U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service Final Report: Recommendations for Implementing a Monitoring Strategy for Double-crested Cormorant Subpopulations in the United States

March 2022

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Cross Flyway-Team

Pacific Flyway

Joe Buchanan – Washington Department of Fish and Wildlife; Colleen Moulton – Idaho Department of Fish & Game; Kyle Spragens – Washington Department of Fish and Wildlife

Central Flyway
Mark Howery – Oklahoma Department of Wildlife Conservation; Sandy Johnson – North Dakota Game and Fish Department; Cliff Shackelford – Texas Parks & Wildlife Department

Mississippi Flyway
Steve Cordts – Minnesota Department of Natural Resources; David Hanni – Tennessee Wildlife Resources Agency; Sherry MacKinnon – Michigan Department of Natural Resources

Atlantic Flyway
Ruth Boettcher – Virginia Department of Wildlife Resources; Sara Schweitzer – North Carolina Wildlife Resources Commission; Josh Stiller – New York Department of Environmental Conservation

Association of Fish and Wildlife Agencies Bird/Fish Conflict Working Group

Scott Anderson – North Carolina Wildlife Resources Commission; Craig Bonds – Texas Parks & Wildlife Department; David Cobb – North Carolina Wildlife Resources Commission; Justine Hasz – Wisconsin Department of Natural Resources

Image credit: Lesley Kordella, U.S. Fish and Wildlife Service

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Abbreviations and Acronyms

AFWA	Association of Fish and Wildlife Agencies
CFR	Code of Federal Regulations
DCCO	Double-crested Cormorant
DEIS	Draft Environmental Impact Statement
DOI	Department of the Interior
EA	Environmental Assessment
EIS	Environmental Impact Statement
FEIS	Final Environmental Impact Statement
MBTA	Migratory Bird Treaty Act
NEPA	National Environmental Policy Act
PTL	Potential Take Limit
Service	United States Fish and Wildlife Service
SDM	Structured Decision Making
USC	United States Code
USDA	United States Department of Agriculture
WS	Wildlife Services

Executive Summary

The double-crested cormorant (cormorant, *Nannopterum auritus*) is a fish-eating migratory bird that is distributed across a large portion of North America. Pursuant to the Migratory Bird Treaty Act (MBTA), it is protected from take unless authorized by the Secretary of the Interior (16 U.S.C. §§ 703-712). The U.S. Fish and Wildlife Service (Service) continues to receive requests from federal, state, tribal, and private entities to lethally take cormorants to alleviate damage and conflicts associated with aquaculture and fishery resources, recreational and sport fisheries, property, natural resources, and threats to human health and safety. In addition, the Service receives requests to take cormorants for research purposes.

To address these cormorant-associated conflicts, the Service promulgated a regulation in 2021 that established a new special double-crested cormorant permit available to states and tribes in the contiguous United States (CFR §21.123). The regulation took effect on February 12, 2021 and allows the take of up to 121,504 cormorants annually for certain purposes. This regulation was developed primarily to provide maximum flexibility to states and tribes that need to manage conflicts associated with cormorants. To meet obligations under the MBTA, all Service actions must be compatible with the conservation of migratory species. Therefore, to allow this level of take, the Service must ensure the cormorant population data are sufficient to assess the cormorant populations in the future.

Federal, state, tribal, and many private entities share the Service's goal of maintaining sustainable cormorant populations. Many of these entities conduct cormorant monitoring and contribute to ongoing research, as well as regional or local cormorant management efforts. However, to date, coordinated monitoring that embody shared objectives and standardized methods across the flyways does not exist. Heavily reflected within comments by states, tribes, nongovernment organizations, and members of the public during the 2020 rulemaking process was the desire to enhance existing monitoring efforts. Therefore, the Service committed to work in partnership with the flyways to develop a more coordinated monitoring program for each subpopulation of cormorants in order to improve subpopulation estimates of cormorant abundance. In the absence of these updated population estimates, uncertainty in population size will increase, which may lead the Service to reduce allowable annual take in the future to ensure the conservation of cormorants.

The Service initiated a collaborative effort with all four flyways during the 2021 winter flyway meetings to address the need for coordinated cormorant monitoring. At that time, the Service requested that each flyway council designate representatives to serve on a cormorant population monitoring development team. The resulting cross-flyway team includes individuals from each region of the Service, USDA Wildlife Services, and three representatives from each of the four flyways. The goal of the cross-flyway team was to conduct a thorough analysis of the problem (i.e., the objectives we want to achieve via a monitoring program) and to provide insight into what type of future monitoring might be needed. To do this, the cross-flyway team employed a Structured Decision Making (SDM) approach to identify specific flyway-based monitoring values, objectives, and monitoring alternatives with the potential to address the associated objectives.

The cross-flyway team held multiple in-depth discussions focused on identifying the purpose and benefits of coordinated monitoring. The team initially identified more than 30 values for what a monitoring program should provide. The team then refined the list of values into a set of five fundamental objectives (FO) and twelve means objectives used through the SDM process:

FO 1: Maximize Cormorant Conservation/Sustainability

- *Maximize power to detect population change*
- *Maximize accuracy of subpopulation abundance estimates*
- *Maximize detection of movement of new and/or growing breeding colonies*
- *Maximize statistical rigor (uncertainty measurement included)*

FO 2: Maximize Defensible Population Management

- *Maximize population information at multiple scales to inform management decisions*

FO 3: Use Public Funds Responsibly

- *Maximize efficiency (benefit per unit cost)*

FO 4: Maximize Shared Ownership of Cormorant Monitoring and Data Stewardship

- *Maximize survey plan longevity; long-term commitment*
- *Maximize secure & accessible data management*
- *Maximize survey standardization across partners*

FO 5: Maximize Survey Utility (value of data)

- *Maximize the number of Birds of Conservation or Management Concern included in survey*
- *Minimize cost*
- *Maximize* survey repeatability (future budget & capacity changes), resiliency

The cross-flyway team also identified monitoring strategies. The team did not assess feasibility of the alternatives, but instead selected alternatives with the potential to meet the needs of both the Service and the states and tribes within a flyway. Alternatives analyzed in this report include:

- Alternative 1: No Coordinated Surveys by Subpopulation
- Alternative 2: Combination of eBird/BBS/CBC Data
- Alternative 3: Probabilistic Survey that Captures X% of a Breeding Subpopulation every 'X' Years
- Alternative 4: Survey including only Colonies >'X' Pairs every 'X' Years
- Alternative 5: Probabilistic Survey that Captures X% of Breeding and Wintering Subpopulation every 'X' Years
- Alternative 6: Maximize Coverage of Birds of Conservation Concern or of Management Concern
- Alternative 7: Census of Only Large Colonies causing Conflict
- Alternative 8: Dual Frame Survey

After identifying monitoring objectives and strategies, the team then evaluated consequences and tradeoffs using the SMART (Simple Multi-Attribute Rating Technique). This method allows users to assign weights based on individual values of each objective, and then calculate a weighted sum of scores for each alternative. This provides insight into which alternative best addresses valued objectives.

This report describes the top-ranked monitoring objectives for the Service and each flyway. The top objectives for the Service provide information necessary to inform the Potential Take Limit (PTL) model used by the Service to evaluate allowable take of cormorants. Top objectives identified by each flyway for monitoring varied considerably. However, a moderate level of alignment resulted among the Mississippi, Central, and Pacific Flyways in terms of top-rated monitoring objectives; these three flyways indicated that the ability to detect population change, estimate abundance, and statistical rigor were all high value objectives. Lower ranked objectives across all flyways included integrating Birds of Management or Conservation Concern (BMC/BCC) into the survey, detecting new or expanding colonies, secure and accessible data management, and survey longevity. The cross-flyway team considered the objective of minimizing cost as 'moderate to low cost' as a constraint rather than an objective.

Despite the variability in relative importance of the objectives among the Service and the flyways, there was a considerable amount of alignment among the top monitoring alternatives. For example, there was complete agreement across the flyways and the Service on both the highest ranked alternative (Dual Frame Survey Design) and the lowest ranked alternative (No Coordinated Survey). Additionally, each flyway exhibited high consistency among the other top three highest ranked alternatives. Except for the Atlantic Flyway, the second-highest ranked alternative was the probabilistic survey design of the breeding population, followed by the probabilistic survey design of both the breeding and wintering populations. The use of existing bird data, such as BBS and eBird, ranked fourth. However whether or not it's possible to obtain a population estimate for cormorants using this method is currently unknown and is something the Service is committed to investigating further.

The Service and the flyways recognize that to continue to manage cormorants and any associated conflicts in a responsible way, a more comprehensive approach to obtaining population information is necessary. Given the complexity of the varying management objectives for each state, province, flyway, and the Service, USDA Wildlife Services, as well as budgetary constraints and uncertainty, the cross-flyway team relied on the SDM framework to begin to identify shared and differing values, objectives, and alternative methods for monitoring cormorants. While the cross-flyway team made significant progress towards characterizing important considerations related to the implementation of a large-scale monitoring program, **monitoring strategies and objectives will require continued refinement over the next year from a broader group of stakeholders, budgetary decision makers, analysts, and divisions of state, tribal, and Canadian provincial fish and wildlife agencies within each flyway.** Implementing a coordinated approach for monitoring cormorants will require continued collaboration between the flyways, the Service, USDA Wildlife Services, states, tribes, and Canadian provinces. Therefore, this report describes a roadmap for next steps that need to occur in each year 2022 - 2026 to ensure this monitoring development effort will continue.

2022 – Next steps in 2022 will focus on fostering dialog with conservation partners and each flyway to continue to refine the monitoring objectives and alternatives identified in this report. The Service will continue to host and support this dialog and asks that each flyway work collaboratively with the Service to select a coordinated monitoring approach at the summer/fall 2022 flyway meetings.

***2023* –**The Service will conduct a power analysis for each flyway. This analysis will assist in making comparisons across different monitoring approaches and will help to delineate costs associated with different strategies. A power analysis will be integral to selecting the most cost-effective approach that will meet the needs of the Service for informing the PTL while considering the resources that states, tribes, and partners can bring to the table. Once a flyway council approves a final design, the Service, states, and tribes will work within their own agencies to determine possible funding mechanisms.

2024 – Cormorant monitoring implementation.

2025 – The Service will analyze population data and update the PTL.

2026 – The Service will produce its planned 5-year report to the public to promote transparency of decision making and evaluation of the effectiveness of the new regulation (CFR §21.123).

Need for Double-crested Cormorant Monitoring

As part of ongoing efforts to address conflicts associated with double-crested cormorants (*Nannopterum auritum*, hereafter cormorants), the U.S. Fish and Wildlife Service (Service) initiated a rulemaking and environmental review process pursuant to the National Environmental Policy Act (NEPA) in 2020. The resulting regulation (CFR §21.123[1]), which took effect on 12 February 2021, allows the take of up to 121,504 cormorants annually across the contiguous United States to address conflicts. Conflicts are wide ranging but are most often associated with the need to reduce predation-related losses of wild or stocked fisheries (both private and commercial), stocks at aquaculture facilities and hatcheries, and recreational and sport fisheries. Conflicts are also associated with the need to reduce predation-related losses of federally listed or candidate fish species. In addition to predation-related losses, conflicts may be associated with adverse effects on habitats important to bird species of concern through habitat destruction, exclusion, and/or nest competition, as well as adverse effects on personal property and vegetation, particularly where cormorants nest, and adverse effects on human health and safety.

To meet obligations under the Migratory Bird Treaty Act (MBTA), all Service actions must be compatible with the conservation of migratory species. Therefore, to allow this level of take, the Service must ensure that population data are adequate to assess cormorant populations in the future. The inability to assess future populations could result in decisions that place additional limitations on take. Population data obtained via a rigorous monitoring program is the best way to enable the Service to assess cormorant abundance, test the PTL model described in the 2020 FEIS (Final Environmental Impact Statement) to ensure cormorant populations remain at sustainable levels[2], and ensure that this regulation continues to allow maximum flexibility to manage cormorants when needed.

State wildlife agencies share the Service's goal of maintaining sustainable cormorant populations. Further, states desire a coordinated, repeatable, and practical approach to cormorant conflict management, which includes appropriately funded and coordinated monitoring throughout each flyway. This desire was reflected in comments the Service received during the 2020 rulemaking process. States, tribes, nongovernment organizations, and members of the public submitted comments requesting that the Service develop and conduct a cormorant population monitoring program. Some state agencies and flyway councils provided specific recommendations for population monitoring. Other commenters requested that the Service provide standardized population monitoring and reporting protocols needed to evaluate impacts of authorized take on cormorant populations. These commenters also requested information describing the level of rigor necessary for new monitoring, as well as the investment of time and resources that would be needed. In response to these important comments, the Service committed to collaborating with the non-game technical sections of the four flyway councils, as well as partnering federal agencies and Canadian provinces, to develop and implement a mutually agreeable standardized monitoring protocol within one year of the rule.

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[1] The previous location of this regulation in the Code of Federal Regulations at publication was CFR §21.28.

[2] The PTL model estimates the maximum allowable annual take of cormorants given management objectives and desired population size. The new regulation under CFR §21.28 in the Code of Federal Regulations allows for a maximum allowable take of up to 121,504 cormorants nationally per year. Subpopulation-specific maximum allowable take levels are as follows: Atlantic, 37,019; Interior, 78,632; Western, 4,539; and Southern (Florida), 1,314.

To accomplish the goal of developing a population monitoring protocol, the Service requested that the flyway councils designate representatives to serve on a cormorant population monitoring development team. The resulting cross-flyway team includes representatives from all four flyways, the Service, and USDA Wildlife Services, which served as a cooperating agency during development of the FEIS. Flyway representatives participating in this cross-flyway team reside with the following state agencies: Idaho, Michigan, Minnesota, North Carolina, North Dakota, New York, Oklahoma, Tennessee, Texas, Virginia, and Washington.

Purpose of Report

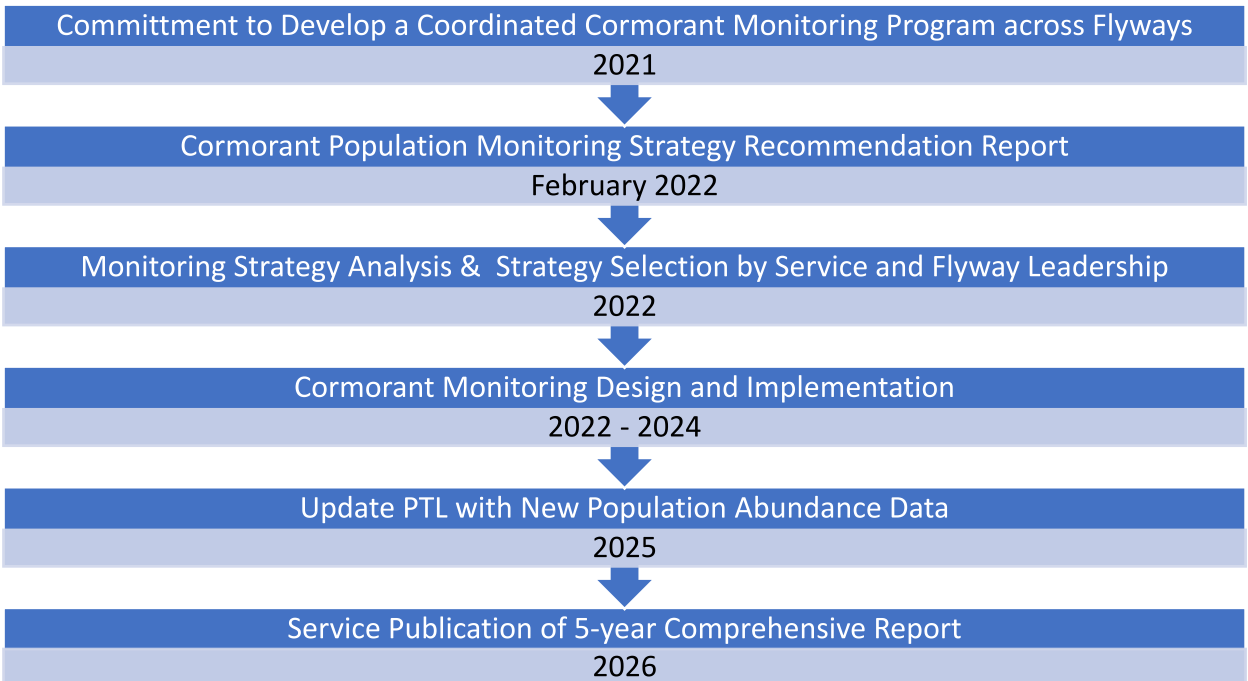
This report provides an in-depth review of strategies for monitoring cormorants to ensure the data used to determine population abundance are adequate to assess the PTL model described in the 2020 FEIS. The potential monitoring strategies listed in this report are intended to serve as the basis for stakeholder meetings between the Service, the flyway councils, USDA Wildlife Services, and conservation partners across states and tribes in calendar year 2022. The Service and the cross-flyway team intend for this report to serve as an initial decision-support document for these entities to discuss and determine which strategy will best serve as an effective monitoring program for cormorant subpopulations. The Service intends to manage and support this iterative process with the goal of finalizing recommendations for monitoring after sufficient stakeholder input from each flyway. This report provides the following tools and analyses to assist in this decision-making process:

1. An assessment of existing monitoring efforts in each flyway;
2. Monitoring objectives for the Service;
3. Monitoring objectives for each flyway;
4. List of potential monitoring strategies;
5. Strengths, weaknesses, opportunities, and threats for identified potential monitoring strategies;
6. Framework for the Service to make informed policy decisions about allowable take in 2026 based on existing monitoring, and uncertainty about populations;
7. Information that enables states to assess tradeoffs of implementing a monitoring strategy; and
8. Roadmap of next steps to further engage with additional stakeholders following the 2022 winter flyway meetings.

In addition to this report, the Service is committed to producing a more comprehensive report in five years that presents the analysis of population monitoring data and other status information as required under new regulation (CFR §21.123). The Service will provide this planned 5-year report to the public to promote transparency of decision making and evaluation of the effectiveness of the new regulation (CFR §21.123) to address conflicts and assess cormorant subpopulations across each flyway or relevant region. That report will include, at a minimum: (1) updated cormorant population status and information on trends in abundance; (2) both requested and reported lethal take of cormorants nationally and by cormorant population; (3) updated PTL analysis based on new or more current population information; (4) the state of the conflict and need for continued management, which will be informed by feedback from states and tribes and by requests for depredation permits (both individually and programmatically by participating states and tribes); and (5) a conflict-management decision and justification for either continued or enhanced management or a new management approach, if needed, in year 2026.

A general timeline for getting to a new PTL analysis in 2026 is summarized in Figure 1. More detailed recommendations for stepping through this timeline can be found in the 'Roadmap to Next Steps' section at the end of this report.

Figure 1. *Suggested Pathway from Monitoring Strategy Development to Updated PTL Analysis*[3].



[3] Some U.S. States and Canadian Provinces implemented cormorant monitoring in calendar year 2021, which may be included in future assessments.

Cormorant Subpopulations and Flyways

In the 2020 FEIS, the Service estimated that 871,001 to 1,031,757 cormorants occur in the continental United States and Canada (Table 1), spanning five breeding subpopulations, variously described by different authors as Alaska (not included in this report), Western, Interior, Atlantic, and Southern (Figure 2). Tyson et al. (1999) estimated that 95% of breeding cormorants in North America occur in the Atlantic, Interior, and Southern subpopulations, with many of those birds (68%) occurring in the Interior subpopulation (Table 1).

Figure 2- Double-crested cormorant range map for all four subpopulations in the United States and Canada (predicted using eBird source data from 2006 – 2020, (eBird, 2021)).

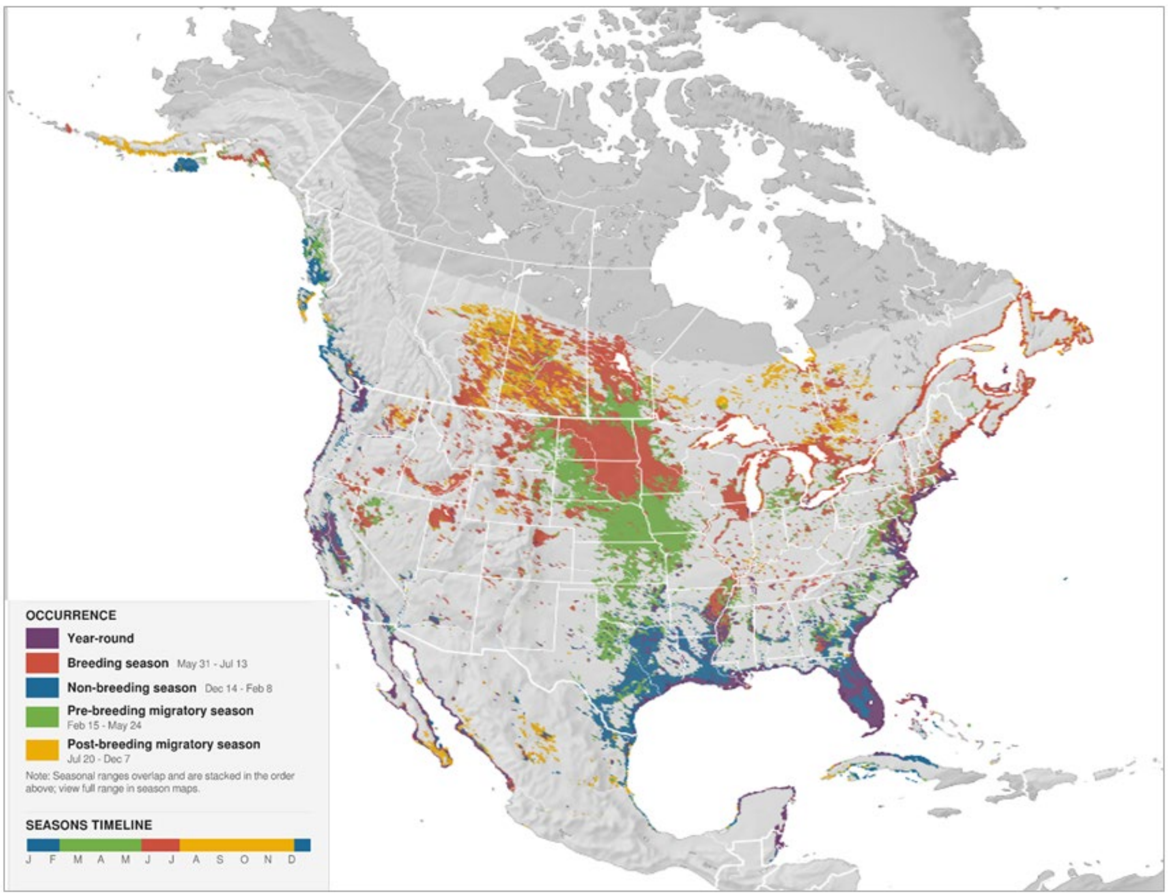


Table 1*- Estimates of double-crested cormorant subpopulations (breeding and non-breeding birds combined) occupying the Canadian provinces and United States in each flyway (US Fish and Wildlife Service, 2020).*

	Population size	
Cormorant Sub-population (subspecies)	Low	High
Western subpopulation (*N. a. albociliatus*)		
Pacific Flyway (excluding Alaska and Mexico)	49,966	94,272
Atlantic subpopulation (*N. a. auritum*)		
Atlantic Flyway		
Canada and Quebec	151,603	171,421
United States	102,442	122,439
Subtotal	254,045	293,860
Interior subpopulation (*N. a. auritum*)		
Mississippi and Central Flyways		
Canada	335,115	370,850
United States	213,315	252,236
Subtotal	548,430	623,086
Southern subpopulation (*N. a. floridanus*)		
Florida	18,560	20,539
Total	**871,001**	**1,031,757**

Distribution of Cormorants throughout the Flyways

In the summer of 2021, the Service administered a questionnaire to the nongame technical committee representatives of each flyway focused on gaining information on the distribution of cormorants throughout the flyways and the management priorities for cormorants in states occupying the flyways. The Service received responses from 20 states and provinces in the Atlantic Flyway (five did not respond), 13 states and provinces in the Central Flyway (two did not respond), and eight states in the Pacific Flyway (two did not respond). All states and provinces in the Mississippi Flyway responded.

Questionnaire participants were asked to describe the size of cormorant colonies (or lack of colonies) in their states and provinces. Participants were allowed to determine whether they considered a colony large or small. Despite the subjectivity, we learned important general characteristics about colony size and distribution throughout each of the flyways. In the Pacific Flyway, states and provinces indicated that while cormorants are generally distributed throughout most of the coastal regions (Figure 2), Oregon is the only state with cormorant colonies of any considerable size. The rest of the states in the Pacific Flyway indicated they have small breeding colonies or none at all. In the Mississippi Flyway, most states (65%) said that they have a mix of both large and small nesting colonies, particularly in the northern breeding states of Minnesota, Wisconsin, and Michigan (Figure 2). Most southern states in the Mississippi Flyway either have no roosting colonies or roosting colonies are considered small (AR, MS, IA, LA, MO; Figure 2), but experience conflicts associated with cormorants at many aquaculture and hatchery facilities and large bodies of water. In the Central Flyway, participants responded that large breeding colonies are found mainly in the most northern states (ND, SD, MT; Figure 2). The rest of the states in the Central Flyway indicated they have small or no colonies at all (Figure 2). In the Atlantic Flyway, about 50% of the participants indicated they have a mix of both large and small breeding colonies, while the other 50% responded they had few to no colonies in their states and only minimal conflict associated with cormorants (Figure 2).

Across all four flyways, questionnaire participants indicated that cormorants nest both in cormorant-only colonies as well as with a diversity of other colonial waterbirds (Table 2). In northern states and provinces, cormorants tend to co-nest with gulls as well as pelicans, in areas where they coexist. In southern states, cormorants tend to co-nest more often with herons and egrets since these species are much more common in southern climates. Where the ranges of herons and Great Egrets overlap with cormorants, it is not uncommon to see them associated with cormorant colonies, especially if the colonies' presence extends into trees. Table 2 below describes the proportion of areas within the flyways in which cormorant co-nest with other waterbird species.

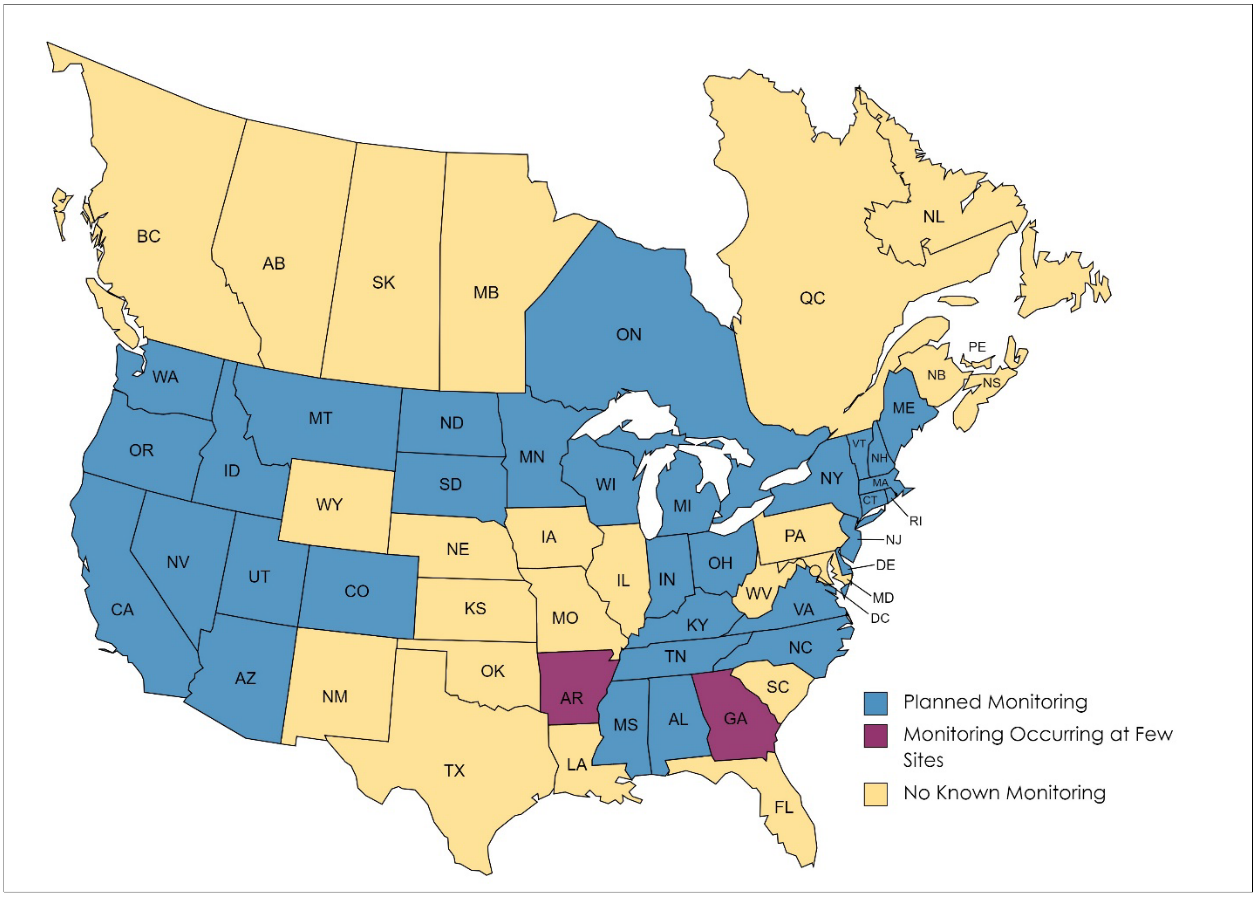
Table 2- *The proportion of states and provinces, by flyway, in which cormorants co-nest with other colonial waterbird species or species of greatest conservation need (SGCN).*

Flyway	Proportion of states and provinces with cormorants co-nesting with other colonial waterbirds	Proportion of states and provinces with cormorants co-nesting with species of greatest conservation need (SCGN)
Pacific	4/6 (67%)	1/6 (16%)
Central	8/11 (73%)	2/11 (18%)
Mississippi	12/17 (71%)	4/17 (24%)
Atlantic	7/15 (47%)	3/15 (20%)

Cormorant Management and Monitoring Programs

The Service, in partnership with the cross-flyway team, administered a different questionnaire in the summer of 2021 focused on assessing past and potential future monitoring for cormorants. The questionnaire's purpose was to better understand where there is uncertainty in past data and determine where monitoring is already planned. Capturing this information helps inform where critical monitoring may need to occur in the future. The Service also wanted to determine if existing monitoring efforts could support data requirements needed for assessing regional trends in cormorant abundance. The Service administered this questionnaire to all contiguous 48 United States as well as the Canadian provinces of British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Saskatchewan. Participants were asked if cormorant monitoring already occurs in a state or province, when the most recent cormorant surveys were conducted, and whether they were breeding surveys, nonbreeding surveys, site-specific (lake or waterbody specific), or if monitoring is done as part of statewide colonial waterbird (CWB) monitoring. The following sections describe both existing management and monitoring efforts within each flyway and subpopulation (Figure 3).

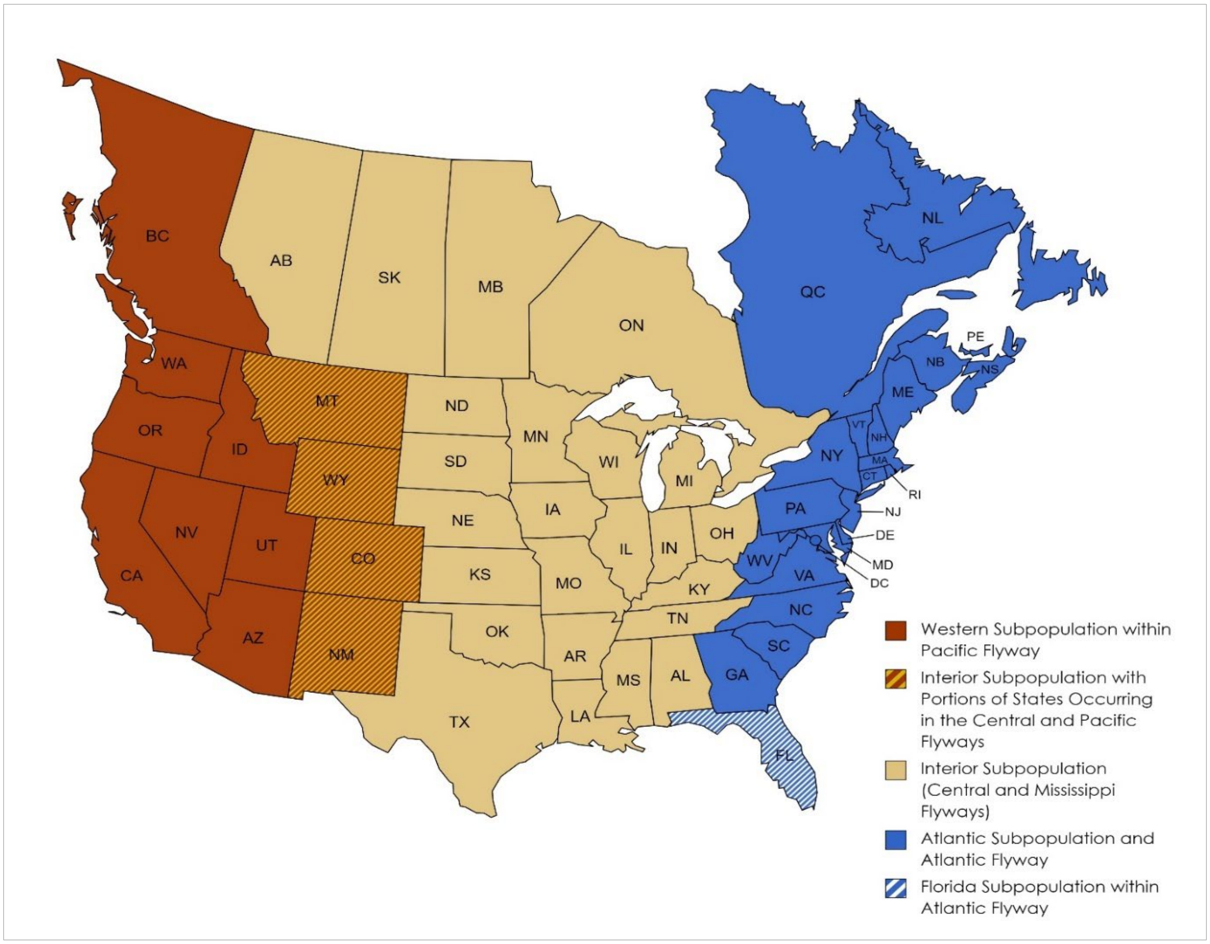
Figure 3- *States and Canadian Provinces that have existing or planned monitoring efforts for Double-crested Cormorants.*



Cormorant Subpopulation Alignment with Administrative Flyways

The geographic scope of cormorant subpopulations does not always align with the administrative framework of the flyways (Figure 4). However, the differences in that alignment are minor. Therefore, this report focuses on the actions that flyways can implement that support the biological framework of each subpopulation. The following sections describe how each subpopulation geographically ties into each administrative flyway, how cormorants are distributed throughout each flyway, and how management priorities and monitoring efforts vary within each flyway.

__Figure 4-__ A map illustrating the geographic scope of each double-crested cormorant subpopulation and how they overlap with each flyway's administrative boundaries.



Western Subpopulation and the Pacific Flyway

Population Overview

The geographic distribution of the Western subpopulation (*N. a. albociliatus*) within the Pacific Flyway encompasses Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. In Colorado, Montana, New Mexico, and Wyoming only those areas west of the Continental Divide are considered part of the Western subpopulation; cormorants in the eastern portions of these states are included in the Interior subpopulation (Figure 4). Cormorants along the Pacific coast are only slightly migratory compared to those breeding in the more interior states where harsh climates likely prompt them to migrate to the Pacific coast for the winter (Hatch 1995; Mercer 2008).

The coastal states and provinces account for greater than 90% of the western subpopulation (Adkins et al. 2014). Growth of the western subpopulation of cormorants is largely attributed to the increase in size of the cormorant breeding colony at East Sand Island, in the Columbia River Estuary in Oregon, which accounted for 39% of the western subpopulation of cormorants during 2008–2010 (Adkins et al. 2014). Outside of East Sand Island, growth of the western subpopulation of cormorants in other areas has been relatively static over the past two decades. Some isolated areas showed limited cormorant increases (e.g., local sites within Arizona, Idaho, Montana, and Washington) and areas of decline (e.g., Salton Sea, California; Pacific Flyway Council 2012). Recent estimates (2017 and 2019) of the breeding Western subpopulation were lower than estimates prior to implementation of the U.S. Army Corps of Engineers cormorant management plan (USACE 2015), however the magnitude of the decrease was less than predicted due to cormorant dispersal and aggregation in other parts of the Columbia River. The Service analyzed the western subpopulation in the 2020 FEIS and predicted that it should stabilize at or just above the current low population estimate of 49,966 cormorants (Table 1) if maximum allowable take is realized.

Cormorant Management in the Pacific Flyway

State representatives from the Pacific Flyway provided information relevant to cormorant-related conflict management in the Western subpopulation. Results indicated that most states with conflict in this region are primarily related to fisheries (federally endangered species; hatcheries; stocked lakes and reservoirs in some southern states and Utah). As a proxy for the magnitude of conflict, Table 3 provides a summary of all authorized take in the Western subpopulation since the new FEIS was implemented. The Service considers these data preliminary in nature, as total authorized take is still being analyzed by the Service. The Service is also still processing take reports from the last year to determine actual take, which is typically less than what the Service authorized.

Pacific Flyway States	Total Authorized Take for Pacific Flyway
Arizona	35
California	280
Oregon	1,507
Utah	710
Washington	550
Total	*2,632*

Table 3- *Total authorized take of double-crested Cormorants in the Pacific Flyway in 2021; maximum allowable take for the western subpopulation is 4,539 birds. Take numbers are preliminary at the time of this report. States not listed exhibited zero authorized take.*

Planned Cormorant Monitoring in the Pacific Flyway

In 2013, the Pacific Flyway Council published A Monitoring Strategy for the Western Population of Double-Crested Cormorants. The Pacific Flyway monitoring strategy is a coordinated monitoring effort to estimate the breeding size, trend, and distribution of the western population of cormorants across the Pacific Flyway. As a part of the cormorant management plan, the U.S. Army Corps of Engineers provided supplemental funding to the Service to support monitoring efforts during the initial years of plan implementation. Monitoring is used to detect potential changes in the size of the western population of cormorants relative to management actions implemented at East Sand Island.

In response to the monitoring questionnaire administered by the Service, state representatives from the Pacific Flyway provided information relevant to past and planned breeding surveys for the Western subpopulation (Table 4). The coordinated monitoring effort outline above is reflected in participants responses.

Table 4- *Most recent and future planned monitoring of breeding double-crested cormorants in the Pacific Flyway – the result of a coordinated flyway-wide monitoring program implemented since 2014. NA indicates that no response to the questionnaire was received by the state or province.*

State/Province	Most Recent Survey	Type of Survey	Next Planned Survey
Arizona	2020	Breeding	2021
British Columbia	N/A	N/A	
California	2019	Breeding	2021-2023
Idaho	2019	Breeding	2021-2023
Nevada	2019	Breeding	2021
Oregon	2020	Breeding	2021
Utah	2020	Breeding	2021-2023
Washington	2019	Breeding	2021-2022

Interior Subpopulation and the Central and Mississippi Flyways

Population Overview

Except for the Canadian Northwest Territories (included in the Central Flyway, but not within the range of the double-crested cormorant), the geographic scope of the Interior subpopulation mirrors that of the states and provinces included in the Central and Mississippi Flyways combined. This includes Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Wyoming, Alabama, Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Ohio, Tennessee, Wisconsin, and the Canadian provinces of Alberta, Ontario, Manitoba, and Saskatchewan (Figure 4).

The Interior subpopulation is the largest of the four subpopulations in both number of breeding birds and distribution (Table 1; Figure 2). Cormorants in this subpopulation exhibit the greatest seasonal movements (Johnsgard 1993) with the primary migration route being through the Mississippi and Missouri River valleys to the Gulf Coast (Palmer 1962; Guillaumet et al. 2011) with large numbers of birds remaining in the Mississippi Delta (Jackson and Jackson 1995; Burr et al. 2020) and other aquaculture producing regions of the southeastern United States (Dorr and Fielder 2017). Recent population data suggest the Great Lakes meta-population may be stable or declining (Guillaumet et al. 2014). This pattern coincides with the onset of widespread cormorant-control measures (largely through the previous Public Resources Depredation Order, or PRDO) in the Great Lakes region.

Cormorant Management in the Central and Mississippi Flyways

About half the states within the Central Flyway manage cormorants to address conflicts related to impacts to natural resources. These conflicts span the geographic scope of the flyway but are mostly concentrated in the northern and southern portions (Table 5). States that primarily have migrating cormorants do not experience conflict with a high magnitude, as cormorants do not remain in those areas long before migrating. In addition, none of these agencies reported cormorants as a management priority. Texas and Montana were the only states in the Central Flyway that indicated that cormorants were a management priority despite large cormorant colonies existing in other states.

Most states within the Mississippi Flyway indicated that conflicts in this region are primarily related to fisheries or other natural resource management concerns such as co-nesting species. Kentucky, Illinois, Iowa, Louisiana, and Missouri indicated that their states have less concern regarding conflicts associated with cormorants, and aside from infrequent, local conflicts, do not consider cormorants a management priority. Even Wisconsin, which experiences its share of conflict due to large nesting colonies (particularly in Green Bay), states that cormorants are not a management concern for their agency.

Regardless of whether cormorants have been defined as a management priority, take of cormorants is requested in every state in both flyways every year. Table 5 outlines the amount of authorized take from all permits combined in the Central and Mississippi Flyways in 2021.

Table 5- *Total authorized take of double-crested cormorants in the Central and Mississippi Flyways in 2021 for all permit types. The maximum allowable take for the Interior subpopulation is 78,632 birds. Take numbers are preliminary at the time of this report. States not listed exhibited zero authorized take.*

Central Flyway States	**Total Authorized Take for Central Flyway**	**Mississippi Flyway States**	**Total Authorized Take for Mississippi Flyway**
Colorado	145	Alabama	1,909
Kansas	210	Arkansas	6,310
Montana	36	Iowa	50
Nebraska	351	Illinois	245
New Mexico	5	Indiana	1,370
North Dakota	1,236	Kentucky	795
Oklahoma	25	Louisiana	90
South Dakota	293	Michigan	10,953
Texas	1,320	Minnesota	5,762
		Missouri	195
		Mississippi	18,150
		Ohio	3,158
		Tennessee	5
		Wisconsin	3,792
Total	*3,623*		*52,784*

Planned Cormorant Monitoring in the Central/Mississippi Flyways

While there is a paucity of monitoring information for cormorant populations in some regions, there are examples of systematic monitoring of cormorants in other regions such as the Great Lakes. This region has participated in coordinated decadal surveys that have enumerated colonial waterbirds (including cormorants) since the 1960's. The Canadian Wildlife Service (CWS) and the Service both invested heavily in this survey in the past and it formed the basis of the population estimate for the Interior subpopulation in the 2020 FEIS. Further, the Great Lakes regional migratory bird program implemented cormorant specific monitoring every other year between 2006 – 2018, but this monitoring was discontinued following vacation of the Public Resources Depredation Order. Discussions are ongoing between the United States and Canada regarding how to continue these important surveys with the assistance of regional partners. Unfortunately, other regions with well-known breeding colonies (e.g., Manitoba, Ontario) have not been monitored regularly, primarily because these colonies are remote and result in little conflict in these Canadian provinces.

Table 6 below describes all known existing or planned monitoring programs in the Central and Mississippi Flyways as reported by representatives from each state.

Table 6- *Most recent and future planned monitoring of breeding double-crested cormorants in the Central and Mississippi Flyways. CWB* denotes that state conducts colonial waterbird surveys with potential to include cormorants. N/A indicates the state did not respond to the questionnaire and there is no known monitoring information.*

State/Province	Most Recent Survey	Type of Survey	Next Planned Survey
Alabama	2019	Breeding; nonbreeding	2021
Arkansas	2021	Non-breeding (site specific)	2022
Colorado	2019	Breeding	2021
Illinois	No monitoring		None planned
Indiana	Not recent		None planned
Iowa	2014	Volunteer CWB monitoring	N/A
Kansas	No monitoring		None planned
Kentucky	2021	Breeding	2022
Louisiana	Unknown		Unknown
Michigan	2018	Breeding	2021 (partial)
Minnesota	2021	Breeding	2026
Mississippi	2021	Breeding; nonbreeding	2022
Missouri	No monitoring		None planned
Montana	2019	Breeding	2021
Nebraska	No monitoring		None planned
New Mexico	2011	CWB	N/A
North Dakota	2014/2015	CWB*	None planned
Ohio	2020	Breeding; nonbreeding	2021
Oklahoma	No monitoring		None planned
South Dakota	2012	Breeding	None planned
Tennessee	2018	Breeding	2023
Texas	No monitoring		None planned
Wisconsin	2018	Breeding	2021-2023
Wyoming	No monitoring	CWB*	None planned
Ontario	2019/2021	Breeding	2022-2024
Manitoba	2017	Breeding	2022-2023
Saskatchewan	No monitoring		None planned
Alberta	Unknown	Unknown	Unknown

Atlantic and Southern Subpopulations and the Atlantic Flyway

Population Overview

The geographic scope of the Atlantic subpopulation encompasses Connecticut, the District of Columbia, Delaware, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, West Virginia, the Canadian Maritimes (New Brunswick, Nova Scotia, and Prince Edward Island), and Quebec (Figure 4). The Atlantic Flyway Council is composed of the same states and provinces, as well as Florida (the State of Florida represents its own cormorant subpopulation), the Canadian territory of Nunavut and provinces of Newfoundland, New Brunswick, and Ontario, plus the United States territories of Puerto Rico and United States Virgin Islands. Although Ontario participates in both the Atlantic and Mississippi Flyways, cormorants occurring in Ontario are part of the Interior subpopulation, and therefore this province is included in the biological and geographic scope of that subpopulation. Similarly, even though Florida is part of the Atlantic Flyway, the Southern subpopulation (subspecies *N. a. floridanus*) encompasses this state and is considered separately from the Atlantic subpopulation.

Like the Interior subpopulation, cormorants within the Atlantic subpopulation also exhibit significant seasonal movement (Johnsgard 1993). The primary migration route for birds occupying this subpopulation appears to run down the Atlantic coast. Conversely, cormorants in the Southern subpopulation occupying Florida and the Caribbean are considered non-migratory (Dorr et al. 2014). Recent genetic data suggest cormorants within the Southern subpopulation are much more geographically restricted, and do not breed with cormorants found in Arkansas eastward to Alabama (Kimble et al. 2020). However, the *N. a. floridanus* subspecies intermixes with *N. a. auritum* during winter in Florida and are indistinguishable from each other (Sheehan 2013).

Due to limited monitoring programs in both the Atlantic and Southern subpopulations, not much is known about how cormorant colonies throughout the flyway have fluctuated over time. In the 2020 FEIS the Service determined that both the Atlantic and Southern subpopulations should stabilize at or just below the current low population estimate of 254,045 and 18,560, respectively, (Table 1) if maximum allowable take is realized annually.

Cormorant Management in the Atlantic Flyway

State representatives provided information relevant to cormorant-related conflict management in both the Atlantic and Southern subpopulations in the questionnaires. In the Atlantic Flyway, about one quarter of the states and provinces indicated that cormorants were a priority for their agency due to conflicts with fisheries or other natural resources. The rest of the states and provinces indicated that cormorant-related conflicts were not a severe problem and did not consider the birds a priority at all. Table 7 describes the amount of take requested and authorized by state under all permit types in 2021. Whether or not the birds are considered a management priority, take of cormorants is requested in every state in the flyway during the breeding or wintering seasons. It should be noted here that due to the amount of intermixing between the two subspecies in this flyway, birds killed during the breeding season in Florida are likely the *floridanus* subspecies, whereas birds taken during winter would be of unknown subspecies.

Table 7*- Total authorized take of double-crested cormorants in the Atlantic Flyway in 2021. * Denotes birds taken in Florida could reflect subspecies found in both the Atlantic and Southern subpopulations due to intermixing. The maximum allowable take for the Atlantic subpopulation is 37,019 birds and 1,314 birds for the Southern subpopulation (i.e., Florida). Take numbers are preliminary at the time of this report. States not listed exhibited zero authorized take.*

Atlantic Flyway States	Total Authorized Take
Connecticut	8
Florida*	547
Georgia	490
Maryland	652
Maine	133
North Carolina	230
New Hampshire	263
New Jersey	96
New York	1,578
Pennsylvania	40
Rhode Island	41
South Carolina	200
Vermont	2,023
Total	*5,753*

Planned Cormorant Monitoring in the Atlantic Flyway

In the Atlantic Flyway, cormorants are regularly counted in only a few states, and this typically occurs as part of a states planned colonial waterbird survey (e.g., NY, MA). However, the Atlantic Flyway states have been interested in developing a more coordinated flyway approach to monitoring colonial species (including double-crested cormorants) and have been in discussions since 2018 about the feasibility of implementing such a survey in 2023. A coordinated flyway strategy would be immensely beneficial to filling information gaps about cormorant population dynamics in this subpopulation.

Coordinated surveys are not yet planned for the State of Florida and there is uncertainty about the feasibility of this state participating in a coordinated flyway-wide monitoring effort. Waterbird colonies are distributed throughout the state in both coastal and interior areas, which may prohibitively increase the expense of colonial waterbird monitoring in this state. Florida has a robust stakeholder partnership responsible for monitoring different areas of the state. However, there is not a standardized monitoring protocol among partners, nor is there currently a single accessible database for accessing colony specific information. Due to the unique situation of Florida, efforts to obtain information about cormorant abundance in Florida will benefit from coordination with and support from the Atlantic Flyway Council and the Service.

Information about planned surveys for cormorants in individual states in the Atlantic Flyway (outside of the coordinated approach identified above) are listed in Table 8.

Table 8- *Most recent and future planned monitoring of breeding and non-breeding double-crested cormorants in the Atlantic Flyway. * Denotes that Florida has no coordinated surveys for the state, but some partners monitor periodically; these partners would need to be contacted for more precise information. N/A indicates that state did not respond to survey and there is no known monitoring information.*

State/Province	Most Recent Survey	Type of Survey	Next Planned Survey
Connecticut	2019	Breeding	likely 2022
DC	N/A	N/A	N/A
Delaware	No Monitoring		None planned
Florida*	No Monitoring*	Breeding*	None planned*
Georgia	2021	Breeding; nonbreeding (few sites)	2022
Maine	2019	Breeding	None planned
Maryland	N/A	N/A	N/A
Massachusetts	2018	Breeding	2023
New Hampshire	No Monitoring		None planned
New Jersey	2021	Breeding	2022-2023
New York	2021	Breeding	2022
North Carolina	2021	Breeding; nonbreeding	2023
Pennsylvania	2021	Breeding	2022
Rhode Island	2019	Breeding	2021
South Carolina	2017	Breeding; nonbreeding	Unknown
Vermont	2021	Breeding	2022
Virginia	2018	Breeding	2023
West Virginia	No Monitoring		None planned
Maritimes	N/A	N/A	N/A
Quebec	N/A	N/A	N/A

Effects of Monitoring on Future Service Decisions

The Service must consider the impacts to the cormorant population when determining the level of take to authorize. The analytical approach used in the 2020 FEIS to set a maximum allowable annual take (Potential Take Level or PTL) required a minimum estimate of abundance (N_{min}) and population growth (r_{max}), and used an additional parameter called a recovery or management factor (F_0). The simplest form of this model is:

$$\mathrm{PTL} = N_{\min} \frac{r_{max}}{2} \mathrm{F}_0$$

The Service intends to use this same general approach in 2026 to again set allowable take limits. Monitoring to estimate cormorant abundance will be needed to update the assessment for each subpopulation. In the absence of updated population estimates, uncertainty in population size will increase, and this may lead the Service to reduce allowable annual take to ensure the conservation of cormorants.

Policy makers in the Service must make decisions in 2026 based on the PTL assessment and will require an estimate of the minimum population size (of each subpopulation) by 2025. Different monitoring alternatives considered in this plan may necessitate establishing a new value of F in year five. In the FEIS, a recovery factor (F) of 1.0 (considered maximum sustainable yield in the PTL model) was used for both the Atlantic and Interior subpopulations which maximizes the amount of take possible without reducing the population size. An F value of 0.75 and 0.5 was used for the Western and Southern subpopulations, respectively. A more conservative approach was taken for these subpopulations due to their smaller sizes, uncertainty of population dynamics (Western), and in the case of the Southern subpopulation, few monitoring programs in place to assess the effect of take on the subspecies (*N. a. floridanus).* These F values were thought to be a starting place and the appropriate value for F in the future will be informed by the state of the conflict, our understanding of the effect of take management on reducing the conflict, and the availability of updated abundance estimates.

For each subpopulation, the following decisions and outcomes will be used by the Service when evaluating population abundance in the 5-year report (Table 9). The decision matrix below (Table 9) outlines scenarios for adaptive decision making. These scenarios are largely dependent on the development and implementation of a comprehensive survey strategy for each subpopulation.

Table 9. *Cormorant monitoring decision matrix for the U.S. Fish and Wildlife Service.*

Monitoring Support for Decision Making	DCCO Subpopulation Abundance	Potential Adaptive Decision	Potential Policy Decision	Potential Monitoring Approach after each five-year review
If a subpopulation is **NOT** monitored in a manner where abundance can be estimated. In this case, either (a) no subpopulation data are collected or updated or (b) a coordinated approach for monitoring is not identified by a flyway.	**Then**, cormorant subpopulation size estimates cannot be updated. Uncertainty about the subpopulation increases. Risk of litigation increases.	The Service will assess the subpopulation and update the PTL based on best available information for the subpopulation.	Due to a lack of robust monitoring, there is increased risk that the Service will lower F_0 and decrease maximum allowable take to compensate for the increase in uncertainty of the subpopulation abundance.	The Service and flyways will need to assess the state of the conflict and bolster a more coordinated monitoring approach.
If a subpopulation **IS** being monitored in a manner where abundance can be estimated. In this case, the flyways agree to continue to work with the Service to (a) select and refine a monitoring alternative identified in this plan, or (b) develop a new strategy with the ability to meet the Service's objective of informing the PTL.	**Then**, uncertainty about abundance will decrease and the cormorant subpopulation can be adequately assessed.	The Service will update the PTL with new abundance data. Maximum allowable take may increase, decrease, or remain unchanged. Any changes will be commensurate with new PTL analysis and cormorant abundance.	The Service will evaluate F_0 to determine if (a) any change in F_0 is appropriate and (b) any change in F_0 is necessary to address the state of the conflict associated with cormorants.	The Service and partners will examine the precision of abundance estimates to determine if the sampling effort needs to be increased or can be reduced.

Identifying Flyway-based Monitoring Values, Objectives, and Alternatives

The cross-flyway team used a Structured Decision Making (SDM; Keeney, 2004) approach to identify specific flyway-based monitoring objectives and monitoring alternatives with the potential to address the associated objectives. SDM provides a framework designed to (1) clarify the decision problem we will be solving; (2) elicit issues, concerns, and values important to stakeholders and decision makers; (3) develop objectives that support identified values; (4) identify potential [monitoring] alternatives; (5) quantify the performance of the alternatives relative to the objectives; and (6) evaluate the tradeoffs among alternative choices. Another important part of this process was to identify key knowledge gaps relevant to the survey decision, such as existing and planned monitoring, barriers to implementation, etc. The goal of this process was to conduct a thorough analysis of the problem and to provide insight into what type of future monitoring will be needed. This process should provide guidance for agency leadership to make an informed and fully transparent decision regarding participation in the survey now and into the future.

Objectives for Monitoring Cormorants

Cormorants represent a shared resource across all four flyways. Therefore, it is essential to understand the purpose of monitoring and what the Service and each state might gain by participating in a multi-flyway partnership. As such, the cross-flyway team held multiple in-depth discussions about what a monitoring strategy should achieve. Each team member worked both on their own and within the larger group to identify cormorant monitoring objectives they deemed important to their state and flyway. Characterizing these objectives is a vital part of the process for two reasons. First, objectives form the basis to enable each flyway to evaluate different alternatives. Second, objectives help provide justification and sideboards for any future decision on monitoring alternatives. Through this process, team members first brainstormed general values related to conducting cormorant monitoring. For example:

- collected data should inform the PTL;
- monitoring should serve to inform management decisions; or
- surveys should provide information on other species besides just cormorants.

In all, more than 30 values were identified for monitoring, and these were refined and transformed into a set of five fundamental objectives and twelve means objectives (Table 10). A means objective defines the way in which the fundamental objectives will be achieved and typically includes the metrics by which each alternative is measured. The resulting means objectives still exhibit some overlap; some influence others, and some are dependent on each other. **The cross-flyway team intends for the resulting objectives to serve as a framework for further discussions with a broader audience of stakeholders in each flyway when designing a cormorant monitoring program.** This report describes this process in more detail in the Next Steps section at the end of this report.

Table 10: *The Fundamental and Means objectives identified by the cross-flyway team and used to evaluate monitoring alternatives.*

Fundamental Objectives	Means Objectives	Scale used to Evaluate Performance of Monitoring Alternatives
Maximize Cormorant Conservation/Sustainability	Maximize accuracy of subpopulation abundance estimates	scale 1 --> 10
	Maximize power to detect population change	scale 1 --> 10
	Maximize detection of movement of new/growing breeding colonies	scale 1 --> 10
	Maximize statistical rigor (uncertainty/bias included)	scale 1 --> 10
Maximize Defensible Population Management	Maximize population information at multiple scales to inform management decisions	scale 1 --> 10
Use Public Funds Responsibly	Maximize efficiency (benefit per unit cost)	scale 1 --> 10
Maximize Shared Ownership of Cormorant Monitoring and Data Stewardship	Maximize survey plan longevity; long-term commitment	scale 1 --> 10
	Maximize degree of survey standardization across partners	(Y/N OR 1/0)
	Maximize secure & accessible data management	(Y/N OR 1/0)
Maximize Survey Utility (value of data)	Maximize number SGCN/BMC/BCC* included in survey	scale 1 --> 10
	Maximize survey repeatability (future budget & capacity changes); resiliency	scale 1 --> 10
	Minimize cost	scale 1 --> 10

* Abbreviations indicate Species of Greatest Conservation Need (SGCN), Birds of Management Concern (BMC), and Birds of Conservation Concern (BCC).

The cross-flyway team evaluated each monitoring alternative against its ability to meet each of these defined objectives. In most evaluations of objectives, the team used a scale of one to 10, with 10 being the best. In two cases, the team used a yes/no metric to indicate the ability of an alternative to meet an objective.

The cross-flyway team defined each means objective (Table 10) based on certain intentions and assumptions as described below.

Maximize power to detect population change- Except for the Pacific Flyway, there has been a lack of coordination or standardization for monitoring cormorants in North America. Historically, most surveys are performed by a patchwork of states and Canadian provinces. Coordination and standardization of monitoring play a critical role in detecting credible trends in population change. Therefore, the cross-flyway team identified the ability to detect change as an important objective for any monitoring alternative. Detecting changes in the population over time is important because it improves the ability to detect impacts to the cormorant population and develop more accurate population projections. Double-crested cormorants are a public trust resource managed by states, tribes, and the Service under the authority of the MBTA. Therefore, the Service needs to ensure allowable take of cormorants is commensurate with population status and take steps to assess whether the cormorant population is sufficient to withstand the level of allowable take. Monitoring the cormorant population, as well as monitoring the state of the conflict, allows states, tribes, and other partners, to adapt management responses when monitoring data indicates a change over time.

Maximize accuracy of subpopulation abundance estimates- An assessment of the abundance of each of the four subpopulations is necessary to inform and update the PTL. Updated estimates also allow adjustments to management actions in a timely manner if any individual subpopulation unexpectedly declines.

Maximize detection of movement of new and/or growing breeding colonies- The ability to detect and monitor new and growing colonies provides critical information about population abundance, growth rate, and shifting distribution within each subpopulation. In addition, monitoring to detect new colonies can inform management needs regarding local conflicts.

Maximize statistical rigor (uncertainty measurement included)- Statistical rigor is needed to make valid conclusions from data and it is the basis for the level of confidence in monitoring. Further, monitoring alternatives with higher statistical rigor increase public trust in decision-making around the outcomes of monitoring. This objective served as a basis for other objectives identified by the cross-flyway team. For example, the cross-flyway team identified an objective of minimizing risk of litigation as it relates to the decision-making around the outcomes of monitoring but felt that maximizing statistical rigor serves as the basis for reducing that risk.

Maximize population information at multiple scales to inform management decisions- This objective stems from the complexity needed to address multiple types of conflicts or population management issues (e.g. declining populations) associated with cormorants across different geographic and temporal scales. Objectives for monitoring will vary among stakeholders within any flyway due to differences in management efficacy, differences between co-nesting species and their level of importance at various scales, differing fishery-related conflicts, or varying distances to aquaculture facilities that experience conflicts. Rating the ability of each alternative to meet this objective will be an essential flyway-specific question when a monitoring protocol is determined within a given flyway.

Maximize survey plan longevity; long-term commitment- The cross-flyway team recognized the need for long-term commitment to a monitoring alternative. A long-term commitment by the Service, states, tribes, and flyway councils to implement a monitoring protocol maximizes other objectives identified in this report. For example, long-term monitoring improves the ability to detect population changes and trends. Datasets from well-designed and coordinated monitoring approaches could improve the ability to more deeply understand the dynamics of the cormorant population and allow for projections that are more accurate.

Maximize the number of Birds of Conservation or Management Concern included in survey- Many states and provinces perform surveys for colonial waterbird species other than cormorants, and the cross-flyway team thought including other species in a monitoring design would maximize the utility of any monitoring performed. Expanding the scope of surveys to include other waterbird species could leverage resources required for cormorant monitoring. Doing so could potentially address multiple management objectives for that state, tribe, or province and help assess impacts that increasing cormorant populations may have on co-nesting species over time.

Maximize survey repeatability (future budget and capacity changes); resiliency- This objective is meant to capture the resiliency of an alternative and the likelihood of the survey to be repeated. This objective relates to the objective "*Maximize survey plan longevity; long-term commitment,*" but focuses more on the financial aspects and the feasibility of being repeatable. Phrased another way, this objective addresses the feasibility of meeting the long-term commitment objective. Some monitoring alternatives may be viewed as too complex or expensive to be repeatable, whereas others may be easier to repeat. Budgetary constraints, staff available to conduct surveys, and other administrative elements greatly influence the ability to repeat monitoring. Repeatability is not necessarily a shared objective, as a flyway may choose to spend more on an alternative that serves other objectives at the expense of being repeatable.

Maximize secure and accessible data management- When data are available in a centralized place and are accessible to all partners, the decision-making process improves and becomes more transparent to stakeholders. It also enhances the ability of other stakeholders to have access to and analyze the data to answer other research and management questions. Further, data management ensures consistency in data collection and recording and that the data are easily accessible for future analysis. Data management policies increase data reliability and cost effectiveness. The cross-flyway team did not yet identify a source for a centralized data system. Rating the ability of each alternative to meet this objective will be an essential flyway-specific question when a monitoring protocol is determined within a given flyway.

Maximize survey standardization across partners- Standardization improves the ability to apply survey protocols consistently, which in turn, produces more statistically rigorous results. Standardization also improves confidence in the data collected, as well as the credibility and reliability of those data. Standardization across partners in a subpopulation and flyway also encourages more coordination and cooperation. To achieve standardization, all partners within a flyway would need to use the agreed-upon methodology and protocols.

Maximize efficiency (benefit per unit cost)- States, tribes, and provinces within a flyway have varying priorities, budgets, time, staff, and other considerations related to capacity. This objective seeks to not only maximize the information gained for the cost it takes to implement monitoring, but also to maximize the indirect benefits related to cormorant monitoring. For example, when a state supports or participates in cormorant monitoring, they also gain knowledge of the location and movement of a breeding colony, or information on other co-nesting species.

Minimize cost- The cross-flyway team universally agreed that the desire to minimize expenses associated with monitoring is an important consideration. However, there was uncertainty about whether it should be an objective. The goal of developing a coordinated monitoring program should not be to design something that costs the least. Instead, the process should consider the needs of the states and the Service and what benefit they will receive for the cost (e.g., efficiency or cost/benefit ratio). This will be different for every state depending on their level of conflict, capacity and budget to conduct monitoring, and how they value cormorant management versus other priorities. As such, in this analysis, cost was considered a constraint. Given this complexity, it was impossible to obtain true cost estimates for each alternative. Therefore, cost was considered on a qualitative basis and the team used a scale of one to 10 to score this objective (one being the least expensive; 10 the most expensive).

Alternatives for Monitoring Cormorants including SWOT Analysis

Alternatives for monitoring approaches are typically generated after the objectives have been articulated. Alternatives describe the possible courses of action that may exist to solve the problem. The cross-flyway team did not assess feasibility or efficacy when generating alternatives, as this step will be performed later with a larger group of stakeholders. Instead, the team evaluated the objectives and determined how alternatives help meet the fundamental objectives. The team considered alternatives that were contrary to past practices and challenged perceived constraints (such as cost and capacity).

Viable alternatives identified by the cross-flyway team should:

- Address key aspects of the problem (e.g., informing the PTL) and apply to a consistent framing of the problem
- Provide sufficient detail for prediction of consequences
- Be distinct enough from other alternatives to be considered a different choice

The cross-flyway team did not comprehensively describe alternatives for this report. Doing so would take extraordinary analytical effort and time due to the complexity of large-scale monitoring design. However, the cross-flyway team developed a coarse description for each alternative that provided sideboards to ensure each team member had the same understanding of each alternative and enabled each person to differentiate one approach from another. Descriptions of each alternative include an accompanying analysis of potential strengths, weakness, opportunities, and threats (SWOT) to the applicable monitoring strategy. These descriptions will likely change in the future as feasibility of an approach continues to be assessed. In general, these descriptions attempted to briefly describe: (1) monitoring design, and (2) organizational structure necessary for implementing a large-scale monitoring effort.

Alternative 1: No Coordinated Surveys by Subpopulation

In this alternative, there would not be any additional coordinated monitoring in the next five years at the scale of a given subpopulation. The Service would continue to receive updated cormorant data from states, tribes, and provinces when and where possible and the Service would continue to derive subpopulation estimates from multiple different sampling designs without any measures of uncertainty. This approach does not have a coordinating body outside of the Service, nor would there be a centralized data management system. When the Service assesses cormorant abundance every five years, the Service must take steps to locate and obtain any available data from individual biologists from all 48 states, 8 provinces, and participating tribes. The Pacific Flyway is the exception, as they conduct an annual dual frame survey for cormorants (at least through 2023). The Mississippi Flyway would continue implementing a decadal survey of all colonially nesting waterbirds.

Figure 5*- Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 1 – No Coordinated Surveys.*

Strengths

- Some data will continue to be collected and inform state decision making
- Budgets exist where surveys are regularly planned
- Some planned surveys already include additional waterbird species
- Some planned surveys already provide critical regional information on colonies, which continue to be valuable to stakeholders

Weaknesses

- Inconsistent and unpredictable application of methods do not inform objectives identified by cross flyway team.
- Survey strategy has little to no statistical power and does not allow the Service to detect changes to the populations over time unless they are precipitous.
- PTL model will provide inconsistent results due to inconsistent inputs.
- Lack of coordination creates information gaps about distribution and population dynamics of cormorants.
- Ineffeciencies getting data to the Service make it difficult to update the PTL model.
- A lack of coordination may result in lost data, unreliable data, inadequate data sharing, and ineffective communication among partners.

Opportunities

- Planned surveys could expand to include other species (SGCN/BMC) in survey
- Planned surveys may identify a colony of signficiant interest by a state that monitors the site on a regular frequency

Threats

- Stochastic events such as a pandemic, budgets, and staff capacity impact ability to survey at a reliable frequency
- Delays in obtaining cormorant data creates unreliability and could even alienate states and tribes from participating if they don’t feel they have a way to contribute to decision making.

Alternative 2: Combination of eBird/BBS/CBC Abundance Data

This alternative relies on the possibility of integrating existing data collected annually via the Breeding Bird Survey (BBS) with eBird abundance data to get a breeding population estimate and using Christmas Bird Count data to estimate the wintering population. The difference between these estimates may provide insight into how many birds might be nesting in Canadian provinces that are not adequately surveyed. This alternative does not incorporate a specific sampling design but draws from modelling techniques that are being developed that may potentially be able to provide estimates of relative abundance when no other data sources are available. This has been done successfully for other birds when count data exist, but power would likely be lower for island-nesting species because of the limitations of available information in these remote locations. We assume the sampling metric for this alternative would consist of individual birds (as opposed to nests). This alternative does not require a coordinator but would require the Service to enter into a contract agreement with the Cornell Lab of Ornithology to perform data analysis and modeling. Further, eBird and BBS utilize standardized databases. There are also standardized protocols for the nationwide BBS, which contributes to meeting the objective of using standardized data collection methods.

***Figure 6**- Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 2 – Combination of eBird/BBS/CBC Abundance Data.*

Strengths

- Efficient use of data that is already being collected; no need for coordination, survey design, or a new data management system
- Estimates may be more precise because multiple data sources are integrated
- Uses standardized methods for obtaining data
- Has potential to provide more information about annual trends when surveys are conducted less frequently

Weaknesses

- This method is untested across a broad geographic range; preliminary comparison with Pacific dual-frame suggests it captures trends well but significantly underestimates abundance, when BBS and eBird used alone
- Data mismatches or violations of model assumptions can lead to biased estimates
- Current analysis relies on N-mixture models, which simulation studies have shown can be especially sensitive to assumption violations
- Analyses based on opportunistic sightings, such as eBird, may be less accurate than those from a designed survey.

Opportunities

- If other surveys aren't conducted because of stochastic events, this alternative may be an adequate fallback
- In addition to integration in data analysis, eBird and other surveys could assist a dual-frame by alerting survey designers about new or growing colonies of cormorants.

Threats

- Unsure whether Cornell would have the capacity for this type of coordinated analytical effort.

Alternative 3: Probabilistic Survey that Captures X% of a Breeding Subpopulation every 'X' Years

The sampling design would likely involve counting nests via aerial transects with ground counts at a subset of sites. The Service would facilitate a power analysis to determine the number of samples and desired precision of estimates. Stratification of sampling within a subpopulation (e.g., more sampling in states with greater historical abundance of cormorants) could reduce required effort. For the purposes of this report, we assumed that the frequency of applying the strategy described in this alternative would be at least every five years, but this would be informed by a power analysis in the future. Depending on design, this strategy could reduce bias related to detection probability of colonies. The primary target of this survey would be cormorants, but other co-nesting birds at these locations or along transects could be counted as well. This survey would occur within the peak nesting period. This alternative would require a coordinating body to assist with survey design, decision making regarding shared protocols with other states in the flyway, coordination of survey implementation, and data management and analysis over time. The Service would facilitate coordination through a working group within each flyway.

Figure 7*- Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 3 - Probabilistic Survey that Captures X% of a Breeding Subpopulation every 'X' Years.*

Strengths	•Results are unbiased and defensible (assuming proper design) •Due to repeatable element, results in subsequent years are comparable •Stratification of design simple •Quantifying uncertainy in estimates straightforward •Analysis should be straightforward •Easily ties into existing PTL model
Weaknesses	•Design and prescision relative to effort may not be as efficient as dual frame unless there is integration of additional available data •Methodology may be expensive to implement relative to some options •Incorporating probability of sample selection of (eg) colonies does not eleviate need for estimate of detection probability at colony level, or even detection of colonies
Opportunities	•Could be incoroporated with other waterbird surveys that are probabilistic •Establish a framework for coordinated monitoring of other priority species
Threats	•Stochastic events such as a pandemic, budgets, and staff capacity impact ability to survey at a reliable frequency or precision.

Alternative 4: Survey including only Colonies > 'X' Pairs every 'X' Years

For this alternative, we assumed that ground surveys of all large breeding colonies would be conducted every one to three years. Surveys would count nests at some point during the breeding period presumably during peak nesting. This survey would require consensus across a flyway(s) around what is considered a “large” colony to achieve consistency in the approach. A power analysis would help to identify how frequently a survey like this would need to occur to obtain the desired precision of abundance estimates. This survey would be coordinated entirely by the Service, including survey design, data management, and data analysis.

Figure 8- *Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 4 – Survey of Colonies >'X' Pairs every 'X' Years.*

Strengths

- Inexpensive relativel to probabilistic sampling designs
- Will provide a minimum estimate useable for the PTL

Weaknesses

- Abundance estimate from large colonies only may be low relative to total population
- Uncertainty whether counts from only large colonies can be extrapolated to whole population
- No estimate of uncertainty from sampling design which would likely result in automatic reduction of PTL
- May require pre-survey ground or aerial reconnaissance to identify colonies that fit the criteria of "large"

Opportunities

- May be a less expensive approach for providing a minimal level of abudance if pre-surveys are not too onerous
- If rules can be developed for what is considered "large," this could easily be expanded into a dual frame approach in the future
- Establish a framework for coordinated monitoring of other priority species

Threats

- Probably not repeatable; large colonies in year "X" may not be large colonies in year "Y" due to colony chages for unknown reasons (thus sampling frame can't be well understood)

Alternative 5: Probabilistic Survey that Captures X% of Breeding and Wintering Subpopulation every 'X' Years

This survey is like the probabilistic survey described above but also includes a survey of the wintering population every three years. This survey would employ a combination of aerial and ground surveys of nesting colonies from late May to late June that counts nests. The winter survey would be equivalent to the mid-winter waterfowl survey targeting reservoirs, rivers, and coastlines in late December/early January. A designed survey of this type should provide strong statistical power if bias can be accounted for in the survey methods. Similarly, this survey alternative would require coordination. The Service would continue to staff a national coordinator that acts as a liaison among flyways. Flyways could also designate a subpopulation coordinator, and state coordinators could work with the flyways to ensure standardized protocols are in place for all the states surveying a subpopulation.

Figure 9- *Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 5 - Probabilistic Survey that Captures X% of Breeding and Wintering Subpopulation every 'X' Years.*

Strengths	•Comprehensive approach, as it would include a more complete survey of an entire subpopulation •Increased ability to estimate population size with some estimate of error •Results much less biased and therefore more defensible (assuming proper design) •Due to repeatable element, results in subsequent years are comparable
Weaknesses	•Methodology may be expensive to implement relative to some options •Winter counts typically do not represent entire subpopulations
Opportunities	•Winter counts may reveal differences in subpopulation trends in areas outside primary breeding range- this may help with regional and localized conflict assessments
Threats	•Stochastic events such as a pandemic, budgets, and staff capacity impact ability to survey at a reliable frequency or precision.

Alternative 6: Maximize Coverage of Birds of Conservation Concern or of Management Concern

This monitoring alternative would be implemented every three to five years and would focus on surveying cormorant colonies that co-nest with other species of concern such as gulls or Species of Greatest Conservation Need (SGCN). The sampling design would be flexible to account for state-by-state logistical constraints and species-by-species constraints (e.g. differences in habitat). The sampling metric would consist of nest counts of all species. Timing would occur during peak incubation of cormorant eggs. Allowing design flexibility among states will result in more assumptions, but this would likely vary given state and site limitations. This survey type would need to include both a Service coordinator and state coordination through the flyway non-game technical committees. Protocols, such as timing, would need to be standardized as much as possible.

Figure 10- *Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 6 - Maximize Coverage of Birds of Conservation Concern or of Management Concern.*

Strengths	•Potential to piggyback DCCO surveys on existing surveys for other species •Maximize data outcomes for a larger suite of colonial waterbirds from limited survey efforts •Maximize effeciency (benefit/unit cost)
Weaknesses	•Highly likely to produce biased estimates of cormorant abundance • Can not track growing or moving cormorant-only colonies nor detect popualtion changes through time • Survey timing during peak cormorant nesting may not align with peak nesting of other co-nesting species of interest •Differences in priority species throughout flyways will result in large gaps where cormorant information is not collected. This would result in the 'No Coordinated Survey' outlined above •More time intensive to conduct the surveys, count nests, etc., for multiple species
Opportunities	•Higher liklihood of survey repeatability and longevity because states may already have established surveys for high priority colonial species
Threats	•Surveys may not be consistent over time •Differing state SGCN lists will reduce options to obtain regional estimates of population status (if some states elect not to survey the other species). •Stochastic events such as a pandemic, budgets, and staff capacity impact ability to survey at a reliable frequency or precision. •In the absence of a coordinated approach to monitoring, there is less accountability, possibly delays in obtaining data, and poor communication and less inclusion in decision

Alternative 7: Survey only Large Breeding Colonies associated with Conflict

This sampling design would target only the cormorant colonies that are causing conflict, either with fisheries or other natural resources. This survey would not occur on a set frequency, but instead would be conducted as needed relative to conflict during the breeding season. To provide information about how to manage these colonies and to inform the PTL, the sampling metric would include active nests. This survey would likely require significant coordination and information flow between the states and the Service to identify conflict colonies and data management protocols.

Figure 11- *Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 7 - Census of Only Large Colonies associated with Conflict.*

Strengths

- Allows the ability to track large cormornat colonies causing conflict
- Identification of areas with conflict that could benefit from management
- Large colonies easy to find and count via complete census or subsampling

Weaknesses

- Results would not represent population abundance nor adequately inform the PTL model
- Results would not account for movement of colonies and how they are associated with conflict
- Difficult to determine and agree upon standards describing level of conflict attributed to a colony and what is considered "large"
- Inability to address conflict occurring from smaller colonies.
- Survey repeatability (future budget & capacity changes) would be questionable due to colony movement related to management actions (i.e. colonies difficult to track and susceptible to double counting)
- Some states may not have large colonies causing conflict and would not be counted.

Opportunities

- Cost may be lower where states or tribes know the location of large colonies
- This type of monitoring could be combined within another type of sampling effort to document SGCN when the conflict is related to disturbance of these species.
- May require less coordination than other survey strategies
- Surveys may tie into other efforts tracking the affect of take on colonies of other species

Threats

- Stochastic events such as a pandemic, budgets, and staff capacity impact ability to survey at a reliable frequency or precision.

Alternative 8: Dual Frame Survey

This survey design is currently employed by the Pacific Flyway. The sampling design would be stratified by colony size, with smaller colonies being randomly selected for survey within the second sampling frame. We assumed this survey would be conducted every three years during peak breeding season which varies latitudinally. This design is preferred by statisticians because of the efficiency of dividing sampling units (i.e., cormorant breeding colonies) into two frames by size, with the larger colonies always being counted when the survey is conducted. Further, this provides the best estimate of uncertainty of any design. This survey effort would require a standardized protocol throughout the breeding area of any subpopulation where it would be implemented and significant coordination on the part of each nongame technical committee. Service biologists, in partnership with state biologists, would be responsible for survey design and the Service would provide data analysis following data collection.

Figure 12- *Identified Strengths, Weaknesses, Opportunities, and Threats associated with Alternative 8 - Dual Frame Survey.*

Strengths

- Method does not rely on surveying every DCCO colony in a state or subpopulation
- Increased ability to detect population changes through time
- Monitoring is performed during a single field season increasing data confidence (surveying over multiple years can be problematic if colonies are moving or changing)
- Always surveying the largest colonies and subsampling the smaller colonies provides a minimum population estimate.
- Results are less biased and therefore more defensible (assuming proper design)
- Protocols already exist in AKN for this survey type thereby minimizing start up costs associated with data management.

Weaknesses

- Methodology may be expensive to implement, especially for sites that need to be flown
- Increased coordination is necessary; finding cooperators, seeking funding, contracting and budgeting across many partners will be a challenge

Opportunities

- Resources and project ownership are shared, which enhances coordination; work across many partners reduces the work on any one agency

Threats

- External influences to funding, capacity, partners, or lack of coordination may yield poor results

Consequences and Tradeoffs of Alternative Monitoring Strategies

The next step in any decision analysis is to understand the consequences or tradeoffs of different alternatives. Another way to think about this is that we want to understand how well each potential alternative, or monitoring strategy, meets the objectives.

Making decisions based on multiple objectives can be difficult because often the comparison is “apples to oranges.” This becomes more challenging when multiple parties are involved that have differing values or preferences for the objectives. These situations require a structured process that enables the group to compare “apples to apples.” There are different strategies for turning a multiple-objective problem into a single-objective problem, but the one chosen for this effort was the SMART (Simple Multi-Attribute Rating Technique) method. In general, this method allows users to normalize the scores of each objective, assign weights based on individual values of each objective, and then calculate a weighted sum of scores for each alternative (Table 11). Typically, the alternative with the highest weighted score is recommended since it performs the best across all the objectives identified as having high value.

Often, in an SDM process, participants can score objectives based on real information they have about alternatives (e.g., cost). When information is lacking, modelling techniques can be used to generate representative information. Given the short time available, it was unrealistic, and unnecessary, to use time-intensive methods to get precise measurements for objectives. Instead, utility scores were used and were elicited from each team member based on their biological expertise (Table 11). Cross-flyway team members scored each alternative, on a scale of 1-10, based on how well it met an objective. To reduce uncertainty, the utility values were averaged across all team members, which moderated the range of opinions. Once the utility scores were averaged for each objective, normalized objective scores were summed to assess each alternative across different objectives (Table 11).

Next, objective weights were determined. Weights represent the relative value that a decision maker places on different objectives and they were elicited from each individual participating in the process. Weight values were elicited from each cross-flyway team member using swing weighting.

The preference for an objective often depends upon the values available to us (i.e., the actual alternatives). For example, a stakeholder may highly value an accurate abundance estimate; if you have an alternative that does a great job estimating abundance, that stakeholder may rank that objective high. However, if all the identified alternatives are prohibitively expensive to meet that objective, the decision maker may decide that high accuracy is less important than some other value or objective. In other words, preferences among objectives are context specific – not just the abstract importance of an objective. They represent real constraints that may exist for a decision maker.

Swing weighting uses the "swing" or range from the worst to best consequence to help elicit these context-specific preferences (Wilson and Arvai 2011). Specifically, the process uses a series of steps to help the decision maker first rank the decision criteria associated with objectives and then consider the relative importance of each decision criterion as compared to the one immediately preceding it in the overall rankings. The user is asked to pick one objective that they think would result in the largest beneficial change. That criterion is ranked highest. The process continues, choosing sequentially, resulting in a complete ranking of the criteria.

***Table 11**- Average objective utility scores and weighted sums as determined by the cross-flyway team. Utility scores identify how each monitoring alternative meets the Service objective of informing the PTL and state objectives for cormorant management and monitoring. Weighted sums were calculated by summing utility scores and multiplying by the average swing weights for each flyway and the Service. Dark blue indicates the highest scored alternatives; red indicates alternatives with lower scores;).*

	AVERAGE UTILITY SCORES												WEIGHTED SUMS				
ALTERNATIVES	Maximize power to detect population change (1-10)	Maximize accuracy of subpopulation abundance estimate (1-10)	Maximize detection of movement of new/growing breeding colonies (1-10)	Maximize statistical rigor (uncertainty included) (1-10)	Maximize population information at multiple scales (1-10)	Maximize survey plan longevity/commitment (Y/N OR 1/0)	Maximize number BCC/BMC included in survey (1-10)	Maximize survey repeatability; resiliency (Y/N OR 1/0)	Maximize secure & accessible data management (Y/N OR 1/0)	Maximize survey standardization across partners (1-10)	Maximize efficiency (benefit per unit cost)(1-10)	Minimize cost (1-10)	FWS	Atlantic Flyway	Mississippi Flyway	Central Flyway	Pacific Flyway
Alternative 1: No Coordinated Surveys	2	2	2	1	3	5	3	4	0	0	4	7	2.454	2.787	2.465	2.707	2.568
Alternative 2: Combination of eBird/BBS/CBC Data	6	5	6	4	5	8	7	7	1	1	8	9	5.300	5.508	5.462	5.469	5.299
Alternative 3: Probabilistic Survey Capturing X% of a Breeding Subpopulation every 'X' Years	8	8	7	8	7	6	4	6	1	1	6	5	5.900	5.351	6.125	5.864	5.559
Alternative 4: Survey including only Colonies > 'X' Pairs every 'X' Years	6	6	5	6	5	6	4	6	1	1	6	5	4.858	4.652	4.972	4.935	4.702
Alternative 5: Probabilistic Survey Capturing X% of Breeding and Wintering Subpopulation every 'X' Years	8	8	7	8	8	5	4	6	1	1	6	3	5.816	5.141	6.116	5.736	5.391
Alternative 6: Maximize Coverage of Birds of Conservation Concern or of Management Concern	6	5	5	5	5	6	9	6	1	1	6	5	4.856	4.765	5.152	4.887	4.697
Alternative 7: Census of Only Large Colonies causing Conflict	4	4	3	4	4	7	5	6	1	1	6	6	4.063	4.268	4.097	4.302	4.099
Alternative 8: Dual Frame Survey	9	9	8	9	8	6	3	7	1	1	7	4	6.470	5.763	6.721	6.409	6.038

Results of Structured Decision-Making Process

Objectives

The top objectives for the Service were those that provided information necessary to inform the PTL and contributed to increasing our understanding of each subpopulation (Table 12).

Among the flyways, there was a lot of variability around which objectives were rated highest. However, there was some alignment between the Mississippi, Central, and Pacific Flyways in that they all selected the ability to detect population change, estimate abundance, and statistical rigor as top-rated objectives (Table 12). Survey standardization, survey longevity, and maximizing efficiency (i.e., getting the most bang for your buck) were rated as the most important criteria by the Atlantic Flyway representatives.

There was also some agreement among flyways around the lowest rated objectives (Table 12). For instance, three out of four flyways, as well as the Service, indicated that including SGCN in the survey was not important compared to other objectives. This was an unexpected result, especially for the Atlantic Flyway because this objective was initially considered to be one of the most important criteria to their coordinated effort. Other objectives that ranked low included: detecting new or expanding colonies, secure and accessible data management, and survey longevity. Minimizing cost was generally rated moderate to low across all the flyways (Table 12).

Table 12: *Average weights applied to each objective for the Service and each flyway as determined by the cross-flyway team members during the swing weighting exercise. Green represents the highest weighted objectives, red represents the lowest weighted objectives, and yellow to orange are objectives were weighted moderately. Swing weights across all objectives (i.e., values in the columns) sum to 100.*

	Flyways				
Objectives	FWS	AF	MF	CF	PF
Maximize power to detect population change	12.82	6.07	13.91	12.58	10.81
Maximize accuracy of abundance estimates	12.8	5.97	13.08	7.95	10.28
Maximize detection of movement of new/growing breeding colonies	7.30	6.99	10.42	3.04	4.14
Maximize statistical rigor (uncertainty included)	10.54	8.88	8.84	12.13	10.94
Maximize population information at multiple scales to inform management decisions	8.63	7.05	11.39	10.74	6.68
Maximize survey plan longevity	5.65	10.43	4.47	8.18	5.69
Maximize number SGCN/BMC included in survey	4.63	5.24	7.98	3.06	4.14
Maximize survey resiliency	7.76	10.02	6.66	11.33	7.79
Maximize secure & accessible data management	7.62	9.78	3.87	3.66	9.71
Maximize survey standardization across partners	9.04	10.51	8.35	12.13	10.65
Maximize efficiency (benefit per unit cost)	7.51	10.22	7.14	7.51	10.26
Minimize cost	5.70	8.83	3.88	7.67	8.89

Alternatives

Despite the variability in relative importance of the objectives among the Service and the flyways, there was a considerable amount of overlap among the top alternatives once the utility scores for each objective were summed and multiplied by the objective weights. For example, there was complete agreement on both the best alternative (Dual Frame Survey Design) and the worst alternative (Status Quo) and a great deal of consistency between the other top three ranked alternatives. For all the flyways except the Atlantic, the second-best alternative was the probabilistic survey design of the breeding population (Table 13), the third-best alternative was a probabilistic survey design of both the breeding and wintering populations, and the use of existing bird data, such as BBS and eBird, ranked 4th.

These results were anticipated given that probabilistic survey designs are statistically robust and as such and perform well meeting the identified objectives. Additionally, the difference in swing weights among objectives was relatively small, an indication that the decision makers (i.e., the cross-flyway team members) had a hard time differentiating which objectives were most important (i.e., they were all important). The small difference in weights among the objectives essentially rendered the weights unimportant to the overall outcome. It's possible that with more refinement of the objectives and a more diverse pool of flyway participants, the swing weights could be much more influential in determining alternative outcomes in future exercises.

Table 13- *Alternatives ranked by their weighted sum for the Service and for each of the four flyways.*

ALTERNATIVES	Flyways				
	FWS	AF	MF	CF	PF
Dual Frame survey (Alternative 8)	1	1	1	1	1
Probabilistic Survey that Captures X% of a Breeding Subpopulation every 'X' Years (Alternative 3)	2	3	2	2	2
Probabilistic Survey that Captures X% of Breeding and Wintering Subpopulation every 'X' Years (Alternative 5)	3	4	3	3	3
Combination of eBird/BBS/CBC Data (Alternative 2)	4	2	4	4	4
Maximize Coverage of Birds of Conservation Concern or of Management Concern (Alternative 6)	6	5	5	6	6
Survey including only Colonies >'X' Pairs every 'X' Years (Alternative 4)	5	6	6	5	5
Census of Only Large Colonies causing Conflict (Alternative 7)	7	7	7	7	7
No Coordinated Surveys (Alternative 1)	8	8	8	8	8

Recommendations for Flyways, Service, and Partners

Outside of the Pacific Flyway, at the time of this report, no large-scale, long-term, coordinated monitoring approach across all four flyways and cormorant subpopulations has occurred. Outside of the Pacific Flyway, management of this species has relied on a patchwork of population information to inform our models and management actions. While the Service and cross-flyway team acknowledge we have always used the best scientific information available, we recognize the need for a more comprehensive approach to obtaining population information is necessary to manage cormorants and any associated conflicts in a responsible way. However, budgetary constraints and uncertainty, the complexity of varying roles of the decision-makers for use of annual budgets, and the varying management objectives for each partner, state, province, flyway, and the Service, do not all align in a manner that has yet allowed for such a coordinated monitoring approach.

To account for this complexity, the cross-flyway team relied on the SDM framework to begin to identify shared and differing values, objectives, and alternative methods for monitoring cormorants. Nevertheless, SDM is an iterative process; objectives, alternatives, and sometimes even the problem, can change as the discussion evolves. What has been documented in this report should be considered a rapid prototype. While the cross-flyway team made significant progress towards characterizing important considerations related to the implementation of a large-scale monitoring program, **this prototype will require continued refinement over the next year from a broader group of budgetary decision makers, and divisions of state and provincial fish and wildlife agencies within each flyway.**

Objective Recommendations

The first attempt at defining utility scores for each alternative was difficult because some objectives were inadequately defined. Survey longevity and survey resilience, for example, were two objectives that caused confusion. Longevity was meant to represent the feasibility of states being able to make a long-term commitment, and resilience was indicative of how flexible the survey design might be to lack of data due to loss of capacity, or a natural disaster such as a pandemic. However, one can imagine a survey not being very resilient if states are unable to make a long-term funding and capacity commitment from the outset. While these objectives were meant to be different, they were not mutually exclusive, creating uncertainty and room for misinterpretation among different individuals conducting scoring. There were other objectives that were also not mutually exclusive. For instance, accurate abundance estimates or detection of population change, require a survey with statistical rigor and standardized survey protocols. The intertwined nature of these objectives makes them impossible to consider as stand-alone criteria. As a next step, we recommend better defining each objective to ensure independence. Independence among objectives will make the consequences easier to define, and the tradeoffs of the various alternatives easier to understand.

The goal of most methods used to make decisions based on multiple objectives is to ultimately simplify the problem if possible. Simplifying the problem is typically achieved by reducing the number of objectives by either combining them or by turning some of them into constraints. In this rapid prototype, it was important to the team to include all the objectives considered so this information could be communicated back to the flyways in a transparent manner. However, the objectives in the consequences table can be simplified and we recommend this as a next step in the refinement process. Specific recommendations include:

- Consider combining survey longevity and survey resiliency. While the cross-flyway team thought these were important considerations, there was too much variability in how these objectives were perceived, making them difficult to score. A better definition of these objectives may allow them to be combined into a single objective, thereby simplifying the problem.
- Survey standardization and secure and accessible data management were objectives that did not serve to differentiate among alternatives (i.e., they had the same score for each objective) and they should be eliminated. Eliminating these objectives doesn't mean they aren't important, only that they don't help establish which alternative is best. These objectives could be converted into expectations necessary for any large-scale monitoring design.

Alternative Recommendations

Despite the continued need to refine the rapid prototype moving forward, one of the benefits of having gone through this process is that it helped identify shortfalls of some potential monitoring strategies that were considered, especially the 'No Coordinated Survey' alternative. It allowed us to show, in a transparent manner, how these alternatives simply don't meet the needs identified by the Service and states. Additionally, this process has characterized a short-list of alternatives for state consideration moving forward. **Whether these objectives and alternatives are reflective of what flyways desire from a coordinated cormorant survey remains to be seen, but we anticipate that the groundwork laid by this rapid prototype process will make it substantially easier to develop the right monitoring approach for each flyway.** Again, SDM is an iterative process with each iteration bringing participants closer to making a decision that can be realistically implemented.

While not a requirement, because there was significant alignment around the top four alternatives, it could be possible to take a unified approach to monitoring across all four flyways. Benefits of a unified approach include the simplicity of designing a single survey instead of different surveys for each flyway, the potential for leveraged funding among states, and other opportunities for efficiency that arise from standardization across regions.

Most team members were surprised that the Dual Frame approach was the top contending alternative. As this process continues to evolve, this alternative may become less attractive, especially once the cost of each alternative is better articulated. However, one of the benefits of the dual frame approach is that there are design flexibilities that could potentially reduce the overall costs to each state while at the same time increasing survey utility. Nevertheless, there are other types of probabilistic designs besides the dual frame - some that were considered in this process and ranked highly - that could also be feasible and should be thoroughly considered in the next steps.

As a next step, the team expects that a power analysis will be conducted as a means of evaluating the various monitoring alternatives. This analysis will define the number of survey sites required in each state for varying precision estimates, it will highlight the tradeoffs of monitoring at different frequencies and will serve to inform decision-making at all levels.

Additional Considerations

Given the complexity of designing a coordinated and repeatable long-term survey that is compatible with the needs and priorities of flyway states, this report is just the start of this process. Emerging from the cross-flyway team are the following additional important considerations:

1. While this survey effort should focus on monitoring cormorants, this species regularly co-nests with other colonial waterbirds, many of management or conservation concern (e.g., Ring-billed Gull, Herring Gull, American White Pelican, Brown Pelican, Caspian Tern, Common Tern). Although targeting Birds of Conservation or Management Concern was not identified as an important survey objective, this is not congruent with past conversations, and we think that not accounting for other species when they co-occur in surveyed cormorant colonies would be a missed opportunity for states and the Service alike. In fact, across all four flyways, 90% of states and provinces reported that other colonial waterbirds besides cormorants are considered a management priority at least to some extent. While some these waterbird species, like herons and egrets, can have very large populations outside of large water bodies; and the degree of commonality of these species can be quite variable among states, counting these species, when they occur, could allow a coarse population index to be developed, and may reveal how cormorants affect the abundance of other species of concern. However, for a more unbiased approach to monitoring other species of concern, state partners would need to develop more targeted surveys to answer those questions.
2. Any selected strategy should include the identification of a governance structure (i.e., the system or process by which decisions about the survey will be made, the mechanisms by which the survey will be implemented, and the procedures to hold people accountable). Potential governance structures could include: (1) flyway nongame technical committees with support and coordination from the Service; (2) a cross-flyway coordination team; (3) regional coordination by Service personnel within each flyway; or even (4) a national cormorant coordinator. Governance actions will likely include decisions about how the survey will get funded and sustained; coordination of protocol development, survey planning, and survey implementation; data management and data analysis; and general communication among state and federal agencies as well as the public.
3. Data management needs to be a consideration throughout and will require dedicated capacity and resources. There is at least one national database (Avian Knowledge Network or AKN) that could be used for this purpose. The Atlantic, Mississippi and Pacific Flyways have already uploaded a considerable amount of historical and recent colonial waterbird data into the AKN and efforts are underway to create a warehouse and tools that would allow for analysis and visualization of these data across multiple spatial scales.
4. As laid out in this report, there is a need to consider how this effort aligns with other planned and ongoing survey efforts for colonial waterbirds across the country. Cormorants are not distributed equally across the country nor is the conflict; therefore, data requirements to inform the PTL are also not equitable across the country. States with large cormorant populations will have an outsized effect on a subpopulation estimate and therefore, these states may require a more intense focus than other locations in the flyway. The way in which other states within the flyway with smaller breeding populations can contribute and support monitoring efforts is a conversation that needs to happen within each nongame technical committee of individual flyways and will depend on the preferred strategy selected for implementation and how the cormorant sites are distributed.
5. An important outcome of the questionnaires was the revelation of who implements and funds cormorant management activities in a state or province. The Service shares the need to determine funding opportunities, costs, and constraints. At this time, the Service, like many states and tribes, does not have funds for cormorant monitoring and has a limited budget for nongame bird management that is directed largely toward declining and at-risk species. The

Service anticipates more coordination with other programs with activities that intersect with cormorant-conflict management, such as Refuges and Fisheries and Aquatic Conservation. States vary widely in their levels of personnel and financial resources but face similar constraints to the Service. Almost 40% of questionnaire respondents indicated that fishery-related programs (e.g., state hatcheries and recreational fisheries divisions) typically carry out the management of cormorants. In many cases, fishery-related agencies conduct the nonlethal management and USDA Wildlife Services conducts lethal removal where authorized. Funding sources for this management stem from these same divisions as well as sport fish restoration programs, license funding, and funding for parks. **Including fishery-related programs and stakeholders in future discussions about how to fund a coordinated monitoring approach so they can continue to benefit from existing cormorant management tools will be necessary and should yield a more comprehensive benefit to all stakeholders.** The cross-flyway team suggests that the states should take the lead to explore such funding strategies within their individual agencies.

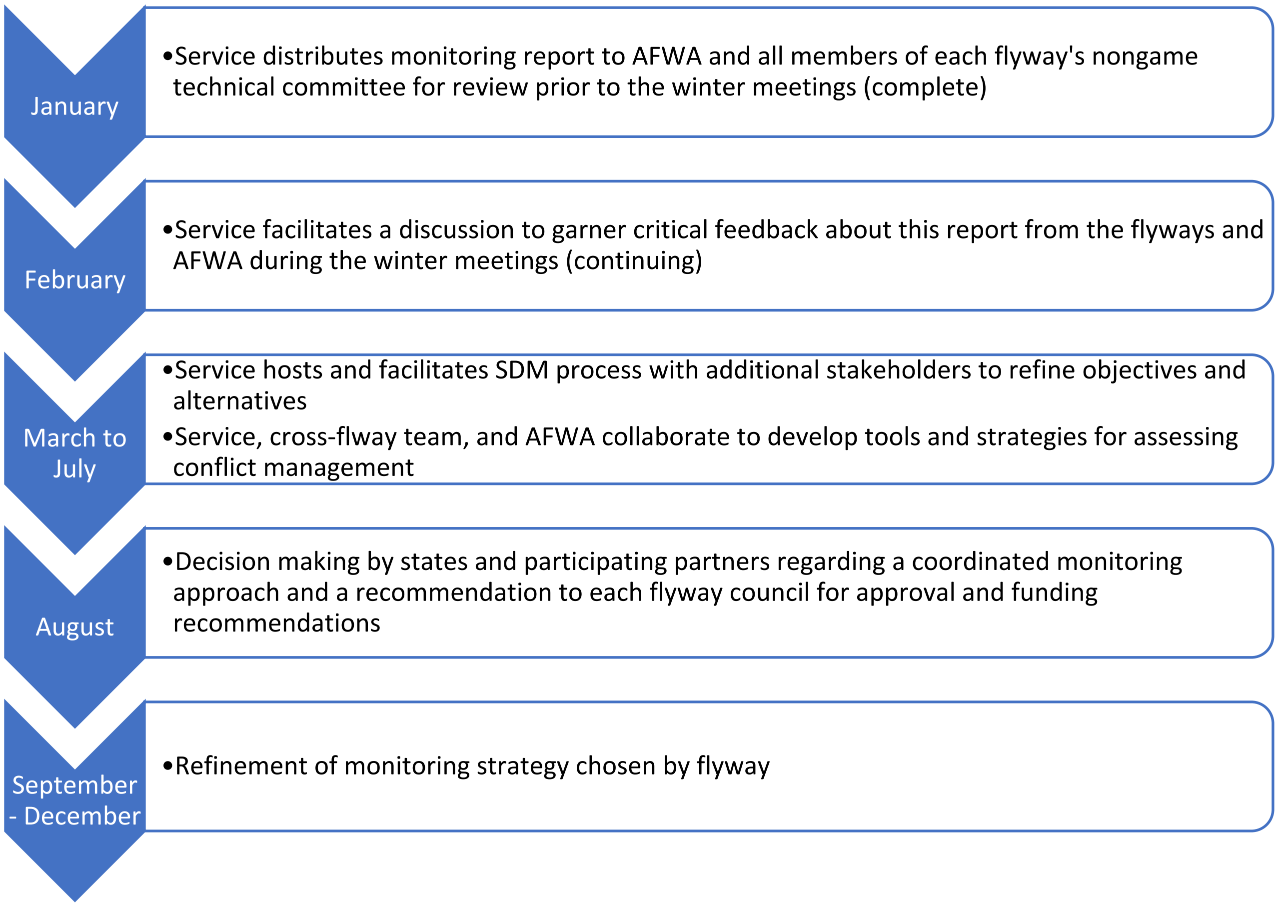
6. One of the greatest barriers to survey participation by the Service, states, provinces and tribes will likely be a lack of capacity and funding. As outlined above, a power analysis will identify how many sites need to be surveyed and how often. This analysis will help delineate the costs of various survey methods and will be integral to selecting a feasible approach that will meet the needs of the Service for informing the PTL while considering the resources that states can bring to the table. This step will be essential to determining how the Service and states can work together to identify financial opportunities to aid in survey completion, including working with other regional and national Service programs such as Fisheries, Refuges, and Migratory Birds.
7. Regardless of the monitoring design selected in the future, the team expects that a power analysis will be conducted as a next step. This analysis will define the number of survey sites that might be required in each state and will highlight the tradeoffs of monitoring at different frequencies. Sites that are identified on Service-owned lands will be the responsibility of the Service.
8. This effort of working together with the Service to further refine a coordinated cormorant monitoring strategy may provide unanticipated benefits for states and flyways. This collaborative process could provide the building blocks necessary to support other work that has been identified as important to various nongame technical committees such as: coordinated monitoring for other species of concern (i.e., this monitoring could happen alongside cormorant monitoring and the Service could provide the technical resources to help plan and implement these additional surveys); data management protocols related to the Avian Knowledge Network (e.g., formalizing a process for entering and using data stored in this database to answer flyway-wide questions); and priorities identified by single-species working groups (e.g., Reddish Egret Working Group or Black Skimmer Working Group) that might benefit from a more coordinated regional approach.
9. Another important consideration that cannot be overlooked is the importance of continuing discussions with the Canadian Wildlife Service and specific Canadian provinces to collaborate on how the Service can get better estimates of cormorants breeding outside of the United States. Although most provinces do not manage cormorants, lethal take occurring in the United States can directly affect the population in both countries. Given that as much as 60% of the population breeds in Canada, it is essential to find a way to include that information into our PTL model to ensure we are not allowing more take than the population can sustain. The Service is committed to facilitating future conversations with Canadian Wildlife Service and specific Canadian provinces.

10. Finally, the cross-flyway team strongly recommends that the Service refill the vacated Waterbird Coordinator position to assist with addressing national waterbird-associated issues like cormorants. Until this action is taken, the cross-flyway team posits that approaches to these issues will be reactionary, litigative, and hasty in response. While the Service is aware of continued national coordination needs constrained budgets will not permit this position to be filled at this time. However, the Service will continue to support this coordinated monitoring effort with existing staff at the national and regional scale and will further assess the need for a designated coordinator as the monitoring process continues.

Roadmap for Next Steps

Implementing a coordinated approach for monitoring cormorants will require continued collaboration between the flyways, the Service, USDA Wildlife Services, states, tribes, and Canadian provinces. This report serves as a basis and framework for those discussions. In addition, because future decisions regarding changes in management, including possible changes to the PTL, stem in part from population monitoring, efforts to assess the state of the conflict should be expanded to include stakeholders in fisheries management. Below, we offer a roadmap of actions and considerations for calendar years 2022-2026 for stakeholders to follow.

Figure 13- *Recommended actions necessary for flyways, the Service, and partners to select a monitoring strategy in 2022.*



The Service aims for the focus of calendar year 2022 to be on fostering dialog with conservation partners and each flyway and refining the monitoring objectives and alternatives identified in this report to reach decisions on coordinated monitoring approaches (Figure 13). The Service would also like to actively work with the Association of Fish and Wildlife Agencies (AFWA) to determine strategies for assessing conflict management. The Service envisions expanding the cross-flyway team to include additional partners, including tribes, Canadian provinces, additional states, and members of the Bird-Fish Conflict Working Group within AFWA.

In January 2022, the Service and the cross-flyway team distributed this monitoring recommendation report to all members of all four flyway nongame technical committees for review prior to the winter meetings. During the winter meetings planned for flyways, the Service presented key recommendations from this report and facilitate a discussion to garner critical feedback. The Service will continue to request specific feedback from the flyways that will help inform how this report will be used within each flyway. **The Service recognizes that while the current cross-flyway team conducted much of the technical pre-work to inform this report, this team doesn't adequately represent all partners necessary for a coordinated monitoring effort.** Therefore, the Service will ask each flyway for commitment to engage in a more inclusive and formalized approach towards selecting an appropriate flyway-wide monitoring approach.

Upon reaching commitments from the flyways and partners, the Service envisions additional collaboration and possible inclusion of a second SDM process with additional partners. Continuing into 2022, the Service will take steps to facilitate discussions with a broader team consisting of additional partners, including tribes, Canadian provinces, additional states, and members of AFWA to support selection of a monitoring strategy most appropriate for each flyway. Decision makers for this monitoring strategy will likely vary across flyways, but this report is intended to serve as a foundation for those discussions. The Service may hire a skilled SDM or analytical facilitator to lead these discussions and an in-depth analysis of the top alternatives for monitoring. This will likely require multiple committee meetings or workshops outside of the regularly scheduled flyway meetings. Key considerations for those discussions may include:

- Refinement of monitoring objectives
- Consideration of other probabilistic monitoring alternatives if necessary
- Cost estimates of considered alternatives
- Barriers to implementing alternatives

The Service will also continue to collaborate with the Bird-Fish Conflict Working Group within AFWA to focus on assessing the state of the conflict. Specific actions already identified for development in 2022 include:

- Development of best practices for improving collaboration and communication between wildlife and fisheries staff within and between state agencies;
- Development of a survey instrument to learn how the existing 21.100 and 21.123 permits are meeting stakeholder needs; and
- Identifying and researching possible metrics that stakeholders can use to determine whether conflicts associated with cormorants are increasing, decreasing, or being maintained.

The flyway nongame technical committees will have an opportunity at the summer flyway meetings to continue discussions around monitoring strategy selection, monitoring design considerations, and better understanding barriers to implementation. Once an approach is selected by each flyway, the Service will support a recommendation and assist in coordination regarding any requests for funding. We anticipate all four flyways to have draft recommendations submitted to the councils at the summer meetings in August 2022. **Based on continued coordination within flyways and with conservation partners, we recommend flyway councils work with the Service to review monitoring approaches in this report and funding mechanisms ahead of the August 2022 flyway meetings.** In the remaining months of 2022, the Service, with continued guidance from the cross-flyway team and additional participating partners, will begin creating a survey design based on the monitoring approach selected by each flyway. This will include a power analysis to determine tradeoffs between precision, accuracy, and cost.

Figure 14- *Recommended actions necessary for flyways, the Service, and partners to select and design the chosen monitoring strategy in 2023.*

January to March

Completion of power analysis to assist Flyways, Service, and partners in selecting a final design;

Provide design recommendation to each flyway council

April to August

States and tribes work within their agencies to determine additional funding needs

Additional report out at August 2023 flyway meetings

September to December

Continued discussions and collaboration on data management needs

The focus of calendar year 2023 will likely be on continued refinement of flyway monitoring design, implementation, and data management (Figure 14). The Service will complete a power analysis for each flyway and present this information at the winter flyway meetings. The Service will also recommend flyways select a final design at this time and provide appropriate recommendations for decisions by each flyway council. Following a decision by each council, states and tribes will work within their own agencies to determine possible funding mechanisms and the process for obtaining any additional necessary funding (e.g., grant applications if necessary) to conduct their portion of the flyway monitoring strategy. Ideally, states will report back to the flyway at the summer 2023 meeting to continue coordination discussions around funding, possible barriers that need to be overcome, and other coordination considerations (e.g., protocols and data management). Discussions around data management and implementation of monitoring are likely to continue through 2023. The Service will continue to host those discussions with all participating stakeholders.

Calendar years 2024- 2026 will largely focus on implementation of monitoring, data management, and continued assessment of the state of the conflict. These efforts will lead to the Service's publication of the 5-year comprehensive report.

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