Distribution and Abundance of Hawaiian Monk Seals in the Main Hawaiian Islands

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The endangered Hawaiian monk seal *Monachus schauinslandi* primarily inhabits the Northwestern Hawaiian Islands (NWHI). However, an increasing number of monk seal births and sightings have recently been documented in the main Hawaiian Islands (MHI) where no systematic surveys of monk seals were conducted prior to 2000. What we know about monk seal abundance and distribution in the MHI is based upon aerial surveys in 2000 and 2001, known pupping records, and non-systematic sightings reported by various sources including cooperating agencies and members of the public. Minimum abundance in 2000 and 2001 was 45 and 52 seals, respectively, based upon aerial surveys of all MHI coastlines and augmented by sightings of seals from the ground. The higher number counted in 2001 likely reflects the use of helicopters, which allowed for more thorough searching than was possible from the airplane used in 2000. These estimates are well below total abundance because they do not account for animals in the water, and every seal on land cannot be detected. Births in the MHI appear to have become more frequent since the mid-1990s. While monk seals have been seen on all the MHI, most are located on Niihau, and the number of sightings tends to decrease moving to the southeast along the island chain. Overlaying this pattern is a tendency for seals to frequent remote areas where human presence or access is limited. Births almost exclusively occur in relatively remote areas; only one female is known to have given birth on a popular public beach (Poipu, Kauai).

1. Introduction

The Hawaiian monk seal is a highly endangered species, which primarily inhabits the remote Northwestern Hawaiian Islands (NWHI), where approximately 1,400 seals reside mainly in six main populations (Fig. 1) (Ragen and Lavigne, 1999; Carretta et al., 2002). Due to steep declines in abundance following surveys in the late 1950's, the species was listed as endangered under the U.S. Endangered Species Act in 1976. Because the remaining animals are almost entirely in the NWHI, efforts to monitor and foster the species' recovery have been focused there for over two decades since the U.S. National Marine Fisheries Service (NMFS) began its research and management programs. Despite many successful management interventions and regulations that protect monk seals and their habitat in the NWHI, the Hawaiian monk seal's future is still not secure.

The historic and current abundance of monk seals in the main Hawaiian Islands (MHI, Fig. 1) is not well known. Rare and sporadic sightings of monk seals in the MHI were documented by Kenyon and Rice (1959) for the early 20th century, and more recently such records have been maintained by the NMFS. Beginning in the 1990s, an increasing number of monk seal births and sightings have been noted in the MHI. Prior to 2000, no systematic surveys of monk seals had been conducted in the MHI, so it is not possible to reliably determine whether there has been a recent increase in the MHI monk seal population, an increase in reporting sightings, or both.

3. Methods

The main Hawaiian Islands (Fig. 2) are a subset of the Hawaiian Archipelago. Spanning 600 km, they consist of eight primary islands, from the northwest to the southeast: Niihau, Kauai, Oahu, Molokai, Lanai, Maui, Kahoolawe, and Hawaii. There are also three small uninhabited crescent-shaped volcanic islets: Kaula Rock, Lehua, and Molokini Crater, and several islets offshore of the various primary islands.

In 2000, aerial surveys were conducted from a Partenavia Observer, a twin-engine, high-wing aircraft. All coastlines were searched by three observers and a pilot at altitudes ranging from 100 to 500 ft and at an average speed of 90 mph. To increase the chances of seeing seals, 2001 surveys were conducted from helicopters (Hughes 500) flying at a slower rate (35-70 mph). Surveys were conducted in summer and autumn, after most pups would have been born (Johanos et al., 1994) and to take advantage of optimal weather. However, scheduling of survey dates were determined to a large degree by aircraft availability and air space closures associated with military operations.

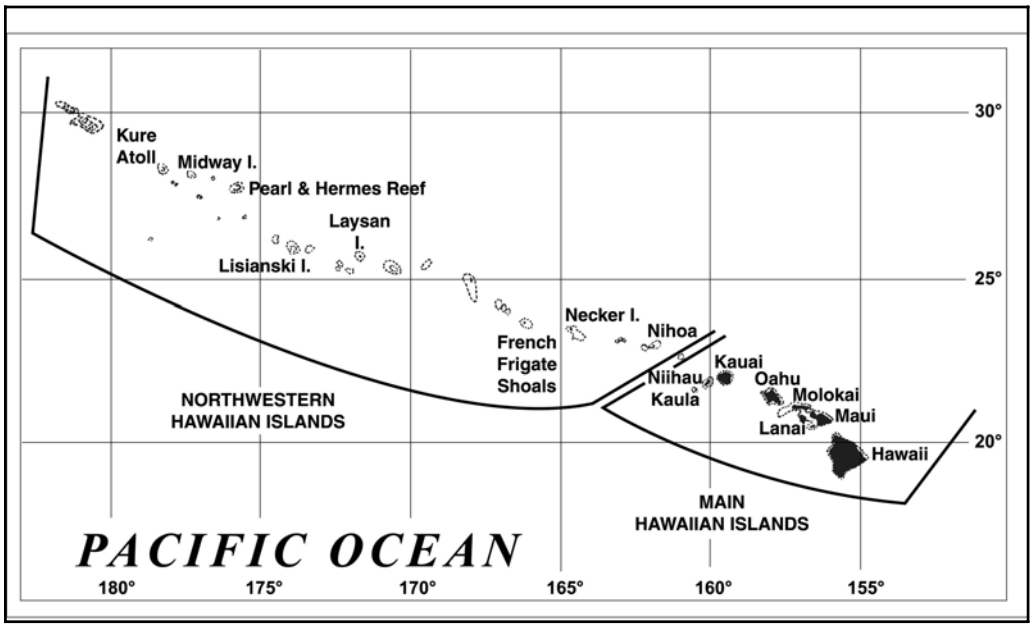

Figure 1. The Hawaiian Archipelago. The six main subpopulations where monk seals reside in the Northwestern Hawaiian Islands are Kure Atoll, Midway Atoll, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and

Each individual island survey was completed within a day, and as much as possible, islands located near one another were surveyed the same day to minimize the potential for double counting seals that might have moved within or between islands. When possible, surveys were begun approximately mid-day following methods used for ground counts of seals in the NWHI. When a seal was sighted, its location and the time were recorded either manually or with a Global Positioning System (GPS) unit, and photos were taken opportunistically. Seals were classified as either nursing pups, weaned pups, juveniles (roughly 1-2 years old), sub-adults (roughly 3-4 years old) or adults

(minimum of 5 years old), according to size and body shape characteristics used in NHWI studies. In some cases, gender could also be determined if seals were lying with their ventral surface exposed, or by association with a nursing pup.

4. Results

Aerial Surveys: In 2000, the islands of Hawaii, Maui, Kahoolawe, Molikini Crater, Lanai, Molokai and Oahu were surveyed once during 10-12 July 2000. However, military operations prohibited flying around the remaining islands immediately thereafter. Thus, Kauai, Niihau, Lehua, and Kaula Rock were surveyed once on 8 August and, because most seals were counted on these islands, a second count was conducted on 26 September 2000.

Estimated minimum abundance in 2000 was 45 seals, calculated as the sum of the maximum counts from each aerial survey (the higher of the two surveys of Niihau, Kauai, Lehua, and Kaula Rock was used), plus four additional seals counted from the ground (Table 1).

Table 1. Number of Hawaiian monk seals counted during aerial surveys of the main Hawaiian Islands in 2000 and 2001. Numbers in parentheses indicate seals that were seen by observers on the ground that were not seen from the air

Island	2000 (1st survey)	2000 (2nd survey)	2001
Kaula Rock	3	0	-
Niihau	5	29	29
Lehua	2	0	3
Kauai	7	7 (2)	5 (2)
Oahu	0	-	1
Molokai	3 (2)	-	3 (2)
Lanai	0	-	1
Maui	1	-	3
Kahoolawe	1	-	2
Hawaii	0	-	0 (1)
Minimum Abundance	24	45[1]	52

[1]Total of second survey tally at Kaula, Niihau, Lehua, and Kauai plus the single-survey tally of all other islands.

In 2001, Hawaii, Maui, Kahoolawe, Molikini Crater, Lanai, Molokai and Oahu were surveyed once from helicopters during 27-30 August 2001. Kauai, Niihau and Lehua Rock were not surveyed until 1 October 2001, when aircraft became available. Kaula Rock was not surveyed in 2001.

The minimum population estimate for 2001 are animals seen from the air (47), plus 5 additional ground sightings, for a total of 52 seals. That more seals were counted in 2001 compared to 2000 likely reflects the more thorough searching that was possible using helicopters. Sightings from the 2000 and 2001 surveys are mapped in Figure 2. In 2000 and 2001, immature animals (pups, juveniles, and subadults) comprised 49% and 56% of the total, respectively.

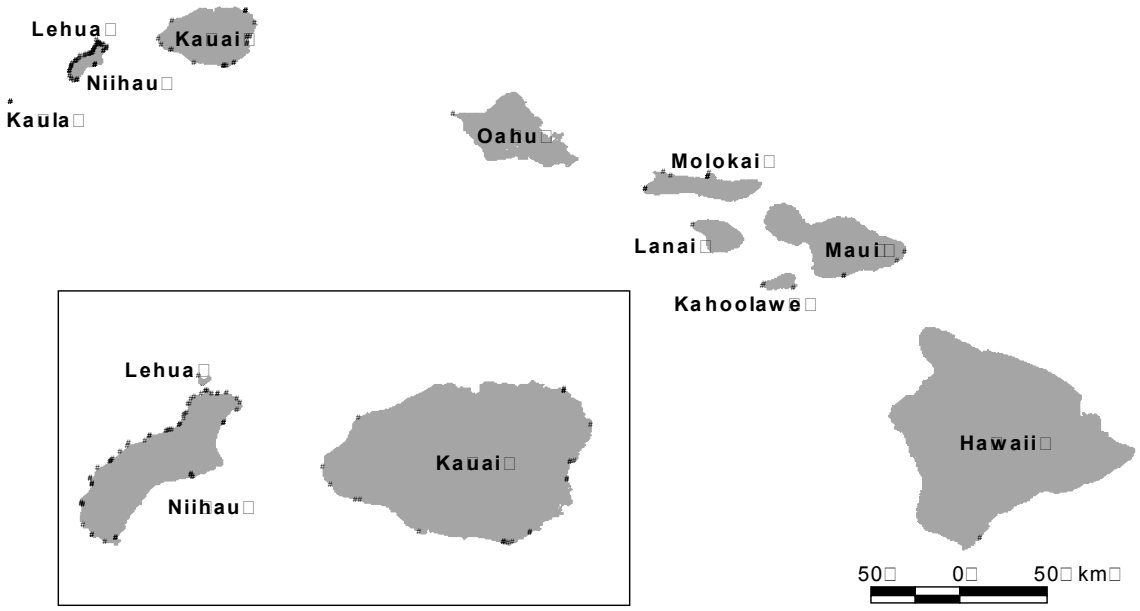

Figure 2. Location of Hawaiian monk seals observed during aerial surveys (and additional ground sightings) in the main Hawaiian Islands during 2000-2001. Insets of Kauai and Niihau (not to scale) are provided. Sightings of multiple seals near one another often appear as one dot.

Births: The first recorded birth in the MHI occurred on Kauai in 1962 (Table 2). This was a rare case in which a pup was found abandoned on the beach. The pup was turned over to the State of Hawaii Fish and Game Department and its fate is unknown, but presumably it died soon thereafter. The next MHI birth was not recorded until 1988. Since 1996, births have been recorded annually and with increasing frequency on various islands. The seven pups noted in 2000-2001 on Niihau were observed by the authors during aerial surveys.

Table 2. Known number of monk seal births in the main Hawaiian Islands

Year	Niihau	Kauai	Oahu	Molokai	Maui	Kahoolawe	Hawaii	Total
1962	0	1	0	0	0	0	0	1
1988	0	1	0	0	0	0	0	1
1991	1	1	1	0	0	0	0	3
1992	0	1	0	0	0	0	0	1
1996	0	0	1	1	0	0	0	2
1997	0	0	1	1	1	0	0	3
1998	0	0	2	1	1	0	0	4
1999	0	1	0	1	1	0	0	3
2000	2	4	0	1	0	0	0	7
2001	5	3	0	2	0	1	1	12
2002	0	1[1]	0	2	0	0	1	4

5. Discussion

The minimum estimates of Hawaiian monk seal abundance in the MHI are certainly much lower than true abundance. Seals in the water were not counted during aerial surveys, and an appropriate multiplier to adjust counts is not available. In the NWHI, it has been estimated that two to three seals exist for every one counted during beach censuses. However, such multipliers are likely determined by habitat characteristics, proportion of time spent foraging (which is likely determined in part by proximity and abundance of prey) and time spent in social activities and sleeping in the water (Parrish et al., 2000). These factors, especially habitat characteristics, may differ greatly between the NWHI and MHI so that we cannot assume NWHI

[1]In addition to a healthy, full-term pup, an aborted fetus was also found on Kauai in 2002.

correction factors apply in the MHI. In addition to seals missed in the water, the probability of detecting seals on land during aerial surveys is less than 100%.

The locations of seal sightings (Figure 2) suggests two factors that may influence their distribution. First, the number of sightings tends to decrease moving along the archipelago from the northwest to the southeast. Second, there is a tendency for seals to locate on islands with relatively low human abundance. Thus, the greatest number of seals was found on Niihau at the northwestern end of the MHI, with a population of only 230 people (Juvik and Juvik, 1998). The second highest counts were consistently on Kauai (human population 58,000). Moving to the southeast, just one seal was seen on densely populated Oahu (population 876,000). However, seals were more regularly sighted on the next island to the southeast, Molokai (population 6,700), the remote areas of Maui (population 91,000), and uninhabited Kahoolawe. One seal was seen on sparsely populated Lanai (population 3,200). Notably, the island farthest to the southeast, Hawaii (population 149,000), comprises 30% of the tidal shoreline of the MHI (Juvik and Juvik, 1998), yet only one seal was found there during this study.

The number of known MHI births is certainly less than the actual number born. Mothers overwhelmingly select remote areas for parturition, with the notable exception of a female which gave birth in 2000 and 2001 on the very popular public beach at Poipu, Kauai. It is likely that not all births are discovered. Also, while most monk seals seen during the aerial surveys were on Niihau, births on that island are not reported to NMFS. Those births listed on Niihau in Table 2 were observed by researchers on just three occasions over a 12-year period.

There is little information available on the history of monk seals in the MHI. Kenyon and Rice (1959) reviewed seven MHI sightings accumulated from 1928 to 1956, which they referred to as "wandering" seals, implying that they had strayed from the NWHI. The distribution seen during aerial surveys (Fig. 2) suggests that seals may be colonizing other parts of the MHI from Niihau. Most monk seals in the NWHI bear colored plastic flipper tags, especially those at sites other than the relatively inaccessible and sparsely populated Necker and Nihoa Islands (Fig. 1). Thus, if seals were immigrating from the NWHI, those originally tagged there should account for a significant portion of seals seen in the MHI. However, only two seals tagged in the NWHI are known to have voluntarily moved to the MHI. In 1987, a juvenile male born at French Frigate Shoals climbed aboard a pleasure boat off the island of Hawaii, and an 8-yr-old female seal born on Midway Atoll appeared in 2000 on both Molokai and Kauai, then gave birth to the first recorded pup on the island of Hawaii in 2001. The rarity of NWHI tagged seals in the MHI supports the supposition that seals have spread from Niihau, where seals are not tagged. It has been reported that seals began to appear on Lehua Rock and Niihau in the 1970s, and those animals likely originated in the NWHI (a consistent tagging program in the NWHI did not begin until the early 1980s). It is also possible that some seals persisted in the MHI prior to this hypothesized dispersal from the northwest.

In addition to seals naturally occurring in the MHI, 21 adult males (ages 5 to $15 yr) were translocated from Laysan Island (NWHI) to various locations in the MHI in 1994. This was done to correct a male-biased sex ratio at Laysan Island, where male aggression was causing

alarming levels of wounding and mortality to females (Hiruki et al., 1993*a,b*; Starfield et al., 1995). While this action augmented the MHI population, the translocated animals appear to make up only a small portion of the MHI seals. All translocated seals were tagged, but the vast majority of adults sighted in the MHI are untagged. Also, all adult females and animals younger than adult occur naturally in the MHI. One male brought to the island of Hawaii in 1994 was sighted on Nihoa in 1996 and again on Oahu in 2000. This is the only translocated male that was subsequently resighted in the NWHI.

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