

National Park Service
Channel Islands National Park

***ISLAND FOX CAPTIVE BREEDING PROGRAM
1999-2000 ANNUAL REPORT***

Technical Report 01-01

Tim Coonan
Keith Rutz

National Park Service
Channel Islands National Park
1901 Spinnaker Drive
Ventura, CA 93001
Voice: (805) 658-5776
Fax (805) 658-5798
Email: tim_coonan@nps.gov

March 2001

ACKNOWLEDGEMENTS

The establishment and maintenance of the island fox captive breeding program Channel Islands National Park has truly been a team effort. We thank the scores of people who have assisted us, many in donating their time and efforts, and unique expertise.

First and foremost are the island fox caretakers, those staff whose concern for the captive foxes on a daily basis insures the success of the program. We thank Susan Coppelli, Patricia Hartman, Don Jones, Julie Goldzman, Andrea Lehotsky, and Skye Loyd for their efforts. Others have volunteered their time to caretake for the foxes, some on short notice or to cover periods when our staff could not be on the islands. We thank Jonathon and Lisa Lewis, Ian and Marcella Williams, Justin and Kyle Stephenson, Tom and Donna Dore, Don, Susan and Allie Morris, Katie Chess, Ray and Lorrie Aichner, Edwin Beckinbach, Kim Asmus, Joe LaBarbera, Cathy Schwemm, Anne Swank, Mike and Sharon Hartman, Eileen Creel, Jeremy Moynier, Julia Parker, Dan Richards, Sarah Chaney, and David Kushner.

Construction of the island fox captive breeding pens required significant labor, and many folks kindly donated time to help us accomplish this. Park maintenance staffers Earl Whetsell, Ed Smith, Tim Jones, Tom Baker, Samuel Guerrero, and Mike Lipoma were invaluable in this regard. Other NPS staff also donated time to pen construction: Dirk Rodriguez, Sarah Chaney, Mark Senning, Don Morris, and Steve Ortega. Aaron Hebshi, Dave Crowell, Marie DesLauriers, Barbara Hajduczek, Kevin Moore, David Ackerman, Steve Junak, Scott Parrish and Ventura College, and the Los Angeles Conservation Corps provided the bulk of the volunteer labor required to build the existing facilities on San Miguel and Santa Rosa Islands.

Assistance in capture of foxes for the captive breeding program was provided by Gary Roemer, Piper Roby, and Julia Parker.

San Miguel Island manager Ian Williams has assisted in all phases of the program on San Miguel, including fox monitoring and capture, pen construction, fox care and feeding, and veterinary care. We appreciate his continued interest and assistance.

We thank our project veterinarian, Mark Willett, for establishing protocols, conducting veterinary exams, and providing veterinary care to foxes. When circumstances required immediate veterinary care, time and effort were kindly donated by Sam Dover, Camilla Lieska, Ron Dalzell, Steve Timm, Julia Parker, and May Ann Meyers.

We thank director Rich Block of the Santa Barbara Zoo for making the zoo an effective partner in island fox captive breeding at the park. Rich has kindly donated the time of his staff for veterinary and fox care on the islands, and we have learned much from their staff's experience with captive island foxes.

Analysis of blood, fecal and other samples from captive foxes was provided by Linda Munson, Allie Brower, Eileen Johnson, and Kari Padgett. Thanks to Cheri Asa and Joan Bauman of the St. Louis Zoo for hormonal monitoring of captive foxes.

Guidance for the program has been provided by members of the captive breeding working group and others, who have donated time and expertise to program oversight. We thank Kathy Ralls, Cheri Asa, Marsha Sovada, Amy Roberts, Linda Munson, Bob Wayne, Phil Miller, Dave Garcelon, Gary Roemer, Mark Willett, Sam Dover, Alan Varsik, Julia Parker, Mary Allen, and Devra Kleiman. Their professional expertise and genuine concern for the fate of the island fox has helped immensely in shaping the island fox captive breeding program. Thanks also to Lynn Hall for sharing his extensive fox husbandry experience with us.

Valuable assistance with developing the camera monitoring system has been provided by Ian Williams, Tree Gottshall, and Kent Bullard.

Thanks to Rhonda Brooks, Fred Rodriguez and Doretta Burgess for effectively coordinating transportation to the islands. We particularly appreciate the skills and efforts of the park's boat crews in getting us and our materials onsite. For this we thank Brent Wilson, John Provo, Dwight Willey, Keith Duran, and Randy Bidwell.

Thanks finally to the park management team and the rest of the park staff for supporting these critical emergency actions for island fox recovery. We especially appreciate the support of Kate Faulkner, Chief of Natural Resources Management, for her support of the program. Beyond the park, Patty Neubacher, Dave Graber, and Jay Goldsmith have been instrumental in support for this program.

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Island fox in captive breeding facility on San Miguel Island, Channel Islands National Park.

Executive Summary

As recommended by a recovery team convened by the National Park Service in 1999, Channel Islands National Park recently initiated a sanctuary/captive breeding program for island foxes (*Urocyon littoralis*) on San Miguel and Santa Rosa Islands. A facility was constructed on San Miguel in 1999 and 14 foxes were brought into captivity. Of those foxes, four were males, and were paired with females in fall 1999 for breeding purposes. One of those pairs had a litter of two pups in spring 2000. The Park constructed a captive breeding facility on Santa Rosa Island in March 2000 and brought nine foxes into captivity. Six of the nine were female; of those females three were pregnant when captured, and had litters (of four, four, and one pup) in spring 2000. One Santa Rosa pup died shortly after birth.

Thirty-eight foxes are now in captivity, 22 on Santa Rosa Island and 16 on San Miguel Island. For the 2000-2001 breeding season there are nine pairs on Santa Rosa Island, and five pairs on San Miguel Island.

Captured foxes were given initial veterinary exams and tested for parasites. Their daily diet consists of approximately 90 g of high-quality dry dog food supplemented by hard-boiled eggs, vegetables and fruits. The foxes are given dead coturnix quail or live/dead deer mice several times per week.

Introduction

The island fox (*Urocyon littoralis*), a diminutive relative of the gray fox (*U. cinereoargenteus*), is endemic to the California Channel Islands. It is distributed as six subspecies, one on each of the six Channel Islands on which the fox occurs. Both morphologic and genetic distinctions support the classification of separate subspecies for each island (Gilbert et al. 1990, Wayne et al. 1991).

The island fox population on San Miguel declined sharply in a five-year period, (Coonan et al. 1998) with the adult population falling from approximately 450 in 1994 to 15 in 1999. Monitoring data from Santa Cruz Island (Roemer 1999) and survey data from Santa Rosa Island indicate that island foxes underwent similar catastrophic declines on those islands as well. Populations are so low that the species warrants listing as endangered under the Federal Endangered Species Act.

In a recent study of island foxes on Santa Cruz Island, golden eagle (*Aquila chrysaetos*) predation was identified as cause of death for 21 of 29 island fox carcasses (Roemer 1999). A radiotelemetry study on San Miguel Island in 1998-1999 confirmed that golden eagle predation was a major mortality source on that island as well (Coonan et al., in prep.) This level of golden eagle predation is unnatural. Until the late 1990's, golden eagles never bred on the Channel Islands and their recent appearance is due to a prey base, feral pigs (*Sus scrofa*) that was not present historically. The absence of bald eagles (*Haliaeetus leucocephalus*), which bred historically on the islands and whose presence may have kept golden eagles away, is another contributing factor driving increased golden eagle predation. Moreover, on much of the northern Channel Islands, historic sheep grazing changed the predominant vegetation from shrub to non-native grasslands, which offer much less cover from aerial predators.

Concerned about the potential loss of three subspecies of island foxes from its lands, the Park convened an island fox recovery team in April 1999 to consider the available information and develop strategies to recover island fox populations to viable levels. The team's recommendations (see Appendix A) concluded that:

- predation by golden eagles is the primary mortality factor now acting on the population
- disease or parasites may be compounding the effects of predation
- natural recruitment is low; and that the most effective conservation measure that could be taken right now is to increase survival of pups, juveniles and adults by reducing or eliminating golden eagle predation

The team also recognized that the size of the fox populations on these three islands is critically small; the natural reproductive potential is low; our knowledge of all of the factors contributing to the population decline may be incomplete; and the effectiveness of proposed golden eagle management efforts in reducing or eliminating predation has yet to be proven. Therefore, the team concluded that establishment of a fox sanctuary and captive breeding program was necessary to safeguard individual foxes and to augment natural recruitment into the population.

Goals and Objectives

OVERALL GOAL

To develop a captive breeding program for island foxes of San Miguel and Santa Rosa Islands in order to increase their wild populations to viable levels.

OVERALL OBJECTIVE

To design and implement captive breeding programs for the primary purpose of generating animals suitable for reintroduction into appropriate habitat, once the threats to the populations in those habitats have been minimized or eliminated.

SPECIFIC OBJECTIVES

- 1) Construct and populate breeding facilities for the San Miguel and Santa Rosa island fox populations. Size of the captive facilities will be determined by overall recovery goals, which in turn will be set by demographic modeling.
- 2) Pair animals for breeding; monitor breeding behavior and results.
- 3) Develop appropriate release strategies.

Program Guidance

Guidance for the captive breeding program is provided generally by the captive breeding working group of the island fox recovery team. Appendix B contains names and addresses for members of the island fox captive breeding working group.

Guidance for design of captive enclosures and development of husbandry protocols was provided by the American Zoological Associations' management recommendations for small canids in captivity, as well as the American Society of Mammalogists' guidelines for the capture, handling and care of mammals (American Society of Mammalogists 1987).

Although cost savings might be realized if there was only one facility to serve both islands, separate facilities are required for each island because of the possibility of disease or parasite transfer. For the same reason, use of mainland facilities is not appropriate. Island foxes housed on the mainland would constitute potential vectors for mainland disease or parasites if returned to the islands.

In July, 2000, the captive breeding working group provided further guidance for the program after reviewing the progress in the first year. Full discussion is contained in the meeting notes (see Appendix C), and the following summarizes the evaluation and recommendations:

Program Goals and Objectives

- Facility size and program duration will be determined by the production needed to achieve population goals for wild populations. Those goals will be set after island fox demographic modeling is conducted to determine vital rates of viable populations.
- No foxes should be released until golden eagles are removed from the islands.
- Program duration will depend upon survivorship of released foxes.

Facility Design and Construction

- Facility size sufficient to insure production is likely to be 25 pens (50 foxes) on each island.
- In order to minimize the chance of disease, parasites or other catastrophe causing extirpation of captive populations, two separate facilities are recommended for each island.
- Consider increasing the distance between pens, while providing hiding places that still allow animals to have visual contact when they choose.
- Annual pen construction should be completed by October to allow pairs sufficient time to bond prior to breeding.
- Establish a minimum of two isolation areas at each facility.

Veterinary Care

- Foxes cannot be returned to the islands, if removed for any reason, because of possible disease/parasite transmission.
- More systematic (regular) veterinary exams need to be scheduled.
- Veterinary protocols need to be established.

Breeding Strategy

- Maintain bonded pairs as long as they reproduce successfully; allow at least two seasons to assess reproductive success.
- Avoid pairings of siblings or parent/offspring.
- Pair captive-born foxes with wild caught mates, as long as this doesn't break up existing pairs, to minimize loss of wild behavioral traits.
- Establish a studbook.
- Presently, the main objective should be to maximize reproductive output; after successful reproduction is established, then rely more on genetic considerations.
- Recommend developing a method for allowing female mate choice.
- Excess females may be housed together if compatible to allow for social interaction or to possibly test reproductive potential of one male with two females.
- Translocation of additional males to pair with excess San Miguel females is an option that should be considered by genetic advisors and veterinarians.
- It is premature to resort to artificial insemination.

Breeding Success

- It is not uncommon to have low or even no reproduction the first year animals are brought into captivity.
- Successful breeding and production of pups by one pair indicates that conditions were adequate for sexual behavior, gestation, parturition and parenting.
- Failure of other pairs on San Miguel is probably attributable to insufficient time for courtship and pair-bonding before the breeding season or to young age and inexperience of several animals.

Release Strategy

- Release a minimum of two family groups at a time
- Recommend soft release into suitable habitat
- Monitor survivorship of released foxes

Program Standard Operating Procedures

Standard operating procedures have been developed for care of captive island foxes (Appendix D) and are updated as required.

Diet

Upon the advice of Mary Allen of the National Zoological Park, the daily island fox diet consists of a high-quality dry dog food (25-28% protein, 10-12% fat), hard-boiled eggs, and a variety of fruits and vegetables. This is supplemented several times per week by live deer mice or dead coturnix quail. The foxes are not given moist meat-based food, such as canned cat or dog food, or fruits high in citric acid, since they may cause gingivitis and tooth loss.

The amount of food given daily is 3-4% dry weight of the foxes' body weight (i.e., a 2.3 kg adult receives 90 g of food daily). Animals are fed around dusk daily, and are provided with water *ad libitum*.

Health/Medical

Each fox is given a veterinary examination soon after capture, and on a semi-annual basis after that. A complete veterinary protocol, including examination schedule and scope, is currently being developed by recovery team members. Veterinary examinations have been conducted by project veterinarian Mark Willett, D.V.M., of Davis, California, and by Sam Dover, D.V.M., of the Santa Barbara Zoo. On-island emergency care has been provided by Mark Willett, Sam Dover, and Steve Timm, D.V.M., of the Institute for Wildlife Studies, Santa Catalina Island.

To date, routine veterinary examinations have been performed in a nose to tail fashion, and have included otoscopic and fundic examination. Blood samples are taken for complete blood counts and chemistry panels, and a portion is stored for potential disease screening and DNA analysis. Fecal samples are collected for parasite screening. Blood and fecal samples are sent to Linda Munson, D.V.M., at the Veterinary Medical Teaching Hospital, UC Davis.

San Miguel Island Captive Breeding Facility

Facility Construction

Of the 11 pens on San Miguel Island, two were built in May, 1999, and the remainder in August, 1999. The pens (Fig. 1) are arrayed in two rows. Distance between the pens is 6-10 feet, except for pens E and F, which are approximately 60 feet west of the rest of the pens. Each pen is constructed of 6 x 10' panels of 1.5" chain-link fencing, with roofs constructed also of 6 x 10' panels. Eight pens are U-shaped and are 500 ft², with two panels on the short side and three on the long side. An interior door splits the pen in two. A 2-foot ground skirt of fencing material is partially buried around the interior of the perimeter, to prevent animals from digging out. Shadecloth is affixed to the bottom portion of the panels to prevent foxes from seeing into adjacent pens. One pen is L-shaped and is 300 ft²; the original two pens are 200 ft² each.

The pens housing fox pairs have two plywood denboxes, one completely enclosed, and the other a more open shade structure.

Fox Capture

Of the 14 island foxes brought into captivity, two were captured in May, 1999, and the remainder in August-October, 1999 (Table 1). Two pups were born in the facility in spring, 2000. Only one island fox, a radiocollared female, is known to remain in the wild. There is no sign (scat or tracks) on the island that is not attributable to her, and remote TrailmasterTM cameras have recorded no images of non-radiocollared foxes. Captive island foxes are marked with passive integrated transponder (PIT) tags, inserted subcutaneously between the scapulae.

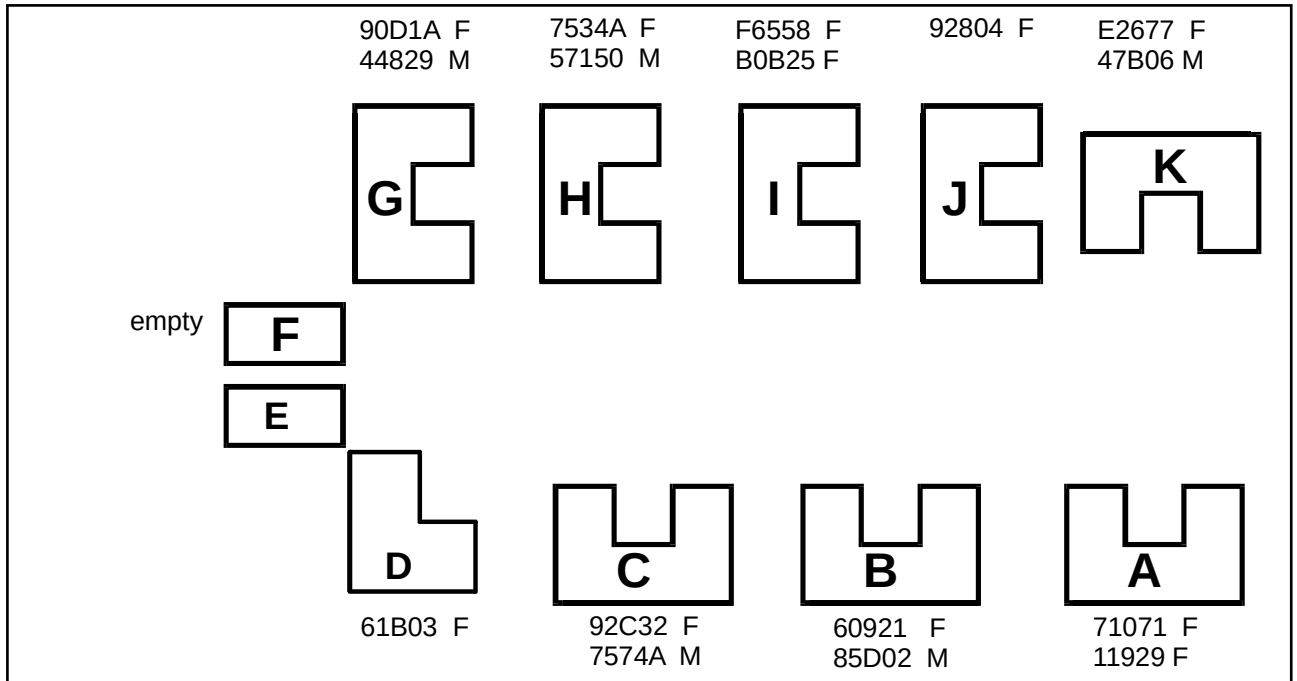


Figure 1. Island fox captive breeding facility, San Miguel Island.

Both age and sex ratios are skewed in the captive population. Only four males were brought into captivity, and only three foxes, all of them female, were older than the young adult, or juvenile, age class (ca. 7 months to 2 years old).

Monitoring

Behavior of captive foxes on San Miguel is monitored by direct observation from a blind, and by review of videotapes from pen cameras. The purpose of monitoring in 1999-2000 was to document general behavior patterns, note problems, and determine if breeding behavior occurred in the four pens with potential breeding pairs (pens B, C, G and H).

An observation blind was built south of the captive breeding pens, and is most useful for direct observations of foxes in pens B and C. In January, 2000, a video monitoring system was installed in the San Miguel pens. Because AC current is not available at the pen site, a DC system is powered by a bank of deep cycling batteries recharged by a solar panel, and the size of the camera system is thus restricted by available power.

“Lipstick” style micro-video cameras are affixed to pen walls and feed into a switcher, which alternately sends video signals from up to four cameras to a videocassette recorder. The VCR uses 8-hour videotapes and is capable of recording 24 hours on one tape. The cameras have low-light (0.05 lux) capability and are black and white in order to pick up infrared illuminated images. Illumination at night is provided by infrared lights; however, the beam of the lights is narrow, and illuminates only a small portion of the pens. Another constraint is the U-shape of the pens, which makes it impossible to provide complete coverage of the pen with just one camera.

Table 1. Island foxes in captive breeding facility on San Miguel Island (ages given are as of spring, 2001).

Pen	PitTag	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
A	11929	F	1	Captive	44829	90D1A		
	71071	F	2	Wild			8/23/99	Cardwell
B	60921	F	3	Wild			9/24/99	
	85D02	M	2	Wild			9/17/99	Cardwell
C	92C32	F	3	Wild			5/17/99	Willow Canyon
	7574A	M	3	Wild			5/14/99	Willow Canyon
D	61B03	F	8	Wild			10/28/99	San Miguel Hill
G	90D1A	F	3	Wild			9/2/99	Willow Canyon
	44829	M	3	Wild			9/4/99	Willow Canyon
H	7534A	F	8	Wild			9/4/99	Nidever Canyon
	57150	M	3	Wild			10/4/99	Green Mountain
I	F6558	F	2	Wild			10/4/99	Green Mountain
	B0B25	F	2	Wild			9/28/99	Nidever Canyon
J	92804	F	9	Wild			10/24/99	Willow Canyon
K	47B06	M	1	Captive	44829	90D1A		
	E2677	F	3	Wild			9/11/99	Willow Canyon

The cameras were initially placed in pens G and H, because those pens were not visible from the observation blind. A camera was added to pen B in , 2000. We installed a camera in a denbox in pen G, but the foxes destroyed the camera's wiring in April, shortly before the female produced a litter.

Although power problems during the winter prevented the system from optimally performing, the system worked intermittently and it recorded hundreds of hours of fox behavior during winter, spring and summer, 2000.

Dr. Cheri Asa of the St. Louis Zoo initiated fecal hormonal analysis of the captive foxes on San Miguel in order to determine the timing of the reproductive cycle. Weekly and/or daily fecal samples were collected from the pens, frozen, and sent to the St. Louis Zoo for analysis. Hormones assayed include cortisol, to monitor stress levels, and progesterone and estradiol for timing of estrus and pregnancy. Fecal cortisol levels in captive foxes declined over time, indicating they became acclimated to captivity. Analysis of reproductive hormones is complicated by a possible inability to distinguish between male and female scats according to hormone levels. Nonetheless, results suggest that only the females housed with males ovulated; females housed by themselves did not (C. Asa, unpubl. data).

Health/Medical

Veterinary examinations in 1999-2000 revealed San Miguel foxes to be in generally excellent physical condition. One female, 92C32, had a prolapsed rectum in May, 1999, but the condition had cleared up by September, 1999. A mild irregular arrhythmia was noted in female 60921, but was deemed of no clinical significance.

Fresh fecal samples from captive foxes were analyzed for presence of parasites by Dr. Linda Munson of UC Davis' Veterinary Medical Teaching Hospital (Table 2). Generally, foxes on San Miguel had significant parasite burdens characterized by hookworms (*Uncinaria* spp.; all 16 foxes tested), spirocerids (9 of 16 foxes) and lungworm (*Angiocolus* spp.; seven of 16 foxes tested). Fox care technicians have also noticed significant numbers of tapeworms (*Mesocostoides* spp.) and roundworms (*Toxascaris* spp.) in scats from San Miguel. In contrast, none of the foxes on Santa Rosa had *Angiocolus*, five had spirocerids, only two had hookworms, and Santa Rosa Island scats generally lacked tapeworm or roundworm proglottids.

Hookworm is a concern because hookworms feeding on the mucosa of the small intestine basically cause hemorrhaging and loss of blood through the intestinal tract, resulting in anemia. Bloody scats have been noted in many of the San Miguel pens. On the other hand, *Uncinaria stenocephala* is relatively innocuous as far as hookworms go, especially compared with *Ancylostoma caninum* (Georgi and Georgi 1991). High incidence of *Uncinaria* spp. has been associated with mortality of fur seal (*Callorhinus ursinus*) and California sea lion (*Zalophus californianus*) pups on San Miguel Island (Lyons et al. 1997).

Although it would be ideal to treat San Miguel Island foxes for hookworm, the presence of *Angiocaulus* and spirocerids has necessitated a cautious approach. *Angiocaulus* is not found in foxes from other islands (L. Munson, UC Davis, unpubl. data). Whereas the pathogenicity of *Angiocaulus* is largely unknown, necropsy of a San Miguel island fox indicated that *Angiocaulus* had caused extensive pulmonary granulomas and was present in heart blood. If such foxes were treated with an anthelmintic which crossed into the bloodstream and killed the *Angiocaulus*, a fatal outcome might occur (Linda Munson, UC Davis, pers. comm.). Moreover, spirocerids may cause a break in the intestinal mucosa which would allow an anthelmintic to cross into the bloodstream. Thus, foxes with *Angiocaulus* or spirocerids have not been treated for hookworm.

Thus far two San Miguel Island foxes have been treated for hookworms with Nemex 2 Wormer (pyrantel pamoate) (Pfizer Corporation, Lee's Summit, Missouri 64081). One fox (61B03) was treated in the spring, and one (F6558) in the fall. As of January, 2001, fecal parasite surveys indicated that F6558 was free of hookworms, whereas 61B03 tested positive for hookworm.

Considerable number of fleas and ticks have been noted on the Santa Rosa foxes, but not on the San Miguel foxes. Two Santa Rosa Island foxes are being experimentally treated with Advantage (imidacloprid) Topical Solution (Bayer Corporation, Shawnee Mission, Kansas 66201).

Breeding

The reproductive cycle of the island fox is not known specifically, but Moore and Collins (1985) outline what is currently known. Courtship occurs in late January and February, with actual breeding taking place in late February and early March. The gestation period is thought to be similar to that of the mainland gray fox (*Urocyon cinereoargenteus*), 50-53 days, and pups are born in late April and early May. Although island foxes can breed successfully at the end of their first year, recent fieldwork suggests that very few first year animals breed. On San Miguel Island from 1993 to 1998, only 20% of juvenile females bred, compared with 60% of all other age classes. Pups first appear outside the den in early to mid June, and by their first fall, when they typically disperse, they are approximately adult size. Island foxes are monogamous and mate for life, but up to 25% of all pups may result from extra-pair copulations between neighbors at territory boundaries (Roemer 1999).

Several features typical of canid reproductive systems (Asa and Valdespino 1998) have consequences for the island fox captive breeding effort. First, most canids are monestrous, having only one estrus period per year. With only one chance annually for successful breeding, the importance of a successful pair bond is heightened, and potential pairs should be housed together well before the onset of breeding in January. Second, the actual period of receptivity by the female may be short; in fennec foxes (*Fennecus zerda*), estrus lasts only 1-2 days. Thus, opportunities for extra-pair matings are reduced.

On San Miguel, only one pair of foxes (pen G) produced a litter in spring 2000. The litter was comprised of two pups, a male and female. A description of each pair and a summary of observed breeding behavior follows.

Table 2. Parasites in captive island foxes, San Miguel and Santa Rosa Islands, 1999-2001 (data from L. Munson, UC Davis). "P" indicates that the parasite was present in at least one fecal or floatation sample during 1999-2000.

Pen	PitTag	Angio-caulus	Spiro-cercids	Unci-naria	Giardia	Isospora	Nema-tode	Rhabditi-form	Sarco-cystis	Tox-ascaris
San Miguel Island										
A	11929			P						
A	71071		P	P						P
B	60921	P	P	P						
B	85D02	P	P	P						P
C	7574A	P	P	P		P				
C	92C32	P		P	P	P				
D	61B03		P	P						
G	44829	P	P	P				P		P
G	90D1A	P		P						P
H	57150			P						
H	7534A			P						
I	B0B25	P	P	P						
I	F6558		P	P						P
J	92804			P						
K	47B06		P	P						
K	E2677			P						P
Santa Rosa Island										
R2 ¹			P							
R2	A7015								P	
R3						P				
R4			P	P			P			
R5			P					P		
R5	F0223									
R6								P		
R7										
R7	10030									
R8					P					
R8	D187A									
R9			P							
R10			P					P		
R11			P	P						
WILD	22412					P				

¹Where PIT tag is not given, fecal sample was not assigned to an individual but rather to pen

Pen B

Female 60921 was captured as a pup in August, 1998 on the Dry Lakebed, at the western end of the island. She was radiocollared in January 1999 in the middle portion of the island, and over the next nine months she ranged over the central west portion of the island. She may have produced a litter, since she was lactating when caught during the spring of 1999. She was brought into captivity in September, 1999.

Male 85D02 was captured as a pup in September, 1999 along the bluffs south of the Cardwell Point Trail. Based upon his capture location, he may be a littermate of 71071.

Table 3. Reproductive success of island foxes in captive breeding facility on San Miguel Island, 1999-2000 breeding season.

Pen	Pit #	Sex	Age (years)	Date Captured	Date Paired	Mating	Birth	Litter Size	Pups First Seen
B	60921	F	2	9/24/99	10/2/99	3/15/99 ¹			
	85D02	M	1	9/17/99	10/2/99				
C	7574A	M	2	5/14/99	7/16/99	3/7/99 ²			
	92C32	F	2	5/17/99	7/16/99				
G	90D1A	F	2	9/2/99	9/4/99	Not observed	4/20/99	2	5/21/99
	44829	M	2	9/4/99	9/4/99				
	47B06	M	0	Born in captivity					
	11929	F	0	Born in captivity					
H	57150	M	2	10/4/99	10/31/99				
	7534A	F	6	9/4/99	10/31/99				

¹Attempted Mount

²Copulatory Tie

The foxes in pen B were paired on October 2, 1999. The first evidence of breeding behavior was recorded on January 21, when the male exchanged muzzle licks with the female but was not allowed to sniff her hindquarters. On February 3 the female allowed the male to sniff her genitals several times, even lifting her leg to allow better access. On February 11, the females rejected the male's attempts to sniff her genitals. On February 12, the male was observed closely following the female about the pen, with considerable scentmarking. The male made two half-hearted attempts to mount on February 18, and was recorded "posturing" (raised hackles and arched back) apparently at the male in pen C. The female raised her leg to allow the male to sniff her genitals. Mutual muzzle touching and genital sniffing were also observed on February 21 and February 23. On March 2 the female rebuffed the male's attempt to sniff her genitals.

On March 3 mounting and thrusting was observed that lasted several seconds. He held her by her neck and she was highly receptive. On March 6 the female became increasingly receptive to the male, and she finally allowed him to attempt to mount her for about 10 minutes. Another attempted mount was observed on March 15. The pair in pen B did not produce a litter in 2000.

Pen C

Male 7574A was caught as a pup on the Dry Lakebed in August, 1998. He dispersed across the island, and was caught and radiocollared at the campground in March, 1999. He was captured in May, 1999 at the airstrip and brought into captivity.

7574A's likely mate in the wild was 92C32, a radiocollared female frequently located with him, or in the same home range. She was caught at the pen site into captivity in May, 1999.

The first evidence of breeding behavior was noted on February 3, when the male attempted to sniff the female's genitals but was rebuffed. He then sniffed the ground where she had been sitting. On February 12 the pair was observed touching noses. On March 3 the female allowed the male to sniff her genitals but was protective of her hindquarters, as she was the next day and the following. The pair were observed in a five-minute copulatory tie on March 7. Another attempted mount was observed on March 15. Despite these observations of breeding behavior, the pair in pen C did not produce a litter in 2000.

Pen G

Male 44829 was first captured as a pup on the Dry Lakebed in 1998. He dispersed across the island and was recaptured and radiocollared near the Ranger Station in March, 1999. Over the next six months he

ranged from Nidever Canyon to Green Mountain. He was caught near the pens in September, 1999, and brought into captivity.

Female 90D1A was first captured as a pup in Willow Canyon in 1998. In October, 1998 she was captured and outfitted with a radiocollar. Over the next six months she ranged in the Willow Canyon area, but occasionally traveled as far west as Point Bennett and as far east as Cardwell Point. She was brought into captivity in September, 1999.

The foxes in pen G were paired together on September 4, 1999. In late January videotape recorded vigorous play behavior at night, and female 90D1A injured her leg when she jumped off the denbox during such a play session on January 27 (she was noticed limping until February 8). Scentmarking by both was noted on January 28, and the female allowed the male to sniff her hindquarters. On February 1 the female allowed the male to sniff her hindquarters several times. The denbox camera recorded a genital sniff followed by an apparent attempted mount on the night of February 2. On February 6 the male sniffed the female's hindquarters and was very interested in places where she had recently urinated or defecated. On February 17 the videotape records a possible "dismount", and there is what appears to be a clumsy attempt to mount the following night. No further breeding behavior was observed.

On or about April 20 the female went into her denbox and was not seen for approximately one week. On April 27 staff investigated the denbox and observed the female with two pups. If parturition occurred on or about April 20, and if gestation period is 50-53 days, then conception occurred between February 27 and March 1. By May 4 the pups had been moved to a hole under the denbox, and the female was observed aboveground for periods of time. On May 18 the adults removed a pup from the den, and the female carried the pup to the other side of the pen, then returned it to the den. On May 19 both pups emerged from the den on their own and were put back in the burrow by the female after a few minutes. After this the pups began spending more time outside the den. By the end of June they were catching their own live mice when fed them, and considerable play behavior was observed between them. On July 7 the pups were captured in livetraps to determine sex (one male, one female) and assess physical condition. The male pup weighed 1.6 kg and the female weighed 1.4 kg.

Pen H

Both foxes in pen H are from the Green Mountain area. Female 7534A was first caught on the San Miguel Hill grid in 1994, making her about seven years old. Having bred in 1995, she is one of the few foxes in the facility with breeding experience.

Her mate, 57150, is considerably younger. He was captured as a pup on the Dry Lakebed grid in August, 1998. He was captured on the west side of Green Mountain in October 1999.

Very little breeding behavior was observed in pen H. The foxes commonly played and rested together. On March 5 the male attempted to mount the female three times. Although she offered little resistance, he gave up quickly. An attempted mount on March 6 ended with the female snapping at the male, and another ended after a few seconds of mounting. Three attempted mounts were also observed on March 12, and one each on April 17 and April 18. The pair did not produce a litter in 2000.

Santa Rosa Island Captive Breeding Facility

Facility Construction

The Santa Rosa facility was constructed in February and March, 2000, with additional pens built in November, 2000. The facility (Fig. 2) comprises 12 breeding pens and two quarantine pens. There are eight 500 ft² U-shaped pens, two 500 ft² S-shaped pens, and one 300 ft² L-shaped pen. Distance between pens is a minimum of 50 feet. Pen design is similar to that on San Miguel.

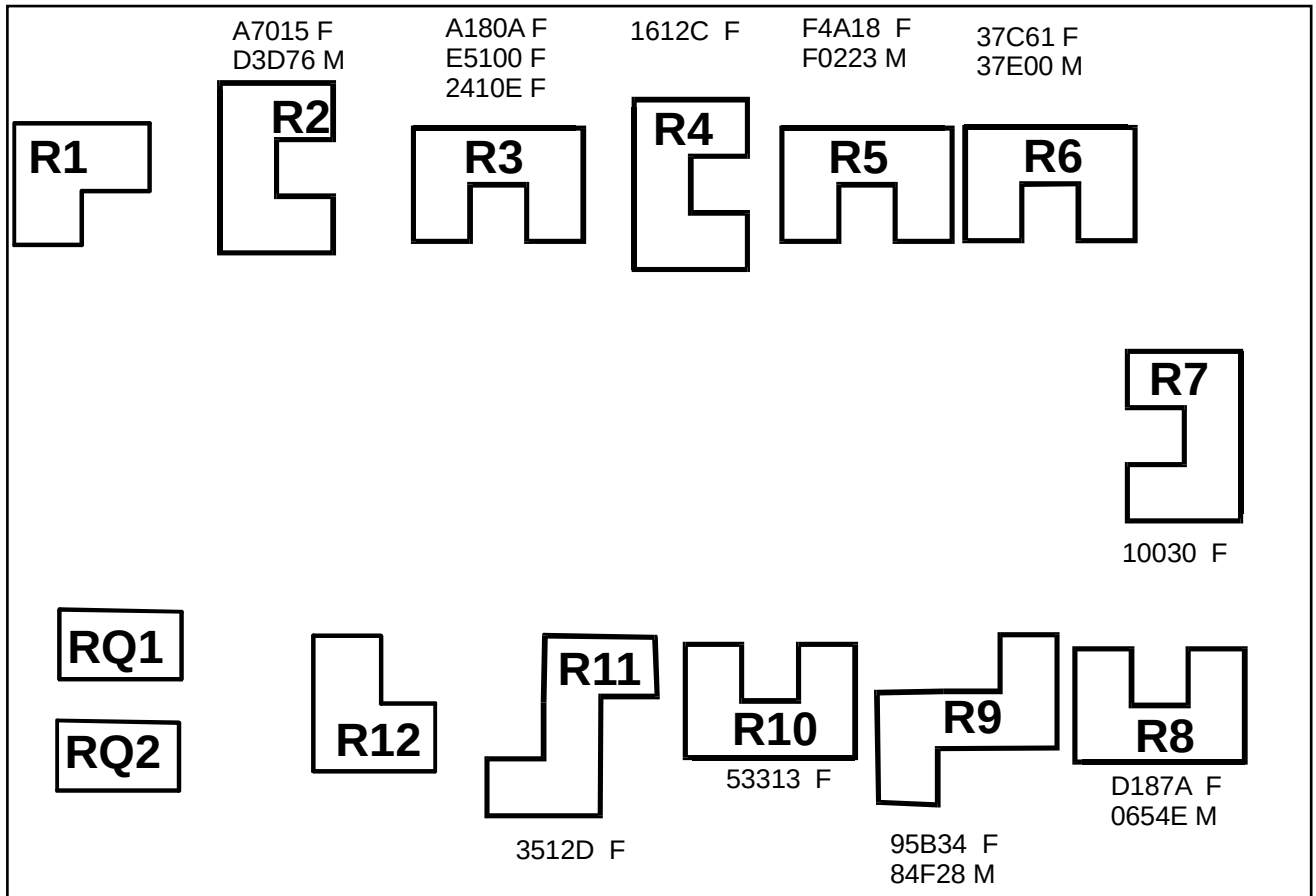


Figure 2. Island fox captive breeding facility on Santa Rosa Island.

One facility problem unique to Santa Rosa is the tendency for Channel Islands spotted skunks (*Spilogale gracilis amphiala*) to dig into the pens (skunks do not occur on San Miguel). We are currently investigating methods to keep skunks out of the pens. These include use of a ground skirt outside the pen walls, and electric fencing.

Fox Capture

Fourteen foxes were captured and brought into the facility in 2000 (Table 4). Nine foxes were captured in March and April, one in July, two in September, one in October, and one in November. Nine foxes were captured along the Smith Highway, over the northern portion of the island, and five were captured in the Torrey Pines/Skunk Point area. As of January, 2001, the only fox sign on the island was from Windmill Canyon, and is attributed to a radiocollared adult female in that area. Fox sign (scat and tracks) is so scarce on the islands that we estimate there to be less than 5 foxes left in the wild on Santa Rosa.

Table 4. Island foxes in captive breeding facility on Santa Rosa Island (ages given are as of spring, 2001).

Pen	PitTag	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
R2	A7015	F	3	Wild			4/3/00	Smith Highway
R2	D3D76	M	2	Wild			3/24/00	Smith Highway
R3	E5100	F	1	Captive		F4A18		
R3	2410E	F	1	Captive		1612C		
R3	13C24	F	1	Captive		F4A18		
R3	A180A	F	1	Wild			10/24/00	Skunk Point
R4	B067E	M	3	Wild			3/26/00	Smith Highway
R4	1612C	F	2	Wild			3/23/00	Smith Highway
R5	F0223	M	3	Wild			4/6/00	Smith Highway
R5	F4A18	F	2	Wild			3/29/00	Smith Highway
R6	37C61	F	1	Captive		F4A18		
R6	37E00	M	1	Wild			9/9/00	Skunk Point
R7	10030	F	3	Wild			4/5/00	Smith Highway
R7	70518	M	1	Captive		A7015		
R8	D187A	F	3	Wild			4/5/00	Smith Highway
R8	0654E	M	1	Captive		A7015		
R9	84F28	M	1	Captive		F4A18		
R9	95B34	F	2	Wild			9/1/00	Torrey Pines
R10	A045A	M	1	Captive		A7015		
R10	53313	F	2	Wild			4/3/00	Smith Highway
R11	3512D	F	3	Wild			11/5/00	Skunk Point
R11	73D0D	M	2	Wild			7/24/00	Torrey Pines

Health/Medical

Veterinary examinations of captive foxes on Santa Rosa were conducted in March and July, 2000, by Dr. Mark Willett. Overall the foxes were in good health and Dr. Willett noted that they were generally less stressed and easier to handle than the San Miguel foxes. Dr. Willett found that fleas were a particular problem for the Santa Rosa foxes, and recommended treatment in several cases. There were also grass awns in several ears, but no sign of infection. Minor skin lesions were noted in some pups, and attributed to sibling play or aggression. Several foxes were noted to have sinus arrhythmia, but it was not thought to be of any clinical significance. One animal had a prolapsed rectum, but recovered.

Although few fecal samples have been screened for parasites, foxes on Santa Rosa generally had less parasites than those on San Miguel (Table 2) and showed no evidence of *Angiocaulus* or *Spirocerca*.

One of the four pups in pen R4, 13C24, injured its paw, perhaps in the pen fence, and required amputation of a digit. The pup sustained the injury on or about June 16 and was examined by Dr. Sam Dover of the Santa Barbara Zoo on June 22. Dr. Dover examined the animal again on June 28th and decided to amputate the outermost digit on the left paw, because the toe bone was almost completely severed and would have invited infection if left attached. The operation was performed on-island and the pup spent the subsequent seven weeks isolated in a restroom of an NPS residence on Santa Rosa while recovering. The pup was placed in an isolation pen on August 18 and reunited with its litter on August 28.

The park has since built a one-room structure (the “foxpital”) at the mouth of Windmill Canyon to serve as a quarantine facility, as well as a location to store and prepare fox food.

Table 5. Reproductive success of island foxes in captive breeding facility on Santa Rosa Island, 1999-2000 breeding season.

Pen	Pit #	Sex	Age (years)	Date Captured	Date Paired	Mating	Birth	Litter Size	Pups First Seen
R2	A7015	F	1	4/3/00	*	Pregnant	4/10/99	4 (3 lived)	5/28/99
	A045A	M	0						
	70518	M	0						
	0654E	M	0						
R4	1612C	F	1	3/23/00	3/31/00	Pregnant	4/26/99	1	6/11/99
	B067E	M	2	3/26/00	3/31/00				
	2410E	F	0						
R5	F4A18	F	1	3/29/00	*	Pregnant	4/16/99	4	5/15/99
	37C61	F	0						
	84F28	M	0						
	13C24	F	0						
	E5100	F	0						

*not paired with potential mate until after breeding season

Breeding

Three of the adult females caught in March-April, 2000 were pregnant, and had litters while in captivity (Table 5). Two others, D187A and 33131, were thought to be pregnant when captured, but never produced litters. Two of the litters had four pups, and the other had one. One of the four-pup litters lost a pup shortly after birth. Female A7015 was thought to have given birth on April 10. On April 18, a dead pup was found in her pen. Subsequent necropsy by Dr. Linda Munson of UC Davis' Wild Carnivore Pathology Laboratory found the lungs to be inflated, but the body was emaciated with no body fat stores. Coupled with the empty gastrointestinal tract, the lack of fat suggested the pup had not nursed. There was no evidence of infectious disease.

The sex ratio of the eight pups is even, with four males and four females. The three litters were born between April 10 and April 26, putting conception between February 18 and March 4.

Three adult males in the captive facility are potentially the wild mates of the three females that produced litters, based upon capture locations. One male, B076E, was housed with female 1612C on March 31, 2000. The other two pairs, D3D76/A7015 and F0223/F4A18 were paired on October 19, 2000. Genetic analysis of the captive fox population will be conducted in 2001, and should determine paternity for these three potential pairs and their offspring.

Island Fox Captive Breeding Tasks

Pair Captive Foxes for Breeding

The captive breeding working group has recommended that annual pairings for breeding purposes be completed by September or October in order to allow adequate time for pair bonds to form prior to breeding the following spring. The pairings for the 2000-2001 breeding season were completed by the end of October, 2000.

Table 6. Pairings for the 2000-2001 breeding season, San Miguel Island (ages given are those as of spring, 2001).

Pen	PIT Tag	Sex	Age (yrs)	Wild/Captive Born	Date Paired	Natal/Capture Area ¹
B	60921	F	3	Wild	10/2/99	Green Mountain
	85D02	M	2	Wild		Cardwell Point
C	92C32	F	3	Wild	7/16/99	Willow Canyon
	7574A	M	3	Wild		Dry Lakebed
G	90D1A	F	3	Wild	9/4/99	Willow Canyon
	44829	M	3	Wild		Green Mountain
H	7534A	F	8	Wild	10/31/99	San Miguel Hill/Nidever Canyon
	57150	M	3	Wild		Green Mountain
K	E2677	F	3	Wild	10/26/00	Willow Canyon
	None	M	1	Captive		(Willow Canyon/Green Mountain)

¹Parentheses indicate the parents' capture location

The following guidelines were used in making pairings:

- Pair captive-born foxes with wild-born mates whenever possible
- Pair foxes in captivity that were likely mated in the wild
- Maintain bonded pairs as long as they reproduce successfully
- Allow two years to gauge the reproductive success of a pair
- Avoid the possibility of sibling matings by pairing animals from different areas of the island
- Choose pairings with minimal age difference between male and female
- House young, unmated females together for the benefits of social contact

San Miguel Island

The four pairs established in 1999 have been kept intact for the 2000-2001 breeding season (Table 6). With only two pups produced in 2000, and only one of them male, breeding decisions were restricted to choice of potential mate for that male pup. Of the four young females, only E2677 has significant experience in the wild (at least one year in the wild prior to being brought into captivity). The others were captured as pups, with only 2-3 months experience in the wild. For this reason the male pup was paired with E2677. However, there is a possibility that E2677 is the aunt of the male pup. The pup's mother, 90D1A, was caught as a pup in 1998 from the same part of the Willow Canyon area as E2677 was captured in 1999. Genetic analysis to be conducted in 2001, by Dr. Gary Roemer will be used to determine relatedness of San Miguel Island captive foxes.

The female pup from pen G was housed with the juvenile female in pen A (71071), for social purposes. Thus there are five pens of potentially breeding pairs (B,C, G, H, and K), one pens of two female (A), three pens of single, mature females (D, I and J), and two empty pens available for quarantine purposes.

Santa Rosa Island

On Santa Rosa Island, three adult females were captured while pregnant and gave birth in captivity. Ideally, these three females would be paired in captivity with their mates from the wild. Three males currently held in captivity are likely to be the respective mates of the three females, based upon trap location data, and have been paired with them (pens R2, R4, and R5). An additional four adult females were paired with captive-born male pups born in spring 2000 (pens R7, R8, R9, and R10), and a captive-born female pup was paired with a wild-born pup (pen R6). Two mature wild foxes from the Skunk Point area, assumed to be mates in the wild, were paired together (pen R11). One pen (R3) houses three female pups from this year's litters, and one female pup born in the wild in spring, 2000.

Table 7. Pairings for the 2000-2001 breeding season, Santa Rosa Island (ages given are those as of spring, 2001).

Pen	PIT Tag	Sex	Age (yrs)	Wild/Captive Born	Date Paired	Capture Area ¹
R2	A7015	F	3	Wild	10/19/00	Windmill Canyon
	D3D76	M	2	Wild		Cow Canyon
R4	1612C	F	2	Wild	3/31/00	Windmill Canyon
	B076E	M	3	Wild		Lobo Canyon
R5	F4A18	F	2	Wild	10/19/00	Arlington Canyon
	F0223	M	3	Wild		Arlington Canyon
R6	37C61	F	1	Captive	10/19/00	(Arlington Canyon)
	37E00	M	1	Wild		Torrey Pines
R7	10030	F	3	Wild	10/19/00	Arlington Canyon
	70518	M	1	Captive		(Windmill Canyon)
R8	D187A	F	3	Wild	10/19/00	Cow Canyon
	0654E	M	1	Captive		(Windmill Canyon)
R9	95B34	F	2	Wild	10/19/00	Torrey Pines
	84F28	M	1	Captive		(Arlington Canyon)
R10	53313	F	2	Wild	10/19/00	Canada Garanon
	A045A	M	1	Captive		(Windmill Canyon)
R11	3512D	F	2	Wild	11/05/00	Skunk Point
	73D0D	M	3	Wild		Skunk Point

¹Parentheses indicate the parent's capture location

Expand Facilities

Captive breeding facilities on both islands need to be expanded, for two reasons. First, facility size is currently inadequate to house captive foxes paired for breeding. The 10 pens on Santa Rosa are currently full. Additional pens need to be built to house pups produced in the spring of 2001. Second, with just one facility on each island, the captive populations are vulnerable to disease outbreak, wildlife, or other catastrophe. The captive breeding working group has recommended that one additional facility be built on each island, sufficiently separated from the original facility to minimize the transfer of pathogens between the two.

In fiscal year 2001 (beginning October 1, 2000), the Park will begin construction of additional facilities on both islands, utilizing donated funds. Actual construction will take place in summer 2001, in order to prevent disturbance to foxes during the breeding season. Estimated cost of 20 additional pens is \$50,000. Only a portion of these will be built in 2001, depending upon availability of donated funds.

Project Lead: Keith Rutz, NPS
Completion Date: September 30, 2001

Conduct Genetic Analysis

Pairings are currently made utilizing information on area of capture and parentage, when known, but without the benefit of genetic data on parentage and relatedness. In fiscal year 2001 the Park will fund genetic analysis of both captive fox populations through a cooperative agreement with the Institute for Wildlife Studies. Dr. Gary Roemer of IWS will work in collaboration with California State University, Los Angeles to conduct both mitochondrial DNA and microsatellite analysis of blood samples from captive foxes. Results will be used to determine relatedness and parentage of captive foxes. Analysis may be complete in late fall, 2000, and will be used to make pairings for the 2001-2002 breeding season. Estimated cost of the analysis is \$28,000.

Project Lead: Dr. Gary Roemer, UCLA/IWS
Completion Date: September 30, 2001

Develop Veterinary Protocols

Formal veterinary protocols need to be developed for the captive breeding program, in order to insure that foxes receive regular, timely examinations and that injuries and illness are treated effectively. This is made difficult by the isolated nature of the islands and lack of veterinary staff on-island. Project veterinarian Dr. Mark Willett is working with Dr. Linda Munson of UC Davis, Dr. Steve Timm of the Institute for Wildlife Studies, and Dr. Sam Dover of the Santa Barbara Zoo to develop effective veterinary protocols.

Project Lead: Dr. Mark Willett, Davis
Completion Date: June 1, 2001

Establish Studbook

A studbook is a recordkeeping system commonly used to track captive populations. A studbook contains all the vital records of a captive population, including births, deaths and lineage. Data in the studbook can be used to help maintain the genetic and demographic integrity of a captive population. Studbooks are required elements of the American Zoo and Aquarium Associations' Species Survival Plans (SSP's).

There is no SSP for the island fox, nor has the recovery team recommended establishing one. However, the team has recommended that a studbook be kept for the island fox captive breeding program. Studbook data are archived in program SPARKS, the Single Population Analysis and Recordkeeping System developed by the International Species Information System. Each studbook requires a "keeper" who is responsible for data entry and is trained in program SPARKS. Recovery team member Amy Roberts of The Living Desert Museum has volunteered to keep the studbook for the island fox captive breeding program. Tim Coonan of NPS will send Amy the relevant information to be entered into SPARKS, as well as annual updates.

Project Lead: Amy Roberts, TLD
Completion Date: January 31, 2001 (Completed)

Repair Camera Monitoring System

The camera monitoring system on San Miguel needs to be repaired prior to January 2001 in order to adequately record breeding behavior. Problems with power need to be addressed and infrared light sources need to be replaced. Tim Coonan of NPS will purchase additional equipment and install prior to January, 2001. Estimated cost: \$5,000.

Project Lead: Tim Coonan
Completion Date: December 31, 2000 (Completed)

Hire Additional Staff

The current staffing level is inadequate to adequately cover island fox care for the two facilities, as well as to build additional pens. The four fox care technicians work alternate tours (week on, week off) and thus there is no one available to cover fox care for periods when staff take annual or sick leave. An additional staff member is also required to free up existing staff to build additional pens in 2001. To alleviate this problem the Park hopes to hire one additional GS-05 fox care technician by spring, 2001. Estimated cost of the additional technician is approximately \$30,000 per year.

Project Lead: Tim Coonan
Completion Date: April 1, 2001

Set Production Goals and Identify Facility Size

Targeted facility size for each island is approximately 25 pens in two locations (or 25 breeding pairs per island), but the exact facility size required is unknown, and dependent upon recovery goals for each population. Those goals, in turn, will depend on the outcome of the demographic modeling meeting conducted in December, 2000. At that meeting, existing demographic data was used to determine vital rates, such as population size and trend, which are characteristic of recovered populations. The group was also asked to model captive populations capable of producing a targeted wild population size in a certain time frame. Dr. Gary Roemer organized the demographic monitoring meeting and will take the lead in producing a final report.

Project Lead: Dr. Gary Roemer, UCLA
Completion Date: February 28, 2001 (draft completed)

Budget

The island fox recovery efforts, including captive breeding, have been funded by a variety of National Park Service funding sources since 1999. Funding sources include the base budget of Channel Islands National Park, or parkbase; clusterbase funding from the NPS Pacific-Great Basin Support Office; the NPS servicewide Natural Resources Preservation Program (NRPP), and the servicewide recreational fee demonstration program.

1999-2000 Costs

Implementation of emergency fox recovery efforts at Channel Islands National Park began in late spring of fiscal year 1999 (October 1, 1998 to September 30, 1999). Recovery actions were funded by both the park and by the clusterbase (Table 7). These funds were used to build pens on San Miguel, trap foxes and caretaker for captive foxes, and begin golden eagle removal from Santa Cruz Island. Total monies expended were \$106,558, of which \$86,340 went to establish the captive breeding program on San Miguel Island.

Costs increased in fiscal year 2000 (Table 8) because captive breeding was added on Santa Rosa Island, and eagle removal efforts continued all year long. Total amount expended on island fox recovery at Channel Islands National Park in FY2000 was \$346,461, of which \$213,000 went to captive breeding.

Three years of NRPP funding for island fox recovery began in FY2000. The park will receive \$167,000 in FY2001 and \$83,000 in FY2002 from this servicewide funding source. The NPS clusterbase funding was one-year only, but the remainder of the NPS recreational fee demonstration money (\$41,000) will carry over to FY2001.

Future Costs

Estimated expenditures for fiscal year 2001 are outlined in Table 9, along with targeted funding sources. Those include the park's base account, a second year of NRPP funding, the remainder of the fee demonstration monies, and a U. S. Navy funding source. San Miguel Island is owned by the U. S. Navy and managed by the NPS as part of Channel Islands National Park. The U. S. Navy is contributing \$100,000 toward island fox recovery efforts on San Miguel Island. Eagle removal in FY2001 will be funded by the U.S. Fish and Wildlife Service and The Nature Conservancy. Island fox monitoring on Santa Cruz Island will be funded by The Nature Conservancy as well.

The costs of the additional tasks outlined in this document are included in the FY2001 cost estimates.

Table 8. Island fox recovery effort expenditures at Channel Islands NP, FY1999.

	Funding Source		
	NPS Clusterbase	Parkbase	Total
Captive Breeding			
Personnel	11,005	30,680	41,685
Island per diem	1,116	3,100	4,216
Pen materials	15,279	11,760	27,039
Fox food	200		200
Transportation	2,500	9,800	12,300
Supplies/equipment			0
Veterinary care	900		900
Subtotal - Captive Breeding	31,000	55,340	86,340
Eagle removal	15,000		15,000
Recovery team meeting		5,218	
Total	46,000	60,558	106,558

Table 9. Island fox recovery effort expenditures at Channel Islands NP, FY2000.

	Funding Source				
	NPS Clusterbase	NPS NRPP	Parkbase	NPS Rec. Fee Demo.	Total
Project Coordinator (GS-12)			75,609		75,609
Captive Breeding					
Personnel	9,302	63,985	17,445	5,451	96,183
Island per diem	1,582	5,902		5,759	13,243
Pen materials	27,600	697		5,847	34,144
Fox food	1,400	1,420			2,820
Transportation	2,648	14,558	6,217	19,568	42,991
Supplies/equipment	5,468	14,298		1,597	21,363
Veterinary care		1,219	1,047		2,266
Subtotal - Captive Breeding	48,000	102,079	24,709	38,222	213,010
Eagle removal	40,000	64,921	11,032		115,953
Subject expert travel				3,763	3,763
Santa Cruz fox monitoring				13,735	13,735
Total	88,000	167,000	111,350	55,720	422,070

Table 10. Estimated island fox recovery costs at Channel Islands NP, FY2001.

	Funding Source						Total
	NPS NRPP	Parkbase	NPS Fee Demo.	US Navy	USFWS	TNC	
Project Coordinator (GS-12)		75,609					75,609
Captive Breeding							
Personnel (3 GS-05's, 1 GS-06)	126,262						126,262
Island per diem	12,896		3,224				16,120
Pen materials	8,000		9,000	21,000			38,000
Fox food	1,500		4,000	1,500			7,000
Transportation	5,000		19,000	26,000			50,000
Genetic analysis				28,000			28,000
Supplies/equipment	10,842		4,000	16,000			30,842
Veterinary care	2,500			2,500			5,000
Subtotal - Captive Breeding	167,000	0	39,224	95,000			301,224
Eagle removal					30,000	25,000	55,000
Subject expert travel				5,000			5,000
Santa Cruz fox monitoring						50,000	50,000
Total	167,000	75,609	39,224	100,000	30,000	75,000	486,833

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Appendices

Appendix A: Recommendations of the Island Fox Recovery Team

FINDINGS AND RECOMMENDATIONS
FROM THE ISLAND FOX RECOVERY TEAM

Convened in Ventura, California

April 21-22, 1999

Meeting Participants:

Paul Collins
Santa Barbara Museum of Natural History

Tim Coonan
National Park Service
Channel Islands National Park

David Garcelon
Institute for Wildlife Studies

Lyndal Laughrin
University of California, Santa Barbara
Santa Cruz Island Preserve

Phil Miller
Conservation Breeding Specialist Group

Linda Munson
University of California, Davis
Department of Pathology, Microbiology and
Immunology

Katherine Ralls
Smithsonian Institution

Gary Roemer
Institute for Wildlife Studies

Ray Sauvajot
National Park Service
Santa Monica Mountains National Recreation Area

Grace Smith
U. S. Navy
Naval Construction Battalion Center

Nancy Thomas
U.S.G.S. Biological Resources Division
National Wildlife Health Center

Brian Walton
University of California, Santa Cruz
Santa Cruz Predatory Bird Research Group

Robert Wayne
University of California
Department of Organismic Biology, Ecology and
Evolution

Mark Willett, D.V.M.
Davis, California

FINDINGS:

Island foxes are declining rapidly toward extinction on the three northern islands.

At least one identified mortality source, predation by golden eagles, has been confirmed. Golden eagles continue to occur on the islands. Loss of historic bald eagle populations from past human impacts (e.g. pesticides), a simplified island habitat from human disturbance, and increased exotic prey availability (e.g. pigs) have unnaturally increased the prevalence of golden eagles on the islands.

Other mortality factors are under investigation and may include disease and/parasites. These potential factors pose an ongoing risk to island foxes.

On San Miguel and Santa Rosa Islands, fox populations are so diminished that continued persistence in the wild is unlikely. On Santa Cruz Island, the population decline is serious but does not appear to be at the crisis level found on the other northern islands.

RECOMMENDATIONS:

1) Initiate immediate rescue/capture efforts of island foxes on San Miguel and Santa Rosa Islands. Captured animals will be held in on-island sanctuaries (pens). All captured animals will receive a comprehensive health evaluation by qualified wildlife veterinarians. Animals will be carefully monitored and evaluated while in captivity and will receive appropriate professional care at all times. The rescue/capture effort serves two purposes:

- a) to provide sanctuary for the few animals that continue to exist on the islands;
- b) to acquire animals necessary for a more detailed captive breeding program to be developed as part of a comprehensive recovery plan for the island fox.

Rescue/capture efforts will begin immediately. All non-reproductive animals will be relocated to the on-island sanctuary. Reproductive individuals will be radio-marked and recaptured after denning in mid-June.

2) Initiate immediate live-capture and relocation of golden eagles from the northern islands. Golden eagles will be humanely captured, radio-marked, and relocated to appropriate distant sites with suitable habitat.

3) Develop a comprehensive species recovery plan to address ultimate recovery goals and objectives. This will include developing specific plans and detailed protocols for animals in the sanctuary and for a captive breeding program to recovery the species. In addition, the recovery plan will include continued research and monitoring of island fox populations on Santa Cruz Island to elucidate factors causing decline.

- 4) Provide all appropriate data and information about island fox biology and conservation to the U.S. Fish and Wildlife Service to initiate evaluation of this species for listing under the Endangered Species Act.
- 5) Aggressively move forward with the reintroduction of bald eagles on the northern islands. This recommendation is based on findings that bald eagles can deter golden eagles from establishing, that bald eagles pose a negligible threat to island foxes, and that bald eagles were a historic component of the island fauna.

Appendix B Members of the Island Fox Captive Working Group

Dr. Katherine Ralls, Chair
2275 Niderer Road
Paso Robles, CA 93446
Work: (805) 237-8215
FAX:
email: rallsk@thegrid.net

Dr. Marsha A. Sovada
USGS Biological Resources Division
Northern Prairie Wildlife Research Center
Jamestown, ND 58401
Work: (701) 253-5506
FAX: (701) 253-5553
email: marsha_sovada@usgs.gov

Amy Roberts
The Living Desert Wildlife & Botanical Park
47-900 Portola Avenue
Palm Desert, CA 92260
Work: (760) 346-5694
Fax: (760) 568-9685
email: tldmamal@netscape.net

Dr. Gary Roemer
Dept. of Org. Biol., Ecol. and Evol.
621 Charles E. Young Drive
University of California
Los Angeles, CA 90095-1606
Work: (310) 559-5034
FAX: (310) 559-5034
email: garyr@lifesci.ucla.edu

Dr. Mark Willett, DVM
651 Alvaroda Ave., No. 6
Davis, CA 95616
Work: (530) 758-1464
FAX:
email: mwillett@davis.com

Dr. Linda Munson
Vet. Med. Teaching Hospital
University of California
1 Garrod Drive
Davis, CA 95616-8739
Work: (530) 752-1368
FAX: (530) 752-3349
email: lmunson@ucdavis.edu

Keith Rutz
National Park Service
Channel Islands National Park
1901 Spinnaker Drive
Ventura, CA 93001
Work: (805) 658-5772
FAX: (805) 658-5798
email: keith_rutz@nps.gov

Tim Coonan
National Park Service
Channel Islands National Park
1901 Spinnaker Drive
Ventura, CA 93001
Work: (805) 658-5776
FAX: (805) 658-5798
email: tim_coonan@nps.gov

David Garcelon
Institute for Wildlife Studies
P.O. Box 1104
Arcata, CA 95521
Work: (707) 822-4258
FAX: (707) 822-6300
email: garcelon@iws.org

Dr. Robert Wayne
Dept. of Org. Biol., Ecol. and Evolution
621 Charles E. Young Ave.
University of California
Los Angeles, CA 90095-1606
Work: (310) 206-0334
FAX: (310) 206-3987
email: rwayne@ucla.edu

Dr. Cheryl Asa
St. Louis Zoo
Forest Park
St. Louis, MO 63110
Work: (314) 768-5488
FAX: 314) 768-5454
email: asa@slu.edu

Dr. Steve Timm, DVM
Institute for Wildlife Studies
P.O. Box 2500
Avalon, CA 90704
Work: (310) 510-3102
FAX: (310) 510-0982
email: keith_rutz@nps.gov

Dr. Sam Dover, DVM
Santa Barbara Zoological Gardens
500 Ninos Drive
Santa Barbara, CA 93103
Work: (805) 962-5339 x30
FAX: (805) 962-3056
email: sdover@santabarbarazoo.org

Alan Varsik
Santa Barbara Zoological Gardens
500 Ninos Drive
Santa Barbara, CA 93103
Work: (805) 962-5339
FAX: (805) 962-3056
email: avarsik@santabarbarazoo.org

Julia Parker
Santa Barbara Zoological Gardens
500 Ninos Drive
Santa Barbara, CA 93103
Work: (805) 962-5339
FAX: (805) 962-3056
email: sdover@santabarbarazoo.org

Appendix C Notes from Captive Breeding Working Group, June 2000

Captive Breeding Group

☛ Analyze past year's breeding season

Keith provided details of breeding season:

San Miguel Island

- One pair was observed copulating, which indicates either that they were already familiar with each other or that there was sufficient time for them to socialize and accept each other as mates.
- Unfortunately this pair did not produce pups, but we can't know for certain that pups were not born and then killed, which can be a problem in captivity if parents are not completely comfortable with conditions.
- Another pair that was not observed copulating did produce a litter of two and raised them successfully, which indicates that, at least for this pair, conditions were adequate for sexual behavior, gestation, parturition and parenting.
- Although cameras with infrared lights were installed in the pens with pairs and in one den box, equipment malfunctions occurred (mostly due to insufficient power from solar panels), so behavioral data on copulation, birth and parenting are incomplete.

Santa Rosa Island

- Foxes were trapped in Feb. and March and 3 females were already pregnant and gave birth within a few weeks of capture, which indicates that, at least during late gestation, the stress of capture and captivity do not necessarily interrupt pregnancy.
- All successfully raised their pups, so conditions were adequate for expression of parental behavior.

Summary

- It is not uncommon to have low or even no reproduction the first year animals are brought into captivity.
- Successful breeding and production of pups by one pair indicates that conditions were adequate for sexual behavior, gestation, parturition and parenting.
- Failure of other pairs on San Miguel is probably attributable to insufficient time for courtship and pair-bonding before the breeding season or to young age and inexperience of several animals.
- See Tables 1 and 2 for details

➤Specify goals of program

Husbandry Protocols

Numerical goals for initiation /termination: Review last year's recommendations
Standard methods of setting numbers is not appropriate
Recommend 25 breeding pairs per island before evaluating if release is appropriate
When releasing foxes, release a minimum of two family groups
Need to monitor survivability of released foxes for several years before setting
termination date of program

Release schedule/ strategy: (Review last year's recommendations)
No release while any golden eagles remain
Recommend soft release into suitable habitat
Need to monitor survivability of released foxes for several years before setting
termination date of program
Release strategies need to be tailored to individual island conditions and population status

➤Provide direction to NPS (Tim Coonan's captive breeding questions)

1. Is it safe to release foxes back into the wild? Not as long as there are golden eagles remaining.
2. Which animals should be released? None should be released now.
3. What principles should guide future pairings for breeding?
 - Maintain bonded pairs as long as they reproduce successfully; allow at least two seasons to assess reproductive success.
 - Avoid pairings of siblings or parent/offspring.
 - Pair captive-born foxes with wild caught mates, as long as this doesn't break up existing pairs, to minimize loss of wild behavioral traits.
 - Establish a studbook.
 - At present, main objective should be for maximum reproductive output; after successful reproduction established, then rely more on genetic considerations.
 - Consider developing a method for allowing female mate choice.
4. How can reproductive success be increased for the San Miguel Island captive population?
 - Successes include (of 4 pairs) one pair that copulated, even though pups were not found

(no way to know if the failure was to conceive, to carry or to properly parent), and one pair that was not seen copulating but did successfully raise 2 pups. This suggests that captive conditions are at least adequate for reproduction.

Unlikely that failure of ovulation or of spermatogenesis was responsible for low reproductive output this year; fecal estradiol and progesterone values (available in a few weeks) will provide information on ovulation in females.

It may be useful to increase distance between pens to increase sense of security; it may be at least or even more important to provide hiding places that still allow animals to have visual contact when they choose.

The young age of some of the foxes and capture during the proestrous period may have contributed to the failure to produce pups.

Age difference less likely than young age and inexperience of the male in the third pair that did not reproduce; also possible they were related, since they seemed socially bonded (Bob Wayne's lab will test relatedness).

5. Should animals not paired for breeding be released, housed separately or housed together?

Do not consider release until all golden eagles are removed.

OK to try housing unpaired females together.

6. Should the captive breeding facilities be expanded?

Yes.

Number of pens should be increased to accommodate 25 breeding pairs per island in two separate facilities

Construction each year should be completed by October so fox pairs have sufficient time to acclimate before the upcoming breeding season.

7. At what point do we consider artificial insemination or translocation of island foxes from other islands to San Miguel?

There may not have been enough time for acclimation and pair-bonding before the breeding season, so it is premature to resort to AI at this time (plus, AI in canids is not as simple as in many other species; Mexican wolf program is developing less invasive techniques; best to wait for progress with wolves or other canids); also premature to consider translocations.

☛ Learning from other programs

Field staff has studied and conferred with people working on the swift fox and Mexican wolf programs

☛ Interactions with eagle removal

☛ Disease risk

Medical intervention

Therapy: Vaccines, de-worming, field treatment for wounds, parasites, recovery of sick animals, major trauma treatment

Field Examinations:

Submit at least 1 gram of fresh feces (<24 hr old) suspended in 70% ethanol (formalin-fixed is an alternative); send to Dr. Linda Munson

Routine Treatment for ancylostoma, uncinaria, toxascara:

1. Fecal floatation and confirmation of parasite load.
2. 10 mg/kg orally pyrantel pamoate suspension (Nemex). May be given in cavity of a mouse or other treat.
3. Repeat fecal exam at next treatment.
4. For hookworms (ancylostoma, uncinaria) retreat at 2 weeks; for ascarids toxoscara)
5. retreat at 3-4 weeks.
6. May retreat every 2 weeks for 3-5 treatments for resistant infestations.
7. Treatment during pregnancy and lactation considered safe.
8. Prior to ANY use of Ivermectin, 3 prior fecal exams need to be negative for heartworm, spirocirca and angiocaulus.

Vet Protocol Development

1. Foxes cannot be returned to island if removed for any reason
2. Need to establish a minimum of two isolation areas at each facility
3. Check with zoos that hold island foxes to coordinate veterinary care

RECOMENDATIONS FOR THE CAPTIVE BREEDING PROGRAM

Numerical Goals:

- Standard genetic and demographic methods of setting numerical objectives is not appropriate because goals of overall program is for captivity only to serve as a refugium and to supply animals for release until the free-ranging population is deemed stable.
- Recommend 50 foxes, preferably as male/female pairs, per island. This recommendation based on adequate numbers to allow:
 1. Sufficient genetic distance between breeding pairs
 2. Female mate choice to ensure pair compatibility and successful reproduction
 3. A hedge against extinction
- Recommend that the 50 foxes be maintained in at least 2 separate facilities/island to protect against catastrophic loss that might affect one facility.

Selecting Potential Pairs for Mating:

- Maintain bonded pairs as long as they reproduce successfully; allow at least two seasons to assess reproductive success.
- Avoid pairings of siblings or parent/offspring.
- Pair captive-born foxes with wild caught mates, as long as this doesn't break up existing pairs, to minimize loss of wild behavioral traits.
- Establish a studbook.
- At present, main objective should be for maximum reproductive output; after successful reproduction established, then rely more on genetic considerations.
- Recommend developing a method for allowing female mate choice.
- Excess females may be housed together if compatible to allow for social interaction or to possibly test reproductive potential of one male with two females.
- Translocation of additional males to pair with excess San Miguel females is an option that should be considered by genetic advisors and veterinarians.
- It is premature to resort to artificial insemination at this time (plus, AI in canids is not as simple as in many other species; Mexican wolf program is developing less invasive techniques; best to wait for progress with wolves or other canids).

Facilities:

- Recommend constructing at least 25 pens in two separate locations per island
- It may be useful to increase distance between pens to increase sense of security; it may be at least or even more important to provide hiding places that still allow animals to have visual contact when they choose.
- Construction each year should be completed by October so fox pairs have sufficient time to acclimate before the upcoming breeding season.

Release:

- Recommend soft releases with a minimum of 2 family groups.
- Monitor survivability of released foxes for several years before setting a termination date of the program.
- Do not release foxes while any golden eagles remain.
- Release strategies need to be tailored to individual island conditions and fox population status.

Research Recommendations

San Clemente (SC):

Brought in usually from May-July
Have started trying to bring in pregnant females earlier
Limited research possible, though, because of lack of funding
(And San Diego Zoo Shrike Program will oppose funding for foxes)

Maybe not ideal for studying behavior or social needs
Santa Catalina (STC):

Santa Barbara Zoo (SBZ) and other zoos could also collect data

Safety trials (SC, STC, SBZ):

- vaccines
- antibiotics
- anthelmintics
- anesthesia

Validate relaxin assay to diagnose pregnancy (SC, STC):

- (Need plasma samples and ultrasound exams of both pregnant and non-pregnant females at

- from 4-6 weeks post-copulation; St. Louis Zoo will run assays on plasma)

- (Advantage to ultrasound exam of San Miguel and Santa Rosa would be to better diagnose

- failure to produce pups, i.e, is failure at the level of ovulation, fertilization, gestation, or parental behavior. Risk of handling to pregnancy success seems low, since pregnant females were captured last year and brought into captivity, but gave birth to healthy pups)

Pup development (SC, SBZ):

- First exam within first week of life

- Den box cameras

- Design den boxes for easy access to pups

Electroejaculation to test semen collection technique and evaluate semen

General Recommendations

1. More than one facility should be established on each island
2. More systematic (regular) veterinary exams need to be scheduled
3. Dedicated budget needs to be established for veterinary care

ACTION ITEMS

1. Complete veterinary protocols: Mark Willett and Steve Timm
2. Circulate current husbandry SOP (Standard Operating Protocol) to group: Keith Rutz
3. Check lab dog husbandry SOP for comparison: Cheri Asa
4. Assemble and circulate all available canid SOPs to group: Keith Rutz and Patricia Hartman

5. Check with entomologists and lab animal specialists for breeding protocols for native prey: Cheri Asa, Keith Rutz, Mark Willett
6. Establish studbook for each captive group: Tim Coonan
7. Tech training in some basic (first response) veterinary procedures:
One or more weeks with Sam Dover at Santa Barbara Zoo
Vets will produce guidelines with Keith Rutz
8. Field trip to fennec fox breeders (CA and FL): Cheri, Keith, Mark, Patricia
9. Island field trips

Table 1. Reproduction in captive foxes on San Miguel Island, 2000.

Pen	Pit #	Sex	Age	Date Captured	Date Paired	Mating	Birth	Litter Size	Pups First Seen
A	71071	F	1	8/24/99					
B	60921	F	2	9/24/99	10/2/99	3/15/99 ¹			
	85D02	M	1	9/17/99	10/2/99				
C	7574A		2	5/14/99	7/16/99	3/7/99 ²			
	92C32		2	5/17/99	7/16/99				
D	61B03	F		10/28/99					
E	B0B25	F	1	9/28/99					
G	90D1A		2	9/2/99	9/4/99	Not observed	4/20/99	2	5/21/99
	44829		2	9/4/99	9/4/99				
H	57150	M	2	10/4/99	10/31/99				
	7534A	F	6	9/4/99	10/31/99				
I	F6558	F	1	9/17/99					
J	92804	F	>7	10/24/99					
K	E2677	F	2	9/11/99					

¹ Attempted Mount

² Copulatory Tie

Table 2. Reproduction in captive foxes on Santa Rosa Island, 2000.

Pen	Pit #	Sex	Age	Date Captured	Date Paired	Mating	Birth	Litter Size	Pups First Seen
R1	A7015	F	1 (age class)	4/3/00		Pregnant	4/10/99	4 (3 lived)	5/28/99
	A045A	M	Born-2000						
	70518	M	Born-2000						
	0654E	M	Born-2000						
R2	D3D76	M	1 (age class)	3/24/00					
R3	2410E	F	Born-2000						
	B067E	M	2 (age class)	3/26/00	3/31/00				
	1612C	F	1 (age class)	3/23/00	3/31/00	Pregnant	4/26/99	1	6/11/99
R4	F4A18	F	1 (age class)	3/29/00		Pregnant	4/16/99	4	5/15/99
	37C61	F	Born-2000						
	84F28	M	Born-2000						
		F	Born-2000						
	E5100	F	Born-2000						
R5	F0223	M	2 (age class)	4/6/00					
R6	10030	F	2(age class)	4/5/00					
R7	D187A	F	2 (age class)	4/3/00					
R8	33131	F	1 (age class)	4/3/00					
RQ2	73D0D	M	2 (age class)	7/24/00					

Appendix D Standard Operating Procedure for Island Fox Care

STANDARD OPERATING PROCEDURE

Animal Care Protocol for Island Foxes Held Captive at Channel Islands National Park Facilities

September, 2000

PURPOSE: To meet animal welfare standards and to insure proper care of island foxes held in captivity.

INSTRUCTIONS:

A. Holding facilities:

There are currently eleven pens (A-K) for housing island foxes on San Miguel Island, and 10 pens on Santa Rosa Island. Pens are constructed of 11½-gauge fence fabric secured to 3/8" tubular frames to form 10 X 10 ft and 6 X 10-ft pen components. Components are fastened together using saddle-clamps. Pens are fully enclosed with wire mesh roofs and 1½ ft ground skirts to prevent foxes from tunneling out. On San Miguel there are eight 500 sq.ft U-shaped pens, one L-shaped 300-sq.ft pen, and two 200 sq. ft rectangular pens. On Santa Rosa there are eight 500 sq.ft.U-shaped pens and two 300 sp.ft L-shaped pens. Pens on San Miguel are 6-10 feet apart with pens E and F approximately 100 feet NW of pens D and H, and pen K is approximately 50 feet SE of pen J. On Santa Rosa pens are a minimum of 50 feet apart.

Pens have combinations of above and below ground wooden den boxes and wooden shade structures. Additional pen furniture is being added. Shade cloth is also attached to pens to provide protection from sun and wind.

San Miguel currently houses 16 island foxes (11 females and 5 males) including two pups born in spring 2000. On Santa Rosa there are currently 20 island foxes in captivity, including 12 adults (seven females, five males) and eight pups (four males, four females) born in captivity in 2000.

B. Health care:

Animals will undergo veterinary examinations as soon after capture as feasible. Sick or injured animals will be treated by the veterinarian. New animals are housed separately for two-four weeks before being introduced to potential mates or brought into proximity of other captive foxes. Hormonal assays will be performed on scat samples taken from captive females to assist in determining reproductive status. Fecal samples are screened for presence of parasites, and blood samples are taken for blood counts and serum chemistry.

C. Feeding and water:

Foxes are fed dry dog food (protein 25-28%, fat 10-12%) daily, supplemented several times a week by dead or live mice, dead coturnix quail, a variety of fruits and vegetables and hard-boiled eggs. They are not given moist meat-based food, such as canned cat or dog food, or fruits high in citric acid since that may result in gingivitis and tooth loss.

The amount of food given daily is equal to 3-4%, dry weight, of their body weight (i.e., a 2.3 kg adult gets 90g of food, daily).

Foxes are provided with water *ad libitum*.

Unconsumed food items and scat are removed from the pens daily. Each fox has an individual food bowl washed out daily with soap and water. Animals are fed near dusk to mimic their natural foraging time.

D. Periodic observations:

Animals are observed during feeding and behavior recorded periodically. Animals that are introduced into already occupied pens are first placed in adjacent pens with a common wall and interactions are recorded via video camera. A remote video camera monitoring system is also being used on San Miguel to document behavior.

E. Other instructions:

The AZA's guidelines for small canid captive breeding were consulted during facility design and program development. Guidelines established by the American Society of Mammalogists (1987) will be followed in all capture and handling of animals. Animal caretakers disinfect their shoes with a chlorine bleach solution before entering each pen to help prevent the transmission of disease between pens.

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Timothy J. Coonan
Biologist

Date