program (October 2016 to May 2017) showed numbers of species which were typically lower than or equal to baseline levels (Figure 34, Table 5). The fall migration period in 2016 had approximately half the number of species as 2010)(Figure 37, Table 5). Number of species at the site during spring migration, 2017, however, were comparable to those in the earlier baseline surveys.

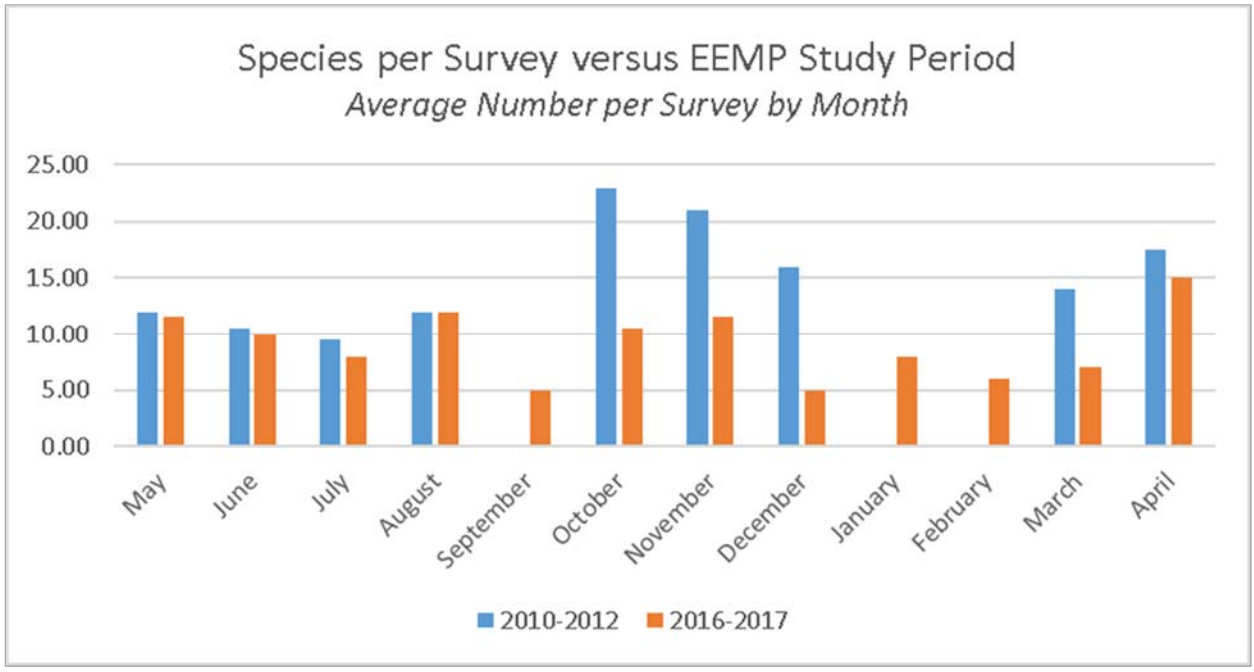

Figure 34. Comparison of diversity of species (number of species per survey) of seabirds and water-associated birds at the FORCE tidal energy demonstration site in 2016-2017 with EEMP studies conducted in 2010-2012.

3.1.4.3 Abundance

Abundance of birds at the FORCE site in 2016-2017 overall was comparable to that observed in the baseline surveys (2010-2012) and followed similar seasonal cycles, although abundances in the fall migration season were lower than in baseline surveys, and abundances during spring migration were

Table 5. Comparison of average abundance (sightings per 30 minutes) and total species per survey, in the survey period (May 1 to April 30), 2016-2017 versus 2010-2012. Surveys arranged by days from January 1. (T) denotes presence of turbine.

SURVEY	ABUNDANCE		SPECIES	
	2010-2012	2016-2017	2010-2012	2016-2017
May.1.2010 (T)	47.70	--	12	--
May.1.2017 (T)	--	75.00	--	13
May.6.2016	--	35.09	--	10
May.13.2010 (T)	40.49	----	12	--
May.27.2010 (T)	56.58		12	--
June.2.2016	--	42.33	--	10
June.12.2010 (T)	69.83	--	12	--
June.21.2012	25.40	--	9	--
Jul.2.2016 (T)	--	19.17	--	8
Jul.4.2012	20.30	--	11	--
Jul.18.2012	7.20	--	8	--
Aug.2.2012	12.40	--	14	--
Aug.2.2016	--	20.00	--	12
Aug.15.2012	13.40	--	8	--
Aug.29.2012	11.10	--	14	--
Sep.1. 2016	--	22.17	--	5
Oct.1, 2016	--	11.08	--	12
Oct.17.2016	--	1.75	--	9
Oct.23.2010 (T)	16.25	--	23	--
Nov.3.2016	--	40.92	--	11
Nov.13.2010 (T)	57.33	--	25	--
Nov.17.2016 (T)	--	10.27	--	12
Nov.22.2010	18.67	--	17	--
Dec.1.2016	--	17.89	--	5
Dec.2.2011 (T)	8.60	--	15	--
Dec.13.2011	6.50	--	17	--
Jan.16.2017 (T)	--	55.80	--	8
Feb.21.2017 (T)	--	10.92	--	6
Mar.13.2017 (T)	--	8.83	--	7
Mar.16.2011	14.70	--	12	--
Mar.31.2011	16.00	--	16	--
Apr.2.2017 (T)	--	21.83	--	13
Apr.15.2011	41.50	--	16	--
Apr.17.2017 (T)	--	267.75	--	17
Apr.30.2011	39.20	--	19	--

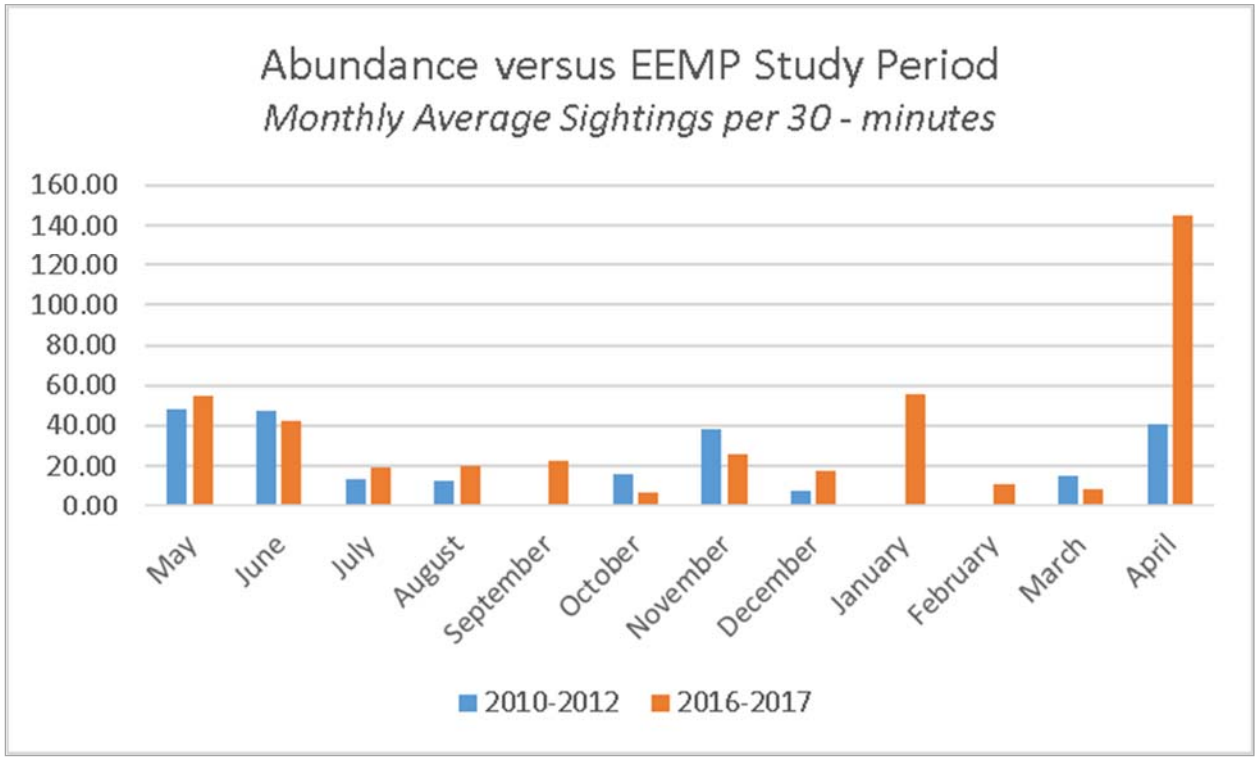

Figure 35. Monthly comparison of abundance of seabirds and water-associated birds (number per 30-minute survey) at the FORCE tidal energy demonstration site in 2016-2017 with EEMP studies conducted in 2010-2012.

higher than baseline years (Figure 35, Table 5). Overall the differences were not significantly different statistically (Kruskal-Wallace One-Way Analysis of Variance, p=0.44, n=14)[1]. On comparable dates between the baseline and Year-One surveys, abundances in surveys in 2016-2017 were similar to or greater than the baseline approximately 75% of the time (12 out of 16 surveys). Surveys in which abundances were greater in the baseline survey were in early June and November 2010 (Figure 35, Table 5).

3.1.5 Use of Open Water Areas

Seabirds and water-associated birds over open water at the FORCE site were recorded as either flying or sitting on the water, a feature which reflects their utilization of the area and is relevant to assessing risk for interactions with tidal energy devices. Birds may fly through the area while moving between distant areas, or pass through open water areas to access or leave from Black Rock and other coastal areas. More seabirds and water-associated birds occupying open water areas throughout most of the year were flying, typically in a ratio of 2:1 (Table 6, Figure 36) although relatively more birds were seen on water than were flying during peak migration periods (e.g. November 3, 2016 and April 17, 2017). Number of seabirds flying were equal to or larger than numbers on the water in 12 surveys (75%), but the differences were not significantly different statistically (Kruskal-Wallace One-Way Analysis of Variance, p=0.19, n=16).

Table 6. Average abundance (sightings / 30-minute survey) of seabirds seen flying or on water in open water areas of the FORCE tidal demonstration site, 2016-2017. n= number of observations.

SURVEY	FLYING		ON WATER	
	Average (SD)	n	Average (SD)	n
May.6.2016	2.73 (0.64)	19	1.55 (0.36)	11
June.2.2016	2.17 (0.43)	20	2.83 (0.57)	19
Jul.2.2016	5.5 (0.69)	40	2.42 (0.31)	15
Aug.2.2016	4.75 (0.65)	40	2.58 (0.35)	23
Sep.1. 2016	4.83 (0.71)	43	2 (0.29)	14
Oct.1, 2016	4.83 (0.53)	25	4.25 (0.47)	30
Oct.17.2016	2 (0.75)	14	0.67 (0.25)	5
Nov.3.2016	6.25 (0.29)	19	15 (0.71)	14
Nov.17.2016	9.64 (0.95)	35	0.55 (0.05)	6
Dec.1.2016	1.22 (1)	7	0 (0)	0
Jan.16.2017	1.8 (0.5)	11	1.8 (0.5)	4
Feb.21.2017	0.83 (0.17)	7	4.17 (0.83)	10
Mar.13.2017	1.75 (0.75)	12	0.58 (0.25)	3
Apr.2.2017	10 (0.69)	22	4.5 (0.31)	9
Apr.17.2017	52.83 (0.35)	51	98.33 (0.65)	47
May.1.2017	8.17 (0.56)	46	6.33 (0.44)	19

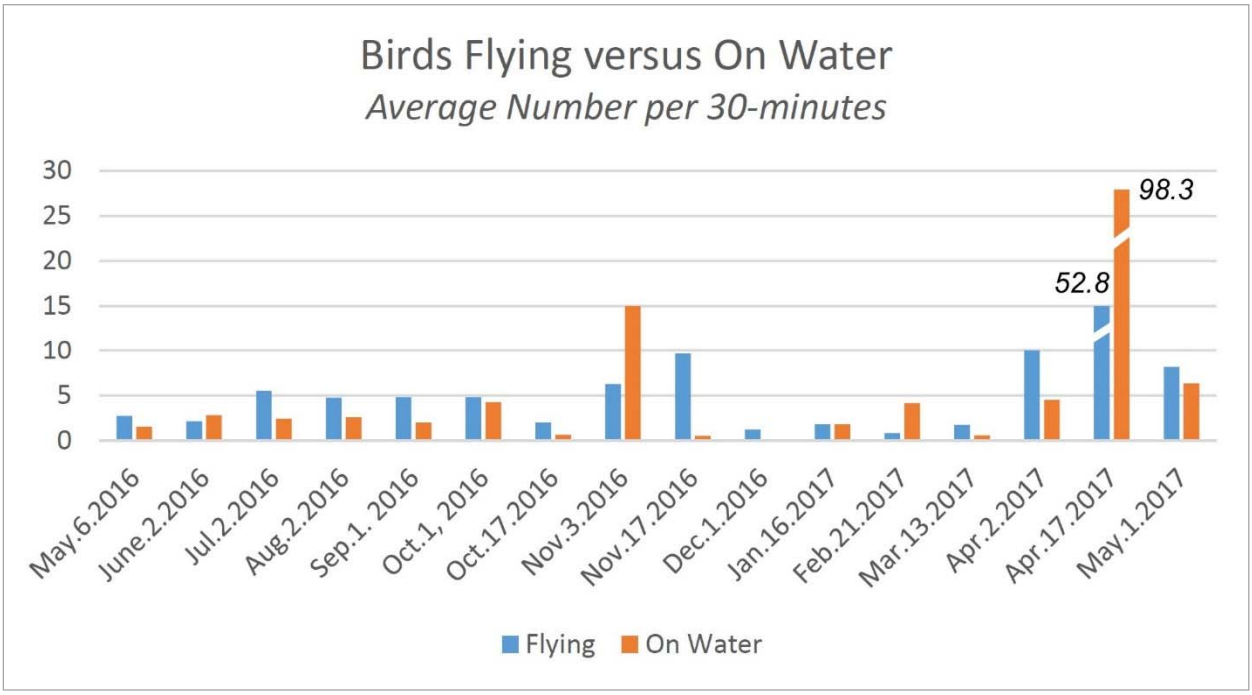

Figure 36. Abundance of seabirds and water-associated birds which were seen flying or on water in shore-based surveys at the Fundy Ocean Research Center for Energy. Parrsboro, Nova Scotia.

3.1.6 Assessment of Impacts

The principal objective of the FORCE EEMP is to verify predictions that the placement of tidal energy devices will not negatively impact seabirds at the site, including both at the population level, and for individual interactions of birds with tidal devices. At times during both survey periods (i.e. 2010 – 2012 & 2016-2017), OpenHydro turbines were installed at Site D of the Crown Lease Area (see Figure 2 for location of berths at the FORCE site). The first was in place from November 2009 to December 2010, and the most recent, a grid-connected turbine[6], from November 2016 to mid-June, 2017, and thus operated through the end of the most recent survey period. In addition to the presence of the turbines, activities related to turbine deployment, principally vessel traffic and use for activities such as equipment installation and removal, have the potential to interact with, and potentially affect seabirds, although not negatively and typically at a negligible level of effect. The FORCE site is also used for personnel transport from shore at the FORCE site to West Bay, and principally for vessels used in turbine deployment and support vessels; however no negative impacts of these activities are predicted.

Verifying the prediction of no effect of tidal-energy-related activities, requires a statistical analysis of information collected in the FORCE EEMP against a backdrop of high natural variability in bird populations which occur at the site and generally in coastal areas. Statistical analyses will be done to formally test impacts of turbine presence and/or vessel operations on seabird presence after the second year of observations, when more information has accumulated to fully document bird populations occurring at the site and seasonal patterns of abundance, both when tidal devices are operating and when they are absent.

[6] Cape Sharp Tidal Development Inc., installed November 7, 2016 and removed June 15, 2017.

Anecdotal observations of lack of effect have been made, however, during this year's surveys, and also when information is examined from earlier surveys in the EEMP (i.e. from 2010 to 2012 and 2016-2017) when tidal energy devices were or were not present at various times, or related activities were taking place. Some of our surveys this year coincided with various types of on-water activities. Observations suggested that overall, seabird activity was not correlated with project activity. For example, on several occasions when vessels were present during surveys, birds on Black Rock were not disturbed and birds were not attracted to vessels. Birds including Double-crested Cormorants and dominant gulls, which frequently rested on Black Rock for long periods of time, did not move when vessels were passing by. The assessment was not systematic, however, and a survey protocol which includes these activities should be developed to allow for collecting information on bird reactions to nearby vessels.

Patterns of overall abundance and species diversity were comparable throughout the surveys (from 2010 to 2017)(Figures 35 & 36; Table 6) during periods when turbines were both operating and absent from the site. There also appeared to be no particular correlation with timing of deployment of the tidal turbine at the site when surveys were separated specifically on the basis of the presence of tidal turbines (Table 7; Figures 37 & 38). Overall, other differences compared with earlier surveys (e.g. the low number of species this year through absence of oceanic and other migrant species) are extremely unlikely to be related to activities at the FORCE site.

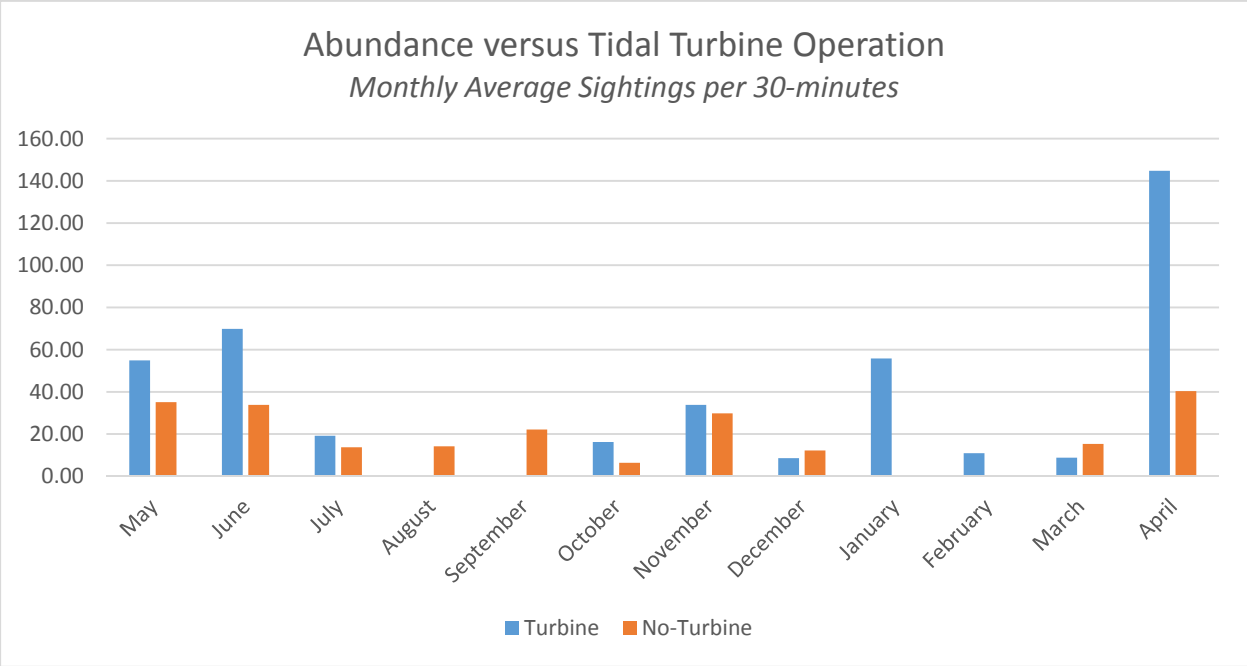

Figure 37. Abundance of seabirds and water-associated birds versus periods of turbine operation in shore-based surveys at the Fundy Ocean Research Center for Energy, Parrsboro, Nova Scotia.

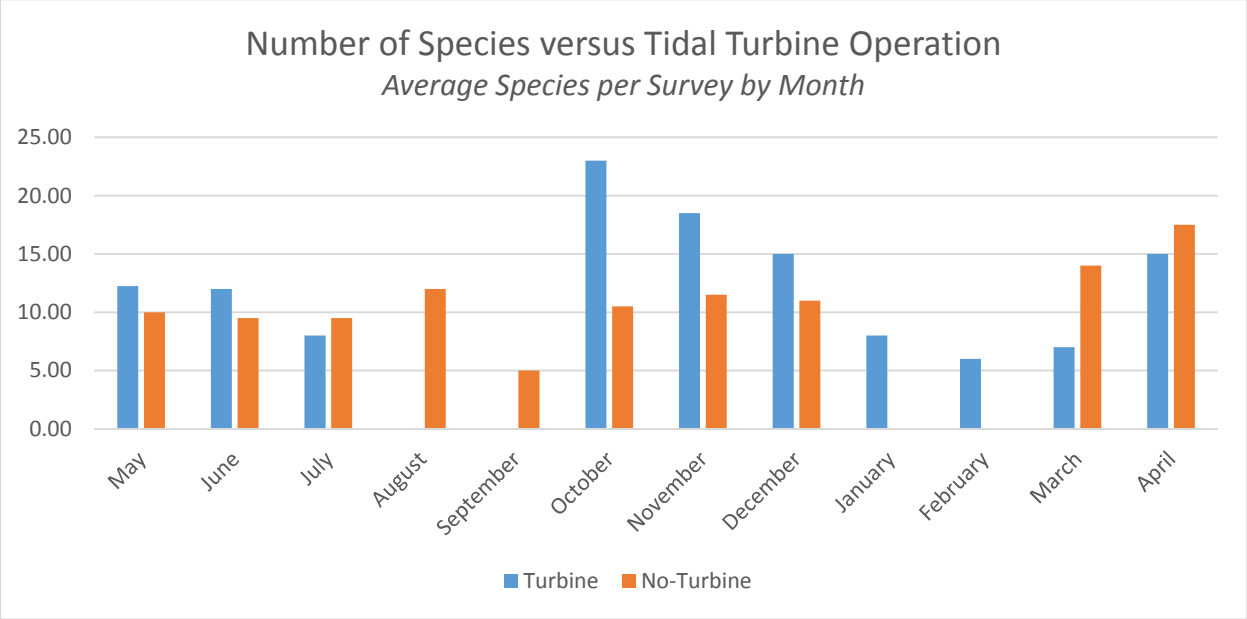

Figure 38. Diversity (number of species per survey) of seabirds and water-associated birds versus periods of turbine operation in shore-based surveys at the Fundy Ocean Research Center for Energy, Parrsboro, Nova Scotia.

Table 7. Comparison of average monthly abundance of seabirds (sightings per 30 minutes) and monthly average species per survey for surveys when turbines were and were not present, over the monitoring period (2010 to 2012 and 2016-2017. For a breakdown of surveys with and without turbines, see Table 5.

MONTH	ABUNDANCE		SPECIES	
	Turbine	No-Turbine	Turbine	No-Turbine
May	54.94 (14.9)	35.09 (-)	12.25 (0.5)	10.00 (-)
June	69.83 (-)	33.87 (12.0)	12.00 (-)	9.50 (0.7)
July	19.17 (-)	13.75 (9.3)	8.00 (-)	9.50 (2.1)
August		14.23 (4.0)		12.00 (2.8)
September		22.17 (-)		5.00 (-)
October	16.25 (-)	6.42 (6.6)	23.00 (-)	10.50 (2.1)
November	33.80 (33.3)	29.80 (15.7)	18.50 (9.2)	11.50 (0.7)
December	8.60 -()	12.20 (8.1)	15.00 (-)	11.00 (8.5)
January	55.80 (-)		8.00 (-)	
February	10.92 (-)		6.00 (-)	
March	8.83 (-)	15.35 (0.9)	7.00 (-)	14.00 (2.8)
April	144.79 (173.9)	40.35 (1.6)	15.00 (2.8)	17.50 (2.1)
Standard Deviations in brackets.				

3.2 Marine Mammals

Three species of marine mammal, the Harbour Porpoise (*Phocoena phocoena),* Harbour Seal (*Phoca vitulina*) and Harp Seal (*Pagophilus groenlandicus)* were observed during the year (May 2016 – May 2017). Harbour Porpoise were observed on eight of the sixteen surveys; Harbour Seal on two surveys; and Harp Seal on one survey. Abundance for each occurrence were low – single seals, and typically a single or pair of porpoise, and only occasionally groups of four to five porpoises (Table 8, Figures 39 & 40).

In total, twenty-one Harbour Porpoise were seen at the site during the survey (Table 1). Harbour Porpoise occurred mainly in the late Spring to Fall (May 1 to October 1) with highest daily sightings and largest group sizes in September and October surveys (Table 8; Figure 39). Single occurrences were in late Fall (November 1) and mid-January 2017. Overall, occurrence and abundance of Harbour Porpoise in the study area is lower than recorded in shore-based surveys from June to August in 2012, although the general location of sightings are similar (Envirosphere Consultants, 2012). The seasonal observations suggest that Harbour Porpoise are less common and abundant in summer. Harbour Porpoise were most commonly observed in the tidal stream outside Black Rock and the Crown Lease area, south and southwest of Black Rock—generally moving in a westerly direction towards the Bay of Fundy with the ebb (out-going) tide (Figure 40; Appendix B). On two occasions (November 17th, 2016 and January 16th, 2017), sightings were made of a single porpoise during the flood tide heading east; however the November 17th sighting was less than an hour before peak high tide and the animal was seen surfacing only once in OB1. The January 16th sighting was about two hours before peak high tide when water levels were relatively high; the porpoise was moving eastward with the incoming tide (Table 8; Appendix B).

The pattern of Harbour Porpoise occurrences is suggested to follow the local pattern of fish distribution and availability, as herring and other runs of migratory species usually take place in late spring to early summer. Seasonal movements of Harbour Porpoise observed at the site have been thought to follow the movements of herring into Minas Basin in the spring, while being largely absent other times of the year (Baker et al 2014).

Prior to the monitoring undertaken by FORCE in 2009, Harbour Porpoise, Harbour Seal, Grey Seal were expected to occur in the study area, but their relative abundance and seasonal occurrence was unknown, as there were few previous recorded sightings for the area. The 2010-2011 shore-based monitoring showed that these species were present, with Harbour Porpoise relatively common in the spring as early as March, and late fall, but not early winter. The 2012 study extended the seasonal occurrence of Harbour Porpoise through the summer (late June to late August) with significant numbers (some of the highest abundances observed at the site) occurring in mid-July and mid-August (Envirosphere Consultants, 2012).

Table 8. Summary of marine mammal observations made during shore-based marine seabird surveys, Fundy Tidal Power Demonstration Site. 2016 – 2017.

DATE	TIME (ADT)	LOCATION & DIRECTION OF SIGHTING	TIDE DIRECTION AT TIME OF SIGHTING	SPECIES	NUMBER OBSERVED
May 6, 2016	15:12 – 15:42	CL into FF	Ebb tide	Harbour Porpoise	2
June 2, 2016	17:00 – 17:30	IB1 into IB2	"	"	1
July 2, 2016	12:08 – 12:10	OB1/OB2 into CL	"	"	2
	12:20 – 12:50	OB2	"	"	1
August 2, 2016	14:00	CL	"	"	1
September 1, 2016	14:50	CL towards FF1	"	"	4
October 1, 2016	14:07 —14:11	IB1 into OB1 through CL into IB2	"	"	2
	14:10 – 14:11	OB3	"	"	1
	14:28 – 14:31; 14:32 – 14:39	IB1 near northeast corner of CL, into IB2; West through IB2	"	"	5
November 17, 2016	13:40	OB1	Flood tide	"	1
January 16, 2017	13:09 – 13:13	CL into OB1, east of BR	"	"	1
	13:00 – 14:30	BR	"	Harp Seal	1
April 3, 2017	12:15	BR	Ebb tide	Harbour Seal	1
April 17, 2017	13:20; 17:50	IB1 close to BR; IB1 close to shore.	Flood tide	"	2

IB: Inside Black Rock. CL: Crown Lease (Turbine Area). OB: Outside Black Rock. FF: Far Field. BR: Black Rock

The Northwest Atlantic population of the Harbour Porpoise (*Phocoena phocoena)* is listed as a Species of Concern by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the status is *threatened* under the Federal *Species at Risk Act*. Harbour Seal (*Phoca vitulina*) is a small species widely distributed along the east coast of North America north of Cape Cod. The species is often associated with bays and inlets from which habit its name is derived. Harbour Seal population trends in the Bay of Fundy are unknown, with trends in adjacent areas ranging from increasing (Maine) to decreasing (Sable Island)(Baird 2001). Harp Seal (*Pagophilus groenlandicus*) is commonly found in more northerly waters including the eastern Scotian Shelf, Gulf of St. Lawrence, Newfoundland and Labrador where it is typically found around ice edges in winters, but individuals often disperse into Nova Scotia coastal waters.

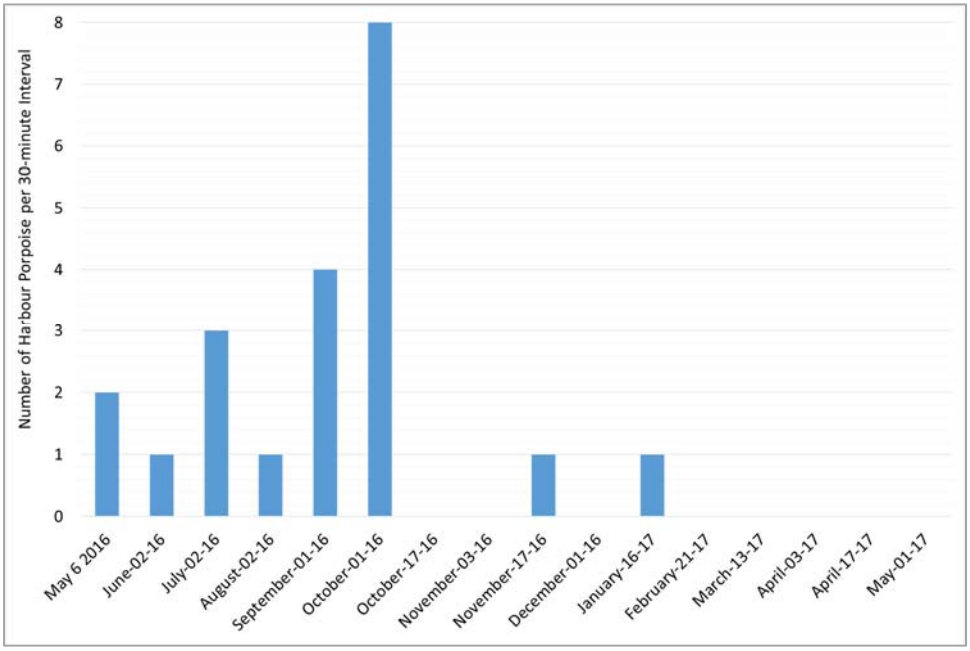

Figure 39. Number of Harbour Porpoise observed during the year-one survey in the study area for the Shore-Based Seabird Survey – Tidal Energy Demonstration Site, Fundy Ocean Research Center for Energy. Parrsboro, Nova Scotia.

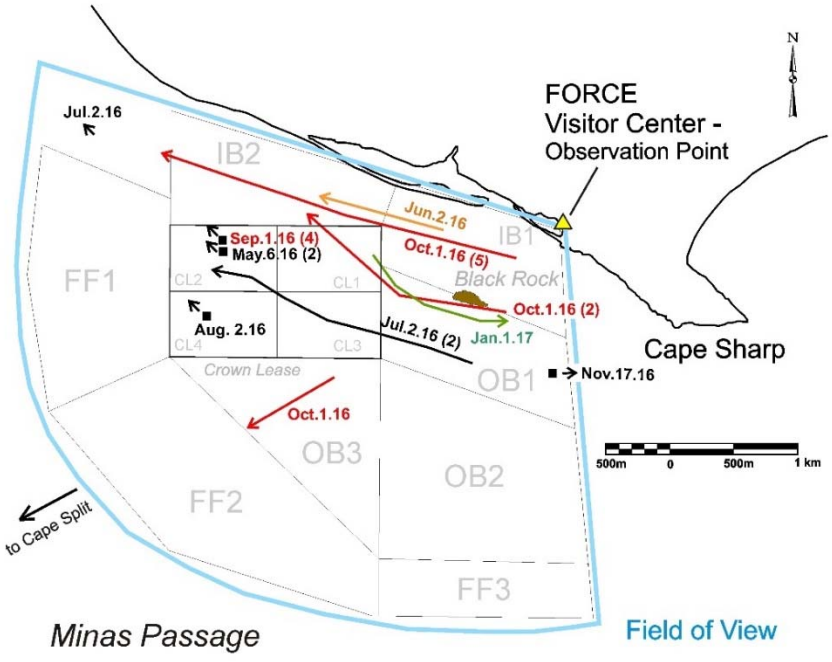

Figure 40. Summary of approximate locations of Harbour Porpoise sightings during the survey year, made from the FORCE Visitor Center during the Shore-Based Seabird Survey – Tidal Energy Demonstration Site, Fundy Ocean Research Center for Energy. Parrsboro, Nova Scotia. May 6, 2016 – May 1, 2017. Harbour Porpoise numbers are in parentheses after the date; all others show single individuals.

4 Conclusions and Recommendations

The series of surveys for seabirds conducted at the FORCE demonstration site from 2016-2017 has provided information relevant to assessing the potential for interactions and impacts of installations of in-stream tidal energy devices and associated activities, as well as increasing the database of information on seabirds and water-associated birds as well as Harbour Porpoise and seals, at the Minas Passage site. The information generated so far (i.e. from 2010-2017) consists of more than two years of observations, with coverage from all seasons, providing a series of snapshots of occurrences and abundance of seabirds and marine mammals at the FORCE site on particular days through the annual cycle.

4.1 Seabirds and Water-Associated Birds

Observations have estimated both the population of resident birds (i.e. birds which occupy, feed, and breed) in the immediate vicinity (i.e. in the outer Minas Basin, Minas Passage, and Minas Channel system of the Inner Bay of Fundy); as well as migrants which occur in the area, and can at times be most numerous; wanderers such as oceanic seabirds (e.g. shearwaters); and casual or occasional species which may occur by chance at the site. Residents are species including Great Black-backed Gull and Herring Gull, Double-crested Cormorant and Great Cormorant, Common Eider, Black Guillemot, and Common Loon; migrants include shorebirds, Red-throated Loon, sea ducks including Black Scoter, Surf Scoter and White-winged Scoter, and Long-tailed Duck, as well as waterfowl such as Red-Breasted Merganser; and casuals such as Snow Goose as well as other seasonally-occurring species such as American Black Duck, alcids (e.g. Atlantic Puffin, Common Murre, Razorbill) which occur at the site at certain seasons.

The present surveys follow the methodologies outlined in the FORCE 2016-2021 Environmental Effects Monitoring Program (EEMP), which reflects survey approaches used in other areas of the world for monitoring seabirds and other water-associated birds in the vicinity of tidal energy installations. Observations were focused on subareas of the site which reflect potential areas of concern (e.g. the zone for turbine deployment—'Crown Lease') as well as nearby 'control' or reference areas, as is standard in Environmental Effects Monitoring designs (Robbins 2012; Jackson and Whitfield 2011). Observation height (~22 m) has been suitable and consistent throughout the survey, and has proven to be effective for our purposes. Observation distances are consistent with other studies (e.g. Robbins 2012; Jackson and Whitfield 2011) (the furthest corner of the Crown Lease area is approximately 3 km from the observation site) and our bird observer can confidently identify the presence of birds at and beyond that distance.

Throughout the monitoring program, surveys have focused consistently on a single time of day and point in the tidal cycle covering the ebb tide from high tide and beginning at mid-day. This was initially both to ensure consistency in two of the major environmental variables (tide and time of day) and also to be logistically achievable in a one-day surveys. This year's surveys followed the recommended monitoring protocol from the FORCE 2016-2021 EEMP (SLR 2015) which mirrored the approach used in the baseline surveys; however some of the surveys could not be completed following this protocol exactly for various logistical reasons, resulting chiefly in having observations overlap the low tide and flood tide period. These surveys, however, provided new and useful information on conditions at the site, such as demonstrating Harbour Porpoise moving through the site with the tidal current on the incoming tide, something that had not been observed before, in previous shore-based surveys. We have also recognized that the focus on noon for observations does not provide information on other times of

day (e.g. morning), all of which could be relevant to assessing impacts of tidal developments. In Year-2, we recommend including a number of additional half-hour periods which include the morning for comparison with the normal survey period.

The Year-One Environmental Effects Monitoring survey at the FORCE site provides the first year-round survey of seabirds and water-associated birds at the FORCE site, using methods which were consistent with those in the baseline monitoring. The earlier surveys differed in having been conducted over three years, and therefore included inter-annual variability, but also omitted the winter and late-summer to early-fall (September to mid-October) period.

Overall, the present survey has shown similar abundance although lower diversity than in the earlier surveys. Abundance of some species of birds at the site, however, by all measures (including species comparisons between periods of time from earlier surveys) is reduced compared with the earlier observations over three years. For example, Northern Gannet were virtually absent this year. However locally nesting species (Black Guillemot and Common Eider) and dominant species are not notably different in abundance and seasonal pattern. Seabirds and water-associated birds using the site were represented mostly by coastal species which use inshore waters on a regular basis or during migration. Also notably absent this year, compared to earlier surveys, were oceanic seabirds such as shearwaters, storm-petrels, and Northern Gannet, which have occurred in past, but the variety of coastal species was also lower. Pacific Loon, for example, which was seen on over half of the earliest surveys, was not observed this year.

Several factors which are potentially important in influencing overall bird abundance at the site include: food availability; changes in atmospheric and oceanographic conditions; direct and indirect effects of presence of the demonstration site (i.e. activity associated with tidal energy development and tidal energy devices--much more activity at present than in earlier surveys); long term trends in abundance of migrants due to conditions in northern breeding areas and overwintering areas; and even fishing activity, in particular activity seiner fisheries for Atlantic Herring in the area, are all potential factors. In particular, an increased understanding of food availability at the site may help to explain some of the observations from the survey.

Comparisons of abundance and diversity in the current versus earlier surveys, have not shown changes related to work at the site, or installation of the tidal turbines, both this year and in the earliest survey period, when a test turbine was installed from November 2009 to December 2010. Although a lower diversity of birds was demonstrated this year, compared to earlier baseline surveys, much of the difference was due to the absence of incidental species such as oceanic seabirds and also to northern nesting species which occur only occasionally at the site often in winter, the occurrence of which are not likely to be impacted by conditions at the site. The main species component (i.e. the dominants) with the exception of Northern Gannet, continue to occupy the site, with approximately the same seasonality and abundance as in earlier years.

The observation protocol used in the survey has been suitable for long-term monitoring. Data recording methods have been the same through the overall program, with minor refinements. Data recording forms and the analysis approach were developed during the first year (2010) and have been used largely unchanged to the present. After the early surveys, the on-site weather station at the FORCE Visitor Centre has provided more-detailed information on atmospheric conditions at the site, and in the present survey, we routinely record sea state information and other information, compiled in the database.

4.2 Marine Mammals

FORCE's activities in environmental effects monitoring for seabirds has continued to provide insight, in addition, into marine mammal and particularly Harbour Porpoise activity in Minas Passage. Fewer sightings of Harbour Porpoise were made overall this past year than in the earlier baseline surveys. Abundance estimates are more qualitative than those for birds as Harbour Porpoise are not the primary objective of observations, which focus on birds and bird abundance, and are incidental to the recording of bird occurrences. Additional information determined this year, for the first time shows movements of Harbour Porpoise through the study area with the incoming tide. Previous shore-based monitoring studies in the FORCE Baseline monitoring did not include flood tides and therefore excluded this type of observation. Observations of Harbour Porpoise obtained in the FORCE monitoring program have provided important information on the occurrence and some of the activities and behavioural traits of the species, which was not known before the monitoring associated with the FORCE project took place. Based on the shore-based surveys, Harbour Porpoise is a common visitor from early spring to fall, with its abundance likely linked to movements of prey species, such as Atlantic Herring.

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APPENDIX A –SEABIRD ABUNDANCE BY SPECIES AND SURVEY

Table A1. Seabird and waterfowl abundance, shore-based observations – May 6, 2016 Survey.

Species	Date: May 6, 2016			Time: 12:30 – 6:30			Observer: Fulton Lavender						
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	0	0	1	1	1	2	0	0	0	1	0	0	0.5
BLSC	0	0	0	0	0	2	0	0	0	1	0	0	0.25
COEI	0	0	2	2	5	5	1	0	1	0	0	0	1.3
COLO	0	0	1	0	0	0	0	0	0	0	0	0	0.08
DCCO	4	5	5	4	4	2	4	5	4	0	6	0	3.2
GBBG	21	20	21	23	23	20	20	20	20	16	1	0	17.1
GRCO	2	0	2	3	0	3	3	5	4	4	0	0	2.2
HEGU	4	5	3	8	7	8	11	5	4	12	7	0	6.2
LBBG	0	0	0	0	1	0	0	0	0	0	0	0	0.08
RTLO	1	6	1	0	0	0	0	0	0	2	0	0	0.8

Table A2. Seabird and waterfowl abundance, shore-based observations – June 2, 2016 Survey.

Species	Date: June 2, 2016			Time: 12:00 – 18:15			Observer: Fulton Lavender						
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	**Average**
BLGU	2	1	0	1	3	0	0	0	0	1	0	0	0.7
COEI	2	0	1	8	6	3	0	6	3	4	4	4	3.4
COLO	0	0	0	0	0	0	1	0	0	0	1	1	0.3
DCCO	6	2	2	2	3	0	2	7	4	9	9	5	4.3
GBBG	34	21	17	24	18	13	22	18	16	15	17	16	19
GRCO	0	0	0	0	1	1	1	1	2	1	1	1	0.8
HEGU	14	20	23	20	21	14	13	5	1	9	7	9	13
LBBG	0	0	0	0	0	1	0	0	0	0	0	1	0.2
RBGU	0	0	0	0	0	0	0	0	0	0	0	1	0.1
RTLO	0	0	0	0	0	1	0	0	0	0	0	1	0.2

Table A3. Seabird and waterfowl abundance, shore-based observations – July 2, 2016 Survey.

Species	Date: July 2, 2016			Time: 11:20 – 17:20			Observer: Fulton Lavender						
	Location: FORCE Visitor Center observation deck facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per 30-minute Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
BLGU	5	2	4	2	1	2	0	0	1	1	0	3	1.8
COEI	0	0	1	3	0	3	4	2	2	3	4	6	2.3
COLO	0	0	1	0	0	1	0	0	0	0	0	0	0.2
DCCO	1	3	1	1	0	1	0	2	3	4	3	3	1.8
GBBG	11	13	3	7	6	9	8	7	5	9	8	8	7.8
GRCO	0	0	0	0	0	0	0	0	2	0	0	0	0.2
HEGU	5	4	5	6	5	4	2	10	4	3	2	4	4.5
RTLO	1	0	0	0	0	0	0	0	0	0	0	0	0.1

Table A 4. Seabird and waterfowl abundance, shore-based observations – August 2, 2016 Survey.

Species	Date: August 2, 2016				Time: 13:00 – 18:30				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
BLGU	1	2	8	2	0	0	1	0	0	0	0	1	1.3
BLSC	0	0	0	0	0	0	0	0	1	0	0	0	0.1
COEI	1	1	2	1	1	1	1	2	2	2	3	0	1.4
COLO	0	0	0	0	1	0	0	0	0	0	0	0	0.1
DCCO	0	1	3	3	3	4	2	1	3	1	2	4	2.3
GBBG	3	4	3	3	2	2	2	2	3	1	1	2	2.3
GRCO	3	1	3	3	3	3	2	2	2	1	2	3	2.3
HEGU	20	13	10	15	5	4	1	1	4	3	2	4	6.8
LBBG	0	0	0	0	0	1	0	0	0	0	0	0	0.1
LEYE	0	0	0	0	0	0	0	0	0	0	0	3	0.3
RBGU	0	0	0	0	4	4	3	3	3	7	6	6	3.0
SPSA	2	0	0	0	0	0	0	0	0	0	0	0	0.2

Table A 5. Seabird and waterfowl abundance, shore-based observations – September 1, 2016 Survey.

Species	Date: September 1, 2016				Time: 13:15 – 18:45				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
DCCO	8	8	14	17	11	12	14	11	8	5	10	8	10.5
GRCO	3	4	4	0	2	1	1	4	5	12	14	21	5.9
HEGU	6	9	3	1	6	2	0	5	3	1	0	1	3.1
RBGU	1	1	0	0	6	12	3	1	2	0	0	0	2.2
WISP	0	0	0	0	4	0	0	0	0	0	0	0	0.3

Table A 6. Seabird and waterfowl abundance, shore-based observations – October 1, 2016 Survey.

Species	Date: October 1, 2016				Time: 11:30 – 17:05				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
BLDU	0	0	0	0	0	0	4	0	0	0	0	0	0.3
BLSC	0	2	9	0	0	0	0	0	0	0	0	0	0.9
CAGO	0	0	1	0	0	0	0	0	0	0	0	0	0.1
COLO	0	2	1	1	1	1	1	1	1	1	1	1	1.0
DCCO	1	2	0	1	0	0	1	2	0	0	2	1	0.8
GBBG	0	0	0	0	0	0	0	0	0	0	0	1	0.1
GRCO	1	1	2	0	1	0	0	1	2	2	1	1	1.0
HEGU	1	3	2	7	0	0	3	0	31	0	1	5	4.4
RBGU	1	2	0	0	0	0	0	0	1	1	3	0	0.7
RBME	0	0	0	0	0	0	0	0	0	1	0	0	0.1
RTLO	1	0	0	0	0	0	0	0	0	0	0	0	0.1

Table A 7. Seabird and waterfowl abundance, shore-based observations – October 17, 2016 Survey.

Species	Date: October 17, 2016				Time: 11:45 – 17:15				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
BLSC	6	0	0	0	0	0	0	0	0	0	0	0	0.5
COEI	0	0	0	0	0	0	1	0	2	2	2	2	0.8
COLO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
DCCO	0	0	0	0	0	0	0	0	0	0	0	1	0.1
GBBG	0	1	0	0	0	0	0	0	0	0	0	1	0.2
GRCO	0	0	1	0	1	2	2	2	2	2	0	0	1.0
HEGU	0	1	2	1	0	0	0	3	0	0	7	7	1.8
RBGU	0	1	0	0	0	0	0	0	0	0	0	0	0.1
WWSC	0	0	0	0	0	0	0	1	0	0	0	0	0.1

Table A 8. Seabird and waterfowl abundance, shore-based observations – November 3, 2016 Survey.

Species	Date: November 3, 2016			Time: 12:15 – 17:45			Observer: Fulton Lavender						
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
BLSC	20	0	0	7	15	0	15	0	97	17	0	221	32.7
COEI	0	0	0	0	0	0	0	1	0	0	0	0	0.1
COLO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
GBBG	0	0	0	0	0	0	0	0	0	0	0	1	0.1
HEGU	2	0	0	0	2	0	0	0	2	4	41	13	5.3
ICGU	0	0	0	0	0	0	0	0	0	0	1	0	0.1
LTDU	0	0	0	0	0	0	5	0	0	0	0	0	0.4
ATPU	0	0	0	0	0	0	0	0	0	0	1	0	0.1
RAZO	0	0	0	0	0	0	0	1	0	0	0	0	0.1
RTLO	0	3	3	2	0	1	0	0	1	1	1	0	1.0
SUSC	0	0	0	0	0	0	0	0	0	12	0	0	1.0

Table A 9. Seabird and waterfowl abundance, shore-based observations – November 17, 2016 Survey.

Species	Date: November 17, 2016				Time: 12:00 – 17:00				Observer: Fulton Lavender			
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.											
	Number of Individuals Sighted per Observation Period											
	1	2	3	4	5	6	7	8	9	10	11	Average
ARLO	0	0	0	0	0	1	0	0	0	0	0	0.1
ATPU	0	0	0	0	0	1	0	0	0	0	0	0.1
BLSC	2	0	0	3	0	0	0	0	0	0	0	0.5
COEI	0	2	0	0	0	0	0	0	0	5	0	0.6
COLO	0	1	0	0	0	0	0	0	0	0	0	0.1
COMU	8	0	0	0	0	0	0	0	0	0	0	0.7
HEGU	2	1	2	0	0	0	1	1	0	1	5	1.2
LTDU	0	0	0	0	0	3	0	0	0	0	0	0.3
RAZO	0	0	0	0	0	1	0	0	0	0	0	0.1
RBGU	0	0	2	0	1	0	0	0	2	0	0	0.5
RNGR	0	0	0	0	0	0	0	1	0	0	0	0.1
RTLO	1	1	1	0	50	8	4	2	0	0	0	6.1

Table A 10. Seabird and waterfowl abundance, shore-based observations – December 1, 2016 Survey.

Species	Date: December 1, 2016			Time: 12:30 – 16:30			Observer: Fulton Lavender			
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.									
	Number of Individuals Sighted per Observation Period									
	1	2	3	4	5	6	7	8	9	Average
ABDU	0	2	0	0	0	0	0	0	0	0.2
COME	0	0	0	0	0	0	0	0	5	0.4
GBBG	0	0	1	0	0	0	0	0	1	0.2
HEGU	0	0	1	0	0	0	0	2	148	12.6

RBGU	0	0	0	0	0	0	0	0	1	0.1

Table A 11. Seabird and waterfowl abundance, shore-based observations – January 16, 2017 Survey.

Species	Date: January 16, 2017			Time: 12:15 – 16:45			Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.										
	Number of Individuals Sighted per Observation Period										
	1	2	3	4	5	6	7	8	9	10	Average
ABDU	3	0	0	0	0	0	0	0	0	0	0.3
COEI	0	0	4	0	0	0	0	0	0	0	0.4
COGO	6	6	8	0	0	0	0	0	0	0	2
COLO	0	1	0	0	0	1	0	0	0	0	0.2
COMU	0	0	1	0	0	0	0	0	0	0	0.1
GBBG	0	0	0	0	0	0	31	63	71	110	27.5
HEGU	4	0	0	0	0	0	1	2	14	231	25.2
ICGU	0	0	0	0	0	0	0	1	0	0	0.1

Table A 12. Seabird and waterfowl abundance, shore-based observations – February 21, 2017 Survey.

Species	Date: February 21, 2017				Time: 12:00 – 17:30				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
COLO	0	0	0	1	0	0	0	0	0	0	0	0	0.1
GBBG	0	0	0	0	0	0	0	0	1	7	8	42	4.8
COGO	5	5	5	5	5	0	0	0	0	1	0	0	2.2
GRCO	0	0	0	0	0	0	0	3	0	0	0	0	0.3
HEGU	1	0	0	0	0	0	1	1	2	22	2	12	3.4
RTLO	0	0	0	0	1	0	0	0	0	1	0	0	0.2

Table A 13. Seabird and waterfowl abundance, shore-based observations – March 13, 2017 Survey.

Species	Date: March 13, 2017				Time: 12:15 – 17:45				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
ABDU	5	0	0	0	0	0	0	0	0	0	0	0	0.4
COEI	5	0	0	0	0	0	0	0	0	0	0	0	0.4
COLO	0	0	0	0	0	0	0	0	1	0	0	0	0.1
GBBG	1	2	3	4	5	5	4	6	7	7	7	8	4.9
GRCO	0	0	0	0	0	0	0	0	0	0	0	2	0.2
HEGU	1	1	0	1	1	2	0	0	0	4	2	20	2.7
RTLO	0	0	0	0	0	0	0	1	0	0	1	0	0.2

Table A 14. Seabird and waterfowl abundance, shore-based observations – April 3, 2017 Survey.

Species	Date: April 3, 2017				Time: 12:15 – 17:45				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
ABDU	0	1	0	0	0	0	7	0	0	0	0	0	0.7
BLGU	0	0	1	1	1	0	0	0	0	0	0	0	0.3
BLSC	0	0	9	0	0	0	0	0	0	0	0	0	0.8
CAGO	0	2	0	10	0	20	2	0	0	0	0	0	2.8
COEI	0	75	0	0	0	0	0	0	0	0	0	0	6.3
COGO	0	2	0	0	0	0	0	0	0	0	0	0	0.2
GBBG	1	1	2	5	1	1	3	2	9	11	11	12	4.9
HEGU	0	0	0	14	2	1	1	5	2	6	7	24	5.2
LTDU	0	0	0	0	0	0	0	0	0	1	0	0	0.1
PUSA	0	0	0	0	0	0	0	0	0	0	1	1	0.2
RBME	1	0	0	0	0	0	0	0	0	0	0	0	0.1
RTLO	0	0	0	4	0	0	0	0	0	0	0	0	0.3
SNGO	0	0	0	0	0	0	1	0	0	0	0	0	0.1

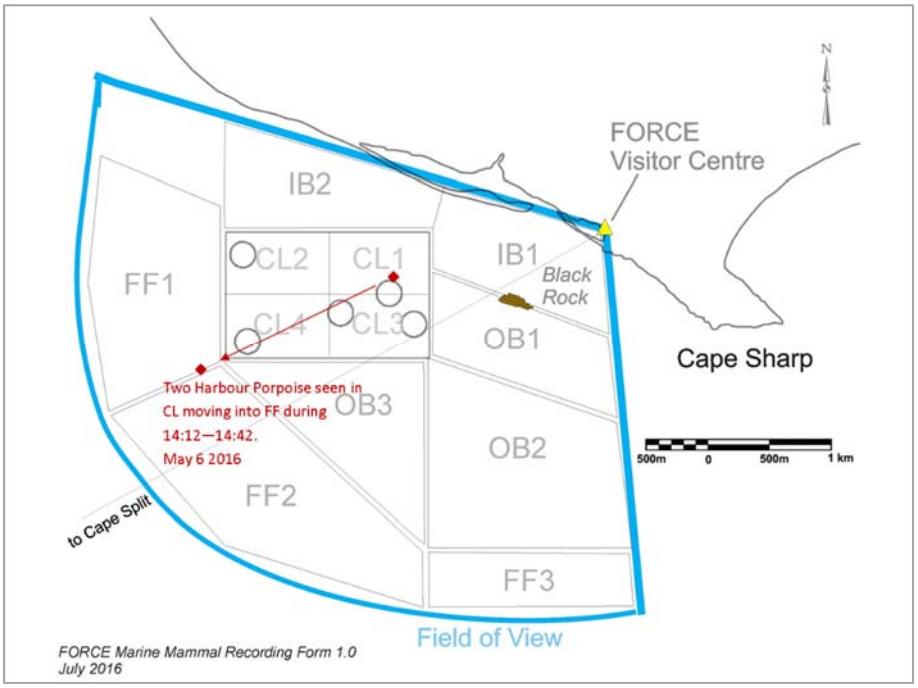
Table A 15. Seabird and waterfowl abundance, shore-based observations – April 17, 2017 Survey.

Species	Date: April 17, 2017				Time: 11:50 – 17:20				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
ATPU	0	0	0	0	0	0	0	0	1	0	0	0	0.1
BLGU	0	0	0	0	0	0	1	0	0	2	0	0	0.3
BLSC	67	116	60	115	30	25	32	95	18	30	0	25	51.1
COEI	0	15	1	2	2	2	2	17	0	2	2	4	4.1
COLO	1	2	0	0	0	9	0	4	0	0	8	0	2.0
DCCO	56	54	14	81	81	81	124	90	80	83	85	128	79.8
GBBG	9	5	61	9	10	7	7	15	18	21	22	20	17.0
GRCO	15	7	3	4	4	1	4	3	3	4	0	2	4.2
HEGU	22	2	70	11	7	7	7	61	41	100	105	101	44.5
ICGU	1	0	0	0	3	12	0	0	0	0	0	0	1.3
LTDU	0	2	63	0	48	5	1	2	140	1	20	0	23.5
NOGA	0	0	2	1	0	0	0	0	1	0	1	0	0.4
RBGU	0	0	0	0	0	0	4	0	0	0	0	0	0.3
RBME	0	3	4	0	0	0	0	3	0	0	0	0	0.8
RTLO	1	8	123	3	12	4	11	6	20	0	2	3	16.1
SUSC	2	0	0	0	140	10	170	5	5	0	0	0	27.7
WWSC	0	2	0	0	2	1	0	0	0	0	0	3	0.7

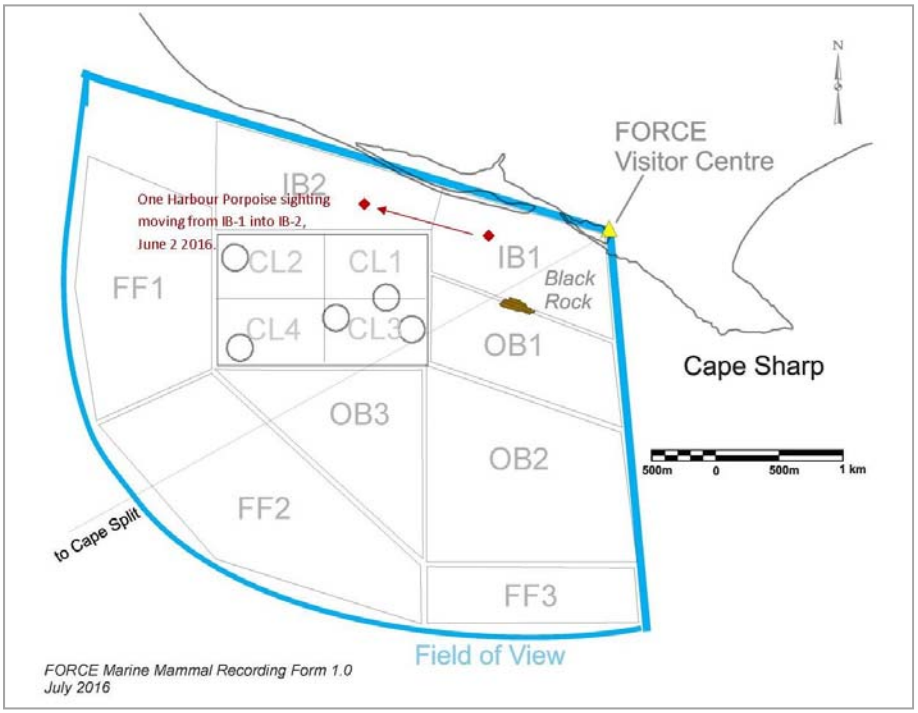
Table A 16. Seabird and waterfowl abundance, shore-based observations – May 1, 2017 Survey.

Species	Date: May 1, 2017				Time: 12:00 – 17:00				Observer: Fulton Lavender				
	Location: FORCE Visitor Center main lobby facing water, Parrsboro Nova Scotia.												
	Number of Individuals Sighted per Observation Period												
	1	2	3	4	5	6	7	8	9	10	11	12	Average
BLGU	2	2	2	3	2	2	0	1	1	2	0	0	1.4
BLSC	0	0	5	0	0	0	0	0	2	0	4	0	0.9
BWTE	2	0	0	0	0	0	0	0	0	0	0	0	0.2
COEI	1	10	3	9	0	0	0	1	0	1	1	3	2.4
DCCO	42	37	17	24	37	32	29	33	33	29	38	31	31.8
GBBG	16	23	19	25	18	15	1	23	30	29	26	26	20.9
GRCO	6	4	1	1	0	4	3	3	2	1	1	1	2.3
HEGU	15	11	13	5	5	13	5	7	8	9	14	15	10.0
LBBG	0	0	0	0	0	0	0	0	1	2	1	1	0.4
LTDU	5	0	1	0	0	0	0	0	0	0	0	0	0.5
RBMR	0	0	0	0	0	0	0	0	0	1	0	0	0.1
RTLO	0	1	2	1	0	0	0	0	0	1	3	4	1.0
SUSC	6	0	0	21	0	0	0	6	2	0	0	0	2.9

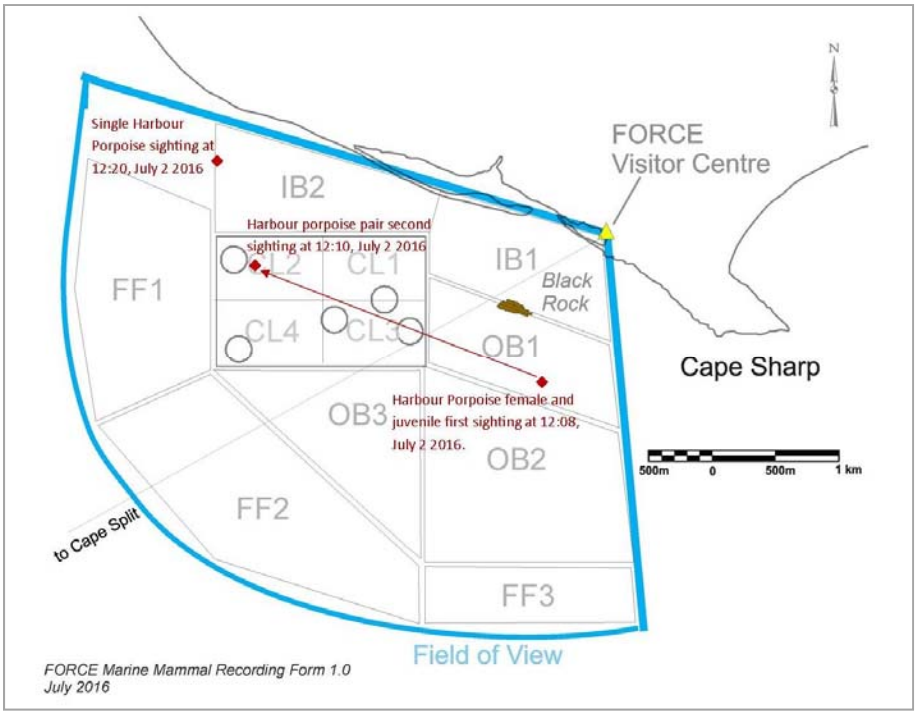
APPENDIX B – SUMMARY OF HARBOUR PORPOISE SIGHTINGS



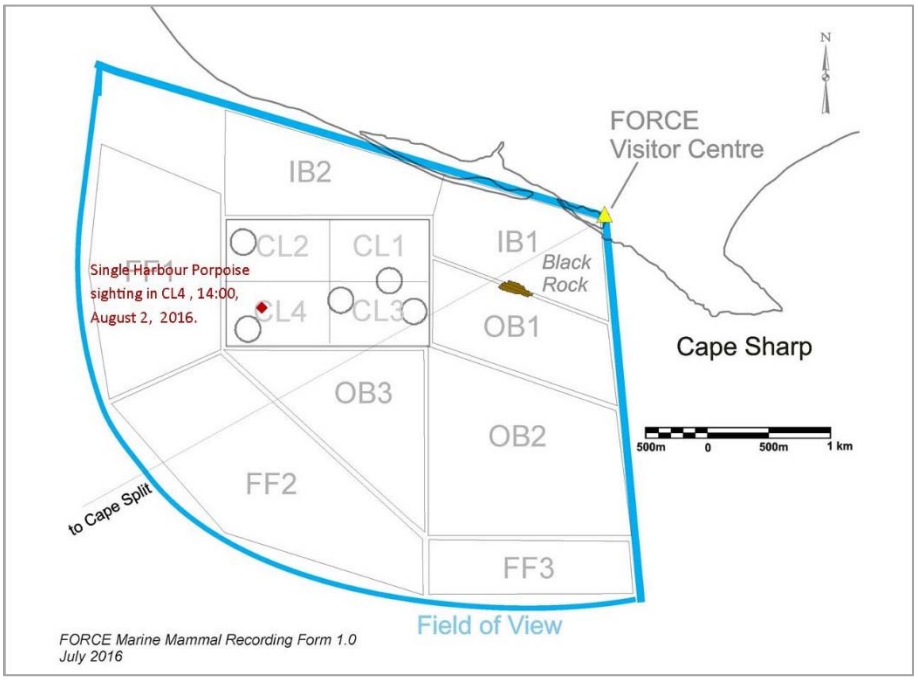
Depiction of a single Harbour Porpoise sighting on May 6 2016 from the FORCE Visitor Center outdoor observation deck.



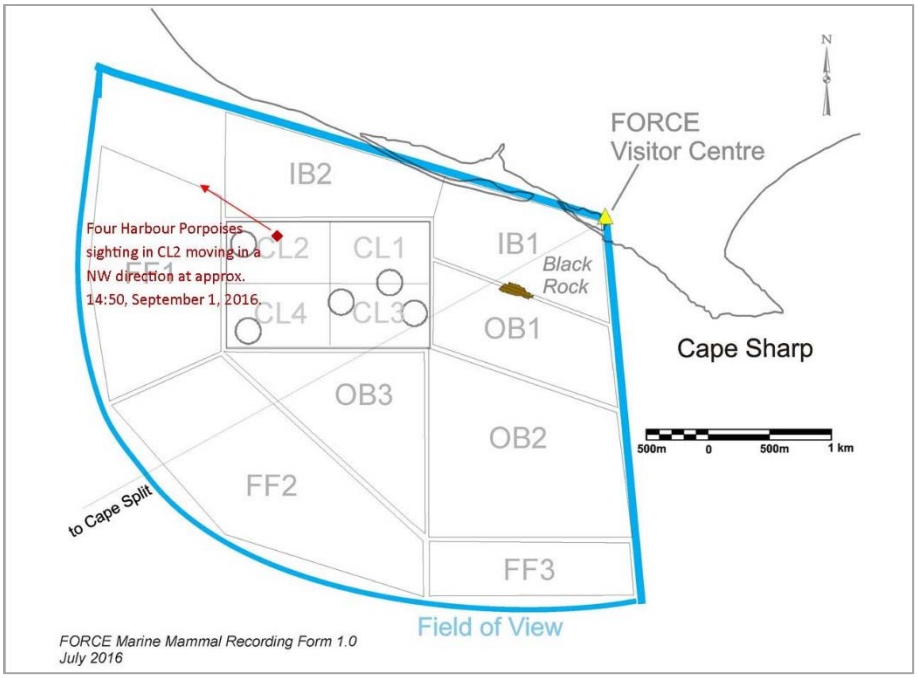
Depiction of a single Harbour Porpoise sighting on June 2 2016 from the FORCE Visitor Center outdoor observation deck.



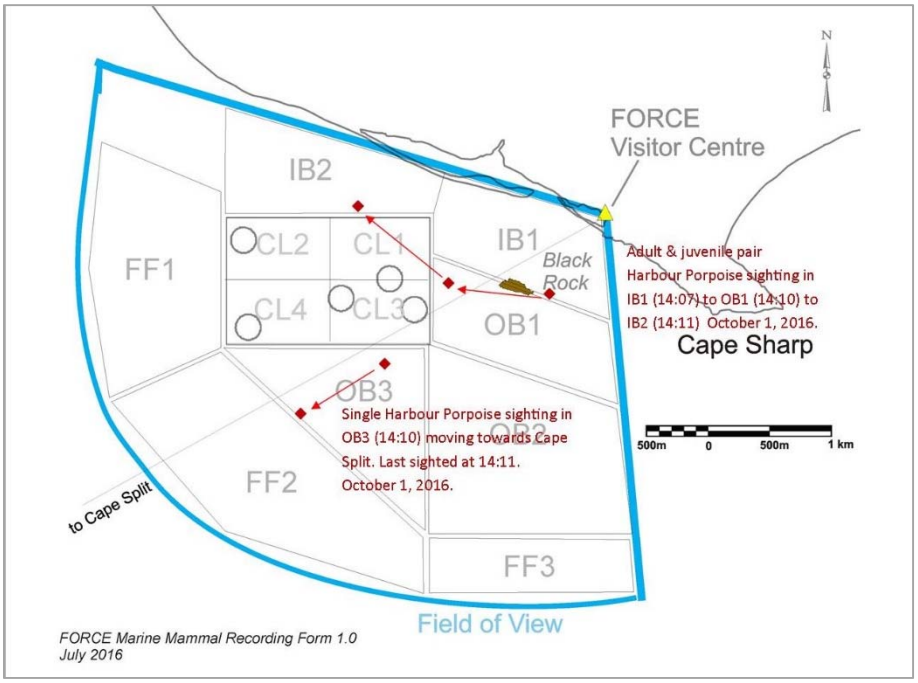
Depiction of Harbour Porpoise sighting on July 2 2016 from the FORCE Visitor Center outdoor observation deck.



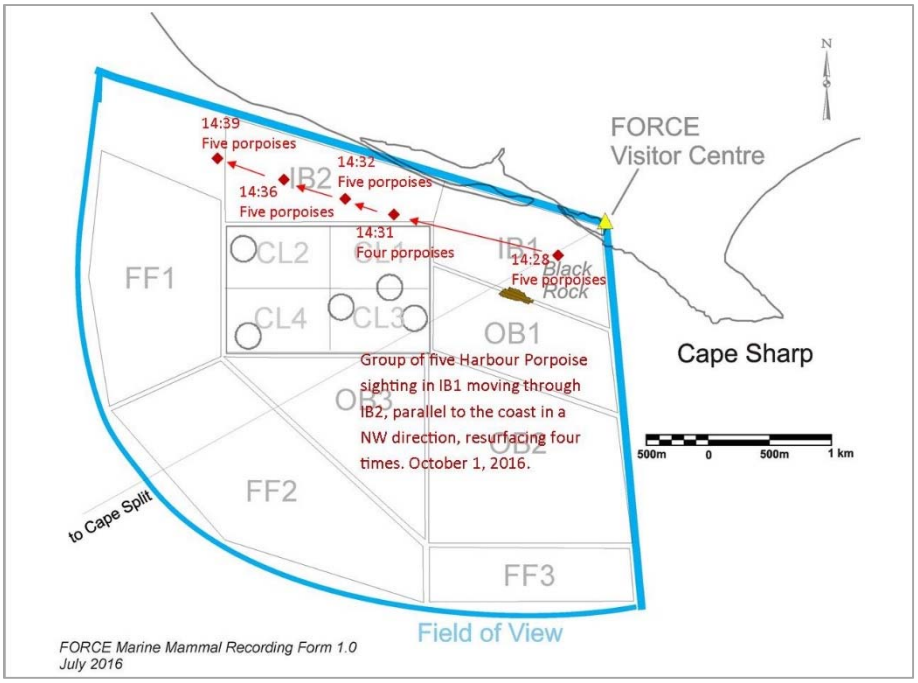
Depiction of a single Harbour Porpoise sighting on August 2, 2016 from the FORCE Visitor Center outdoor observation deck.



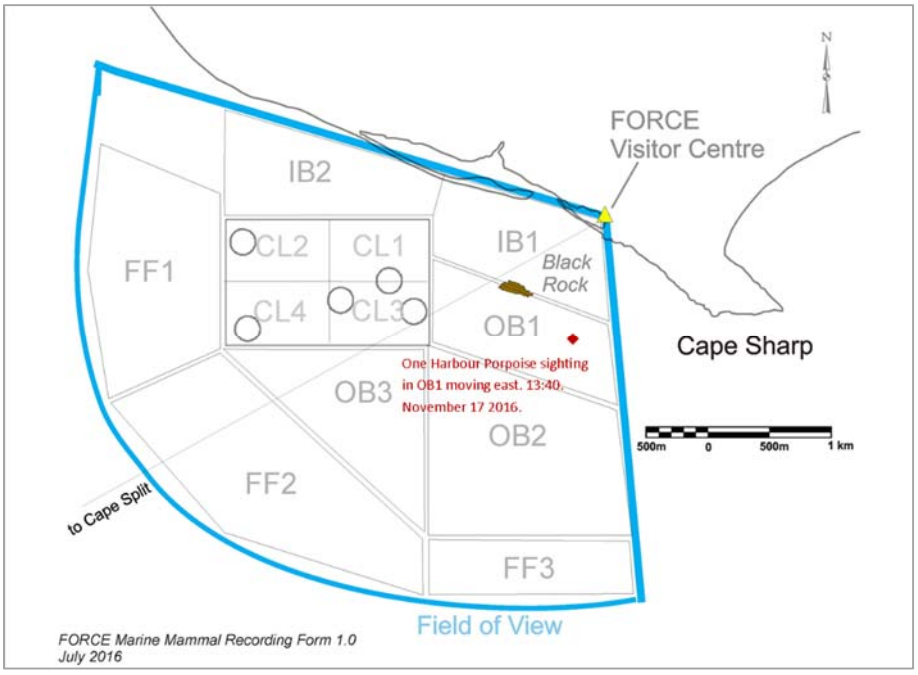
Depiction of Harbour Porpoise sighting on September 1, 2016 from the FORCE Visitor Center outdoor observation deck.



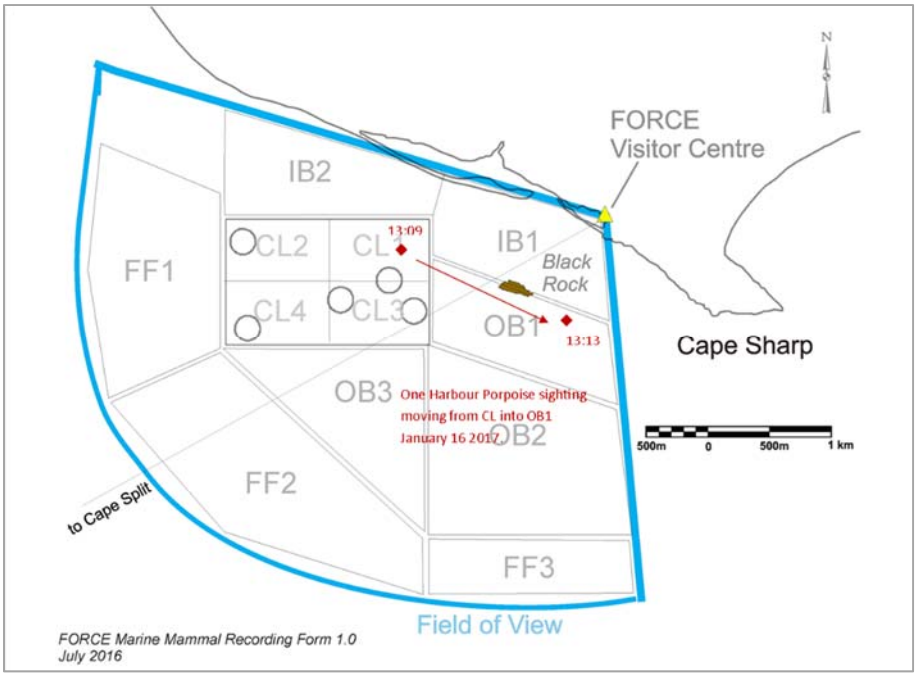
Depiction of first Harbour Porpoise sighting on October 1, 2016 from the FORCE Visitor Center outdoor observation deck.



Depiction of second Harbour Porpoise sighting on October 1, 2016 from the FORCE Visitor Center outdoor observation deck.



Depiction of Harbour Porpoise sighting on November 17, 2016 from the FORCE Visitor Center outdoor observation deck.



Depiction of Harbour Porpoise sighting on January 16, 2017 from the FORCE Visitor Center outdoor observation deck.

APPENDIX C – CONSERVATION STATUS OF SEABIRDS, OTHER WATER-ASSOCIATED BIRDS, AND COASTAL RAPTORS AT THE FORCE SITE, 2010-2017

Table C1. Conservation status of seabirds and other water-associated birds and coastal raptors at the FORCE Tidal Energy Demonstration Site, 2010-2017.

Common Name	Scientific Name	Conservation Status/Rank					
		COSEWIC	SARA	NS Endangered Status	Provincial Rarity Rank	Provincial General Status Rank (NR=not rated)	Other Comments
American Black Duck	*Anas rubripes*				S5	4 Secure	
Arctic Loon	*Gavia arctica*					NR	Accidental
Atlantic Puffin	*Fratercula arctica*				S3B, S5N	3 Sensitive	
Bald Eagle	*Haliaeetus leucocephalus*	Not at Risk			S5	4 Secure	Terrestrial
Black-Bellied Plover	*Pluvialis squatarola*				S3M	4 Secure	
Black Guillemot	*Cepphus grylle*				S4	4 Secure	
Black-Legged Kittiwake	*Rissa tridactyla*				S3B, S5N	3 Sensitive	
Black Scoter	*Melanitta nigra*				S4N	4 Secure	
Black Tern	*Chlidonias niger*	Not at Risk			S1B	2 May Be At Risk	
Blue-Winged Teal	*Anas discors*				S3S4B	2 May Be At Risk	
Canada Goose	*Branta canadensis*				SNAB, S4N	4 Secure	
Common Eider	*Somateria mollissima*				S3S4	4 Secure	
Common Goldeneye	*Bucephala clangula*				S2B, S5W	4 Secure	
Common Loon	*Gavia immer*	Not at Risk			S3B, S4N	2 May Be At Risk	
Common Merganser	*Mergus merganser*				S5	4 Secure	
Common Murre	*Uria aalge*				S1?B, S5N	4 Secure	
Cory's Shearwater	*Calonectris diomedea*				SNA	8 Accidental	
Double-Crested Cormorant	*Phalacrocorax auritus*	Not at Risk			S4B	4 Secure	
Great Black-Backed Gull	*Larus marinus*				S4S5	4 Secure	
Great Cormorant	*Phalacrocorax carbo*				S2S3	3 Sensitive	

Table C1. Conservation status of seabirds and other water-associated birds and coastal raptors at the FORCE Tidal Energy Demonstration Site, 2010-2017.

Common Name	Scientific Name	Conservation Status/Rank					
		COSEWIC	SARA	NS Endangered Status	Provincial Rarity Rank	Provincial General Status Rank (NR=not rated)	Other Comments
Great Shearwater	*Puffinus gravis*				S5N	4 Secure	
Greater Yellowlegs	*Tringa melanoleuca*				S3B, S3S4M	3 Sensitive	
Harlequin Duck	*Histrionicus histrionicus*	Special Concern	Special Concern	Endangered	S2N	1 At Risk	
Herring Gull	*Larus argentatus*				S5	4 Secure	
Horned Grebe	*Podiceps auritus*				S4W	4 Secure	
Iceland Gull	*Larus glaucoides*				S4N	4 Secure	
King Eider	*Somateria spectabilis*				SNA	4 Secure	
Laughing Gull	*Larus atricilla*				SHB	2 May Be At Risk	
Lesser Black-Backed Gull	*Larus fuscus*				SNA	8 Accidental	
Least Sandpiper	*Calidris minutilla*				S1B, S3M	4 Secure	
Lesser Yellowlegs	*Tringa flavipes*				S3M	4 Secure	
Long-Tailed Duck	*Clangula hyemalis*				S5N	4 Secure	
Mallard	*Anas platyrhynchos*				S5	4 Secure	
Mew Gull	*Larus canus*				SNA	8 Accidental	
Northern Gannet	*Morus bassanus*				SHB, S5M	4 Secure	
Northern Harrier	*Circus cyaneus*	Not at Risk			S3S4B	4 Secure	Terrestrial
Northern Shoveler	*Anas clypeata*				S2B	2 May Be At Risk	
Pacific Loon	*Gavia pacifica*				SNA	8 Accidental	
Peregrine Falcon	*Falco peregrinus*	Not at Risk	Special Concern	Vulnerable	S1B, SNAM	3 Sensitive	Terrestrial
Purple Sandpiper	*Calildris maritima*				S3?N	3 Sensitive	

Table C1. Conservation status of seabirds and other water-associated birds and coastal raptors at the FORCE Tidal Energy Demonstration Site, 2010-2017.

Common Name	Scientific Name	Conservation Status/Rank					
		COSEWIC	SARA	NS Endangered Status	Provincial Rarity Rank	Provincial General Status Rank (NR=not rated)	Other Comments
Razorbill	*Alca torda*				S2B, S4N	3 Sensitive	
Ring-Billed Gull	*Larus delawarensis*				SUB, S5N	4 Secure	
Red-Breasted Merganser	*Mergus serrator*				S3S4B, S5N	4 Secure	
Red Phalarope	*Phalaropus fulicarius*				S2S3M	3 Sensitive	
Red-Necked Grebe	*Podiceps grisigena*				S4N	4 Secure	
Red-Necked Phalarope	*Phalaropus lobatus*	Special Concern	No Status		S2S3M	3 Sensitive	
Red-Throated Loon	*Gavia stellata*				S4N	4 Secure	
Ruddy Turnstone	*Arenaria interpres*				S3M	4 Secure	
Sanderling	*Calidris alba*				S3M, S2N	4 Secure	
Semipalmated Plover	*Charadrius semipalmatus*				S1B, S3S4M	4 Secure	
Semipalmated Sandpiper	*Calidris pusilla*				S3M	3 Sensitive	
Sooty Shearwater	*Puffinus griseus*				S5N	4 Secure	
Snow Goose	*Anser caerulescens*				SNA	4 Secure	
Spotted Sandpiper	*Actitis macularius*				S3S4B	3 Sensitive	
Surf Scoter	*Melanitta perspicillata*				S4N	4 Secure	
Thick-Billed Murre	*Uria lomvia*				SNA	4 Secure	
Wilson's Storm-Petrel	*Oceanites oceanicus*				S5N	4 Secure	
White-Winged Scoter	*Melanitta fusca*				S4N	4 Secure	

Table C2. Conservation status codes used in Table C1. Source: Atlantic Canada Conservation Data Centre, http://www.accdc.com/en/rank-definitions.html

Provincial) Rarity Rank

S1 **Critically Imperiled-** Extremely rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.

S2 **Imperiled-**Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to rarity or other factors.

S3 **Vulnerable-**Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in at some locations (21 to 100 occurrences).

S4 **Apparently Secure**-Usually widespread, fairly common throughout its range in the province, and apparently secure with many occurrences, but the Element is of long-term concern (e.g. watch list). (100+ occurrences).

S5 **Secure**-Demonstrably widespread, abundant, and secure throughout its range in the province, and essentially ineradicable under present conditions.

SU **Unrankable -** Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

SNA **Not Applicable –** A conservation status rank is not applicable because the species is not a suitable target for conservation activities.

Codes Attached to Provincial Rarity Rank

B **Breeding-** Conservation status refers to the breeding population of the province.

NB **Nonbreeding-**Conservation status refers to the non-breeding population of the province.

M **Migrant-**Migrant species occurring regularly on migration at particular concentration spots where the species might warrant conservation attention; status refers to the agtregatin transient population of the species in the area.

? **Inexact or Uncertain-**Denotes inexact or uncertain numeric rank (The ? qualifies the character immediately preceding it in the S-rank.)

Provincial General Status of Wild Species Rank listed for Nova Scotia

0.2=Extinct (Blue);	4=Secure (Green);
0.1=Extirpated (Purple);	5=Undetermined (light grey);
1=At Risk (Red);	6=Not Assessed (dark grey);
2=May be at Risk (Orange);	7=Exotic (Black);
3=Sensitive (Yellow);	8=Accidental (Aqua).