BROWN PELICAN
BREEDING COLONY MONITORING PROTOCOL

Binational Network for Monitoring and Conservation of the Brown Pelican

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1. INTRODUCTION

Brown Pelican (*Pelecanus occidentalis*) populations in North America have undergone fluctuating expansions and contractions over time on both the Atlantic and Pacific coasts. Population numbers dropped drastically during the 1960s because of pesticide contamination and the species was listed as a "threatened" under the Endangered Species Act of 1973. At present, despite the removal of Brown Pelican from the list in 2009 by the U.S. Fish and Wildlife Service (USFWS), its population status still requires a thorough evaluation assessment amidst climate change scenarios, exploitation of fisheries resources in areas of pelican distribution, and anthropogenic disturbance. In the Pacific, nesting colonies of California Brown Pelican (*P. o. californicus*) are found on islands in the South Bay region of California, the west coast of the Baja California Peninsula, the Gulf of California, and wetlands and islands along Mexico's west coast (Anderson *et al.*, 2013). The center of the total breeding population is located in the Gulf of California, with an estimated population of 43,350 ± 230 breeding pairs (Anderson *et al*., 2013). This region is an important source of recruitment for the species (Anderson and Gress, 1983).

The El Niño-Southern Oscillation (ENSO) climate phenomenon affects annual productivity and behavior of the Brown Pelican (Anderson *et al.*, 2013). In particular, in the southern part of the Midriff Islands Region, the nesting population has declined in the last decade (Anderson *et al.*, 2017). Furthermore, this species is still listed as a "threatened" in the Official Mexican Standard NOM-059-SEMARNAT-2010 (SEMARNAT, 2010).

The state of the California Brown Pelican population is an important indicator of ecological health at a regional scale. Therefore, a long-term standardized study that allows gaining in-depth knowledge of all the biological and ecological aspects of the species is imperative. In addition, the analysis of population monitoring data has made it possible for us to increase our understanding of habitat connectivity and quality of the islands in the Gulf of California and the Mexican Pacific, which are the nesting grounds for the Brown Pelican.

2. OBJECTIVES

Overall Objective

- Assess the distribution, abundance, and population trend of the California Brown Pelican (*Pelecanus occidentalis californicus*) across its range.

Specific Protocol Objectives

1. Develop and implement a monitoring program to generate homogeneous and standardized data that can be compared between Brown Pelican colonies in the South Bay of California (BSC), South Pacific of Baja California (SPBC), Gulf of California (GC), and estuaries on Mexico's west coast, off the coast of Sinaloa (ECS).
2. Identify patterns in the range and abundance of Brown Pelicans during breeding season.
3. Obtain the minimum required information for the management and conservation of the Brown Pelican in BSC, SPBC, and GC.

4. Promote coordination and cooperation among organizations that conduct monitoring, research, and conservation of Brown Pelicans by enabling the exchange of information for the conservation of this species.

3. CONVENTIONAL MONITORING

Design: Undertake a direct count of all nests in the field, while also taking into account all the types of nests (active, abandoned, and incomplete).

Population: Count Brown Pelican nests at each monitoring site. This protocol can also be used to monitor other species of ground nesting seabirds (e.g. cormorants and frigatebirds.)

Frequency and period: Ideally, we monitor nests three times during the nesting season and at least once during the peak of nesting in each region. Each monitoring group defines the monitoring period according to the phenology of the species at the site (Table I).

Table I. Specifications of conventional monitoring by region.

Region	Frequency	Period
Gulf of California		
Islands of Bahía de los Ángeles and San Lorenzo Archipelago.	Once per season	May through June
Sonoran Islands (Chaperona Island, San Pedro Nolasco Island)	Annually (once a season)	March through May
Sonoran Islands (Alcatraz Island)	Every 15 days	December through June
Sinaloa Islands	Monthly	November through May
La Ballena Islet	One to two excursions per month	March through June
Pacific		
Channel Islands National Park	Every 15-30 days	December through September
Baja California Pacific Islands	Every 15-30 days	March through July

Definition of the counting area: depends on the size of the island where the colonies are counted. Colonies on small islands can be counted at a single time, while larger islands usually require dividing the area into several sections to make counting easier.

What do we do?

Depending on the site, colonies are counted from land at strategic points that allow observing the greatest number of nests, or from a vessel (e.g. boat, barge) circumnavigating the island. The monitoring date depends on each region and the capacities of the monitoring teams (Table I). There should be at least two observers. The nests observed are counted with the help of binoculars and/or telescopes and, if possible, the monitored patches are marked on a map in order to provide continuity between years.

Limiting Factors

Without a drone, it is impossible to determine the number of nesting attempts on Alcatraz Island and the Sinaloa Islands.

In all cases, monitoring requires sufficient funding for fieldwork, particularly when the use of boats and unconventional equipment (e.g. drones) is required.

In Mexico, any operation that requires landing on islands needs special permits (Ministry of the Interior, National Commission of Natural Protected Areas (CONANP), Ministry of the Navy (SEMAR)).

Post-season monitoring

This count is conducted once the breeding colony leaves the nesting site, to observe and count areas that are difficult to see from a vessel and land.

This monitoring takes place before the rain and wind remove signs of nesting and before carcasses decompose beyond recognition. All nests of the year are counted; active and abandoned nests are accounted for separately. Active nests are recognized by the existence of an extensive circle of guano or unhatched eggs. An abandoned nest is a nest platform built during the nesting season, but shows few signs of occupancy, i.e. no obvious circle of guano present. We recommend marking ground nests with biodegradable ink to avoid double counting. Nestling carcasses can also be counted to help interpret mortality. If possible, determine the approximate age of death.

Additional information (specifications by site)

Islands of Bahía de los Ángeles and San Lorenzo Archipelago. Record the number of young and adult pelicans.

Alcatraz Island. Record the number of chicks (without differentiating age), fledglings, and other age classes around the island. This takes place at the end of the breeding season, when most of the fledglings are still on the island.

Sinaloa Islands. Count all species that use the site in general.

La Ballena Islet. From 2015 to 2016, nests, adults and chicks were counted from land with the use of binoculars. This was inconclusive because the vegetation and geomorphology of the islet itself made it hard to access. Consequently, counting certain areas was also affected. Since 2018, nests are counted with the use of a UAV (drone) as described in section 4. Individuals outside the colony are counted once a month from a vessel along the coastline of the entire Espíritu Santo Archipelago.

Channel Islands National Park. Colonies are monitored every three to four weeks either on a vessel or by land. We start monitoring when there are signs of breeding

(material for nest formation) and/or breeding plumage, and stop monitoring when the last chick leaves the island. Data collected: number of occupied nests, number of empty nests, number of chicks by age, and total number of adults and sub-adults either attending or resting in the colony. We conduct a post-season count and make productivity subplots, depending on the progress of the nesting season. We record breeding success on at least two subplots on each island.

Baja California Pacific Islands. We record the number of adults and chicks observed, as well as the approximate age of the chicks according to Lewis *et al.* (1988).

Who conducts the counts?

Counts are usually conducted by two observers, together with support staff and boat drivers.

Funding. Monitoring resources come from national and international funding sources (Table II).

Table II. Funding sources by region for brown pelican monitoring.

Region	Funding
Sonoran Islands (Chaperona Island, San Pedro Nolasco Island)	CONANP
Alcatraz Island	Sonoran Joint Venture
Sinaloa Islands	CONANP
Islands of Bahía de los Ángeles	CONANP
Baja California Pacific Islands	Packard Foundation, NFWF
Channel Islands	National Park Service, U.S. Fish and Wildlife Service
La Ballena Islet (PNZMAES)	CONANP

What data are recorded?

Record the following data as the minimum required information for monitoring:

1. Place
2. Date
3. Start time and end time
4. Specify whether by vessel or by land
5. Weather conditions: wind (qualitative scale), cloud cover (%), rainfall (qualitative scale), temperature (°C). See Appendix I.
6. Approximate observation distance.
7. Number and name of observers
8. Number of active nests
9. Number of abandoned nests
10. Number of incomplete nests
11. Number of patches defined by location

12. If nesting in the same place with other species forming mixed colonies, e.g. with Double-crested Cormorant.
13. Human activities that are recorded during monitoring
14. Other threats observed while monitoring
15. Observations

Minimum material required:

- Binoculars
- Field notebook
- Data capture form
- Camera

4. AERIAL MONITORING

Design: This is referred to as a "direct nest count." The total number of breeding pairs in a colony is calculated based on the total number of nests constructed. The nest count is performed on the computer and based on the image of an orthomosaic map, which is generated with the aerial photographs. Subdividing the area and recording the number of nests in each sample area is usually preferred. Ideally, subdivisions should not be ambiguous so they can be used for subsequent counts in the same season and between nesting seasons. Thus, if any part of the area is not visible, then it is noted.

Population: Brown Pelican nests are counted in each colony. However, if natural area managers and local monitors are interested in recording observations of other bird species that share the nesting site (e.g. herons, gulls, or other ground nesting waterbirds) they can use this protocol. For burrow nesting species, the method recently proposed by Albores-Barajas *et al.* (2018) can be used.

Frequency and period: At least one count and ideally three counts per breeding season. The period will depend on the phenology of the species at each monitoring site.

Definition of the area counted: The area of nesting sites varies in size, but it is focused on specific nest areas. These colonies are well-defined areas delimited by a polygon on the map of each island; the counts are generally repeated every year (i.e. the same areas are monitored). With respect to small islands and islets, the entire entity should be covered. For larger islands, we recommend covering the area of the colony as well as a buffer of at least 100m surrounding the colony.

Tides: May vary between both sites and years. For reasons of navigation in shallow places, we recommend undertaking counts with drones during high tides.

4.1. DRONE MONITORING

What is done?

Count unobserved nests in aerial photographs taken from unmanned aerial vehicles (UAVs) flying over each nesting colony. This type of survey must be conducted between March 1 and May 15. During this time, it is possible to generate a monthly photographic record by colony. UAVs should fly over each colony when the sun is at or near the zenith, i.e. between 1100 and 1500.

Following a flight plan, undertake one flight (or the number required to cover the entire area) per colony to take aerial photographs (Figure 1). The plan should be previously designed and uploaded from a ground control station, allowing the UAV to do it autonomously (Figure 2). This flight plan must have the photogrammetric requirements (80% photographic overlap of forward flight direction and 60% photographic overlap between flight lines) for the photographs to be subsequently processed and the orthomosaic map on which the count will take place to be generated. During flight, the camera should focus on the nadir, i.e. at a -90° angle with respect to the position of the UAV (Figure 2, right). In turn, the front part of the UAV must point in the same direction as the flight, thus ensuring the necessary overlap of the photographic sequence.

The UAV must take off from an area far from the colony and arrive at a sampling height before reaching the colony. The flight plan can then be initiated. Flying at a height of 60 meters (Albores-Barajas *et al.*, 2018) is advised for good quality photos without causing disturbance to the birds (nesting or others).

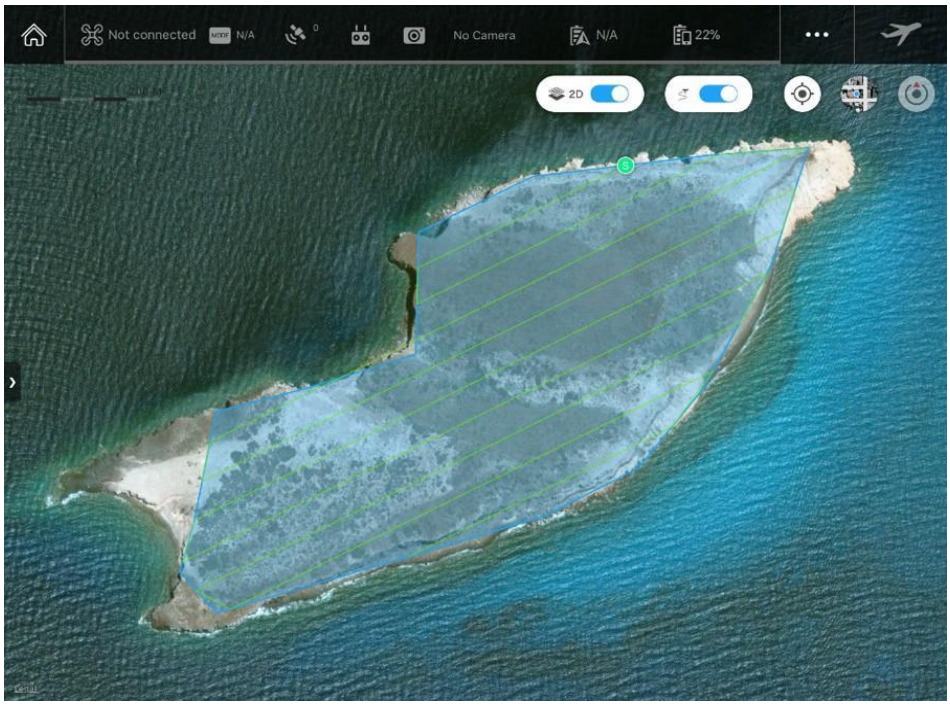

Figure 1. Example of a flight plan based on reference points designed for a Brown Pelican nesting area. Green lines represent the flight lines of the multicopter, and the blue polygon represents the area covered by the photographic record, the same area that will undergo photogrammetric reconstruction. (There are different applications to create flight plans, both free and paid, which include FlyLitchi and DJI Go).

If this protocol is used to estimate aggregations of Brown Pelicans in roosting or overnight sites rather than colonies, the sampling units will focus on roosting or overnight habitats of Brown Pelicans and focal species. Aerial photographs allow identification of age classes since they allow a more in-depth observation, similar to a conventional survey (Schreiber *et al.,* 1989). For this, the drone flight is piloted manually at a low altitude (approximately 50m), scanning the area with the camera focusing at an estimated 45° angle with respect to the ground, making a special effort to focus on groups of individuals (Figure 2). These aerial shots allow for the identification of age classes, since they provide a more in-depth observation, similar to a conventional survey (see Palacios, 2018).

Out of the total number of sampling units in a roosting habitat, at each site one can include them all or randomly select a subset of the units. This design is called "multistage cluster sampling." Multistage sampling consists of a cross-sectional spatial design in which sites (e.g. Mazatlán Bay) are selected in each region (e.g., Sinaloa coast) and representative sampling units are established at each site.

Figure 2. Left: Take-off from an Inspire 1 quadcopter UAV. Right: Inspire 1 in the air conducting an autonomous flight mission.

Orthomosaic generation

Photogrammetry uses using Agisoft Photoscan Pro software for processing. Photoscan is a tool that carries out photogrammetric processes by generating data in three-dimensional spaces from photographs based on the Structure-from-Motion (SfM) technique. In general, the work conducted by Photoscan to generate models can be divided into three processes, listed below:

1) In the first phase the program aligns the images. In this process, Photoscan builds a point cloud in a three-dimensional space from the reference points and connections between photographs identified by the program according to the photographic sequence, as well as the metadata of each photograph. This process is carried out based on the SfM technique.

2) Photoscan then uses dense stereo reconstruction and multiview based on the aligned photographic sequence to build the scenery of the model.

3) Finally, Photoscan generates a texture based on the photographic sequence.

Photoscan uses high quality parameters (Table III) to generate high-resolution orthomosaic maps that allow the best and most accurate identification of nests. The orthomosaic maps can be exported as georeferenced models to estimate the percentage of nesting by sampling area. Metadata of the photographs based on the UAV's internal GPS are used as geodesic data for model georeferencing.

Table III. Workflow and processing parameters

Alignment	
Accuracy	Higher
Generic preselection	Yes
Benchmark preselection	Yes
Key point limit	40,000
Dense point cloud	
Quality	High
Depth filter	Aggressive
Grid	
Surface type	Height field
Face count	High
Source data	Dense point cloud
Interpolation	Enabled
Orthomosaic	
Fusion mode	Mosaic
Surface	Grid

An orthomosaic map by colony and sampling date are the final products of photogrammetric processing. All files are exported from Photoscan as georeferenced orthomosaic maps in TIFF format with the global reference system WGS84/UTM zone 12 and at the maximum resolution possible for each model.

Surveys

The geographic information system QGIS is used to conduct nest surveys. QGIS is a free access tool to visualize, analyze and edit geospatial data (https://www.qgis.org/en/site/).

In QGIS, a vector layer is built for each orthomosaic map to which an 11 x 11 m grid will be applied to make counting nests easier. This then allows researchers to estimate the percentage of nests by area by colony. Subsequently in the vector layer, we can place a spatial object by a nest by using an alphanumeric code that corresponds to a color legend for the nest category (abandoned, active, or incomplete).

Which nests are counted?

We count all Brown Pelican nests in the colonies. Nests are surveyed based on digital images (orthomosaics), a product of fieldwork and photogrammetric processing. These will allow us to not only count the number of nests in the colonies with greater certainty, but also be able to distinguish the type of nest (abandoned, active, or incomplete) (Figure 4).

Count duration. Variable according to the sampling area but never exceeding the autonomy limit of the equipment's batteries. The sampling flights will take place between approximately 1100 and 1500, when the sun is at or near the zenith.

Limitations. One cannot fly with winds equal to or greater than 50 kph, which varies depending on the equipment (UAV model and its specifications). Similarly, one cannot fly in rainy conditions. UAVs can take-off and land either from the ground or a stationary vessel and during low wave conditions, to avoid possible damage or loss of equipment.

Figure 3. Example of a sampling area with an 11 x 11 m grid superimposed to facilitate nest counting.

Figure 4. Section of an orthomosaic map constructed from an aerial photograph from a UAV in a California Brown Pelican (*Pelecanus occidentalis californicus*) nesting colony. The red polygon shows an example of an abandoned or incomplete nest while the blue polygon shows an example of an active nest.

Figure 5. Terrestrial photograph of an active Brown Pelican nest in a colony.

Additional information. While UAV sampling is taking place, no other activities are carried out in the area to prevent the movement of birds from their nests. After completing the flight, conventional surveys will be conducted by teams of at least two people, recording both the number of nests and their category (abandoned, active, or incomplete) (Figure 5). To do this, we select circular areas with a radius of 4.37 m and a surface area of 60 m^2. These same circles are photographed with the UAV by placing a rope on the ground a reference for the radius. Nests present in a direct field count and in a remote count in the photo will be counted independently by two different people.

For photographic records, both the start and end time of each flight and the sampling site must be noted. During photogrammetric processing, photographic records are processed as separate projects according to the date of sampling and the colony sampled. In order to do this it is important to know both the start and end time of each flight and the date of each photographic record.

Implementation

Who oversees the counts?

Only one UAV pilot is needed for aerial photography and video. If the UAV takes off and lands from a vessel, there should be someone available to hold the equipment when taking off and to receive it when landing. Someone with Photoscan Pro skills is needed for photogrammetric processing; similarly, someone familiar with the QGIS tool is needed for censuses with orthomosaic maps.

Funding. This protocol is implemented by the resources of the organizations that comprise the monitoring network and with funds from U.S. federal agencies (USFWS through the Sonoran Joint Venture).

4.2. AIRCRAFT/HELICOPTER MONITORING

What is done?

Conducting Surveys

Photographs are taken using a high-resolution (20.1 MP DSLR camera with a telephoto lens (typically an 18mm-200mm zoom lens). One or two photographers (see below) and a data recorder are preferred for conducting the surveys. Photographers take overhead and/or slightly oblique photos of all pelican nesting areas. A data recorder documents the general location of photographs (e.g. Middle Islet, Sheep Canyon) and photograph numbers for each camera pertaining to each location (e.g. photos 58-75).

Anacapa Island. Due to pelicans nesting across a large elevation gradient on steep slopes within and between subcolonies and the large extent of the colony spread out across the island, photographs from a fixed-winged aircraft typically will not work as they are often out of focus and very difficult to capture the extent of the colony. Photographing from a helicopter flown at 1000' elevation has proven successful in photographing all pelican nesting areas at Anacapa Island. Typically one photographer can conduct this survey as the helicopter can hover near the colony while the photographer takes overview (~35 – 80 mm focal length) and close (~135mm to 200mm focal length) photos. Photographing these colonies properly requires removing the rear door of the helicopter to be able to aim downward with the camera. Safety equipment (e.g., restraints, helmets, hearing protection) is needed when conducting surveys with doors removed. When funding is available, surveys are flown three times per breeding season, based on observation of breeding phenology made from ground/boat surveys.

Santa Barbara Island. Surveys at this location may be flown with fixed-wing aircraft or a helicopter. Use of helicopters allows for one photographer as well as easier

processing and counting of photographs. However, a helicopter survey is nearly twice as expensive as an airplane survey. Surveys are flown at 1000' altitude with all nesting locations photographed. When funding is available, surveys are flown three times per breeding season, based on observation of breeding phenology made from ground surveys. As at Anacapa Island, surveys are flown in a "doors off" configuration. Airplane surveys are flown in a twin-engine, high-wing Partenavia P68 aircraft. Pelicans are photographed mainly through the belly port, but occasional photographs are taken through side windows. Two photographers are essential when conducting airplane surveys and one data recorder is also highly recommended.

Analyzing Photographs

Photographs from all surveys are analyzed for their representation of peak breeding population size for each distinct nesting area within each island. Typically the first or second survey is used to count well-developed nesting areas, depending in the survey that shows "peak" nest attempts. Each distinct nesting area is analyzed and counted separately and later summed with all nesting areas for a total number of nests for each island. Occasionally, well-developed colonies are counted in one survey, but additional distinct nesting groups can be identified in later surveys. Any additional distinct nesting group is counted and summed with the earlier survey numbers. The asynchronous nesting behavior of pelicans on these islands requires this level of analysis.

All images of each individual island are inspected for clarity, location within the island, and extent of island coverage. Those best suited for nest counts based on those criteria are then uploaded into photo editing software (Adobe Lightroom) (Figure 6). To avoid counting nests or birds more than once, the analyst uses this software to "stitch" the selected photographs together into one image (a photomosaic) of each distinct nesting area for each survey date. If more than one survey is needed to get a total count of nests, two to 45 twenty megapixel photographs can be stitched together, though photomosaics of more than 35 photos tend to take a long time to merge (Figure 7). The analyst then inspects the merged photomosaics against original photographs for clarity, distortion, and any duplication or gaps in the merged photo. Occasionally a specific photo will need to be added or removed to improve the final photomosaic. Once this process is completed for all distinct nesting areas, the analyst can use ESRI's ArcMap software to begin counting the newly created images. It is important to note that these photomosaics are not georeferenced.

Within a dedicated dotting geodatabase, a new feature class is created for each subcolony's stitched photomosaic(s), with fields for survey date, island, subcolony (with discreet locations), subcolony area, dotter ID, date of dotting, species, and location of photograph. Additionally, three fields are created containing limited drop-down menus for Bird (status of individual bird dotted), Nest (nest structure type), and Chick (age class of chicks dotted). Each of these categories are represented by symbols of different colors, shapes, and sizes as selected by the analyst. The analyst uses these fields to manually "mark" all nests and pelicans, which are then recorded in the shapefile database. Shapefiles are created for each subcolony and saved regularly during dotting efforts. Pelicans and nests are tallied from the shapefile database after all photo analysis is completed.

"Birds" are classified as follows:

- Adult (Adult plumage)
- Juvenile (dark head, white belly, dark feet if visible)
- Dead
- Roosting out of nesting area
- Unknown

Nest are classified as follows:

- Well-built nest (with attending adult, and with or without chicks visible)
- Poorly-built nest (pre egg-laying, during nest building)
- Nest with chicks but without attending adults
- Abandoned nest (with eggs and unattended by adult)
- Empty nest (unattended nest without eggs or chicks)

When possible, chicks are classified based on plumage in the following age categories:

- 0-5 weeks
- 6-8 weeks
- 9+ weeks
- FLYY (fledged young of the year)

Together, these categories allow us to determine the number of pelican nests at each colony even though pelicans may have nested asynchronously.

Quality Assurance/Quality Control

Analysis of aerial photographs are generally conducted by several personnel. Personnel new to photo analysis are trained initially in person, but frequent consultation by phone and email thereafter need to occur to ensure consistency and aid in troubleshooting. Because numerous combinations of composition and timing of breeding can be encountered, consultation can be frequent, especially at the start of analysis.

In-person training includes discussing: (1) photo quality parameters and rejecting unusable photos, (2) creating photomosaics, (3) operation of counting software, (4) category definitions, and (5) exporting data to the database from ArcMap. An important feature of quality assurance/quality control is the ability to delete points. If a bird or nest is accidentally marked twice or miscategorized by selecting the wrong symbol from the Create Features menu, erroneous symbols are easily detected and deleted. Instances when the wrong symbol is selected are usually conspicuous to the photo analyst. Given the conspicuousness of miscategorizations to the analyst and the associated functionality of the GIS software, the opportunities for marking errors are minimal.

Figure 6. Examples of photographs taken from a helicopter during California Brown Pelican surveys at Anacapa Island.

Figure 7. Example of a photomosaic created by "stitching together" multiple individual photographs of a California Brown Pelican nesting area. In this example, the Big Cliff nesting area is shown.

Implementation

Who oversees the counts?

One or two photographers and a data recorder are preferred for conducting the surveys. Photo analysis is carried out by different individuals to ensure data quality.

5. BANDING

The banding of Brown Pelican chicks and fledglings makes it possible to study dispersal and migration, as well as behavior and population dynamics. Information arising out of this activity is very useful to guide conservation efforts. The specific objective for the different work groups is shown in Table IV.

Table IV. Objectives of the banding of chicks and fledglings for the different regions.

Region	**Banding objective**
Sonoran Islands (Chaperona Island, San Pedro Nolasco Island)	Determine connectivity and site fidelity between colonies and islands
Alcatraz Island	Determine connectivity and site fidelity between colonies and islands; Understand if pelicans change nesting areas between years
Sinaloa Islands	Dispersion and use of habitat in Ohuira Bay*
Islands of Bahía de los Ángeles and San Lorenzo Archipelago.	
Baja California Pacific Islands	Determine the site fidelity, migration, and survival of individuals Describe the change in plumage from fledgling to adult
La Ballena Islet (PNZMAES)	Carry out a long-term monitoring of population dynamics that will allow us to conduct an in-depth demographic study of the species in the coming years, e.g., mortality and emigration
Channel Islands	No banding conducted

**Not a CONANP activity*

What is done?

Determine the area where the birds will be captured and the monitoring station will be installed. Look for sites where it is relatively easy to capture the chicks and that guarantee the safety and integrity of both the chicks and banding staff. It is very important that capture, handling, and banding is carried out by staff qualified for this activity as well as having the appropriate permits.

Chicks are captured from the age of 3-4 weeks to 10-week-old fledglings. Depending on the sites and number of people, up to 20 birds can be captured at a time. Body weight and length of the bill of each chick or fledgling, among other morphometric data, are recorded (Table V). While body weight and length of the bill are the two main variables to note, each working group will define other morphometric variables to record and biological samples to take according to their particular research interests. Metal and Darvic type rings are used for bird banding, varying by region (Table VI and Appendix II).

Table V. Morphometric data taken from banded chicks or fledglings.

Region	Weight	Bill Length	Wing Length	Tarsus Length	Head-bill length
Islands of Bahía de los Ángeles and San Lorenzo Archipelago.	X	X			
La Ballena Islet (PNZMAES)	X	X			
Baja California Pacific Islands	X	X	X	X	X

Limiting Factors

Pelicans occasionally nest in places with steep slopes and dense, spiny vegetation. We recommend avoiding those places.

Table VI. Information on Brown Pelican bands for the different regions where this species is monitored.

Region	Band type	Color	Serial number	Contact details
Islands of Bahía de los Ángeles	Darvic	Orange with white numbers; green with black numbers.	-12-48 -101-136 -34-43	rosaliaavalos@yahoo.com.mx.
Baja California Pacific Islands	Darvic	Red with white letters; on left leg	X001 - X999 Y001 - Y999	anillos@islas.org.mx
	Metal	On right leg	MX03001-MX06000	
La Ballena Islet (PNZMAES)	Darvic	Green with white numbers; black with white letters and numbers; yellow with black letters and numbers	036 - 125 029n - 043n A00 - A99 B00 - B99	anillos@cicese.mx
	Metal		UU00001 - UU00200 P00001 - P00100	
Pelicans rescued	Darvic	Blue with white letters		https://www.bird-rescue.org/contact/found-a-bird/reporting-a-banded-bird.aspx

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Appendices

Appendix I. Environmental variables to record during conventional monitoring. Taken from the standardized protocol of the Migratory Shorebird Project (2010).

Variable	Value	Category	Description
Wind	0	Calm	Smoke rises vertically (<2 km/h).
	1	Light air	Direction of wind shown by smoke but not by wind vanes (2-5 km/h).
	2	Light breeze	Wind felt on face; leaves rustle; ordinary vane moved by wind (6-11 km/h).
	3	Gentle breeze	Leaves and small twigs in constant motion; wind extends small flag (12-19 km/h).
	4	Moderate breeze	Raises dust and loose paper; small branches are moved (20-29 km/h).
	5	Fresh breeze	Small trees begin sway; crested waves form on inland waters (30-38 km/h).
Precipitation	0	None	There is no rain
	1	Mild	Intermittent light, slight mist, dew, drizzle
	2	Fog	Fog
	3	Permanent	Permanent rain (suspension of survey).

Appendix II. Images of rings by region

Region	Image
Islands of Bahía de los Ángeles	 
Baja California Pacific Islands	 
La Ballena Islet (PNZMAES)	 

Rescued pelicans		

Appendix III. Pelican aging by plumage (all text and pictures from Frank Gress)

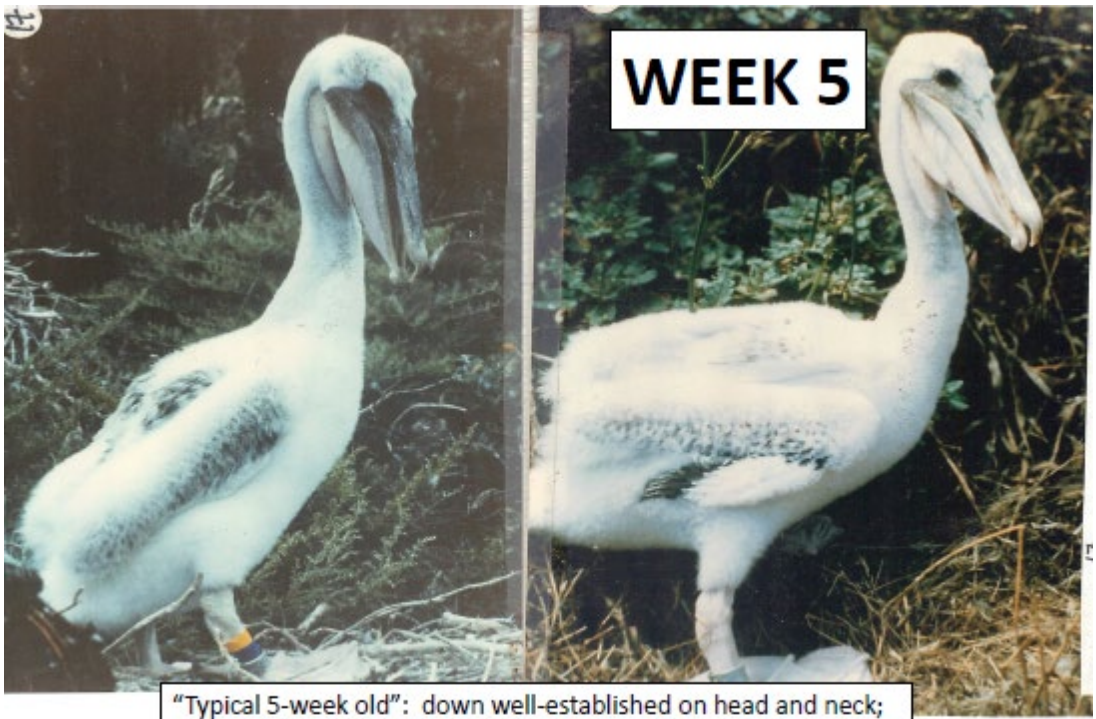
WEEK 2

16-21 Days old: down appearing in primary region of wing; down is longer and covers most of body, but head and neck still naked; chick appears downy white; closely brooded

WEEK 3

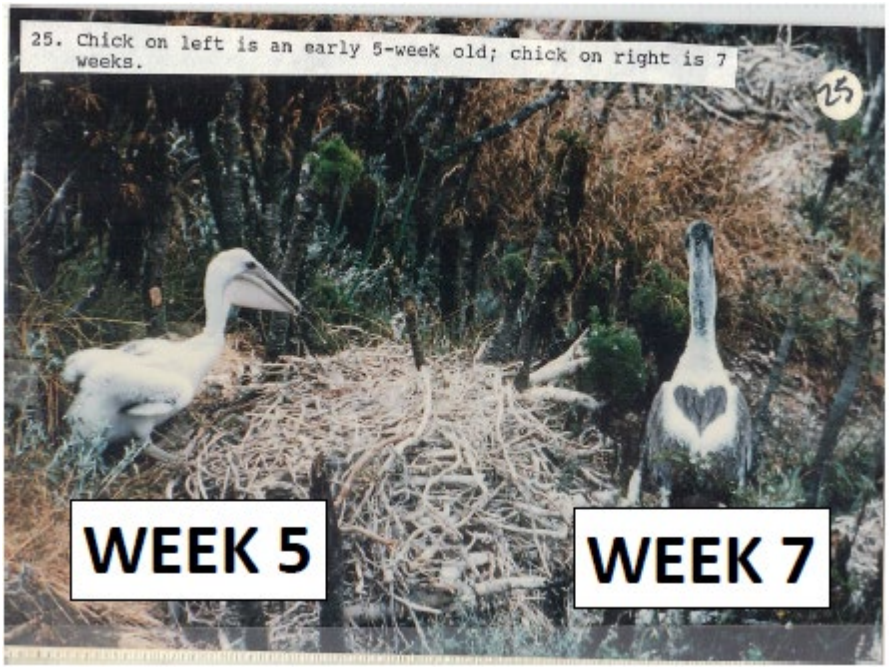
Typical "3-week old" chick: all downy white; good mobility but still confined mostly to nest; neck and head mostly covered by down; parent bird generally always present, but only broods closely in hot or cold weather conditions (and at night)

Both chicks about 24-28 days old ("typical" 4-week old chicks): note downy head and neck, also scapular feathers just emerging on back; primary feathers on wings may also be showing; very mobile and begins exploring off the nest

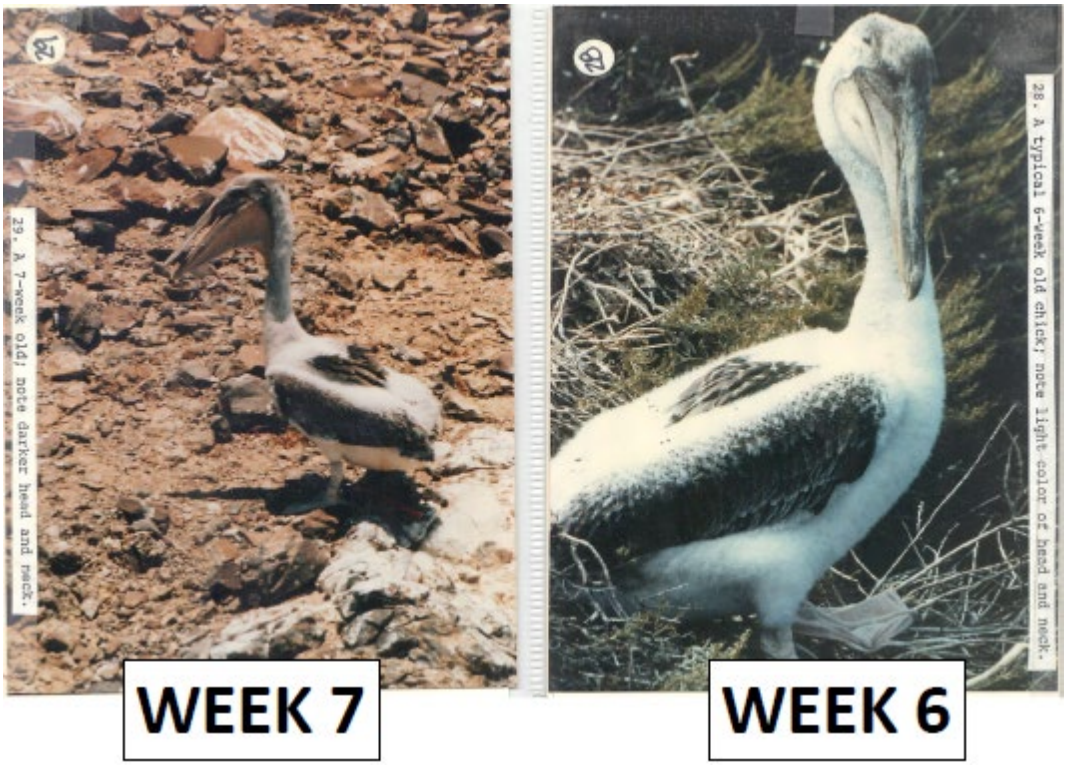


"Typical 5-week old": down well-established on head and neck; scapulars and wing feathers developing; brown starts showing up on back at about 30 days (note bands on leg; only chicks 4 weeks or older are banded); head becoming gray.

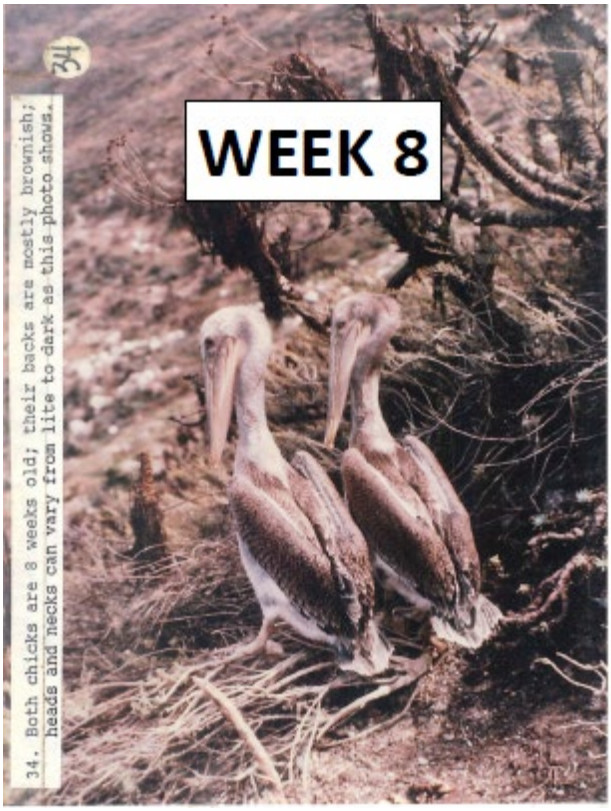
The two chicks in center are about 6 weeks old; chick on right is about 7 weeks old; wing feathers at 7 weeks are about 1/4 grown in; back appears mostly gray brown by end of week 7; notice how much browner the feathers are on all 3 chicks – from age 6 weeks, chicks become progressively browner with age.



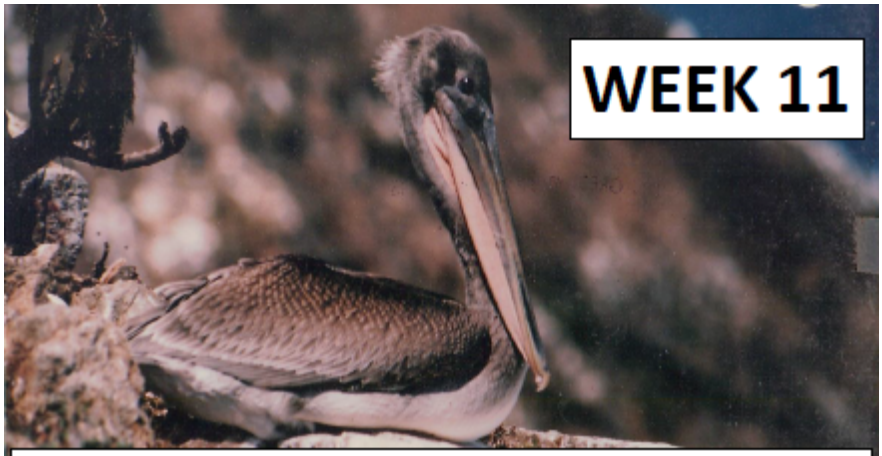

WEEK 6
WEEK 7
27. Two birds on left are about 6 weeks; two on right are about 7 weeks; note darker head and neck of 7-week olds--head and neck become darker with age (heads of 6-week olds are lightly gray).


WEEK 7
WEEK 6
29. A 7-week old; note darker head and neck.
28. A typical 6-week old chick; note light color of head and neck.

Chicks in middle are all about 7 weeks; chick to left is 8 weeks– note its darker appearance (back, head and neck all appear gray-brown); although not visible in this photo; at 8 weeks the belly is beginning to show emerging feathers; also wing feathers are about 1/2 grown in



Both chicks are about 10 weeks old; at 9 weeks, wing feathers are about 3/4 grown in, and at 10 weeks wing feathering is more-or-less complete. Belly feathering at 10 weeks is nearly complete, but some down still on lower belly (not down on chick to left); down also remains on rump, mid-back, lower neck and in axilla (under wing); head and neck progressively become darker.



A nearly-fledged 11-12 week old (difficult to age in photo); note dark head and neck; last of down by end of week 11 (only on flanks and axilla); unable to fly, but are flapping wings and moving around colony a great deal. By week 13-14, chicks will fledge; some down may still exist under legs and wings.

NOTE: For purposes of monitoring, there is no need to age chicks older than 9 weeks; it is very difficult from a distance to distinguish pelican chicks 9-14 weeks old. It is sufficient to pool all chicks 9 weeks and older into a single category, which I call "OYY" (older young-of-the-year) or label as "9+ weeks"