

# ISLAND CONSERVATION ACTION IN NORTHWEST MÉXICO

C. Josh Donlan<sup>1,2</sup>, Bernie R. Tershy<sup>1,4</sup>, Brad S. Keitt<sup>1,3</sup>, Bill Wood<sup>1</sup>, José Ángel Sánchez<sup>5</sup>, Anna Weinstein<sup>1</sup>, Donald A. Croll<sup>1,4</sup>, Miguel Ángel Hermosillo<sup>5</sup>, and José Luis Aguilar<sup>6</sup>

<sup>1</sup> Island Conservation and Ecology Group, P. O. Box 141, Davenport, CA 95107  
(831) 469-8651, FAX (831) 469-8651, E-mail: jdonlan@cats.ucsc.edu

<sup>2</sup> Dept. of Biology, A-316 E.M.S. Building, University of California, Santa Cruz, CA 95064  
(831) 459-4581, FAX (831) 459-4882

<sup>3</sup> Dept. of Ocean Sciences, A-316 E.M.S. Building, University of California, Santa Cruz, CA 95064  
(831) 459-4581, FAX (831) 459-4882

<sup>4</sup> Institute of Marine Sciences, A-316 E.M.S. Building, University of California, Santa Cruz, CA 95064  
(831) 459-3610, FAX (831) 459-4882

<sup>5</sup> Grupo de Ecología y Conservación de Islas A. C., AP 71, Guerrero Negro, Baja California Sur 23940 México  
011-52 (115) 7-11-20, FAX 011-52 (115) 7-11-20

<sup>6</sup> Departamento de Áreas Naturales Protegidas, Secretaría del Medio Ambiente Recursos Naturales y Pesca, Delegación Baja California. Privada Riviera # 1-A, Conjunto PRONAF, Zona Centro. Ensenada, Baja California 763510 México  
011-52 (617) 6-35-10, FAX 011-52-(617) 6-09-77

## ABSTRACT

Introduced mammals are present on many of the over 230 islands and islets in northwest México. Introduced mammals threaten many endemic species with extinction: of the 19 island vertebrate extinctions in northwest México, 18 can be attributed to introduced mammals. Over the past four years the Universidad Nacional Autónoma de México (UNAM) and the Island Conservation and Ecology Group (ICEG) have worked with Mexican government agencies (Mexican Office of National Protected Areas of Secretaría del Medio Ambiente Recursos Naturales y Pesca (SEMARNAP), Vizcaíno Biosphere Reserve, and the Gulf of California Islands Reserve) and local Mexican fishing cooperatives to protect island ecosystems. These collaborations have resulted in introduced mammal removal projects on nine islands in the region. Introduced mammals have been removed from nine islands: feral cats from Isabel, Asunción and Coronado Norte Islands; feral cats and rats from Isla San Roque; rats from Isla Rasa; goats and sheep from Isla Natividad; feral cats and rabbits from Isla Todos Santos Sur; and goats and burros from the Islas San Benito Oeste and Medio. Additional removal projects are currently in progress: feral cats from Isla Natividad and rats from Isla Isabel. To aid in the systematic prioritization of islands for conservation action and guide research activities, we have developed an island conservation relational database for the northwest México region that is available over the Internet via the World Wide Web at: <http://islandconservation.org>.

**Keywords:** Baja California, introduced mammals, endemic, extinction, seabirds, rats, cats, goats, rabbits, burros, relational database.

## INTRODUCTION

Islands cover 2.7% of the earth's surface (AMNH 1998). Islands around the world are of critical importance to global biodiversity because they are rich in endemic species and important breeding areas for many wide-ranging marine animals (e.g., sea turtles, seabirds, and marine mammals). Furthermore, islands are natural habitat fragments to which species and communities have adapted. Unlike man-made habitat fragments in continental protected areas, natural ecological and evolutionary processes can persist on protected islands without intensive management. Thus by conserving island ecosystems, both significant biological diversity and important ecosystem processes are preserved with minimal land requirements (Tershy and Croll 1994).

The most serious threat to islands worldwide is the introduction of nonnative plants and animals. The majority of recorded animal extinctions (75%) have been on islands and most of these island extinctions can be attributed to introduced species (Diamond 1989; Groombridge 1992). Plants show a similar pattern: of the 250 plant species listed in the 1978 International Union for Conservation of Nature and Natural Resources Plant Red Data Book, 96 (38%) are from islands and many of these plants are threatened by introduced species (IUCN 1978). In addition to direct effects, introduced species can also lead to numerous indirect effects, which can have dramatic consequences on island communities and ecosystems (Elton 1958; Moors 1985; Mooney and Drake 1986; Cushman 1995).

There are over 230 islands and islets in northwest (NW) México. Overall, these islands harbor considerable biodiversity, including a wide taxonomic range of endemics (Huey 1964; Avise 1974; Soulé and Sloan 1966; Soulé and Yang 1973; Cody et al. 1983, Lawlor 1983; Murphy 1983;

Grismer 1993). These islands are considered by some biogeographers to be one of the most ecologically intact non-polar archipelagos in the world (Case and Cody 1983). Despite this, introduced plants and animals threaten many of the region's island ecosystems. For example, the introduced iceplant *Mesembryanthemum crystallinum* and the introduced annual *Malva parviflora* have become common or dominant plants on some of the region's islands (Junak and Philbrick 1994a, 1994b, 1999; J. Donlan, pers. obs. 1998). Introduced mammals are responsible for 18 of the 19 animal extinctions that have taken place on islands in NW México (ICEG, unpublished 1998). Introduced mammals are present on at least 39 islands in NW México (ICEG, unpublished 1998). The most common nonnative mammals in this region include black rats (*Rattus rattus*), Norway rats (*Rattus norvegicus*), cats (*Felis catus*), dogs (*Canis familiaris*), european rabbits (*Oryctolagus cuniculus*), goats (*Capra hircus*), and burros (*Equus asinus*).

A number of groups have participated in introduced species removal projects on islands in NW México: the Mexican Office of National Protected Areas (ANP) of the Secretaría del Medio Ambiente Recursos Naturales y Pesca (SEMARNAP), Instituto Nacional de Ecología (INE), Universidad Nacional Autónoma de México (UNAM), Gulf of California Islands Reserve, Delegación SEMARNAP of Baja California, and the Island Conservation and Ecology Group/Grupo de Ecología y Conservación de Islas (ICEG/GECI). In this paper, we first review past and present introduced mammal removal projects in this region, with an emphasis on the projects of ICEG. We then discuss a recently developed island conservation database. This relational database, developed by ICEG, compiles relevant conservation data for islands in the region to help prioritize conservation action.

## INTRODUCED SPECIES REMOVAL IN NORTHWEST MÉXICO

### Gulf of California

#### Isla Rasa

The fall of 1994 marked the beginning of introduced species eradication on the islands of NW México. Jesús Ramírez (Centro de Ecología, UNAM) in conjunction with Enriqueta Velarde (INE) started the removal of Norway rats (*R. norvegicus*) and house mice (*Mus musculus*) from Isla Rasa (60 ha) in the central Gulf of California (Figure 1). Following techniques developed in New Zealand, Ramírez worked with a large team of undergraduate and community volunteers to set bait stations filled with Talon Weatherblock (0.05% brodifacoum). The bait stations were maintained for one year on this uninhabited island.

The eradication effort was successful; the island has been free of introduced mammals for over three years. Isla Rasa is one of the most important seabird colonies in North America with more than 90% of the global populations of



**Figure 1.** Islands in northwest México where introduced species have been removed or are currently being removed.

elegant terns (*Sterna elegans*) and Heermann's gulls (*Larus heermanni*). An estimated 360,000 gulls and terns breed on this small island between March and June (Velarde and Anderson 1994). Guano miners introduced rats and mice at the turn of the century. While rats and mice had minor impacts on the gulls and terns, they are possibly responsible for the absence of nocturnal hole and crevice nesting birds such as the Craveri's murrelet (*Synthliboramphus craveri*), black storm-petrels (*Oceanodroma melania*), least storm-petrels (*O. microsoma*), and black-vented shearwaters (*Puffinus opisthomelas*). Isla Rasa was the first island in NW México to receive protected status (in 1964) and since then has been a conservation success story.

#### Isla Isabel

Cristina Rodríguez Juárez and Hugh Drummond (Centro de Ecología, UNAM) led a program to remove cats and black rats (*R. rattus*) from Isla Isabel (98 ha) located at the mouth of the Gulf of California (Figure 1). This island, off the Pacific coast of the state of Nayarit, was once the largest sooty tern (*Sterna fuscata*) colony in México; however, over the last 60 years cat predation has decreased the size of the colony considerably. Feral cats prey on these terns as well as the native lizards *Sceloporus clarki* and *Cnemidophorus costatus* (Rodríguez Juárez 1998).

Some 600 cats were removed from Isla Isabel between 1995 and 1998. Both poisoning, trapping, and hunting were used to remove cats from the island. As of winter 1999, the island appeared to be free of cats. Rats were poisoned using Talon Weatherblock. However, rat removal has not been successful due to native land crabs consuming much of the rat bait (invertebrates are not affected by Talon; Rodríguez Juárez 1998). Alternative methods for rat removal are being investigated.

## Pacific Islands

### Isla Coronado Norte

The Los Coronados Islands are located close to the México/U.S. border, approximately 13 km<sup>2</sup> offshore of Tijuana (Figure 1). This island group consist of four rocky islands: Isla Norte, Isla Sur, Isla Medio and a small unnamed islet (combined: 250 ha). While cats were recorded on Isla Coronado Sur as early as 1908 (Wright 1909), they were not introduced onto Isla Coronado Norte until the late 1970s or early 1980s (Everett 1991). However, earlier introductions and natural extirpations are a possibility (McChesney and Tershy, In press). Between 1995 and 1996, the Baja California State Office of ANP and ICEG removed feral cats from Isla Coronado Norte. A total of 22 cats were removed from the island and several subsequent follow-up trips have shown no sign of cat presence.

The impacts of the Isla Coronado Norte cat population on seabirds was substantial (Table 1). Leach's storm-petrel (*Oceanodroma leucorhoa*) and Cassin's auklet (*Ptychoramphus aleuticus*) colonies have been extirpated from Isla Coronado Norte, most likely from cat predation. Cats are also responsible for the mortality of hundreds of Xantus' murrelets (*Synthliboramphus hypoleucus*) and black storm petrels (*O. melania*) annually (McChesney and Tershy, in press and references therein). In addition to important seabird colonies, Isla Coronado Norte is home to one endemic mammal, two endemic reptiles, and two endemic landbirds (Table 2). Given the diverse diet of feral cats (Jones and Coman 1981; Warner 1985; Churcher and Lawton 1987), it is likely that the feral cat population once present on Coronado Norte preyed upon all of these endemics.

### Isla Todos Santos Sur

The Todos Santos Islands are located in the Bay of Ensenada 6 km north of Punta Banda, a promontory just south of Ensenada (Figure 1). These two islands are approximately 90 km south of the México/U.S. border. Todos Santos Sur (100 ha) is the larger of the two islands and is inhabited year-round by the abalone aquaculture business, Abulones Cultivados. A building is located on the northeast side of the island and is home to approximately 20 workers. There is also a small structure on the south end of the island used by several lobster fishermen from September to February.

The Todos Santos islands have a long history of introduced species. European rabbits (*O. cuniculus*) were introduced to the South island sometime between 1969 and 1979 (Moran, unpublished, 1979 ref. not seen by authors). Cats were introduced sometime between 1910 and 1923 (Howell 1912; Van Denburgh 1924). Both cats and rabbits were present in large enough numbers to be observed in 1978 and 1987 (Junak and Philbrick 1994a). On Todos Santos Sur, cat predation has been reported on Xantus' murrelets (Van Denburgh 1924; B. Tershy, pers. obs. 1997) and Cassin's auklets (J. Jehl, pers. comm., cited in Tershy and McChesney,

In press). This predation is likely the main cause for the extirpation of these two species from this island (Table 1).

In conjunction with the Baja California State Office of ANP, personnel from the Gulf of California Islands Reserve, and Abulones Cultivados, ICEG began a removal effort for both rabbits and cats on the South Island in November 1997. A combination of trapping and hunting was used to remove both rabbit and cat populations. Over 30 cats and 40 rabbits were removed on Isla Todos Santos Sur between November 1997 and July 1998. There has been no sign of rabbits or cats during several follow-up trips during the fall 1998 and winter 1999. On Todos Santos Norte, where a removal program is planned, rabbits and cats are present along with four burros.

While Todos Santos Sur is depauperate in botanical endemism (one multi-island endemic species, *Eschscholzia ramosa*), five endemic vertebrates until recently inhabited the island (Table 2; Van Denburgh 1924; Huey 1964; Mellink 1992; Grismer 1993; Junak and Philbrick 1994a). Unfortunately, it is very likely that introduced cats drove an endemic species and subspecies to global extinction prior to the removal program. While Van Denburgh (1924) reported the endemic Todos Santos packrat (*Neotoma anthonyi*) as being abundant, it has not been observed recently despite trapping efforts by Donlan (unpublished 1999) over the last two years and by Mellink in 1991 (Mellink 1992). The endemic subspecies of the rufous-crowned sparrow (*Aimophila ruficeps sanctorum*) appears also to be extinct, with predation by cats a likely cause. Mellink (1992) searched for the bird with the aid of bird-call recordings with no success. We have not seen the sparrow during two years of frequent visits. Todos Santos Sur is also home to two endemic snakes: the Todos Santos ringneck snake (*Diadophis punctatus anthonyi*) and the Todos Santos mountain kingsnake (*Lampropeltis zonata herrerae*). These endemic subspecies are unique to the island and introduced cats were likely a threat to their existence. Cats may also have competed for food resources with the kingsnake, by preying on island lizards and skinks. This kingsnake feeds primarily on lizards belonging to the genus *Sceloporus* and to a lesser degree skinks belonging to the genus *Eumeces* (Grismer 1993). Interestingly, the Todos Santos Islands are the only Pacific Baja California islands where these three taxa co-occur: *L. zonata herrerae*, *Sceloporus occidentalis longipes*, *Eumeces skiltonianus interparietalis*, the latter two occurring on both the north and south islands (Grismer 1993).

### Islas San Benito

The San Benito Islands (combined: 640 ha) are approximately 65 km west of Punta Eugenia, the tip of the Vizcaíno peninsula (Figure 1). These three oceanic islands are 30 km northwest of Cedros Island. West San Benito is the largest of the group, possessing the most topographic and biological diversity. There is a lighthouse on West San Benito, which is maintained by one person year-round. In addition, there is a permanent fishing camp run by a fishing

**Table 1. Nesting seabirds on nine northwest Mexican islands where introduced species were removed or are currently being removed<sup>a</sup>. An X indicates breeding presence, an E indicates the colony has been extirpated and an E? indicates the species may have nested historically and has been extirpated. Table is modified from McChesney and Tershy, in press.**

	Isabela	Rasa	Coronado Norte	Todos Santos Sur	Natividad	San Benitos <sup>b</sup>	Asuncion	San Roque
Black-vented shearwater ( <i>Puffinus opisthomelas</i> )		E?			X	X	E?	E?
Ashy storm-petrel ( <i>Oceanodroma homocroa</i> )			X					
Black storm-petrel ( <i>Oceanodroma melania</i> )		E?	X		E?	X	E?	E?
Leachs storm-petrel ( <i>Oceanodroma leucorhoa</i> )			E		E?	X	E?	E?
Least storm-petrel ( <i>Oceanodroma microsoma</i> )		E?				X		
Magnificent frigatebird ( <i>Fregata magnificens</i> )	X							
Red-billed tropicbird ( <i>Phaethon aethereus</i> )	X							
Brown pelican ( <i>Pelecanus occidentalis</i> )	X		X		X		E	X
Brown booby ( <i>Sula leucogaster</i> )	X							
Blue-footed booby ( <i>Sula nebouxii</i> )	X							
Red-footed booby ( <i>Sula sula</i> )	X							
Brandts cormorant ( <i>Phalacrocorax pencillatus</i> )			X	X	X		X	X
Double-crested cormorant ( <i>Phalacrocorax auritus</i> )			X	X	X		X?	X
Heermanns gull ( <i>Larus heermanni</i> )		X						X
Western gull ( <i>Larus occidentalis</i> )			X	X	X	X	X	X
Elegant terns ( <i>Sterna elegans</i> )		X						X
Sooty terns ( <i>Sterna fuscata</i> )	X							
Royal terns ( <i>Sterna maxima</i> )		X						
Brown noddy ( <i>Anous stolidus</i> )	X							
Xantus murrelet ( <i>Synthliboramphus hypoleucus</i> )			X	X		X	E	E?
Craveris murrelet ( <i>Synthliboramphus craveri</i> )		E?				X		
Cassin auklet ( <i>Ptychoramphus aleuticus</i> )			E	E	E	X	E	E

<sup>a</sup>Sources: Boswall 1978; Rodriquez Juarez 1998; ICEG, unpublished, 1998; McChesney and Tershy in press.

<sup>b</sup> West San Benito and Middle San Benito Islands.

cooperative based on Cedros Island, Pescadores Nacionales de Abulón. During abalone season there are as many as 70 people based at the Benito Camp; however, the area directly impacted on the island is relatively minimal (J. Donlan, pers. obs. 1998). Pescadores Nacionales de Abulón is actively participating with ICEG in the conservation projects on the Benito islands, providing housing and transportation.

While diversity is lower in comparison to the Pacific islands to the north, endemism is high on the San Benito Islands. The San Benito group harbors at least three endemic plants (one of which is restricted only to West San Benito), four endemic landbirds, and one endemic lizard (Table 2; Van Rossem 1943; Boswall 1978; Grismer 1993, 1996; Junak and Philbrick 1999). No native mammals are present on these islands. One of the endemic bird subspecies, the McGregor house finch (*Carpodacus mexicanus mcgregori*) is thought to be extinct (Boswall 1978). While the cause of the extinction is uncertain, cats were historically present on the San Benito Islands (Anthony 1925; Hanna 1925).

Introduced herbivores (i.e., goats and burros) have been reported on the San Benito islands as early as 1948; however, their presence has not been continuous (Junak and Philbrick 1999). Rabbits were introduced to West San Benito sometime during the early 1990s (Junak and Philbrick 1999). In addition to rabbits, seven goats and five burros were observed on West San Benito in December 1997 (J. Donlan, pers. obs. 1997). Rabbits were not introduced onto the East and Middle island until 1995 or 1996 (Junak and Philbrick 1999; B. Tershy and D. Croll, pers. obs. 1996). Introduced rabbits, goats and burros threaten many of the plants on the San Benito Islands. Introduced herbivores on West San Benito nearly drove the endemic Live-forever, *Dudleya linearis*, to extinction. Before the start of the removal campaign, very few individuals of this species were present on the island. Botanist S. Junak observed few live and many dead plants during a visit in 1996 (Junak and Philbrick 1999). During December 1997, J. Donlan (pers. obs. 1997) observed only 16 seedlings concentrated on one rocky slope.

**Table 2. Animal endemics on nine northwest Mexican islands where introduced species were removed or currently are being removed<sup>a</sup>. An X indicates presence, an E indicates the species or subspecies is extinct. The Endemism column indicates the level of endemism.**

	Isabela	Rasa	Coronado Norte	Todos Santos Sur	Natividad	San Benitos <sup>b</sup>	Asuncion	San Roque	Endemism
<b>Birds</b>									
San Benito horned lark ( <i>Otocoris alpestris baileyi</i> )						X			Subspecies
San Benito rock wren ( <i>Salpinctes obsoletus tenuirostris</i> )						X			Subspecies
San Benito savannah sparrow ( <i>Passerculus sandwichensis sanctorum</i> )						X			Subspecies
Los Coronados song sparrow ( <i>Melospiza melodia coronatorum</i> )			X						Subspecies
Todos Santos rufous-crowned sparrow ( <i>Aimophila ruficeps sanctorum</i> )				E					Subspecies
Los Coronados house finch ( <i>Carpodacus mexicanus clementis</i> )			X						Subspecies
McGregor house finch ( <i>Carpodacus mexicanus mcgregori</i> )							E		Subspecies
<b>Reptiles</b>									
San Benito side-blotched lizard ( <i>Uta stellata</i> )						X			Species
Los Coronados whiptail lizard ( <i>Cnemidophorus tigris vividus</i> )			X						Subspecies
Los Coronados alligator lizard ( <i>Elgaria multicarinata nana</i> )			X						Subspecies
Todos Santos ringneck snake ( <i>Diadophis punctatus anthonyi</i> )				X					Subspecies
Todos Santos mountain kingsnake ( <i>Lampropeltis zonata herrerae</i> )				X					Subspecies
<b>Mammals</b>									
Los Coronados white-footed mouse ( <i>Peromyscus maniculatus assimilis</i> )			X						Subspecies
San Roque white-footed mouse ( <i>Peromyscus maniculatus cineritius</i> )							E		Subspecies
Natividad white-footed mouse ( <i>Peromyscus maniculatus dorsalis</i> )					X				Subspecies
Todos Santos white-footed mouse ( <i>Peromyscus maniculatus dubius</i> )				X					Subspecies
Todos Santos wood rat ( <i>Neotoma anthonyi</i> )				E					Species

<sup>a</sup> Sources: Van Rossem 1943; Huey 1964; Boswell 1978; Grismer 1993, 1996; ICEG, unpublished, 1998; Rodriguez Juarez 1998.

<sup>b</sup> West San Benito and Middle San Benito Islands

Introduced herbivores grazed heavily on the multi-island endemic, *Lavatera venosa*, (found on six islands) threatening the populations of the San Benito Islands (Junak and Philbrick 1999; J. Donlan, pers. obs. 1997). A San Benito endemic fishhook cactus, *Mammillaria neopalmeri* has also been heavily impacted by the introduced herbivores along with many of the non-endemic plants. In addition to these impacts on the island plants, rabbits may have competed for burrows with the many hole-nesting seabirds of the San Benito islands (Table 1).

In collaboration with the Baja California State Office of ANP and Pescadores Nacionales de Abulón, ICEG began removing rabbits and goats from West San Benito in January 1998. A combination of hunting and trapping was used for the removal. Over 400 rabbits were removed from West San Benito over a seven month period. During that same time period approximately 15 rabbits were removed from Middle San Benito. Seven goats were removed from West San Benito and the burros were permanently corralled, with processed food provided. Multiple follow-up trips were made over the fall of 1998 and will continue to be made throughout 1999. Presently, the West and Middle San Benito islands appear to be free of rabbits and goats. Many of the

impacted plant species have already shown sign of recovery (J. Donlan, unpublished 1999). ICEG plans to remove rabbits from East San Benito during the fall of 1999.

### Isla Natividad

Isla Natividad (~1000 ha) is 5 km north of Punta Eugenia (Figure 1). There is a town of 400 permanent residents on the south end of the island; most inhabitants are members of the fishing cooperative, Buzos y Pescadores. In 1996 ICEG initiated a cooperative research project with the Vizcaíno Biosphere Reserve and Buzos y Pescadores to study the natural history and conservation of the Baja California endemic black-vented shearwater (*P. opisthomelas*; Keitt 1998). The island has a diverse assemblage of breeding birds including: osprey (*Pandion haliaetus*), peregrine falcons (*Falco peregrinus*), brown pelicans (*Pelecanus occidentalis*), Brandt's and double-crested cormorants (*Phalacrocorax penicillatus*, *P. auritus*), western gulls (*Larus occidentalis*), and over 90% of the world population of black-vented shearwaters (*P. opisthomelas*) (Table 1). Feral cats, and to a lesser extent introduced herbivores and human disturbance, pose a serious threat to this important breeding area (Keitt 1998).

Natividad has a long history of human inhabitation and consequently the first scientific reports mention the presence of introduced mammals (Brandege 1900; Anthony 1925). In 1967 Delong and Crossin (unpublished 1968) reported cats on the island and remarked about the numerous shearwater carcasses scattered around the colony. During 1997 and 1998 feral cats were responsible for the mortality of hundreds of black-vented shearwaters (Keitt 1998). During 1997, we encountered a band of 40 goats and 15 sheep on the island along with a new mammal introduction, an antelope squirrel tentatively identified as *Ammospermophilus harrisi*. Goats and sheep were causing damage to native vegetation and impacting the black-vented Shearwater colony. It is unclear what impacts, if any, the antelope squirrels may be having on Natividad.

In addition to investigating the basic breeding biology of the black-vented shearwater, we conducted informal environmental education programs with island residents. Over the past two years, we have made presentations to the school children about the native animals on the island, conducted class field trips to see the breeding birds, and organized games to help raise awareness about island conservation (Keitt 1998). In 1997, with the cooperation of Vizcaíno Biosphere Reserve, we succeeded in moving all of the goats and sheep to a farm near Ensenada, México. In 1998, in part due to our education efforts and the unusually high numbers of shearwater carcasses found near town, island residents requested assistance from ICEG in removing cats from the island. By August 1998 only a few cats remained on the island. At the request of the island residents, ICEG and the Vizcaíno Reserve will assist in removing the few remaining cats from the island during 1999.

### Islas Asunción and San Roque

Asunción (92 ha) and San Roque (38 ha) islands are located in Baja California Sur off the Vizcaíno Peninsula, inside Asunción Bay (Figure 1). These islands once had large nesting colonies of seabirds including the Xantus' murrelet (*S. hypoleucus*) and one of the five largest colonies of Cassin's auklets (*P. aleuticus*) in the world (Table 1; Everett and Anderson 1991; B. Tershy and D. Croll, unpublished 1994). Cats were likely introduced to Asunción and San Roque sometime during the 1970s. Predation on burrow-nesting seabirds by cats extirpated the population of Cassin's auklets and perhaps other species by 1992 (McChesney and Tershy, In press). Cat predation may have also caused the extinction of the San Roque endemic white-footed mouse, *Peromyscus maniculatus cineritius* (B. Tershy and D. Croll, unpublished 1994).

The SEDUE, predecessor of INE, began cat eradication efforts (with the participation of local fisherman) in the late 1980s; however, the project was terminated before all cats were removed. In 1994 a collaboration between the Vizcaíno Biosphere Reserve, the Cooperativa California de San Ignacio (the local fishing cooperative), and ICEG formed a restoration team that removed the remaining cats from

Asunción and San Roque Islands. In addition, black rats (*R. rattus*) were removed from San Roque Island. Cats were removed on both islands by trapping. Rats were poisoned with Talon Weatherblock containing brodifacoum and Vengeance Aquablocks containing bromethalin. Bait was placed in corrugated plastic pipe bait stations set on a 50 x 50 m grid across the island. Additional bait was placed in holes and crevices along the shoreline of the island where rats were thought to be more abundant. The bait stations were maintained for one year.

Concurrent with the removal programs, ICEG conducted a community education campaign with the fishing community on the mainland adjacent to the islands. The community involvement and education campaign was designed and conducted by L. Flores and R. Skydancer. They worked with local teachers to design a curriculum on island conservation for local school children, arranged a series of community presentations and produced a video for the local people on the importance of the local islands and the restoration project.

The education campaign facilitated the removal of introduced cats and black rats. Due in part to the education campaign, there was significant involvement and support by individuals and institutions in the community. The removal campaigns were successful on both islands. Automatic seabird vocalization playback devices were placed on the islands during December 1996 (e.g., Podolsky and Kress 1992). These solar-powered CD players and speakers were implemented to encourage the return of nesting seabirds. The light-activated devices play continuous recordings of nesting Cassin's auklet (*P. aleuticus*) and Leach's storm-petrel (*O. leucorhoa*) colonies during the night hours. Follow-up trips planned for 1999 will begin to determine the success of the playback devices.

### ISLAND CONSERVATION DATABASE

Since 1993 ICEG has been compiling data on the biotic and abiotic resources of the islands in NW México. The goal of these efforts has been to establish a central location for information on the islands, which can be used to assess and prioritize conservation efforts. This data have been recently loaded into a relational database and is available over the Internet via the World Wide Web (WWW).

Relational databases can be powerful conservation tools (Farr and Rossman 1996; Umminger and Young 1996). The ICEG database facilitates a means to provide data necessary for the Mexican government and non-governmental organizations (NGOs) to prioritize conservation action. The database contains information pertaining to the conservation and study of the NW México islands including: 1) geography and geology of the islands, 2) introduced species accounts, 3) zoological and botanical species accounts, 4) human use data, 5) endemism data, 6) extinction data, and 7) reference literature.

The data for the island conservation database was collected from a massive literature search, including published

journal articles along with U.S. and México gray literature. Some of the data comes from the authors and other biologists' field notes on the islands. We are in the process of contacting experts from various fields to confirm and update the data. The accuracy of the data continues to be improved through communication with biologists.

The relational database is powered by ORACLE software and currently resides on a Windows NT Server. Dynamic HTML reports and queries are publicly available via the WWW (<http://islandconservation.org>). Full access to the database will be granted to the Mexican government, NGOs and other key conservation planners. In addition, the data residing in the database will be updateable over the WWW by experts in their field.

## CONCLUSION

México is a megadiversity hotspot (Mittermeier 1988; Mittermeier et al. 1998). In assessing conservation priorities in México, Ceballos et al. (1998) ranks the Baja California islands an area of high priority. Not only do these islands support high endemism across taxa (Case and Cody 1983), they support the ecological and evolutionary processes that promote the differentiation of endemic forms (MacArthur and Wilson 1967; Lawlor 1983). By combining 1) on-the-ground restoration work with U.S. and Mexican collaborators, 2) sound environmental education and community involvement, and 3) the ability to assess and prioritize conservation needs at a macro level (e.g., ICEG Database), a platform is provided for a sustainable and permanent conservation program for an entire region. The Office of National Protected Areas of SEMARNAP, Instituto Nacional de Ecología, Gulf of California Islands Reserve, Universidad Nacional Autónoma de México, and the Island Conservation and Ecology Group have begun to develop such a platform.

While many islands in NW México remain threatened by introduced species, seven islands have been freed of introduced mammals: Rasa, Asunción, San Roque, Coronado Norte, Todos Santos Sur, West and Middle San Benito. Introduced mammals are currently being removed from two islands: Isabela (cats have been removed, rats remain), Natividad (goats and sheep have been removed, cats being removed). These islands should be free of introduced mammals in the near future. Thirteen terrestrial animal endemics along with many endemic plants are present on these nine islands (Table 2). Introduced mammals directly or indirectly threatened the majority of these endemics. These islands are important nesting sites for 22 species of seabirds (Table 1). While four extinctions have likely occurred, we expect other endemics and seabird species to recover on the restored islands in the near future.

## ACKNOWLEDGMENTS

Research and restoration was funded by the Packard Foundation, Weeden Foundation, Switzer Foundation,

Conservation International-México, Special Expeditions, Grant-in-Aid of Research from the National Academy of Sciences through Sigma Xi, Myers Oceanographic and Marine Biology Trust, and the American Museum of Natural History. Work was conducted under permits 750-10289, 750-10290, 750-10291, 750-11275 from SEMARNAP and 307 from Secretaría de Gobernación. We thank the Abulones Cultivados, Pescadores Nacionales de Abulón, and Buzos y Pescadores for their assistance and participation in the projects, along with the many field assistants whom provided excellent assistance on many of the projects. We also thank the ORACLE Research and Alliance for their support of the database project along with M. Donlan and M. Adlam of ORACLE Government, Education, and Health for providing technical consulting. We would like to thank S. Junak for his information, time, and enthusiasm during these projects. We thank B. Bedolfe, L. Flores, Q. G. Lozano, V. Sánchez, R. Skydancer and A. Zavala for their support and contributions to these projects. We also thank the ICEG board of Directors for their support: G. Anaya, L. Bourillón, D. Brimm, G. Ceballos, B. Heneman, A. Robles, M. Soulé, R. Terhshy, and S. Webster. We would especially like to express our gratitude to our partners in conservation: INE, SEMARNAP, ANP, Vizcaíno Biosphere Reserve and the Mexican Navy.

## LITERATURE CITED

- American Museum of Natural History (AMNH). 1998. Halls of Biodiversity. An exhibit at AMNH Museum. New York, NY.
- Anthony, A. W. 1925. Expedition to Guadalupe Island, México, in 1922. The birds and mammals. Proceedings of the California Academy of Sciences (Fourth Series) 14:277-320.
- Avise, J. C., M. H. Smith, R. K. Selander, T. E. Lawlor, and P. R. Ramsey. 1974. Biochemical polymorphism and systematics in the genus *Peromyscus*. V. insular and mainland species of the subgenus *Haplomydomys*. Systematic Zoology 23:226-238.
- Boswall, S. 1978. The birds of the San Benito Islands, Lower California, México. Bristol Ornithology 11:23-32.
- Brandegge, T. S. 1900. Voyage of the Wahlberg. Zoa 5:20-29.
- Case, T. J. and M. L. Cody (eds.). 1983. Island Biogeography of the Sea of Cortez. University of California Press. Los Angeles, CA.
- Cody, M. L., R. Moran and H. Thompson. 1983. The plants. Pages 49-99 in Island Biogeography of the Sea of Cortez. University of California Press. Los Angeles, CA.
- Ceballos, G., P. Rodríguez and R. A. Medellín. 1998. Assessing conservation priorities in megadiverse México: mammalian diversity, endemism, and endangerment. Ecological Applications 8:8-17.
- Churcher, P.B. and J. H. Lawton. 1987. Predation by domestic cats in an English village. Journal of Zoology. 212:439-455, London.

- Cushman, J. H. 1995. Ecosystem-level consequences of species additions and deletions on islands. Pages 135-147 in Vitousek, P. M., L. L. Loope and H. Anderson (eds.), *Islands: Biological Diversity and Ecosystem Function*. Springer-Verlag, New York, NY.
- Diamond, J. M. 1989. Overview of recent extinctions. Pages 37-41 in Western, D., and M. C. Pearl (eds.), *Conservation for the Twenty-first Century*. Oxford University Press, New York, NY.
- Elton, C. S. 1958. *The Ecology of Invasions by Animals and Plants*. Methuen, London.
- Everett, W. T. 1991. Breeding Biology of the Black Storm-petrel at Islas Coronados, Baja California, México. M.S. Thesis, University of San Diego.
- Everett, W. T. and D. W. Anderson. 1991. Status and conservation of the breeding seabirds on offshore Pacific islands of Baja California and the Gulf of California. Pages 115-139 in Croxall, J. P. (ed.), *Seabird Status and Conservation: a Supplement*. ICBP Technical Publications No. 11. Cambridge, England.
- Farr, D. F. and A. Y. Rossman. 1996. Integration of data for biodiversity initiatives. Pages 475-490 in Reaka-Kudla, M. L., D. E. Wilson, and E. O. Wilson, eds. *Biodiversity II: Understanding and Protecting our Biological Resources*. Joseph Henry Press, Washington DC.
- Grismer, L. L. 1993. The insular herpetofauna of the Pacific coast of Baja California, México. *Herpetological Natural History* 1(2):1-10.
- Grismer, L. L. 1996. *Cnemidophorus tigris* does not occur on Isla San Benito, Baja California. *Herpetological Review* 27(2):69-70.
- Groombridge, B. (ed.). 1992. *Global Biodiversity: Status of the Earth's Living Resources*. Chapman and Hall, London.
- Hanna, G. D. 1925. Expedition to Guadalupe Island, México, in 1922: general report. *Proceedings of the California Academy of Sciences (Fourth Series)* 14:217-275.
- Howell, A. B. 1912. Notes from Todos Santos Island. *Condor* 19:187-191.
- Huey, L. M. 1964. The mammals of Baja California. *Transactions of the San Diego Society of Natural History* 13(7):85-168.
- International Union for Conservation of Nature and Natural Resources (IUCN). 1978. *The IUCN Plant Red Data Book*. Morges, Switzerland.
- Jones, E. and B. J. Coman. 1981. Ecology of the feral cat, *Felis catus* (L.) in South-Eastern Australia I. Diet. *Australian Wildlife Research*. 8:537-47.
- Junak, S. A. and R. Philbrick. 1994a. The vascular plants of Todos Santos Island, Baja California, Mexico. Pages 407-428 in Halvorson, W. L. and G. J. Maender (eds.), *The Fourth California Islands Symposium: Update on the Status of Resources*. Santa Barbara Museum of Natural History, Santa Barbara, CA.
- Junak, S. A., and R. Philbrick. 1994b. The flowering plants of San Martin Island, Baja California, Mexico. Pages 429-447 in Halvorson, W. L., and G. J. Maender, (eds.) *The Fourth California Islands Symposium: Update on the Status of Resources*. Santa Barbara Museum of Natural History, Santa Barbara, CA.
- Junak, S. A. and R. Philbrick. 1999. Flowering plants of the San Benito Islands, Baja California, Mexico. Pages 235 to 246 in Browne, D. R., K. L. Mitchell, and H. W. Chaney (eds.), *Proceedings of the Fifth California Islands Symposium*. 29 March to 1 April 1999. Santa Barbara Museum of Natural History, Santa Barbara, CA. Sponsored by the U.S. Minerals Management Service, Pacific OCS Region, 770 Paseo Camarillo, Camarillo, CA 93010. OCS Study No. 99-0038.
- Keitt, B. S. 1998. Ecology and conservation biology of the Black-vented Shearwater (*Puffinus opisthomelas*) on Natividad Island, Vizcaíno Biosphere Reserve, Baja California Sur, México. M.S. Thesis. University of California Santa Cruz, CA.
- Lawlor, T. E. 1983. The mammals. Pages 265-289 in Case, T. J., and M. L. Cody (eds.), *Island Biogeography in the Sea of Cortéz*. University of California Press, Los Angeles, CA.
- MacArthur, R. H. and E. O. Wilson. 1967. *The Theory of Island Biogeography*. Princeton University Press, Princeton, NJ.
- McChesney, G. J. and B. R. Tershy. In press. History and status of introduced mammals and impacts to seabirds on the California Channel and Northwestern Baja California Islands. *Colonial Waterbirds*.
- Mellink, E. 1992. The status of *Neotoma anthonyi* (Rodentia, Muridae, Cricetinae) of Todos Santos Islands, Baja California, México. *Bulletin of the Southern California Academy of Sciences* 91(3):137-140.
- Mittermeier, R. A. 1988. Primate diversity and the tropical forest: case studies from Brazil and Madagascar and the importance of megadiversity countries. Pages 145-154 in Wilson, E. O. (ed.), *Biodiversity*. National Academy Press, Washington, DC.
- Mittermeier, R. A., N. Myers, J. B. Thomsen, G. A. B. da Fonseca, and S. Olivieri. 1998. Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. *Conservation Biology* 12:516-520.
- Mooney, H. A. and J. A. Drake (eds.). 1986. *Ecology of Biological Invasions of North America and Hawaii*. Springer-Verlag, New York, NY.
- Moors, P. J. (ed.). 1985. *Conservation of Island Birds*. International Council for Bird Preservation, Cambridge, England.
- Murphy, R. W. 1983. The reptiles: origins and evolution. Pages 130-158 in Case, T. J., and M. L. Cody (eds.), *Island Biogeography in the Sea of Cortéz*. University of California Press, Los Angeles, CA.
- Podolsky, R. and S. W. Kress. 1992. Attraction of the endangered Dark-rumped petrel to recorded vocalizations in the Galápagos Islands. *Condor* 94:448-453.



- Rodríguez Juárez, Cristina. 1998. Erradicación de gatos y ratas en una isla tropical del Pacífico de México. M.S. Thesis. Universidad Nacional Autónoma de México.
- Soulé, M., and A. J. Sloan. 1966. Biogeography and distribution of the reptiles and amphibians on islands in the Gulf of California, México. *Transactions of the San Diego Society of Natural History* 14:137-156.
- Soulé, M., and S. Y. Yang. 1972. Genetic variation in side-blotched lizards on island in the Gulf of California. *Evolution* 27:593-600.
- Tershy, B. R. and D. Croll. 1994. Avoiding the problems of fragmentation by preserving fragments: the benefits of conserving small islands. Page 158 *in* Abstracts, 1994 International Meeting of the Society for Conservation Biology and the Association for Tropical Biology. Guadalajara, Jalisco, México.
- Umminger, B. L., and S. Young. 1996. Information management for biodiversity: a proposed U.S. national biodiversity information center. Pages 491-504 *in* Reaka-Kudla, M. L., D. E. Wilson, and E. O. Wilson (eds.), *Biodiversity II: understanding and protecting our biological resources*. Joseph Henry Press, Washington D.C.
- Van Denburgh, J. 1924. The birds of Todos Santos Islands. *Condor*. 26:67-71.
- Van Rossem, A. J. 1943. The Horned Lark and the Rock Wren of the San Benito Islands, Lower California. *Condor* 45:235-236.
- Velarde, E. and D. W. Anderson. 1994. Conservation and management of seabird islands in the Gulf of California: setbacks and successes. Pages 229-243 *in* Nettleship, C. N., J. Burger and M. Gochfeld (eds.), *Seabirds on Islands Threats, Case Studies and Action Plans*, Birdlife Conservation Series No. 1. Birdlife International. Cambridge, United Kingdom.
- Warner, R. E. 1985. Demography and movements of free-ranging domestic cats in rural Illinois. *Journal of Wildlife Management* 49(2):340-346.
- Wright, H. W. 1909. An ornithological trip to Los Coronados Islands, México. *Condor* 11:96-100.

#### UNPUBLISHED MATERIALS

- Moran, R., San Diego Museum of Natural History, P.O. Box 121390, San Diego, CA 92112-1390 USA. Field notes for 11 May 1979. Unpublished manuscript on file in the library.
- Donlan, C. J., Island Conservation and Ecology Group, P. O. Box 141, Davenport, CA 95107 USA. Personal observation 1997.
- Donlan, C. J., Island Conservation and Ecology Group, P. O. Box 141, Davenport, CA 95107 USA. Personal observation 1998.
- Donlan, C. J., Island Conservation and Ecology Group, P. O. Box 141, Davenport, CA 95107 USA. Unpublished data 1999.
- Delong, R. L. and R. S. Crossin. National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA. 98115. Status of seabirds on Islas de Guadalupe, Natividad, Cedros, San Benito and Los Coronados. Unpublished manuscript, 1968.
- Island Conservation and Ecology Group (ICEG), P. O. Box 141, Davenport, CA 95107 USA. Unpublished data 1998.
- Tershy B. T., Island Conservation and Ecology Group, P. O. Box 141, Davenport, CA 95107 USA. Personal observation 1997.
- Tershy B. T. and D. A. Croll, Island Conservation and Ecology Group, P. O. Box 141, Davenport, CA 95107 USA. Unpublished data 1994.
- Tershy B. T. and D. A. Croll, Island Conservation and Ecology Group, P. O. Box 141, Davenport, CA 95107 USA. Personal observation 1996.