Pelagic Aerofauna Overlap with Potential Future Development Areas

Product Objective

This series of figures summarizes the overlap between key components provided by ECCC-CWS-Atlantic and the Potential Future Development Areas (PFDAs; Figure 1) described in the Regional Assessment of Offshore Wind Development in Nova Scotia Interim Report (NS Interim Report). These products highlight the spatial and temporal distributions of regional pelagic aerofauna to facilitate the identification of potential future lease areas. Summaries are provided for each PFDA across the following seasons: Spring (April–May), Summer (June–August), Fall (September–October), and Winter (November–March). In cases where year-round data are not available, the specific period under consideration is indicated.

Summaries by PFDA are available for the following products:

- Pelagic Bird At-Sea Seasonal and Annual Modeling
- Collision and Displacement Vulnerability Models
- Colonial Bird Theoretical Foraging Radii
- Breeding Seabird Foraging Distributions

Note that the Sydney Bight PFDA includes areas proposed for both fixed and floating technologies, therefore results for both technologies are presented individually and combined.

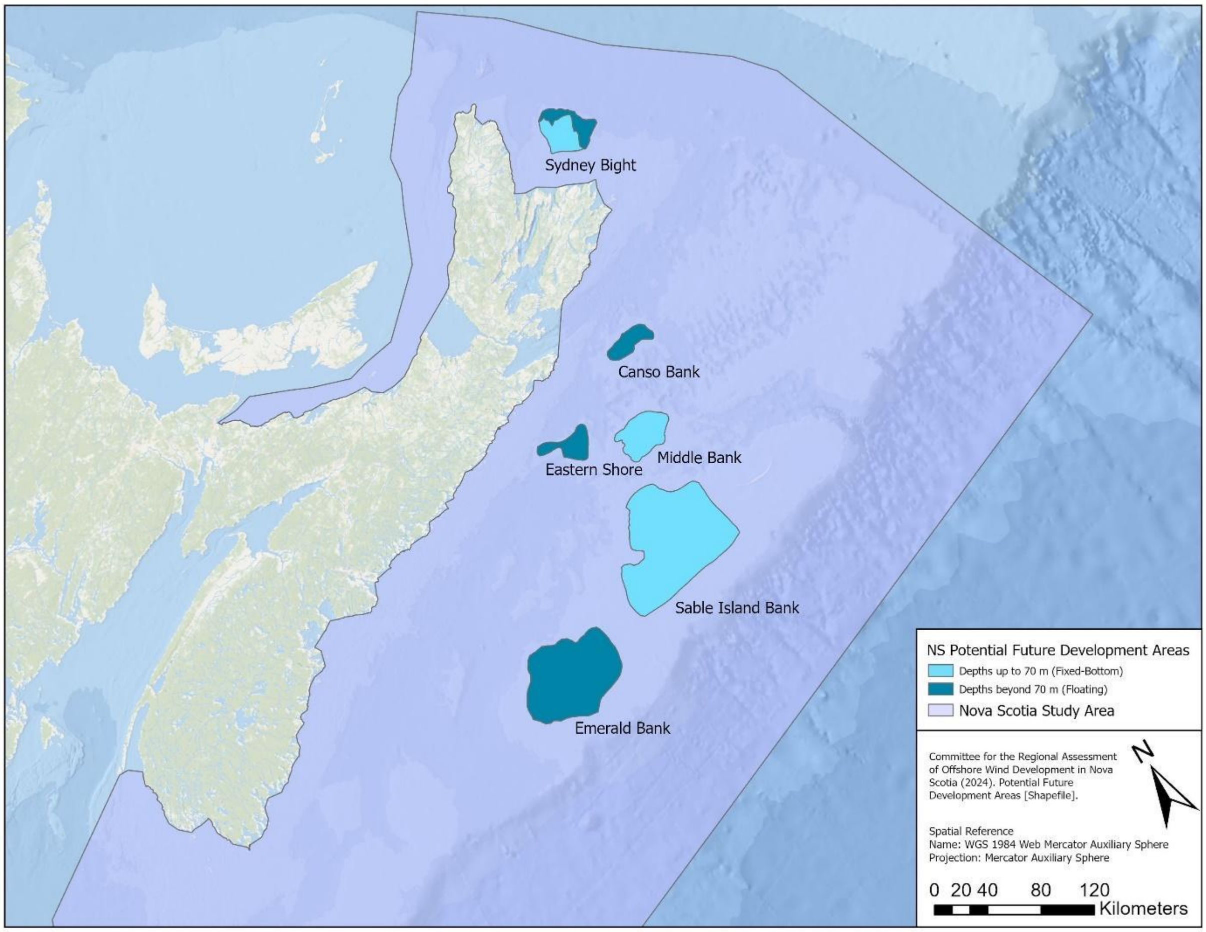

Figure 1. Potential Future Development Areas identified in the Nova Scotia Interim Report, including technology depth.

At-Sea Seasonal and Annual Modeling – Pelagic Birds

The density surface models used boat-based Eastern Canada Seabirds at Sea (ECSAS) surveys and environmental variables to predict the density of seabirds across the Atlantic region over four seasons (2006-2022). Models were built by Fifield et al., (2022) for 14 seabird taxa within the NS Regional Assessment study area. Of note, some species are combined into broader taxa if species-level identification could not be established (e.g., Shearwaters). For each season and taxa, the average predicted density of birds was calculated both within each PFDA and across the Nova Scotia study area (Figure 1). To avoid including species with low predicted density that are not expected to be present in a PFDA, any species with a predicted density lower than 0.001 bird/km^2 was set to 0. Following this, the predicted density for each species within a PFDA was summed to provide an estimated number of individuals. Any species with a summed PFDA density of less than 5 individuals was considered to be effectively absent from the PFDA and the average density for that species was set to 0. Then, the ratios of densities inside the PFDAs and the NS study area were calculated. A ratio greater than 1 relates to an above average species density within the PFDA. A ratio less than 1 relates to a below-average density within the PFDA relative to the NS study area.

Density classes were assigned based on the following ratio values: Low ≤ 1; Medium > 1 and ≤ 2; and High > 2. An example of the seasonal variations across species densities within a PFDA is shown found in Figure 2. The remaining plots are available in the accompanying folder. A summary of species with high relative density within each PFDA across seasons is provided in Table 1.

Interpretation

Ratio plots (Figure 2) present seasonal variation of the density ratios for each species within a PFDA. Color bands indicate ratio classes: Low (blue, ≤ 1), Medium (yellow, > 1 and ≤ 2), or High (red, > 2). Each point within a species grouping represents a different season. Table 1 lists species with higher density within the PFDA compared to the rest of the NS study area, indicating potential density hotspots for that species. A high-density ratio class indicates a given species may be disproportionately impacted by potential OSW energy developments in the PFDA. For example, Middle Bank overlaps with higher species densities in spring (e.g., Razorbill) and fall (e.g., Black-legged Kittiwake and Northern Gannet) compared to the NS study area (Figure 2). Conversely, Middle Bank overlaps with lower densities compared to the NS study area for most species in winter, except Black-legged Kittiwake.

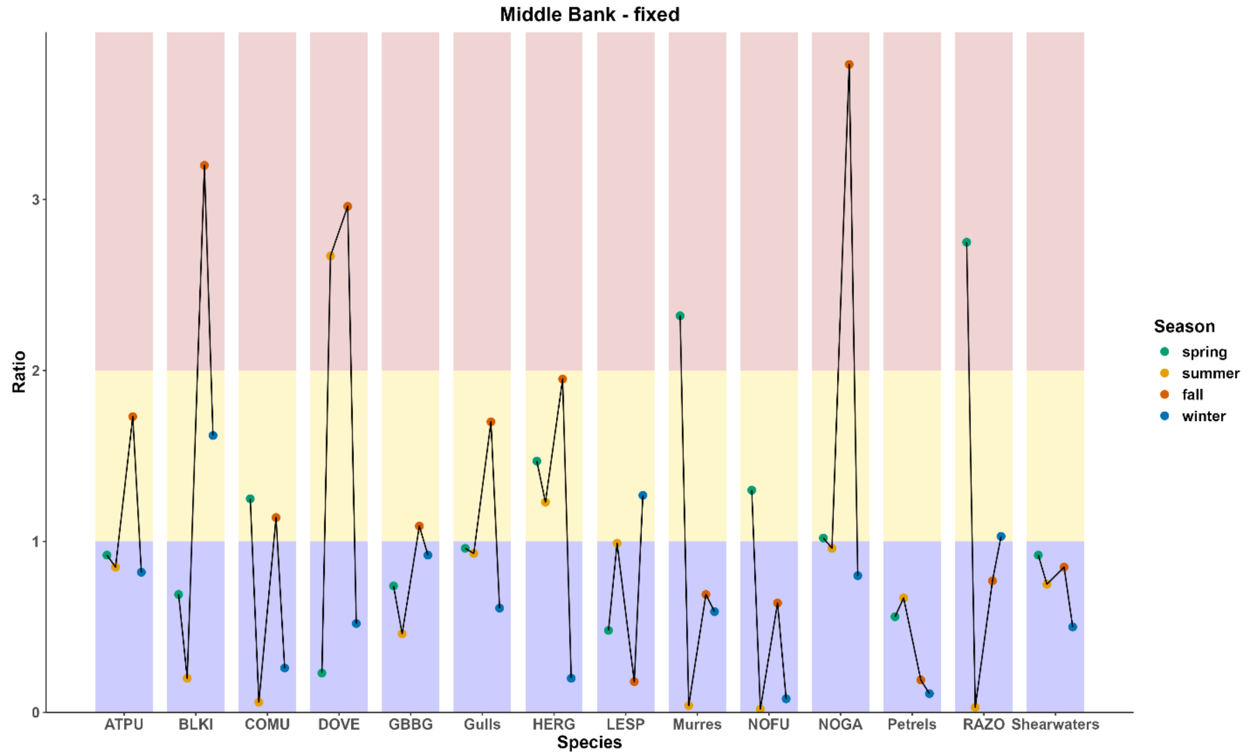

Figure 2. Ratio of predicted species density within the Middle Bank PFDA compared to the Nova Scotia study area. Points indicate the ratio for each season and color bands indicate Low (blue, ≤ 1), Medium (yellow, > 1 and ≤ 2), or High (red, > 2) ratios. Four-letter codes are provided for the following species: ATPU = Atlantic Puffin, BLKI = Black-legged Kittiwake, COMU = Common Murre, DOVE = Dovekie, GBBG = Great Black-backed Gull, HERG = Herring Gull, LESP = Leach's Storm Petrel, NOFU = Northern Fulmar, NOGA = Northern Gannet, RAZO = Razorbill.

Table 1. Predicted high-density species within each PFDA compared to the Nova Scotia study area across seasons.

Region	Technology Type	Spring	Summer	Fall	Winter
Canso Bank	Floating	Murres, Razorbill	Dovekie, Northern Gannet	Atlantic Puffin, Black-legged Kittiwake, Dovekie, Northern Gannet	-
Eastern Shore	Floating	Razorbill	-	Gulls, Herring Gull, Northern Gannet	-
Emerald Bank	Floating	-	-	-	Dovekie
Middle Bank	Fixed	Murres, Razorbill	Dovekie	Black-legged Kittiwake, Dovekie, Northern Gannet	-
Sable Island Bank	Fixed	Shearwaters	-	-	Leach's Storm Petrel, Shearwaters
Sydney Bight	Fixed	Black-legged Kittiwake, Northern Gannet	Atlantic Puffin, Black-legged Kittiwake, Northern Gannet	Black-legged Kittiwake, Northern Gannet, Razorbill	-
Sydney Bight	Floating	Black-legged Kittiwake	Atlantic Puffin, Black-legged Kittiwake, Northern Gannet	Black-legged Kittiwake, Murres, Northern Gannet, Razorbill	-
Sydney Bight	Combined	Black-legged Kittiwake, Northern Gannet	Atlantic puffin, Black-legged Kittiwake, Northern Gannet	Black-legged Kittiwake, Murres, Northern Gannet, Razorbill	-

Assumptions and Caveats:

- This work is based on density surface models that are preliminary and subject to change.
- This work is based on the ECSAS survey database and can be influenced by survey effort gaps from that product, especially during winter months (December to March).
    - See the Pelagic Bird Survey Effort product for potential data gaps.
- For both the plots and summary table, a high-density ratio does not imply that the actual density of the species/taxa is high. A high-density ratio indicates that those species aggregate more in this area than in the rest of the study area. Potential OSW development could pose a disproportional risk to those species, and further exploration is warranted.
- Results are presented in relation to the Nova Scotia study area and may not represent the whole Atlantic region.
- Seasonal estimates can be biased by the temporal presence of birds, especially in winter (November to March). This may include density estimates based on late remaining and/or early arriving individuals when the species would otherwise be mostly absent during the rest of the season.

References

Environment and Climate Change Canada. 2023. Atlas of Seabirds at Sea in Eastern Canada 2006 - 2020 (50 km hex update). Unpublished internal data.

Fifield D, Gjerdrum C, Wong S, Beaumont M, Bolduc F, Miller D. 2023. Unpublished data from study: Density Surface Modeling of seabird abundance in NW Atlantic and Eastern Canadian Arctic.

Collision and Displacement Vulnerability

These products summarize the collision (CV) and displacement (DV) vulnerability risks for all pelagic bird species inside each of the current PFDAs. Species-specific metrics were developed to assess vulnerability of colliding with or being displaced by offshore wind energy development. Two series of products were created using these values:

- **Density-weighted models**: CV and DV scores were multiplied across the predictive pelagic bird density surface model rasters (Fifield *et al.*, 2023) to generate spatial estimates of vulnerability weighted by bird density.
- **Normalized models**: density surface model rasters were first normalized (rescaled between 0 and 1) and then CV and DV scores were applied.

These steps were repeated for each species and then summed to produce all-species rasters for collision and displacement vulnerability. These vulnerability rasters were produced with a resolution of 15 km x15 km then resampled into a grid with a cell size of 1 km x 1 km and summarized into quintiles within the Nova Scotia study area to represent collective vulnerability in each cell. Vulnerability values were classed as follows: Low (0-20%), Low-moderate (20-40%), Moderate (40-60%), Moderate-high (60-80%), High (80-100%). Each cell inside the PFDA was assigned a ranking. The proportion of each ranking was then calculated for each PFDA by risk type and product (collision and displacement; normalized and density-weighted) across seasons.

Summary plots are presented for the normalized (Figure 3) and density-weighted (Figure 4) vulnerability rankings relative to the study area. Absolute seasonal average vulnerability scores are also provided to inform how vulnerability changes between seasons for normalized (Figure 5) and density-weighted (Figure 6) scores.

Interpretation

These products demonstrate the seasonal variation of species-specific collision and displacement vulnerability scores within each PFDA. In Figures 3 and 4, lighter colors indicate the proportion of high vulnerability scores overlapping with a PFDA while darker colors indicate overlapping with lower vulnerability scores. For example, the Eastern Shore PFDA has a higher collision score during the fall than the Sydney Bight PFDAs. Note that “Low” vulnerability scores are not present within any of the PFDAs. Figures 3 and 4 present vulnerability proportions relative to the entire NS study area. A high proportion of high vulnerability does not necessarily equate to a high vulnerability score. Therefore, Figures 5 and 6 present the absolute seasonal variations in vulnerability scores. Score values are influenced based on whether the products are density-weighted or normalized.

Density-weighted scores consider the estimated number of birds present and provide higher scores in areas where more birds can be found (e.g., Sable Island Bank). These values are influenced by species with high density estimates. Normalized scores standardize density values between zero and one, which creates a product that is more easily comparable across species.

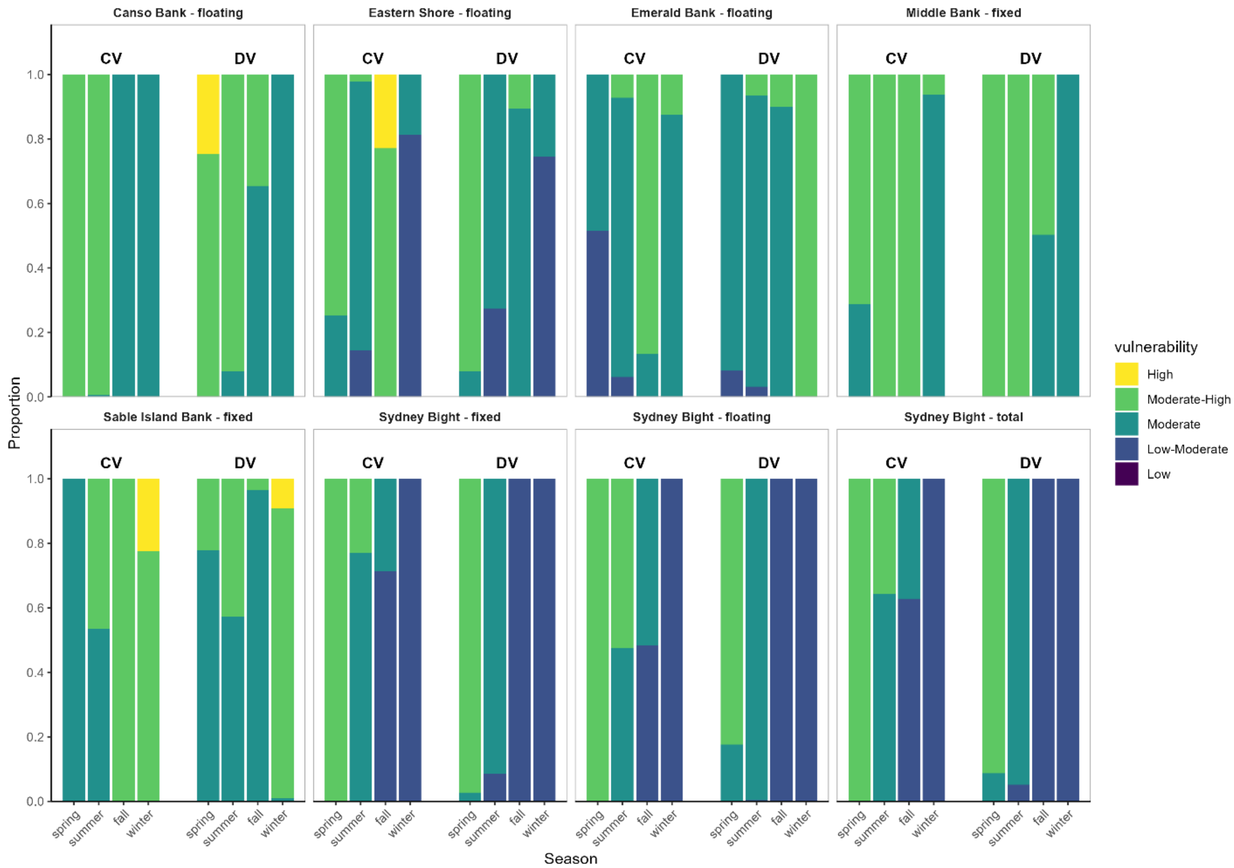

Figure 3. Seasonal proportion of normalized collision vulnerability (CV) and displacement vulnerability (DV) scores within each Potential Future Development Area (PFDA).

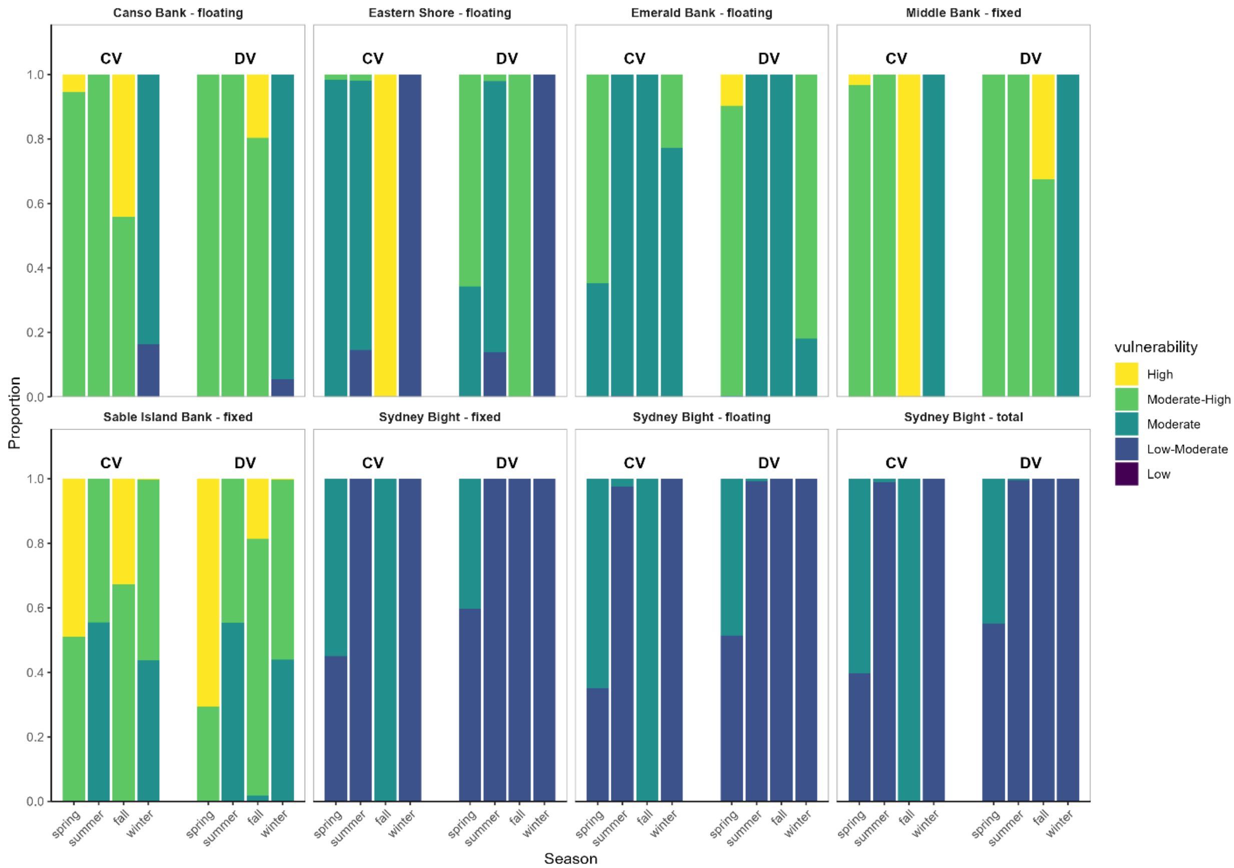

Figure 4. Seasonal proportion of density-weighted collision vulnerability (CV) and displacement vulnerability (DV) scores within each Potential Future Development Area (PFDA).

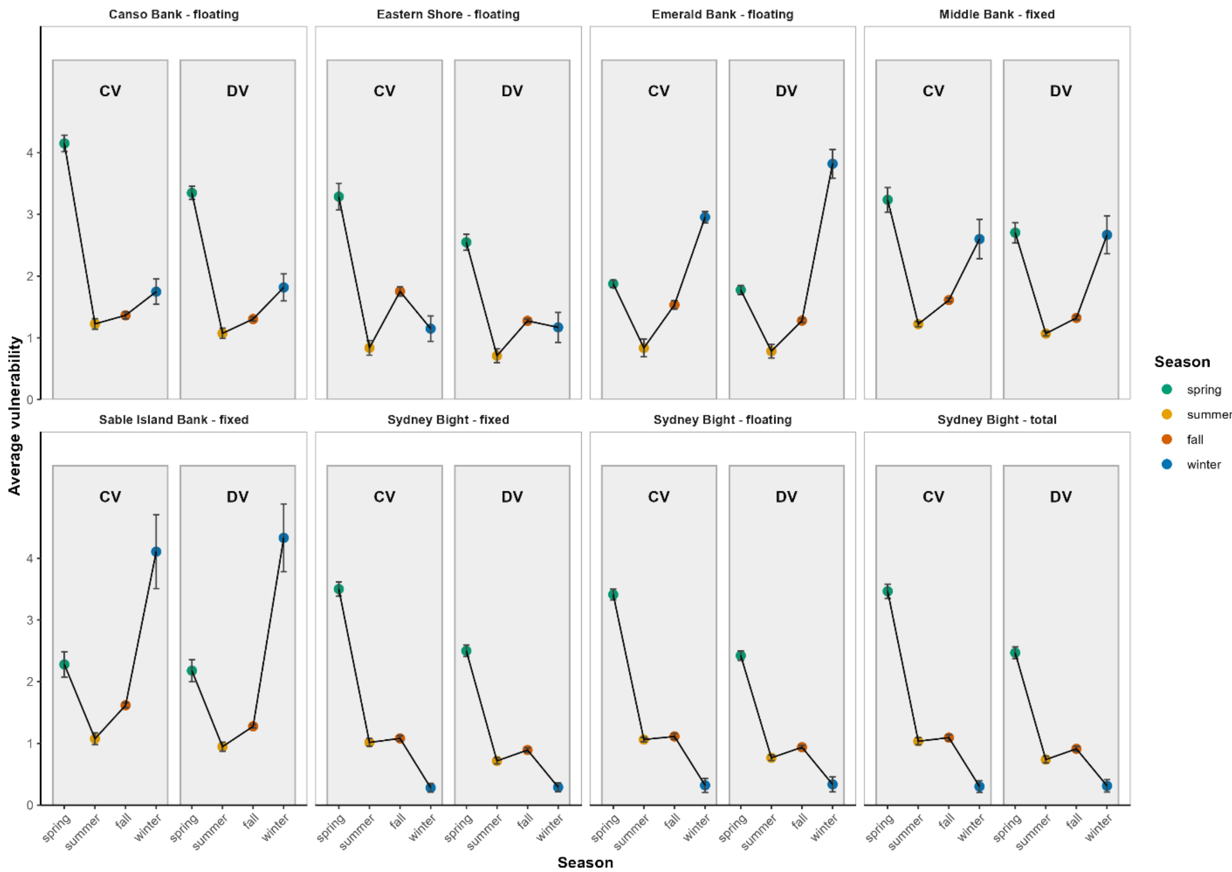

Figure 5. Normalized seasonal average collision vulnerability (CV) and displacement vulnerability (DV) scores inside each Potential Future Development Area (PFDA).

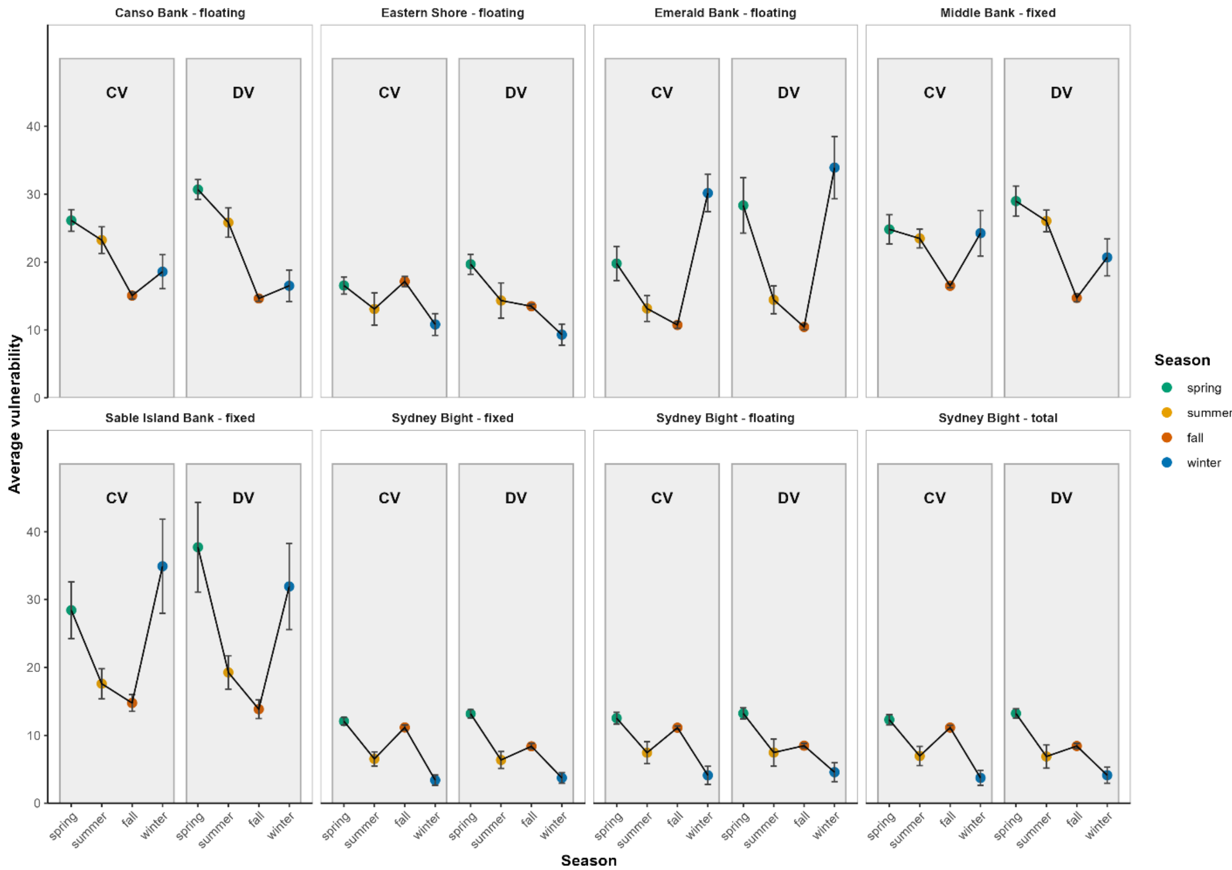

Figure 6. Density-weighted seasonal average collision vulnerability (CV) and displacement vulnerability (DV) scores inside each Potential Future Development Area (PFDA).

Assumptions and Caveats

- The density surface models used to inform this work are preliminary and will be updated to correct erroneous predictions. This includes a known overestimation of Leaches Storm-petrel densities in winter.
- The scores are presented in relation to the Nova Scotia study area and might not represent the Atlantic region.
- Proportions and classifications in Figures 3 and 4 are relative to the season. This helps identify areas of risk during a particular season. However, this does not indicate an absolute increase or decrease in risk. For absolute risk changes, refer to Figures 5 and 6.
- The products present scores aggregated for all species. Vulnerability scores can differ at the species level and may not follow the patterns presented here.
- These products only consider pelagic aerofauna species. Information on other vulnerable aerofauna species that may be present, such as migrating landbirds and shorebirds, is not included. Additional consideration for these species groups will be required for siting decisions.

References

Fifield D, Gjerdrum C, Wong S, Beaumont M, Bolduc F, Miller D. 2023. Unpublished data from study: Density Surface Modeling of seabird abundance in NW Atlantic and Eastern Canadian Arctic.

Colonial Bird Theoretical Foraging Radii

Foraging radius models were developed for 23 bird species with known colonies within Atlantic Canada, following the work of Critchley et al., (2018). Using species-specific mean maximum foraging estimates, buffers were mapped and weighted by 50% of the maximum historic population estimate at each colony from 1974 to 2024. The resulting product represents a theoretical density-weighted foraging radius that estimates where individuals might forage at the highest densities (birds/km^2) during the breeding season. More details are available in the Colonial Foraging Range submissions. For each species and foraging guild, the average predicted density of foraging birds was calculated both within each PFDA and across the Nova Scotia study area. A summary of the ratio between the PFDA and the regional average predicted densities was then calculated. A ratio greater than 1 represents an above-average bird density within the PFDA relative to the NS study area, while a ratio less than 1 represents a below-average density within the PFDA relative to the NS study area. Density classes were assigned based on the following ratio values: Low ≤ 1; Medium > 1 and ≤ 2; and High > 2.

Interpretation

Ratio plots represent the density ratios for each species (Figure 7) or foraging guild (Figure 8) inside a given PFDA during the breeding season. Colored bars indicate ratio classes: Low (blue, ≤ 1), Medium (yellow, > 1 and ≤ 2), or High (red, > 2). A high-density ratio class indicates a given species may be disproportionately impacted by potential OSW energy developments within a PFDA. Species with similar foraging behaviour will likely demonstrate similar traits, such as flight height, while searching for prey. These behaviours link directly to the risk of collision by placing birds within the rotor-swept zone. A summary of the species found within each foraging guild is presented in Table 2. Of note, neither the coastal nor benthic foraging guild summaries are presented as they do not include species with foraging ranges that overlap the current PFDAs.

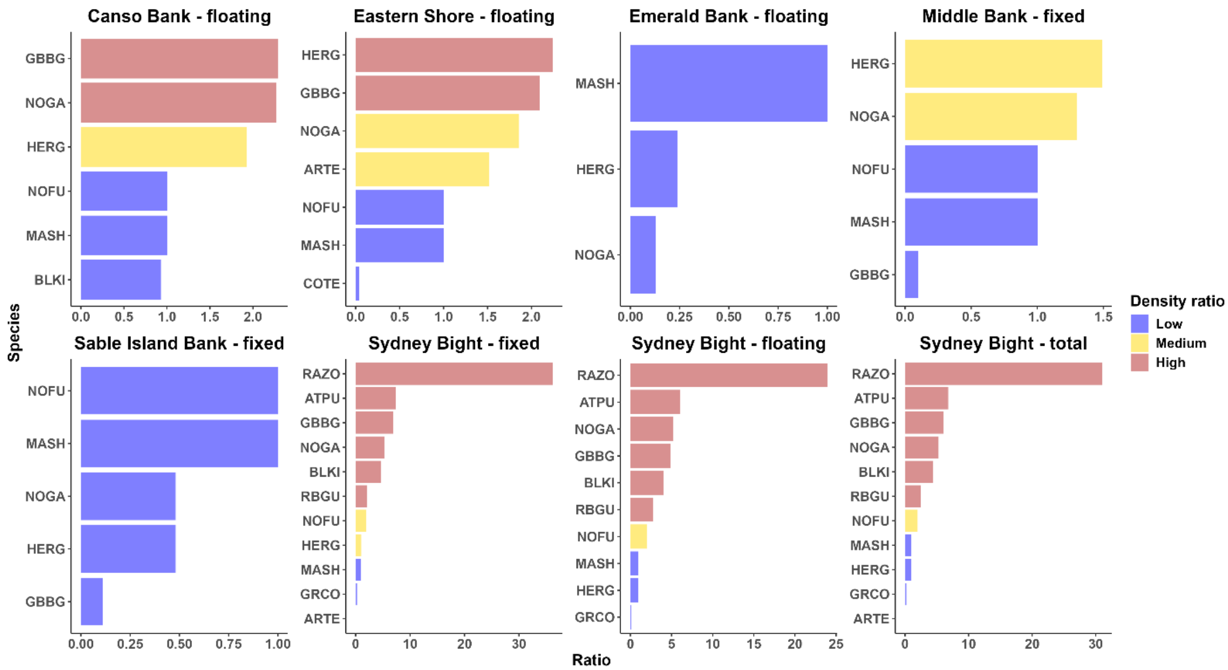

Figure 7. Ratio of the predicted density of foraging birds during the breeding season within each PFDA compared to the Nova Scotia study area for each species using a theoretical foraging radii approach. Colors indicate whether the ratio is considered Low (blue, ≤ 1), Medium (yellow, > 1 and ≤ 2), or High (red, > 2). Four-letter codes are provided for the following species: ARTE = Arctic Tern, ATPU = Atlantic Puffin, BLKI = Black-legged Kittiwake, COMU = Common Murre, COTE = Common Tern, GBBG = Great Black-backed Gull, GRCO = Great Cormorant, HERG = Herring Gull, MASH = Manx Shearwater, NOFU = Northern Fulmar, NOGA = Northern Gannet, RAZO = Razorbill, RBGU = Ring-billed Gull.

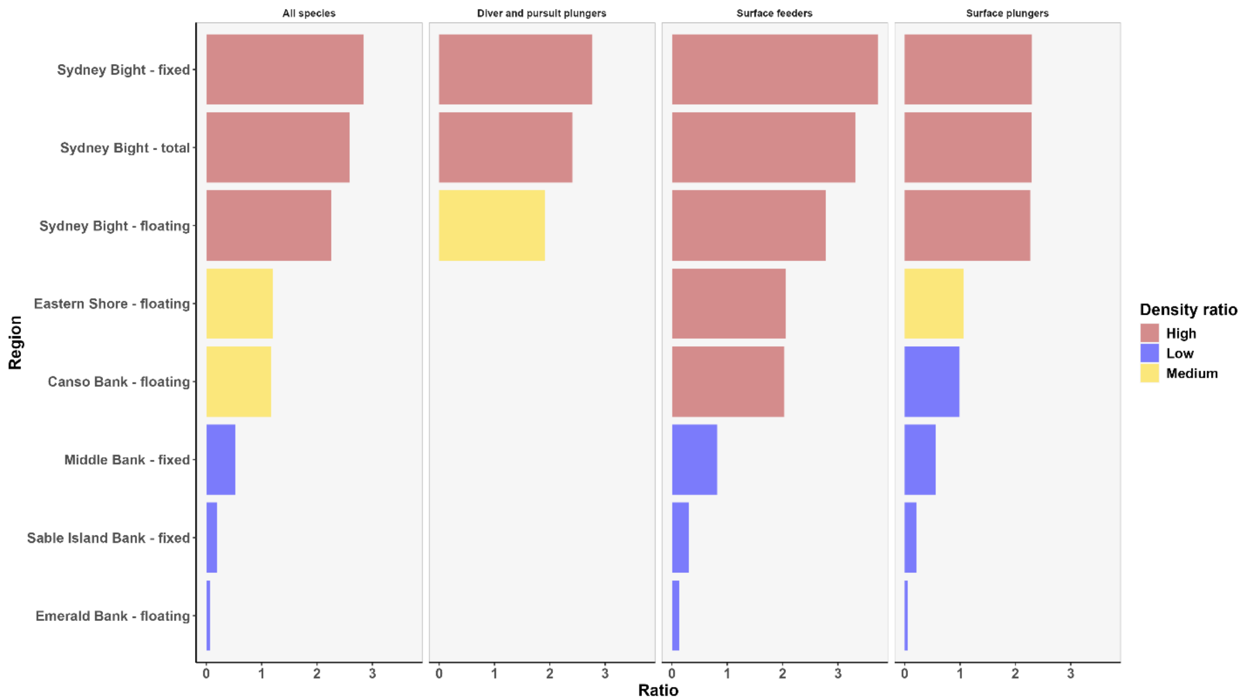

Figure 8. Ratio of the predicted density of foraging birds during the breeding season within each PFDA compared to the Nova Scotia study area, summarized for all species combined and by foraging guild using a theoretical foraging radii approach. Colours indicate whether the ratio is considered Low (blue, ≤ 1), Medium (yellow, > 1 and ≤ 2), or High (red, > 2). Species included in each foraging guild are highlighted in Table 2.

Table 2. Summary of species that comprise each foraging guild. Note: not all species within a given foraging guild have individual buffers that overlap with current PFDAs; those species with current overlap are indicated in bold with an asterisk (*). The remaining species may need to be considered for foraging buffer overlap if additional PFDAs are proposed.

Foraging Guild	Species
Diver and Pursuit Plungers	**Atlantic Puffin***, Black Guillemot, **Common Murre***, Double-crested Cormorant, **Great Cormorant***, **Manx Shearwater***, **Razorbill***, Thick-billed Murre
Surface Feeders	Black Tern, **Black-legged Kittiwake***, Glaucous Gull, **Great Black-backed Gull***, **Herring Gull***, Laughing Gull, **Northern Fulmar***, **Ring-billed Gull***
Surface Plungers	**Arctic Tern***, Caspian Tern, **Common Tern***, **Northern Gannet***, Roseate Tern

Assumptions and Caveats

- Ratios provide the relative density compared to the entire Nova Scotia study area. These do not indicate the absolute density of birds overlapping with a given PFDA.

- Density ratios are limited to the breeding season, during which half of the population are assumed to stay at the nest. As the breeding season progresses, the estimated density of birds is likely to increase in the offshore due to both parents foraging simultaneously and chick fledging. Therefore, density ratios may underestimate the overlap with PFDAs during the dispersal period.
- Maximum colony population estimates between 1974 – 2024 were extracted to capture variation in survey methods and the cyclic nature of populations. The density ratios may not reflect the most current population estimates. However, these ratios represent a precautionary approach to species densities.
- Ronconi et al., (2022) generated estimates from predictive density modelling that incorporated environmental variables (see below). As a result, the Ronconi et al. estimates will be more robust and colony specific for single-species applications or regional conservation measures.

References

Critchley, E. J., Grecian, W. J., Kane, A., Jessopp, M. J., Quinn, J. L. (2018). Marine protected areas show low overlap with projected distributions of seabird populations in Britain and Ireland. Biological Conservation, 224: 309–317

Ronconi, R.A., Lieske, D.J., McFarlane Tranquilla, L.A., Abbott, S., Allard, K.A., Allen, B., Black, A.L., Bolduc, F., Davoren, G.K., Diamond, A.W. and Fifield, D.A. (2022). Predicting seabird foraging habitat for conservation planning in Atlantic Canada: Integrating telemetry and survey data across thousands of colonies. Frontiers in Marine Science, 9, p.816794.

Breeding Seabird Foraging Distributions

Ronconi et al., (2022) built colony-centered foraging distribution models using tracking data (GPS/PTT/VHF) and environmental variables for 14 species of seabirds breeding at colonies in Atlantic Canada. Species were tracked from various colonies within the region using tags deployed on breeding adults. This approach used machine-learning models to further predict foraging distributions at un-sampled colonies.

To create a complementary comparison to the theoretical foraging radii (above), average predicted density of foraging birds was calculated both within each PFDA and across the Nova Scotia study area. A summary of the ratio of average predicted density between the PFDA and the regional densities was then calculated. A ratio greater than 1 relates to an above-average density within the PFDA relative to the NS study area, while a ratio less than 1 relates to a below-average density within the PFDA. Density classes were assigned based on the following ratio values: Low ≤ 1; Medium > 1 and ≤ 2; and High > 2.

Interpretation

Ratio plots represent the density ratios for each species (Figure 9) within a given PFDA during the breeding season. Coloured bars indicate ratio classes: Low (blue, ≤ 1), Medium (yellow, > 1 and ≤ 2), or High (red, > 2). A high-density ratio class indicates a given species may be disproportionately impacted by potential OSW energy developments within a PFDA. However, ratios do not indicate absolute density. Low and medium density ratios indicate that a given species is found at a lower or similar average density to the entire NS study area. High numbers of these species may still overlap with a PFDA.

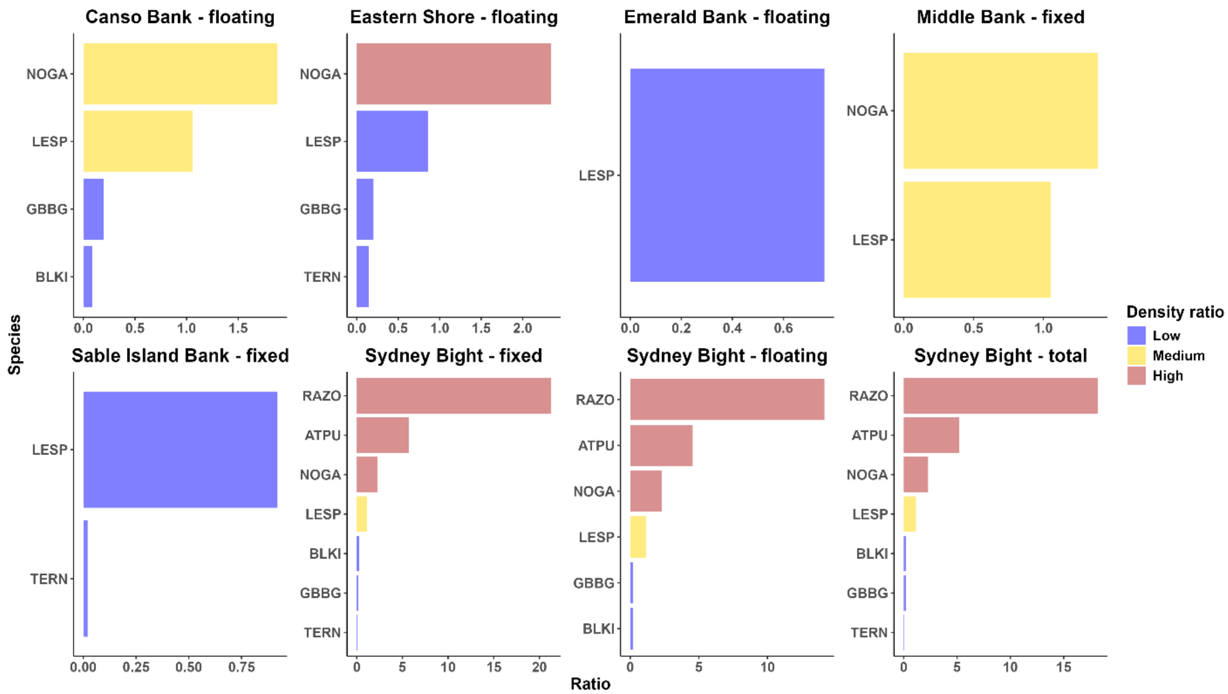

Figure 9. Ratio of the predicted density of foraging birds during the breeding season within each PFDA compared to the Nova Scotia study area for each species using predictive density distribution models. Colours indicate whether the ratio is considered Low (blue, ≤ 1), Medium (yellow, > 1 and ≤ 2), or High (red, > 2). Four-letter codes are provided for the following species: ARTE = Arctic Tern, ATPU = Atlantic Puffin, BLKI = Black-legged Kittiwake, GBBG = Great Black-backed Gull, LESP = Leach's Storm-Petrel, NOGA = Northern Gannet, RAZO = Razorbill, TERN = Terns (Arctic tern and Common tern).

Assumptions and Caveats

- The initial analysis was limited to tracking data collected during the breeding seasons. The resulting ratios represent only the comparison of foraging bird densities during that same period.
- Ratios do not indicate the absolute density of birds overlapping with a given PFDA.
- These maps were developed only for species with sufficient tracking data, as per Ronconi et al., 2022. For species with limited tracking data, the theoretical foraging radii (above) should be applied to fill those knowledge gaps.

References

Ronconi, R.A., Lieske, D.J., McFarlane Tranquilla, L.A., Abbott, S., Allard, K.A., Allen, B., Black, A.L., Bolduc, F., Davoren, G.K., Diamond, A.W. and Fifield, D.A. (2022). Predicting seabird foraging habitat for conservation planning in Atlantic Canada: Integrating telemetry and survey data across thousands of colonies. Frontiers in Marine Science, 9, p.816794.