Vaccination Plan for Hawaiian Monk Seals: Summer/Fall 2016

Timeline

Early June 2016	• Continue vaccination efforts of wild seals on O‘ahu, prioritizing a subset of seals for capture and sampling. • Begin vaccination of wild seals on Kauai using the pole syringe. • Vaccinate weaned pups at Kalaupapa at time of flipper tagging.
Mid-June through October 2016	• Support vaccination of weaned pups at Kalaupapa as necessary. • Continue vaccination efforts of wild seals on O‘ahu and Kaua‘i.

Background

In late 2015, Merial made available a limited quantity of monovalent *Purevax*® canarypox-vectored recombinant distemper vaccine, labeled for ferrets. This product was previously tested for safety and efficacy in captive harbor seals (Quinley et al. 2013) and Hawaiian monk seals (HMS; Yochem and Gulland, pers. comm.) before going on indefinite backorder in 2013. Given this recent window of availability, it was decided that use on wild HMS was appropriate in order to begin implementing a prophylactic vaccination strategy.

In the winter of 2016, 7 seals were fully vaccinated at Ke Kai Ola without adverse effects. Then, between February and May 2016, efforts were expanded to include wild seals on O‘ahu. Nine seals have been fully vaccinated to-date (one seal is awaiting booster vaccination in late May) and no adverse effects have been observed.

Vaccination of Free-Ranging Seals in the Main Hawaiian Islands

O‘ahu was chosen as the initial site for vaccinating free-ranging HMS for several reasons. First, disease outbreak modeling indicates that the spatial structure of the MHI monk seal population makes herd immunity achievable with a relatively low number of vaccinations because of the small number of seals using specific islands or island clusters. Immunizing 17-26 seals on O‘ahu is estimated to provide 90-100% herd immunity. Second, GPS-tagged seals moving between Kaua‘i/Ni‘ihau and Maui Nui always appeared to land on O‘ahu as an intermediate step. Thus, O‘ahu is likely a central node in the movement of seals within the MHI so that achieving herd immunity on O‘ahu yields the best chance of containing an outbreak that may occur anywhere in the MHI. Finally, it will be logistically most feasible to

achieve follow-up observations and conduct sampling of a subset of seals on O‘ahu because this is the island on which most staff are based.

Refer to "Herd Immunity on O‘ahu, 2015-2020" below for more information on disease outbreak modeling and interpretation.

Approach

Sufficient vaccines are available to fully vaccinate approximately 58 additional monk seals before October 8, 2016 (vaccine expiration date). Expired product will not be used. Until additional product becomes available with a longer shelf life, this project will be put on-hold indefinitely by October 8, 2016.

Activities will be conducted under NMFS Permit 16632 (Pacific Islands Fisheries Science Center).

Methods of vaccine administration include hand injection (during handling) and pole syringe injection, consistent with the draft Vaccination Implementation Strategy disseminated by webinar in winter 2014 and a Vaccination Drill conducted in summer 2015 on O‘ahu.

The pole syringe will be the primary means of vaccine administration. To date, most seals vaccinated in this manner on O‘ahu have shown minimal responses (i.e., vocalize/shift body position but do not flush).

The short shelf life of available vaccines and the booster window largely dictate the timeline required for this effort. Seals will ideally receive a booster at the first available opportunity (but no less than 3 weeks) after the initial vaccine is administered.

A subset of animals (2-6 additional seals) will be handled for collection of pre- and post-vaccination blood samples and swabs (to be consistent with the plan for KKO seals, which parallels the controlled studies conducted previously in captive seals). Handling will likely be restricted to O‘ahu given availability of a full capture team on that island, but may occur opportunistically elsewhere. These seals will be sampled on the day of initial vaccination to obtain baseline samples. If the opportunity is ideal for on the day of the second vaccination (no less than 3 weeks later), they may be sampled at the time of booster. If capture prospects are not ideal during the booster window, the pole syringe will be used to administer the booster sans handling. These individuals may be sampled once more in several months (<1 year) to re-examine serum titers and then again every 1-2 years. This research will add to our growing body of knowledge about changes in serum titers over time and inform future booster vaccination protocols.

Individuals will be chosen for capture and sampling based on frequency of sighting. For example, **male and juvenile female seals that are routinely observed (on O‘ahu) in safe capture locations (e.g., sandy beaches) will be preferentially chosen for sampling**. We do not anticipate any difference in response between males and females, but

preferential capture of males reduces the capture risk to potentially breeding females, given difficulties in early pregnancy detection. All current PIFSC protocols will be followed for seal handling, keeping in mind that vaccinating seals in this instance is preventative and need not assume any additional risk. Seals can always be handled or vaccinated another day.

Priority Seals & Seals to Avoid

A prioritized list of candidate seals for vaccination on Oʻahu and Kauaʻi has been generated. Seals identified by contact rate analysis as having a high connectivity with other seals (in other words, potential disease spreaders) are given high priority. Among these, seals that are often sighted in good capture locations and have a high likelihood of being re-sighted for boostering will be prioritized. Seals born at Kalaupapa in 2016 may also be vaccinated, due to the ease of vaccination of weaned pups during tagging and the high likelihood of re-locating those seals in the same area a month later for booster administration. Any seal that has a known health concern will be avoided. Females that are likely to be pregnant based on reproductive history or age (>4 years old) will be avoided. The exception to this is that adult females may be candidates for vaccination during the 2 month period immediately after weaning a pup (booster must be given by 2 months post-weaning). Female seals age 4 or younger that do not have any outward signs of pregnancy (very large body/abdomen size) are candidates for vaccination. Molting seals may be vaccinated using the pole syringe but should not be captured/handled, which is consistent with existing protocols.

Adverse Effects

Since the beginning of prophylactic vaccination efforts of monk seals in January 2016, 33 vaccines have been administered to 17 seals and no adverse effects have been observed. Captive seals (harbor and monk seals) were vaccinated with this product several years ago with no adverse reactions. It has also been used in many terrestrial species including large felids, canids (African wild dogs, wolves, foxes), red pandas (which are sensitive to vaccine induced disease with modified live vaccines), ferrets, otters and procyonids without any ill effects. Concerns for adverse effects are low, nonetheless we are taking a conservative approach. In general, immediate signs of adverse reactions to vaccines can range from localized swelling to anaphylaxis. Monitoring will be conducted by staff immediately following administration of a vaccine and a veterinarian will be on-call and able to respond immediately from Oʻahu if any concerns arise.

Sampling Scheme

All samples are being archived at this time. Once serial serum samples are collected at multiple time points, the serum will be analyzed by serum neutralization for antibodies to CDV and PDV (University of Georgia/UGA and Cornell University) and archived. Nasal, conjunctival and rectal swabs will be analyzed by PCR for PDV and poxvirus (University of California Davis; UCD) and archived.

Table 1. Sample collection scheme

	Day 1	**Day 30 (approx.)**	**Day >60 but <365**
Activity	Handle 1st vaccine Collect samples	Booster vaccine (Handle & sample ONLY if excellent conditions; otherwise pole syringe)	Handle Collect samples
Samples to collect	Serum (-80C) Nasal swabs (2 VTM and 2 dry) Conjunctival, rectal swabs (2 VTM each)	Serum (-80C) Nasal swabs (2 VTM and 2 dry) Conjunctival, rectal swabs (2 VTM each)	Serum (-80C) Nasal swabs (2 VTM and 2 dry) Conjunctival, rectal swabs (2 VTM each)
Sample details	Serum➔CDV/PDV antibody titers Nasal swab (VTM)➔PDV PCR Nasal, conjunctival, rectal swabs (VTM)➔archive (send only if poxvirus PCR + on subsequent samples) Standard biomedical samples#	Serum➔CDV/PDV antibody titers Nasal swab (VTM)➔PDV PCR Nasal, conjunctival, rectal swabs (VTM)➔ poxvirus PCR	Serum➔CDV/PDV antibody titers Nasal swab (VTM) ➔PDV PCR Nasal, conjunctival, rectal swabs (VTM) ➔poxvirus PCR Standard biomedical samples#

Abbreviations:
CDV: canine distemper virus
PDV: phocine distemper virus
VTM: viral transport media

#Biomedical sampling will be conducted consistent w/ standard HMSRP protocols –whole blood, plasma, serum, PAX gene tube, oral, ocular, nasal, genital and rectal swabs. Samples will be collected for NIST and HMSRP archiving as well as submitted for recheck CBC/chemistry.

Acknowledged tradeoffs

Vaccinated seals will be indistinguishable from naturally exposed seals by serology alone, at least for the time being. If a test is developed in the future to distinguish vaccinated from naturally exposed seals, this tradeoff will be eliminated. For now, such a small number of individuals will be vaccinated by this initial effort that it will be easy to track these individuals based on ID. All vaccinated seals will be identified by natural markings, applied bleach marks or flipper tags (and flipper tags will be confirmed during vaccination).

Herd Immunity on Oʻahu, 2015-2020

To support planning for use of available vaccine, we estimated the number of seals that would need to be vaccinated in order to achieve herd immunity on Oʻahu, given specified assumptions and scenarios.

Herd immunity is an epidemiological term. It can be thought of as population immunity for wildlife. It is achieved when enough animals have immunity that the disease will not spread throughout the population as an outbreak. The number needed to achieve this can be calculated using: (a) contact rates between individual seals, (b) the estimated amount of time that infected seals can infect other seals, and (c) and the number of susceptible seals in the population (in this case, Oʻahu).

In a fully unexposed and unvaccinated population, all individuals are considered susceptible to getting the virus. This is supported by decades of monitoring of monk seals for exposure to morbillivirus, through which no natural immunity has been detected. The objective of vaccination is to reduce the number of susceptible seals in the population sufficiently that any introduction of the disease will effectively be a dead-end, securing the bulk of the population into the future.

For this exercise, we used the total number of unique individuals seen on Oʻahu in 2015 (N = 43) as the current population size. We then modeled 1000 different possible outbreak scenarios to determine how many seals we would need to vaccinate to achieve herd immunity and prevent an outbreak in 80%, 90% and 100% of possible scenarios. For example, for a population of 43 seals, 26 would need to be immunized to cover 100% of scenarios, 17 for 90%, and 8 for 80%, and so on.

This analysis helps guide decision-making about the effective use of vaccines, but does involve some assumptions. For example, our analysis assumes that all vaccinated seals achieve perfect immunity and that our range of values for contact rate and infectious period are correct.

As time goes on, we will need to periodically vaccinate more seals to maintain herd immunity as some previously vaccinated seals may move away from Oʻahu or die, and new susceptible seals will be born or move to Oʻahu.

In practice, we can continue to monitor the serum antibody levels, survival and location of vaccinated seals, as well as count the total number of seals on O‘ahu. This will help us better track the number of susceptible seals and thus our confidence in achieving herd immunity.

References

Quinley N, Mazet JA, Rivera R, Schmitt TL, Dold C, McBain J, Fritsch V, Yochem PK. 2013. Serologic response of harbor seals (*Phoca vitulina*) to vaccination with a recombinant canine distemper vaccine. J Wildl Dis. 49(3):579-86. doi:10.7589/2012-06-156.