Ongoing Project Updates and New Project Summaries by Members of the Atlantic Marine Bird Cooperative

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At-Sea Surveys

Visibility Correction Factors for Multiple Species of Sea Ducks and Diving Ducks using an Aerial Remote Sensing Approach

Contact: Luke Fara, USGS Upper Midwest Environmental Sciences Center, (608) 781-6233, lfara@usgs.gov
Collaborators: Mark Koneff, USFWS, Division of Migratory Bird Management
Drew Fowler, Wisconsin Department of Natural Resources, Office of Applied Sciences
Taylor Finger, Wisconsin Department of Natural Resources, Bureau of Wildlife Management

Aerial ocular surveys provide the most cost and time-efficient method to evaluate the relative abundance and spatial distributions of breeding, staging, and wintering waterfowl. However, the survey method is subject to substantial visibility bias and visibility correction factors must be calculated to correct for incomplete detection. Calculation of visibility correction factors in remote or hard to access places, such as open water environments, is difficult but new technologies are offering a means to estimate such correction factors. To estimate visibility correction factors for waterbirds in open water environments, we will be using the advanced remote sensing capabilities of the U.S. Fish and Wildlife Service - Division of Migratory Bird Management. We will capture high-resolution digital imagery of waterbirds in Green Bay, annotate avian species within the images, and compare annotated image counts to ocular counts that will be flown just after image collection. Results of this combined survey will allow for estimation of visibility correction factors and associated uncertainties at variable spatial and temporal scales, the exploration of how density plays a role in visibility correction factors, and provide baseline relative abundance and spatial distribution estimates for multiple species of waterfowl and waterbirds in the survey area. Estimation of visibility correction factors will be important for agencies that are conducting aerial surveys over open water environments to assess waterfowl abundance and distributions during the non-breeding period. Surveys are planned to begin fall 2021.

Post-construction mortality monitoring at the Coastal Virginia Offshore Wind Pilot Project

Contact: Greg Forcey, Normandeau Associates, Gainesville, FL, gforcey@normandeau.com

Normandeau is conducting post-construction bird and bat monitoring for Dominion Energy at the Coastal Virginia Offshore Wind (CVOW) Pilot Project. Post-construction monitoring is being done using a combination of remote sensing technologies and 6 boat-based surveys being done throughout the first year of operations. Our remote sensing approach consists of 2 ATOM systems collecting data from each turbine platform during winter, spring, and fall during the first year. Each ATOM system consists of 4 sensor types that collect data 24/7: 2 thermal cameras operating in stereo which permits flight height estimation, a visible light camera to supplement the thermal cameras during the day, 2 bird and 2 bat acoustic detectors, and a VHF receiver and associated whip antennas for detecting NanoTagged birds. These systems characterize the bird and bat activity in the rotor swept zone and can provide insights into micro-avoidance behavior.

VHF receivers can also provide data on the presence of NanoTagged birds in the vicinity of the turbines.

Monitoring Birds at Sea in Eastern Canada

Contact: Carina Gjerdrum, Canadian Wildlife Service, Environment and Climate Change Canada, carina.gjerdrum@ec.gc.ca

The Canadian Wildlife Service (CWS) of Environment Climate Change Canada (ECCC) has been conducting seabird surveys at-sea from both ships and aircraft since 2006 to quantify abundance and distribution in the western North Atlantic. Despite a reduction in monitoring effort due to COVID-related travel restrictions, we collected data along 23,000 km representing 192 survey days in 2020 and 2021. The data are used to help understand the threats faced by birds at sea and help define areas for marine protection. An atlas providing maps and datasets representing at-sea densities in eastern Canada from 2006-2016 can be found on the Government of Canada open data portal (https://open.canada.ca/data/en/dataset/f612e2b4-5c67-46dc-9a84-1154c649ab4e), soon to be updated to include data collected through 2021.

In-flight Machine Learning for Automated Detection and Classification of Wildlife from Digital Aerial Imagery

Contacts: Bradley Pickens, USFWS Division of Migratory Bird Management, bradley_pickens@fws.gov; Mark Koneff, USFWS Division of Migratory Bird Management, mark_koneff@fws.gov; Timothy White, BOEM Environmental Studies Program, timothy.white@boem.gov; Kyle Landolt, USGS Upper Midwest Environmental Sciences Center, klandolt@usgs.gov; Enrika Hlavacek, USGS Upper Midwest Environmental Sciences Center, ehlavacek@usgs.gov; Jennifer Dieck, USGS Upper Midwest Environmental Sciences Center, jdieck@usgs.gov

The U.S. Fish and Wildlife Service (USFWS), Bureau of Ocean Energy Management (BOEM), and U.S. Geological Survey (USGS) are developing a digital aerial imagery and annotation database that will be used to train machine learning algorithms for the automated detection and classification of seabirds and other marine wildlife. In addition, USFWS and BOEM are developing and deploying advanced multi-camera arrays and direct geo-referencing systems as well as computing systems for in-flight image processing and machine learning (Figures 1, 2). In 2020-2021, over 1.8 million images have been obtained over the Atlantic Ocean Outer Continental Shelf. This includes data from migratory, summer, and winter seasons. A first-generation bird detection algorithm, based on machine learning methodology, has now been developed and provides in-flight detection of birds in images. The detection algorithm is critical to improving efficiency in processing because the sheer volume of data precludes manual processing and <3% of imagery contains birds. A central database for imagery is active and will enable coordination of data annotation by numerous taxonomic experts from multiple agencies and institutions to develop a species-level classification methodology. In the future, machine learning models will automate wildlife detection and species classification to improve airborne wildlife survey by improving efficiency, reducing observer bias, and improving the spatial accuracy of airborne wildlife surveys and to improve our knowledge of wildlife distribution and

abundance to inform environmental assessments and impact analyses of offshore energy developments as well as other population take assessments.

Figure 1. High-resolution camera array integrated with direct geo-referencing system and in-flight data processing components mounted in U.S. Fish and Wildlife Service aircraft.

Figure 2. Operator workstation for remote sensing and machine learning systems control in U.S. Fish and Wildlife Service aircraft.

Analysis of Black Scoter Population Count Data

Contact: Beth Ross, South Carolina Cooperative Fish and Wildlife Research Unit, bross@usgs.gov
Partners: USFWS, Environment and Climate Change Canada

Sea ducks are understudied relative to other species of waterfowl, especially in the southern U.S. Atlantic Coast. Climate change and human activity could affect sea duck wintering sites and, therefore, cause negative carry-over effects through the rest of their lifecycle. This project was designed to better describe wintering sites, movement, and habitat use of black scoters along the southern U.S. Atlantic Coast using satellite telemetry and aerial survey data. Results could be used to better inform survey methods for black scoters or to decrease conflict with wind energy development in the area. For more information: https://www1.usgs.gov/coopunits/project/135018399744/beross

Recent products:

Plumpton, H.M., S.G. Gilliland, and B.E. Ross. 2020. Geographic differences in the winter movements of the Atlantic population of Black Scoters. Submitted to Avian Conservation and Ecology. https://doi.org/10.5751/ACE-01654-150206

Stellwagen Sanctuary Seabird Stewards

Contacts: Anne-Marie Runfola, Program Coordinator anne-marie.runfola@noaa.gov; Caitlin Fitzmaurice, S4 Program Assistant and Data Manager caitlin.fitzmaurice@noaa.gov
The Stellwagen Sanctuary Seabird Stewards (S4) program began in 2011 and is a community science research and monitoring effort collecting data on seabirds in and around NOAA's Stellwagen Bank National Marine Sanctuary (SBNMS). Standardized boat-based surveys follow a dedicated transect throughout the Sanctuary, with a recorder and observer team collecting information on sightings within 300 m of the vessel. The S4 program is run by SBNMS staff and skilled volunteers with seabird knowledge and training. Some goals of the program include collecting systematic baseline data on spatial and temporal distribution of seabirds, informing and educating the public, and training volunteers as seabird observers.

Despite the challenges of the pandemic, we were still able to collect S4 data. While whale watching trips and Second Side surveys have temporarily stopped due to safety precautions, we successfully conducted three Standardized surveys in 2020 (two pre-pandemic) and six Standardized surveys in 2021.

Since the program began in 2011, we have completed a total of 41 Standardized surveys and approximately 300 opportunistic whale watch surveys. Our data includes over 280,000 sightings, of which about 275,000 sightings were seabirds.
In addition to the 280,000 sightings from the past ten years of surveying effort, our database includes info on seabird behavior, age, and plumage, a GPS location for each sighting, and additional environmental data on sea surface temperature and chlorophyll-a concentration for each standardized survey. The S4 database is ready for joint project proposals, so please be in touch if interested!

Current partnerships include student and intern projects. This past Fall, we continued our partnership with the Boston University Marine Program (BUMP) and worked closely with a group of students who each used the S4 data to answer a research question. Other intern projects included a comparison of survey efforts (Standardized vs. Second Side) by Derek Garvey, a look into seasonal distribution of large resident gulls by Lara Hakam, and an analysis of environmental and biological factors influencing alcid abundance and distribution by Max Fournier.

We are working to answer baseline questions about the abundance and distribution of seabird species in SBNMS. We have established relative seasonal abundance by seabird family through 2016, but plan to include data from 2017-2021. Effort correction spatially using a grid cell system has also been completed with help of intern Jaxine Wolfe and volunteer Kevin Powers, and is ready for initial analysis. We hope to layer our seabird data with sand lance and whale data to examine overlap between species. We look forward to answering these questions and many more!

High Resolution Aerial Baseline Surveys of Marine Wildlife in the New York Offshore Planning Area

Contact: Julia Robinson Willmott. Normandeau Associates, Gainesville, FL, jwillmott@normandeau.com

On behalf of NYSERDA, Normandeau in collaboration with APEM is completing the reporting on the three-year survey effort collecting spatial data using high-resolution digital aerial surveys of wildlife (birds, marine mammals, sea turtles, sharks, rays, large bony fish and fish shoals) in the New York Offshore Planning Area (OPA), from the south shore of Long Island to the continental shelf break. The approximate size of this area is 12,650 square nautical miles and includes state and federal waters. With four seasonal surveys per year, these surveys became the world's largest aerial digital survey effort in the offshore environment. The ultra-high resolution aerial digital surveys are designed to capture seasonal variations in wildlife distributions for three consecutive years. Targets within images are identified to the lowest possible taxonomic group and georeferenced. The objectives are to provide information to support the responsible siting of offshore wind projects, and to act as a baseline for monitoring impacts of stressors on wildlife in the OPA. The survey reporting determines the distribution and relative abundance of wildlife and determines the seasonal and inter-annual variability of the distribution.

The ReMOTe (https://remote.normandeau.com) data management system is used for this project, which allows input from remote collaborators and facilitates data processing, project monitoring, and visualization for the client through a secured password protected log-in. Final reports are also posted here. ReMOTe provides efficient workflow, traceable QA/QC, and provides quality data outputs in a timely manner. As resulting data are to support responsible siting of offshore wind projects, the cloud-based interactive GIS visualization tools on ReMOTe provided for client view, and to a lesser extent public view, includes toggle on and off buttons to view distributions by season, species, flight height, and species associations with bathymetry.

High Resolution Aerial Ecological Baseline Studies of the U.S. Outer Continental Shelf, North Carolina and South Carolina

Contact: Julia Robinson Willmott. Normandeau Associates, Gainesville, FL, jwillmott@normandeau.com

On behalf of Bureau of Ocean Energy Management (BOEM), Normandeau in collaboration with APEM is completing the reporting on the ultra-high resolution digital surveys along the North Carolina and South Carolina coast line. Survey effort includes more detailed grid surveys of four wind energy areas defined by BOEM. The area covers approximately 11,000 square nautical miles and the surveys record the presence of marine mammals, turtles, birds, cartilaginous fish, large bony fish, boats and other structures, location of sargassum and weed mats, and fish shoals. The ultra-high aerial digital surveys are designed to capture the seasonal variations in wildlife distributions for two consecutive years. Targets in images are identified to the lowest possible taxonomic group and georeferenced. The objectives are to provide information to support the responsible siting of offshore wind projects, and to act as a baseline for monitoring impacts of stressors on wildlife around the North and South Carolina coastline. The survey reporting determines the distribution and relative abundance of wildlife and determines the seasonal and inter-annual variability of the distribution.
The ReMOTe (https://remote.normandeau.com) data management system is used for this project, which allows input from remote collaborators and facilitates data processing, project monitoring, and visualization for the client through a secured password protected log-in. Final reports are also posted here. ReMOTe provides efficient workflow, traceable QA/QC, and provides quality data outputs in a timely manner. As resulting data are to support responsible siting of offshore wind projects, the cloud-based interactive GIS visualization tools on ReMOTe provided for client view, and to a lesser extent public view, includes toggle on and off buttons to view distributions by season, species, flight height, and species associations with bathymetry.

Metocean Buoy Surveys of Marine Wildlife in the New York Offshore Planning Area

Contact: Julia Robinson Willmott. Normandeau Associates, Gainesville, FL, jwillmott@normandeau.com

Two floating LiDAR (light detection and ranging) buoys were deployed in the New York Bight in the summer of 2019 and will be collecting wind resource data for a period of two-years. The project is being extended for another year, with one buoy deployed in the vicinity of OCS-A 0537 (Central Bight). On behalf of NYSERDA, Normandeau Associates worked with Ocean Tech to add wildlife sensors to the deployed buoys and are analyzing and making wildlife data collected from the buoys available through the ReMOTe (https://remote.normandeau.com) data management system. These data include passive acoustic microphone data of detected vocalizations by birds and bats, hydrophone data of detected vocalizations by marine mammals, and MOTUS and VEMCO receiver data of detected NanoTagged birds and fishes.

Gulf of Mexico Marine Assessment Program for Protected Species

Contacts: Aerial surveys: Randy Wilson, USFWS Migratory Bird Field Office, randy_wilson@fws.gov Vessel-based surveys: Jeff Gleason, USFWS Gulf Restoration Office, jeffrey_gleason@fws.gov
Collaborators: Aerial surveys: Randy Wilson, USFWS; Jim Lyons, USGS; Emily Silverman, USFWS; Allison Sussman, USGS; Elise Zipkin, Michigan State University; Kayla Davis, Michigan State University. Vessel-based surveys: Jeff Gleason, USFWS; Patrick Jodice, USGS - SC CFWRU; J. Chris Haney, Terra Mar Applied Sciences LLC; Pamela Michael, SC CFWRU – Clemson University; Yvan Satgé, SC CFWRU-Clemson University; Kathy Hixson, SC CFWRU-Clemson University.

Despite the importance of the Gulf of Mexico for marine species, there is limited information available to quantify species-use in the region (but see DWH Bird Study #6- Haney et al. 2019). To bridge this gap, the Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS), was developed as a federal partnership between the Bureau of Ocean Energy Management, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, and the National Oceanic and Atmospheric Administration. For seabirds, a combination of ship-based and aerial surveys (USFWS Kodiak amphibious aircraft) were employed. Seabird vessel surveys aboard NOAA Vessels of Opportunity (VOO) began in April 2017 and the last vessel survey was completed in September 2019. In total, ~40,000kms, ~2,200hr of observation effort over ~265 days at sea were conducted on 20 pelagic cruises in the northern Gulf of Mexico. Using standard, transect-based methodology ~10,700 detections representing ~51,000 individuals of 121 species (n = 44 seabird species) were amassed. Preliminary results indicate that the Top 10 seabird species (based on # of individuals) were: Black Tern (*Chlidonias niger*), Sooty Tern (*Onychoprion fuscatus*), Laughing Gull (*Leucophaeus atricilla*), Royal Tern (*Thalasseus maximus*), Audubon's Shearwater (*Puffinus iherminieri*), Northern Gannet (*Morus bassanus*), Herring Gull (*Larus argentatus*), Sandwich Tern (*Thalasseus sandvicensis*), Bonaparte's Gull (*Chroicocephalus philadelphia*), and Magnificent Frigatebird (*Fregata magnificens*). High numbers of non-breeding Black Terns occurred in the Mississippi River delta and Western Gulf habitat; a widespread presence of Brown Booby (*Sula leucogaster*), a tropical species commonly associated with coastal environments, occurred broadly in pelagic waters; an extended presence of European breeding Band-rumped Storm-petrel (*Oceanodroma castro*) in US waters from March to September; and the regular occurrence of Black-capped Petrel (*Pterodroma hasitata*; see https://www.int-res.com/abstracts/esr/v46/p49-65/). The final vessel-based surveys were completed in Aug – Sept of 2019. Low-level (200'ASL) aerial surveys covering the coastal waters out to 50nm were conducted from the USA-Mexico border to Key West, FL (including the Dry Tortugas) from February 2018 to February 2020. 180 EPA 40km2 hexagons were randomly selected by generalized random tessellation stratified sampling (GRTS). For each hexagon, a random flight direction was selected, thus defining two additional, adjacent hexagons and creating a three-hexagon sampling unit. Using a double-observer protocol, three observers collected data along 3 parallel 10nm transects spaced 1nm apart or 30nm of transects/sample unit. Preliminary results indicated no apparent detection bias based on observer or seat location, though flock size estimation differed between observers in the front v. rear seats. The final aerial survey was completed in Feb 2020. Over 3 years (2018-2020), 600 hexagons were surveyed representing 1,800 transect segments and >36,000km of effort. Aerial survey crews detected and identified 52 species of birds (n = 23 seabird species). In winter, detections were dominated by

gulls (Larus sp.), Northern Gannets offshore, waterfowl (e.g., mergansers) and Common Loons (*Gavia immer*), whereas in summer several true pelagic species were observed near the outer continental shelf break (e.g., shearwaters and storm-petrels) while gulls, terns, and Brown Pelicans (*Pelecanus occidentalis*) dominated the nearshore environment. Detection probability estimated from our preliminary models was 0.91. We are currently **In Progress** on the BOEM Final Report entitled, "*Gulf of Mexico Marine Assessment Program for Protected Species (GOMMAPPS): Seabird Surveys in the Northern Gulf of Mexico, 2017-2020*".

Anticipating Shifts in Marine Bird Distributions for Planning, Leasing, and Assessment of Energy Development on the US Atlantic Outer Continental Shelf

Contact: Arliss Winship; arliss.winship@noaa.gov; CSS Inc. under contract to NOAA National Centers for Coastal Ocean Science (NCCOS), Silver Spring, MD
Co-PIs: Michael Coyne, Jacob Howell, and Jeffery B. Leirness; CSS Inc. under contract to NOAA NCCOS and John Christensen, NOAA NCCOS

The US Bureau of Ocean Energy Management (BOEM) previously partnered with the National Oceanic and Atmospheric Administration (NOAA) National Centers for Coastal Ocean Science (NCCOS) to apply habitat-based species distribution modeling to at-sea survey data to describe the spatial distributions of marine bird species on the Atlantic Outer Continental Shelf (Winship et al. 2018. OCS Study BOEM 2018-010). The results of that study represented average long-term spatial distributions of marine birds from the late 1970s through the mid-2010s. However, spatial distributions can change over time in response to changes in environmental conditions and prey distributions. Furthermore, BOEM is required to consider potential impacts of future activities in their planning, leasing, and assessments. To address changes in distributions over time, BOEM and NOAA NCCOS have continued their partnership in this new study (Interagency Agreement M20PG00009) to describe the past, current, and future spatial distributions of marine bird species on the Atlantic OCS. Habitat-based species distribution modeling is again being employed to relate at-sea counts of birds to environmental data matched in space and time, and those relationships are then being used to predict past, current, and future spatial distributions of bird density. Future distributions are necessarily predicted from forecasted environmental data. Currently, the project is considering the past 30 years (early 1990s to near present) as the retrospective time period and the following 30 years as the forecast time period. Study results are expected in 2022.

Colony Management and Monitoring

Seabird Conservation in a Coastal Urban Setting: An Adaptive Management Challenge

Contacts: Ruth Boettcher, Becky Gwynn, David Norris and Stephen Living, VA Dept. of Wildlife Resources, ruth.boettcher@dwr.virginia.gov
Daniel Catlin, Sarah Karpanty, Daniel Gibson, Kelsi Hunt, Jim Fraser, Virginia Tech Shorebird Program, Fish and Wildlife Conservation, Virginia Tech, https://www.vtshorebirds.org/hrbt

The Hampton Roads Bridge-Tunnel (HRBT) is part of the Interstate-64 corridor that spans the mouth of James River between Norfolk and Hampton, VA. The facility comprises bridges, artificial islands and subaqueous tunnels that accommodate over 100,000 vehicles per day during peak traffic. From 1983 – 1998, several thousand common terns, state-threatened Gull-billed Terns and Black Skimmers nested on the facility's South Island in relative harmony with HRBT operations on habitat managed by Virginia Department of Transportation. In 1999, breeding Laughing Gulls arrived and over four years their numbers increased to several thousand pairs displacing the terns and skimmers from a managed nesting area to unpaved spaces adjacent to roadways, parking lots and the interstate. This led to additional management measures designed to reduce road and avian mortality. In 2006, Royal Terns began nesting on South Island. The arrival of Laughing Gulls and Royal Terns transformed South Island into the Commonwealth's largest seabird colony ($\bar{x}$ = 15,000 breeding adults, 2007-2017). In the fall of 2017, the HRBT Expansion Project was approved; the largest and most complex transportation project in Virginia's history. One of the project's mandates included the permanent relocation of all South Island nesting birds to avoid avian-related restrictions and provisions.

In February of 2020, the governor of Virginia charged the Virginia Department of Wildlife Resources (DWR) with (1) providing temporary nesting habitat for seabirds displaced by the HRBT Expansion Project in time for the 2020 breeding season and (2) working with the US Army Corps. of Engineers (Corps) and its Beneficial Uses of Dredge Material Program to begin the process of constructing a new seabird nesting island. The first directive stated that the DWR would create temporary habitat on Ft. Wool, an existing artificial island attached to South Island by a rock revetment and on flat-topped barges secured in the embayment between South Island and Ft. Wool. We created 1.5 acres of suitable nesting habitat on Ft. Wool by: defoliating and placing 6 – 8 inch layer of sand and gravel on the parade grounds; constructing barriers at all building entrances, over turret wells and other ingresses to prevent adults and chicks from entering; and reducing the Norway Rat population on the island. The DWR leased flat-topped barges to create an additional acre of nesting habitat on the top-sides of the vessels. Suitable substrate was placed and secured on the barges, barriers were erected to keep flightless chicks contained, and shelters were installed to provide shade and cover. The DWR procured decoys and audio lures to attract target species to Ft. Wool and the barges. The Virginia Tech Shorebird Program installed and maintained the social attraction equipment and remote cameras during the 2020 and 2021 breeding seasons.

Following habitat creation, Royal Terns, Sandwich Terns, Common Terns, Gull-billed Terns, Black Skimmers and Laughing Gulls nested on the Ft. Wool/Barge complex in 2020 and 2021. Royal Terns and Sandwich Terns nested exclusively on the Ft. Wool parade grounds and whereas Laughing Gulls nested primarily on the island's south-facing rip-rap and on top of north facing casements. In 2020, nine pairs of Common Terns nested on Ft. Wool, but were absent from the site in 2021. Common Terns, Black Skimmers, and Gull-billed Terns occupied the barges in both seasons. The number of estimated breeding adults was higher in 2021 than in 2020 for all species except Sandwich Terns and Laughing Gulls, whose estimates are still pending. 13,377 birds were banded on South Island and the Ft. Wool/Barge complex from 2018 - 2021, of which 9,605 received an additional uniquely coded white plastic field readable band. Royal Tern chicks made the majority of birds banded at both locations.

Though successful, the barges and historic Fort Wool are not permanent solutions for these birds, as each has its own challenges. In 2019, the DWR initiated a project with the U.S. Army Corps of Engineers under the Beneficial Uses of Dredge Material Program (Section 204 of the federal Water Resources Development Act) to construct an artificial island near the current nesting site at a location that does not conflict with other interests or uses. Public interest in this initiative has been high, with unanticipated engagement in a variety of ways and new partnerships. Through its Watchable Wildlife program, the DWR has found innovative ways to provide information to satisfy citizenry demands in the absence of allowing access to the site. Translating this engagement into name recognition of and long-term support for the DWR is an important to the agency's efforts to cultivate relationships with new and under-served constituents.

Evaluating the Effectiveness of Gull Control as a Management Tool for Increasing Common Eider Duckling Survival

Contact: Dustin Meattey, Biodiversity Research Institute, Portland, ME, dustin.meattey@briwildlife.org
Co-PIs and Collaborators:
Lucas Savoy, Biodiversity Research Institute, Portland, ME
Brad Allen, Maine Department of Inland Fisheries and Wildlife, Bangor, ME
Kelsey Sullivan, Maine Department of Inland Fisheries and Wildlife, Bangor, ME
Daniel G. McAuley (retired), U.S. Geological Survey, Orono, ME
Robin Dyer, USDA, APHIS, Wildlife Services, Augusta, ME
Chris Dwyer, U.S. Fish and Wildlife Service, Region 5, Hadley, MA

Duckling survival has been identified as a significant limiting factor for a sustainable population of the American common eider. Although periodic boom/bust cycles in duckling survival and breeding success of females have helped maintain common eider populations in the past, evidence suggests that fewer and/or less frequent years of increased production have occurred within the Gulf of Maine which is necessary for maintaining the eider population. In 2016, a collaborative project among Biodiversity Research Institute, U.S. Fish and Wildlife Service, Maine Department of Inland Fisheries and Wildlife, and the U.S. Geological Survey, initiated a pilot-study to test the feasibility of marking with nasal tags and VHF radios and tracking individual eider broods to determine duckling survival at an important eider nesting colony located in Casco Bay, Maine. The effort was successful and we determined that duckling survival could be measured effectively through both marked and potentially un-marked broods. Through the support of the Waterfowl Research Foundation, U.S. Fish and Wildlife Service, Maine Department of Inland Fisheries and Wildlife, and the U.S. Geological Survey, we continued to nasal mark and VHF radio tag hens during the 2017-21 seasons and collected additional duckling survival rates during the 2018-21 seasons.

In summer 2021 we began implementing active gull control efforts at the focal eider nesting colony, targeting great black-backed gulls, to evaluate the effectiveness of gull control as a management tool to increase common eider duckling survival. We culled 120 gulls, a mix of herring and great black-backed. In addition, we tagged 16 adult hen eiders with VHF radio transmitters to track them for the summer season and record duckling counts. Through these counts, in parallel with gull control, we documented a marked increase in eider ducklings

surviving to fledge this season compared to previous seasons (42% survival compared to a previous high of 22%). These preliminary results are encouraging, and suggest that localized gull control efforts appear to have boosted eider duckling survival at our study site. If gull control activities continue to be successful in bolstering eider duckling survival, these methodologies could provide the framework necessary for achieving short-term increases in eider production at key locations as part of a broader geographic American common eider management action. Additional gull control efforts will be conducted in 2022, with duckling surveys continuing through 2023.

Colonial Waterbird Management and Monitoring in North Carolina

Contacts: Sara Schweitzer, sara.schweitzer@ncwildlife.org & Carmen Johnson, carmen.johnson@ncwildlife.org, NC Wildlife Resources Commission
Lindsay Addison, laddison@audubon.org, Audubon, NC
Ray Danner, dannerr@uncw.edu, University of NC Wilmington
Rebecca Harrison, rebecca_harrison@fws.gov, U.S. Fish and Wildlife Service
Meaghan Johnson, Meaghan_Johnson@nps.gov, National Park Service

Management:
In North Carolina, the NC Wildlife Resources Commission (NCWRC) leads a multi-partner effort to manage and monitor colonial waterbirds (as well as nesting shorebirds) in the state. Approximately 84-94 sites are posted annually against trespass by 13-15 partner agencies and organizations. There are two sites with "bird steward" programs, South Wrightsville Beach and Emerald Isle, where volunteers educate the public about beach-nesting birds, including Least Terns, Common Terns, and Black Skimmers.

NCWRC works with the US Army Corps of Engineers (USACE) to insure that dredge material placed on spoil islands takes the needs of nesting seabirds (primarily terns and Black Skimmers) into consideration during dredging projects. NCWRC also works with the USACE on beach nourishment projects to minimize disturbance to sea- and other waterbird species. Vegetation management by Audubon NC to benefit Royal and Sandwich Terns, among others, takes place annually at two dredge islands on the Cape Fear River with a combination of fire and herbicide treatments as needed. We anticipate new sand deposits on these islands in the winter of 2021/2022.

Predator management takes place at multiple sites around the state, focusing on mammalian predators including raccoons and coyotes, and was carried out in both 2020 and 2021.

Monitoring:
The triennial Colonial Waterbird Survey was conducted from May-June 2020. This statewide effort counts nests of all colonial waterbird species on the coast of North Carolina. Counts are timed to coincide with peak of incubation, are usually conducted on foot with observers walking through sites in transects, and data are collected in an online database maintained by NCWRC. The Colonial Waterbird Survey has been taking place since the 1970s.

At most sites, intensive nest and chick monitoring to estimate productivity is not conducted, with exceptions in some years depending on student projects and staff time available (see below,

Research). However, chick and fledgling counts to provide a measure of success are done at NPS, Audubon NC, and USFWS sites. These counts include Least Terns, Black Skimmers, and Common Terns. When conducted, Royal and Sandwich Tern banding (see below, Research) also provides an estimate of chick production.

Audubon NC, NCWRC, NC Coastal Reserve volunteers, and other volunteers conducted International Shorebird Surveys conduct ISS-type surveys at 13-14 sites in 2020 and 2021. We include in these surveys counts of all bird species, including AMBC focal species.

Research:
In 2020, Ray Danner and students in the Department of Biology and Marine Biology at UNC-Wilmington and Cape Hatteras National Seashore initiated a Cooperative Agreement to study Least Tern productivity and behavior. Research is led by UNCW graduate students Erin Gallagher (PhD expected fall 2024) and Alex Smith (MS expected fall 2022) and involves close collaboration with NPS staff and USFWS staff. Research takes place on Cape Hatteras National Seashore and Pea Island National Wildlife Refuge. This research includes measures of nest and chick survival, chick movements, chick banding and radio telemetry (with Cellular Tracking Technologies), and behavioral responses to anthropogenic activities.

Since 2017, Audubon NC has been banding Black Skimmer chicks, in coordination with other states' banding schemes. Over 300 chicks have been banded in the state to date, with just under 1,000 resights made. Skimmers from North Carolina have thus far have been resighted in North Carolina (off-colony), New Jersey, Maryland, Virginia, South Carolina, Georgia, and Florida. In 2021, this work expanded to Cape Lookout National Seashore.

Through the partnership of site managers, independent researcher John Weske has banded most Royal Tern and Sandwich Tern chicks fledged in the state, as well as a smaller proportion of Brown Pelicans, since the 1970s. Due to the Covid-19 pandemic, in 2020 this work was restricted to Royal and Sandwich Terns on the Cape Fear River. There was no tern and pelican banding in 2021.

Seabird Colony Management at Maine Coastal Islands NWR

Contact: Linda Welch, USFWS, Linda_Welch@fws.gov

Maine Coastal Islands NWR has been working for more than 35 years to restore, manage, and monitor colonial nesting seabirds along the coast of Maine. The Refuge owns 73 seabird nesting islands, and actively manages six islands for nesting common, Arctic, and roseate terns, Atlantic puffins, razorbills, common murres, black guillemots, Leach's storm-petrels, common eider, and laughing gulls. We have a long history of cooperatively managing several of the islands with National Audubon Society. We monitor productivity and chick growth rates, diet composition and feeding rates, and conduct metapopulation research on puffins and Arctic terns. Management efforts focus on predator control and habitat enhancement. Recently our research efforts have focused on trying and understand how the climate driven changes in the Gulf of Maine are influencing seabird fitness and productivity. The 2021 season was particularly challenging for seabirds in the Gulf of Maine. A combination of inclement weather, high

predation rates, and poor food availability resulted productivity rates dropping to a record low of 0.10-0.20 chicks/pair.

Colonial Seabird Monitoring and Conservation in Atlantic Canada

Contact: Sabina Wilhelm, Canadian Wildlife Service, Environment and Climate Change Canada, sabina.wilhelm@ec.gc.ca

The Atlantic Canadian Colonial Seabird Monitoring and Conservation Program, coordinated by Environment and Climate Change Canada's Canadian Wildlife Service (ECCC-CWS), focuses on monitoring 20 species of seabirds from 8 groups (fulmars, shearwaters, storm-petrels, gannets, gulls, terns, alcids, and cormorants), to maintain updated information on the distribution, status and trends of seabirds breeding in four Atlantic Region provinces (New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador). This program also aims to identify anthropogenic pressures on seabirds, how these influence the observed population trends, and work with partners to monitor pressures and implement conservation actions. Ongoing projects to achieve these objectives include:

- Coastal population surveys of terns, gulls, kittiwakes, and cormorants by air;
- Population surveys of alcids and storm-petrels by ground/boat;
- Population surveys of Northern Gannets via aerial photographs;
- Maintain the Atlantic Colonial Waterbird Database which houses georeferenced colonial seabird data for Atlantic Canada collected by ECCC-CWS and partners;
- Assess hunting pressures from the Newfoundland murre hunt and Aboriginal seabird hunt on Thick-billed and Common Murres and Razorbills in partnership with indigenous groups in Labrador;
- Facilitate the implementation of Canada's National Plan of Action and other initiatives in partnership with the Department of Fisheries and Oceans to reduce bycatch of seabirds in Canadian waters;
- Characterize strandings of recently fledged Atlantic Puffins and Leach's Storm-Petrels in coastal communities and onshore industrial sites, assess impacts on populations, and raise awareness on the issue of light attraction and actions to reduce strandings and mortality, in partnership with various non-government organizations.

Seabird Tracking Studies

Tracking and Movement Patterns of Black-capped Petrels Captured At-sea

Contact: Patrick Jodice, pjodice@usgs.gov & Yvan Satgé, ysatge@clemson.edu, U.S. Geological Survey South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University

The Black-capped Petrel (*Pterodroma hasitata*) is a highly endangered seabird in the North Atlantic, is listed as globally Endangered by the International Union for the Conservation of Nature, and is currently being reviewed for listing under the U.S. Endangered Species Act. In May 2019, we captured 10 petrels along the western edge of the Gulf Stream east of Cape Hatteras, North Carolina. We used a hand-held net launcher powered by compressed air to capture birds in flight over chum. 3 birds were female and 7 birds were males. Five birds were

classified as dark forms, and five birds were classified as light forms. Birds were equipped with 8 g solar-powered satellite tags set on a 6 hour on/28 hour off duty cycle. Subsequent tracks (May – November) showed that most locations ranged from 28.4 – 41.2 degrees latitude. Two petrels travelled to Hispaniola in late September (light-form individual) and early November (dark-form individual). Dark and light forms had significantly distinct non-breeding distributions. The dark form used a core area entirely in the US EEZ, along the continental break and western wall of the Gulf Stream, from the Charleston Bump to the latitude of the Chesapeake Bay. The light form had a more northeasterly, pelagic distribution, with a core area shared between US EEZ (78%) and international waters (22%). Off the coast of North America, the dark form is more exposed to risks associated with mercury, plastic, and ship traffic, while the light form is more exposed to fisheries. One light-form individual was present in exploratory lease areas for oil and gas in Nova Scotia, and the home range of the dark form weakly overlapped with the North Carolina lease area for offshore wind (0.05% of the home range).

Using GLS, TDR, and GPS to track Alcids on the Newfoundland and Labrador Shelf

Contacts: Gail Davoren (gail.davoren@umanitoba.ca), Lauren Lescure (llescure@contractor.usgs.gov), Emily Runnells (emily.runnells@umanitoba.ca), Matthew Legard (matthew.legard@umanitoba.ca), University of Manitoba, Department of Biological Sciences

The Davoren Lab continued their decadal scale research on seabirds and their prey on the east coast of Newfoundland. Recent work has focused on alcids breeding on James Island. In 2020, GPS and TDRs were simultaneously deployed on chick-rearing Razorbills to study both intra- and inter-annual responses in foraging behavior to variation in capelin biomass. Between 10-15 GLS loggers have been deployed on Atlantic Puffins and Razorbills each year starting in 2019, with 13 tags per species recovered to date. Tagged Razorbills traveled all the way from the Labrador Sea down to Cape Hatteras in some years, while a diversity of movement paths was evident among the puffins, including some that gathered in the Gulf of Maine. In 2021, 19 combination GLS and TDR loggers were deployed on Razorbills. These GLS and GLS-TDR datasets, combined with stable isotope analysis on feathers (secondaries, head/neck, contour), will be used by students to study species niche overlap and carry over effects, along with the effects of personality on foraging behavior, non-breeding distribution and reproductive success. Logger deployments and retrievals are planned to continue in 2022.

Resources and Guidelines for Archiving Argos Satellite Tracking Data

Contact: David Douglas, USGS Alaska Science Center, ddouglas@usgs.gov

A growing collection of publicly accessible wildlife satellite tracking data releases is curated by the USGS Alaska Science Center at https://doi.org/10.5066/P9VYSWEH. The collection contains data from many studies (over several decades) that have satellite-tracked animals using the Argos System. To-date, one study (tundra swans, https://doi.org/10.5066/P9KBR79C) has tracked individuals into the Atlantic region. Nevertheless, because many avian tracking studies in the Atlantic have also used the Argos System, members of the Atlantic Marine Bird Cooperative may find other resources in the USGS collection useful, such as the overall framework that was

adopted to archive Argos data for perpetuity, the comprehensive metadata for different Argos data formats and variables, or the catalog of legacy Argos user manuals. Persons interested in archiving Argos tracking data are welcome to contact the USGS Alaska Science Center curators for advice or assistance.

Forage Ecology, Diet & Prey

Multi-scale relationships between marine predators and forage fish

Contact: Evan Adams (evan.adams@briwildlife.org)

The New York State Energy Research and Development Authority has been funding a project to understand the connections between forage fish and their predators in the New York and Atlantic Bights. While there is no new data collection with this project, we are working to expand our understanding of how spatial and temporal changes in forage fish availability influences seabird behavior and distributions using existing data sets. Work began on this project in 2019 and is slated to be completed in early 2023. To date, we have developed joint species distribution models for 12-15 forage fish in the Northeast Continental Shelf using trawl survey data and described spatial and temporal changes in surface aggregations of forage fish using aerial survey data. We use these results to explain changes in movement behaviors for Northern Gannets, Red-throated Loons, and Long-tailed ducks. We've found that primary productivity can drive patterns across these trophic scales and likely organizes much of the observed spatial variation in predator/prey interactions. The next year will be used to compare forage fish availability to distributions and long-term temporal changes of seabirds and other marine predators. Results from this project will be made available via marine data portals for use in future studies.

Isotopic Niche Overlap of Common and Roseate Terns along the Northeast U.S. Coast

Contact: Henry Legett, Smithsonian Environmental Research Center, LegettH@si.edu; Michelle Staudinger, DOI Northeast Climate Science Center, mstaudinger@usgs.gov
Co-PIs and Collaborators: Alexander Gerson, Jeffrey Lucas, Donald Lyons

Colonial nesting seabirds compete for limited resources, often resulting in the spatial segregation of foraging locations and partitioning of prey. Understanding this competition can be important for the management and conservation of target species. We are assessing and contrasting the foraging ecology of adult Common Terns (*Sterna hirundo*) and endangered Roseate Terns (*S. dougalii*) nesting on coastal islands located along the Northeast United States coast using isotopic metrics. Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes, which serve as ecological tracers of diet, were measured in eggshell tissues collected from ten islands in 2018 and 2019. The islands were divided into two subregional groups: five "warm water" islands south of Cape Cod (Great Gull Island, Faulkner Island, Ram Island, Penikese Island, Bird Island), four "cold water" islands north of Cape Cope in the Gulf of Maine (White Island, Stratton Island, Jenny Island, Eastern Egg Rock), and one island located at the boundary of the warm-cold water groups (Monomoy Island). Terns in each subregion are known to differ in their diets and productivity (US Fish and Wildlife Service 2010). Results from stable isotope analyses indicate a high degree

of isotopic niche overlap between Common and Roseate Terns on each island. Eggshells from the "warm water" island group had higher $\delta^{15}N$ values compared to "cold water" islands, although this difference is likely reflective of regional isotopic baselines and not differences in foraging ecology. We also detected interannual shifts in foraging ecology, as Roseate terns on almost all islands had significantly narrower dietary niche breadths in 2019 compared to 2018. Overall, our results suggest similarity in the diets and foraging locations of Common and Roseate Terns, and that Roseate Terns are likely more vulnerable to changes in foraging conditions and interspecific competition when prey is scarce.

Products:

Legett, H., Gerson A., Lucas, J., Shannon, P., and Staudinger, M. In preparation. Isotopic niche overlap of colonial-nesting terns in the Gulf of Maine and Southern New England. Anticipated submission to Animal Ecology spring 2022.

Assessment of diet and mercury levels in the Black-capped Petrel

Contact: Yvan Satgé, ysatge@clemson.edu & Patrick Jodice, pjodice@usgs.gov, U.S. Geological Survey South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University; Gemma Clucas, gemma.clucas@cornell.edu, Cornell University; Sarah Janssen, sjanssen@usgs.gov, U.S. Geological Survey Upper Midwest Water Science Center

The Black-capped Petrel (*Pterodroma hasitata*) is a highly endangered seabird in the North Atlantic, is listed as globally Endangered by the International Union for the Conservation of Nature, and is currently being reviewed for listing under the U.S. Endangered Species Act. In parallel with tracking efforts at breeding sites in April 2018 and at sea in May 2019, we collected fecal samples and breast feathers for analyses of diet and contaminants, respectively. We analyzed six fecal samples (breeding, n= 4; non-breeding, n=2) using high-throughput DNA metabarcoding. Identification to the genus level was possible in 47% of sequence reads, and to the family level in 62% of reads. Preliminary results show a lower occurrence of cephalopoda than previously measured in Black-capped Petrels, and higher fish diversity. Fish guilds include genus performing diel migration, deep-sea species, and at least three species fished commercially. In parallel, we also measured total mercury levels in 20 feather samples: mean concentration was ca. 30ppm (dry weight), placing Black-capped Petrel in the top tier of mercury levels in the Pterodroma genus.

The Ecological Role of Sand Lance in the Northwest Atlantic

Contact: Michelle D. Staudinger, DOI Northeast Climate Science Center, mstaudinger@usgs.gov; Linda Welch, Maine Coastal Islands NWR, Linda_Welch@fws.gov.

The American sand lance (*Ammodytes americanus*, Ammodytidae) and the Northern sand lance (*A. dubius*, Ammodytidae) are small forage fishes that play an important functional role in the Northwest Atlantic Ocean (NWA). The NWA is a highly dynamic ecosystem currently facing increased risks from climate change, fishing and energy development. We need a better understanding of the biology, population dynamics and ecosystem role of Ammodytes to inform relevant management, climate adaptation and conservation efforts. To meet this need, we synthesized available data on the (a) life history, behaviour and distribution; (b) trophic ecology; (c) threats and vulnerabilities; and (d) ecosystem services role of Ammodytes in the NWA.

Overall, 72 regional predators including 45 species of fishes, two squids, 16 seabirds and nine marine mammals were found to consume Ammodytes. Priority research needs identified during this effort include basic information on the patterns and drivers in abundance and distribution of Ammodytes, improved assessments of reproductive biology schedules and investigations of regional sensitivity and resilience to climate change, fishing and habitat disturbance. Food web studies are also needed to evaluate trophic linkages and to assess the consequences of inconsistent zooplankton prey and predator fields on energy flow within the NWA ecosystem. Synthesis results represent the first comprehensive assessment of Ammodytes in the NWA and are intended to inform new research and support regional ecosystem-based management approaches.

Products:

Staudinger, M. D., H. Goyert, J. Suca, K. Coleman, L. Welch, J. Llopiz, I. Altman, D. Wiley, A. Appelgate, P. Auster, H. Baumann, J. Beaty, D. Boelke, L. Kaufman, P. Loring, J. Moxley, S. Paton, K. Powers, D. Richardson, J. Robbins, J. Runge, B. Smith, C. Spiegel, H. Steinmetz. 2020. The role of sand lances (*Ammodytes* sp.) in the Northwest Atlantic Ecosystem: A synthesis of current knowledge with implications for conservation and management. Fish and Fisheries, 00:1–34 https://doi.org/10.1111/faf.12445

Assessing the Pre-breeding Foraging Ecology of Seabirds Along the Northeast U.S. Coast Using Stable Isotope Analysis

Contact: Michelle Staudinger, DOI Northeast Climate Science Center, mstaudinger@usgs.gov; Lindsay Yue, lindsay.yue@uconn.edu
Co-PIs and Collaborators: Henry Legett, Alexander Gerson, Linda Welch

As part of the Five College Coastal and Marine Sciences summer internship program (https://www.fivecolleges.edu/marine), students at the University of Massachusetts Amherst, in collaboration with the DOI Northeast Climate Adaptation Science Center, USFWS, National Audubon Society Seabird Institute, and regional state agencies evaluated the pre-breeding foraging ecology of seabirds nesting along the Northeast U.S. coast. Stable carbon and nitrogen isotopes, which serve as ecological tracers of diet, measured in hatched eggshell tissues were collected during the 2016-2020 nesting seasons. Evaluations tested intra- and inter-specific differences among species on shared islands and across nesting colonies, primarily in terns but also include alcids and other species of interest.

The first project from this work (R. Bratton) evaluated inter and intra-specific differences in the pre-breeding foraging ecology of Arctic terns (*Sterna paradisaea*), Common terns (*S. hirundo*), and the federally endangered Roseate tern (*S. dougallii*) on seven nesting islands (Matinicus Rock, Eastern Egg Rock, Jenny Island, Outer Green Island, Stratton Island, Seal Island NWR, Pond Island NWR) in the Gulf of Maine from 2016-2018. Results show at the interspecific level, adult foraging patterns are consistent with expectations based on chick diets. At interisland and interannual scales, variation in isotopic values and niche breadths suggest foraging habits are highly localized. While uncertainty remains, interannual trends also suggest warmer ocean conditions are either affecting tern foraging behaviors and/or prey resource availability during the late spring and early summer.

The second project (L. Yue) evaluated 1) interspecific differences in foraging ecology among co-occurring Common Terns (*Sterna hirundo*), Roseate Terns (*Sterna dougalli*), and Least Terns (*Sternula antillarum*) nesting on Stratton Island, and 2) intraspecific differences in foraging ecology among Black Guillemots (*Cepphus grylle*) breeding on five different islands (Outer Green Island, Eastern Egg Rock, Metinic Island, Seal Island National Wildlife Refuge, Petit Manan Island). Nitrogen signatures were not found to differ among terns nor among Black Guillemot colonies indicating each group foraged at similar trophic levels. Carbon signatures were found to differ significantly within each group. Least Terns had more enriched carbon signatures compared to Common and Roseate Terns. This suggests that although Least terns are foraging at a similar trophic level as Common and Roseate Terns, they are foraging in more inshore and estuarine habitats near Stratton Island. Black Guillemots from Outer Green Island had significantly depleted carbon signatures compared to those from other islands and a much narrower isotopic niche. This suggests that Black Guillemots from Outer Green Island foraged in more offshore or pelagic habitats and across a narrower range of habitat compared to other colonies. This study represents some of the first foraging ecology data on adult Least Terns and Black Guillemot in the Gulf of Maine and provides insights into the critical post-migration, pre-breeding period of their life history.

Products:

Bratton, R. 2019. Using Stable Isotope Analysis of Eggshell Membrane to Examine the Foraging Ecology of Three Tern Species Nesting in the Gulf of Maine. University of Massachusetts Amherst. Undergraduate Honors Thesis. 33 p.

Bratton, R., H. Legett, P. Shannon, K. Yakola, A. Gerson, and M.D. Staudinger. In review. Pre-breeding foraging ecology of three tern species nesting in the Gulf of Maine. Under consideration in *Avian Conservation Ecology*.

Yue, L. 2021. Using Stable Isotope Analysis to Determine Variation in Seabird Foraging Ecology in the Gulf of Maine. Amherst College. Undergraduate Honors Thesis. 64 p.

An Examination of Common, Arctic, Roseate, and Least Terns Diets in a Changing Climate in the Gulf of Maine

Contact: Michelle D. Staudinger, DOI Northeast Climate Science Center, mstaudinger@usgs.gov ; Keenan Yakola, Oregon State University, kyakola@gmail.com

Keenan Yakola, a Masters student at the University of Massachusetts Amherst and a fellow with the DOI Northeast Climate Adaptation Science Center, completed his thesis evaluating chick diets of Common, Arctic, Least and Roseate Terns on seven seabird colonies (Matinicus Rock, Eastern Egg Rock, Jenny Island, Outer Green Island, Stratton Island, Seal Island NWR, Pond Island NWR) in the Gulf of Maine, USA. Provisioning data was collected over a 32 period (1986 and 2017) and evaluated to: 1) quantify and compare dietary differences among tern species; 2) discern spatial and temporal differences in foraging ecology across the region, 3) characterize long-term dietary trends across nesting islands, 4) describe within-season dietary phenology, and 5) quantify how climate change influences dietary patterns. Findings suggest there are significant differences in diets among tern species and islands; however, three prey groups (hake, sand lance and herring) comprise the majority of chick diet for all terns and islands. The reliance on a few prey items led to narrow foraging niches, potentially increasing their vulnerability to climate

change, fisheries practices, or other localized disturbances. Over time there was a declining trend in the occurrence of hake and increasing amounts of sand lance in Common tern diets. In addition, hake and sand lance occur with higher frequency earlier in the season, while butterfish and a variety of other fish (historically of lower importance) showed the opposite trend. Furthermore, results indicated that the within-season decline of hake occurs more rapidly in years with earlier spring onset, potentially indicating a phenological shift. Finally, warming sea surface temperatures were found to be negatively correlated with hake and positively correlated with the "other fish" prey group. Results from this project identify forage fish species that support the long-term sustainability of regional tern populations and provide insights on how climate change is altering the availability of forage resources to seabirds nesting in the Gulf of Maine. The islands included in this study and data collection is managed by the National Audubon Society Seabird Institute and USFWS Maine Coastal Islands NWR who are collaborators on this project.

Products:

Yakola, K., An examination of tern diets in a changing Gulf of Maine. University of Massachusetts Amherst. Masters Thesis. 104 p.

Yakola, K., A. Jordaan, S. Kress, P. Shannon, M.D. Staudinger. In review. Interspecific and local variation in tern chick diets across nesting colonies in the Gulf of Maine. Under consideration in *Waterbirds*.

Yakola, K., A. Jordaan, C. Sutherland, S. Kress, and M.D. Staudinger. In preparation. Long-term trends and within-season phenology of common tern (*Sterna hirundo*) chick diet in the Gulf of Maine, USA. Anticipated submission to *PloS One*, winter 2022.

Seabird Diets in a Warming climate: An Assessment of Critical and Emergent Trophic Relationships of Terns (*Sterna* sp.) in their Northern Breeding Range

Contact: Michelle Staudinger, DOI Northeast Climate Science Center, mstaudinger@usgs.gov
Co-PIs and Collaborators: Adrian Jordaan, Henry Legett, Ian Nisbet, Linda Welch, Don Lyons, Carolyn Mostello, Margaret Rubega, Gemma Clucas, Tammy Wilson, Liz, Craig, Kristina Vagos, Susi vonOettingen, Joan Walsh, Nathan Furey

The Northeast coast of the United States is a seasonally important area for variety of colonial nesting seabirds including terns (*Sterna* sp.). This group of species migrates to the region to take advantage of highly productive waters during the warmer months to breed and provision their young. During this period, adult seabirds are place-based foragers and highly dependent on local abundances of prey resources to support chick growth and survival. Long-term diet studies show terns exhibit high dependence on a few prey groups when provisioning chicks. This specialization makes regional populations sensitive to changes in prey availability and at risk to the direct and indirect impacts of climate change. Understanding long-term changes in prey resources and how they affect tern nutrition and productivity is a key management concern. To meet this need, this project is synthesizing existing long term data and monitoring protocols and develop ecological models to: 1) identify critical and emergent trophic relationships between Common, Least, Arctic, and the federally endangered Roseate terns and their prey throughout their Northern breeding range, 2) evaluate the relationship between tern diet, climate drivers, and productivity, and 3) develop a standardized framework and set of tools for assessing seabird diet

and productivity. This work will be conducted in cooperation with seabird mangers from State and Federal agencies and non-governmental organizations that monitor breeding colonies along the Northeast coast. Results will provide insights into tern energetic needs across decadal scales and in different habitats as well as quantify how populations are responding to changing environmental conditions due to climate change.

Foraging Ecology of Herring and Black-backed Gulls along an Urban Gradient

Contact: Lesley Thorne, Stony Brook University, Lesley.thorne@stonybrook.edu

Gulls are abundant worldwide and exhibit highly plastic behavior, utilizing both urban and marine areas for foraging and breeding. Since 2016, the Thorne Lab at Stony Brook University has been conducting work on gulls that integrates GPS tracking data with stable isotope and microbial analyses to assess how urbanization influences the behavior, trophic ecology, and microbiome of gulls on both the individual and colony level. Herring gulls have been tracked since 2016 at three colonies along the east coast of the US (Jamaica Bay, NY; Stony Brook, NY; and Tuckernuck, MA) representing high, medium, and low levels of urbanization, respectively. Great black-backed gulls have been tracked since 2019 at the colony in Stony Brook, NY. All gulls were tracked during the incubation period using archival GPS loggers that were attached to the 3-4 central tail feathers using TesaTape. Results from tracked herring gulls in 2016-2017 revealed that gulls from our more remote colony (Tuckernuck, MA) showed higher levels of microbial diversity, associated with a wider range of habitat use. Further, herring gulls from less urban environments showed lower foraging site fidelity and took shorter foraging trips. Results from 2019-2021 from the Stony Brook colony revealed that great black-backed and herring gulls showed stark differences in their habitat use, despite sympatric nesting and close evolutionary relatedness. Great black-backed gulls primarily utilized marine environments for foraging and exhibited higher $\delta^{13}C$ and $\delta^{15}N$ values than herring gulls, which primarily utilized urban environments for foraging. Results from our ongoing study suggest that the use of urban environments can greatly influence an animals' behavior and foraging ecology.

Marine Debris

Identifying and Addressing Impacts of Marine Debris on Birds in the Gulf of Maine Region

Contact: Caleb Spiegel - USFWS Migratory Birds Program, caleb_spiegel@fws.gov
Project Leads and Collaborators: Michael Andranovich - University of Rhode Island; Meg Harrington, USFWS Contractor; Pam Loring, USFWS Migratory Birds; Demi Fox - NOAA Marine Debris Program

Marine debris has been documented to adversely impact bird species around the globe via mechanisms including entanglement/entrapment, ingestion, and degradation of nests and breeding colonies. However, such impacts remain understudied, particularly in the Gulf of Maine region (here defined as southern Atlantic Canada to Cape Cod). In spring 2020, the USFWS and

NOAA Marine Debris Program initiated a project with a University of Rhode Island graduate student to draft a report on what is currently known about the impacts of marine debris on birds in the region, identify information gaps for understanding impacts of marine debris on birds, and elucidate strategies for addressing these impacts. This work was recommended in the NOAA-coordinated Gulf of Maine Marine Debris Action Plan, and directly supported plan objectives. In addition to the report, project leads worked with over two dozen regional partners (Federal, state & provincial agencies; commercial groups; NGOs; universities) to step down priority information gaps and strategies identified in the report into priority actionable first steps for meeting specific measurable objectives: termed an Implementation Framework (see webinar for more details). The final project report and Implementation Framework will be released in January 2022 and made available on the Atlantic Marine Bird Cooperative website. USFWS is currently helping coordinate partners on filling priority information gaps and addressing priority impacts, with specific emphasis on better documenting and addressing derelict fishing gear.

Genetics

Population Genetic Analysis of Caribbean and Northeastern Roseate Terns

Contact: Terry Chesser, USGS Eastern Ecological Science Center, tchesser@usgs.gov
Partners: University of Louisiana at Lafayette, USFWS—Virgin Islands, Smithsonian Institution

Paige Byerly, a grad student at the University of Louisiana at Lafayette, recently completed her dissertation evaluating population genetics of the Roseate Tern in the Atlantic Basin. This species includes a federally endangered Northeastern population and a threatened Caribbean population. No gene flow has been thought to occur between these populations, based largely on their geographic separation and a lack of recoveries of banded birds, and they have been managed accordingly. However, Roseate Terns disperse widely and individuals from the Northeastern population stop over in the Caribbean during migration and overlap with the Caribbean population on their South American wintering grounds. Moreover, research effort in the Caribbean has been low relative to that in the northeast, making band recoveries less likely. Thus, the assumption of no gene flow needed to be addressed directly by analyzing genetic distinctiveness and connectivity of the two populations. Surprisingly, given their dispersal capabilities and potential for intermixing, genetic data from these populations, as well as from the population in the Azores, indicate that the three populations are significantly differentiated genetically and suggest minimal gene flow between the Caribbean and Northeastern populations. These results indicate limited contemporary connectivity among these populations, supporting the current management strategy and meaning that the loss of genetic diversity within a population is unlikely to be counteracted by dispersal from other populations.

The genetic data also showed evidence of recent population declines in all sampling populations, consistent with known declines in the Northeastern population and probable declines in the Caribbean population. Because these populations may have been connected before mass declines, range contraction, and habitat loss in the 20th century, a temporal analysis of connectivity using tissue from museum specimens is also being performed. Connectivity may

contribute to understanding of long-term population declines, because genetic isolation is known to negatively affect population viability. Results from this research will be used to make within-population comparisons between historical and contemporary population parameters, including genetic diversity and effective population size, which may further aid in identifying potential inhibitors to population growth and recovery.

Phylogenetics, diversification, and speciation in shearwaters (*Puffinus*, *Ardenna*, and *Calonectris* species), including assessment of the current taxonomy of the group

Contact: Terry Chesser, USGS Eastern Ecological Science Center, tchesser@usgs.gov
Partners: University of Barcelona (Spain), Durham University (UK), Centre National de la Recherche Scientifique (France), Smithsonian Institution

Joan Ferrer Obiol, a grad student at the University of Barcelona, recently completed his dissertation on the processes that drive diversification and speciation in the shearwaters, a group of 30 species of seabirds of the order Procellariiformes. One paper, which integrated two genomic techniques to resolve the evolutionary radiation of the group, has recently been published (Systematic Biology 70: 976–996, 2021) and another, which links paleoceanographic changes to the rapid diversification of the shearwaters, is now in press in the Journal of Biogeography. The latter paper also examines the validity of the current taxonomy of the group. Species limits in the shearwaters are of particular conservation and management interest because 55% of shearwater species are listed as threatened by the IUCN Red List of Threatened Species. The genomic results indicate that the species status of several species, including the three *Calonectris* species of the Atlantic Basin, should be re-evaluated.

Phylogenetics, diversification, and speciation in the Procellariiformes (tube-nosed seabirds), including assessment of the current taxonomy of the group

Contact: Terry Chesser, USGS Eastern Ecological Science Center, tchesser@usgs.gov
Partners: Durham University (UK), Centre National de la Recherche Scientifique (France), Smithsonian Institution

Many species of seabirds are threatened or endangered, and the 140+ species of the order Procellariiformes, which includes the petrels, shearwaters, and albatrosses, face the greatest risks among seabirds. More than 50 species of Procellariiformes are listed as Vulnerable, Endangered, or Critically Endangered by the IUCN Red List, including many that occur in the Atlantic Basin. The goal of this collaborative project is to investigate the evolutionary diversification of this group worldwide and assess its current taxonomy through genomic sequencing of all currently recognized species and subspecies. Although the Procellariiformes are reasonably well described, their phylogeny is poorly documented and species limits are controversial. Our sampling will enable us to address species limits by providing preliminary assessments of genetic divergence, gene flow, and possible cryptic speciation. This is especially important in the Procellariiformes because of the conservative morphology of many groups of Procellariiformes and the prevalence of cryptic speciation in this order. Better understanding of the taxonomy of the group will directly affect the assessment of conservation and management units in the Procellariiformes.

Multi-topic and Miscellaneous Updates

Investigating drivers of Leach's Storm-Petrel population decline in Atlantic Canada

Contacts: April Hedd, Environment and Climate Change Canada, april.hedd@ec.gc.ca;
Laura McFarlane Tranquilla, Birds Canada, ltranquilla@birdscanada.org;
Katie Studholme, Environment and Climate Change Canada, Katharine.studholme@ec.gc.ca
Project Partners: Birds Canada, Environment and Climate Change Canada, Kenyon College, Bowdoin College, Memorial University, Acadia University.

Ongoing monitoring of Leach's Storm Petrels in the north Atlantic indicates that many major breeding colonies have declined by ~50% over the past 20-30 years, and Leach's Storm-Petrel has been recently assessed as globally threatened and listed 'Vulnerable' on the IUCN Red List (December 2016). Causes of population decline are multi-faceted and not well understood, but may include predation at colonies, environmental contaminants (eg. mercury), risks at sea (attraction/collision with vessels, flares, windfarms), and climate-driven changes in food supply. Understanding this complex ecological system requires a focus on collecting year-round life cycle information, as well as demographic information for the species (i.e., occupancy, breeding success, chick growth, and adult survival), at key sites throughout New Brunswick, Nova Scotia and Newfoundland, and strong collaboration between partners in the region. Our project aims to understand cumulative factors influencing populations of Leach's Storm-Petrels at key colonies across Atlantic Canada, and to develop recommendations addressing key conservation threats to the species in Atlantic Canada and the north Atlantic Ocean. Pulling together a range of partners (government, academic, and NGO community), we have been working over the last several years (2017-present) to:

1. Monitor and compare population demography (burrow occupancy, adult survival, breeding success, and chick growth) at key colonies over three years to understand long-term population sustainability across Atlantic Canada. This information tracks population health and helps understand where to focus conservation attention by identifying the life stage and ecological processes where conservation problems occurs – for example, if chick growth and breeding success are poor, this would focus conservation concerns locally, on the breeding grounds; whereas if the bottleneck for adult survival was found to be low during the non-breeding season, risks at sea, on migration routes, or wintering grounds would become the focus for conservation attention.
2. Update population estimates of known significant colonies in Newfoundland, Nova Scotia and New Brunswick, to closely monitor trends of this declining species.
3. Track movements of Leach's Storm-Petrels from key colonies annually to identify colony-specific marine areas of use (breeding and non-breeding season) and the environmental conditions and risks encountered in those areas.
4. Monitor contaminant levels in Leach's Storm-Petrels to annually investigate the effects of contaminants (mercury and others) on reproductive success and adult survival, and to

investigate relationships among diet, foraging areas (through concurrent tracking), and contaminants.

5. Enhance and support collaboration among multiple partners over the long-term to synthesize and analyse data, develop conservation recommendations, develop management plans (including species Conservation Plan using Open Standards tools) for key Leach's Storm-Petrel colonies (all of which are Important Bird Areas), and communicate results.

Migration Patterns and Wintering Distribution of Common Loons Breeding in the Upper Midwest

Contact: Kevin Kenow, Upper Midwest Environmental Sciences Center, kkenow@usgs.gov
Partners: Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, University of Florida, University of Wisconsin-Madison

The common loon is considered one of the most vulnerable Minnesota migratory birds from effects of the Deepwater Horizon oil spill. Staff from the Minnesota Department of Natural Resources requested information on migration patterns, wintering distribution of loons breeding in Minnesota, and more detail on winter range and habitat use. The USFWS Species Status Assessment and Conservation Plan for the common loon recommends research to develop geographic linkages among breeding, migratory, and wintering common loon populations. Identifying location and timing of use of migration and wintering sites will inform regional and national conservation planning efforts and compensation of loons lost during marine oil spill events.

Product:

Kenow, K.P., Fara, L.J., Houdek, S.C., Gray, B.R., Heard, D.J., Meyer, M.W., Fox, T.J., Kratt, R.J., Ford, S.L., Gendron-Fitzpatrick, A. and Henderson, C.L. (2021), Migration patterns and wintering distribution of common loons breeding in the Upper Midwest. J Avian Biol, 52:. https://doi.org/10.1111/jav.02609

Identifying Areas of Importance for Sea Ducks throughout their Annual Cycle

Contact: Nic McLellan, Ducks Unlimited Canada, n_mclellan@ducks.ca

In an effort to make the best information on sea duck habitat use available for guidance and habitat protection, the Sea Duck Joint Venture (SDJV) is developing a key site atlas. This atlas identifies and provides site specific information on the most important areas for sea ducks in North America, throughout their annual life cycles. We foresee this product being a useful tool to support habitat planning and protection. We mirrored the site write-ups from Mallory and Fontaine (2004), "Key marine habitat sites for migratory birds in Nunavut and the Northwest Territories" which has been a useful tool for land planning in Arctic Canada. The sites have been selected using specific criteria of 1) ≥ 5% of at least one sea duck species' (or sub-species') continental population OR if 20,000 total sea ducks of all species are present, AND 2) the total density of sea ducks is ≥ 10/km^2. The intent of these criteria were to restrict key site designation to areas that are vital to sea ducks at a scale that is meaningful and practical in terms of habitat conservation and protection. The third criterion was included to ensure that large

geographic areas of low bird density were not included, for example, an entire species range, or an area as broad as the Canadian boreal forest, which is certainly important to sea ducks (e.g., scoters) but is so expansive that it dilutes the focus we hoped to provide by identifying key sites. To date, all key sites have been identified and data have been reviewed to determine whether sites meet the minimum criteria of sea duck abundance and density. To accompany this, polygons have been developed to depict these areas of importance and create a density estimate. Because bird numbers can fluctuate from year to year, peak numbers from the last 20 years are used. Currently, write-ups with site specific information are being completed and reviewed. The final product will be a write-up and map of all key sites with associated shapefiles available for public use. Subsequently, a web application will be developed for users to explore the site information more fully and allow the product to be a living document. Currently, the Atlantic Coast of the United States has seven key sites identified: Coastal Maine, Nantucket, southern Long Island, Delaware Bay, Upper Chesapeake Bay, Lower Chesapeake Bay, and the southern Atlantic Coast.

Advanced Technologies for Waterbird Research

Contact: Diann Prosser, USGS Eastern Ecological Science Center, dprosser@usgs.gov
Partners: USFWS, USACE, Maryland Environmental Service, Unmanned Aerial Systems, BioSpace, LLC

Threats such as habitat loss, increased severity of storm events, and emerging diseases are affecting wildlife populations; particular concern is for threatened and migratory species. Unfortunately, much of the data required to understand how to best manage these affected species requires heavy disturbance to obtain or is not able to be gathered from available methods. Thus, USGS scientists aim to develop and test a variety of technologies to address these issues and inform the management of waterbird species. For instance, surveying colonies with remote sensing technologies could increase efficiency and decrease disturbance in surveying breeding waterbird populations. Eventually, additional equipment could be added to unmanned aerial vehicles to allow for thermal imaging or other approaches. Similarly, deploying remote camera systems at nests could allow researchers to gather a constant data stream that would allow the examination of fine scale behaviors that may be influencing nest success.

Recent products:

Assessing nest attentiveness of common terns via video cameras and temperature loggers, https://doi.org/10.1186/s40657-020-00208-7

Using thermal infrared cameras to detect avian chicks at various distances and vegetative coverages, https://doi.org/10.3996/072019-JFWM-062

Update on the Cooperative Roseate Tern Metapopulation Project

Contact: Dr. Jeff Spendelow, Emeritus Research Wildlife Biologist, USGS, JSpendelow@usgs.gov

I have been coordinating the Cooperative Roseate Tern Metapopulation Project (CRTMP), a research program on the metapopulation dynamics and ecology of the endangered NW Atlantic breeding population of Roseate Terns (ROSTs, *Sterna dougallii*) for 35 years. The primary goal of the CRTMP is to determine the major factors that are limiting the recovery and growth of this population. I rely on many cooperators to band and identify individual terns at their breeding

colony sites, and since 2011 have focused my personal fieldwork on staging site studies, mainly in the Cape Cod area of southeastern Massachusetts (CCMA). This research involves sighting colorbanded individuals with 3-character plastic field-readable (PFR) bands for the purpose of examining temporal and geographic variation in the use of staging sites by ROSTs of different ages and breeding status (e.g., Hatch Year [HY] birds; nonbreeding 1-, 2-, and 3-yr-old adults; failed and successful breeders that are not caring for an HY; and successful breeders that are giving postfledging care to HYs) coming from about a dozen colony sites spanning the entire breeding range.

Because no 2020 report was requested, this one will cover both 2020 and 2021 results. As part of an expanded CRTMP partnership with colleagues in South America, in January and February 2020 Pedro Lima and his crew banded just over 500 ROSTs (from both the NW Atlantic and the Caribbean breeding populations) with PFRs at two wintering areas in Brazil. Covid-related circumstances later in the summer, however, caused cutbacks or cancellation of fieldwork at some breeding colony sites in the US and Canada. As a result, only 390 PFRs were put on ROST chicks at 7 sites from Lobster Bay in SW Nova Scotia (NS) to Falkner Island, CT (FICT) and no ROST chicks were banded at Country Island, NS; Monomoy NWR, MA; or at Great Gull Island, NY (GGNY) in 2020. Although no chick banding or adult trapping was done at GGNY, PFRs were read there on several trips from late May through the first half of June, and again on 2-3 August. These trips resulted in the identification of 10 PFRs at GGNY that had been placed on ROSTs in Brazil, and two more were seen at Stratton Island, ME (SNME). Three PFRs from Brazil were identified at Tuckernuck Island (northwest of Nantucket, MA). I saw one of those birds and 7 others, so overall 22 ROSTs that had been given PRs in Brazil were seen later in North America in 2020.

Covid-related circumstances also delayed the start of my own fieldwork until late August 2020 and my first few days were done in Rhode Island, so only the results from Weeks #12-14 in 2020 in Table 1 are directly comparable to similar periods in prior years. The end of the terns' staging period in 2020 was most similar to the same period in 2018, and fewer PFRs/day were read in the last three weeks of 2020 than in 2019.

Covid-related events prevented winter fieldwork in Brazil and again caused cutbacks or cancellation of fieldwork at colony sites in CT, NY, MA, and NS in 2021. In fact, none in the CT-MA area received any, and only 314 ROST chicks in the NH-NS area received PFRs in 2021. Grace Cormons has led the GGNY ROST fieldwork for more than 30 years, but didn't do observations there this year and as of when this report was written neither she nor I had received a complete list of resights made by others there. So I do not know how many PFR-banded ROSTs from Brazil in 2020 were seen at GGNY in 2021 and can only make comparisons between what was seen on CCMA and further north in 2020 (12) and 2021 (28).

The start was delayed a little, but I spent 59 days from 20 July to 27 September doing fieldwork on CCMA. Despite the fact that far "fewer-than-normal" ROST chicks got PFRs this year, with only one exception (Table 1, Week #8), numbers of PFRs read/day were at record highs in August 2021 compared to numbers read during the same weeks in 2016-2019. However, after the first week in September, while 500 or more terns were seen on most days, they stopped landing in places where I could see their legs and so unusually low numbers of PFRs were read/day for

the last three weeks (#12-#14). Notable observations made in 2021 included 229 PFRs read on both 25 & 30 Aug, a 6-yr-old (so potentially a breeding) ROST from Ireland was seen on 26 Aug, and a 28-yr-old (so potentially a new age record) ROST was seen on 19 & 20 Aug. Although I retired at the end of 2018, I plan to continue to collect and analyze data on staging terns for several more years as an "Emeritus".

Table 1. Weekly average observation statistics of staging terns with plastic field-readable (PFR) bands on Cape Cod, MA. Shown are the weekly average number of Roseate Terns and Common Terns (combined) with PFR bands identified/day by Jeff Spendelow over a 14-week period starting as early as 20 June each year. Note the relatively low values (highlighted in yellow) for periods 10-13 in 2017 compared to the values from 2015-16, and 2018-19. nd = no data. Note: in 2020, weekly periods began 3 days earlier; Week 11 was done in Rhode Island, not CCMA.

Week Number and Starting Date (6-20 = 20 June; 9-19 = 19 September)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Year	6-20	6-27	7-04	7-11	7-18	7-25	8-01	8-08	8-15	8-22	8-29	9-05	9-12	9-19
2014	3.7	1.4	1.3	1.6	3.3	2.5	41	27	32	59	64	19	10	6
2015	0.3	0	0.4	0.9	1.7	6.9	25	nd	43	36	55	66	49	15
2016	nd	4	4.7	6.1	14	34	58	77	50	40	50	49	38	nd
2017	nd	nd	nd	5.5	20	55	44	44	50	16	15	15	22	8.4
2018	nd	nd	nd	nd	nd	26	41	49	54	61	72	89	36	12
2019	nd	0	3.3	5	19	52	59	69	67	77	120	134	44	32
2020*	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.5*	76	38	4.4
2021	nd	nd	nd	nd	38	76	84	60	99	144	136	7	14	1

Improving our understanding of light attraction in Leach's Storm-Petrel through the Regional Assessment of Offshore Oil and Gas Exploratory Drilling East of Newfoundland and Labrador

Contact: Sabina Wilhelm, Canadian Wildlife Service, Environment and Climate Change Canada, sabina.wilhelm@ec.gc.ca

In 2019, the Impact Assessment Agency of Canada launched the first Regional Assessment (RA) in Canada with the purpose to improve the efficiency of the federal impact assessment process for industry for future exploratory drilling projects in the Newfoundland and Labrador offshore, while ensuring the maintenance of high standards regarding environmental protection. Environment and Climate Change Canada (ECCC) was actively engaged throughout the process, highlighting concerns pertaining to aspects of oil and gas activities on migratory birds, including light attraction and the risk of oil spills. In 2020, the Minister of the Environment signed off on several recommendations made by the RA committee, including the following three key commitments relating to Leach's Storm-Petrel: 1) Increasing research to understand storm-petrel light attraction, 2) Supporting industry to implement stranded bird surveys, and 3) Supporting industry on strengthening seabird observer training. Following is an overview of some of the initiatives that are currently underway, led and/or supported by ECCC and involving many partners, including academic, non-government organizations, and other government departments, to improve our understanding of Leach's Storm-Petrel to light attraction:

- Quantifying light radiance and light footprint in the marine and terrestrial landscape;
- Supporting and enhancing seabird observer training for offshore personnel conducting at-sea and stranded bird surveys to ensure that ECCC standards are being followed by trainers and observers;
- Developing and implementing systematic stranded bird surveys at various industrial sites (offshore and onshore across different types of industries, including offshore oil and gas, energy production and storage, and fishing) to estimate stranded bird encounters, quantify impacts, and enable release of live stranded birds;
- Examining different approaches to reduce attraction and mortality associated with strandings occurring at onshore industries, which ultimately could be applied to the offshore;
- Conducting scientific studies, which include appropriate controls, manipulating light characteristics (e.g., lighting type, intensity, wavelength) to investigate differences in attraction across age classes;
- Developing the use of marine radar to monitor local movements and understand factors leading to strandings;
- Identifying source colonies of stranded juvenile Leach's Storm-Petrels using genomics and biomarkers;
- Monitoring and characterizing Leach's Storm-Petrel onshore strandings across Atlantic Canada using a citizen science approach;
- Conducting a Public Opinion Research study in coastal communities of Newfoundland where mass strandings of Leach's Storm-Petrels occur to understand human perceptions toward this species to inform conservation actions.

Regional Collaboration to Understand and Minimize Waterbird Impacts from Offshore Wind Energy Development

Contact: Kate Williams, Biodiversity Research Institute, kate.williams@briwildlife.org

The New York State Energy Research and Development Authority is leading a range of science-based stakeholder engagement efforts under the umbrella of the Environmental Technical Working Group for Offshore Wind (E-TWG). In relation to birds, a stakeholder workgroup from the 2020 State of the Science Workshop on Wildlife and Offshore Wind Energy Development recently finalized a report summarizing recommendations for short-term (<5 year) research priorities to improve understanding of cumulative impacts to wildlife as the offshore wind industry progresses in the United States. Currently, we are initiating a new effort in collaboration with the U.S. Fish and Wildlife Service Migratory Bird Program and Bureau of Ocean Energy Management to develop guidance for conducting project-specific pre- and post-construction monitoring at offshore wind farms to detect changes in marine bird habitat use (e.g., displacement, attraction, and macro- to meso-scale avoidance). We will be soliciting AMBC members' expertise and engagement on this effort, including participation in a committee to oversee guidance development. If you are interested in being involved, please email Kate Williams. For more information about E-TWG activities and to sign up for the e-mail listserv, visit www.nyetwg.com.

Wildlife and Offshore Wind (WOW): A Systems Approach to Research and Risk Assessment for Offshore Wind Development

Contacts: Kate Williams, Biodiversity Research Institute, kate.williams@briwildlife.org
Evan Adams, Biodiversity Research Institute, evan.adams@briwildlife.org

The U.S. Department of Energy recently announced the award of a $7.5 million project to provide critical environmental and wildlife data to support offshore wind development. *Wildlife and Offshore Wind (WOW): A Systems Approach to Research and Risk Assessment for Offshore Wind Development from Maine to North Carolina* will be a five-year study focused on gathering data on the effects of the first commercial-scale offshore wind energy developments in the U.S. on marine mammals, birds, and bats. Duke University leads the WOW team, a research consortium of more than 15 institutions with expertise in statistical and ecological modeling; geospatial data analysis and modeling; marine megafauna research; avian and bat ecology; bioacoustics and behavioral ecology; biological oceanography; and technology development. The avian research components of this project will be led by the Biodiversity Research Institute and Stony Brook University and will emphasize data synthesis across multiple taxa and wind energy areas. The project will kick off in early 2022 with a year of planning and research framework development.