A Monitoring Strategy for the Western Population of American White Pelicans within the Pacific Flyway

Photo: Idaho Department of Fish and Game

Inquiries about this monitoring strategy may be directed to member States of the Pacific Flyway Council or to the Pacific Flyway Representative, U.S. Fish and Wildlife Service, 911 N.E. 11 Avenue, Portland, Oregon 97232. Information regarding the Pacific Flyway Council and management plans can be found on the internet at PacificFlyway.gov.

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Prepared for the

Pacific Flyway Council

by the

Pacific Flyway Nongame Migratory Bird Technical Committee

as directed by the

American White Pelican Subcommittee

March 26, 2013

Approved by:______________________________ ____________May 10, 2013______
Chair, Pacific Flyway Council — Date

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EXECUTIVE SUMMARY

Localized depredation issues within the Pacific Flyway prompted the Pacific Flyway Council to develop a management framework for the American White Pelican (*Pelecanus erythrorhynchos;* herein pelican). In July 2012, *A Framework for the Management of American White Pelican Depredation on Fish Resources in the Pacific Flyway* was approved and adopted by the Pacific Flyway Council (Pacific Flyway Council 2012). The highest priority strategy under the Population Assessment Objective in the Management Framework called for developing and implementing a monitoring strategy for pelicans at the flyway scale to guide and assess management actions.

The goal of the monitoring strategy is to establish a coordinated, long-term monitoring effort to estimate the breeding population size, trend, and distribution of the Western Population of pelicans. This information is fundamental for developing effective management recommendations, and for guiding and assessing management actions pertaining to pelican depredation on fish resources.

The monitoring objective is to have the ability to detect a 5% change/year in the Western Population of pelicans with 80% power ($\beta = 0.20$) and a 10% Type I error rate ($\alpha = 0.10$). All breeding colonies will be monitored (i.e., a census). There are currently 18 active breeding colonies in the Western Population. A power analyses was conducted to identify the most cost effective sampling scheme that achieved the monitoring objective. Monitoring will begin in 2014 and occur every third year thereafter for at least 10 years (i.e., 2014, 2017, 2020, 2023).

Surveys will consist of a combination of existing monitoring efforts, which are funded by other entities, as well as new efforts that will require additional funding. Twelve of the 18 breeding colonies are included in on-going monitoring efforts and thus will not contribute new monitoring costs. Estimated additional cost to implement the monitoring strategy will be $3,000 per monitoring year to conduct a coordinated flight to monitor pelicans at the 6 breeding colonies in the Klamath Basin of Oregon and California.

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BACKGROUND

Localized depredation issues within the Pacific Flyway prompted the Pacific Flyway Council to develop a management framework for the American White Pelican (*Pelecanus erythrorhynchos;* herein pelican). In July 2012, *A Framework for the Management of American White Pelican Depredation on Fish Resources in the Pacific Flyway* (herein Management Framework) was approved and adopted by the Pacific Flyway Council (Pacific Flyway Council 2012). The goal of the Management Framework was to maintain pelicans as a natural part of the waterbird biodiversity of the Pacific Flyway, while minimizing negative ecological, economic, and social impacts of pelican depredation actions. The Management Framework included a synopsis of species' biology and status, and descriptions of resource conflicts, management options, regulatory requirements, and recommended management strategies. The highest priority strategy under the Population Assessment Objective in the Management Framework called for developing and implementing a monitoring strategy for pelicans at the flyway scale to guide and assess management actions.

Currently, no coordinated pelican monitoring strategy exists for the Pacific Flyway. Pelicans have been monitored independently by the U.S. Fish and Wildlife Service (USFWS), State wildlife agencies (States), and other entities as part of various monitoring programs; however, monitoring effort, timing, and techniques have varied.

Scope

Spatial —This monitoring strategy pertains to the Western Population of pelicans, which includes all pelicans known to breed west of the continental divide and the pelicans within the colonies at Molly Islands of Yellowstone National Park, Wyoming and Canyon Ferry Lake and Arod Lake, Montana. Within the Western Population, pelicans breed at 18 colonies within 8 States and British Columbia (Fig. 1, Table 1).

Temporal —Monitoring will begin in 2014 and occur every third year thereafter for at least 10 years (i.e., 2014, 2017, 2020, 2023). However, there likely will be a need to continue monitoring within the Pacific Flyway beyond this timeframe as long as pelican depredation issues require management action. Thus, throughout the duration of the monitoring strategy, the Nongame Technical Committee and Pacific Flyway Council, in consultation with the U.S. Fish and Wildlife Service, will evaluate the monitoring strategy's effectiveness, make modifications as needed, and continue monitoring as necessary.

Extent —The monitoring strategy will provide information about the breeding population status and trend of the Western Population of pelicans. Monitoring of the breeding population is sufficient to track trends, and breeding population information is commonly used to inform management decisions. The strategy does not include a monitoring component for the non-breeding segment of the population. It is cost prohibitive to monitor non-breeders because a substantially greater survey effort is required. Additionally, non-breeders are difficult to distinguish from breeders using standard monitoring techniques (e.g., aerial surveys).

Not all monitoring needs pertaining to pelicans and depredation issues will be covered by this monitoring strategy. Depredation take permits may require additional monitoring of local pelican populations, documentation of impacts to fish resources, and measuring the effectiveness of management actions. Guidelines and procedures to address pelican depredation issues are described in the Impact Reduction Objective in the Management Framework. States and other entities may have research and management priorities that require additional monitoring and data collection beyond what is included in this monitoring strategy. These efforts should be conducted as necessary and coordinated within the Pacific Flyway to the greatest extent possible. Protocols for additional monitoring efforts are not included within this document.

Figure 1. Size and location of pelican breeding colonies in the Western Population.

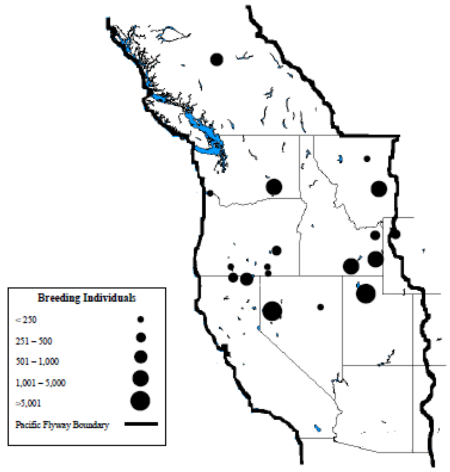

Table 1. The most recent estimate of the number of breeding individuals at pelican breeding colonies in the Western Population.

Colony[a]	# of Breeding Individuals[b]	Year	Source[c]
British Columbia			
Stum Lake	600	1993-02	Van Spall et al. 2005
California			
Clear Lake NWR	750	2010	BRNW, unpubl. data
Lower Klamath NWR	500	2010	BRNW, unpubl. data
Idaho			
Blackfoot Reservoir	3,034	2012	IDFG, unpubl. data
Minidoka NWR	4,408	2012	IDFG, unpubl. data
Island Park Reservoir[d]	300	2012	IDFG, unpubl. data
Montana[e]			
Arod Lake	112	2012	MFWP, unpubl. data
Canyon Ferry Lake	4,102	2012	MFWP, unpubl. data
Nevada			
Anaho Island NWR	8,000	2011	NDOW, USFWS, unpubl. data
Ruby Lakes NWR	50	2012	NDOW, USFWS, unpubl. data
Oregon[f]			
Crump Lake	130	2011	KBO, unpubl. data
Malheur NWR	400	2011	KBO, unpubl. data
Upper Klamath NWR	58	2011	KBO, unpubl. data
Pelican Lake	130	2011	KBO, unpubl. data
Miller Sand Spit	194	2011	Roby et al. 2012
Utah			
Gunnison Island WMA	16,170	2012	UDWR 2012
Washington			
Badger Island, McNary NWR	2,228	2011	Roby et al. 2012
Wyoming[e]			
Molly Lake, Yellowstone NP	451	2012	WGFD, unpubl. data
TOTAL	**41,617**		

[a] States/provinces not listed have no known breeding population.
[b] In some cases, the number of nests or breeding pairs was multiplied by 2 to derive the number of breeding individuals.
[c] BRNW=Bird Research Northwest; IDFG=Idaho Department of Fish and Game; KBO=Klamath Bird Observatory; MFWP=Montana Department of Fish, Wildlife, and Parks; NDOW=Nevada Department of Wildlife; UDWR=Utah Division of Wildlife Resources; USFWS=U.S. Fish and Wildlife Service; WGFD=Wyoming Game and Fish Department
[d] Colony was first documented in 2012.
[e] Estimates for Montana and Wyoming only refer to the Western Population portion of the State.
[f] At some sites, exact colony location differed minimally from location name due to local water conditions.

Goal

The goal of the monitoring strategy is to establish a coordinated, long-term monitoring effort to estimate the breeding population size, trend, and distribution of the Western Population of pelicans. This information is fundamental for developing effective management recommendations, and for guiding and assessing management actions pertaining to pelican depredation on fish resources.

Monitoring Objective

The monitoring objective is to be able to detect a 5% change/year in the Western Population of pelicans with 80% power ($\beta = 0.20$) and a 10% Type I error rate ($\alpha = 0.10$). The Nongame Technical Committee determined this level of monitoring was appropriate given the conservation status of pelicans, management considerations, and monitoring objectives for species of similar conservation status. It is less stringent than monitoring objectives of species of greater conservation concern than pelicans. Hatch (2002) recommended a similar monitoring standard for seabirds of detecting a 50% decline in 10 years (6.7% change/year) with 90% power ($\beta = 0.10$) and a 5% Type I error rate ($\alpha = 0.05$). Commonly used values of α range from 0.001 to 0.10, and of β range from 0.01 to 0.20 (Gibbs and Ene 2010). The North American Breeding Bird Survey (Sauer 1993, Peterjohn et al. 1995) and Partners in Flight Program (Butcher et al. 1992) monitoring standard is detection of a 50% decline over a 25-year period (2.7% change/year). Monitoring objectives for post-delisted species are typically <3% change/year (USFWS 2003, USFWS 2009).

MONITORING STRATEGY

Definition of Terms

Active Breeding Colony —A breeding colony that contained ≥5 active nests or 10 breeding individuals at least 1 time during the past 5 years (2008–2012).

Active Nest —A nest that contains a pelican egg(s) or fledgling(s) or with at least 1 adult in direct attendance, either incubating or standing directly on a nest.

Breeding Population —The number of pelicans that nest in a given year. The number of breeding adults can be derived by multiplying the number of active nests by 2.

Non-breeding Population —The number of pelicans that do not nest in a given year. Fledglings produced during a given year should not be included in the non-breeding population

Sampling Approach

Years to Monitor Breeding Colonies— Monitoring will begin in 2014 and occur every third year thereafter for at least 10 years (i.e., 2014, 2017, 2020, 2023). Data collected during other years can augment analyses, but the goal is to conduct a comprehensive, standardized monitoring effort during the years specified. The 3-year monitoring interval was chosen based on the results from the power analysis (see below and Appendix A), an appropriate frequency to update population information as determined by the Nongame Technical Committee, and the average age of pelican first breeding (average age = 3; Sloan 1982, Knopf and Evans 2004). For the power analysis, we evaluated 9 temporal sampling schemes, where monitoring occurred every year, every other year, or every third year for 3, 5, 7, and 9/10 years in duration. The most cost effective temporal sampling scheme (i.e., the fewest number of total sampling units) that achieved the monitoring objective was to monitor every third year for a 10-year duration.

Locations to Monitor—All breeding colonies within the Western Population will be monitored (i.e., a census) during a monitoring year. All breeding colonies will be monitored for the duration of the monitoring strategy, even if no breeding is reported for a given year. New breeding colonies will be monitored during the year they are discovered and for the remainder of the monitoring strategy, even if no breeding is reported for a given year. There are currently 18 active pelican breeding colonies in the Western Population. Summary statistics of the breeding colonies and the 4 breeding colony size classes are given in Appendix A, Table A1.

Conducting a census of all breeding colonies will provide the best understanding of pelican population dynamics. When sampling, it is not possible to determine whether a decrease in abundance at a colony reflects an actual decrease in the metapopulation or is complemented by an increase at an unmonitored colony. Additionally, since there are few breeding colonies (n=18), monitoring all colonies will ensure the best chance of detecting a population trend. If it is not possible to conduct a census, monitoring priority should be give to the largest colonies since they have the largest influence on determining trend.

Timing of Breeding Colony Monitoring—The mid- to late incubation period is the most ideal time to survey breeding colonies, since peak counts occur during this time (Steinkamp et al. 2003, USFWS 2008). Pair formation and nest site selection begins soon after arrival of adults to the nesting grounds. Egg laying starts approximately 4–5 days after nest site selection (Knopf and Evans 2004), and hatching occurs approximately 30 days after laying (Knopf 1979). Suggested monitoring dates for breeding colonies within Pacific Flyway States/Provinces are given in Table 2. These dates provide a tentative guideline but may be subject to change given local or annual environmental and colony conditions. Target monitoring dates for 2014 are given in Table 3.

Table 2. Suggested monitoring dates for Pacific Flyway States/Provinces.

Time Period	State/Province	Reference
early May	CA and southern OR	Shuford and Gardali 2008
early–mid May	NV	Wiemeyer et al. 2007
mid May	B.C.	Dunbar 1984
mid-May–early Jun	WY	Baril et al. 2010
mid May–mid-Jun	UT	UDWR, unpublished data
late May–early Jun	MT	MFWP, unpublished data
late May–early Jun	ID	IDFG 2009
late May–Jun	WA and northern OR	Roby et al. 2012

MONITORING TECHNIQUES

Overview

Air-, water-, and ground-based techniques can be used to monitor pelicans (Steinkamp et al. 2003, USFWS 2008). Taking photographs or video during aerial flights is the recommended method to monitor pelican breeding colonies. Monitoring can involve either total counts for smaller colonies, or partial counts for larger colonies (see below). Total counts should be conducted when possible. Conducting multiple counts of a breeding colony during a monitoring year is recommended when possible to better estimate peak abundance and variability. This is strongly recommended for areas where pelicans nest in vegetation that may hinder detectability. If adults show evidence of breeding in an area (e.g., carrying food, mating or distraction displays) but there is no confirmed active nest or fledglings observed, sites should be revisited at a later date to confirm the breeding status of the colony. When monitoring colonies, detection probability and sampling variance should be estimated when possible. This can be achieved in many ways, including the same or different observer(s) recounting the same location or photograph multiple times, conducting trials to estimate detection probability for an observer(s) or area(s) and then applying the correction thereafter, or using double-observer sampling approaches (Nichols et al. 2000, Steinkamp et al. 2003).

Pelicans are sensitive to disturbance, and monitoring techniques that reduce the amount of disturbance to the colony are preferred. Adult pelicans can destroy eggs and kill fledglings when flushing and may abandon nests if disturbed repeatedly (BCME 1998, Knopf and Evans 2004, USFWS 2008). Individuals should be particularly cautious of disturbance in newly established breeding colonies because pelicans may abandon areas if disturbance levels are too high. It is recommended that adults should not be off the nest >10–30 minutes. Additionally, caution should be exercised when 1) wind chill temperature is <65ºF, 2) it is sunny and air temperature is >80ºF, 3) it is cloudy and air temperature is >90ºF, 4) it is raining or there is a high probability of rain, 5) egg or chick predators are present and appear able to approach exposed nests, and 6) the majority of the colony is in the nest-building or early incubation stage (USFWS 2008).

Aerial Counts

Taking photographs or video during aerial flights is the recommended method to monitor pelican breeding colonies. This is the current method used to monitor most active breeding colonies within the Western Population. Aerial photography reduces the amount of disturbance to the breeding colony and is more accurate than conducting direct aerial counts. Direct aerial counts can be highly unreliable and are not recommended. Flight altitudes between 150–400m above the colony have been recommended. However, altitudes may need to be adjusted to comply with local regulations or if flights cause disturbance to the colony. Aerial photographs can either be 1) a single photo of an entire island or nesting colony (usually using a 50mm lens) or 2) overlapping, close-up photos of colonies (using a 200mm or 300mm lens). When enumerating nests from photographs, ≥2 independent counts of the image should be made when possible. If the breeding status of pelicans cannot be determined from aerial photographs, the location should be visited if possible to verify breeding status.

Boat Counts

Boat counts can be used to monitor colonies proximal to water, especially if ground counts within the colony or aerial flights are not possible. If anchoring the boat is possible, colony counts can be conducted similar to perimeter counts (see below). If breeding is more dispersed, Trocki et al. (2010) recommended boat speeds of approximately 5 km/h. Boats should be kept at a distance where safe boat operation is feasible and disturbance to the colony is minimal. Photographs or video can also be taken from the boat to later determine nest counts.

Ground Counts

With ground counts, monitoring can occur from 1) the perimeter of the colony or 2) within the colony. If within-colony counts are conducted, efforts should be made to reduce disturbance by minimizing noise, the time spent within the colony, and the proportion of the breeding area disturbed.

Perimeter Counts—Perimeter counts involve monitoring a colony from set survey points on the periphery of a colony. The number and location of survey points will depend upon the unique characteristics of each colony. Survey points should be close enough to count individual nests but far enough away so that individuals do not flush. Survey points should be spaced appropriately to count the maximum number of nests without double counting. To avoid double counting nests, a unique and specific segment of the colony should be surveyed from each survey point. Identifying unique landmarks or distinguishing features within the colony can help to delineate the survey area for a particular survey point. Perimeter counts should only be conducted when all nests are visible from the perimeter of the colony.

Within-Colony Total Counts— Within-colony total counts involve counting all nests within the colony boundary. It is generally recommended that within-colony total counts be conducted when there are <500 nests/observer for ground nesting colonies and perimeter counts are not possible (USFWS 2008). If the colony is small (<50 nests) or located along a narrow corridor, a single unmarked transect can be walked and every nest counted. If all nests are not visible from a single transect, the colony should be delineated into strips (i.e., strip transects) using flagging or other markers. Nests are counted within each strip, and the strip totals are combined to provide a colony total. The width and number of strips will depend upon site-specific characteristics, but should ensure that every nest within the strip can be viewed without double-counting nests within other strips. Total counts on larger colonies can be achieved relatively quickly by having a line of multiple observers walk side-by-side within a strip transect. Each observer uses a clicker and communicates with their neighbor to assure nests are not missed or double-counted.

Within-Colony Partial Counts—Within-colony partial counts are used when the colony is too large or too much time is required to conduct a total count. It is generally recommended that partial nest counts be conducted when there are >500 nests/observer for ground nesting colonies (USFWS 2008). To conduct a partial count, the total area occupied by the colony needs to be determined first by mapping the colony boundary. A proportion of the total area is sampled using transects, quadrants (i.e., squares), or circles. When using sampling circles, GPS points within the colony are first determined. An observer places a pole at that point with an attached piece of string or rope (10–20m typically). The observer then surveys all nests within the area of the circle created by the length of the string or rope. Sampling transects, quadrants, or circles should be randomly placed within the colony, and, if there are known differences in habitat or nest density within the colony, a stratified random sampling approach should be used. The sampled area should encompass 20–40% of the entire colony and sampled areas should not overlap; 40% is preferred under most circumstances. Once the total number of nests is determined for the sampled area, these estimates are extrapolated to the remaining proportion of the colony not sampled to estimate a total colony nest count. Partial counts can also be used for perimeter, boat, and aerial counts, using the same estimation techniques (i.e., surveying a known proportion of the colony, then extrapolating those counts to estimate the entire colony).

IMPLEMENTATION

Responsibilities

The Nongame Technical Committee member of each State will facilitate reporting and sharing of data with the Pacific Flyway Council and USFWS. The data sheet for collecting and reporting data is provided in Appendix B. A centralized database will be housed within the USFWS Division of Migratory Bird Management Region 9 office. The USFWS will manage the database and provide status and other reports concerning data gathered from this monitoring strategy to the Nongame Technical Committee, Pacific Flyway Council, States, and other interested entities. The USFWS Nongame Technical Committee representative will coordinate interactions between the Nongame Technical Committee and the USFWS.

The Nongame Technical Committee will periodically review and revise the monitoring strategy, evaluate its effectiveness, and brief the Pacific Flyway Council. Continued collaboration and dialogue among the Pacific Flyway Council, Nongame Technical Committee, USFWS, States, and other entities will be essential for the successful implementation of this monitoring strategy.

BUDGET

Pelicans within the Western Population are surveyed by a number of uncoordinated monitoring efforts. This monitoring strategy aims to coordinate existing monitoring efforts and augment them when necessary in order to achieve the monitoring objective. The additional estimated cost above and beyond existing efforts to implement the monitoring strategy is $3,000 per monitoring year to conduct a coordinated flight within the Klamath Basin of Oregon and California (Table 3). There are 6 known breeding colonies in the Klamath Basin, 4 of which are located on National Wildlife Refuges. The exact location of breeding colonies can vary due to local environmental conditions (e.g., whether a location has water, levels of disturbance). Monitoring the 6 locations and surrounding areas during 1 flight would ensure a more accurate breeding population estimate for the Klamath Basin. It takes approximately 4 hours to fly the area, and flight costs are approximately $500 per hour (D. Mauser, USFWS, pers. comm.). Thus, we estimated that the total cost for a flight and to enumerate photographs was $3,000 (i.e., $500 per location ($3,000/6)).

We assumed that the monitoring costs at the 12 breeding colonies outside of the Klamath Basin would be covered by on-going monitoring efforts and thus would not contribute new cost to implement the monitoring strategy. Of the 12 breeding colonies outside of the Klamath Basin, 6 breeding colonies are on a National Wildlife Refuge (n=4), Wildlife Management Area (n=1), or

National Park (n=1). Pelicans are typically monitored at these locations annually. Five breeding colonies in Montana, Idaho, and British Columbia are monitored annually by States/Provincial wildlife agencies. Miller Sand Spit, Oregon is monitored annually by Bird Research Northwest and affiliates as part of on-going monitoring on the Columbia River.

Estimated cost to fully implement the monitoring strategy is $15,500 per monitoring year based upon the projected budget (Table 3). In subsequent monitoring years, the number and location of breeding colonies and funding support for existing monitoring programs may change, which will influence funding needs for the monitoring strategy. For each location, survey methodology and a cost estimate were provided by individuals with knowledge of that location. If information was not available, estimated costs were based upon Idaho Department of Fish and Game waterbird ground surveys, flight expense, and USFWS and Bird Research Northwest expense to enumerate photographs from aerial surveys. For aerial monitoring, estimated costs were $2,000 and $1,000 for large (>2,000 breeding individuals) and small colonies (<2,000 breeding individuals), respectively. For ground monitoring, estimated costs were $1,000 and $500 for large and small colonies, respectively. No cost was included for an individual(s) to coordinate monitoring, manage the database, analyze data, and produce reports. It is assumed these duties will be covered in-kind by Nongame Technical Committee, State, and USFWS personnel.

Table 3. Estimated cost and survey information for 2014 monitoring locations.

Colony	Survey G=ground A=aerial	Time of Year	Lead Organization(s)	Description	Estimated Cost per Monitoring Year	Estimated Cost Covered Under Existing Programs	Estimated New Cost per Monitoring Year
British Columbia							
Stum Lake	G	mid May	CWS	Nest count conducted annually at Stum Lake	$500	$500	$0
California							
Clear Lake NWR*	A	early May	*	New monitoring - Coordinated Klamath Basin flight	$500	$0	$500
Lower Klamath NWR*	A	early May	*	New monitoring - Coordinated Klamath Basin flight	$500	$0	$500
Idaho							
Blackfoot Reservoir	G	late May–early Jun	IDFG	Included in on-going colonial waterbird monitoring efforts	$1,000	$1,000	$0
Minidoka NWR	G	late May–early Jun	IDFG	Included in on-going colonial waterbird monitoring efforts	$1,000	$1,000	$0
Island Park Reservoir	G	late May–early Jun	IDFG	Included in on-going colonial waterbird monitoring efforts	$500	$500	$0
Montana							
Arod Lake	G	late May–early Jun	MFWP	Included in on-going colonial waterbird monitoring efforts	$500	$500	$0
Canyon Ferry Lake	G	late May–early Jun	MFWP	Included in on-going colonial waterbird monitoring efforts	$1,000	$1,000	$0
Nevada							
Anaho Island NWR	A	early–mid May	USFWS	Included in on-going avian monitoring efforts on Anaho Island NWR	$2,000	$2,000	$0
Ruby Lakes NWR	A	early–mid May	USFWS	Included in on-going avian monitoring efforts on Ruby Lakes NWR	$1,000	$1,000	$0
Oregon							
Crump Lake*	A	early May	*	New monitoring - Coordinated Klamath Basin flight	$500	$0	$500
Malheur NWR*	A	early May	*	New monitoring - Coordinated Klamath Basin flight	$500	$0	$500
Upper Klamath NWR*	A	early May	*	New monitoring - Coordinated Klamath Basin flight	$500	$0	$500
Pelican Lake*	A	early May	*	New monitoring - Coordinated Klamath Basin flight	$500	$0	$500
Miller Sand Spit	A	late May–Jun	BRNW	Included in on-going monitoring efforts on the Columbia River	$1,000	$1,000	$0
Utah							
Gunnison Island WMA	A	mid May–mid-Jun	UDWR	Included in on-going avian monitoring efforts on Great Salt Lake	$2,000	$2,000	$0
Washington							
Badger Island, McNary NWR	A	late May–Jun	BRNW, USFWS	Included in on-going monitoring efforts on the Columbia River	$1,000	$1,000	$0
Wyoming							
Molly Lake, Yellowstone NP	A	mid-May–early Jun	NPS	Including in on-going monitoring efforts in Yellowstone NP	$1,000	$1,000	$0
				TOTAL**	**$15,500**	**$12,500**	**$3,000**

*A new coordinated flight to monitor the Klamath Basin is proposed. $3,000 is the estimated cost to monitor the 6 locations and surrounding areas in the Klamath Basin during a single flight and enumerate photographs; $500 is the estimated cost per location ($3,000/6).
**No cost was included for an individual(s) to coordinate monitoring, manage the database, and analyze data/produce reports. It is assumed these duties will be covered in-kind by Nongame Technical Committee, State, and USFWS personnel.

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APPENDICES

APPENDIX A: Sampling Approach

All breeding colonies within the Western Population will be monitored (i.e., a census) during a monitoring year. Breeding colonies will be monitored for the duration of the monitoring strategy, even if no breeding is reported for a given year. New breeding colonies will be monitored during the year they are discovered and for the remainder of the monitoring strategy, even if no breeding is reported for a given year.

Conducting a census of all breeding colonies will provide the best understanding of pelican population dynamics. When sampling, it is not possible to determine whether a decrease in abundance at a colony reflects an actual decrease in the metapopulation or is complemented by an increase at an unmonitored colony. Since there are few breeding colonies (n=18), monitoring all colonies will ensure the best chance of detecting a population trend. If it is not possible to conduct a census, monitoring priority should be give to the largest colonies since they have the largest influence on determining trend. Pelican use of breeding locations is relatively stable, and new breeding colonies are typically found and reported with a high degree of certainty without organized monitoring efforts. A completely randomized, dual-frame (Haines and Pollock 1998), or similar sampling approach was not considered to be necessary or cost-effective since there is minimal colony turn-over and little need to devote a large amount of monitoring effort to discover new breeding colonies.

Summary Statistics and Description of the Western Population—There are currently 18 active pelican breeding colonies in the Western Population. The two largest colonies, Gunnison Island WMA, Utah and Anaho Island NWR, Nevada, comprise approximately 56% of the Western Population. The 6 largest colonies comprise 88% of the Western Population (Table A1).

Colonies were stratified into 4 size classes (>6,000, 5,999–2,000, 1,999–300, and 299–10 breeding individuals) based on suspected differences in colony dynamics. Colony data from the last 10 annual counts were used to calculate the mean number of breeding pairs and percent coefficient of variation of the number of breeding pairs for the 4 size classes (i.e., strata; Table A1). These summary statistics were used in the power analysis (see below). Monitoring recommendations may need to be adjusted if these values change substantially in the future. If the percent coefficient of variation values increase, a greater number of sampling units will be needed to achieve the desired management objective. Thus, monitoring costs will be greater than those presented in this document.

Power Analysis—We conducted a power analysis using Program R (R Development Core Team 2008) to identify the most cost effective sampling scheme (i.e., fewest number of total sampling units) that achieved the monitoring objective. The monitoring objective is to have the ability to detect a 5% change/year in the Western Population of pelicans with 80% power ($\beta = 0.20$) and a 10% Type I error rate ($\alpha = 0.10$). We examined 9 temporal monitoring schemes, where monitoring of the 18 breeding colonies occurred every year, every other year, or every third year for 3, 5, 7, and 9/10 years in duration.

Simulations were based upon route regression procedures in Program Monitor (Gibbs and Ene 2010). For each simulation, a deterministic linear trend was calculated for each size class given the initial mean colony size, the years monitoring occurred, and the specified percent change per year (i.e., trend). The trend values tested were 1%, 5%, 10%, and 15%. We assumed that the current pelican population estimate (2011 and 2012) for the Western Population could be used for future data analysis. Thus, trends were generated as if 2011 was the first year of data and temporal sampling schemes began in 2014. Random data sets for the 4 size classes were generated from a random normal distribution using the deterministic trend means of each time period and the calculated percent coefficient of variation of each stratum (Table A1). A constant percent coefficient of variation was used so that variance was proportional to the deterministic trend mean over time. Data sets were constrained so that negative values were truncated at 0. The number of data sets generated for each size class equaled the number of colonies sampled per monitoring year within each stratum. Data sets were then combined to create the overall, or metapopulation, dataset. The slope of the metapopulation dataset was calculated using a linear model. The confidence interval of the metapopulation slope was calculated using a 10% Type I error rate ($\alpha = 0.10$). A positive trend was detected if the confidence intervals of the metapopulation slope were both greater than zero. Power was calculated as the proportion of iterations ($i = 2{,}500$) that the metapopulation trend was detected.

Results from Power Analysis—The power to detect trend increased as the number of years, duration of years, and trend values increased (Table A2; Fig. A1). Monitoring >9 years in duration will most likely be necessary to ensure detection of a 5% trend with approximately 80% power (Table A2; Fig. A1). Shorter durations may be sufficient if trends values are greater than 5%. Only 2 monitoring schemes achieved the objective: monitoring every year for a 9-year duration and monitoring every third year for a 10-year duration. Power estimates to detect a 5% trend were slightly higher when monitoring every year compared to every third year (0.86 vs. 0.81), but the total number of units sampled was much greater (162 vs. 72; Table A2; Fig. A1).

Monitoring Recommendation from Power Analysis—The most cost effective sampling scheme that will achieve the monitoring objective is to monitor every third year for a 10-year duration.

Table A1. Pelican breeding colony summary statistics and input values for the power analysis. Percent coefficient of variation (% CV) was calculated using the last 10 available annual counts. For colonies without available annual count data, the number of breeding individuals from the most recent survey was reported and no percent coefficient of variation estimate was given.

Colony Size (Breeding Individuals)	# of Colonies in Size Class	Mean Colony Size (Breeding Individuals)	% CV	Total Count (Breeding Individuals)	% of Total Population
>6,000	2	11,062	32%	22,124	56%
5,999-2,000	4	3,143	35%	12,571	32%
1,999-300	7	597	44%	4,178	11%
299-10	5	112	*44%	562	1%
TOTAL	18			39,434	100%

Colony	State	Mean Colony Size (Breeding Individuals)	% CV
Gunnison Island WMA	UT	12,486	18%
Anaho Island NWR	NV	9,638	46%
Canyon Ferry Lake	MT	3,950	21%
Clear Lake NWR	CA	3,278	49%
Minidoka NWR	ID	3,018	38%
Blackfoot Reservoir	ID	2,325	34%
Badger Island, McNary NWR	WA	1,190	54%
Molly Lake, Yellowstone NP	WY	742	35%
Lower Klamath NWR	CA	614	41%
Stum Lake	BC	600	20%
Malheur NWR	OR	400	—
Arod Lake	MT	331	71%
Island Park Reservoir	ID	300	—
Miller Sand Spit	OR	194	—
Crump Lake	OR	130	—
Pelican Lake	OR	130	—
Upper Klamath NWR	OR	58	—
Ruby Lakes NWR	NV	50	—

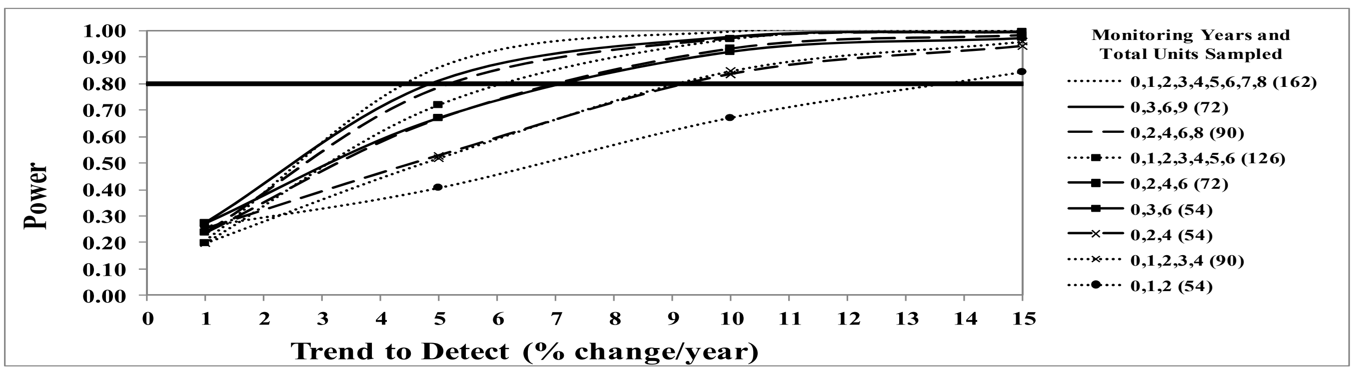
* % CV was not available for this size class. The % CV value of the next largest size class (44%) was used in the power analysis.

Table A2. Power to detect trend (i.e., % change/year) for various temporal sampling schemes. Temporal sampling schemes include monitoring every year, every other year, and every third year for 3, 5, 7, and 9/10 years in duration. Highlighted is the recommended sampling scheme, which is the most cost effective sampling scheme (i.e., fewest number of total sampling units) that achieved the monitoring objective of detecting a 5% change/year with 80% power.

	Number of Units Sampled in Each Size Class Per Monitoring Year						Power to Detect Trend (% change/year)			
Monitoring Years	>6,000 (100%)	5,999-2,000 (100%)	1,999-300 (100%)	299-10 (100%)	Number of Monitoring Years	Total Units Sampled Over Monitoring Program (18 units/monitoring year)	1%	5%	10%	15%
0,1,2	2	4	7	5	3	54	0.26	0.41	0.67	0.84
0,1,2,3,4	2	4	7	5	5	90	0.20	0.52	0.85	0.96
0,1,2,3,4,5,6	2	4	7	5	7	126	0.20	0.72	0.97	1.00
0,1,2,3,4,5,6,7,8	2	4	7	5	9	162	0.21	0.86	1.00	1.00
0,2,4	2	4	7	5	3	54	0.25	0.53	0.84	0.94
0,2,4,6	2	4	7	5	4	72	0.24	0.67	0.93	0.98
0,2,4,6,8	2	4	7	5	5	90	0.24	0.79	0.97	1.00
0,3,6	2	4	7	5	3	54	0.27	0.67	0.92	0.97
0,3,6,9	2	4	7	5	4	72	0.28	0.81	0.98	1.00

*Monitoring year 0 is 2014. Power estimates were calculated assuming that the current pelican population estimate (i.e., 2011 and 2012) would be used in future analysis (e.g., monitoring years 0, 3, 6, 9 represents the power to detect a trend using data generated in the years 2011, 2014, 2017, 2020, 2023).

Figure A1. Power to detect trend (i.e., % change/year) for various temporal sampling schemes. Temporal sampling schemes include monitoring every year (dotted line), every other year (dashed line), and every third year (solid line) for 3 (●), 5 (x), 7 (■), and 9/10 (no mark) years in duration. The solid line with no marks is the recommended sampling scheme, which is the most cost effective sampling scheme (i.e., fewest number of total sampling units) that achieved the monitoring objective of detecting a 5% change/year with 80% power. The solid horizontal line denotes 80% power.



*Monitoring year 0 is 2014. Power estimates were calculated assuming that the current pelican population estimate (i.e., 2011 and 2012) would be used in future analysis (e.g., monitoring years 0, 3, 6, 9 represents the power to detect a trend using data generated in the years 2011, 2014, 2017, 2020, 2023)..

APPENDIX B: Data Sheet

PACIFIC FLYWAY AWPE MONITORING STRATEGY DATASHEET
BREEDING COLONY ACTIVE NEST COUNT

RECORD # (DO NOT FILL-IN): 2014 AWPE DS#____________

General Information

____________________ Lead observer name

____________________ Lead observer contact phone #

________ State

________________ County

____________________ Latitude (Decimal; e.g. 49.492667)

____________________ Longitude (Decimal; e.g. -123.916667)

____________________ Colony Name or Location Name

____________________ General Directions to colony or location; e.g. 2 mi W of Salem

Survey Information

Survey Method (check 1)

- [ ] Perimeter
- [ ] Boat
- [ ] Other:__________
- [ ] Ground
- [ ] Aerial

Survey Method (check 1)

- [ ] Full (complete) survey
- [ ] Partial survey

If partial survey, what technique was used

- [ ] Strip Transects
- [ ] Circles
- [ ] Quadrants
- [ ] Other ___________________

____________ # of total observers

____________ Est. total time in colony

*Colony Classification Codes:
NoB = Non-breeder (no active nest, egg, or fledgling)
Bn = Breeder; active nest confirmed
Be = Breeder; active egg confirmed
Bf = Breeder; active fledgling confirmed

Count Information

Sample #	Observer initials	Date (mm-dd-yy)	Time (0000-2400)	*Colony Classification	% of colony sampled	# of nests in sampled area	Total colony nest count	Nest Count Std. Deviation
1								
2								
3								
4								
5								
6								
7								

AVERAGE TOTAL COLONY NEST COUNT __________

Comments