CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

PENINSULAR BIGHORN SHEEP 2019-20 ANNUAL REPORT

This report presents information on the status, distribution, and management of Peninsular bighorn sheep from 1 June 2019 to 31 May 2020

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Photo by J. Young

California Department of Fish and Wildlife
Peninsular Bighorn Sheep 2019-20 Annual Report
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Photo by Jeff Young

EXECUTIVE SUMMARY

Desert bighorn sheep (*Ovis canadensis nelsoni*) inhabit the desert slopes of the Peninsular Ranges of southern California and extend into the mountains of Baja California in Mexico. The population within the Peninsular Ranges was listed as threatened in 1971 under the California Endangered Species Act. In 1974, the population was estimated at 1,171 (Weaver 1975) but by 1996 the range-wide population estimate had declined to only 277 adult sheep (USFWS 2000). Peninsular bighorn sheep were listed by the U.S. Fish and Wildlife Service as a federally endangered population segment in 1998 (63 FR 13134). Reasons for this listing were: 1) habitat fragmentation, degradation, and habitat loss by urban and commercial development; 2) disease; 3) predation coinciding with low population numbers; 4) human disturbance; 5) insufficient lamb recruitment; 6) nonnative toxic plants; and 7) prolonged drought (USFWS 2000).

The last range-wide population survey, conducted in 2016, estimated a stable population of 884 Peninsular bighorn sheep. The current population status of Peninsular bighorn sheep is unknown because surveys were not conducted in 2018 due to lack of helicopter availability and/or funding limitations. Therefore, it is unknown whether the range-wide population has remained stable, increased, or decreased since the 2016 surveys.

Maintaining a representative sample of 25% to 30% radio-collared bighorn sheep in each recovery region is important for generating reliable mark-resight population estimates and accurately tracking trends in distribution and movement patterns, adult survivorship, cause-specific mortality, and overall health status. Unfortunately, due to on-going funding shortages, only 16% of the estimated range-wide ewe (female) population was radio-collared at the beginning of the current reporting period compared to only 13% at the end of the reporting period (based on 2016 generalized ewe population survey estimate of 552). Therefore, all descriptive statistics presented for the current reporting period may not necessarily be representative of the greater Peninsular bighorn sheep population. By 2021, the following recovery regions will have little to no radio-collared bighorn sheep representation: Coyote Canyon, Northern and Southern San Ysidro Mountains, and the Southern Santa Rosa Mountains. Consistent funding for every recovery region is needed before information on population status and dynamics can be accurately assessed.

On average, 12.8% of all active radio-collared bighorn sheep die each year with predation accounting for 7.5%, unknown causes 2.5%, nonpredation 1.8%, capture related 0.6%, and urban related 0.4%. Over the current reporting period, 14.1% of all active radio-collared bighorn sheep died of which 10.9% was attributed to predation, 2.2% was due to unknown causes, and 1.1% was due to nonpredation.

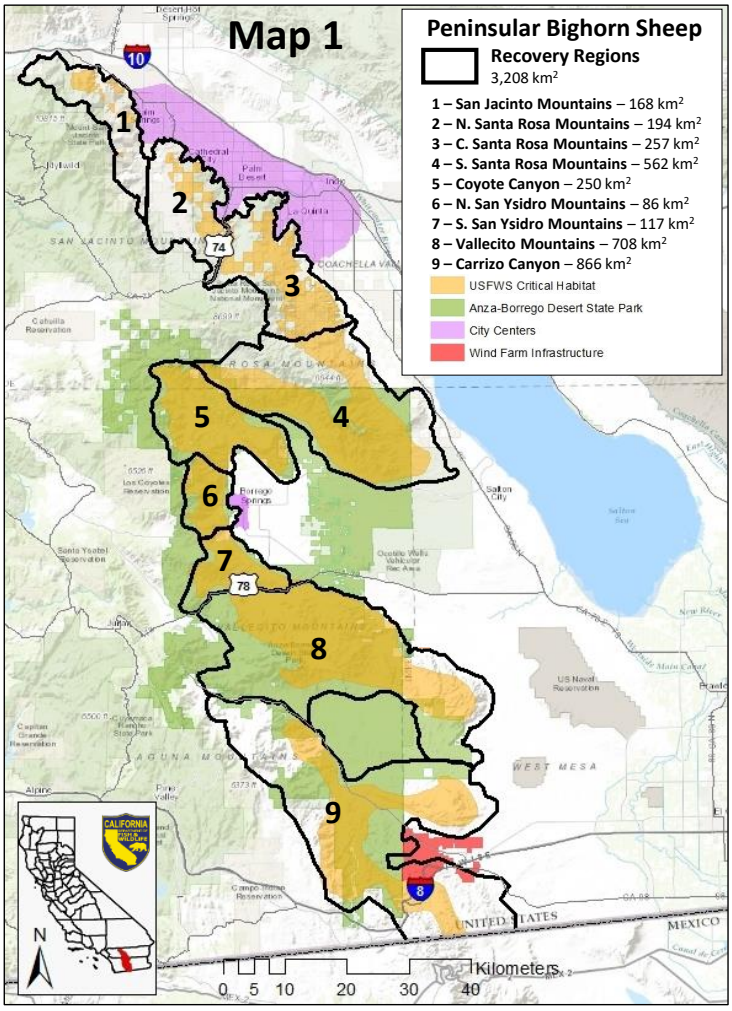
Average annual range-wide survival of radio-collared ewes is 88.4% ± 1% (annual Kaplan-Meir survival rates reported as mean percent survival ± 95% Confidence Interval). For the current reporting period, average annual range-wide survival of radio-collared ewes was 85.4% ± 7% with the caveat that range-wide representation of radio-collared ewes was only 16% at the start of the reporting period and likely underestimates the actual survival rate.

Respiratory disease in lambs has been a persistent problem in all recovery regions of the Peninsular Ranges. Evidence suggests that once pneumonia is introduced within a population, healthy periods are of short duration and persistently low recruitment rates below 30% may pose a significant obstacle in population recovery (Cassirer et al. 2013). In Coyote Canyon, and the Northern and Southern San Ysidro Mountains recovery regions where lamb recruitment monitoring efforts have been ongoing for the past 12 years, lamb recruitment indices have only exceeded 30% twice for each recovery region. Recruitment indices for 2019 were as follows: In-Ko-Pah ewe group 40% and Tierra Blanca ewe group 28% (both in Carrizo Canyon recovery region), Central Santa Rosa Mountains 29%, Coyote Canyon 28%, Northern Santa Rosa Mountains 24%, Northern San Ysidro Mountains 19%, San Jacinto Mountains 7%, and Southern San Ysidro Mountains 1%.

Since 2009, California Department of Fish and Wildlife has deployed Global Positioning System (GPS) radio-collars on female bighorn sheep to understand ewe group structure and seasonal movements within the Peninsular Ranges. Thus far, there have been 19 ewe groups identified within the Peninsular Ranges. Based on GPS data available for the current reporting period, there have been no significant spatial changes in overall ewe group home range size or movement among ewe groups. However, there was very little GPS data available for several recovery regions including Coyote Canyon, Southern Santa Rosa Mountains, Southern San Ysidro Mountains, and the Jacumba ewe group in Carrizo Canyon recovery region.

Presently, there is substantial genetic variation and gene flow among bighorn sheep populations within the Peninsular Ranges and across the U.S./Mexico Border indicating functional connectivity (Buchalski et al. 2015). However, connectivity between the U.S. and Mexico is threatened by the current construction of a bollard fence along the international border through the extent of bighorn sheep habitat. Additional factors that may hinder recovery efforts range-wide are disease, climate change, the loss of natural water sources and the lack of regular maintenance for artificial water sources, reduction and fragmentation of bighorn sheep habitat, habitat modification due to invasive nonnative plants, bighorn sheep use of urban areas, and human disturbance of essential sheep habitat especially around the urban centers.

Effective management strategies depend on consistent and accurate monitoring and research efforts that can only be attained with consistent, long-term funding. Federal, state, and local government agencies need to commit to Peninsular bighorn sheep population recovery and protection of bighorn sheep habitat by following all guidelines outlined in the U.S. Fish and Wildlife Service Recovery Plan if recovery efforts are to succeed.



BACKGROUND

This report summarizes radio-collar monitoring activities undertaken by the California Department of Fish and Wildlife (CDFW) of bighorn sheep in the Peninsular Mountain Ranges of southern California. Desert bighorn sheep inhabiting the Peninsular Ranges are a federally listed endangered species (USFWS 2000). CDFW carries out population monitoring and recovery efforts under U.S. Fish and Wildlife Service (USFWS) Endangered Species Permit TE163017-1. This report summarizes monitoring activities over a 12-month period from 1 June 2019 to 31 May 2020.

The Peninsular Mountain Ranges contain 9 designated Peninsular bighorn sheep (PBS) recovery regions occupying portions of southern Riverside, western

Imperial, and eastern San Diego Counties (Map 1). The 9 recovery regions are: 1) San Jacinto Mountains (SJM), 2) Northern Santa Rosa Mountains (NSRM), 3) Central Santa Rosa Mountains (CSRM), 4) Southern Santa Rosa Mountains (SSRM), 5) Coyote Canyon (CoC), 6) Northern San Ysidro Mountains (NSYM), 7) Southern San Ysidro Mountains (SSYM), 8) Vallecito Mountains (VM), and 9) Carrizo Canyon (CC).

RECOVERY PROGRAM OVERVIEW

Monitoring Activities

Activities conducted during this reporting period were tied to recovery elements contained in the Recovery Plan for bighorn Sheep in the Peninsular Ranges, California (USFWS 2000). Section II of the recovery plan addresses the need to "Initiate or continue research programs necessary to monitor and guide recovery efforts". Monitoring activities are covered in sections II.D.2.1 (Monitor population status), II.D.2.1.2 (Monitor distribution), and II.D.2.1.4 (Monitor survivorship and cause-specific mortality) of the recovery plan.

CDFW monitored all Very High Frequency (VHF) and Global Positioning System (GPS) radio-collared sheep range-wide using a combination of satellite, remote-download, and field monitoring. Monitoring efforts focused on the following: 1) radio-collared sheep status (alive/dead), 2) mortality investigations, 3) observations of sheep group composition, health, lamb recruitment and survival, and 4) spatial and temporal movements.

Personnel

Mr. Randy Botta, Senior Environmental Scientist (Specialist) CDFW South Coast Region, is the Endangered Species Permit TE163017-1 Principal Officer and responsible for oversight on range-wide monitoring activities and providing all notifications and reports to USFWS. Range-wide PBS field monitoring activities and mortality investigations were carried out by Ms. Janene Colby, Environmental Scientist with the South Coast Region under the lead of Mr. Botta. Starting in the second half of the current reporting period, mortality investigations and field monitoring activities for PBS recovery regions 1-3 were carried out by Ms. Erin Schaeffer, Environmental Scientist CDFW Inland Deserts Region, under the supervision of Mr. Jeff Villepique, Senior Environmental Scientist (Supervisor). Field monitoring activities in PBS recovery regions 1-3 were conducted jointly by CDFW and Bighorn Institute. Justin Conley, Environmental Planner for the Agua Caliente Band of Cahuilla Indians assisted CDFW with mortality investigations and field monitoring activities in PBS recovery region 1.

RADIO-COLLAR STATUS

The recovery plan (USFWS 2000) recommends maintaining active radio-collars on approximately 25-30% of the PBS population within each recovery region. Maintaining a representative sample of radio-collared PBS is important for generating reliable mark-resight population estimates and accurately tracking trends in distribution and movement patterns, adult survivorship, cause-specific mortality, and overall health status. The cost associated with radio-collars and capture operations are extremely high and it has become increasingly difficult for CDFW to procure funds on a consistent basis. Without consistent funding to maintain active radio-collars on minimally 25% of PBS within each recovery region each year, it will be impossible to accurately estimate population abundance and viability. With limited funding, CDFW has focused efforts on radio-collaring ewes since they are the reproductive base of the population.

At the beginning of the reporting period (1 June 2019), the 9 recovery regions contained 92 (89F, 3M) active radio-collared bighorn sheep (Table 1). Over the reporting period, 13 radio-collared ewes died and radio-collars for 2 ewes became nonfunctional (censored). At the end of the reporting period (31 May 2020), there were 77 (74F, 3M) active radio-collared bighorn sheep. Range-wide, approximately 16% of the estimated ewe population was radio-collared at the beginning of the reporting period compared to only 13% at the end of the reporting period (based on 2016 generalized ewe population survey estimate of 552). Currently, the percentage of radio-collared ewes in each recovery region, except for the NSRM, falls far below the recommended minimum of 25% (Table 1); and thus, the information provided within this report is likely not representative of the greater PBS population. Uneven distribution of radio-collars across recovery regions is due to funding often being tied to specific areas only. On average, approximately 19.5% of radio-collars are lost each year due to

deaths (12.8%) and collar failure (6.6%); therefore, regular captures are necessary to maintain a representative sample of marked animals. A capture is planned for November 2020 in the SJM, NSRM, CSRM, VM and CC recovery regions. Unfortunately, there is no funding available for captures in some areas where collars are needed most such as CoC, SSYM, NSYM and SSRM. Consistent funding for every recovery region is needed before information on population status and dynamics can be accurately assessed.

Table 1. Distribution and numbers of active radio-collared female (F) and male (M) bighorn sheep within the 9 recovery regions starting on 1 June 2019 and ending on 31 May 2020. The estimated percentages of radio-collared females (% F Collared) at the beginning (grey font) and end (black font) of the reporting period is based on the generalized ewe abundance estimates from the 2016 helicopter survey. Mortalities (red font) are the number of bighorn sheep that died during the reporting period. Censored (green font) is the number of bighorn sheep with radio-collars that became nonfunctional during the reporting period.

Category	SJM		NSRM		CSRM		SSRM		CoC		NSYM		SSYM		VM		CC		Subtotal		Grand
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	Total
6/1/2019	6	1	15	0	8	0	11	0	2	0	8	0	4	0	17	0	18	2	89	3	92
%F Collared	19%		54%		12%		20%		4%		28%		14%		17%		11%		16%		
mortalities	1		2		1		1		1		3				1		3		13		13
censored			1				1												2		2
5/31/2020	5	1	12	0	7	0	9	0	1	0	5	0	4	0	16	0	15	2	74	3	77
%F Collared	16%		43%		11%		17%		2%		17%		14%		16%		9%		13%		

The general term "radio-collar" includes 3 types of telemetry systems currently deployed on bighorn sheep in the Peninsular Ranges: VHF, GPS, and satellite collars (Table 2). While both GPS and satellite collars record location data using a satellite system, the method by which location data are obtained differs. The GPS collars currently being used in the Peninsular Ranges are solar powered, store-on-board with remote line-of-site data download capabilities. Obtaining location data from these GPS collars is labor-intensive; however, the collars are very reliable, often collecting hourly location data for up to 6 years. The satellite collars can transmit location data to a data portal every 1 to 3 days and the data can be easily viewed and accessed from a web-service. The satellite collars currently deployed are scheduled to drop off in fall 2020. The planned November 2020 capture will attempt to capture and fit new satellite collars on ewes in the SJM, NSRM, CSRM, VM and CC recovery regions. Hereafter, GPS collars will be used to describe both solar GPS and satellite collars unless otherwise stated.

Table 2. Total number of GPS, Satellite, and VHF radio-collars available during the reporting period not counting collar losses due to mortality or censored over the reporting period.

Region	Radio-collar type			Total by Region
	GPS	Satellite	VHF	
1 SJM		6	1	7
2 NSRM		12	3	15
3 CSRM	8			8
4 SSRM	3	4	4	11
5 CoC	1		1	2
6 NSYM	4		4	8
7 SSYM			4	4
8 VM	9	1	7	17
9 CC	5	1	14	20
Total	42	24	26	92

The VHF collar brand currently used by CDFW are inexpensive and often last between 7 and 10 years, which can minimize the number of times sheep need to be recaptured and collared. While GPS collars are the best method to define home range use and movement, VHF collars are the most cost-effective method for maintaining a representative sample of radio-collared PBS for generating reliable mark-resight population estimates.

POPULATION ABUNDANCE

From 1996 to 2010, the range-wide PBS population steadily increased from an estimated 277 to 955 (Table 3). While surveys are typically conducted biennially, they were not conducted in 2012, 2014, 2018 or 2020. The last range-wide population surveys were conducted in 2016 and estimated a stable range-wide PBS population of 884. The 2016 survey

marked the first time since PBS were listed as an endangered species that 25 ewes or more were counted in each recovery region. As such, 2016 marked year 1 of 6 consecutive years in meeting criterion 1 in section II.B.2 for downlisting PBS from endangered to threatened status (USFWS 2000). Unfortunately, because surveys were not conducted in 2018 or 2020 due to lack of a state-wide helicopter services and/or funding limitations, it is unknown if 25 ewes were maintained within each recovery region for the past 4 years. Currently, it is unknown whether the range-wide population has remained stable, increased, or decreased since the last survey; therefore, without regular population estimates it is not possible to assess if recovery goals are being met. If surveys are conducted in 2022, mark-resight estimates may not accurately reflect abundance in recovery regions that lack adequate representation of radio-collared ewes such as in the SSRM, CoC, NSYM, and SSYM.

Table 3. Population abundance estimates (adult rams + adult ewes + yearlings) per Recovery Region (RR) for Peninsular bighorn sheep from 1994 to 2016 based on helicopter surveys. Bighorn Institute (BI) conducted helicopter surveys in RR 1-4 from 1994-2008 and used a variety of statistical methods to generated population abundance estimates (Green italic numbers). CDFW conducted helicopter surveys in RR 5-9 from 1994-2008, and RR 1-9 in 2010 and 2016: population abundance estimates (blue bold numbers) were generated using Chapman's (1951) modification of the Peterson estimator (Seber 1982) unless otherwise noted. Due to a lack of a CDFW helicopter contract and/or lack of funding, surveys were not conducted in 2012, 2014, & 2018.

Recovery Region	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018
RR 1 - San Jacinto Mtns.	*17*	*19*	*23*	*17*	*22*	*32*	*21*	*26*	**16**			**56**	
RR 2 - N. Santa Rosa Mtns.			*22*	*32*	*40*	*57*	*49*	*77*	**90**			**37**	
RR 3 - C. Santa Rosa Mtns.	*117*[a]	*94*[a]	*72*	*53*	*115*	*No*	*163*	*122*	**133**			**119**	
RR 4 - S. Santa Rosa Mtns.			*35*	*51*	*84*	*Surveys*	*179*	*155*	**149**	No Range-wide Survey	No Range-wide Survey	**83**	No Range-wide Survey
RR 5 - Coyote Canyon	**29**	**37**	**35**	**35**	**35**	**47**	**42**	**52**	**66**			**69**	
RR 6 - N. San Ysidro Mtns.	**68**	**39**	**34**	**33**	**47**	**50**	**79**	**82**	**72**			**59**	
RR 7 - S. San Ysidro Mtns.	**19**	**26**	**41**	**39**	**41**	**47**	**38**	**53**	**55**			**42**	
RR 8 - Vallecito Mtns.	**29**	**28**	**45**	**64**	**155**[b]	**150**[b]	**77**	**123**[b]	**142**			**163**	
RR 9 - Carrizo Canyon	**58**	**34**	**28**	**82**	**127**	**101**[b]	**145**	**186**[b]	**232**			**256**	
Total*	**337**	**277**	**335**	**406**	**666**	**Unknown**	**793**	**876**	**955**	**Unknown**	**Unknown**	**884**	**Unknown**

*This is the sum of recovery regions (Generalized) rather than a range-wide population abundance estimate.
[a]BI reported 1 helicopter survey estimate for all recovery regions combined (RR 2-4) in the Santa Rosa Mountains in 1994 and 1996.
[b]Due to the low proportion of radio-collared animals observed a "markless" population estimator was used.

CAUSE-SPECIFIC MORTALITY

Between 1 June 2019 and 31 May 2020 there were 13 radio-collared ewe mortalities (Table 4). Ewe mortalities by recovery region were SJM = 1, NSRM = 2, CSRM = 1, SSRM = 1, CoC = 1, NSYM = 3, VM = 1, and CC = 3. On average, 12.8% of all active radio-collared sheep die each year with predation (hereafter includes possible lion, probable lion and lion predation combined) accounting for 7.5%, unknown causes 2.5%, nonpredation 1.8%, capture related 0.6%, and urban related 0.4%. Over the current reporting period, 14.1% of all active radio-collared sheep died of which 10.9% was attributed to predation, 2.2% was due to unknown causes, and 1.1% was due to nonpredation. In 4 of the last 5 reporting periods, the percentage of radio-collared sheep deaths due to predation has increased (Figure 1).

Table 4. Cause of death for 13 radio-collared bighorn sheep by recovery region within the Peninsular Ranges of Southern California from 1 June 2019 to 31 May 2020. There are 3 categories under the umbrella of mountain lion predation that are based on direct evidence of a mountain lion kill (Lion), substantial amount of indirect evidence of a mountain lion kill (Lion – Probable), and some evidence of a mountain lion kill (Lion – Possible).

Region	Animal ID	Sex	Age	Mortality Date	Mortality Cause
SJM	480	F	6	4/23/2020	Lion - Probable
NSRM	470	F	6	12/13/2019	Lion
NSRM	[a]473	F	6	12/26/2019	Lion
CSRM	358	F	16	1/2/2020	Lion - Probable
SSRM	408	F	9	8/19/2019	Unknown
CoC	399	F	12	9/24/2019	Lion - Probable
NSYM	[b]308	F	13	1/2/2020	Lion - Probable
NSYM	309	F	11	1/26/2020	Lion
NSYM	315	F	16	4/23/2020	Age-related disease
VM	343	F	12	2/10/2020	Unknown
CC-TB	462	F	8	6/28/2019	Lion
CC-CC	330	F	10	3/19/2020	Lion
CC-IKP	278	F	10	6/13/2019	Lion - Possible

[a]Ewe 473 was pregnant at time of death
[b]Ewe 308's newborn lamb's remains were also found at the mortality site.

The long-term data indicates that predation risk is highest from December through March and is lowest in June and July. Multiple regression analysis indicates that average monthly temperature and average monthly precipitation significantly predicts the number of predation events (Adjusted $R^2 = 0.84$, $F(2,9) = 28.88$, $p < 0.0001$). As the temperature decreases ($\beta = -0.44$, $p = 0.005$) and precipitation increases ($\beta = 8.72$, $p = 0.05$), there is an increase in the number of predation

events. For the current reporting period, 7 of 10 predation events occurred between December and April at a time when ewes are either pregnant or caring for a lamb. Ewe 473 was confirmed pregnant and ewe 309 was likely pregnant at the time of their deaths. Ewe 308 and her newborn lamb were both killed by a mountain lion. Atypical to the long-term trend, 2 predation events occurred in June and 1 occurred in September. However, both ewes 399 and 462 were killed at natural water sources and ewe 278 was killed within a mile of an artificial water source.

Over 28 years, the average age of ewes when first captured and radio-collared was 5 years (age range = 0.8-12 years) with most ewes captured between the ages of 1 and 8 years. In comparison, the average age of radio-collared ewes that died due to predation was 9.2 years (age range = 3-18 years) with most predation deaths occurring between the ages of 7 and 11 years (n = 142). Similarly, for all nonpredation causes of death combined (excluding unknown causes), the average age of radio-collared ewes was 9.7 years (age range = 2-19 years) with most nonpredation deaths occurring between the ages of 7 & 10 years (n = 50). For the current reporting period, the average age of ewes that died due to predation (n = 10) was 10.2 years (age range = 6-16 years).

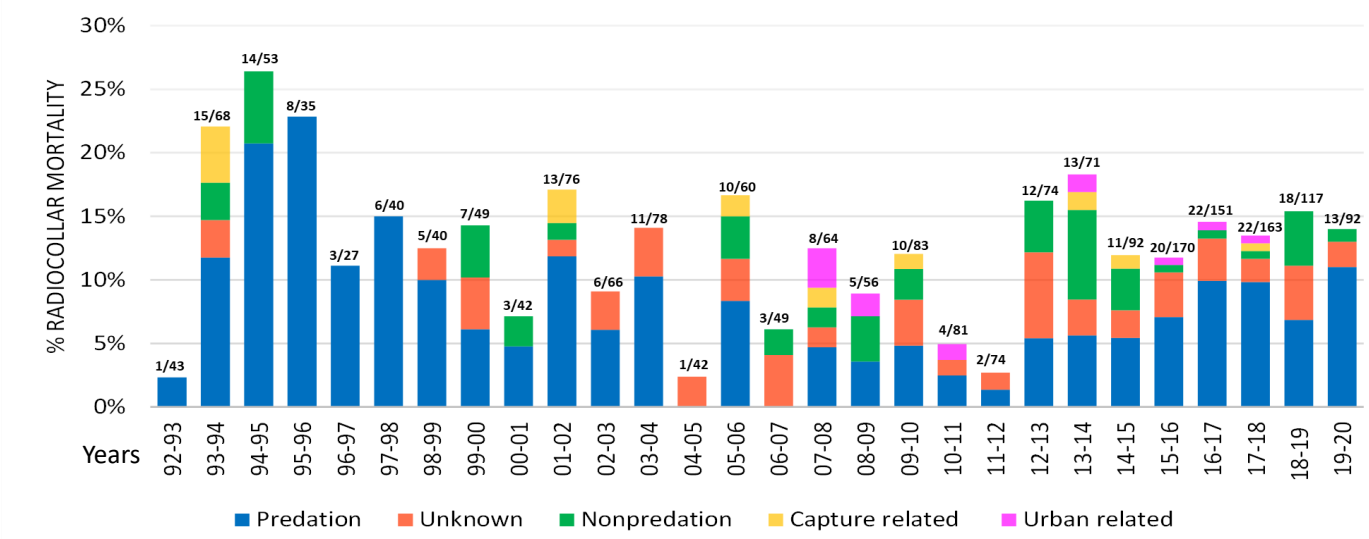


Figure 1. Percentage of radio-collared bighorn sheep mortality (number of radio-collar deaths ÷ number of radio-collared sheep) due to predation, unknown, nonpredation, capture related, and urban related causes for all radio-collared bighorn sheep over 28 reporting periods. Numbers above bar: number of radio-collared mortalities/number of radio-collared sheep. A reporting period is 12 months starting on June 1 of one year and ending 31 May of the following year. First reporting period: 1 June 1992 to 31 May 1993 (92-93). Current reporting period 28: 1 June 2019 to 31 May 2020 (19-20).

Non-collared Mortalities (Range-wide)

Documentation and mortality investigations of non-collared sheep deaths and/or injuries were undertaken when discovered by CDFW personnel during field monitoring or when reported by the public or government agencies. Because these mortalities are found by chance alone and typically near urban centers, they are not necessarily representative of the overall PBS population. Lambs with pneumonia have been documented in every recovery region; however, most deaths are documented in urban areas because lambs are more visible and easily found in comparison to lamb deaths in very remote areas. For the current reporting period, there were 21 non-collared bighorn sheep deaths reported (Table 5). The urban environment was directly responsible for most of the non-collared sheep deaths with 7 deaths due to drowning and 6 deaths due to vehicle collisions.

The section of the Coachella Canal running through SilverRock golf course and the community of PGA West is not fenced and is responsible for 11 of the 15 known cases of drowning between 2012 and the first half of 2020. The majority of PBS that drown are rams (12M, 3F) and most drown in August and September during the peak of the breeding season. During this reporting period, 3 rams drowned in the canal at PGA West, 1 lamb drowned in the canal at SilverRock, 1 ram drowned in Lake Cahuilla, and 2 rams drowned in residential pools that were not fenced.

Highway 74 and Interstate 8 are the leading roadways for vehicle-caused deaths within PBS habitat. Since 2007, there have been 31 (18M, 11F, 2 unknown sex) reports of sheep killed by vehicles on Highway 74. Despite the installation of flashing warning signals at either end of key crossing points on Highway 74 in May of 2018, a record number of sheep were killed in 2018 with 2 deaths prior to May and 4 deaths after signal installation. Data concerning PBS killed on Interstate 8 was not collected prior to 2012; however, since 2012 there have been 16 sheep killed on the Interstate. To date, there have been no corrective measures undertaken by responsible federal and state agencies to address the problem.

Table 5. Cause of death for 21 non-collared bighorn sheep by recovery region within the Peninsular Ranges of Southern California from 1 June 2019 to 31 May 2020. All mortalities were investigated by CDFW unless otherwise noted.

Region	Location	Date	Age	Sex	Cause
NSRM	Hwy 111/ Rancho Mirage	9/6/2019	Lamb	M	Vehicle Collision
NSRM	Carrizo Canyon	11/8/2019	Lamb	F	Pneumonia
NSRM	Cathedral City	11/15/2019	8	M	Drowned in homeowner's pool
NSRM	Grapevine Creek	12/12/2019	7	M	Lion Predation
NSRM	Bradley Canyon	1/22/2020	Lamb	M	Pneumonia
NSRM/CSRM	Highway 74	5/11/2020	Yearling	Unk	[a]Vehicle Collision
NSRM/CSRM	Highway 74	5/11/2020	Adult	F	[a]Vehicle Collision
CSRM	Lake Cahuilla County Park	7/31/2019	10	M	Drowned in Lake
CSRM	PGA West	8/5/2019	2	F	Heart disease (Myocarditis)
CSRM	PGA West	9/7/2019	3	M	Drowned in Coachella canal
CSRM	PGA West	9/17/2019	8	M	Drowned in Coachella canal
CSRM	PGA West	10/19/2019	Lamb	M	[b]Pneumonia
CSRM	PGA West	11/4/2019	Yearling	M	Drowned in Coachella canal
CSRM	SilverRock	5/30/2020	Lamb	M	Drowned in Coachella canal
CoC	Second Crossing	9/22/2019	5	F	Lion Predation - Possible
NSYM	Borrego-Palm Canyon	7/13/2019	8	F	Lion Predation - Probable
NSYM	DeAnza Country Club	8/28/2019	6	M	Drowned in homeowner's pool
SSYM	County Road S3	6/21/2019	Lamb	F	Vehicle Collision
SSYM/VM	Highway 78	10/15/2019	6	F	Vehicle Collision
CC	Tierra Blanca Mtns	9/1/2019	3	M	Lion Predation - Possible
CC	Interstate 8	12/13/2019	3	F	Vehicle Collision

[a]Reported by a motorist that saw the accident.
[b]Investigated by USFWS.

EWE SURVIVAL

Population viability is most sensitive to changes in ewe survival (Ruben et al. 2002); therefore, it is crucial to have consistent representative samples of radio-collared ewes in every recovery region each year to accurately track trends in survivorship. Very low numbers of radio-collars result in ewe survival estimates that are subject to a high degree of stochasticity and are thus not reliable indicators of survival. Furthermore, without consistent representative samples it is not possible to discern what factors may or may not be driving survival trends among regions.

Over the previous 27 years, average range-wide survival of radio-collared ewes was 88.4% ± 1% (annual Kaplan-Meir survival rates reported as mean percent survival ± 95% Confidence Interval). For the current reporting period, average range-wide survival of radio-collared ewes was 85.4% ± 7% with the caveat that range-wide representation of radio-collared ewes was only 16% at the start of the reporting period.

The estimated percentage of radio-collared ewes was below 25% at the start of the reporting period in every recovery region except for the NSRM (Table 1). Additionally, the number of radio-collared ewes was low in the SJM, CSRM, and NSYM and therefore, the following survival rates should be assessed with caution and most likely are artificially low: SJM 83.3% ± 30%, NSRM 86.7% ± 17%, CSRM 87.5% ± 23%, SSRM 90.9% ± 17%, NSYM 62.5% ± 34%, VM 94.1% ± 11% and CC 83.3% ± 17%. Survival rates in CoC and SSYM were not calculated due to the extremely low number of radio-collared ewes present in each of these regions.

LAMB SURVIVAL AND RECRUITMENT

Outside of all-age outbreaks of disease, lamb survival is considered the best demographic indicator of the health of bighorn sheep populations (Cassirer et al. 2017). Unfortunately, respiratory disease in lambs has been a persistent problem in all recovery regions of the Peninsular Ranges. The bacterium *Mycoplasma ovipneumoniae* (hereafter referred to as *M.ovi*) has been identified as the primary pathogen associated with pneumonia in wild sheep populations throughout the western United States (Besser et al. 2008, and Besser et al. 2012). Results from blood samples collected from PBS captured from 1999 to 2015 found that approximately 51% of sheep in each recovery region tested positive for the presence of *M.ovi* (Testing performed by Washington Animal Disease Diagnostic Laboratory at Washington State University).

Poor lamb survival to approximately 4 months of age is considered the most sensitive indicator of pneumonia-induced mortality in lambs (Cassirer et al. 2017). Furthermore, persistently low recruitment below 30% may pose a significant

obstacle in population recovery (Cassirer et al. 2013). Lamb:ewe ratios are used as indices of lamb survival (survival to ~ 3 to 4 months) and yearling:ewe ratios are used as indices of recruitment (survival to 1 year). Due to concerns of respiratory disease in lambs, lamb survival and recruitment data have been collected by CDFW since 2008 in CoC, NSYM and SSYM recovery regions and in the In-Ko-Pah (IKP) and Tierra Blanca (TB) ewe groups both in the CC recovery region since 2010 and 2014 respectively (Table 6). Survival and recruitment data were added in the CSRM recovery region in 2015 and for other recovery regions when time allowed (Table 6). In addition to survival and recruitment indices listed in Table 6, lamb recruitment was 15% in 2019 and lamb survival was 26% in 2020 in the VM recovery region.

Table 6. Index of lamb survival to approximately 4 months old (Survived) and recruitment of lambs to yearlings (Recruited) in CoC (Coyote Canyon), NSYM (North San Ysidro Mountains), SSYM (South San Ysidro Mountains), IKP (In-Ko-Pah) and Tierra Blanca ewe groups in CC (Carrizo Canyon) recovery region, CSRM (Central Santa Rosa Mountains), SJM (San Jacinto Mountains), and NSRM (North Santa Rosa Mountains) recovery regions. Lamb survival was calculated from lamb:ewe ratios from group observations obtained in the field from May-June of the year lambs were born and matched with yearling:ewe ratios (recruited) from January - June of the following year. For example, in 2019 in CoC, 43% of lambs survived to 4 months (Survived), and 28% survived to become yearlings (Recruited).

Year	CoC		NSYM		SSYM		IKP-CC		Tierra Blanca-CC		CSRM		SJM		NSRM	
	Survived	Recruited	Survived	Recruited	Survived	Recruited	Survived	Recruited	Survived	Recruited	Survived	Recruited	Survived	Recruited	Survived	Recruited
2008	66%	21%	43%	21%	64%	29%	*	*	*	*	*	*	*	*	*	*
2009	51%	31%	30%	24%	41%	18%	*	*	*	*	*	*	*	*	*	*
2010	37%	24%	14%	19%	61%	28%	79%	39%	*	*	*	*	*	*	*	*
2011	56%	4%	21%	3%	58%	17%	63%	20%	*	*	*	*	*	*	*	*
2012	36%	7%	13%	13%	63%	38%	70%	45%	*	*	*	*	*	*	*	*
2013	26%	7%	7%	18%	93%	*	51%	26%	*	32%	*	*	*	*	*	*
2014	25%	22%	38%	34%	*	27%	10%	8%	17%	15%	*	35%	*	*	*	*
2015	35%	27%	19%	11%	47%	23%	86%	35%	70%	41%	56%	16%	*	*	*	*
2016	73%	52%	66%	43%	94%	42%	75%	33%	67%	32%	74%	23%	*	*	*	*
2017	[a]41%	24%	77%	34%	83%	32%	b	26%	35%	33%	24%	18%	*	*	*	*
2018	31%	18%	33%	22%	22%	11%	41%	13%	28%	21%	67%	17%	*	14%	*	4%
2019	[a]43%	28%	20%	19%	5%	1%	[c]67%	40%	57%	28%	b	29%	4%	7%	b	24%
2020	29%		24%		20%		67%		11%		48%		13%		17%	

[a]Lamb:ewe ratio obtained from Anza-Borrego Desert State Park annual sheep count for CoC
[b]Not enough observation data were obtained for 4-month lamb:ewe ratios.
[c]Adjusted due to higher recruitment than survival data
* Recruitment and survival data were not collected

While indices of lamb survival can vary widely by ewe group, season and year, indices for lamb recruitment for adjacent ewe groups share similar trends (Figure 2). Coyote Canyon and NSYM ewe groups overlap spatially and temporally much more than does NSYM and SSYM ewe groups (Map 2) and this is reflected in recruitment trends among the 3 groups over a 12-year period (Figure 2). Between 2008 and 2010 all 3 ewe groups had similar recruitment indices roughly between 20% and 30%. In 2011, indices in both CoC and NSYM declined to a record low of less than 5% recruitment while SSYM remained relatively higher at 17%. After 2011, recruitment indices slowly increased both in CoC and NSYM but rebounded more quickly for SSYM. In a 12-year period, each ewe group attained recruitment indices above 30% only twice with all 3 attaining their highest recruitment indices above 40% in 2016 (with the caveat that no recruitment data were collected in the SSYM for 2013). Since 2016, recruitment indices have been on a downward trajectory in all 3 ewe groups.

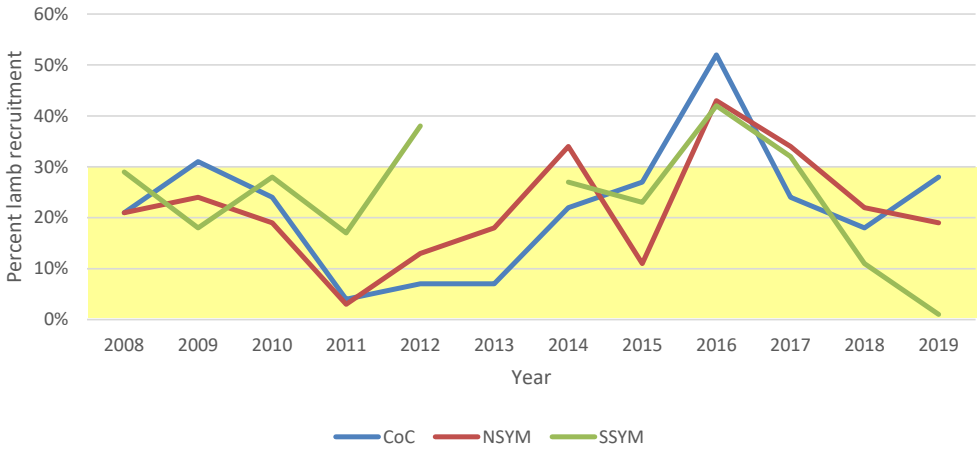
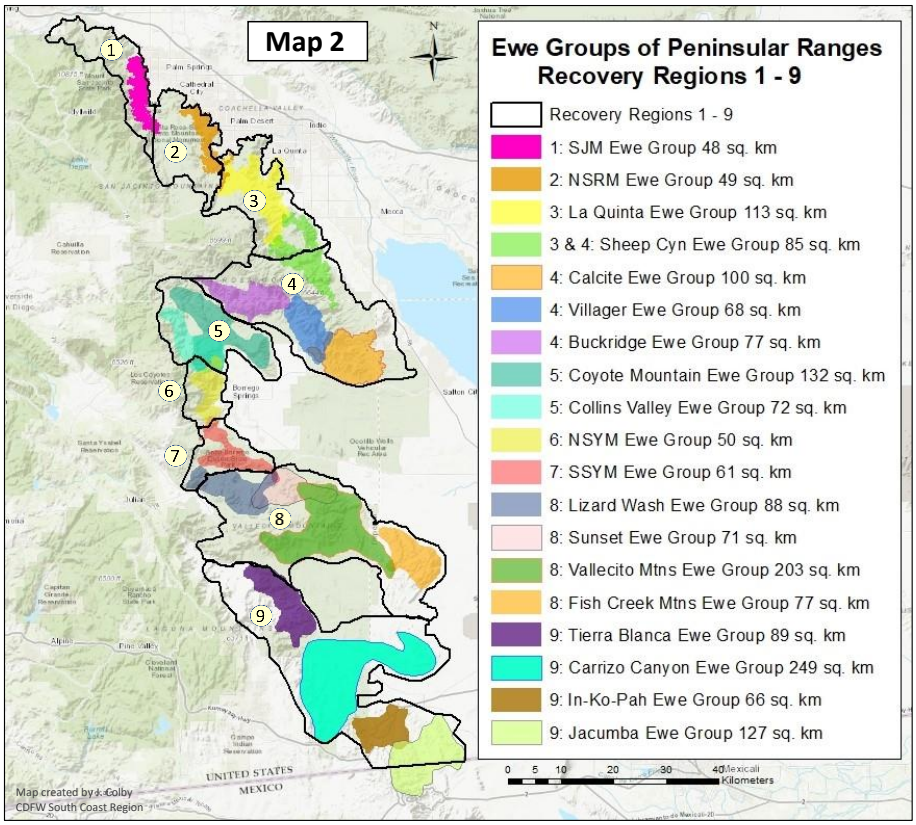


Figure 2. Lamb recruitment indices for CoC, NSYM and SSYM recovery regions from 2008 to 2019 based on CDFW group observations.

DISTRIBUTION AND MOVEMENT

Since 2009, CDFW has deployed GPS collars on bighorn sheep range-wide to build a foundation of knowledge concerning distribution, movement, and ewe group structure within the Peninsular Ranges. Each individual ewe's GPS location data is analyzed and grouped by summer (1 June – August 31), pre-lambing (1 September – 31 December), and lamb-rearing (1 January – 30 May) seasons. All ewes with similar seasonal patterns of habitat use are grouped together into a single ewe group and, if appropriate, those individuals displaying distinct patterns of habitat use into sub-ewe groups. Presently, there are 19 ewe groups identified in the Peninsular Ranges; additionally, within almost every ewe group, several sub-ewe groups have been identified (Map 2). Refer to CDFW 2016-17 Annual Report for detailed information and maps of ewe group distribution and movement in the Peninsular Ranges.



For the current reporting period, GPS location data were available in all recovery regions except the SSYM, the Sunset ewe group in the VM, the Jacumba ewe group in the CC recovery region, and CoC recovery region. Based on GPS data currently available, there have been no significant spatial changes in overall ewe group home range size or movement among ewe groups; however, ewes are spending a greater portion of their time in low elevation habitat particularly during the lamb-rearing season based on GPS data and direct observations. This temporal shift may be a response to long-term drought conditions. Section I.B.1 of the PBS Recovery Plan (FWS 2000) states that alluvial fans, washes, and desert flats are crucial to the viability of bighorn sheep populations because they seasonally provide high-quality vegetation, particularly during times of drought. Vegetation and water-rich cactus are more abundant in alluvial fans than in steep terrain and provide an important source of nutrition and water during lactation (Hansen and Deming 1980). In a recent study that characterized lamb-rearing habitat, ewe groups in CoC, CC, and IKP moved closer to alluvial fans when choosing lamb-rearing habitat (Hines 2019).

The increase in time spent in low elevation habitat is not just a phenomenon of ewe groups living adjacent to urban areas but occurs in wilderness areas as well. GPS data for ewe 320, a member of the Vallecito Mountains ewe group in the VM recovery region, exemplifies this shift to lower elevation use each year during the first 4 months of lamb-rearing season (Figure 3). Regardless of the cause of the seasonal shift to lower elevation habitat, sheep in wilderness areas such as within ABDSP have abundant low elevation habitat available for their unrestricted use as needed. In contrast,

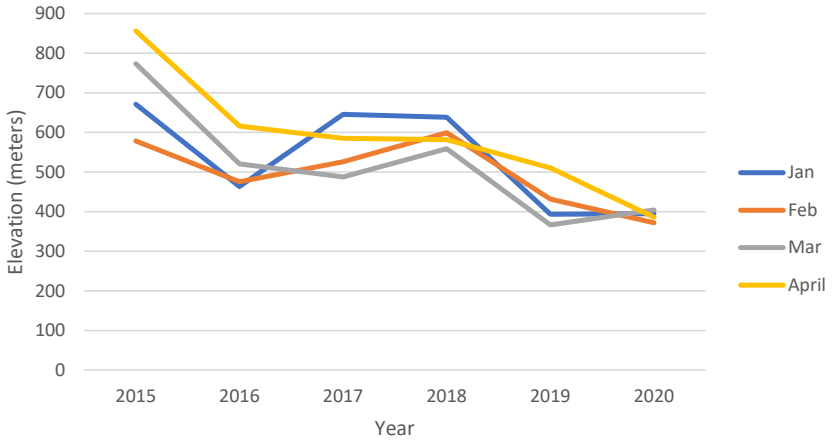
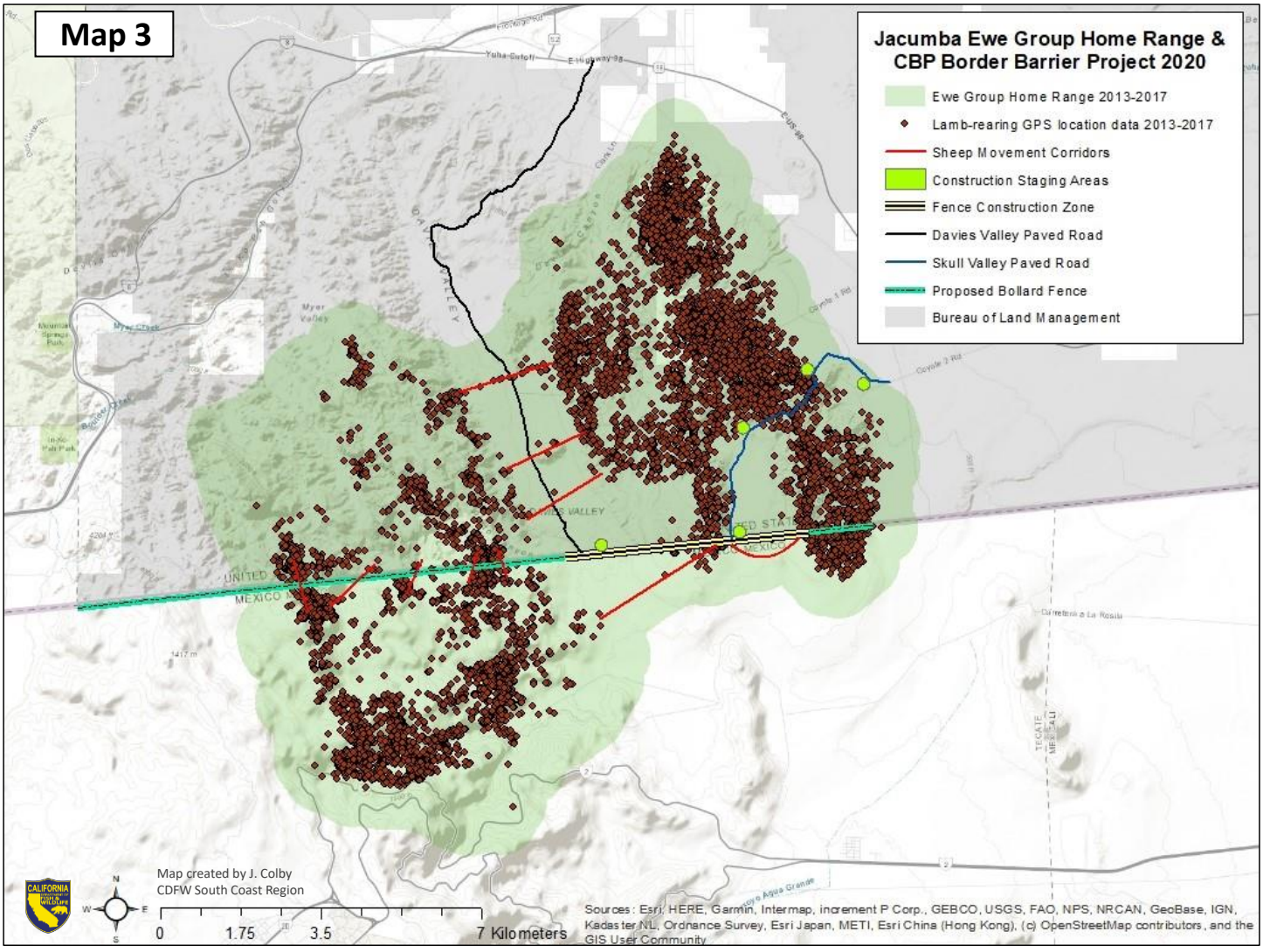


Figure 3. Average monthly elevation of GPS location data for ewe 320 during the lamb-rearing season (January – April) from 2015 through 2020.

most low elevation habitat in recovery regions 1-3 has been developed or is greatly impacted by human recreational activities.

One very important area that does not have GPS data available for the current reporting period is the Jacumba ewe group within the CC recovery region. In October 2013, CDFW captured 7 PBS (4 ewes and 3 rams) in the Jacumba Wilderness and fitted them with solar GPS collars. GPS location data from these sheep provided the first and only glimpse to date of home range use for this ewe group (Map 3). Location data demonstrated how this ewe group is dependent upon resources both within the United States and Mexico. Since 2014, CDFW's annual reports have provided maps and information about the Jacumba ewe group and have emphasized the importance of keeping connectivity between the United States and Mexico for the continued viability of this ewe group (Colby & Botta 2014, 2015, 2016-17, 2017-18, and 2018-19). In Spring of 2020, CDFW submitted comments and recommendations to assist U.S. Customs and Border Protection (CBP) in avoiding or minimizing potential impacts to endangered bighorn sheep from border barrier construction. However, because the border barrier project was deemed an emergency, environmental regulations and review were waived and construction of an 11-mile bollard fence through the middle of bighorn sheep habitat started in May 2020. A paved road built through Davies Valley cuts across several key sheep movement corridors and the paved road built into Skull Valley runs through core lamb-rearing habitat (Map 3). All construction activities occurred during the peak of the lamb-rearing season and most construction staging areas were within sensitive lamb-rearing habitat and movement corridors. To what extent the construction activities have impacted sheep is not known as the GPS units on the remaining 4 radio-collared sheep (2 ewes and 2 rams) no longer function.



THREATS TO RECOVERY

Section II.D.1.1-1.4 of the Peninsular Ranges bighorn sheep recovery plan (USFWS 2000) describes a series of interim and long-term actions that, if implemented, would eliminate, or significantly reduce threats to population recovery. Actions described in the recovery plan address a broad range of known and potential threats to recovery. These threats (generally described) include but may not be limited to the following: 1) Disease, 2) habitat loss and fragmentation, 3) loss of habitat connectivity, 4) loss of habitat quality due to natural (fire) and human causes (introduction of exotic/toxic vegetation), 5) loss, reduction, or diversion of water sources, 5) use of the urban interface, 6) road and highway crossing, and 7) human activities known or found to be directly or indirectly detrimental to sheep.

Because bighorn sheep in the Peninsular Ranges reside in a network of state, federal, private, and tribal government lands which lie adjacent to large human urban populations, reaching recovery goals and assuring long-term protections for sheep requires an on-going understanding and commitment to eliminating threats within and among recovery regions. For a review of the current threats and concerns within each recovery region refer to CDFW 2017-2018 Annual Report.

Photo by Jeff Young

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