

**Title: The Northern Elephant Seal (*Mirounga angustirostris*) Rookery at Año Nuevo: A Case Study in Colonization**

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Published 2011 in Aquatic Mammals, 37( 4), 486-501,

**What the paper is about and why of interest to docents**

This paper examines the colonization process (at Año Nuevo) of a large mammal(Northern Elephant seals), documenting the development of a breeding colony from inception 1961 until 2010, a period during which worldwide population was expanding rapidly.

Researchers aimed to describe the origin, development and present status of a peripheral colony at Año Nuevo, California, in the northern part of the breeding range and to examine its growth in relation to developments in the general population.

Colony growth was rapid initially. Pup production reached 2731 births in 1995. Numbers stabilized at approximately 2500 over the next decade but declined after 2005.

The pattern of colony growth and decline is explained by species specific seal behavior; population variables that influence migration rate; local environmental factors such as breeding space, animal density and tidal/surf conditions during peak season that might increase pup mortality. Colony growth was driven primarily by young females coming from large southern rookeries.

Births on Año Nuevo Island peaked in 1980 and then declined by 50% in association with increased density and pup mortality.

Births on the adjacent Año mainland stabilized from 1995-2006 despite ample space and low pup mortality.

Cessation of growth on the mainland is associated with reduced recruitment of females from bigger southern colonies.

Primiparous (means having given birth once) females pioneer the establishment of new colonies, overcrowded breeding sites have higher mortality and thus settling new less crowded sites improves weaning success.

## **Background and Motivation for this research**

The long term study of the development of a single colony provides vital information on this process and is applicable to other mammals. Elephant seals are large predators offering scientists an opportunity to identify and count since they breed annually and predictably in discrete colonies. As apex/top predators elephant seals may regulate the abundance and population growth rates of many prey species and thus have important consequences for ecosystem management.

The colonization at Año Nuevo recapitulates the growth process happening at other colonies during the population expansion. This pattern of colony development is to be expected in future colonies.

## **Methods**

Censuses were taken of populations from 1961 to 2010. In some years data included direct counts. In other years mathematical models were used to estimate numbers of males, females pups and weaned pups.

Pup production estimated by direct count and by estimates of parous females.

Resident female natality: Observation used to estimate the proportion arriving pregnant and giving birth. Summing living and dead pups provided best estimate of females that were present and gave birth. Bleach marking arriving females allowed following their progress and giving an estimate of natality.

Statistical models were applied in years when low sample sizes were taken or bad weather caused unusual movements of animals.

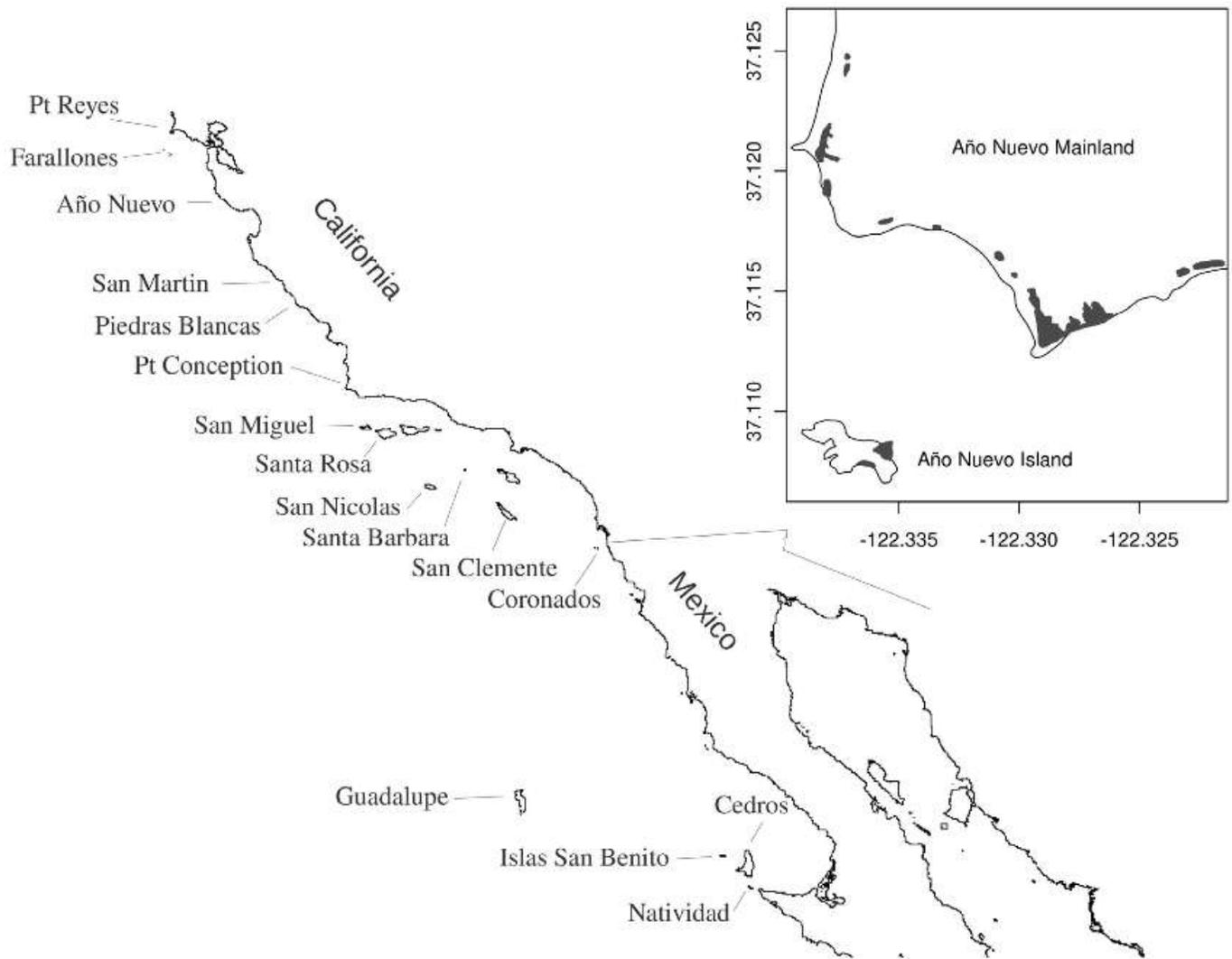
## **Findings, observations and important take-aways for docents from this publication**

### **Northern Elephant Seal population level**

The growth of the the population since near extinction in the late 1800's and the subsequent recolonization of California from the mother colony in Baja California, Mexico in the 20th and 21st centuries is a model of recovering and expanding mammal populations and is well documented.

Over the last 200 years the population was reduced by sealers from thousands in Mexico and California to a few survivors in the late 1880's, on Isla Guadalupe, Mexico. The effective population in 1884 may have been as low as 20. Since this time population has recovered to number 166,000 (at time of publication 2010). Breeding range has been reestablished from central Baja, Mexico to central California.

At time of writing this paper 21 elephant seal breeding locations are known in Mexico and United States. Approximately 83% of population is found in CA, mostly southern California. See Fig 1 for these locations.



**Figure 1.** The principal rookeries of the northern elephant seal (*Mirounga angustirostris*) are shown for 2010. A few animals breed in Oregon and Washington (not shown) in years when the weather and sea condition are moderate. The inset shows the Año Nuevo colony, which encompasses the island and mainland portions separated by a channel measuring approximately 500 m at high tide. Harem locations at peak season are indicated as dark areas.

### **Northern Elephant Seals at Año Nuevo**

Elephant seals were first recorded on the island in 1955. The first pup recorded in 1961 when 12 pups were recorded (the number implies pups were there a year or two before but were not documented). The first birth on adjacent mainland in 1975.

No evidence or record to indicate whether breeding occurred anywhere at Año Nuevo prior to sealing in the 1800's.

### **Año Nuevo Island**

Pups born on the island increased rapidly from 1961 until a peak of 1,216 in 1980. Thereafter pup production declined to 751 in 1987 and 410 in 2010.

### **Año Nuevo Mainland**

Single pup born on mainland in 1975, thereafter pup production increased rapidly to that of 2,014 born in 1995. By 1987 more pups were born on the mainland than on the island.

From 1995 to 2005 the number of pups stabilized at about 2,000. Ensuing years saw a decrease to 1,735 in 2010.

### **Año Nuevo Colony - island and mainland combined**

**Pups born in entire region** increased to as high as 2731 in 1995. ( Brief reversals seen in some years prior). This approximately 35 y after colonization, a growth rate of 16.2%. Numbers stabilized 1995 - 2005 but thereafter declined to a low of 2,144 in 2010. The rate of increase was high during initial years of colony establishment but has declined steadily at both sites after reaching peak.

#### **Males present:**

Up to 1985 the number of breeding males rose steadily as did females. After 1985 the number of breeding males did not increase proportionally to breeding females. The number of breeding females continued to rise above 1,500 but males stabilized at about 500.

#### **Pups weaned**

Weaning rate and the number of pups weaned were shown to be different on the mainland versus the island. The mean annual survival rate on the mainland was 91.8% versus 75.9% on the island. The island also had a higher annual standard deviation in survival than that of the mainland.

#### **Pup Mortality**

Pup mortality was especially high on the island in years of severe winter El Nino conditions. In 1983 the entire breeding beach was inundated with high surf and most pups were separated from their mothers. The major mainland beaches were relatively immune to storm effects with ample space above the high surf line. 2004 saw a high pup mortality on the island but was not due to high surf and remained unexplained.

### **Expansion and Leveling off of pup production**

This paper explains the expansion and leveling off as being due to factors operating at both the population level and the local level.

#### *Population factors affecting expansion and leveling off of population:*

The authors argue that the pattern of pups born was due to an influx of young breeding females dispersing from larger colonies to the south, a general pattern observed throughout the growth of the whole population. Initially survivors observed only on Isla de Guadalupe, subsequently the population expanded, mostly northwards, in number and breeding range.

In the 1930's new colonies were formed on the Baja California( Mexico), Islands of Islas San Benito and Coronados. Thereafter in the early 1950's the southern California (US) islands of San Miguel, San Nicholas and Santa Barbara saw colony establishment. Colonies appeared on central California at Año Nuevo in 1961, Southeast Farallon in 1972 and point Reyes in 1981.

In 1960, 91% of the entire population was concentrated on Guadalupe Island and included 3,500 pups born. Growth ceased at the Mexican colonies in the 1970's. By 1991 entire population produced 28,000 pups, in 2005 entire population pup production was 42,000. The total population of Northern Elephant seals estimated at 165,000.

At time of this paper writing( 2010) 83% of pup production is from US rookeries in California.

The islands of San Clemente, Santa Barbara, San Nicholas and San Miguel produce 81% of US born pups. 11% are born on the Big Sur coast ( Point Conception, Piedras Blancas and Cape San Martin) and 8.6% from Central California ( Año Nuevo, Southeast Farallon and Point Reyes).

Tagging studies confirmed that San Miguel and San Nicholas islands were colonized by Northern Elephant seals from Guadalupe Island.

During the 1970's elephant seals born at San Nicholas and San Miguel were the source of seals colonizing Año Nuevo, Southeast Farallon and Point Reyes.

During the 1990's San Miguel, the largest colony in California, reached carrying capacity ( the breeding space was overcrowded with females at the peak) and the population leveled off at approximately 14,000 pups. During this period new colonies were established at nearby Santa Rosa Island and adjacent mainland location of Piedras Blancas, most likely by females born at San Miguel Island.

Growth and dispersal patterns of the population suggest that the Año Nuevo colony was populated by females born on San Miguel and to some extent individuals from San Nicholas. The estimates of low pup survival rate for the first 30 years of Año Nuevo colony suggest that colony growth was a result of this external recruitment and not internal recruitment.

The cessation of growth and decline of pups born seen since 1995 at Año Nuevo is coincident with the explosion of growth at Santa rosa and Piedras Blancas. Young females from San Miguel are dispersing to the more proximal colonies of Santa Rosa and Piedras Blancas.

Loss off recruitment to Año Nuevo from San Miguel is confirmed with tagging studies. In 1971 and 1972 43% of males and females at Año Nuevo came from San Miguel and San Nicholas, 1989-1998 only 30% from these Islands at Año Nuevo, 13% in period 1999-2005 and only 6% in period 2006 -2009 were from San Miguel and San Nicholas.

*Behavior and Local Factors affecting colony growth, leveling or decline:*

Pup survival depends on close association of mother and pup. Suitable space for females to give birth and nurse, especially at peak season is especially significant in terms of the number of pups successfully weaned and surviving.

High tides and high surf associated with inclement weather at peak season and ardent males attempting mating are both factors that can cause mother-pup separation and increase pup mortality.

Weaning success is positively correlated with increased age and size of females. Young females, especially first time mothers have lower weaning success than older mothers. Younger mothers lack experience and can confuse their pups with that of another; are subordinate to older/larger females thus making them prone to separation from their pup or being unable to protect their pup from neighboring females. Subordination can result in being shunted to the periphery of the harem where they are exposed to aggressive male mating attempts while nursing or the danger of high surf.

Younger mothers give less milk energy and have pups weighing less at birth and weaning.

In effect the higher density of a breeding area the more difficult it is for a younger female to maintain contact, nurse and wean her pup. Once females breed successfully in a certain location they tend to return to that breeding location the following year; those that fail to wean their pup at a natal site, however, more readily move to a new site to give birth. They are the pioneers in the colonization process and most of them are primiparous (having given birth only once).

How do young females settle on new birth sites? Yearling and juveniles go to sea to feed, they move northward and the feeding trip lasts 2 to 5 months. Some elephant seals appear at island or mainland sites along the migratory route during or after migration. Young females, when of breeding age, appear at sites where they were previously observed. This compared to "prospecting" in other animal species. Once females give birth in new site, males will follow and more females join the breeding site.

This behavior pattern is the underlying behavior for density dependent dispersal, the establishment and growth of new colonies and ultimately population growth.

This is illustrated by comparison of the growth patterns of the island and mainland portions of the Año Nuevo colony. Pup production on the island increased rapidly initially. Available breeding space became crowded and females dispersed to the mainland of Año Nuevo, Southeast Farallon and Point Reyes. Pup mortality on the island soared over 50% and up to 76% in years when peak season coincided with high surf conditions. In these conditions young females were at a disadvantage and thus

more likely to disperse to new sites. Seals observed to disperse to less dense breeding sites than that from which they are moving and also to move before maximum density was observed in the rookery.

Mainland portion of Año Nuevo does not have a space limitation and lower pup mortality is seen there. Nevertheless pup production on mainland ceased to increase after 1995. This cessation in growth attributed to lowered external recruitment from the southern rookeries. The authors suggest that pup production could increase again at Año if carrying capacity is reached at Santa Rosa or Piedras Blancas colonies and animals once again disperse northward.

Pup production at Año Nuevo and other colonies is affected by both population factors and local factors of geographical environment, weather and sea conditions, intra-specific competition and local population density. Viewed over the last 110 years the northern elephant seal population has exhibited range wide density dependence which has caused young females to disperse and colonize new sites. This regulatory progression is expected to continue until all optimal habitat is occupied or until elephant seals come into competition with humans over beach space.

Factors such as food and predation could also play a role in population growth and size. White sharks prey on individuals near rookeries. Ocean warming can affect foraging and it is observed that gestating females thus impacted give birth to smaller pups. The impact of such factors on survival and colony growth is unknown.