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Pelagic seabird monitoring and research in the northwest Atlantic

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Abstract

The east coast of Canada supports millions of seabirds that are an integral part of the marine ecosystem. The Canadian Wildlife Service (CWS) of Environment Canada collects data on their offshore distribution and abundance in order to identify and minimize the impacts of human activities on birds at sea. Since 2006, almost 100,000 km of ocean track have been surveyed in Atlantic Canada and the Gulf of St. Lawrence, and over 120,000 birds have been sighted. These data provide critical up-to-date information for environmental assessments related to offshore developments, emergency response related to oil spills, risk assessments, marine protected area planning, and other management and conservation initiatives.

Introduction

The northwest Atlantic supports significant numbers and important congregations of seabirds throughout the year, including species that breed in eastern Canada as well as migrants from the Arctic, northeastern Atlantic, and southern hemisphere. Data on their offshore distributions and abundance are required to understand the role seabirds play in marine ecosystems and to identify and minimize human impacts on birds at sea.

In Atlantic Canada, data were collected from 1965 - 1992 under PIROP (Programme intégré de recherches sur les oiseaux pélagiques). The data were used to describe oceanographic factors that influence seabird distribution (Brown 1970; 1976; 1979; 1985) and a series of atlases were produced to summarize their seasonal distribution in the northwest Atlantic (Brown et al. 1975; Brown 1977, 1986). Despite the dynamic nature of the marine environment and of bird populations themselves, these data continued to be used for current environmental assessments and impact statements associated with human activities, including developments of offshore oil and gas facilities off the east coast of Canada. As a result, in 2005, the Canadian Wildlife Service (CWS) of Environment Canada reinvigorated the pelagic seabird monitoring program (Eastern Canada Seabirds at Sea; ECSAS). The specific objectives of the program are to 1) update information on the abundance, distribution and trends of seabirds occurring offshore; 2) address knowledge gaps; 3) identify and minimize threats to seabirds in their marine habitat; and 4) increase awareness and support for seabirds and seabird conservation.

Methods

At-sea surveys

Data are collected from ships-of-opportunity that travel over large geographic areas, and those that target priority areas, such as offshore oil and gas developments, proposed areas for marine protection, and areas where we have little to no data. These data provide critical information for environmental assessments related to offshore developments, emergency response related to oil spills, risk assessments, marine spatial planning, and other management and conservation initiatives. Data are collected year-round and provide the only information on bird densities at sea in the region.

Following a standardized protocol (Gjerdrum et al. 2012), a survey consists of a series of 5 min observation periods (10 min observation periods were used prior to November 2007) while the ship is steaming, dedicated to detecting birds. As many consecutive observation periods are conducted as possible, regardless if birds are present or not. At the beginning of each observation period, we record the ship's position, time of day, ship speed and direction, and a number of environmental variables (i.e., visibility, sea state, swell height, wind speed and direction). Surveys are conducted while looking forward from the ship's bridge (travelling 4-19 knots), scanning at a 90˚ angle from either the port or starboard side, limiting observations to a transect band 300 m wide from the beam of the ship. The transect is continuously surveyed by eye to count and identify birds present in air or on water. Binoculars are used to confirm species identification when necessary, and other details, such as age, moult, and behaviour. All birds observed on the sea surface are continuously recorded throughout the observation period. A count of all flying birds passing through the transect would be a measure of bird flux and would overestimate bird density (Tasker et al. 1984). Therefore, we record flying birds using instantaneous counts at regular intervals throughout each survey (Tasker et al. 1984). The perpendicular distance between the observer and bird(s) sighted is also recorded. For surveys in the Gulf of St. Lawrence, methods are similar except that bird locations are recorded continuously rather than binned into discrete 5-min observation periods.

In addition to ongoing ship-based surveys, aerial surveys in the Bay of Fundy and Gulf of St. Lawrence are also undertaken to generate information on seabird abundance and distribution in areas and times of year when no ships are available. Systematic transects are flown by two observers who identify and count flying birds and those on water. Distance sampling is done to correct apparent densities for decreasing detection with distance from the observer. Data on glare and other survey conditions also are collected.

Hotspot analysis

The primary objective of this work is the identification of important marine habitat sites through a science-based, transparent process, founded on best-available information. ECSAS data were merged with PIROP data to produce distribution maps that show the number of birds encountered per kilometre. Data, which included date, number of birds encountered per kilometre travelled, distance travelled in kilometres, were summarized into points associated with the latitude and longitude of the start of each 'transect' (typically 0.6 to 3.7 km in length). We created a 5 km X 5 km grid covering our area of interest. We used a kernel point density estimator (quadratic kernel function), centred on each square's centroid location, with a fixed radius of 25 km. This approach makes use of values from multiple points within a given area, although the number of points contributing to kernel calculations varies across the landscape. The total weightings of all calculated point values located within a kernel equal the probability density of the point on which the kernel is centered. Hence, each grid square on the landscape is given its probability density value. This process creates a smoothed relative abundance (probability density) surface. Values were not calculated for grid squares in which no data were available, emphasizing the location of spatial data gaps. As there is a clear correlation between survey intensity (number of days a given square was visited) and the magnitude of high count values, we corrected for intensity of effort by dividing a grid square's probability density value by the number of days a square was visited.

Results and Discussion

Survey effort

Within the NAFO convention area, a total of 99,798 km of ocean track have been surveyed since 2006 (ECSAS), compared to 177,480 km between 1965-1992 (PIROP). Both monitoring programs have focused their survey efforts on the Scotian Shelf and Grand Banks, although more PIROP surveys were conducted in the eastern Arctic and George's Bank (Figure 1). Most of the survey effort for both PIROP and ECSAS programs occurred in summer, between May and August (51% and 49% respectively).

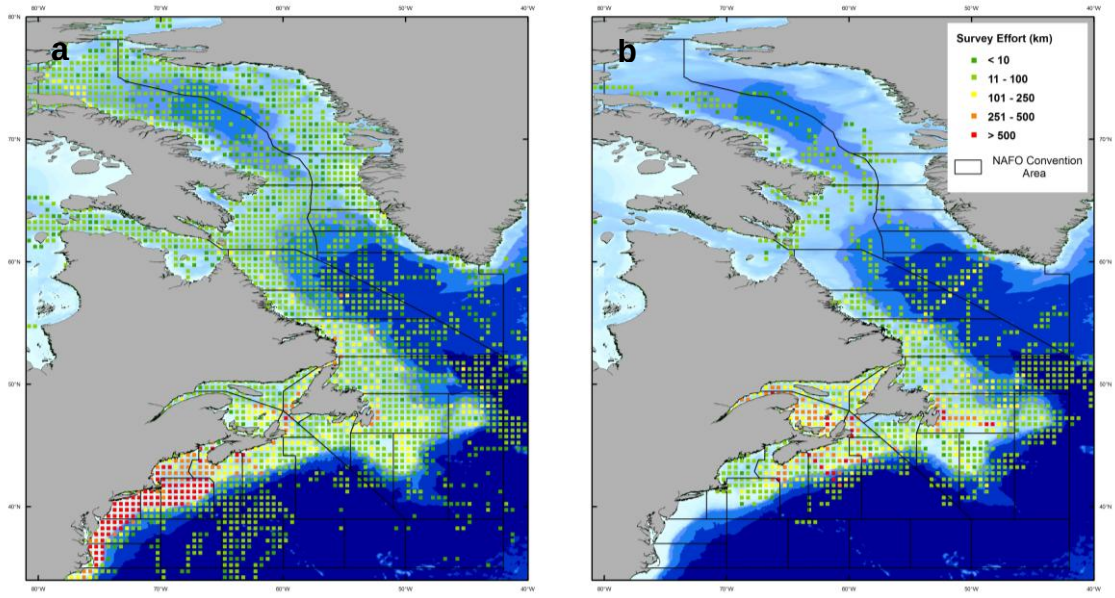

Figure 1. Survey effort within the NAFO convention area from (a) 1965-1992 under Programme intégré de recherches sur les oiseaux pélagiques (PIROP), and (b) 2006 - 2012 under the Eastern Canada Seabirds at Sea (ECSAS) program. The number of kilometres surveyed is summed for each 30 minute cell.

Relative abundance

Since 2006, ship-based surveys have detected a total of 120,057 individual birds within the NAFO convention area. These sightings represent 38 species from 9 families (Table 1). The most numerous species observed was the dovekie (18% of sightings), followed by northern fulmar (16%), great shearwater (13%), black-legged kittiwake (8%), thick-billed murre (6%), Leach's storm-petrel (6%), common murre (5%), and phalaropes (4%). However, community composition changes markedly between seasons. Detailed descriptions of the most common seabird families sighted in the NAFO convention area are given in Appendix I.

Seabird Densities and the development of an online atlas

The Eastern Canada Seabirds at Sea (ECSAS) monitoring program follows recommendations for standardized recording techniques (Tasker et al. 1984) that are used in the North Sea and northeastern Atlantic with modifications to allow for the estimation of bird detectability (Buckland et al. 2001). By incorporating distance sampling methods, we can address variation in bird detectability, which allows for the calculation of correction factors to account for missed birds (Buckland et al. 2001). We also reduced the observation period length from 10 min to 5 min in order to obtain more precise spatial information for each bird sighting.

The protocol developed for collecting seabird data offshore (Gjerdrum et al. 2012) enables us to generate precise density estimates that can be used to monitor the status of seabird populations in Atlantic Canada. Although the status and trends of seabird populations are often monitored at colonies, where large numbers of individuals congregate and where population size can be relatively easily counted or indexed, colony monitoring by itself cannot provide the full suite of monitoring needs for seabirds. Specifically, colony monitoring provides minimal information on the distribution of seabirds, especially in the non-breeding season, and provides no data on seabirds that do not breed on monitored colonies (be they breeding in Canada or elsewhere).

Seabird densities within the NAFO convention area between 2006-2009 have been published by Fifield et al. (2009). We are currently working on the development of an interactive, dynamic, on-line atlas of seabird densities and distribution information that is publically available. The data will be summarized on a regular basis to provide the most up-to-date information, and we will combine the pelagic seabird data with the colony data into one atlas to provide the most comprehensive information on the population status of Atlantic seabirds.

Table 1. Seabird sightings within the NAFO convention area from 2006 – 2012.

Family	Species	Scientific name	Number observed
Diomedeidae	Albatross	Diomedeidae	1
Procellariidae	Northern fulmar	*Fulmarus glacialis*	18625
	Cory's shearwater	*Calonectris diomedea*	343
	Great shearwater	*Puffinus gravis*	16114
	Manx shearwater	*P. puffinus*	91
	Audubon's shearwater	*P. lherminieri*	5
	Sooty shearwater	*P. griseus*	1675
	Unidentified shearwater	*Puffinus* or *Calonectris*	64
Hydrobatidae	Leach's storm-petrel	*Oceanodroma leucorhoa*	6623
	Wilson's storm-petrel	*Oceanites oceanicus*	1171
	Unidentified storm-petrel	*Oceanodroma* or *Oceanites*	2461
Phalacrocoracidae	Great cormorant	*Phalacrocorax carbo*	5
	Double-crested cormorant	*P. auritus*	121
	Unidentified cormorant	*Phalacrocorax*	16
Sulidae	Northern gannet	*Morus bassanus*	2042
Scolopacidae	Red phalarope	*Phalaropus fulicaria*	1845
	Red-necked phalarope	*P. lobatus*	117
	Unidentified phalarope	*Phalaropus* spp.	4400
Stercorariidae	Long-tailed jaeger	*Stercorarius longicaudus*	108
	Parasitic jaeger	*S. parasiticus*	22
	Pomarine jaeger	*S. pomarinus*	309
	South polar skua	*S. maccormicki*	39
	Great skua	*S. skua*	48
	Unidentified jaegers and skuas	Stercorariidae	241
Laridae	Ivory gull	*Pagophila eburnea*	1
	Bonaparte's gull	*Larus philadelphia*	11
	Laughing gull	*L. atricilla*	8
	Ring-billed gull	*L. delawarensis*	66
	Herring gull	*L. argentatus*	2480
	Iceland gull	*L. glaucoides*	93
	Glaucous gull	*L. hyperboreus*	787
	Lesser black-backed gull	*L. fuscus*	42
	Great black-backed gull	*L. marinus*	2233
	Sabine's gull	*Xema sabini*	7
	Black-legged kittiwake	*Rissa trydactyla*	9917
	Unidentified gull	*Larus* spp.	1050
	Common tern	*Sterna hirundo*	72
	Arctic tern	*S. paradisaea*	22
	Unidentified tern	Sternidae	226
Alcidae	Common murre	*Uria aalge*	5998
	Thick-billed murre	*Uria lomvia*	7694
	Unidentified murre	*Uria*	6297
	Razorbill	*Alca Torda*	255
	Unidentified murre or razorbill	*Uria* or *Alca*	286
	Dovekie	*Alle alle*	21122
	Black guillemot	*Cepphus grylle*	136
	Atlantic puffin	*Fratercula arctica*	3706
	Unknown Alcidae	Alcidae	1062
Total number observed			120057

Identification of important marine habitat sites for birds

Seabirds tend to be most vulnerable to natural and anthropogenic stressors when congregated (e.g., breeding colonies, foraging areas within range of breeding colonies, refuges used for moulting, food-rich staging areas, migratory corridors, food-rich wintering areas). Using all data available for the offshore, we identify important marine habitat sites for a suite of migratory birds in Eastern Canada to both inform conservation and protected area planning, help identify knowledge gaps (spatial, temporal, and species-specific) and direct future survey efforts. Although important offshore marine habitats may vary among species, some overlap can be expected where significant physical and biological oceanographic processes enhance the feeding conditions for seabirds. We provide here a map for the northern gannet (*Morus bassanus*), which highlights areas of increased abundance in relation to the colonies that collectively host 100% of the North American breeding population (Figure 2).

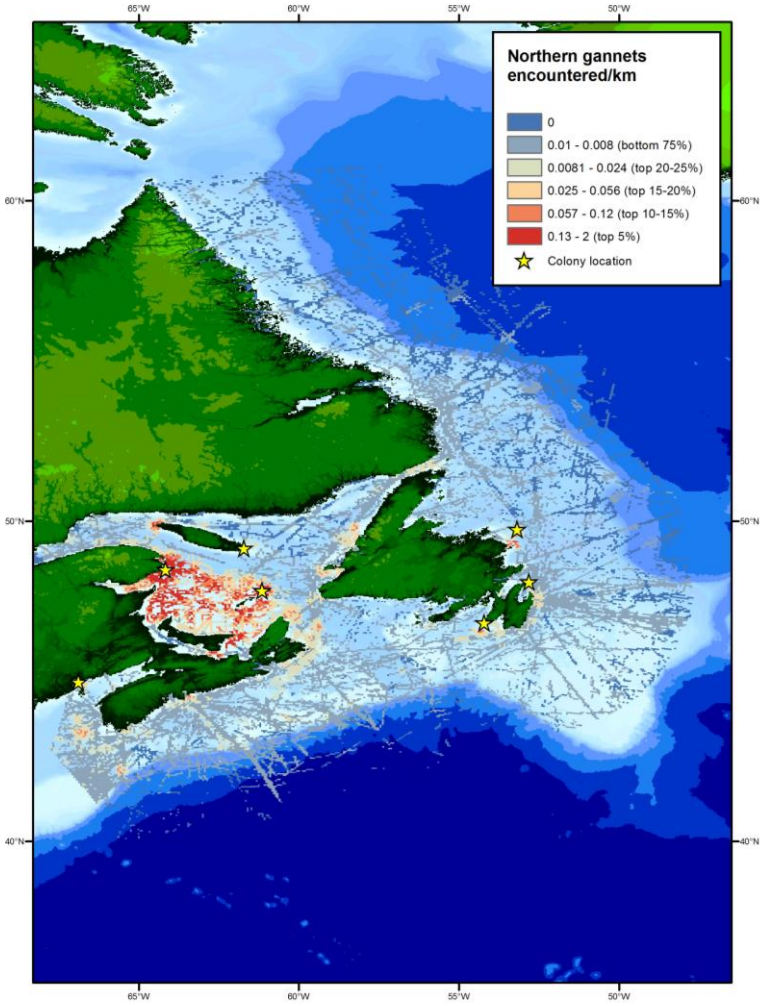

Figure 2. Important marine habitat for the northern gannet and colony locations in eastern Canada.

The northern gannet is restricted to continental shelf waters on both sides of the Atlantic. In North America, the species breeds at 7 colony locations, 3 in Quebec, 3 off the coast of Newfoundland, and in New Brunswick where recent limited breeding attempts have occurred (Figure 2). The species tends to breed at high densities at colonies within foraging distance (< 225 km; Garthe et al. 2007) of their principal prey, the herring and mackerel. Post-breeding gannets forage in the Gulf of St. Lawrence, Strait of Belle Isle, nearshore waters off Labrador, and the east coast of Newfoundland. During migration gannets pass through the Cabot Strait and along Nova Scotia's Eastern Shore (Figure 2) before moving

farther south for the winter (Mowbray 2002). In winter, birds are more dispersed but remain mainly over shelf waters. In North America, their non-breeding range extends from New England south to Florida, and west along the Gulf of Mexico coast to Texas. During the breeding season, the northern gannet feeds primarily on surface-schooling fish including mackerel, herring, and capelin. To feed, they fly to a height of 10-40 m, turn, then use gravity to drop and plunge through the surface of the water, known as plunge-diving. They descend to a depth of 3-5 m, or even deeper if they swim to pursue their prey (Mowbray 2002).

Detection of trends in seabird distribution and abundance'

The pelagic seabird monitoring program in eastern Canada is designed to collect long-term data on the distribution and abundance of birds living offshore. Over the past 6 years, CWS has surveyed close to 100,000 km in the region, collecting data on seabird abundance and distribution. We are now in a position to use the data to analyze trends in abundance and distribution of the most common marine bird species in Atlantic Canada over a 45-year period, assess the persistence of hotspots, and examine whether observed changes can be linked to oceanographic variability at multiple scales (e.g., Gjerdrum et al. 2008). We are also looking to model marine bird distribution related to physical and oceanographic features and conservation risk factors, including fisheries, energy development and marine transport. Our monitoring and research efforts will ensure we can continue to evaluate the status of seabirds in Canada, and support conservation initiatives related to the offshore.

Monitor the spatial pattern of oil pollution for Canada's East Coast

Information collected through Transport Canada's National Aerial Surveillance Program (NASP) and the Canadian Ice Service's Integrated Satellite Tracking of Oil Polluters (ISTOP) program can provide information on when and where oil discharges occur. CWS is currently collaborating with Transport Canada and the Canadian Ice Service, as well as research professors in several Canadian universities, to develop the methods needed for these data to be used to monitor trends in marine oil pollution. This project will help identify oil pollution "hotspots" and surveillance gaps in the Atlantic Region, and highlight areas where oil and bird hotspots overlap. The results will assist regional conservation planning and emergency preparedness. More specifically, the results will contribute to the development of Best Management Practices for the oil and gas and shipping industries, and ultimately reduce the number of birds killed by oil in Atlantic Canada.

Characterization of seabird attraction to offshore oil and gas installations

There are potentially important impacts on bird populations associated with offshore oil and gas installations, including mortality caused by attraction to lights and gas flares and associated collisions with infrastructure. Worldwide there are thousands of active offshore petroleum platforms and so there is potential for important cumulative impacts. Using a combination of traditional at-sea surveys with instruments such as radar, VHF, GPS and satellite tags, Acadia University, EnCana and CWS will study the patterns of movement and occurrence of birds in and around multiple offshore gas platforms in the vicinity of Sable Island, with a focus on identifying the mechanisms that underlie these patterns. Results will be used to propose and test measures that can reduce bird-human interactions at offshore facilities.

Conclusion

In 2005, CWS reinvigorated the pelagic seabird monitoring program with the goal of identifying and minimizing the impacts of human activities on birds in the marine environment. Since 2005, a scientifically rigorous protocol for collecting data at sea and a sophisticated geodatabase have been developed, relationships with industry and DFO to support offshore seabird observers have been established, and almost 100,000 km of ocean track have been surveyed by CWS trained observers. These data are now being used to identify conservation issues and potential threats to birds in their marine environment.

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Appendix I

Descriptions of the most common seabird families in the NAFO convention area.

Alcidae

Members of the family Alcidae made up a combined 31% of the sightings since 2006. Dovekie was most abundant in the winter on the Grand Banks, Scotian Shelf, and in the Gulf of St. Lawrence (Figure 2). At this time of year, Brown (1988) found that the largest concentrations occurred over the shelf-breaks where apparently large numbers of zooplankton aggregate. Dovekie dive to depths of between 20 and 30 m (Falk et al. 2000), feeding almost exclusively on planktonic crustaceans. More recent data indicates a large degree of spatial overlap between high dovekie densities and *Calanus* biomass, particularly in Newfoundland slope waters, near the Greenland coast, northeastern Grand Banks and Cabot Strait during the fall (Gjerdrum et al. 2008). Dovekie are almost absent from the area during the summer (May-August) when they are on breeding colonies in the high Arctic, particularly in northwestern Greenland.

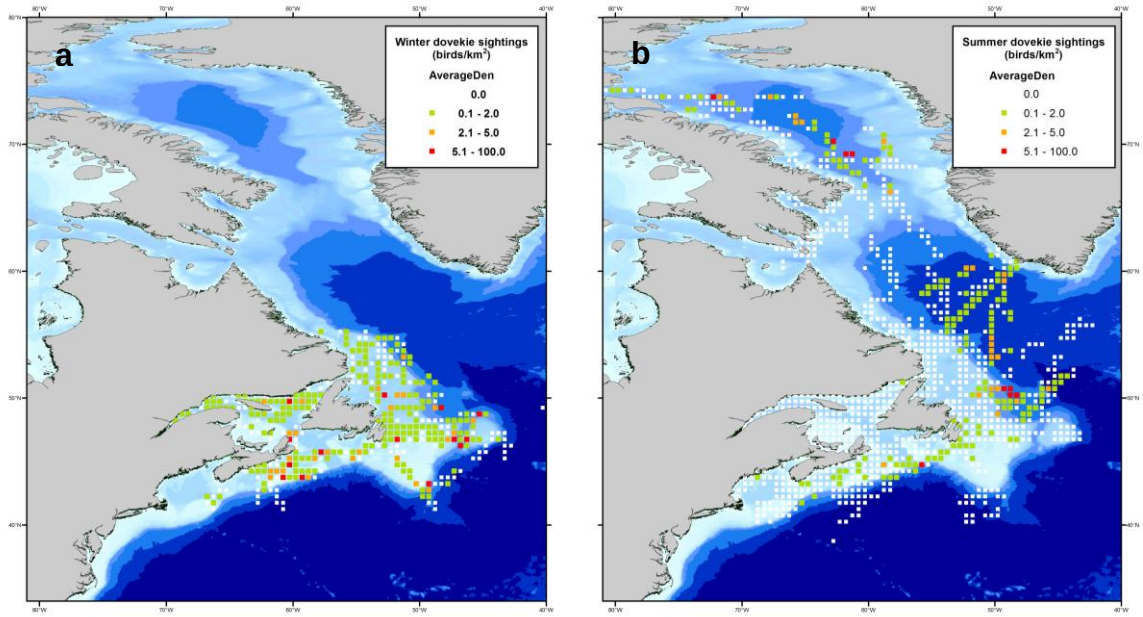

Figure 2. (a) Winter and (b) summer densities of dovekie within the NAFO convention area from 2006 - 2012 under the Eastern Canada Seabirds at Sea (ECSAS) program. The number of birds per kilometre is averaged for each 30 minute cell.

Murres (thick-billed and common) accounted for 17% of the observations from ECSAS surveys. In Atlantic Canada, thick-billed murres (*Uria lomvia*) breed in southern Labrador, and in small numbers on the north shore of the Gulf of St. Lawrence and in Newfoundland. The largest colonies are in the High Arctic. Most of the common murres in Atlantic Canada breed in eastern Newfoundland (Brown 1986). Murres breeding in the eastern Canadian Arctic winter mainly offshore Newfoundland and Labrador, with smaller numbers in the Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy, and Georges Bank. They are found mainly in continental shelf waters, not commonly close inshore (Brown 1986). Like all species in the family Alcidae, thick-billed murres pursue their prey underwater using their wings. Typical dive depth is about 20 m, but depths as great as 200 m have been recorded (Gaston and Hipfner 2000). Adults prey mainly on midwater schooling fish such as cod, smelt, and sand lance, but also on crustacea, benthic fishes, shrimps, squid, and annelids (Gaston and Hipfner 2000).

Other Alcids less commonly observed included the Atlantic puffin (*Fratercula arctica*), razorbill (*Alca torda*), and black guillemot (*Cepphus grille*). Over 12 million pairs of Atlantic puffins are estimated to

breed in the North Atlantic (Brown 1986). During the winter, they are widely dispersed and well offshore. Razorbills breed in the boreal and low Arctic regions of the North Atlantic (Brown 1986) and are believed to winter in large numbers in the Bay of Fundy (Huettmann et al. 2006). Black guillemots are more coastal in distribution and are only observed occasionally in ECSAS surveys.

Procellaridae

Procellaridae made up 31% of the birds sighting during ECSAS surveys. Northern fulmars (*Fulmarus glacialis*) are related to the petrels and shearwaters and are abundant in both Alaska and the Canadian Arctic. The majority of fulmars in North America breed in the eastern Canadian Arctic above 65˚N (Hatch and Nettleship 1998). They are widely dispersed throughout the Atlantic during the non-breeding season, but major concentrations exist on the Grand Banks off Newfoundland. They are commonly found over deep, cold waters in low-Arctic regions, and show a preference for shelf break habitats (Hatch and Nettleship 1998). Northern fulmars are omnivorous, eating fish, cephalopods, zooplankton, offal, and carrion (Hatch and Nettleship 1998). They pick their prey from the surface of the water, but may also plunge under the surface and pursue their prey. Fulmars are well known for following fishing vessels and scavenging offal.

Great shearwater (*Puffinus gravis*) breed at three main sites in the south Atlantic. These are two very remote islands in the Tristan da Cunha group and on Gough Island. Individuals leave the breeding grounds in April and migrate along the coasts of South and North America to feeding grounds in the north Atlantic. Virtually all the world's population is thought to spend the non-breeding season in the northwest Atlantic (Brown 1986). Adults return south to the breeding islands in September, although younger birds likely remain in the area through November. New tagging studies show birds follow a Z-shaped migration route (Ronconi 2007), using wind patterns to cross the Atlantic to the west coast of Africa, then south along the African coast before crossing the Atlantic a second time to coastal regions of Argentina. From there, they turn east again, returning to breeding colonies in the central south Atlantic. Great shearwater eat fish, squid, and crustaceans from the surface of the water, but are also known to pursue prey underwater.

Other shearwater species observed included the Cory's shearwater (Calonectris diomedea), Manx shearwater (P. puffinus), Audubon's shearwater (P. lherminieri), and sooty shearwater (P. griseus). Like the great shearwater, sooty shearwater breed on remote islands in the southern hemisphere and spend their non-breeding season in the north Atlantic. The bulk of the Manx shearwater population breeds in the UK, but a small number (~100 pairs) breed on Middle Lawn Island off southern Newfoundland (Lien and Grimmer 1978), and sightings are most common during the summer. Audubon's shearwaters breeding in the Caribbean have only rarely been seen in the NAFO convention area. Cory's shearwaters breed in the northeast Atlantic and are most common in August and into the fall.

Lariidae

Gulls and terns accounted for 14% of the birds sighted during ECSAS surveys, most of which were herring (*Larus argentatus*) and great black-backed gulls (*L. marinus*). Herring gulls have a circumboreal breeding range, and in eastern North America, breed along the Atlantic coast from Baffin Island to Cape Hatteras. During the winter, these birds are distributed fairly continuously along the Atlantic coast, and show a strong association with open fresh or salt water (Pierotti and Good 1994). They breed predominantly on predator-free islands, but are also known to nest in cities or on rooftops near water (Pierotti and Good 1994). Some individuals remain around breeding colonies in the winter, while others move south to tropical coastlines. These birds are most common close to land, although they are seen regularly offshore outside the breeding season (Brown 1986). Large numbers of juveniles are known to associate with humpback whales in the Gulf of Maine and the Scotian Shelf when fish are driven to the surface (Pierotti 1988).

Great black-backed gulls occur only in the North Atlantic, and breed from North Carolina to Hudson Strait, with small populations scattered inland to the Great Lakes and west to northern Europe (Brown 1986). Like the herring gulls, great black-backed gulls are most common close to land, but are regularly

observed offshore outside the breeding season. Typically, they occur farther offshore than the herring gulls, and breed farther north. Their wintering grounds extend as far south as Florida. During winter, they are often associated with coastal communities, roosting near ports, docks, dumps, and at estuaries (Good 1998).

Several other species from the family Laridae have been observed in the NAFO convention area (Table 1). Black-legged kittiwakes (*Rissa tridactyla*) are one of North America's most widely distributed gulls. They have a circumpolar breeding distribution, although most breed in the Arctic and Subarctic. In Atlantic Canada, the largest colonies are found in eastern Newfoundland and the Gulf of St. Lawrence. During the breeding season, they remain relatively close to the coast, foraging within 50 km of the colony at upwellings or oceanic fronts (Baird 1994). During migration, they are distributed offshore, often along the edge of sea ice. Black-legged kittiwakes winter from Newfoundland south to Georges Bank, feeding over a variety of water depths on capelin, sand lance, arctic cod, and pollock (Baird 1994).

Other gull species observed include the ring-billed gull (*Larus delawarensis*), Iceland gull (*L. glaucoides*), glaucous gull (*L. hyperboreus*), and laughing gull (*Leucophaeus atricilla*). Ring-billed gulls breed throughout Atlantic Canada except in Nova Scotia. Small numbers are observed on the Bank during the spring and fall migration when the birds are moving between their breeding grounds and wintering areas along the eastern coast of the US. Arctic-breeding Iceland and glaucous gulls are more often sighted on the Bank during the non-breeding season. Laughing gulls are also occasionally observed during the winter, before migrating south to breeding grounds located from central Maine to Georgia. Bonaparte's gulls (*L. philadelphia*) breed on lakes in the boreal forests of western Canada and Alaska, and are occassionally sighted during the non-breeding season. All these gull species are more typically observed along the coastline than locations far from shore.

Common (*Sterna hirundo*) and arctic terns (*S. paradisaea*) are also occasionally observed during offshore surveys, although both species tend to occur closer to the coastline. The common tern nests along the Atlantic coast from southern Labrador, throughout the Gulf of St. Lawrence, south to the Gulf Coast of Louisiana. The arctic tern breeds around the Arctic Ocean to the northern tip of Greenland south to Cape Cod, Massachusetts. Common terns spend their winter mainly along the coasts of Central and South America, while the arctic terns winter principally around Antarctica.

Hydrobatidae

Wilson's and Leach's storm-petrels made up a combined 9% of the ECSAS sightings. Like the great and sooty shearwaters, Wilson's storm-petrels (*Oceanites oceanicus*) breed in the southern hemisphere but spends the non-breeding season in the north Atlantic. They migrate between hemispheres in all oceans, although they are uncommon in the Pacific. Non-breeders may remain in the north Atlantic throughout the year (Harrison 1988).

Leach's storm-petrels (*Oceanodroma leucorhoa*) are also relatively abundant from March through September. In the northwest Atlantic, this species breeds on islands from southern Labrador to Massachusetts. The largest breeding population in the world is thought to be on Baccalieu Island in Newfoundland, where some 3.5 million pairs are estimated to nest (Sklepkovych and Montevecchi 1989). They concentrate at fronts and eddies, where upwelling brings prey to the surface, and may forage more than 200 km from breeding colonies (Huntington et al. 1996). Both species of storm-petrel feed by dipping their feet into the water, capturing prey from the surface. They feed primarily on amphipods, *Euphausia*, squid, and fish. They readily follow ships, attracted by the offal, and whales and dolphins.

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