decomposed into CO and H_2. Some carbon deposition on the nickel electrode was also noted. This is in accordance with the thermodynamics of the C-H-O equilibria (*5*), where all mixtures with H_2/CO ratios smaller than 3 lie within the carbon deposition boundary under these experimental conditions.

The rate of methanation was calculated from the rate of formation of CH_4. The intrinsic catalytic activity of the nickel electrodes for both the CO and CO_2 methanation reactions was determined under open-circuit conditions. Figure 2 shows the dramatic effect of the use of this solid-state ionic technique on the observed methanation rates; the rate of formation of CH_4 from H_2 and CO is twice the intrinsic value. The change is more pronounced in the case of H_2-CO_2 mixtures, which show an enhancement of nearly two orders of magnitude. Methane can be formed at appreciable rates at 810°C, despite its thermodynamic instability and the negligible intrinsic catalytic activity of nickel at that temperature.

The intrinsic rates for CH_4 formation from H_2-CO mixtures were appreciably higher than from H_2-CO_2 mixtures. This finding agrees with earlier results that indicate the difficulty of hydrogenating CO_2 in the presence of CO (*1*). However, there is no significant difference in the methanation rates from these different gases when the solid-state ionic technique is used. This observation supports recent results (*6*) which suggest that the same mechanism is critical to the formation of CH_4 from both CO and CO_2, that is, the dissociation of CO to produce a surface carbon, which then undergoes a hydrogenation reaction. This work illustrates the feasibility of using the solid-state ionic technique to influence the rates of heterogeneous synthesis reactions.

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Demography of Northern Elephant Seals, 1911–1982

Abstract. *Northern elephant seals* (Mirounga angustirostris) *were hunted to near extinction in the 19th century. Protection has allowed them to recolonize former habitat on islands off California, where the population is increasing more than 14 percent per year. Immigration of young pregnant females from Baja California initiated the California rookeries but is responsible for only a small part of recent population growth. Almost 25,000 northern elephant seal pups were born in the species' range in Mexico and the United States in 1982 in comparison with only six known births in 1911.*

Effective protection of shore-breeding marine mammals in Mexico and the United States over the last 50 years has allowed northern elephant seals (*Mirounga angustirostris*) to return to islands off the California coast from which commercial hunting had extirpated them in the 19th century (Fig. 1). This recovery provides an unusual opportunity for quantitative analysis of a population of large mammals recolonizing former habitat after successful conservation.

Elephant seals once bred from north of San Francisco Bay to the tip of Baja California, Mexico. Thought extinct about 1880, the species was rediscovered on Isla Guadalupe, Baja California Norte, in 1892. The world population probably numbered no more than 100 until after 1900 (*1*).

Transient males visited the California Channel Islands as early as 1925, but breeding began there only after 1950. Eighty pups were seen on San Miguel Island, west of Santa Barbara, in 1958, and 48 on San Nicolas Island in 1959 (*2*). Adult males appeared on Año Nuevo Island, north of Santa Cruz, in the late 1950's; the first pups were born there in 1961. Pupping began on the Farallon Islands, west of San Francisco, in 1972 (*3*). Elephant seals have bred on the mainland opposite Año Nuevo Island since 1975 (*4*). A few breed on Santa Barbara and San Clemente Islands, California, and on the Islas de los Coronados off Tijuana. Elephant seals share the Channel Island chain with five other pinniped species (*5*).

Single pups are born from December to February. Pups are sedentary and conspicuous, allowing reliable counts of both live and dead animals. Since the entire adult population is not ashore at once, pup numbers are the most satisfactory indicators of population trends. Pups have been counted by different observers at varying intervals on all the occupied islands. This report is based on published data (*2, 4, 6–8*) and on our recent counts (*9*) on San Miguel and San Nicolas Islands.

Pup production on San Miguel, San Nicolas, and Año Nuevo Islands has increased at a nearly uniform exponential rate since the end of an initial establishment phase (Figs. 2 and 3). Logarithmic regressions of pup production as a

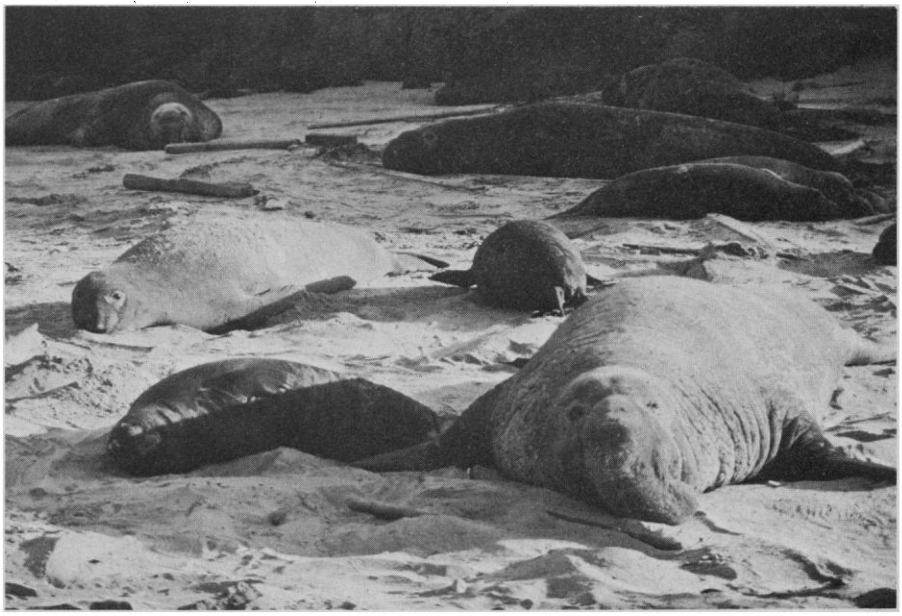

Fig. 1. Female northern elephant seal (*Mirounga angustirostris*) and pup on San Miguel Island, California, March 1980. Other elephant seals are in the background.

function of time (*10*) closely fit the observations on each island (Table 1).

These three islands dominate pup production in California. San Miguel Island accounted for more than 60 percent of the 1982 pups. San Nicolas Island, 120 km to the southeast, had nearly 20 percent, and Año Nuevo Island, 400 km north, some 13 percent. The annual rate of increase on San Miguel Island is somewhat less than at the other two locations, but the difference is slight (Table 1). Growth of the California population as a whole is about 14.5 percent per year.

The colonies on San Miguel and San Nicolas Islands show no apparent decline in rate of increase (Fig. 2). Regressions were calculated from pup counts through the 1981 breeding season. The San Miguel Island regression equation predicted that pup production there would be 7820 in 1982 [95 percent prediction interval (*11*), 6553 to 9338]; the actual number was 7370. On San Nicolas Island, the predicted count for 1982 was 1480, (prediction interval, 1017 to 2152). The actual number was 2305. Pup production on the two islands together was 4 percent greater than predicted.

To assess the future course of the California population, we examined data from central Baja California, the original focus of elephant seal reestablishment. There were reliable counts of pups in the largest colony, on Isla Guadalupe, in 1965 and in 1977 (*8*, *12*). The average annual rate of increase in pup production between those years was 5.4 percent. This could have been the result of fast growth in the early part of the period and stabilization of numbers in more recent years. However, a visual estimate of "about 4,000" pups in 1968 (*13*) is consistent with a growth rate near 5 percent immediately after 1965 rather than with a higher rate at that time (Fig. 3). Counts were made on Isla San Benito in 1965 and 1977. The average annual rate of increase there was 5.9 percent, which is comparable to that on Isla Guadalupe (Fig. 3). Isla Cedros had 121 pups in 1977 (*12*), but the entire island was not surveyed. None was seen in 1965.

Townsend, who discovered the Isla Guadalupe population, saw six pups during a revisit in 1911 (*14*). Until about 1930, population growth on Isla Guadalupe was limited by occasional harvest. It is not possible to reconstruct completely the history of the Mexican population, but if pup production on Isla Guadalupe in 1930 was in the neighborhood of 50, and thereafter increased at about the 14.5 percent rate recently observed in California, by 1965 there would have been approximately the number of pups actually counted on Isla Guadalupe in that year. Observed growth was considerably slower than in California between 1965 and 1977. The population status since 1977 is not known.

Elephant seal females in the uncrowded California population usually bear their first pup at age 3 or 4, a few as early as age 2. Females are fully grown at age 6 (*8*). Pup mortality on San Miguel Island ranged from 3 to 8 percent in the years 1979 to 1982 (*9*). Mortality on San Nicolas Island has consistently been near 4 percent since 1971 (*7*, *15*). Pup losses have been considerably greater on the more exposed Año Nuevo Island (*8*). Reliable age-specific mortality and fecundity data for other age classes are lacking, as are data on changes in these factors with increasing population density. It is therefore not possible to construct dynamic models to predict future trends of the California population.

Colonization of the California Channel Islands must have resulted from regular immigration of primiparous females from Baja California rather than from a single pulse of founders. The number of pups on San Miguel Island increased at a calculated average rate of 47 percent per year between 1958 and 1964 (there were no counts in the interim). Pup production on Año Nuevo Island increased 41 per-

Table 1. Growth of northern elephant seal populations during recent period of exponential increase, based on pup counts. Pup production on the islands of San Miguel and San Nicolas is from 1982 counts; numbers elsewhere are from extrapolation to 1982 of regression relationships of Figs. 2 and 3 and last reported estimates from minor rookeries.

Location	Dates	Number of counts	Annual rate of increase	r^2	1982 pup estimate
		California			
San Miguel	1964–1981	10	.136	.99	7,400
San Nicolas	1959–1981	12	.165	.98	2,300
Año Nuevo	1968–1980	11	.158	.99	1,600
Farallones	1974–1980	7	.533*	.96	300
Other Channel Islands and mainland					300
Total					11,900
		Central Baja California			
Guadalupe	1965–1977	2	.054		9,000
San Benito	1965–1977	2	.059		2,100
Other					200
Total					11,300
Total pup production for entire species					23,200

*Mostly from immigration.

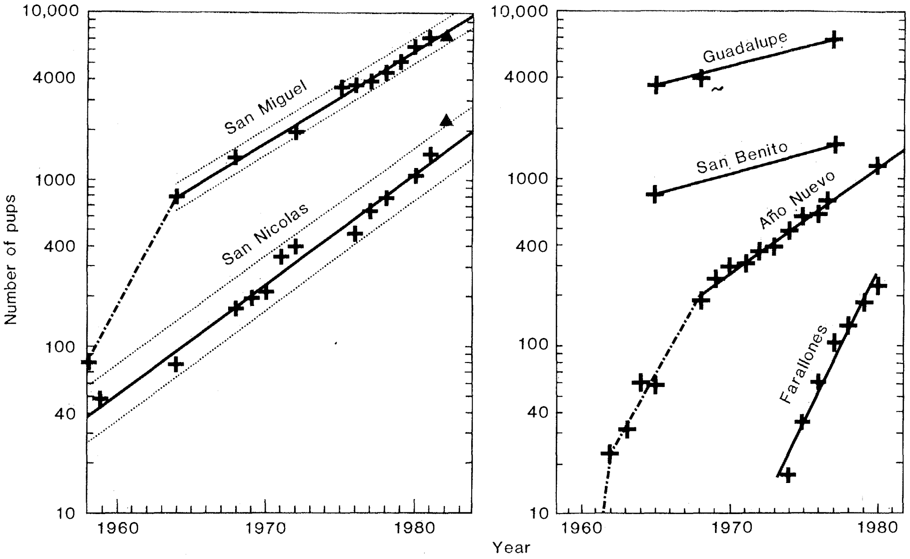

Fig. 2 (left). Trend of elephant seal pup production on San Miguel and San Nicolas Islands. Dashed lines are the limits within which pup counts for individual years are expected to fall with 95 percent probability (*11*). Counts for 1982 (▲) were not used in calculation of regression. Fig. 3 (right). Trend of pup production on Año Nuevo Island and the Farallon Islands (central California) and Isla Guadalupe and Isla San Benito (Baja California). Pup counts on Año Nuevo Island and the Farallones in 1981 and 1982 have not been publicly reported.

cent per year from 1962 to 1968 (Fig. 3). Such growth rates are impossible in a species with delayed reproduction and single births without continued addition of breeding-age females. Young females pupping for the first time appear to be the primary colonists. Thereafter, they tend to return to the same location to give birth each year (*8*).

It appears that continuous dispersal from Baja California cannot have been sufficient both to hold down the growth rate there and to account for the uniformly high rates in California during the last 15 years. The growth of the combined Californian and Mexican populations was about 8.3 percent per year between 1965 and 1977. We calculated the number of pregnant females that must have emigrated each year to hold the increase in pup production on Guadalupe to 5.4 percent if the true species growth rate was 8.3 percent. In the unlikely event that all the presumed surplus females reached the California islands to give birth, pups born to immigrants plus reproduction by females born on the islands could have been responsible for the growth of pup numbers in California until about 1973 but not thereafter. Calculated immigration cannot account for the observed number of pups born in California in recent years if the true species growth rate is only 8.3 percent. Immigration from Baja California probably contributes to population growth in California, but how much can be established only through extensive tagging data. If the number of immigrating females has been relatively constant over the years, their impact on population growth would progressively lessen as the indigenous population grows.

Approximately 11,900 elephant seal pups were born in California in 1982 (Table 1). If the population growth observed on the Baja California islands between 1965 and 1977 had continued at the same rate since 1977, pup production there would have been about 11,200 in 1982, for an aggregate total of some 23,000 births. It has been stated that the Baja California population has stabilized (*12*), but there are no recent census data to verify this.

The California elephant seal population has been doubling every 5 years for more than two decades. Processes associated with increased density must eventually slow the rate of growth. Crowding could lead to mother-pup separation, disruption of harem structure and breeding success, and crushing of pups by adult males. Females may increasingly be forced to use exposed beaches where losses of pups to storms are high. Increased density may lead to delayed maturity, a greater fraction of nonbreeding mature females, and lower adult and pup survival. Growth and maturation of the southern elephant seal (*Mirounga leonina*) accelerated when its population was reduced by man (*16*); the reverse process seems equally likely.

When the population growth rate will begin to decline is not known. Le Boeuf and Panken (*4*) stated in 1977 that "the Año Nuevo rookery seems to have reached its carrying capacity," yet population growth there continued at the same exponential rate as before at least through 1980 (Fig. 3). There are still insufficient data to define the optimal population of northern elephant seals in California.

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Gene for Hereditary Retinoblastoma Assigned to Human Chromosome 13 by Linkage to Esterase D

Abstract. *Evaluation of three families with hereditary retinoblastoma demonstrates close linkage of the gene for this tumor with the genetic locus for esterase D. These results assign the gene for the hereditary form of retinoblastoma to band q14 on chromosome 13, the same region which is affected in the chromosome deletion form of this eye tumor, and therefore suggest a common underlying mechanism in the pathogenesis of these two forms of retinoblastoma.*

Retinoblastoma is the prototype of human developmental tumors (*1*). When there is a positive family history of the tumor, it usually follows an autosomal dominant inheritance pattern. The majority of cases occur sporadically. A small subgroup of retinoblastoma patients has been found to have a deletion of band 13q14.

We have previously assigned the locus for esterase D (ESD) to chromosomal region 13q14 by deletion mapping (*2*). This assignment raised the possibility that the hereditary nondeletion form of retinoblastoma might be controlled by a gene in band 13q14 close to the ESD locus. Our present studies verify this hypothesis by demonstrating tight linkage between the loci for hereditary retinoblastoma and ESD.

We were able to evaluate ESD enzyme activity and electrophoretic types in 35 families in which the inherited form of retinoblastoma occurs. Families were ascertained through contacts with ophthalmologists who were caring for these patients; all persons were given eye examinations to determine the presence or