Gap Analysis of Collective Performance on Established Stakeholder Values by Contemporary Gulf of Mexico Bird Monitoring Programs

Final Report, Phase 1: Seabird and Shorebird Programs

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Cover photos: (left) Brown Pelicans, Royal Terns, Sandwich Terns, and other seabird species roosting on the Isles Dernieres Barrier Island Refuge, Louisiana, 2013; (right) American Oystercatcher, Caminada Headlands, Louisiana, 2012. Photo credits: J. L. Schulz.

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their willingness to participate and share their information and knowledge. The findings and conclusions in this Report are those of the author(s) and do not necessarily represent the views of Ducks Unlimited, Inc. or the U.S. Fish and Wildlife Service. Any mention of trade names is purely coincidental and does not represent endorsement by the funding agencies, the government, or GoMAMN.

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INTRODUCTION

Coastal habitats are increasingly impacted by an array of anthropogenic activities and climatic changes that occur at multiple spatial scales. In the Gulf of Mexico, bird populations face challenges with sea-level rise, extreme weather events, commercial and residential development, energy development, pollution, and other factors that often cross physical and political boundaries (Baldera 2018, Burger 2018). Unfortunately, developing and implementing monitoring strategies that allow for strong inference of broad-scale impacts to bird populations is challenging due to diversity of ecosystems, economic use, and decision-making jurisdictions (see Wilson et al. 2019). A piecemeal approach to monitoring can have negative implications for conservation efforts, as exemplified by the paucity of baseline data that was critically needed in the aftermath of the Deepwater Horizon oil spill in 2010, which impacted coastlines from Texas to Florida (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). A lack of comprehensive, integrated bird resource data prior to and following the spill slowed the mobilization of monitoring/response and prevented meaningful evaluation of on-the-ground response efforts (see Bjorndal et al. 2011, Love et al. 2015, Woodrey 2017). In the years since the spill, there has been an unprecedented focus on (and dedicated resources for) coastal recovery and restoration of injured resources (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016).

In this context, a diverse group of partners across the northern Gulf coast with a shared interest in a comprehensive approach to bird monitoring established the Gulf of Mexico Avian Monitoring Network (GoMAMN). GoMAMN's purpose is to promote collaborative, integrated avian monitoring across the Gulf of Mexico, and the group is utilizing principles of decision theory and conceptual models to tackle this challenge. Using a structured decision-making framework, partners and stakeholders have collectively identified the core values and concerns underpinning bird monitoring efforts in the Gulf of Mexico and used them to develop a set of fundamental objectives and sub-objectives for bird monitoring (Wilson et al. 2019, Fournier et al. 2021). These objectives serve as a framework for maximizing the utility of bird monitoring data to inform restoration and advance bird-habitat conservation across the northern Gulf of Mexico.

Understanding the current monitoring practices, knowledge gaps, and data needs is vital to maximizing the usefulness of bird data in an integrated framework (Adams et al. 2019). Having established a list of stakeholders' key values and objectives regarding bird monitoring, GoMAMN's next step was to determine how well the monitoring community of practice in the Gulf of Mexico is collectively addressing/meeting those objectives. With this goal in mind, we conducted a gap analysis of contemporary monitoring efforts focusing on the three fundamental objectives identified by GoMAMN stakeholders during the SDM process, which are: (1) maximize relevance of monitoring data, (2) maximize integration of bird monitoring efforts, and (3) maximize scientific rigor (Fournier et al. 2021).

Additionally, stakeholders further broke down the topic of "relevance" into the following sub-objectives: (1.1) maximize monitoring of management effectiveness, (1.2) maximize monitoring of population and habitat status, and (1.3) maximize monitoring of ecological processes. Collectively, these sub-objectives help define the aspects of monitoring relevance, integration, and rigor that are most important to stakeholders.

METHODS

To better understand various aspects of current monitoring practices, it was necessary to compile a list of active avian monitoring programs across the Gulf of Mexico. In the interest of limiting our analysis to programs that are truly collecting monitoring data, we defined "monitoring program" as "any effort where birds are repeatedly counted or surveyed with a duration of at least 5 years." Programs were required to collect at least one bird-specific parameter such as presence/absence, relative abundance, productivity, and bird locations.

An inventory of bird monitoring programs constructed for a gap analysis of Gulf monitoring programs (Love et al. 2015) served as the foundation for our program list. Additional programs were added to the list as we were made aware of them, often with assistance from representatives for other programs and GoMAMN working group members. It is common for monitoring programs to undergo changes over time, so program records were vetted via one-on-one conversations with lead points of contact for those programs, who confirmed that all information was accurate and up to date. Programs on existing lists that did not meet the above criteria were omitted, and we restricted the list of programs for this analysis to those that were actively collecting data during 2020.

Some programs in our inventory are organized as a collection of sub-components (e.g., the Alabama, Louisiana, Mississippi, and Texas Coastal Bird Surveys, which are statewide-scale programs nested under the multi-state Audubon Coastal Bird Survey program). We kept records of both "parent" and "child" programs in the inventory; however, we only included survey responses for "parent" programs (i.e., programs at their largest operational scale) in our analysis to avoid redundancy.

GoMAMN's stated objectives, and, in some cases, the specific metrics by which they can be measured, provide a means of evaluating current monitoring practices and identifying opportunities for improvement and integration. We developed a list of "parameters of interest" based on the 27 sub-objectives and priority needs as described within Fournier et. al. (2021) and the taxa-based chapters for seabirds and shorebirds within the Strategic Bird Monitoring Guidelines for the Northern Gulf of Mexico (Jodice et al. 2019 and Brush et al. 2019, respectively).

To understand how each monitoring program performs relative to each of these parameters, we designed a survey which, when completed by a representative from each program (hereafter "participant"), provided direct and indirect information about how each program performs relative to our

parameters of interest (for full survey form, see Appendix A). Survey responses thus populated the data set for this analysis. Since we are analyzing program data collectively in the interest of evaluating Gulf-wide performance on these parameters, we designed questions that allowed participants to describe the relevant aspects of their programs such that they could be summarized quantitatively and/or qualitatively (see Results below). Responses to some questions can be used to gauge collective performance for parameters collectively (e.g., species monitored, scale, etc.).

Questions were designed to evaluate most, but not all of the sub-objectives identified. Some sub-objectives focus on the "appropriateness" of certain project aspects (such as the appropriateness of survey design, stated objectives, and target taxa relative to the research question), and thus, are more useful in the context of evaluating individual project proposals. Others were deemed not relevant to this effort, either because they were simply too difficult to gauge a response or because they represented a value judgment for a specific monitoring program. Ultimately, we omitted five sub-objectives from the survey completely and replaced ten with questions that solicit descriptive information relevant to the topic. Additional basic data about programs (such as program lead, agency, state, etc.) were collected and served to uniquely identify each monitoring program, but this information was not included in the analysis.

Surveys were requested following the updating of program records and received on a rolling basis over the course of seven months. As each survey was received, it was reviewed for completeness. At this time, any clarifications needed were addressed via phone or email contact with the participant before converting the data into spreadsheet format. Once all survey records were deemed complete, we worked in teams of two to quality-check the participants' data on a line-by-line basis to ensure that data entered matched data submitted. A small number of participants were contacted following this step to address any remaining questions.

We performed summary statistics for each question based on the survey results we received. For multiple-choice questions, this meant tallying how many programs chose each option for each question. Several questions were in open-response format, meaning participants could respond by submitting written responses in a text box provided. As expected, written responses showed a great deal of variation, so we reviewed responses collectively and summarized trends relevant to each topic. Survey questions were arranged in a slightly different order from the way their corresponding topics are ordered in Fournier et al. (2021) to provide an easy flow for participants and results are presented in the order in which topics were arranged on the survey.

RESULTS

We sent the survey to representatives from 50 programs in the Gulf of Mexico that monitor shorebirds and/or seabirds and received responses for 44 programs (88% response rate). We removed 13 responses from this dataset because their programs either did not meet criteria for duration or current

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activity or because they were technically nested under a broader parent program (which may or may not have participated). However, five responses from programs that are "partially nested" (i.e., they constituted a sub-component of a broader program to which they contribute data, but also collect additional data to address local needs independently from the parent program) were included in the data set to represent those local efforts specifically. Thus, 31 responses for shorebird/seabird monitoring programs are included in this analysis (see Appendix B for full list of participating programs).

Relevance of monitoring data

Population and habitat status: Every program surveyed monitors at least one of GoMAMN's bird species of conservation concern (Wilson et al. 2019; we refer to these as "priority species" hereafter for brevity). Thirty programs (96%) monitor at least one priority seabird or shorebird species, and 24 programs (77%) monitor >1 priority species (Figures 1-3). Thirteen (42%) programs focus on monitoring birds within a single taxa group. Most other programs cover 2-4 taxa groups, with one program monitoring species from all taxa groups except for one (passage migrants) (Figure 4). Twenty programs (65%) monitor seabirds, and 26 (84%) monitor shorebirds, whereas 14 (45%) monitor both. For both shorebirds and seabirds, species that breed on the Gulf coast are monitored by more programs than those that do not.
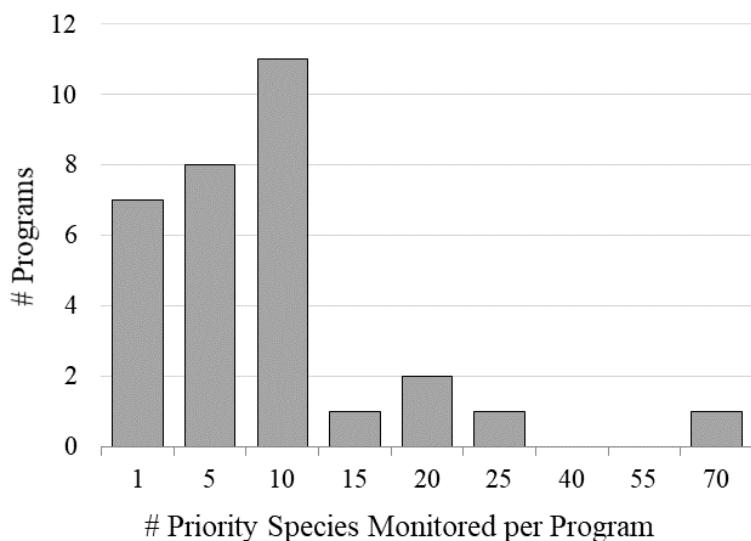
Figure 1. Number of priority species monitored by Gulf of Mexico seabird and/or shorebird monitoring programs. Bars show number of species per program that are found on GoMAMN's list of bird species of conservation concern (see Jodice et. al. 2019 and Brush et al. 2019 for lists of priority seabird and shorebird species, respectively).

Conservation trend and concern scores produced in 2017 by Partners in Flight (Panjabi et al. 2017) were used as a metric for understanding and comparing conservation need between species (see Jodice et al. 2019 and Brush et al. 2019 for tables showing trend and concern scores for priority seabirds and shorebirds, respectively). We took a closer look at monitoring coverage for four seabird/shorebird species (Piping Plover *(Charadrius melodus)*, Red Knot *(Calidris canutus)*, Black Skimmer *(Rynchops*

niger), and Black-capped Petrel *(Pterodroma hasitata)* on GoMAMN's priority species list that have a PIF score of 5 (highest concern). Of these, Black Skimmer, a seabird that commonly breeds across the northern Gulf of Mexico, is monitored by the largest number of programs (n = 15, 48%); which span all five Gulf States. This list includes two multistate programs, and at least one statewide-scale program that monitors Black Skimmers exists in each state (except for Alabama, where the species is being monitored by a local-scale program). Louisiana is also home to five distinct local and statewide programs that focus on this species, all led by different entities and having different objectives.

No programs we surveyed specifically target the Black-capped Petrel for monitoring, likely because we would only expect this species to be encountered at–sea. No pelagic seabird focused monitoring programs met our criteria for inclusion in this analysis, but four nearshore-based programs named at least one priority pelagic seabird as focal species.

Piping Plover and Red Knot, shorebird species that use the Gulf coast during winter and migration, are each monitored by 12 programs, including 11 programs that monitor both species. These programs span all five Gulf states; however, monitoring for these species in Mississippi and Alabama occurs only under large-scale (multistate or international) programs, while the other three Gulf states each have several additional programs focused on these species that operate at the local or state levels.
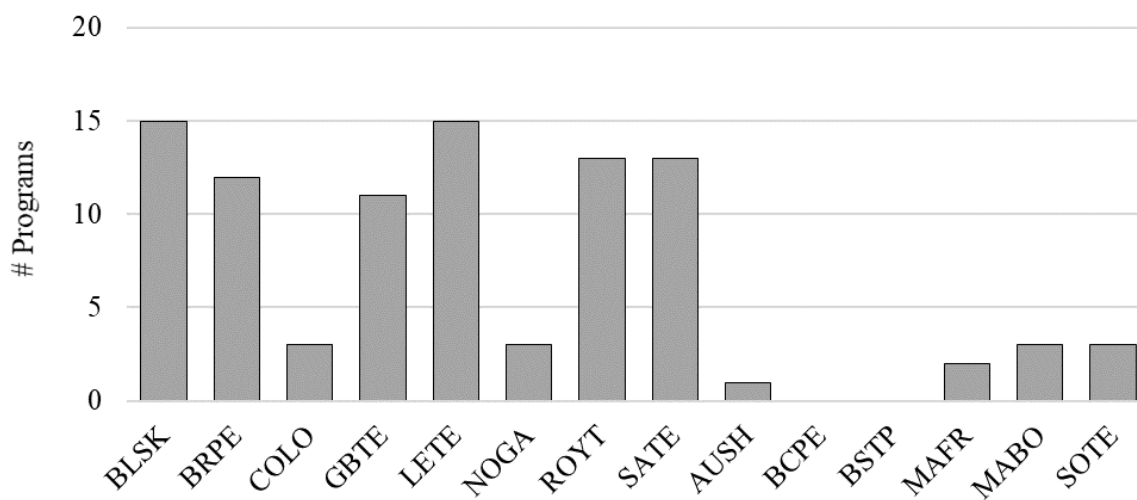
Figure 2. Number of programs monitoring each priority seabird species in the Gulf of Mexico. Four-letter codes on X-axis represent standardized species-specific "alpha" codes established by the AOU for use as shorthand. BLSK = Black Skimmer *(Rynchops niger)*, BRPE = Brown Pelican *(Pelecanus occidentalis)*, COLO = Common Loon *(Gavia immer)*, GBTE = Gull-billed Tern *(Gelochelidon nilotica)*, LETE = Least Tern *(Sterna antillarum)*, NOGA = Northern Gannet *(Morus bassanus)*, ROYT = Royal Tern *(Thalasseus maximus)*, SATE = Sandwich Tern *(Thalasseus sandvicensis)*, AUSH – Audubon's Shearwater *(Puffinus lherinieri)*, BCPE = Black-capped Petrel *(Pterodroma hasitata)*, BSTP = Band-rumped Storm Petrel

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(Hydrobates castro), MAFR = Magnificent Frigatebird *(Fregata magnificens)*, MABO = Masked Booby *(Sula dactylatra)*, and SOTE = Sooty Tern *(Onychoprion fuscatus)*.
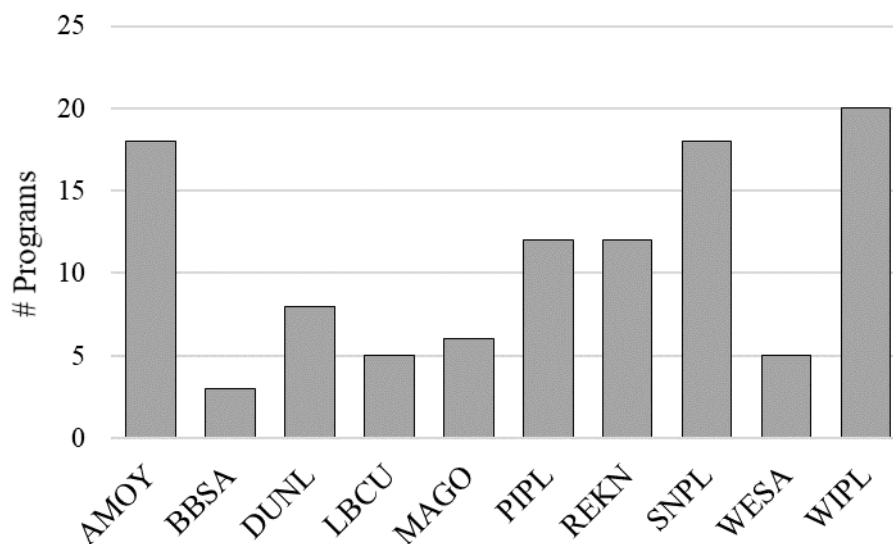
Figure 3. Number of programs monitoring each priority shorebird species in the Gulf of Mexico. Four-letter codes on X-axis represent standardized species-specific "alpha" codes established by the AOU for use as shorthand. AMOY = American Oystercatcher *(Haematopus palliatus)*, BBSA = Buff-breasted Sandpiper *(Calidris subruficollis)*, DUNL = Dunlin *(Calidris alpina)*, LBCU = Long-billed Curlew *(Numenius americanus)*, MAGO = Marbled Godwit *(Limosa fedoa)*, PIPL = Piping Plover *(Charadrius melodus)*, REKN = Red Knot *(Calidris canutus)*, SNPL = Snowy Plover *(Charadrius nivosus)*, and WIPL = Wilson's Plover *(Charadrius wilsonia)*.

Figure 4. Number of avian taxa groups monitored per Gulf seabird and/or shorebird monitoring program. Each priority bird species a program monitors falls into one of seven taxa groups identified in GoMAMN's Strategic Bird Monitoring Guidelines (Wilson et al. 2019), including landbirds,
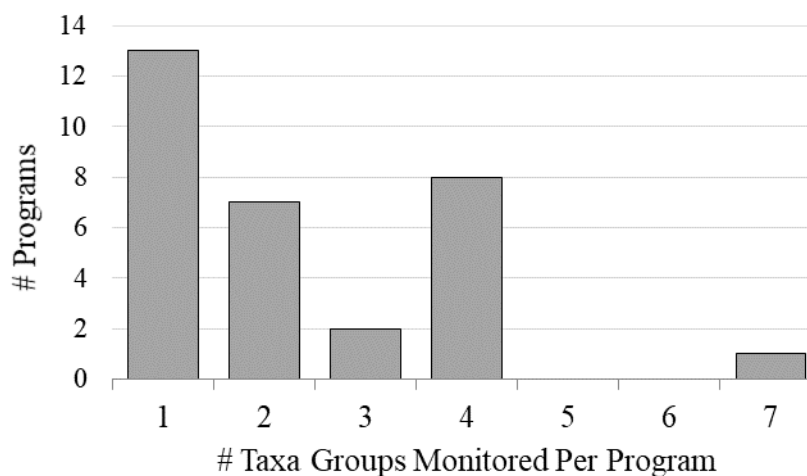
marsh birds, raptors, seabirds, shorebirds, wading birds, and waterfowl. While all programs included in

this analysis monitor seabirds and/or shorebirds, some of these programs also monitor birds that fall in other groups.

The duration of Gulf monitoring programs ranges from 5-120 years (Figure 5). Forty-five percent of programs surveyed were initiated over the last decade; however, because we restricted our analysis to programs that had been active for at least five years, all of those were initiated between 2010 and 2015. We know at least six other currently active programs began after 2015, but these were omitted.
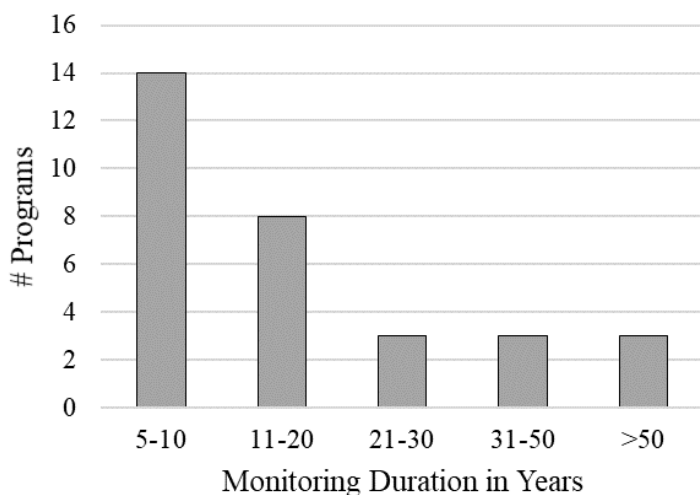
Figure 5: Monitoring duration of currently active Gulf shorebird and seabird programs. Bars show the number of programs for which the duration of monitoring falls within the year ranges shown.

Gulf monitoring programs occur at a wide variety of spatial scales (Figure 6). Currently, the majority of programs ($n = 17$, 55%) monitor birds at a local scale, defined for our purposes as a footprint smaller than statewide. Examples of local-scale programs include those targeted at a single site (e.g., a National Wildlife Refuge, restoration site, city beach, etc.) or multiple sites that are clumped relatively close together (i.e., not well-distributed across a species' statewide range). On the other end of the scale spectrum, international programs (those that conduct monitoring in the United States and at least one other country) comprise 10% ($n = 3$) of efforts in the GoM.
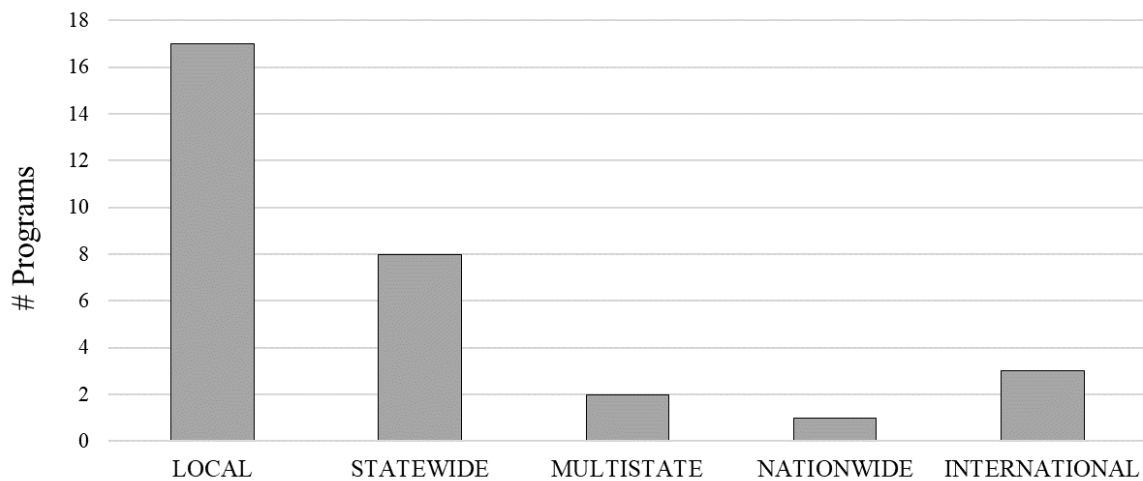
Figure 6: Geographic scale of Gulf seabird & shorebird monitoring programs. Currently, 55% of programs occur at the local scale, e.g., individual sites or multiple sites not spread across a species' statewide range.

GoMAMN stakeholders value maximization of the spatial and temporal scope of habitat quantity and quality assessments (Wilson et al. 2019). We asked programs if they collect habitat quality data, what types of data they collect, and over what time frames. Roughly a third of programs ($n = 11$, 35%) indicated that their respective programs collect data about habitat quality, and multiple data types were reported (Table 1). Responses ranged from very general (e.g., "habitat characteristics," "habitat type") to very specific (e.g., "relative wrack abundance," "predator type," "vegetative cover at nests"). Less than half of these participants provided a time scale for the collection of habitat quality data, but those who did reported time frames of 2-10 years.

Table 1. Types of habitat quality data collected by current Gulf seabird and shorebird monitoring programs. Responses to this question were grouped into categories based on themes, shown below.

Type of habitat quality data collected	# programs collecting	% of programs surveyed
Predation (presence, type, pressure)	5	16%
Human disturbance	5	16%
Vegetation (as cover and unspecified)	4	13%
General "types" or "characteristics" of habitat used for nesting or other behaviors	4	13%
Prey (broadly/availability)	3	10%
Wrack material (presence/abundance/type)	2	7%
Elevation (at nest sites, or unspecified)	2	7%
Slope	1	3%
Trash (abundance)	1	3%
Invasive species (presence)	1	3%

Ecological processes: GoMAMN working groups identified 13 key ecological process uncertainties for seabirds and 7 for shorebirds (for full list, see Appendix C). Program leads were asked to refer to this table and select any/all uncertainties being addressed by their monitoring program. Seventeen (54.8%) of the participating programs stated that they currently collect data about ecological processes (Figure 7). Only four (30.7%) of the seabird uncertainties are being addressed by current monitoring efforts (1-4 programs each). In contrast, all seven shorebird uncertainties are being addressed, by 1-6 programs each.
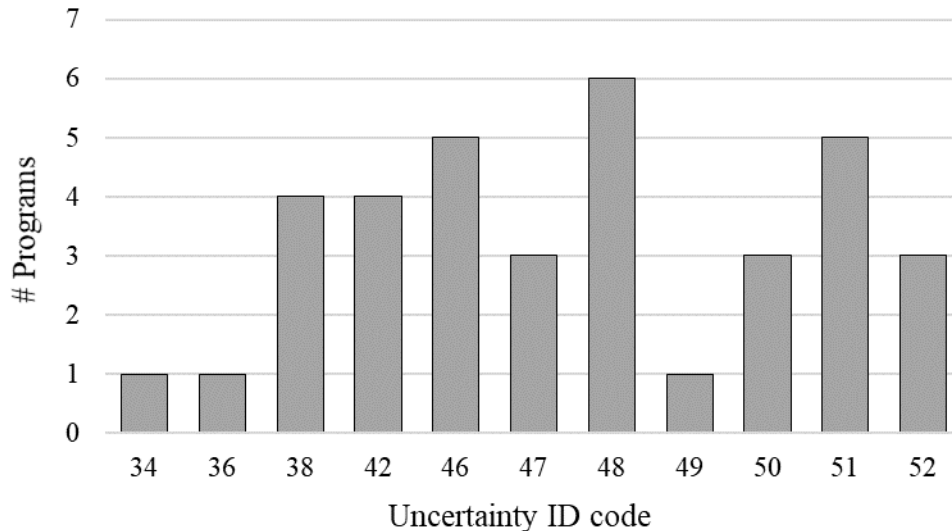
Figure 7. Ecological process uncertainties addressed by current Gulf seabird and shorebird monitoring programs. Each bar represents the number of programs addressing a specific ecological process uncertainty, which is indicated by the ID code below it. These codes correspond to the uncertainty descriptions in Appendix C. Codes 34, 36, 38, and 42 refer to uncertainties specific to seabirds and codes 46-52 are specific to shorebirds.

       All four seabird uncertainties addressed by current programs focus on "nearshore" seabirds during the breeding season (Figure 7). One program is looking at the direct and indirect effects of sea-level rise on various productivity metrics at a statewide scale. Uncertainties around the productivity effects of avian/mammalian predation and hurricane timing/intensity are being addressed by four programs each (two programs are looking at both).

       The most addressed ecological process uncertainty for shorebirds represents the degree to which habitat loss due to severe weather impacts shorebird survival and population trends. Of the 26 programs monitoring shorebirds in the Gulf, 23% ($n = 6$) are attempting to address this specific uncertainty. Uncertainty regarding population-level impacts to specific focal species from changes in local breeding habitat availability due to changes in vegetation community through succession and sea-level rise are each being addressed by five programs. The effects of red tide and climatic changes on reproductive success, survival, and population size for all shorebird species are each being addressed by three programs. Three programs are monitoring wintering Piping Plovers to understand potential population-level effects of succession-related changes in winter habitat on various metrics regarding year-round processes such as health, migration timing, breeding success, etc. The least-commonly addressed uncertainty for shorebirds relates to effects of cyanobacteria blooms on reproductive success and survival; this is being addressed by one program.

       Nine of 13 priority ecological process uncertainties (Appendix C) for seabirds remain unaddressed by existing monitoring programs. Four of these uncertainties apply specifically to processes impacting productivity metrics for breeding pelagic seabirds, which are unlikely to be addressed without international collaboration. Uncertainties about the impacts of climate change-related factors (e.g., sea-level rise, ocean acidification) on seabird foraging behavior and prey dynamics on seabird productivity, survival, and density are also not addressed. Finally, there are no existing monitoring programs evaluating potential effects from oil or other chemical pollutants on seabird health, condition, and survival (see also Ottinger et al. 2019).

       Management effectiveness: Of the 31 participating programs, 24 (77%) are monitoring birds in the context of understanding management or restoration actions. As with ecological process uncertainties, we asked program leads to refer to a table of specific uncertainties identified as "priorities" by GoMAMN

working groups (Appendix D) and list which uncertainties are addressed by their program. Leads for two programs stated that they monitor in the context of management/restoration uncertainty generally, but do not address any of the uncertainties from GoMAMN's list. The other 22 (71%) programs stated they are addressing at least one uncertainty from the list.

Of the nine uncertainties identified for seabirds, six are being addressed by current programs (Figure 8). The three most commonly addressed uncertainties are related to whether or not island creation/restoration improves habitat quality during breeding and nonbreeding seasons for seabirds nesting in beach habitat ($n = 9$), marsh habitat ($n = 2$), and other habitat types ($n = 5$) (comprising 45%, 10%, and 25% of seabird-monitoring programs, respectively). Two uncertainties being addressed by current monitoring are about the effectiveness of predator control as a means of improving reproductive success for beach-nesting ($n = 3$, 15%) and marsh-nesting ($n = 1$, 5%) seabirds. Finally, uncertainty regarding the effects of reducing human disturbance on the reproductive success and nonbreeding habitat use of nearshore seabirds is being addressed by eight (40%) seabird programs.

Three management/restoration uncertainties regarding seabirds remain unaddressed. Currently, none of the programs surveyed are focusing on the influence of freshwater management on habitat and prey for nearshore seabirds, effects of Sargassum harvest on prey availability and population-level consequences for two specific pelagic species, or the effects of commercial fishing on three species of nearshore seabirds.
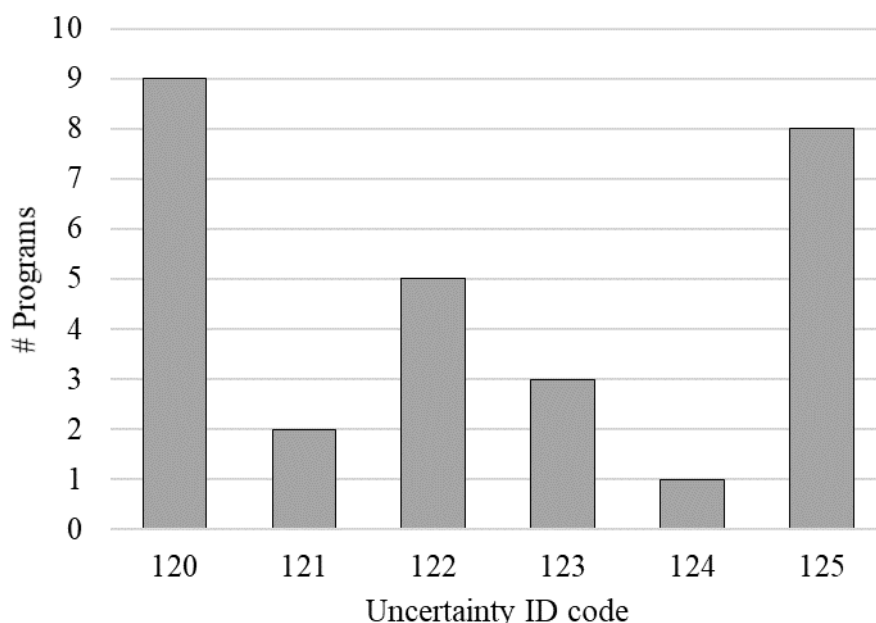

Figure 8. Management uncertainties addressed by current Gulf seabird monitoring programs. Each bar represents the number of programs addressing a specific ecological process uncertainty, which is

indicated by the uncertainty ID code below it. These codes correspond to the uncertainty descriptions in Appendix D, Table D1.

GoMAMN's shorebird taxa group identified 23 key management/restoration uncertainties (Appendix D, Table D2). The top four most commonly addressed uncertainties for shorebirds are focused on three species that breed on the Gulf coast: American Oystercatcher, Snowy Plover, and Wilson's Plover. Six programs (23% of the programs monitoring shorebirds) are looking at the effects of human disturbance and/or stewardship activities such as nest site protection on reproductive success and population size for these species. Similarly, five programs (19% of shorebird programs) are looking at whether islands designed and managed for shorebirds can support larger nesting populations. Beach driving is another factor of interest, with 5 programs (19%) evaluating effects of this specific human activity during the breeding season or at other times of the year. Twelve additional uncertainties identified by GoMAMN are being addressed by one or more monitoring programs; see Figure 9 (below) and Appendix D, Table D2 for details.

Seven uncertainties on GoMAMN's list (#s 129, 137, 138, 139, 145, 146, and 151; Appendix D, Table D2) remain unaddressed by the programs surveyed. One common theme that emerged was a question of whether or not various strategies for habitat or site management on wintering areas negatively affect prey abundance and/or availability to a degree where the health and body condition of wintering adult shorebirds are impacted, and if so, whether such effects result in carry-over effects across other life-history stages or seasons (e.g., Norris 2005, Norris and Taylor 2006); thus, impacting species at the population-level. Uncertainties associated with this question included general management practices (129), management of dense/woody vegetation (137), freshwater management (138 and 139), and human disturbance (145 and 146). Similarly, the question of whether contaminants (e.g., pesticides) at key stopover points for migrating Buff-bellied Sandpipers and Long-billed Curlews lead to decreased survival and/or reproductive success, and whether such effects are direct (e.g., exposure-induced mortality) or indirect (e.g., reduced prey availability) is not being addressed by current monitoring efforts.
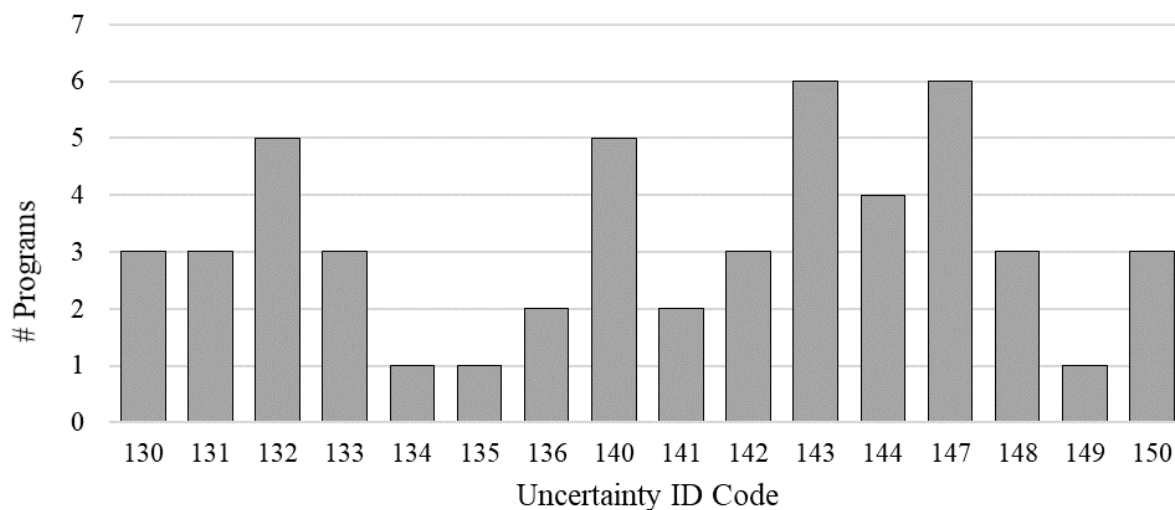
Figure 9. Management uncertainties addressed by current shorebird monitoring programs. Each bar represents the number of programs addressing a specific ecological process uncertainty, which is indicated by the uncertainty ID code below it. These codes correspond to the uncertainty descriptions in Appendix D, Table 2.

We asked participants a series of questions to determine whether they are monitoring birds in the context of adaptive management. These questions were distilled from key concepts about adaptive management as defined by Williams et al. (2009). Thus, definitions used are consistent with GoMAMN's terminology (Wilson et al. 2019, Fournier et al. 2021). Based on the responses we received, no current seabird or shorebird program is doing 100% adaptive management per this definition; however, several programs are very close to meeting these criteria. Of the programs monitoring in the context of understanding management/restoration action, five (20.8%) would qualify as "(conducted in the context of) adaptive management" under our criteria IF multiple conceptual models were being compared, as in a multi-model framework (i.e., they answered "yes" to all adaptive management questions except for the last one). Table 2 below shows these results by question.

Table 2. Adaptive management tenets met by current monitoring programs. Questions below are from the survey form used by participants (Appendix A). Percentages shown are relative to the subset of programs that are monitoring in the context of understanding the effects of management actions ($n = 24$).

Survey question	# of programs that answered "YES"
a: "Is monitoring linked to an explicit management objective?"	11 (45.8%)
b: "Is/are the management action(s) being monitored associated with iterative decisions?"	14 (58.3%)
c: "Have decision makers and other stakeholders identified a key uncertainty about the management action that impedes decision making?"	10 (41.6%)
d: "Is monitoring associated with a conceptual model or set of hypotheses about how the management action/decision impacts birds?"	6 (25.0%)
e: "If 'yes' to question d, are multiple conceptual models being considered and compared, as in a multi-model framework? AND if so, is there an explicit (formal) process for updating model/hypothesis weights to reduce uncertainty and inform decision-making?"	0 (0.0%)

Integration of bird monitoring efforts

As currently defined in Fournier et al. 2021, the six sub-objectives in this field serve primarily to guide decision-makers in the context of choosing where to allocate resources among multiple monitoring project proposals and are thus outside the scope of this project. However, we are interested in knowing current program performance related to these objectives. We did not address two sub-objectives that were less relevant to the scope of this analysis ("*Broad Impacts*" and "*Leverage*") and replaced two ("*Data Sharing*" and "*Alignment*") with simple descriptive questions as a means to improve our understanding of existing monitoring programs.

Existing priorities: Participants were asked if their program addresses established priorities in any existing conservation plans (e.g., U.S. Shorebird Conservation Plan, state wildlife action plans, etc.). If a participant chose "Yes," they were prompted to explicitly identify which existing conservation plan(s) were linked to their programs' monitoring efforts. This follow-up question was framed as an open

response, so participant s could answer however they wanted. As a result, response formats varied and were more qualitative than quantitative in nature, reducing ease of interpretation. Some participants gave us the exact titles of conservation plans, authors, and dates of publication. Some identified the plans and specified which priorities within those plans are being addressed by their programs. In other cases, participants simply provided plan name(s), either via exact title, an abbreviated title, or in some cases, an incorrect title. All responses were re-checked to ensure it was clear as to which plan(s) were being referenced.

Twenty-four (77%) of the 31 participating programs identified established priorities in 29 existing conservation plans (collectively; Appendix E). The number of plans addressed per program ranged from 1 to 14. Fifty-eight percent of participants only referenced a single conservation plan. Plans varied in scale, including very local (e.g., "comprehensive conservation plans" for National Wildlife Refuges), statewide (e.g., state wildlife action plans (SWAPs), regional (e.g., oil-spill related plans targeting GoM states and waters), national (e.g., U.S. Shorebird Conservation Plan), and international (e.g., North American Waterbird Conservation Plan). The top four conservation plans, each referenced by 5 monitoring programs, were the United States Shorebird Conservation Plan, Texas Conservation Action Plan, Florida Beach-Nesting Bird Plan, and Florida's Species Action Plan for Four Imperiled Beach-Nesting Birds (see Appendix E for details).

Partners and alignment: Current programs range widely in the degree of partnership/collaboration involved in monitoring efforts. Participants from programs that do collaborate with outside organizations listed anywhere from one to over 900 partners (Figure 10); however, the median of that range is 5, so the data are heavily skewed toward 5 or fewer partners (including the 16% of programs surveyed that do not partner with any other organizations). Fifty percent of programs also claimed "other" (unspecified) types of partners. The majority ($n = 20$, 64.5%) of participants state that their monitoring is generally in alignment with other monitoring programs. Two (6%) were unsure if it was or not.
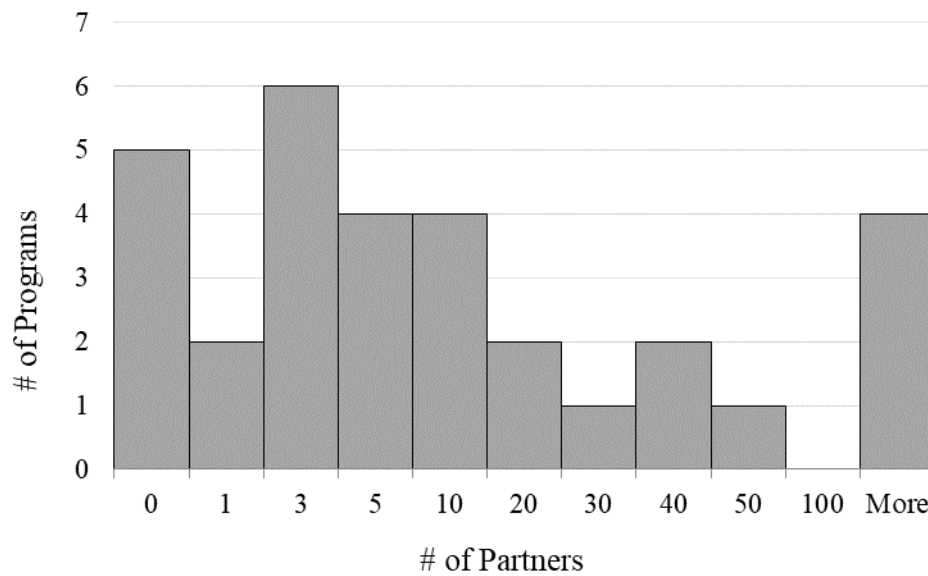
Figure 10: Histogram showing the variation in the number of organizations participants identified as partners on their monitoring programs. Sixteen percent of programs have zero partners, but the other 84% partner with anywhere from one to 900+ organizations.

Of the 26 monitoring programs that do involve partnerships, most (92%) had more than one type of partner. State government agencies were the most common (89%), followed by federal government agencies (77%) and non-profit/non-governmental organizations (73%). Private companies and local governments also served as program partners (42% and 39%, respectively).

Data sharing and storage: Data collected by the vast majority of programs are generally not restricted from being shared, at least officially. Only 3% of programs ($n = 1$) are officially restricted from sharing data, potentially because the data include sensitive information (e.g., locations of sensitive species, personally identifying information, etc.) though we did not ask participants to explain the reason. Approximately 45% of the programs surveyed ($n = 14$) have not established a plan to share their data with the broader scientific community in any specific timeline, or do not intend to share (Figure 11). Of the 55% that have established timelines for sharing, the majority ($n = 18$, 59%) plan to share within 1 year of project completion.
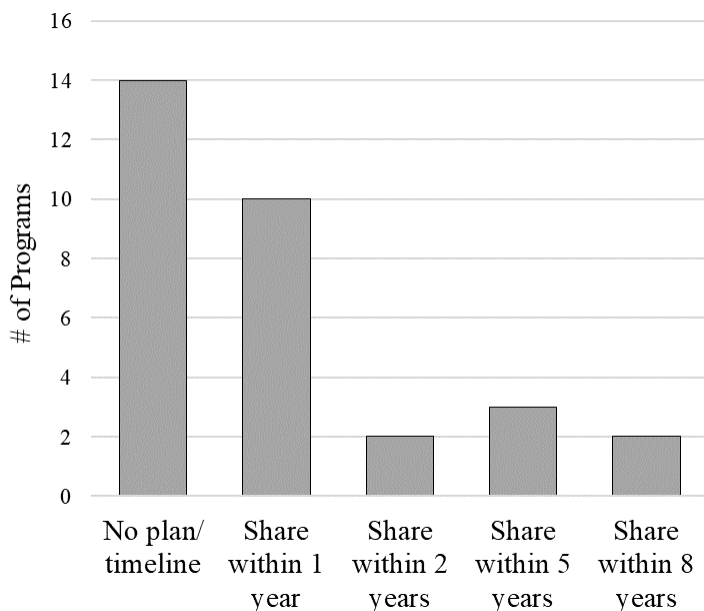
Figure 11. Summary of data sharing timelines for seabird and shorebird monitoring practitioners in the northern Gulf of Mexico. Almost half of programs surveyed (45%) have not established a plan or timeline for data sharing. Of those that have established plans or timelines, the majority (59%) plan to share within one year of project completion.

Participants were asked where their monitoring data was currently stored (or would be stored in the future) and given options to choose from in the form of a dropdown menu. If their storage location was not on that list, or if they use more than one repository for data storage, they were able to free-write any additional repositories in a separate field. Eighteen programs (58.1%) reported that their data was not stored in a shared location, but stored locally in a manner not accessible to others (may include options such as physical datasheets, electronic files stored on a local hard drive, etc; however, participants did not generally specify beyond selecting the "local" option). Of the shared data repositories selected from the list or filled in by participants, the most commonly used repository was the Florida Shorebird Database, which is used by 5 programs we surveyed. The Christmas Bird Count and eBird databases were also used by 3 and 4 programs, respectively. See Table 3 for a summary of data storage responses.

Table 3. Data repositories currently in use by seabird and shorebird monitoring practitioners in the northern Gulf of Mexico.

Data Repository	Program Count
AMOY Working Group online database	1
Avian Knowledge Network	1
Biotics (NatureServe) database	1
Christmas Bird Count	3
eBird	4
Florida Shorebird Database	5
Gulf of Mexico Research Initiative Information & Data Cooperative	1
ScienceBase	1
USFWS NWRS ServCat database	1
Other project-specific cloud-based database (e.g., ISS cloud servers, Google Drive for partners)	3
Data "shared" via published reports	1
Data stored locally/in-house (i.e., not in shared repository)	18

Scientific Rigor

As written, all eight sub-objectives under this fundamental objective are somewhat outside the scope of this analysis, some more so than others. Rather than ask questions about certain aspects of monitoring programs that do not provide relevant insight regarding existing monitoring programs (*"Target Taxa," "Statistical Rigor*," *"Budget,"* and *"Timeline"* as defined in Fournier et al. 2021), we replaced the remaining sub-objective parameters (below) with descriptive questions to enable us to loosely summarize responses and look for common themes.

Monitoring objectives: Approximately 74% of programs (*n* = 23) surveyed self-identified as having a clearly stated/defined monitoring objective or hypothesis. Participants were asked to state these objectives/hypotheses in a free-response field. In the context of evaluating individual proposals, GoMAMN recommends that proposals should construct objectives/hypotheses that are clearly defined and also appropriate to answer the research questions at hand (Adams *et al.* 2019). For the purpose of this analysis, we are instead interested in identifying trends in the stated objectives of current monitoring programs. We identified some broad categories of objectives based on priorities identified by GoMAMN stakeholders and added some others based on common practices (Table 4). We then reviewed participants' responses to both the objectives/hypotheses question and the question about response variables and determined how many programs could be conscribed into each category. Most programs had more than one objective and several categories overlap topically, so programs could be counted under as many categories were applicable.

We selected three categories/themes because they were identified during GoMAMN stakeholder workshops as three primary needs underpinning Gulf restoration: (1) evaluation of restoration/management actions; (2) establishment of baselines (especially populations and habitat); and (3) understanding ecological processes. Additional topics that emerged from survey responses include: descriptive goals, e.g., tracking species diversity or habitat use on a refuge, identifying important sites for sensitive species; productivity, e.g., nest success, abundance of breeding pairs; spatial patterns, e.g., distribution, density, mapping; conservation support, e.g., stewardship of breeding areas or monitoring with a goal of explicitly inform conservation action; and objectives that require tracking of individual birds, e.g., site fidelity, movement, and survival. Examples of overlap between categories include objectives such as tracking the number of breeding pairs using an area over time, which could fall in both the "population assessment" and "productivity" categories.

Table 4. Common objectives of current Gulf monitoring programs. Participants' self-described objectives were grouped into categories based on topic/theme.

Topic/theme	# programs
Status Assessment - Populations	19
Productivity/Breeding metrics	15
Spatial patterns/distribution	12
Evaluation of management/restoration	9
Conservation support	9
Descriptive	6
Status Assessment - Habitat (Qnty, Qlty, Veg, Trash, etc)	4
Tracking individuals	3
Understanding Ecological Processes	2
Meeting mandated requirements	2

Sampling/survey design: Participants were asked to specify what kind of sampling/survey design they use. To demonstrate what kind of "design" we were looking for, we offered some examples, including "simple random, simple non-random, treatment/control (randomized or non-randomized), BACI (before-after/control-impact), and panel." However, this was another "free-write" field, so participants could write whatever they wanted. As such, we ended up with a wide variety of responses, not all of which were names of survey design types. A few participants did simply name a formal design type, but others briefly explained their approach or stated that they used a standardized protocol. Our interest in this field is mostly descriptive, so we summarized common themes about the responses we received.

All but one program surveyed responded to this question. Three programs replied that they used an unspecified "standardized protocol." Three more identified a specific protocol used. Five programs

specifically stated that they use a "census" design, and another five implied that they do (e.g., "completely survey" a site). Three programs differentiated the designs used for site selection from the design of actual surveys (e.g., "space-for-time substitution method to select sites, random sampling of nest plots"). One program, known to have a mark-recapture approach, specified that it is "not a survey."

We also searched the survey responses for survey design terms, including the examples we suggested. The following design terms came up one or more times in survey responses (number of times specified): "census" - 5; "non-random" - 8; "transect" - 4; "route" - 2; "stratified systematic" - 1; "control/impact" - 3; 'area count' – 2; "BACI" (before-after/control-impact) - 1.

In a separate question, we asked if a formal power analysis had been performed when designing (or revising) their study. Only 10% ($n = 3$) responded affirmatively. Participants for two programs (7%) were unsure if one had been done or not.

Data management: We asked participants a series of questions regarding specific aspects of data management strategies. Approximately 61% of programs ($n = 19$) have explicitly documented plans for managing monitoring data (two were unsure). Almost all ($n = 30$, 96.8%) of programs reported that they collect data in a standardized way (e.g., datasheets). If data manipulation is necessary following its collection, 52% of programs ($n = 16$) manipulate data in a way that such manipulation can be tracked/documented (e.g., using a program like SQL or R). Sixteen percent of participants ($n = 5$) were unsure if this was the case for their program. Only six programs (19%) follow documented metadata standards as part of their data management plans (29% were unsure, $n = 9$). A majority of programs ($n = 24$, 77.4%) perform QA/QC on their data before sharing (7% were unsure or did not respond, $n = 2$).

DISCUSSION

The results of our survey are primarily descriptive, but they shed some light on the current status of seabird and shorebird monitoring efforts in the northern Gulf of Mexico. Thanks to previous work drawing on the experiences of experts across the Gulf (Wilson et al. 2019), we began this project with an understanding of specific knowledge gaps for seabirds (see Jodice et al. 2019) and shorebirds (see Brush et al. 2019), as well as a general idea of current deficiencies in program integration and scientific rigor that will need to be improved in order to effectively address these gaps (Adams et al. 2019). Prior to this effort, we did not know the level of monitoring effort currently targeting these areas by programs monitoring these two taxa groups. Thus, we attempted to quantify the degree and scale at which are important uncertainties are being addressed as well as the scale/severity of various "process gaps" contributing to the "knowledge gaps"; that is, to what degree are programs integrating across space, and what "best practices" in terms of scientific rigor are being implemented.

Relevance of monitoring data

Current seabird and shorebird monitoring programs in the northern Gulf of Mexico are doing a good job at focusing monitoring efforts on priority species in nearshore environments; however, the well-documented monitoring gap for pelagic species (see Jodice et al. 2019, Love et al. 2015) persists. While a handful of programs collect data about species like Northern Gannet, Masked Booby, Magnificent Frigatebird, Common Loon, and Sooty Tern that are sometimes encountered by land-based observers, only aerial or vessel-based programs would be able to monitor the Black-capped Petrel and Audubon's Shearwater, which are primarily found in open ocean habitat in the northern Gulf. To our knowledge, these two priority seabirds remain unmonitored.

Several long-term population-scale programs focused on collecting population status & trends data currently operate in the Gulf, including the International Shorebird Survey (initiated in 1974), Audubon's Christmas Bird Count (1900), and the International Piping Plover Census (1991). The newest such program that participated in this analysis is the American Oystercatcher Rangewide Survey, which was initiated in 2003 (but see discussion below about programs that did not participate). Performed every five years, this program provides an aerial census of American Oystercatchers across their U.S. wintering range, which includes all five Gulf states. These programs, which involve many partners due to their geographic coverage, collect little (if any) data about habitat quality, ecological processes, or specific local management actions. However, they provide critical long-term population data which makes it possible to detect temporal trends in abundance and distribution and provides for the effectiveness of recovery efforts to be evaluated at a broad scale.

Major gaps in monitoring habitat use, ecological processes, and health metrics persist, particularly for seabirds. This is consistent with the Ocean Conservancy's recent findings (Love et al. 2015) and we are able to provide a bit more fine-scale detail. The few programs currently collecting habitat data are conducting monitoring at smaller geographic scales, across multiple seasons (at least for birds; frequency of habitat data collection is unknown), and are focused mostly on shorebirds, though several beach-nesting bird programs include seabirds as well. Unsurprisingly, the focus of programs is reflected in the types of habitat data they collect. Data collected by beach-nesting bird programs tends to include descriptive elements of habitats used for nesting as well as factors known to affect productivity, such as predation and disturbance, which were the two types of data identified most often by participants. The three programs that collect some form of data about "prey" are specifically looking at the prey base for shorebirds outside of the breeding season. One additional program monitors "foraging habitat use."

Natural processes such as beach succession, predation, and severe weather events are relevant to priority species across their range, but effects are typically measured locally and/or opportunistically. We found that 55% of current monitoring programs ($n = 17$) collect data on ecological processes, and of

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those, 59% operate at the local scale ($n = 10$) and 35% at a statewide scale ($n = 6$). One international program stated that it collects data about ecological processes, but is not addressing any of GoMAMN's priority uncertainties in this area. Similarly, many management activities such as beach restoration, predator control, vegetation management, and disturbance reduction are applied and evaluated at the local level, but are being conducted across the Gulf coast range for multiple priority species. Several programs operating at multistate, national, and international scales (one program each) are currently monitoring priority species in the context of evaluating management effects. Of the other 21 Gulf programs that monitor in this context, 67% operate at a local scale ($n = 14$) and 33% at a statewide scale ($n = 7$).

Decision-making can be hindered by uncertainties regarding the impacts of specific management activities and the natural processes underpinning the ecosystem being managed. An adaptive management strategy offers an opportunity to address such uncertainties while simultaneously evaluating management actions in real time (Lyons et al. 2008). Adaptive management is not appropriate in all situations; however, it may be particularly useful for those 45% of current programs which are already monitoring in the context of evaluating iterative management decisions. In these situations, opportunities may exist for maximizing the usefulness of monitoring data by moving toward an adaptive management approach. For example, perhaps management objectives can be clarified, key uncertainties can be identified and described, and conceptual models can be considered and compared.

While none of the programs currently monitoring to evaluate management actions (77% of those surveyed) currently meet our full criteria for "monitoring in the context of adaptive management," it is notable that five programs (including one local, one nationwide, and three statewide programs) are very close, lacking only a multi-model framework approach. Some of these programs are already leading the Gulf in terms of data integration, so it would be interesting to see what it would take to incorporate this component to these programs. If successful, the example these programs are already setting for the broader community of practice could potentially grow into an even more effective roadmap for other programs to follow.

Integration of bird monitoring efforts

The degree of integration within and among current seabird and shorebird monitoring programs in the northern Gulf of Mexico varies considerably but seems to be increasing based on evidence of both continuing and new/recent integration of programs. Our conversations with program leads also indicated a general interest in integration, at least conceptually. The apparent openness of many practitioners to the integration of monitoring data and/or programs may lead to improvements in our collective ability to address temporal & spatial monitoring gaps going forward. Work currently being performed in an integrated framework is beginning to demonstrate this potential.

Outside of international-scale programs, the state of Florida is home to some of the most highly integrated monitoring efforts in the Gulf. In 2009, a network of local partnerships was created to make the maximize the conservation and management value of monitoring work being conducted under constrained resources. The Florida Shorebird Alliance now consists of over 130 partners from government, private, non-profit, academic, and other sectors operating statewide. Individual partners have different resources and constraints, but generally use the same standardized protocol and store their data in a shared database. Collectively, the group monitors 10 of GoMAMN's priority species (and at least eight additional species) during the breeding season and at least 21 priority species of nonbreeding seabirds and shorebirds. The system was designed to be flexible enough to allow for both the collection of standardized data that can be compiled and analyzed at statewide scales as well as additional methods/data customized to meet answer questions about management effectiveness, survival/recruitment, movement patterns, and other topics at smaller scales. This way, partners can collect the data that meets their local needs while simultaneously contributing to a larger data set that aims to address critical knowledge gaps at a larger scale.

Florida also conducts an annual "mid-winter shorebird survey" in which 27 partner organizations conduct coordinated surveys across the state during a one-week window in early February to provide a snapshot of winter distribution of shorebirds and seabirds. In addition to providing long-term status and trends data, this survey contributes to conservation efforts by helping partners identify key wintering sites. These surveys follow the FSA non-breeding shorebird survey protocol, so these surveys also add to data set for that program.

Since the DWH oil spill, several multi-state monitoring efforts have been initiated, either as completely new programs or as a result of smaller-scale programs expanding or integrating. Audubon's Coastal Bird Survey, aimed at understanding patterns in shorebird/waterbird distributions and abundance at multiple scales, began in 2010 and currently operates in Texas, Louisiana, Mississippi, and Alabama. Staff and volunteers for the program survey fixed coastline transects for wintering and migrating waterbirds in three seasonal pulses. The survey protocol aligns with that of the International Shorebird Surveys, and partners submit data via the ISS eBird portal. Coastal Bend Bays and Estuaries Program initiated a program in 2009 using geolocators and nanotags to investigate distribution and migratory connectivity patterns for Red Knots in Texas. In the aftermath of the spill, they partnered with the Barataria-Terrebonne National Estuary Program to expand mark/recapture efforts into Louisiana, and unaffiliated observers in other parts of the Gulf coast contribute resighting data as well. American Bird Conservancy (ABC) oversees a collaborative partnership with a number of organizations monitoring breeding and nonbreeding birds in support of conservation/stewardship using methods adapted from the Florida Shorebird Alliance protocol. Audubon-affiliated partners in Alabama, Mississippi and Louisiana

now lead beach nesting bird stewardship programs that are integrated with and largely homologous to ABC's, though some differences exist between states in terms of protocols, objectives, etc. ABC refers to their expanded/integrated operations as the ABC Gulf Coastal Program and Applicable Partner Programs.

We found that the number of partners per monitoring program was somewhat related to program scale, but there was some variation in this relationship. Large-scale programs are obviously expected to have more partners than smaller-scale programs, and this was mostly true in the programs we surveyed. The only programs working completely independently (i.e., zero partners claimed) were local and statewide programs, and with one exception, the only programs claiming more than 50 partners are those operating internationally. The exception was the Florida Shorebird Alliance Breeding Shorebird program, which operates statewide and has 135 partners. This is considerably more than all other programs operating at multistate or smaller scales, and almost 100 more than the next highest-partnered. Also contrary to this trend are the two multistate programs surveyed, which involve far fewer partners than many of the local and statewide programs; however, these programs have very specific objectives regarding site use and other factors pertaining specifically to nonbreeding birds, and their methods were developed with some alignment with other programs. Both the broad relationship of partners to geographic scale and the exceptions to it underscore the idea that it is necessary to use multiple metrics to define "integration" as a concept.

In addition to those currently working to integrate or scale up, multiple program leads described plans/intentions for near-term efforts to expand their own monitoring efforts in terms of spatial scale, species monitored, or partners involved. While most smaller-scale programs we surveyed operate independently, there is some evidence of integration. Several local and statewide programs are already working to integrate their monitoring (methods, data, etc) with other partners, and some newer programs have been designed to address some of the issues GoMAMN has identified across multiple Gulf states. This is not captured in the present data set, but suggests that future surveys may reveal a trend of increasing integration.

We did not ask participants about potential obstacles to integration, but this would be a logical question. Some program leads seem to have more flexibility than others in terms of what they are able to do and the degree to which they can partner with other organizations. A number of participants reported that they collect data on non-focal species opportunistically while surveying focal species, which may indicate a potential openness to collecting additional data beyond their primary objectives if they continue to have the capacity and there is clear value in doing so.

Based on conversations with program leads during the inventory population process, we expect that the current variation in number of partners per program is related to factors such as property ownership/access (i.e., who owns or has jurisdiction over the property being monitored), staff constraints

(e.g., survey participants from multiple organizations), logistical assistance needed (e.g., a partner may contribute by transporting surveyors or lending equipment), and data analysis assistance (e.g., the organization leading the surveys enlists an outside person to help with statistics).

Another likely factor is variation in how participants define what constitutes a "partner" for their program, which was left largely up to their discretion. We provided little guidance in the survey question, simply defining "partner" as "organizations, not including [the participant's]," that are "involved in" the project in question. Some participants asked for clarification and were advised that we were looking for *organizations*, not individuals (as interpreted by some participants seeking clarification), and that while the decision to count an organization as a "partner" on the survey was theirs, they should consider the extent to which the organization in question participates in/contributes to the planning and/or execution (but not necessarily funding) of said program. Participants were also advised not to include funding entities as "partners" unless they went beyond that role and participated in other critical program components (e.g., data collection, access/logistical support, etc.); however, this guidance was only given to participants who specifically asked if funders could be considered partners. As a result, we don't know the exact manner in which partners contribute to current monitoring programs.

Another strength in current seabird/shorebird integration is that most contemporary programs are already addressing existing priorities (though we should point out that we did not attempt to understand how many priorities in existing conservation plans are being addressed as we are focused on GoMAMN's priorities from SDM process). We suspect that the metric we used to understand this objective (i.e., the number of programs citing specific conservation plans; see results in Appendix E) actually underestimate the true number of plans/priorities addressed by programs. While it is unlikely that participants would identify plans inappropriately (i.e., plans containing only priorities that their program does not actually address), multiple participants suggested that their programs likely address additional (unspecified) priorities as well. We did not ask any follow-up questions about these responses, but it's possible that these individuals were not aware of all the conservation plans/priorities that apply to the monitoring they do, or they may have simply provided incomplete lists due to time constraints or other reasons.

Scientific Rigor

GoMAMN stakeholders have agreed that there is a need to improve the scientific rigor of the methods used by monitoring programs to collect data, and have identified several key aspects of programs that, if employed with greater attention/intention in the design phase, can achieve this. Because we surveyed existing programs that are in the implementation phase already, we chose to ask some general questions that help us understand which of these aspects were already considered or employed either during the planning phase or at some point since. Judging the "appropriateness" of program aspects such as survey design, response variables statistical rigor, timeline, etc. relative to their objectives is outside

the scope of this analysis and better left to taxa/quantitative experts interested in specific programs or topics. Instead, we describe what we learned about survey designs, objectives, and response variables used by current programs in a qualitative sense, as derived from responses to free-response survey questions.

The primary thing we learned from the array of responses we got regarding program objectives, response variables, and survey designs used was that participants clearly interpreted these metrics and questions differently. Some programs stated actual survey design types while others briefly described their methods. Some referred to standardized protocols used but only about half of those named those protocols. In "RFP mode" (i.e., when evaluating funding proposals), GoMAMN stakeholders agree that objectives must be clearly stated, and variables and survey designs must be "clearly appropriate to achieve proposed objectives in a scientifically robust manner" (Fournier et al. 2021). Again, it was beyond the scope of this project to assess whether this was true for each program individually, but the common themes we identified among responses for these metrics may provide useful insight.

Power analysis is a useful statistical tool when designing bird surveys that achieve monitoring objectives. This method provides a way of estimating the sample size needed to detect an effect of a certain size, which can be valuable in many real-life monitoring scenarios. For example, if restoration planners are required to document the impact of a certain management decision on local bird populations, a power analysis would show them how frequently they would have to survey to detect, say, a 30% change in population. Very few programs (<10%) responded that they performed a formal power analysis when planning their monitoring approach, so this is a metric that could be improved upon Gulfwide, especially given the prevalence of programs aimed at evaluating management actions. We suspect that this is not an intentional omission in most situations. Some participants reached out for clarification on this question, asking "what [we] meant by power analysis," and 6.5% responded that they are "unsure" if a project had performed a power analysis (possibly a result of turnover in original planning staff). Given the specific definition of "power analysis," we also suspect that many participants may not be familiar with the concept itself or how to perform such an analysis.

We were able to take a more quantitative approach to understanding data management practices by asking about key components of a healthy data management plan identified in Evans et al. 2019. The vast majority of current Gulf seabird/shorebird monitoring practitioners is already using standardized data collection methods (like datasheets) and performing QA/QC on data before sharing. Roughly half of programs claimed that any data manipulation they performed is done in such a way that it can be easily tracked/documented, as GoMAMN recommends. One area of collective weakness is in metadata standards: less than 20% of participants stated they follow documented metadata standards as part of their management plans, and almost 30% were unsure if they did, leading us to question how familiar

practitioners are with documented metadata standards. We didn't ask participants to identify which specific metadata standards they currently use.

Notably, the most widely used data management practices, including standardized data collection methods and quality-checking data, are those that could logically apply to any bird monitoring program, regardless of what they ultimately do with their data. Other practices, such as using computer programs to track data manipulation and using standardized metadata standards, require more technical knowledge to use and are useful only in certain contexts; for example, if programs intend to analyze and share their data. We know from participants' responses to another survey question that not all programs have such a plan, and those that do not may have little reason to use these tools. However, we do not know if that is the only reason they are used less frequently.

Over a third of programs surveyed do not have an explicitly documented data management plan at all, which raises concerns about the usefulness of these data sets over time and in potential future collaboration efforts. Data storage is also an issue, especially for small/local programs, which generally store data locally rather than in secure online portals. Several NWR staff stated concerns about what would happen to their data after they leave or retire, as they are the only individuals with access to the electronic records stored on their local machines or drives with restricted access. This is alarming given that some larger monitoring programs at refuges have been reduced to a single staffer, some of which are nearing retirement.

Lessons Learned

We are cautiously optimistic regarding the use of these data as a "baseline" for future comparison. Despite our high response rate, the size and completeness of the current data set may be limiting our understanding of current efforts. We succeeded in capturing a wide variety of programs in both our program inventory and gap analysis survey, and inventory records can potentially fill in some gaps about programs that did not participate in the survey. Still, we know for a fact that our data set is incomplete, and because of the small sample size, missing programs likely has an outsized effect on our results. For instance, some important large-scale monitoring programs that operate in the northern Gulf of Mexico, including the North American Breeding Bird Survey (BBS) and the MOTUS program, are missing from this data set. It also is likely lacking some partially nested local-scale programs that collect data for local needs in addition to participating in a larger parent program, especially in Florida's highly integrated network of partners. Florida Shorebird Alliance programs, for example, were surveyed collectively under the FSA umbrella, but we did speak with representatives for some local programs whose efforts independent of FSA methods/repositories qualified them as "partially-nested" in our eyes. We expect there are more programs such as these that we are not aware of, and it is hard to know what insights we are missing as a result.

The survey we designed could be easily repeated, and participants were informed of our intent to do so. Because the overall number of monitoring programs is small, it would be important for future surveys to include as many of the same programs as possible in the data set. For the parameters that are most relevant in "RFP-mode," we chose to avoid passing judgment on the "appropriateness" of elements like objectives, survey design, etc. at this time and instead see if common "themes" emerged from participants' responses that would help us describe current efforts in terms of these topics. This ad-hoc approach generated data that, while interesting, are too likely subjective to be used for comparison. The more quantitative data about how programs are currently operating (e.g., species being monitored, uncertainties being addressed, etc.) could hypothetically be compared to this data set. Still, several factors may make it difficult to directly compare those results.

Future integration of programs (which GoMAMN encourages) may complicate quantitative comparisons, as could leadership changes in programs that are not in the process of integrating. We approached survey responses collectively, summarizing the number of programs that responded in certain ways to our questions. Using this approach, the merging/replacement of programs represents a fundamental change to the study sample and will influence a direct comparison of these metrics, potentially in ways that appear "favorable," at least superficially. In the likely event that personnel changes occur for some programs between surveys, variation in interpretation between past and current participants could result in within-program artifacts that could be difficult to account for given the small sample size. Thus, it will be important to look beyond the difference between survey results over time and look closely at the sources of these changes.

Ultimately, the value of these data as a "baseline" may depend on the comparison to be made and GoMAMN's goals for each stakeholder fundamental objective or sub-objective/criterion. Because no specific goals or targets have been set for these objectives at the time of this writing, the concept of "progress" (unless defined as an increase in the number of programs that meet a certain criterion for these objectives) is currently ambiguous and difficult to measure. As mentioned above, a more effective way to measure progress over time might be to break the fundamental objectives and sub-objectives down into more specific goals (potentially by taxa group or other useful segments), define what "progress" would look like for those goals, identify critical obstacles, try various solutions, and conduct periodic assessments like this one to track progress and identify new obstacles. Using a "social psychology" approach to surveying program leads would be advantageous here, and we recommend exploring this option in more depth before attempting subsequent surveys. In the meantime, the sub-objectives that serve as criteria for integration and rigor are perhaps most useful in "RFP mode," and less for obtaining a static measure of "how we are doing" right now or in comparison to another point in time.

Finally, we learned that the resource investment necessary to do this project well is greater than initially estimated. Construction of the program inventory and completion of the gap analysis (including data collection, analysis, and reporting for all seven taxa groups) was estimated to take six months. This project, as described in full in this report, ultimately took one person working 20 hours per week about two years to complete inventory updates for roughly half of the known monitoring programs and a gap analysis for two of the seven taxa groups. This does not include any of the additional time contributed by other GoMAMN colleagues in support of the project (see Acknowledgements below). We also received feedback from several other programs doing similar types of projects, and they shared that it took at least 2-3 years for small teams to reach completion. Future plans to expand on this project, such as if GoMAMN decides to expand the inventory and gap analysis to include the other five taxa groups, closer attention to the time and personnel required is warranted.

CONCLUSION

This snapshot of current shorebird/seabird programs reveals more information about the Gulf monitoring community's strengths and weaknesses. A number of our priority species in both taxa groups enjoy wide-scale attention, particularly those that breed on Gulf beaches. Less focus has been placed on monitoring outside of the breeding season. A major information gap persists regarding pelagic seabirds and those that nest on the Gulf coast in habitats other than beaches (e.g., marshes).

Regarding the integration and rigor of monitoring efforts, many in the seabird/shorebird monitoring community of practice are aware of the benefits of integration and, if not already working to integrate with other programs, are actively connected with colleagues doing similar work. Several programs stand out as potential models for those looking to improve in this area, whether or not they monitor seabirds or shorebirds. Most programs are diligent about using standardized protocols and ensuring the quality of their data prior to sharing or analyzing it; however, clearly-documented data management plans are still not standard and many programs still have no set plans or timelines for sharing their data. Many programs are aimed at evaluating management actions, and interest in collaboration/integration seems high, suggesting high potential for eventually being able to answer questions about their population-level impacts.

In our conversations with program leads, we saw strong signals that monitoring practitioners in the Gulf are passionate about the birds they monitor and very much want to know that their efforts are contributing valuable data that serve conservation needs at local and population scales. Evidence shows that many practitioners are not only aware of the need for integrated monitoring data but have been initiating and working toward such integration for years. We see this as an indication that future integration of monitoring efforts/data is very much possible and the concept is generally supported by the community of practice. GoMAMN is well-poised to facilitate future integration by learning more about

the obstacles faced by these professionals, finding/assisting with solutions, and providing additional resources for practitioners. The high degree of between-program variation in objectives, scale, survey design, integration, jurisdiction, resources, and other factors (and the likelihood that program-specific challenges vary widely in nature as well) suggests that a qualitative approach to collecting this data will be advantageous, and that solutions coming from practitioners themselves may be more successful than a fully prescriptive approach.

Future efforts to understand "how we're doing" on stakeholder values and objectives would benefit from (1) more refined problem statements and clearer intentions for how the information will ultimately be used, and (2) a deeper dive into some of the integration- and rigor-specific objectives in GoMAMN's objectives hierarchy such that we clearly describe the values that underpin them and define the contexts in which they are relevant (i.e, "RFP-mode," gap analysis, baselines for comparison, etc.). Further exploration into ways of measuring progress for all objectives in various contexts would also be useful. Ultimately, these details can be used to guide recommendations, best practices, and support for monitoring practitioners, as well as track our collective progress toward a rigorous, integrated monitoring framework that enables practitioners to answer critical questions about natural processes and management decisions impacting priority species at the population level.

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APPENDIX A: Gap Analysis Survey Form

This section contains the survey form we designed to collect data from seabird and shorebird monitoring practitioners in the northern Gulf of Mexico from January to July 2020. Following the construction of our inventory of monitoring programs, this form was emailed to the lead "point of contact" for each program with whom we had been in direct contact during the inventory update process. The responses we received from them formed the basis for our data set.

The seven-page survey, designed as a fillable pdf document for ease of completion, was preceded by the introduction page below.

GoMAMN Bird Monitoring Program Survey: 2020

PURPOSE: Your survey response contributes to two products.

- **MONITORING PROGRAM INVENTORY**. We are updating GoMAMN's inventory of current and past avian monitoring programs across the Gulf of Mexico, which will be soon be upgraded to a searchable web-based database. This inventory will serve as areference tool and facilitate connections and collaboration between bird monitoring professionals, researchers, and the greater GoMAMN community of practice. **The following responses will be included in this inventory and thus visible to anyonewho may look up your program on the web tool:**
  - **Responses in Section A: General Information**
  - **Responses in Section B, questions 1-4 and 13 ONLY**
  Note: you may be contacted for additional information to help us update your programrecord depending on what we have on file.

- **GOMAMN PROGRAMMATIC GAP ANALYSIS**. Questions 1-19 We are conducting a gap analysis to understand and show how contemporary avian monitoring efforts in the Gulf coast region are collectively performing in terms of their ability to meet and address GoMAMN stakeholder values (Wilson et al., 2019, in press). Subsequent analyses (conducted at five-year intervals) will enable the Gulf coast community of avian monitoring practitioners to track improvements over time and identify areas where opportunities for improvement still exist. Ultimately, our vision is for the gap analysis process to serve as a tool for evaluating GoMAMN's programmatic performance.

NOTE: We are not collecting actual monitoring data in the gap analysis process. Rather, the questions in the following pages will allow us to better understand broader topics including (butnot limited to) WHAT is being monitored, HOW monitoring is being conducted, and IF/HOW/WHEN monitoring programs plan to share data. The questions relate directly to the 27stakeholder values in GoMAMN's objectives hierarchy (Wilson et al., 2019).

Responses to survey questions 1-19 will be summarized and the results for the Gulf of Mexicoregion *as a whole* will be communicated to the GoM community of practice. NOTE: Responseswill NOT be used to judge/evaluate monitoring programs on an individual basis.

We recognize that completing this questionnaire is an extra demand on your limited time. As a member of the GoM avian monitoring community of practice, please know that we truly appreciate your time and your responses. The results of this gap analysis will benefit our collective monitoring efforts, and ultimately, the birds we monitor.

NEED HELP? If you have any questions or are unsure about how to respond to any part of thisquestionnaire, please contact Jessica Schulz at 978-302-1024 or jschulz@ducks.org.

GoMAMN Monitoring Program Inventory & Gap Analysis Questionnaire

Monitoring Program Name   **Date**

Program Point-of-Contact Name   **POC Organization/Company Name**

POC Phone   **POC Email Address**

Alternative POC *(optional)*   **Alt Phone**   **Alt Email**

Program description (brief overview)

Program webpage (if applicable)

When did monitoring begin? (Month/Year)

Is this monitoring program current/ongoing?

⭘ Yes   ⭘ No

If No, when did monitoring end? (Month/Year XX/XXXX)

If yes, is there a projected end date (or "funded-through" date)? (Month/Year XX/XXXX or "NA")

Does the total duration of monitoring (funded, projected, or and/or completed to date) equal 5 years or more?

⭘ Yes   ⭘ No

To be included in the gap analysis, monitoring programs must involve repeated surveys, be currently active, and have a total duration of at least 5 years (including future monitoring if funding secured).

If your program meets these criteria, please complete questions 1-20 below.

If your monitoring program is not currently active and/or has a duration of fewer than 5 years, we only ask that you complete questions 1-4 and 13. We will not include your program in the gap analysis, but we can still include it in our online inventory of Gulf of Mexico avian monitoring programs.

SPECIES MONITORED AND METHODS

1. **Below is the full list of GoMAMN's Priority Bird Species. Which of these species are monitored in your program? Check all that apply.** (Please include only those species monitored specifically pertaining to your program objective, not species included opportunistically.)

Landbirds
- [ ] Bachman's Sparrow
- [ ] Brown-headed Nuthatch
- [ ] Chuck-will's-Widow
- [ ] Common Ground-Dove
- [ ] Grasshopper Sparrow
- [ ] Henslow's Sparrow
- [ ] LeConte's Sparrow
- [ ] Loggerhead Shrike
- [ ] Louisiana Waterthrush
- [ ] Northern Bobwhite
- [ ] Painted Bunting
- [ ] Prothonotary Warbler
- [ ] Red-cockaded Woodpecker
- [ ] Red-headed Woodpecker
- [ ] Rusty Blackbird
- [ ] Swainson's Warbler
- [ ] Wood Thrush
- [ ] Yellow-throated Warbler

Marsh Birds
- [ ] American Bittern
- [ ] Black Rail
- [ ] King Rail
- [ ] Least Bittern
- [ ] Marsh Wren
- [ ] Nelson's Sparrow

- [ ] Seaside Sparrow
- [ ] Sedge Wren
- [ ] Yellow Rail

Raptors
- [ ] Bald Eagle
- [ ] Osprey
- [ ] Peregrine Falcon
- [ ] SE American Kestrel (state listed-FL)
- [ ] Short-eared Owl
- [ ] Swallow-tailed Kite

Seabirds (nesting and/or pelagic)
- [ ] Black Skimmer
- [ ] Brown Pelican
- [ ] Common Loon
- [ ] Gull-billed Tern
- [ ] Least Tern
- [ ] Northern Gannet
- [ ] Royal Tern
- [ ] Sandwich Tern
- [ ] Audubon's Shearwater
- [ ] Black-capped Petrel
- [ ] Band-rumped Storm-Petrel
- [ ] Magnificent Frigatebird
- [ ] Masked Booby
- [ ] Sooty Tern

Shorebirds
- [ ] American Oystercatcher
- [ ] Buff-breasted Sandpiper
- [ ] Dunlin
- [ ] Long-billed Curlew
- [ ] Marbled Godwit
- [ ] Piping Plover
- [ ] Red Knot
- [ ] Snowy Plover
- [ ] Western Sandpiper
- [ ] Wilson's Plover

Wadingbirds
- [ ] FL Sandhill Crane (state-listed-FL)
- [ ] MS Sandhill Crane
- [ ] Little Blue Heron
- [ ] Reddish Egret
- [ ] Snowy Egret
- [ ] Tricolored Heron
- [ ] Whooping Crane
- [ ] Wood Stork

Waterfowl
- [ ] Lesser Scaup
- [ ] Mottled Duck
- [ ] Northern Pintail

Passage migrants* [ ]
*specifically during migration window

2. **Are you monitoring additional species not on this list? If yes, describe briefly... list up to five or give category/taxa group (Choose from the following taxa groups: Landbirds, Marsh Birds, Raptors, Seabirds, Shorebirds, Wadingbirds, Waterfowl)**

3. Do you have a clearly stated/defined monitoring objective/hypothesis?

◯ Yes   ◯ No

3a. If yes, what is it? (Briefly/one sentence)

3b. What variables/parameters are you measuring?

4. Pick the option that best describes the scale/footprint of this monitoring program.
(For nested programs: Choose scale at which the overall program operates.)

◯ Local (smaller scale than statewide)   ◯ Gulfwide (every Gulf state)

◯ Statewide (throughout most or all of one state)   ◯ Nationwide (throughout the U.S.)

◯ Multistate (multiple, but not all, Gulf states)   ◯ International (U.S. plus at least one other country)

5. What kind of sampling/surveying design do you use? *Some examples: simple random, simple non-random, treatment/control (randomized or non-randomized), BACI, Panel, etc.*

6. Was a formal power analysis performed when designing the study (or more recently)?

◯ Yes   ◯ No   ◯ Unsure

INTEGRATION

7. Does this program address established priorities in any existing conservation plans, such as State Wildlife Action Plans?

◯ No, don't know, or monitoring might address conservation plan priorities but was not specifically designed to do so.

◯ Yes, monitoring addresses a general priority in a specific plan(s) (e.g., support monitoring, a priority within the Louisiana Wildlife Action Plan)

If yes, which plan(s)?

8. How many partners (organizations, not including yours) are involved in this project?
(If zero partners, enter "0" and move to question 10. If one or more partners, please
answer follow-up question 8a.)

> Partners

8a. What type(s) of organizations are partners on this project? *Check all that apply.*

☐ Federal gov.   ☐ Non-profit/NGO   ☐ Other

☐ State gov.   ☐ Private company

☐ Local gov.   ☐ Academic institution

9. Is your monitoring in alignment with other monitoring programs? *(e.g.: bird monitoring
aligns with similar bird/sea turtle/etc monitoring at same site; partner/work closely with
another group; maybe data sharing between programs. Example: individuals monitoring
birds for this project opportunistically count sea turtles encountered for a separate project.)*

○ Yes   ○ No   ○ Unsure

DATA MANAGEMENT AND SHARING

10. Do you have an explicitly documented plan for managing your monitoring data?

○ Yes   ○ No   ○ Unsure

a. Are the data collected in a standardized way? (e.g., standardized hard-copy data sheets or
digital collection data form)

○ Yes   ○ No   ○ Unsure

b. After data are collected, if data manipulation is necessary, is it performed in a way
that can be tracked/documented (e.g., using a program like R or SQL)?

○ Yes   ○ No   ○ Unsure

c. Does your data management plan follow documented metadata standards?
*(Examples: Ecological Society of America's Ecological Metadata Language (EML),
other standards such as those established by Federal Geographic Data Committee
(FGDC), International Standards Organization (ISO), or National Academies of
Sciences, Engineering, and Medicine (NASEM))*

○ Yes   ○ No   ○ Unsure

d. Do/will you perform QA/QC on your dataset prior to sharing/storing?

○ Yes   ○ No   ○ Unsure

**11. Are the data for this project restricted from being shared (e.g., because it contains personally
identifiable information or endangered species locations) or unrestricted?**

○ Restricted (uncommon)   ○ Unrestricted

12. How soon do you plan to share this data with the broader scientific community once the project is complete/what is the time frame for sharing your data? Choose from below.

- ○ within 8 years of project completion (or end date of funding agreement)
- ○ within 5 years of project completion
- ○ within 2 years of project completion
- ○ within 1 year of project completion
- ○ No timeline established/no plan to share data

13. Where are this monitoring program's data stored? Or, if there are concrete plans to share this data in the future, where will it ultimately be stored? (If using more than one storage site, list additional locations in 13a)

-choose one-

13a. If "Other," where?

STATUS & TRENDS

14. Does this monitoring program collect data about HABITAT QUALITY? *(ie: vegetation, water quality, prey base, etc)*

○ Yes (answer a-c below)   ○ No (skip to question 15)

   a. **If yes, what kind(s)?** *(e.g.: vegetation, water quality, prey base, etc)*

   b. **Is habitat quality data collected more than once?**

   ○ Yes   ○ No

   c. **What is the total <u>duration</u> of time habitat quality data will be collected?** (*Actual, planned, or currently funded; from beginning to end, in years*)

       years

ECOLOGICAL PROCESSES

15. Does this project collect data about ECOLOGICAL PROCESSES that may impact your focal species? *(e.g., climatic processes, interactions between organisms, etc.)*

○ Yes (continue to question 16)   ○ No (skip to question 17)

16. See accompanying table(s) for a list of current uncertainties regarding ECOLOGICAL PROCESSES, as identified per taxa group by GoMAMN. Which of these uncertainties are addressed by this monitoring program? List all applicable by ID code (column 1), separating multiple codes with commas. If none, enter "NA". (Note: uncertainties may be specific to certain species and/or seasons, as listed.)

MANAGEMENT ACTIONS

17. **Are you monitoring birds in the context of understanding MANAGEMENT or RESTORATION ACTIONS?** Answer yes if there is any intention and/or likelihood of using monitoring data for this purpose, from the perspective of those conducting monitoring and/or management action.

⭕ Yes (continue questions 18-19) ⭕ No (skip to question 20)

18. **See accompanying table(s) for a list of current uncertainties regarding MANAGEMENT ACTIONS, as identified per taxa group by GoMAMN. Which of these uncertainties are addressed by this monitoring program?** List all applicable, by ID code (column 1, separating multiple codes with commas). If none, enter "NA". (Note: uncertainties may be specific to certain species and/or seasons, as listed.)

19. **Are you monitoring this management action(s) in the context of adaptive management (see Williams et al 2009)?** *(Determined by answers to a-e below.)*

    a. **Is the monitoring linked to an explicit management objective(s)?** *(Example: build 100-acre marsh to benefit birds)*

      ⭕ Yes   ⭕ No

    b. **Is/are the management action(s) you are monitoring associated with an <u>iterative decision</u>?** i.e., is the management decision made on a regular temporal (monthly, annually, etc) or spatial interval (management action repeated in another area) which provides opportunity to use your monitoring data to inform decisions made repeatedly in the future for this management action? *(Example: If you are monitoring birds at a beach nourishment project, will your bird monitoring data be used to inform decisions about future beach nourishment projects, either at the same site or elsewhere?)*

      ⭕ Yes   ⭕ No

    c. **Have decision makers and other stakeholders identified a key uncertainty (about the management action) that impedes decision making?** *Example: do we know what elevation to build the island?* (If there is no uncertainty about management actions, there is no need for adaptive management.)

      ⭕ Yes   ⭕ No

    d. **Is monitoring associated with a conceptual model or set of hypotheses about how the management decision/action impacts birds?**

      ⭕ Yes   ⭕ No

e. If "yes" to above: Are multiple conceptual models being considered & compared, as in a multi-model framework? AND, if so, is there an explicit (formal) process for updating model (hypothesis) weights to reduce uncertainty and inform future decision making? *(Example: adaptive harvest management for waterfowl - waterfowl abundance, habitat and harvest data collected annually then subsequently used to set harvest regulations for the next year.)*

◯ Yes   ◯ No

Section D: Wrapping up

20. Is there anything else you'd like to share about your monitoring program?

End of survey. Thank you!

APPENDIX B: Participating Programs

Data for this gap analysis was provided by the following 31 programs via the survey form in Appendix A (in alphabetical order by program name). All of these programs were actively monitoring birds as of July 2020. For the complete inventory of program data collected on past and present seabirds & shorebird monitoring programs, contact the Gulf of Mexico Avian Monitoring Network or visit www.gomamn.org.

Program Name	Contact Name	Contact Organization	Start Year	Scale
American Oystercatcher Monitoring	Janell Brush	Florida Fish and Wildlife Conservation Commission	2006	LOCAL
American Oystercatcher Rangewide Survey	Shiloh Schulte	Manomet, Inc.	2002	NATIONWIDE
American Oystercatcher Stewardship Project	Susan Heath	Gulf Coast Bird Observatory	2011	STATEWIDE
Audubon Coastal Bird Survey - Gulfwide	Erik I. Johnson	Audubon Louisiana	2010	MULTISTATE
Audubon's Christmas Bird Count	Kathy Dale	National Audubon Society	1900	INTERNATIONAL
Beach Nesting Bird Protection & Habitat Stewardship Program - Texas	Kacy Ray	American Bird Conservancy	2012	STATEWIDE
Beach Nesting Bird Stewardship Program	Lianne Koczur	Alabama Audubon Society	2015	LOCAL
Beach Nesting Bird Stewardship Program - Mississippi	Abby Darrah	Audubon Mississippi	2014	LOCAL
Beach-nesting Bird Stewardship Program	Katie Barnes	Audubon Louisiana	2012	STATEWIDE
Breton NWR Colonial Seabird Production Assessment	Barret Fortier	U.S. Fish and Wildlife Service (Southeast Louisiana National Wildlife Refuges Complex)	1990	LOCAL
Breton NWR Piping Plover Survey	Barret Fortier	U.S. Fish and Wildlife Service (Southeast Louisiana National Wildlife Refuges Complex)	1995	LOCAL
Brown Pelican Monitoring	Paul Leberg/Brock Geary	University of Louisiana - Lafayette	2013	STATEWIDE
Caminada Headland Beach-nesting Bird Surveys	Delaina LeBlanc	Barataria-Terrebonne National Estuaries Program	2010	LOCAL
Cedar Keys NWR Wading Bird Rookery Surveys	Vic Doig	U.S. Fish and Wildlife Service	1964	LOCAL
Eglin AFB Nonbreeding Shorebird Surveys	Kathy Gault	U.S. Air Force	2005	LOCAL
Florida Mid-winter Shorebird Survey	Beth Forys	Eckerd College	2013	STATEWIDE

Florida Shorebird Alliance Monitoring Network - Non-breeding Shorebird Surveys	Raya Pruner	Florida Fish and Wildlife Conservation Commission	2010	STATEWIDE
Florida Shorebird Alliance Monitoring Network- Breeding Shorebird Surveys	Janell Brush	Florida Fish and Wildlife Conservation Commission	2010	STATEWIDE
International Piping Plover Census	Elise Elliott-Smith	U.S. Geological Survey	1991	INTERNATIONAL
International Shorebird Survey	Brad Winn/Lisa Schibley	Manomet, Inc.	1974	INTERNATIONAL
Isles Dernieres Barrier Island Monitoring	T.J. Zenzal	U.S. Geological Survey	2013	LOCAL
J.N. 'Ding' Darling National Wildlife Refuge Wildlife Drive Bird Survey	Jeremy Conrad	U.S. Fish and Wildlife Service	1980	LOCAL
Louisiana Coastal Beach-Nesting Bird Surveys	Delaina LeBlanc	Barataria-Terrebonne National Estuaries Program	2005	STATEWIDE
Louisiana Colonial Waterbird Surveys	Rob Dobbs	Louisiana Department of Wildlife and Fisheries	1986	LOCAL
Migratory Gamebird Program, Alabama Wildlife & Freshwater Fisheries - Aerial Surveys for Waterfowl	Seth Maddox	Alabama Dept of Conservation and Natural Resources	1960	LOCAL
Mustang and Padre Island Gulf Beach Focal Shorebird Surveys	David Newstead	Coastal Bend Bays and Estuaries Program	2011	LOCAL
Red Knot Migration Monitoring Program	David Newstead	Coastal Bend Bays and Estuaries Program	2009	MULTISTATE
San Bernard National Wildlife Refuge Migratory Shorebird Surveys	Jennifer Wilson	U.S. Fish and Wildlife Service	2000	LOCAL
Sanibel-Captiva Conservation Foundation Shorebird Program	Audrey Albrecht	Sanibel-Captiva Conservation Foundation	2002	LOCAL
Snowy Plover Monitoring	Raya Pruner	Florida Fish and Wildlife Conservation Commission	2004	LOCAL
Wilson's Plover Monitoring	Raya Pruner	Florida Fish and Wildlife Conservation Commission	2012	LOCAL

APPENDIX C: Ecological Process Uncertainties

Table C1: Seabirds

This table was adapted from Jodice et al. 2019 (see Table 6.3). Unique ID codes were assigned to each uncertainty to ease the data collection process for participants.

ID CODE	Species	Seasons	Ecological Process Category	Question	Endpoint to Measure	Uncertainty Description
33	All Seabirds	Breeding, Non-breeding	Climatic Processes	Do climate, sea-level rise, and/or ocean acidification affect habitat quantity and quality for seabird prey, prey availability for seabirds, and ultimately reproductive success and/or individual survival?	Adult annual survival, nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, post-fledgling survival, abundance of prey available to seabirds	Sea-level rise regional variance not understood; plasticity in foraging behavior unknown
34	Nearshore Seabirds	Breeding, Non-breeding	Climatic Processes	How does sea-level rise influence the frequency and severity of flooding/overwash events, habitat quality during breeding and nonbreeding seasons, and subsequent reproductive success and/or individual body condition?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, size-corrected body mass (or other energetic condition estimators), number & frequency of overwash events	Sea-level rise regional variance not understood; creation of new habitat from SLR not well understood

35	Pelagic Seabirds	Breeding	Climatic Processes	How does sea-level rise influence the frequency and severity of flooding/overwash events, habitat quality during breeding season, and subsequent reproductive success?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, size-corrected body mass (or other energetic condition estimators), number & frequency of overwash events	Sea-level rise regional variance not understood; creation of new habitat from SLR not well understood
36	Nearshore Seabirds	Breeding	Climatic Processes	How does sea-level rise influence predator access to nest sites and colonies, and subsequent reproductive success?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests; species composition, occupancy, and abundance of predators at seabird colonies	Sea-level rise regional variance not understood; predator response to SLR not understood
37	Pelagic Seabirds	Breeding	Climatic Processes	How does sea-level rise influence predator access to nest sites and colonies, and subsequent reproductive success?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests; species composition, occupancy, and abundance of predators at seabird colonies	Sea-level rise regional variance not understood; predator response to SLR not understood
38	Nearshore Seabirds	Breeding	Interactions Between Organisms	How does avian and mammalian nest predation influence reproductive success and subsequent the colony and population dynamics of seabirds?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, annual variation in fecundity, true breeding colony abundance over multiple years	Predation rates are not understood across most species and geographies

39	Pelagic Seabirds	Breeding	Interactions Between Organisms	How does avian and mammalian nest predation influence reproductive success and subsequent the colony and population dynamics of seabirds?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, annual variation in fecundity, true breeding colony abundance over multiple years	Predation rates are not understood across most species and geographies
40	Audubon's Shearwater, Sooty Tern	Breeding, Non-breeding	Climatic Processes	How will climate change affect Sargassum distribution and abundance, seabird foraging, and subsequent seabird survival and reproductive success?	True density of at-sea seabirds, density of prey available to seabirds, adult annual, annual fecundity estimates for marked individuals x species x colony	Climate change effects on Sargassum are unknown; factors that regulate distribution and abundance of Sargassum poorly understood
41	Pelagic Seabirds	Breeding, Non-breeding	Climatic Processes	How will climate change affect tuna abundance and distribution, prey availability and foraging success for seabirds, and ultimately population demographics?	True density of at-sea seabirds, density of prey available to seabirds, adult annual, annual fecundity estimates for marked individuals x species x colony	Relationship between predatory fish and seabirds poorly understood in GoM
42	Nearshore Seabirds	Breeding	Natural Disturbance Regimes	How does the timing and intensity of hurricanes affect seabird survival and reproductive success?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, adult annual survival, before & after effects of hurricanes on habitat quantity & quality	Extent to which frequency and intensity of hurricanes will vary with climate change poorly understood; direct and indirect effects of hurricanes on seabird behavior and survival poorly understood

43	Pelagic Seabirds	Breeding	Natural Disturbance Regimes	How does the timing and intensity of hurricanes affect seabird survival and reproductive success?	Nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, adult annual survival, before & after effects of hurricanes on habitat quantity & quality	Extent to which frequency and intensity of hurricanes will vary with climate change poorly understood; direct and indirect effects of hurricanes on seabird behavior and survival poorly understood
44	All Seabirds	Breeding, Non-breeding	Not Defined	How does contact with spilled oil and associated chemicals (e.g., dispersants) affect individual health, body condition, and annual survival?	Body condition index (or other energetic estimators), multi-faceted health assessment, adult annual survival	Long- and short-term survival poorly understood for most species; sublethal effects difficult to quantify
45	All Seabirds	Breeding, Non-breeding	Not Defined	How does contact with spilled oil and associated chemicals (e.g., dispersants) affect prey availability and quality, and subsequent individual health, body condition, and annual survival?	Body condition index (or other energetic estimators), multi-faceted health assessment, adult annual survival	Diet data generally known, but not detailed across all species and study area; effects of oiling on prey dynamics not well known

Table C2. Shorebirds

This table was adapted from Brush et al. 2019 (see Table 7.3). Unique ID codes were assigned to each uncertainty to ease the data collection process for participants.

ID CODE	Species	Seasons	Ecological Process Category	Question	Endpoint to Measure	Uncertainty Description
46	Snowy Plover, Wilson's Plover	Breeding	Formation of Biophysical Habitats	Does habitat succession and transition within the beach/dune system impact reproductive success and survival via loss or gain of nesting habitat?	Reproductive Success, Survival	For these species we know early successional habitat is preferred. Some information exists on transitional states, reproductuctive success and survival. Preliminary work suggests dune succession leads to increased predation rates at the local scale, leading to reduced reproductive success and survival. Population level impacts unknown.
47	Piping Plover	Wintering, Migratory	Formation of Biophysical Habitats	Does change in habitat over time, through natural habitat succesion, lead to loss of foraging habitat availability and subsequently to declines in overwinter survival and population size?	Reproductive Success, Survival, Population Size	Piping Plovers have very high winter site fidelity. What is the rate of emmigration to new wintering areas due to habitat succession and what are the potential impacts of staying vs. emmigrating (body condition, survival, time of departure, reproductive success)?

48	All	All	Natural Disturbance Regimes	When key stopover, wintering, and breeding habitats are lost and shorebirds are forced to shift to new habitats, does it result in survival and population declines?	Reproductive Success, Survival, Population Size	Degree of impact of habitat loss due to hurricanes and severe weather events on survival and population trends.
49	All	All	Hydrological Processes	Does the occurrence of blue-green algal (Cyanobacteria) blooms lead to declines in shorebird reproductive success and survival?	Reproductive Success, Survival	Impacts to shorebirds have not been studied and the risks of cyanotoxins to natural resources remain relatively unknown. There is a potential to impact shorebirds year-round. The seasonality of occurrence will impact the direction of overall influence and the spatial scale. Degree and direction of this effect is highly dependent upon extent, duration, and frequency of blue-green algal blooms.
50	All	All	Natural Disturbance Regimes	What is the extent of the impact of red tide on shorebird survival, reproductive success and populations?	Reproductive Success, Survival, Population Size	Red tide is a frequently cited conservation threat to shorebirds but little is known. It is unclear why some shorebird species are impacted more than others and which environmental factors to consider. Very little work has been completed on survival and reproductive success of impacted birds as well as tracking birds in the

					area that emmigrated or were documented as not impacted.
51	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Climatic Processes	Does sea level rise impact reproductive success, survival, and populations via loss or gain of nesting habitat?	Reproductive Success, Survival, Population Size	Uncertainty in response of shorebirds to SLR, most models predict population declines. Also expected gains as the beach migrates.
52	All	All	Climatic Processes	Sea level rise and changes in seasonal weather patterns will likely influence prey base, roosting and foraging habitat availability and connectivity. Will changes result in a decline in body condition and fat gain influencing survival, time of departure, reproductive success and population size?	Reproductive Success, Survival, Population Size	We know that body condition and time of departure can influence reproductive success and survival. No information available on how SLR, climate change, and seasonal weather will change prey base as well as foraging and roosting habitat availability and connectivity and the resulting body condition, time of departure, reproductive success, and survival.

APPENDIX D: Management Uncertainties

Table D1: Seabirds

This table was adapted from Jodice et al. 2019 (see Table 6.2). Unique ID codes were assigned to each uncertainty to ease the data collection process for participants.

ID CODE	Species	Season(s)	Management Category	Question	End-point to measure mgmt. performance	Uncertainty Description
120	Beach-nesting Seabirds	Breeding, Non-breeding	Habitat and Natural Process Restoration (Habitat Restoration)	Does island creation/restoration improve habitat quality during breeding and nonbreeding seasons?	Nest counts, nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, abundance estimation (nonbreeding), residency time (nonbreeding)	Other on-site (e.g., nest predators) and off-site (e.g., prey availability) factors contribute to process uncertainty and partial observability affects status uncertainty differently depending on the monitoring end point
121	Marsh-nesting Seabirds	Breeding, Non-breeding	Habitat and Natural Process Restoration (Habitat Restoration)	Does island creation/restoration improve habitat quality during breeding and nonbreeding seasons?	Nest counts, nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, abundance estimation (nonbreeding), residency time (nonbreeding)	Other on-site (e.g., nest predators) and off-site (e.g., prey availability) factors contribute to process uncertainty and partial observability affects status uncertainty differently depending on the monitoring end point

122	Breeding Seabirds	Breeding, Non-breeding	Habitat and Natural Process Restoration (Habitat Restoration)	Does island creation/restoration improve habitat quality during breeding and nonbreeding seasons?	Nest counts, nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests, abundance estimation (nonbreeding), residency time (nonbreeding)	Other on-site (e.g., nest predators) and off-site (e.g., prey availability) factors contribute to process uncertainty and partial observability affects status uncertainty differently depending on the monitoring end point
123	Beach-nesting Seabirds	Breeding	Invasive/Problematic Species Control (Predator Management)	Does predator control improve reproductive success?	Predators (species composition and abundance estimation), nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests	Other on-site (e.g., weather) and off-site factors (e.g., prey availability) contribute to process uncertainty;predation rates not well documented and strong spatial variation
124	Marsh-nesting Seabirds	Breeding	Invasive/Problematic Species Control (Predator Management)	Does predator control improve reproductive success?	Predators (species composition and abundance estimation), nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests	Other on-site (e.g., weather) and off-site factors (e.g., prey availability) contribute to process uncertainty;predation rates not well documented and strong spatial variation

125	Nearshore Seabirds	Breeding, Non-breeding	Site/Area Management (Disturbance)	Does restricting or reducing human activity improve reproductive success (breeding) and use (nonbreeding)?	Nest attendance patterns, nest temperatures, indices of human activity, nest success and/or daily survival rates of marked nests, daily survival rates of chicks in marked nests	Other on-site (e.g., weather) and off-site factors (e.g., prey availability) contribute to process uncertainty;human activity is correlated with weather conditions and may lead to difficulties with observability
126	Nearshore Seabirds	Breeding, Non-breeding	Habitat and Natural Process Restoration (Freshwater Management)	Can freshwater management influence the amount of prey habitat and prey availability for seabirds?	Water chemistry, prey community structure	Reliance on estuarine resources varies among species and sites and diet not well documented, environmental variation in these processes will be large and difficult to observe the process
127	Audubon's Shearwater, Sooty Tern	Breeding, Non-breeding	Species Management (Habitat Management)	Does Sargassum harvest reduce prey availability, reduce adult survival, and/or reduce reproductive success?	Distribution and abundance of Sargassum	Abundance, distribution, and harvest (location, landings) of Sargassum poorly understood making the process difficult to observe; affects of Sargassum on prey habitat and seabird foraging not well documented- likely to vary among species
128	Brown Pelican, Royal Tern, Sandwich Tern	Breeding, Non-breeding	Species Management (Fisheries Management)	Does commercial fishing activity affect seabird populations via direct harvesting of forage fish or via supplemental feeding	Harvest:bycatch ratios, seabird diets, fisheries stock assessments, seabird entanglements in nets, seabird mortality from	Diet diversity is not well-documented over time, landings/bycatch not always well-documented and varies among sites

				from discarded bycatch?	longline fisheries (where allowed)	

Table D2. Shorebirds

This table was adapted from Brush et al. 2019 (see Table 7.2). Unique ID codes were assigned to each uncertainty to ease the data collection process for participants.

ID CODE	Species	Season(s)	Management Category	Question	End-point to measure mgmt. performance	Uncertainty Description
129	American Oystercatcher, Dunlin, Long-billed Curlew, Marbled Godwit, Piping Plover, Red Knot, Snowy Plover, Western Sandpiper, Wilson's Plover	All	Site/Area Management (Habitat Management)	Do incompatible coastal habitat management practices impact prey availability and the required distance necessary in order to obtain prey, leading to decreases in body condition, fat gain, and time of departure and subsequent declines in reproductive success and annual survival for breeding and non-breeding shorebirds?	Reproductive Success, Survival, Population Size	Uncertainty in how and to what extent coastal management practices impact prey availability, body condition and survival. Monitoring associated with management practices typically is not conducted at appropriate temporal and spatial scales to determine direct or indirect impacts to shorebirds.
130	American Oystercatcher, Snowy Plover, Wilson's Plover,	Breeding	Site/Area Management (Habitat Management)	Does incompatible habitat management (i.e., beach raking, over planting, etc.) decrease reproductive success and survival for breeding shorebirds?	Reproductive Success, Survival, Population Size	High uncertainty in how reproductive success and survival are reduced by incompatible management. Limited research outside of documented direct take of nesting birds. Impact likely varies based on the degree and

						type of incompatible management implemented.
131	American Oystercatcher, Dunlin, Long-billed Curlew, Marbled Godwit, Piping Plover, Red Knot, Snowy Plover, Western Sandpiper, Wilson's Plover	Wintering, Migratory	Site/Area Management (Habitat Management)	Will the alteration of coastal habitat influence reproductive success, survival and population size?	Survival, Population Size	This action can be positive and negative. It creates habitat, but a variety of habitats are required for shorebirds. Need to examine how habitat structure relates to reproduction and survival. It is unclear how it equates to population level metrics and population trends.
132	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Site/Area Management (Habitat Restoration)	Will islands designed and managed for shorebirds support larger nesting populations?	Population Size	The creation of islands is known to be successful for seabird colonies, uncertainties in the colonization of created sites by solitary species (AMOY, SNPL, WIPL). Tolerance to nearby pairs unknown. Little information is available for WIPL. Few documented records of SNPL nesting on dredge spoil islands and may not tolerate

						nesting within large colonies of mixed seabirds.
133	All	All	Site/Area Management (Habitat Restoration)	Does creation of new shorebird breeding habitat move existing nesting individuals or expand nesting?	Population Size	Uncertainity related to population size and reproductive success. Does newly created shorebird breeding habitat move shorebirds from adjacent nesting sites or grow numbers of nesting birds? If birds moved, are they more productive at the new site?
134	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Site/Area Management (Habitat Restoration)	Will shorebirds have greater reproductive success when islands are designed and managed specifically for them?	Reproductive Success	Uncertainty is high because species of interest (American Oystercatcher, Snowy Plover, Wilson's Plover) typically nest in solitary situations and often experience higher predation rates when nesting in high nest densities. Additionally, other site specific factors contribute to reproductive success (e.g., proximity to Laughing Gull colonies or other avian predator

					species), much less information is available for Wilson's Plover.
135	All	All	Invasive/Problematic Species Control (Vegetation)	Will targeted removal of woody vegetation (pines, etc.) near key roosting and nesting sites decrease predation rates and increase reproductive success and survival?	Reproductive Success, Survival, Population Size	It is known that nonbreeding shorebirds select roosting locations that are far from habitat features that may be attractive to mammalian and avian predators (ex. woody vegetation, perches, etc.). This management strategy has not been implemented in an adaptive management framework.
136	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Site/Area Management (Habitat Management)	Does increased density of non-woody vegetation at or near breeding sites limit reproductive success and survival?	Reproductive Success, Survival, Population Size	This specific metric has not been studied tied to integrated predator control. Presence of dense vegetation potentially provides cover for mammalian predators, likely contributes to increases in ghost crabs and may contribute to the increased presence of overwintering raptor species (e.g., Northern Harrier).

137	American Oystercatcher, Dunlin, Long-billed Curlew, Marbled Godwit, Piping Plover, Red Knot, Snowy Plover, Western Sandpiper, Wilson's Plover	Wintering, Migratory	Site/Area Management (Habitat Management)	Does increased density of non-woody vegetation at or near wintering foraging and/or roosting sites limit overwinter survival?	Survival, Population Size	There is very little information on the sources of overwinter mortality events for most shorebirds. However, the presence of dense vegetation potentially provides cover for mammalian predators and may contribute to the increased presence of overwintering raptor species (e.g., Northern Harrier).
138	All	All	Habitat and Natural Process Restoration (Freshwater Management)	Are shorebird populations impacted by decreased freshwater discharge/salinity regimes in the estuary through changes in habitat and prey abundance? Changes in prey abundance and availability can affect body condition and survival.	Survival, Reproductive Success	Difficult to predict future state of estuary communities. Uncertainity about how much of an impact freshwater management has on altering estuary habitat, prey abundance, and nutrient loads and how this impacts shorebird populations.
139	All	All	Habitat and Natural Process Restoration (Freshwater Management)	Blue-green algal blooms can lead to reduced or altered prey production, availability and abundance. For shorebirds, will resulting changes in prey lead to reduced body condition, fat gain, changes in habitat use and	Reproductive Success, Survival, Population Size	High uncertainty related to the role freshwater management plays in reproductive success and survival directly or indirectly (prey abundance, suboptimal habitat used, etc.) related to algal blooms. Limited

				stopover patterns, consequently contributing to declines in shorebird reproductive success and survival?		data outside local mortality events.
140	American Oystercatcher, Snowy Plover, Wilson's Plover	All	Site/Area Management (Habitat Management)	Do activities such as beach driving reduce habitat use and quality for breeding and nonbreeding shorebirds?	Reproductive Success, Survival, Population Size	The degree of this effect is highly dependent upon extent, duration, frequency of beach driving, and site configuration. Even when public beach driving is eliminated there is often frequent driving for management and enforcement purposes. Ability to predict events and effects is poor. There is little research available that examines beach habitat quality and conditions once beach driving is removed.
141	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Site/Area Management (Disturbance)	Does the effect of human disturbance increase with proximity to breeding shorebirds, resulting in reduced reproductive	Reproductive Success	Positive impacts to shorebird reproductive success associated with protection from disturbance with posting are well known. However, appropriate buffer

				success the closer disturbances occur?		distances are less understood for specific species in various habitats and under various relative disturbance thresholds.
142	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Site/Area Management (Disturbance)	Do the impacts of human disturbance at key times during the nesting season have variable influence on reproductive success based on the stage of breeding (nest initiation, incubation, brood rearing) and corresponding time during nesting season (early, mid, late)?	Reproductive Success	There is limited research to identify points during the breeding season where disturbance has the most influence on reproductive success incorporating other site-specific variables (e.g., predation, presence of predators).
143	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Site/Area Management (Disturbance)	Does human presence lead to declines in reproductive success and survival?	Reproductive Success, Survival, Population Size	Recent research found the presence of people reduced fledgling survival of Piping Plovers on northern Atlantic breeding grounds. There is limited to no work in the GoM that has quantified and evaluated impacts of human presence on reproductive success and survival and how impacts vary in the GoM.

144	All	Wintering, Migratory	Site/Area Management (Disturbance)	What is the influence of anthropogenic disturbance, predation/disturbance pressures in the GoM on body condition, survival, and emigration rates?	Survival, Population Size	If and at what point and how do habitat alteration, predation or disturbance pressures negatively impact birds and how likely are birds to move to new habitats despite the potential benefits/consequences of moving?
145	All	Wintering, Migratory	Site/Area Management (Disturbance)	Do anthropogenic activities during the winter reduce prey availability and foraging success, resulting in reduced body condition and survival for shorebirds?	Survival, Population Size	Degree of this effect is highly dependent upon extent, duration, and scale of anthropogenic activities. To what extent do activities impact body condition and survival?
146	All	Wintering, Migratory	Site/Area Management (Disturbance)	Does human disturbance on beaches during the winter reduce prey availability and foraging success for migratory shorebird species, leading to reductions in body condition and subsequent delays in departure ultimately resulting in lower reproductive success on their breeding grounds?	Reproductive Success	Degree of this effect is highly dependent upon extent, duration, and frequency of disturbance events. May be interactive with other unknown stressors on the breeding grounds.

147	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Site/Area Management (Species Stewardship)	Do protection measures at nesting and brood-rearing locations increase reproductive success?	Reproductive Success	Increases in nesting populations have been documented following implementation of protection measures at nesting sites across the GoM.
148	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Invasive/Problematic Species Control (Predator Management)	Targeting problematic individual predators will increase the efficacy of predation management and limit potential negative impacts to other coastal dependent nesting species (i.e., beach mice) and increase reproductive success at nesting sites.	Reproductive Success	Will targeting problematic individual predators increase the efficacy of predation management and limit potential negative impacts to other coastal dependent nesting species (e.g., beach mice) and increase reproductive success at nesting sites?
149	All	Wintering, Migratory	Invasive/Problematic Species Control (Predator Management)	Does removal of predators improve survival for wintering and migratory shorebirds?	Survival	It is known that nonbreeding shorebirds select roosting locations that are far from habitat features that may be attractive to mammalian and avian predators (ex. woody vegetation, perches, etc.). When shorebirds are pushed out of preferred (safe) areas (i.e., high tide roosts overwashed, etc.) they are susceptible to predation, leading to reduced survival.

150	American Oystercatcher, Snowy Plover, Wilson's Plover	Breeding	Invasive/Problematic Species Control (Predator Management)	Does removal of predators improve survival and reproductive success for breeding shorebirds?	Survival, Reproductive Success	The influence of predator pressures on shorebird reproductive success has been well documented in literature, however predation rates on solitary nesting shorebirds poorly understood and documented.
151	Buff-breasted Sandpiper, Long-billed Curlew	Migratory	Site/Area Management (Contaminants)	Does the presence of pesticides and other contaminants at key stopover locations result in decreased reproductive success and survival? How much of a role does decreased prey abundance and availablilty play?	Reproductive Success, Survival, Population Size	Direct mortality has been observed, risks associated with new classes of pesticides are not known. Exposure to other classes of toxins are unknown.

APPENDIX E: Conservation plans with priorities actively targeted by current Gulf monitoring programs.

Collectively, the seabird and shorebird monitoring practitioners that participated in our survey identified 29 unique conservation plans whose priorities are targets for their respective monitoring programs. The table below contains the full list of plans identified.

Plan Title	Authored/Administered by	Year Published or Implemented
North American Waterbird Conservation Plan	Waterbird Conservation for the Americas/Kushlan et al.	2002
Western Hemisphere Shorebird Reserve Network Conservation Plan for the Wilson's Plover	Western Hemisphere Shorebird Reserve Network/Zdravkovic	2013
Atlantic Flyway Shorebird Conservation Business Strategy	Atlantic Flyway Shorebird Initiative/Winn et al.	2013
Atlantic Flyway Shorebird Conservation Business Plan	Atlantic Flyway Shorebird Initiative	2015
Draft Revised Recovery plan for the Northern Great Plains Piping Plover, Vol 1	U.S. Fish and Wildlife Service	1988
Draft Revised Recovery plan for the Northern Great Plains Piping Plover, Vol 2 (and Comprehensive Conservation Strategy for the Piping Plover in its Coastal Migration and Wintering Range in the Continental US)	U.S. Fish and Wildlife Service	2015
Recovery Strategy for the Piping Plover in Canada	Environment Canada	2012
Business Plan for the American Oystercatcher	National Fish and Wildlife Foundation	2008
U.S. Shorebird Conservation Plan	U.S. Shorebird Plan Council/Brown et al	2001
Deepwater Horizon Oil Spill Phase 2 Early Restoration Plan	Deepwater Horizon Natural Resource Trustees	2012
GoMAMN Strategic Bird Monitoring Guidelines for the Northern Gulf of Mexico	Gulf of Mexico Avian Monitoring Network/Wilson et al.	2019
Gulf Islands National Seashore Final General Management Plan	U.S. National Park Service	2014
Lower Mississippi/Western Gulf Coast Shorebird Planning Region Plan	U.S. Shorebird Plan Council/Brown et al.	2000
Recovery Plan for the Great Lakes Piping Plover	U.S. Fish and Wildlife Service	2003
Restoring the Gulf for Coastal Waterbirds: A Long-term Vision	National Audubon Society	2012

Southeastern Coastal Plains–Caribbean Region Report	Hunter et al. 2000	2000 (revised 2002)
Florida Park Service Management Plans (includes individual plans for state parks and units)	Florida Department of Environmental Protection	2014
Florida's State Wildlife Action Plan	Florida Fish and Wildlife Conservation Commission	2019
Louisiana Coastal Master Plan	Coastal Protection and Restoration Authority	2017
Alabama Wildlife Action Plan	Alabama Department of Conservation and Natural Resources, Division of Wildlife and Freshwater Fisheries	2015
Florida Imperiled Species Management Plan	Florida Fish and Wildlife Conservation Commission	2016
Mississippi Wildlife Action Plan	Mississippi Department of Wildlife, Fisheries, and Parks	2015
Louisiana Wildlife Action Plan	Louisiana Department of Wildlife and Fisheries	2015
Florida Beach-Nesting Bird Plan	Schulte et al.	2016
Florida's Species Action Plan for Four Imperiled Beach-Nesting Birds	Florida Fish and Wildlife Conservation Commission	2013
Texas Conservation Action Plan (aka Texas Wildlife Action Plan)	Texas Parks and Wildlife Department	2005/2012
Eglin Integrated Natural Resources Management Plan	U.S. Air Force	2017
J.N. "Ding" Darling NWR Comprehensive Conservation Plan	U.S. Fish and Wildlife Service	2010
BTNEP Comprehensive Conservation and Management Plan	Barataria-Terrebonne National Estuary Program	2019