CHAPTER 14

CALIFORNIA SEA LION MORTALITY:
NATURAL OR ARTIFACT?

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The California sea lion, *Zalophus californianus*, well known to the public as the "circus seal," is the most numerous pinniped found in the waters of the western United States and Mexico. Yet, compared to other species in the same area, it is the least understood in terms of biology, ecology and behavior. Systematic data on mortality at various stages in development are notably lacking. Mortality statistics and population data are most complete for species that have been exploited commercially, such as the northern fur seal, *Callorhinus ursinus* (Bartholomew, 1970).

When environmental disturbances occur, whether in the form of unexpected oil blowouts, increasing levels of pesticides in marine waters, or reported infectious epidemics, questions arise concerning the effect on the sea lion population. Are they being affected adversely? Are they dying in greater numbers? Is the increase in the number of carcasses washing up on the beaches significant? We will attempt to provide a context and background for answering some of these questions.

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This paper reviews briefly what little we know about natural mortality in *Zalophus*; it calls attention to premature births that have been noted in recent years, and reports data bearing on the possible association of pesticides and oil pollution on sickness and mortality in these animals; it speculates on these possible links and stresses the need for normative data.

**NATURAL MORTALITY**

Mortality figures are usually obtained from pup deaths during the pupping season or from carcasses of animals of all ages found on the rookeries or washed up on mainland beaches at various times of the year.

The pupping season for California sea lions is from about the last week in May until the end of June; females deliver a single pup. Peterson and Bartholomew (1967) reported that the mortality rate of pups on land in their study area on San Nicolas Island in 1965 was much less than that of *Callorhinus* on the Pribilof Islands, which ranges between 5% and 16% during the breeding season (North Pacific Fur Seal Commission, 1962:5). They counted only ten dead pups out of 250 born in their study area. However, they point out that since *Zalophus* stays close to the water, pup carcasses may easily wash out to sea and not be counted, thus minimizing the mortality estimate. Estimates in *Callorhinus* are more reliable because females give birth further inland, thus decreasing the possibility of pups being washed out to sea alive or dead. Dan Odell, who has studied *Zalophus* on San Nicolas Island during the 1969 and 1970 breeding seasons, reports a mortality figure of 15% or more in his study area; most carcasses washed out to sea quickly (personal communication).

Bonnot, Clark and Hatton (1938) estimated that 25% of *Zalophus* pups die on the rookeries during the pupping season from multiple causes. They also stated that less than 50% of the pups produced in a year reach the age of one year. This is similar to the figure reported for *Callorhinus* in the 1961 year class, in which 14% died on the rookery and an additional 50% died at sea (Roppel, Johnson and Chapman, 1965).
In the 1968 breeding season, one of us (R.L.B.) and Ralph W. Schreiber counted living and dead pups on two locations at San Nicolas Island on May 29. Schreiber continued to census one of these areas periodically until August 22. These data are shown in Table 1. There is great variation in the percentage of dead to living pups in these repeated censuses of the same area. The overall average from May 29 to August 22 is 21%, dead to living. These figures must be interpreted with caution for the following reasons: (1) some of the carcasses may have been counted more than once; (2) carcasses may be washed out to sea or buried and so not counted; (3) carcasses washed out in other areas may have washed up here and been included in the count; (4) live pups present difficulties in counting since some may be in the water, particularly late in the season, and some may be hidden behind rocks. In both the latter cases, the denominator in the mortality figure would be reduced and an overestimate of the true mortality would result. On May 29, in a different location (Area 4A), Schreiber and Brownell found that 82 out of 102 pups were dead. This extremely high number of dead pups may have been due to any of several of the reasons already cited, or to the fact that many of these carcasses represented premature births dating back to as early as February, which, because of the terrain, did not wash out to sea. Premature pupping will be treated separately in a subsequent section.

On July 4 and 14, 1970, 697 newborn pups at the far western tip of San Miguel Island were marked with yellow plastic and monel tags as part of a long-term study of the movements of Zalophus. Within two months, 15% of the marked pups were found dead on or near the areas where they had been tagged. We are aware that the tagging operation, itself, may have influenced the mortality figure, for the procedure creates a temporary separation of mother and young. However, previous tagging operations of Zalophus on several different rookeries over a three-year period lead us to believe that the detrimental influence is low and accounts for less than 3% of the dead.

The causes of pup mortality on the rookery are probably similar to those reported for the northern fur seal by Keyes (1965): malnutrition, trauma, parasitism, miscellaneous infection and gastrointestinal infection. In addition, Zalophus pups are often washed out to sea.
The cause of death in young Zalophus after they go to sea and begin feeding seems to be parasite related. This is particularly true of young sea lions who display massive infections of the lungworm, Parafilaroides decorus (Dailey, 1970). As many as 18 endoparasites have been found in this species (Dailey and Brownell, in press). The lungworm and the liver fluke, Zalophotrema hepaticum, are the most numerous parasites found. For example, 11 out of 17 young Zalophus examined by William A. Walker (in litt., October, 1970) at Marineland of the Pacific, were parasitized by lungworms. Heavy parasite infestations weaken the hosts and make them more susceptible to other diseases, particularly of a respiratory nature, which ultimately are the principal cause of death.

From time to time, there have been reports of epidemics in several pinnipeds, including Zalophus, which are usually attributed to infectious diseases (Scheffer, 1958). Scheffer (1958:28) writes of an anonymous report which claimed that numerous dead sea lions were seen on the beaches of California in the autumn of 1947 and "health authorities... diagnosed the cause of death to be streptococcal pneumonia." Scheffer tried but was unable to obtain more factual information about this presumed epidemic. The most recent epidemic report claims that a "mysterious malady" is responsible for the deaths of numerous California sea lions on the coast of northern California (San Francisco Chronicle, October 14, 1970). The basis for the claim is that 30 Zalophus have been found sick or dead during a one-month period in September and October on beaches near San Francisco (New York Times, October 15, 1970). While this may turn out to be a real epidemic, there is no basis for making such a claim on such meager evidence. There is no basis for claiming that such a figure is "unusually high" when no systematic data on what is usual exist. The mass movements of thousands of Zalophus up and down the coast of California and Mexico have a great effect on the number of sick and dead found at a particular place at a particular time. For example, the number of Zalophus increases tenfold to a total of approximately 10,000 at Ano Nuevo Island, about 70 miles south of San Francisco, during the months of September and October (Peterson and Le Boeuf, 1969). One would certainly expect to find more carcasses and sick animals in the vicinity at this time of year simply because there are more animals in the general area.
Killer whales, sharks, and man prey on sea lions. Killer whales, *Orcinus orca*, are common around *Zalophus* hauling areas like Año Nuevo Island and some of the larger rookeries, such as San Miguel Island and Islas San Benito in Baja California, Mexico. Remains of California sea lions were found in three of nine killer whales taken in Californian waters (Rice, 1968). Heller (1904:244), who studied *Zalophus* at the Galapagos Islands, reported that "sharks, chiefly the genera *Carcarhinus* and *Galeocerdo*, are the worst enemies the seals have to contend with. Their depredations are confined largely to the pups, though the latter genus is a serious menace even to the adults." Man destroys numerous sea lions each year. Animals are shot by fishermen to keep them away from fishing operations, and weekend sailors on pleasure boats shoot them for sport or for no apparent reason. The few adult carcasses found by Peterson and Bartholomew (1967) on San Nicolas Island during the 1965 breeding season showed signs of buckshot wounds or evidence of clubbing or stoning.

**ABORTIONS AND PREMATURE BIRTHS**

Although the majority of California sea lion pups are born during the period between May 25 and June 25 (Peterson and Bartholomew, 1967), some females give birth as early as late January and early February. These offspring are best called abortions for they are hairless, not fully developed, and are apparently born dead. Figure 1 shows one of these abortions that washed ashore at Año Nuevo Island on February 1, 1969. The abortion in Figure 2 was photographed at San Miguel Island on March 25, 1969. Dan Odell (personal communication) reports observing *Zalophus* abortions as early as late January on San Nicolas Island. The phenomenon has also been noted in Steller sea lions, *Eumetopias jubata*, at Año Nuevo by Orr and Poulter (1967) and Le Boeuf (unpublished observations).

During the first week in March, 1968, Peterson, Gentry and Le Boeuf (unpublished report of investigations of pinnipeds on San Miguel and San Nicolas Islands, February-March, 1968) observed several freshly dead pups on San Miguel Island and six pups on San Nicolas Island. The external appearance of these pups made it obvious that they had been born prematurely. On San Nicolas Island, one female
protected her dead pup for several minutes, grasping it in her mouth as she moved in and out of the surf. On March 25-28 of the following year, Peterson and Le Boeuf (unpublished report of an expedition to San Miguel Island) counted 26 dead pups in the Point Bennett area of San Miguel Island. All of them were incompletely developed and had been delivered recently. Schulz, Radovsky and Budwiser (1970) saw six newly dead _Zalophus_ pups and a few live pups on April 7-8, 1968, at Isla San Martín, and Simpson and Gilmartin (1970) reported "a number of aborted California sea lions" on San Miguel Island on April 11, 1970. In late April of 1968, Brownell, DeLong and Schrieber (unpublished report on pinniped populations at Islas de Guadalupe, San Benito, Cedros, and Natividad, Baja California, in 1968) noted numerous dead pups on Cedros Island, Natividad and Islas San Benito. Fifty dead pups were counted on Isla San Benito del Centro. Nose to tail measurements on seven males ranged from 56 to 72.5 cm, and 61 to 67 cm for five females measured. A few viable pups seen at this time appeared weak and lethargic. Females were seen moving into the water carrying dead or feeble pups in their mouths. These females seemed reluctant to desert the pups even though they were dead or dying.

On San Nicolas Island between January and the end of the third week in May, Dan Odell counted 135 premature dead pups in 1969 and 442 in 1970. These figures represent more than a 300% increase from one year to the next.

As the normal pupping season approaches, premature pups resemble full-term pups more and more, particularly in their size, weight, and external appearance, e.g., those born in February are hairless while those born later are increasingly hirsute. The first viable pups are weak and uncoordinated and probably die after a few days. Those born closer to May show coordinated movements resembling those of full-term pups born in June and are more likely to survive.

This phenomenon of premature pupping could represent normal variation in the population. Those females who pup well before the normal pupping season do not produce viable offspring and their genes, if the aberrancy is inherited, are selected out of the population. Even if their pups survive and the post partum estrus is normal (we do not know if
it is), there may be no males around to reimpregnate these "early" females. In other words, what we may be seeing is the normalizing aspect of natural selection in progress. If this is the case, we would expect the frequency of premature pupping to be lowest early in the year at the extreme end of the continuum and to increase to a high near the normal pupping period in late May and June, the set-point. Getting baseline data on premature pupping and relating it to adult population estimates in order to determine whether the phenomenon represents normal incidence is made difficult by problems encountered in censusing pups, as well as the large population of adults (Peterson and Le Boeuf, 1969).

On the other hand, the problem may be man-made, an indirect result of man's technology and attempted control of the environment. We shall explore this possibility in the sections which follow.

OIL

The blowout of Union Oil Platform A in the Santa Barbara Channel on January 28, 1969, caused crude oil to wash up on San Miguel Island and San Nicolas Island, two islands where California sea lions breed. Although public attention and scientific concern centered on the northern elephant seals, *Mirounga angustirostris*, who were breeding at the time (Chapter 13), the State of California Department of Fish and Game (1969) reported three dead sea lions in their wildlife survey of the area from February 3 to March 28, 1969. No autopsies were performed and no attempt was made to link these deaths with the crude oil spill.

When crude oil from Platform A washed up on San Miguel Island in mid-March, 1969, the National Park Service asked the Naval Undersea Research and Development Center at Point Mugu, California, to investigate pinniped mortality at Northwest Cove, the location of the oil slick (see Fig. 3 in Chapter 13). The report by Simpson and Gilmartin (1970) which resulted covered examination of both *Mirounga* and *Zalophus*. The blood of two aborted *Zalophus* pups obtained on April 11 was examined for petroleum residue analysis and found to be negative. The report concluded that the
cause of death of animals found on San Miguel Island was unknown.¹

Public concern for sea lions became nationwide in early June when Life magazine (June 13, 1969) published an article linking oil pollution on San Miguel Island to the deaths of over 100 sea lions and elephant seals. Although no more oil had washed ashore at Northwest Cove, the slick remained and approximately 1,000 Zalophus females were using the cove as a nursery and a place to give birth. Representatives of Life magazine visited San Miguel Island on May 25, shortly after pupping had begun. The article was emotional and impressionistic and included statements which implied conclusions not based on fact. Consider the following three quotes:

"Some of the seal lions--a particularly skittish species of seal--could scarcely be distinguished from their lethargic cousins, the elephant seals."

"Until we became weary and sick of the tally, we counted over a hundred dead sea lions and elephant seals in the immediate area. Some of these were adult animals but most were newborn pups."

¹These investigators also implied that the number of deaths was not unusual because high pup mortality has been reported in other species (i.e., over 50% in Steller sea lion pups on the Año Nuevo rookery). They based this assertion on an observation by Evermann (1921) on Año Nuevo Island, reporting 100 live pups and 106 dead or dying at the time a count was made. They failed to mention the unusual circumstances that preceded this census. Evermann (1921:19) explained that this high mortality "was caused by a severe storm which occurred about the middle of June when the sea washed over the entire rookery, washing practically all the pups off the rocks and into the water. At that time the pups had not yet learned to swim and many were drowned outright. Others were probably so seriously injured they could not get back upon the rocks, and still others were washed ashore. The mothers do not appear to make any search for them and they crawl about and finally starve."
"As to the cause-and-effect relationships of it all, no one can say with any certainty which pups had died of toxicity from nursing a mother whose teats had been dragged through the sludge or which from pneumonia in oil-suffused lungs or of starvation caused by maternal abandonment."

The first quote implies that oil caused sickness, the second implies that oil caused death and the last concludes that oil caused numerous sea lion deaths but the mechanism by which it did this remains unknown.

That the animals these people observed were coated with crude oil is undeniable; further substantiation of this fact follows. However, their interpretation, based on the correlation between the presence of oil and deaths, was derived without consideration or knowledge of other important facts. For example, most of the dead pups they counted had been born prematurely. We have already pointed out that this phenomenon occurs at other rookeries where Zalophus breeds and has been observed at several locations on San Miguel Island in previous years, before the oil slick washed ashore. Furthermore, they did not know or acknowledge that a pup mortality rate of at least 15% during the pupping season is normal, as we have indicated in a previous section.

In an attempt to assess the effect of oil on Zalophus pup mortality, Le Boeuf and R. L. DeLong censused the pup population at Northwest Cove on June 16, 1969, by walking the length of the cove counting all live pups and pups that had died within the last two weeks (inferred from carcass decomposition). Both living and dead pups were divided into two categories: oily and non-oily. Oily pups were defined as pups with 25% or more of their bodies covered with crude oil. Pups with 25% or less of their bodies covered with crude oil were defined as clean. The results are shown below:

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total pups</td>
<td>881</td>
<td></td>
</tr>
<tr>
<td>Total dead</td>
<td>112</td>
<td>12.7%</td>
</tr>
<tr>
<td>Oily dead</td>
<td>76</td>
<td>67.8%</td>
</tr>
<tr>
<td>Total living</td>
<td>769</td>
<td>87.3%</td>
</tr>
<tr>
<td>Oily living</td>
<td>352</td>
<td>45.8%</td>
</tr>
</tbody>
</table>
In spite of the fact that 46% of the living pups and 68% of the dead pups were oily, the mortality rate was less than 13%. This figure is well within the normal limits alluded to earlier in this paper. The higher number of oily animals in the dead category may have been due to the fact that they had moved around the rookery and become more soiled than younger, living animals before they succumbed. On the basis of the above data, one still cannot exclude the possibility that oil contamination had a deleterious effect on pup health and in some way increased the probability of death. If this occurred, the effect was unquestionably very small.

ORGANOCHLORINE PESTICIDES

Accumulations of DDT and its metabolites are persistent components of the marine ecosystem (Risebrough, et al., 1967). DDT residues in phytoplankton in Monterey Bay, California, have increased threefold between 1955 and 1969 (Cox, 1970). Concentrations of these pesticides in organisms increase from lower to higher trophic levels and it has been demonstrated that environmental contamination by organochlorine pesticides causes reproductive failure in several species of birds which feed at the top trophic levels. These pesticides affect enzymes associated with egg shell thickness in several avian species (Ames, 1966; Peakall, 1967; Ratcliffe, 1967; Hickey and Anderson, 1968). The thin egg shells break during incubation, resulting in death of the developing young. Gress (1970) reported that eggs from brown pelicans, Pelecanus occidentalis, collected from Anacapa Island, off Southern California, contained pesticide residues up to 2,600 ppm of DDE, the principle metabolite of DDT, and that reproductive success of pelicans in California has been near zero during the last few years.

Like many large marine birds, most pinnipeds feed near the top trophic level in the marine environment and, therefore, might be expected to accumulate high concentrations of pesticides. However, concentrations of organochlorine pesticides reported from most pinnipeds thus far are low compared to the maximum concentrations found in pelicans. Sladen, Menzie, and Reichel (1966) found DDT residues of 39 ppb in the blubber and 13 ppb in the liver of the crab-eater seal, Lobodon carcinophagus, which inhabits Antarctic waters. Concentrations up to 5.1 ppm were found in the
liver of 30 northern fur seals from the Pribilof Islands (Anas and Wilson, 1970). Holden and Marsden (1967) reported DDT concentrations up to 14.8 ppm in the blubber of gray seals, Halichoerus grypus, collected in Scotland. Cook and Baker (1969) found a total residue concentration of 1.16 ppm in the milk of one harp seal, Pagophilus groenlandicus, in the Canadian western Atlantic. They point out that the Canadian Food and Drug Directorate has set a tolerance of pesticide residues in milk for human use at 1.0 ppm.

Simpson and Gilmartin (1970) examined kidney, liver and spleen of 11 newly aborted Zalophus pups found on San Miguel Island on May 1-2, which were analyzed and found negative for hydrocarbons, DDT and DDE. Similar tests on tissue samples of the uterus, ovaries and blood of an adult female that had just aborted were also negative. However, Michael Bonnell and Le Boeuf (unpublished observations) found total DDT residues in the blubber of four adult California sea lions collected at San Miguel Island in September, 1970, ranging from 41 ppm to 1929 ppm. Maximum residues in brain tissue, muscle and liver were 10.0 ppm, 2.5 ppm and 18.0 ppm, respectively.

It is obvious from these few observations that organochlorine pesticide residues vary greatly among different species of pinnipeds. One would expect this to be so since some of the species studied are not closely related, different species usually feed on different organisms and inhabit and exploit different aspects of the marine environment, and pesticide concentrations are higher in some areas than others. Toxic levels in pinnipeds have not been established.

The configuration of DDT is similar to synthetic estrogen, diethylstilbestrol. DDT has two main isomers: 80% is in the form p,p'-DDT and 15-20% of DDT is in the form of the isomer, o,p'-DDT. The reproductive tissues of rats and birds treated with o,p'-DDT responded as if treated with estrogen while rats receiving p,p'-DDT showed little if any response (Bitman, et al., 1968). It has also been shown in women that the o,p' isomer is more actively metabolized during pregnancy and 10.2 times more highly concentrated in the blood than the p,p' isomer (Polishuk, et al., 1970). It is unfortunate, as Moats and Moats (1970:461) point out, that "most published residue analysis for DDT, DDD, and DDE
are based on the p, p' isomers so there is no way of assessing the practical importance of residues of the o, p' isomers in biological systems."

Since DDT can mimic estrogen, it might have something to do with premature pupping in sea lions. We will speculate on how this might come about. The California sea lion is believed to show delayed implantation, as do most other pinnipeds that have been investigated (Bartholomew, 1970), for example, the northern fur seal (Craig, 1964). The period of delay, from the time of fertilization to implantation of the fertilized egg to the uterine wall is 3-1/2 to 4 months in Callorhinus (Craig, 1964) and Zalophus is expected to show a similar delay. The changes that cause the blastocyst to become implanted to the uterine wall are unknown in pinnipeds. In rats, Shelesnyak and co-workers (Shelesnyak, Kraicer and Zeilmaker, 1963; Shelesnyak and Kraicer, 1963) have shown that, in addition to a required progesterational uterus, implantation of the rat blastocyst depends on an estrogen surge which occurs a few days after mating has taken place. If an increase in estrogen titers is implicated in implantation in sea lions, then the estrogen-mimicking action of o, p'-DDT may be affecting the time at which implantation occurs by causing no delay or by causing the delay to be shortened, and thus causing some pups to be delivered prior to the normal pupping period. If this explanation alone was correct, the premature pups, at delivery, should resemble full-term pups. The data do not substantiate this reasoning, for abortions occurring February and March are clearly unfinished. This may be the case for pups born in April and early May, but the descriptions of these pups lack sufficient detail. It is possible that failure of implantation to be delayed is coupled with early deliveries; however, this degree of complexity is unlikely. More frequency data and descriptions of premature pups are needed.

Another possibility is that delayed implementation is unaffected and the fetus develops normally for at least four months. After this time, o, p'-DDT, by mimicking estrogen, might terminate pregnancy (see Craig, 1964). It is known that estrogen blocks progesterone, and in doing so could interfere with pregnancy (Csapo, 1956). The reason why abortions do not occur sooner (if they occur, they have not
been reported) may be due to the diet sea lions are eating at this time of the year. Some prey undoubtedly concentrate DDT more than others. In this regard, it is notable that Korschgen and Murphy (1967) observed reduced reproductive rates in mature female white-tailed deer when their diet was supplemented with 25 ppm of Dieldrin, an organochlorine pesticide. Dieldrin is stored at concentrations 50% less in pregnant than nonpregnant women (Polishuk, et al., 1970), thus indicating faster metabolism in the former.

DISCUSSION

Sea lions die from a number of causes. Whether oil pollution, pesticides, or other artifacts in the marine environment have any effect on sea lion mortality is unclear at this time. Contamination with crude oil did not have a marked effect on pup deaths on the rookery at San Miguel Island during the 1969 breeding season. The effect of organochlorine pesticides on sea lion mortality is unknown. California sea lions show the highest DDT residues of any pinniped examined thus far and investigations of the possibility that pesticides induce premature pupping in this species are just beginning. Unequivocal answers to questions concerning the causes of mortality will be made possible and facilitated by the collection of normative data. We cannot say what is unusual without reference to what is usual. Frequency data of the following kind will be most helpful in evaluating future calamities: estimates of premature pupping, pup deaths on the rookeries, and strandings and carcass wash-ups on hauling grounds and mainland beaches.

Frequency data on premature pupping could suggest whether the phenomenon is due to "technological fallout" or simply reflects natural variation in a large population. The former would be indicated if abortions were concentrated at a certain time of the year, say early February, and did not grade into the normal pupping period in early summer. We do not have sufficient data at present to determine whether this is the distribution that obtains. An unnatural causation would also be suspected if premature pupping on a single rookery increased dramatically from one year to the next, without a concomitant increase in the adult population. Odell's (1970) observations on San Nicolas Island, which indicate a tripling of premature pups from 1969 to
1970, suggest an artifactual interpretation. Natural causation is most likely to be reflected by relatively stable frequencies from year to year; and within a single year, by a gradual increase in premature pupping from a low early in the year to a high which blends in with the normal pupping period in May and June.

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Sladen, W. J. L., C. M. Menzie, and W. L. Reichel
Table 1

Mortality Rate of Pups on Area 1B* at San Nicolas Island, California, during the 1968 Breeding Season (Modified from Schreiber, 1970)

<table>
<thead>
<tr>
<th>Date</th>
<th>Total Pups</th>
<th>Live Pups</th>
<th>Dead Pups</th>
<th>Percentage Dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 May</td>
<td>77</td>
<td>55</td>
<td>22</td>
<td>28</td>
</tr>
<tr>
<td>17 June</td>
<td>229</td>
<td>197</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>2 July</td>
<td>230</td>
<td>222</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>22 August</td>
<td>80</td>
<td>50</td>
<td>30</td>
<td>37</td>
</tr>
</tbody>
</table>

*The area we refer to as "1B" is the upper portion of 1B referred to by Peterson and Bartholomew (1967).
Figure 1. A California sea lion abortion found on Año Nuevo Island on February 1, 1969. The specimen is hairless and smaller than a full-term pup. A large segment of umbilical cord is still attached. Photographed by Le Boeuf.

Figure 2. A California sea lion abortion photographed by Le Boeuf on San Miguel Island on March 25, 1969.