The Role of the Main Hawaiian Islands in the Recovery of the Hawaiian Monk Seal

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Fossil evidence suggests that the Hawaiian monk seal (*Monachus schauinslandi*) evolved 15 or more million years ago (Repenning and Ray 1977). If that is the case, then the Hawaiian monk seal species appears to be older than the islands currently referred to as "the main Hawaiian Islands" (Macdonald et al. 1983). Where the species evolved, when it arrived in the Hawaiian Archipelago, and what the archipelago looked like at the time of its arrival is unknown. The extent to which monk seals occupied the main Hawaiian Islands in their current configuration is also unknown.

The absence of information on monk seals in the main Hawaiian Islands is consistent with the hypothesis that they did not occupy these islands and associated waters in pre-historical times. The absence of information also is consistent with the alternative hypothesis that they did occupy these islands but the evidence of their presence either did not persist to the present time or has not been discovered. Based on our current understanding of monk seals, their life history patterns, their distribution and movement patterns, and the dynamic nature of the coastal environment in the main Hawaiian Islands, it is reasonable to hypothesize that they did occur in the main Hawaiian Islands. The islands supported no large predators that would have posed a threat to monk seals. The marine ecosystems and potential foraging habitat around the main Hawaiian Islands are similar in many respects to those around the Northwestern Hawaiian Islands. Documented movement patterns of monk seals are large enough to have brought them to the main Hawaiian Islands even if they originally arrived at sites now part of the Northwestern Hawaiian Islands. If they did occur in the main Hawaiian Islands, they were probably confined to beach areas and rocky shorelines where change is rapid on all time scales and where artifacts that might shed light on the species history are not likely to have been preserved. Even today, the presence of reproducing monk seals in these areas suggests that they are able to sustain themselves in this habitat. However, none of the above information is sufficient to confirm or deny the presence of monk seals in the main Hawaiian time in pre-historical times. For the purposes of this workshop specifically and the recovery of the species generally, it is their current and future presence in the main Hawaiian Islands that is important. The following is intended to explain why the establishment (or re-establishment) of monk seal subpopulations in the main Hawaiian Islands may greatly enhance the species' prospects for recovery.

1. <u>The Hawaiian Monk Seal "Metapopulation"</u>

The Hawaiian monk seal species comprises a metapopulation, or a set of local "subpopulations" linked by limited amounts of migration. Subpopulations are added to and removed from the metapopulation through the processes of migration/colonization and extinction or extirpation, similar to the manner in which individuals are added to or removed from a subpopulation through the processes of birth and death. In its current configuration, the Hawaiian monk seal metapopulation consists of six main reproductive subpopulations (Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals), two smaller subpopulations (Necker and Nihoa Islands) that may not be capable of sustaining themselves, and a small number of animals in the main Hawaiian Islands (Fig. 1).

Most of the seals in the main Hawaiian Islands are located around Kauai Island and, particularly, Ni'ihau Island.

The persistence of a metapopulation depends on the persistence of its constituent subpopulations. Since the 1800s a number of subpopulations of Hawaiian monk seals have been extirpated, followed by recovery that was probably enhanced by or resulted from migration of seals from other sites. The Kure Atoll subpopulation declined from a subpopulation producing about 30 pups per year in the early 1960s to one producing a single pup in 1986, and its re-establishment was enhanced considerably by human-assisted migration. The Midway Islands subpopulation may have gone extinct two times in recent history, first in the late 1880s (Bailey 1952) and then again in the late 1950s and early 1960s (Kenyon 1972). Its recent recovery was stimulated by migration from neighboring Kure Atoll and Pearl and Hermes Reef. In 1912 Bailey landed on Lisianski Island where he saw only two seals and on the sand islands of French Frigate Shoals where he did not encounter any seals (Bailey 1952). And a number of visitors to Laysan Island in the late 1800s and early 1900s saw few or no seals (Schauinslandi 1899, Wilder 1905, Dill and Bryan 1912, Munro 1946, Bailey 1952). These examples indicate that the loss of subpopulations has not been uncommon. The loss of the entire metapopulation (i.e., the extinction of the species) would occur if all subpopulations were in an extirpated state at the same time. These observations suggest that is a real possibility.

2. The Role of the Main Hawaiian Islands in Hawaiian Monk Seal Recovery

The establishment of reproductively sustainable Hawaiian monk seal subpopulations in the main Hawaiian Islands likely would reduce considerably the possibility of the species' extinction. In the following paragraphs, the potential benefits and risks associated with sustainable monk seal subpopulations in the main Hawaiian Islands are discussed in qualitative terms.

Increased habitat and carrying capacity—An examination of the marine communities and physiography of the Northwestern Hawaiian Islands suggests that monk seals are presently confined to a very limited amount of habitat. The terrestrial habitat of those islands is on the order of about 13 to 14 km^2. The beach area (the area that the seals use) is much smaller and amounts to only a small fraction of the total beach area in the main Hawaiian Islands. Their marine habitat appears to consist primarily of the shallow waters (less than 500 to 1000 m depth) around the islands and banks of the Northwestern Hawaiian Islands. In effect, their foraging habitat consists of a series of small oceanic oases surrounded by pelagic deserts. This habitat and the resources it contains probably determine the environment's carrying capacity for monk seals. The development of subpopulations in the main Hawaiian Islands would increase considerably the amount of foraging habitat and prey available to monk seals and, as a consequence, their carrying capacity.

Increased total abundance or number of seals—Of the many factors that can affect a species' risk of extinction, the most obvious is its total abundance, or the number of individuals in the species. In general, the risk of extinction is greater for species comprised of smaller numbers of individuals than for species with larger numbers of animals. As noted above, the establishment of monk seal subpopulations in the main Hawaiian Islands would increase the environmental carrying capacity for the species, presumably allowing locally favorable survival and reproductive rates and growth in abundance until the carrying capacity was approached and density-dependent factors precluded further growth. More males and females would participate in reproduction, thereby increasing the effective population size and genetic variability in the species. Taken together, these effects would increase the probability that the monk seal genome

would be able to withstand the selective forces imposed by an ever-changing environment, and thereby increase the probability of the species' long-term conservation.

Increased number of subpopulations—The persistence of a metapopulation depends upon a number of factors including the number of subpopulations, the expected persistence of those subpopulations, the degree of correlation among the subpopulations in response to perturbations, and the probability of major perturbations. One of the questions before the workshop participants is whether the addition of subpopulations of monk seals in the main Hawaiian Islands will increase the species' expected persistence time (or reduce the risk of the species' extinction). In addition to the benefits described above (increased available habitat and prey resources, number of individuals, and genetic variability), an increased number of subpopulations is expected to increase persistence of the species by decreasing the probability that all subpopulations will be extirpated at the same time, increasing the number of sources for recolonization of extirpated subpopulations and by extending the effective geographic range of the metapopulation and thereby decreasing its vulnerability to large-scale environmental perturbations.

Nisbet and Gurney (1982) suggested that persistence time for a metapopulation should increase exponentially as a function of the number of potential habitat patches that are occupied[1] (i.e., the number of subpopulations that exist). Their model was based on the assumptions that expected persistence time for each subpopulation is equal and trends of any one subpopulation are independent of trends at the other subpopulations. A simpler way to view this phenomenon suggests that persistence time will increase geometrically with increasing number of subpopulations. Assume that each of multiple subpopulations can occur in one of two states, populated versus extirpated, that the probability of being populated at a given point in time for each subpopulation individually is, say, 0.9, and that the probability of being in an extirpated state is 0.1. If the metapopulation consists of two potential subpopulations, then the probability of metapopulation extinction (both subpopulations in an extirpated state at the same time) is $0.1*0.1$, or 0.01^2. If the metapopulation consists of three subpopulations, then the probability of its extinction is $0.1*0.1*0.1 = 0.001$, or 0.1^3. Hence, under these assumptions, metapopulation persistence time would appear to increase geometrically with increasing number of subpopulations.

The assumptions required for these simple heuristic models are not completely true. To comprise a metapopulation, the dynamics of the subpopulations must be linked by at least a small amount of migration if recolonization of extirpated subpopulations is to occur. With regard to the Hawaiian monk seal, the existing evidence suggests that the different subpopulations in the existing Hawaiian monk seal metapopulation do not vary in a completely independent manner. Schmelzer (2000) for example, suggested covariance among some of the six existing subpopulations based on evidence that the western populations are somewhat linked in their subpopulation dynamics, and that Lisianski and Laysan Islands subpopulations may be somewhat correlated. Periodic field observations of reproduction and survival also indicate a degree of covariance among all sites, such as was observed in 1990 and again in 2001. Nevertheless, although the assumptions required by these simple models are not completely true, the general pattern of increasing metapopulation persistence with increasing number of subpopulations is almost certainly true.

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[1]They based their conclusion on the equation: $T_M = T_L \exp[P^2/(2/(H-P))]$, where T_M is the expected persistence time of the metapopulation, T_L is the persistence time of a local population, P is the equilibrium number of occupied habitat patches, and H is the number of habitat patches.

Increased risk of major perturbation—The possibility of increased availability of habitat and prey resources, species abundance, genetic variability, and number of subpopulations all suggest that the establishment of monk seal subpopulations in the main Hawaiian Islands would boost the species' expected persistence time (or reduce its probability of extinction) considerably. The single concern that has been raised is that an increasing number of animals in the main Hawaiian Islands might increase the exposure of the population to disease and thereby undermine the advantages of having a larger total population distributed over a larger range in more subpopulations. This possibility will be addressed by Dr. R. Braun in his presentation.

3. A Personal Observation on the Value of this Workshop

Even after the passage of the Endangered Species Act in 1973, some considered the Hawaiian monk seal to be a relict species destined for imminent extinction for reasons unrelated to human activities. Debates over listing the species and the designation of critical habitat revealed a sharply divided management community. Through the perseverance of a small number of dedicated persons, the species was listed and a research/recovery program was initiated. That effort, however, was largely defined in terms of Hawaiian monk seals in the remote Northwestern Hawaiian Islands. That is, the geographical scale of the monk seal recovery effort was conceptually confined to the Northwestern Hawaiian Islands. During the 1980s and early to mid 1990s, the focus of recovery efforts remained on the six reproductive subpopulations in the Northwestern Hawaiian Islands and the operational paradigm was that recovery efforts should include everything possible to rebuild and recover *these six reproductive subpopulations*. The goal was to bring the species to a state that was as close to "recovered" as possible, even though the Hawaiian monk seal might always be "endangered." In my view, however, the goals of this work were limited by the resources that could be brought to bear to facilitate recovery, and the meager resources available were limited to the Hawaiian monk seal program of the National Marine Fisheries Service, supported by other agencies that operated in the Northwestern Hawaiian Islands.

This meeting, and the possibility of sustained monk seal subpopulations in the main Hawaiian Islands, represents a three-fold shift in the recovery paradigm. First, the participation of individuals from a wide range of management agencies and interest groups clearly indicates that the management community has expanded and can contribute considerably more resources to advance the cause of monk seal recovery. Such resources include funding and staff, but also include the ideas, energy, and commitment of a larger group of management participants.

Second, the possibility of sustained monk seal subpopulations in the main Hawaiian Islands not only increases the species' expected persistence time (or decreases its probability of extinction), but also offers the possibility that the metapopulation, or the species as a whole, may achieve a truly recovered state. It is conceivable that the species might be successfully removed from the endangered species list.

Third, the increased prospect of Hawaiian monk seal recovery has great implications for the persistence of an entire genus, *Monachus*. Hawaii now has an opportunity to demonstrate leadership not only within the U.S., but also to the world, with regard to its ability to conserve this ancient but still viable species. Caribbean and Mediterranean nations have been faced with the question and the challenge of whether they could adjust or modify their cultures, life styles, and impacts on the marine environment to an extent that would allow for the persistence of older, more vulnerable species, *M. monachus* and *M. tropicalis*. The results have been disheartening: *M. tropicalis* is considered extinct and *M. monachus* is on the verge of extinction.

Hawaii has an opportunity to follow a different path. It has an opportunity to show the rest of the world that it has a vision of paradise, and that vision is one that is enriched by the diverse biological community that is its heritage. Hawaii can show the world that its vision includes "ilio-holo-i-ka-uaua" - a dog that runs in the rough seas. I hope and believe this workshop is a very significant step toward that vision.

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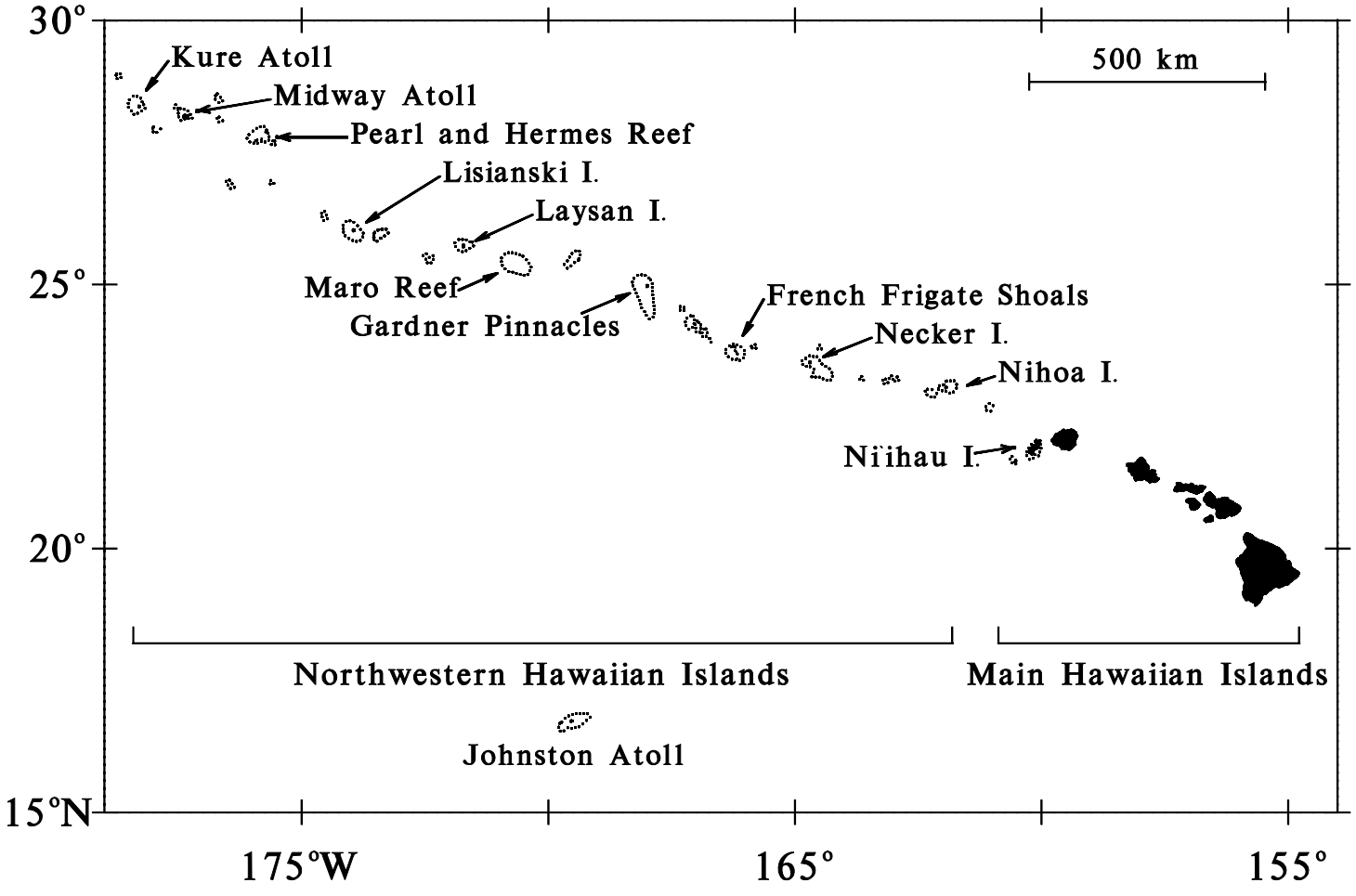

Figure 1. The Hawaiian Archipelago, including the main Hawaiian Islands and the Northwestern Islands.