

## Appendix J.

## **Kahuku Wind Power Post-Construction Monitoring Protocol**

Sampling to estimate the mortality occurring at a wind energy facility must consider spatial and temporal factors at different scales. At the scale of the individual turbine, the area searched should encompass the majority of where expected mortalities will fall; in addition, the search interval has to be of a frequency where most carcasses will be discovered before they are scavenged. When spatial and temporal variation within a site are considered, individual turbines within a site should be sampled sufficiently to account for the spatial variation that exists among turbines, as well as across seasons of the year when species of interest are at the greatest risk of turbine collision.

The accuracy of a mortality estimate itself depends on several factors. The probability of finding a carcass depends on the search interval and scavenging rates at the site. Scavenging rates are typically estimated by conducting trials to yield representative carcass retention times and search intervals are then adjusted accordingly. Another factor that determines the probability of finding a carcass is searcher efficiency. Searcher efficiency will account for individuals that may be killed by collision with project components but that are not found by searchers for various reasons, such as vegetation cover.

This monitoring protocol outlines the scavenger and searcher efficiency trials that Kahuku Wind Power will conduct as well as the search methods that will be used to locate carcasses impacted by the operation of the wind facility.

### **EARLY POST-CONSTRUCTION STUDIES**

The field methods proposed below are based primarily on a refinement of the methods that have been used at Kaheawa Wind Power (KWP) on Maui since operations began in June 2006 (Kaheawa Wind Power 2006). Other recent studies of bird and bat fatalities at wind power projects in the U.S. and Europe were also reviewed to develop and refine previously-approved methods and search techniques (e.g., Kerns and Kerlinger 2004, Pennsylvania Game Commission 2007, Stantec 2008, Stantec 2009, Arnett 2005, Jain et al. 2007, Fiedler et al. 2007 ).

The initial period of fatality monitoring at Kahuku Wind Power will entail frequent, systematic searches of the area beneath each turbine by trained technicians. Carcass removal and searcher efficiency trials will be conducted within this period. Subsequently, systematic sampling at a pre-determined reduced effort will be conducted for one year at 5-year intervals with attendant SEEF trials and carcass removal trials. A regular rapid assessment technique will be developed for the interim years to determine direct take occurring between years of systematic monitoring.

### **Factors Considered for Scavenger and Searcher Efficiency (SEEF) Trials**

Factors that may affect the results of scavenger and SEEF trials include seasonal differences, vegetation types and carcass sizes. All scavenger and SEEF trials will be conducted in accordance with DOFAW monitoring guidelines.

Seasonal differences are presumed to affect the outcome of carcass removal trials. The rate of carcass retention may vary due to seasonal changes in density of predators on site, or seasonal changes in predator behavior. For the monitoring protocol at Kahuku Wind Power, the year is divided into two seasons, the winter/spring season (December – May) and summer/fall (June – November). Results from carcass removal trials may vary with season, as they are known to at KWP (Kaheawa Wind Power 2008) but the outcome of SEEF trials are not expected to vary with season.

Search plots will be mowed monthly and maintained throughout the life of the project. For this reason, scavenger and SEEF trials are not expected to vary with vegetation type.

Carcass sizes will also likely affect the outcome of both scavenger and SEEF trials. Three size classes have been established to reflect the size classes of the Covered Species: bat size, medium birds (waterbirds) and large birds (seabirds, owl). Based on studies conducted at KWP and elsewhere, it is expected that as size increases, both carcass retention times and searcher efficiency will increase.

#### Placement of Carcasses for Searcher Efficiency and Carcass Removal Trials

Each carcass used in searcher efficiency or carcass removal trials will be placed randomly within the search plots. These points will be generated within each identified vegetation zone using ArcView 9x with the Generate Random Points tool in Hawth's Analysis Tools 3.27. Parameters that will be specified for each randomly chosen location will include the minimum distance between random points. Minimum distances between random points will ensure that carcasses are not placed too close together. This will maintain the independence of the samples and prevent predator swamping. These points will subsequently be loaded into a GPS as waypoints to allow the accurate placement of the carcasses.

#### Carcass Removal Trials

The objective of performing carcass removal studies at Kahuku Wind Power will be to determine the average amount of time an avian or bat carcass remains visible to searchers before being removed by scavengers or otherwise rendered undetectable. Trials will be conducted at Kahuku Wind Power with the purpose of maintaining an ongoing record of scavenging rates at different times of year, that will best reflect site-specific conditions in the event that a take does occur. Eight to twelve carcass removal trials will be conducted during the initial survey year, designed to enable four to six trials within a corresponding season (summer/fall and winter/spring). These trials will be used to adjust the number of estimated direct takes of Covered Species observed by correcting for carcass removal bias.

Each carcass removal trial will consist of placing a pre-determined number of carcasses (up to a maximum of seven specimens) of varying size classes on the ground at random locations within search plots. The carcass will be placed such that it approximates what would be expected if a bird/bat came to rest on the ground after having collided with an overhead structure. The intent will be to distribute trials within the project area to represent a range of habitat conditions and seasonal variability. Fresh carcasses will be used whenever available, if frozen carcasses are used, all carcasses will be thawed before being deployed. An example of a possible sampling design is presented in Table 1.

All carcasses will be checked daily for up to 30 days, or until all evidence of the carcass is absent. On day 30, all remaining materials, feathers or parts will be retrieved and properly discarded. Results of trials provide a basis for determining the search frequency necessary to ensure that birds and bats are not scavenged before they can be detected by searchers (see Barrios and Rodriguez 2004 and Kaheawa Wind Power 2008). In some instances, carcasses may be monitored beyond the 30 day survey duration if the information being gathered substantially informs the conclusions of the monitoring exercise. Data will be analyzed by season, and carcass size classifications.

Table 1. Possible Sampling Scheme for Kahuku Wind Power Carcass removal trials for One Season

Size class	Season	Vegetation	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total sample size
Bats	Winter / Spring	Mowed grass	4		4		4		12
Medium Birds	Winter / Spring	Mowed grass	3		3		3		9
Large Birds	Winter / Spring	Mowed grass		3		3		3	9
<b>Total</b>			7	3	7	3	7	3	30

### Searcher Efficiency Trials (SEEF)

As with SEEF trials at KWP, trials will be conducted in association with the regular search effort to estimate the percentage of avian/bat fatalities that are found by searchers. Searcher efficiency will be evaluated according to differences in carcass detection rates for different sized birds and for bats. Estimates of searcher efficiency will be used to adjust estimates of direct take by accounting for carcass detection bias.

Personnel conducting carcass searches will not be told when or where trials will be conducted. Trials will be administered during the monitoring period but dates will be chosen randomly. Each trial will consist of 3 - 7 bird carcasses and/or bats or bat surrogates. Prior to a search commencing that same day, each carcass will be placed at randomly selected locations. Each trial carcass will be discreetly marked and located by GPS so it can be relocated and identified when found. If carcasses of the Covered Species are not available, carcasses of surrogate species will be used as previously described. Data will be analyzed according to carcass size classifications. If the results between trials is highly variable, more trials will be conducted to increase statistical confidence in the resultant values and enable mean searcher detection probabilities to be ascertained for the project site.

### Procurement of Carcasses for Trials

If using state or federally protected species as surrogates for trials, all state and federal laws pertaining to transport, possession, and permitted use of these species along with appropriate animal use protocols will be followed. A scientific permit will be obtained for all species that may be used in trials. The Applicant will cover all costs and responsibilities for acquiring carcasses for trials. Carcasses used in the trials will be selected to best represent the size, mass, coloration, and if possible should be closely related to or roughly the same proportions as the Covered Species. For example, Wedge-tailed shearwaters, a close taxonomic relative of the Hawaiian Petrel and Newell's Shearwater, exhibit a close resemblance to both these covered seabird species, and have been used successfully at KWP and elsewhere in carcass removal trials. All carcasses used for the trials will be fresh or freshly thawed. Dark colored mammals (e.g., small rats, mice) and small passerines (e.g. house finch, house sparrow) may be used as surrogates for bats. Other types of avian carcasses that may prove useful for trials include locally-obtained road kills, downed seabirds, owls, and waterbirds, or species not protected under the MBTA such as pheasant (*Phasianus colchicus*) and rock dove (*Columba livia*). Use of species protected under ESA or MBTA will require permission from DLNR and USFWS.

### Search Intervals

Consultation with the Endangered Species Recovery Committee (ESRC) and DLNR has indicated a preference for search intervals that are equal to approximately 50% of the mean carcass removal rate. Studies at the KWP facility indicate a mean carcass removal time of 9.2 days ( $n = 17$ ). While Kahuku Wind Power will be conducting its own carcass removal trials, due to an expected higher density of mongoose at Kahuku Wind Power than at KWP, an average carcass retention time of one week (seven days) is assumed for the time being. Therefore, in order to comply with the request of ESRC and DLNR and account for variability in these removal rates, search intervals of three or four days were chosen. Thus, searches will be carried out twice a week at the Kahuku Wind Power turbines. These search intervals may be adjusted to more accurately reflect seasonal carcass removal rates as carcass removal trials are conducted and data indicate appropriateness of sampling design modifications.

Should SEEF trials indicate that carcass retention times are less than 7 days, trapping may be conducted to depress scavenger populations and increase carcass retention times. All applicable permits will be obtained.

### Search Areas Beneath Meteorological Towers

The search area beneath the temporary met towers will be circular and extend 10 m beyond the supporting guy wires. The search area beneath the permanent unguyed met tower (80 m) will also be circular and be half the height of the tower at 40 m search radius.

### Search Areas Beneath Individual Turbines

Several studies of small-bodied animals (songbirds and bats), with adequate sample sizes ( $n = 69 - 466$ ), have shown that the majority of carcasses are found within a search area of less than 50% of the maximum turbine height (Arnett 2005, Jain et al. 2007, Fiedler et al. 2007; see Fig. 1a, b, 2a, b, c, d, e). Most of the carcass distributions (% fatalities vs. distance from turbine) appear to be well described by 2<sup>nd</sup> degree polynomials, with most fatalities found at approximately 25% of the distance of turbine height, then decreasing with few fatalities occurring beyond 50% of the maximum turbine height (Fig 2a, b, c).

These data are also supported by the distribution of carcasses that have been found at the operating KWP facility. To date, after more than 3000 turbine plot searches conducted during the three years operation at KWP, only eight carcasses have been found that are clearly attributable to collisions with the turbines. The carcasses consist of one Hawaiian hoary bat, one Hawaiian petrel, three nēnē, one barn owl, one ring-necked pheasant, and one white-tailed tropicbird with distances from the turbine ranging from 2 – 73 m (2 – 81 % of maximum turbine height at 90 m). Search plots for KWP are of 90 m radius (100% turbine height) and no intact carcasses were found beyond a distance of 50% turbine height, with the exception of the white-tailed tropicbird which was found in two locations (56% and 81% maximum turbine height) in which a portion of the carcass was discovered at 81% maximum turbine height. It should not be ruled out that the material recovered in this case may have been moved by a scavenger.

Most studies have concentrated on the fatality distributions of small birds and bats. However, these fatality distributions are also expected to apply to larger bodied birds, though because of their greater weight, they will likely be found closer to the base of the turbines.

Given the considerations detailed above, it is proposed that search areas beneath individual turbines for Kahuku Wind Power will consist of a combination of sample areas including 50% and 75% maximum turbine height (64 m and 96 m, radii, respectively).

### Spatial and Temporal Sampling Scheme During the First Year of Intensive Sampling

#### Frequency of Sampling

Sampling at Kahuku Wind Power will initially consist of twice weekly carcass searches. The actual search intervals will be adjusted based on the results of the seasonal carcass removal trials as they become available. The search intervals will be determined in consultation with DLNR and USFWS.

#### Temporal Sampling Scheme

The first weekly search will consist of sampling all 12 turbines with a search area radius of 50% maximum turbine height (Figure 3A). The second search of the week will consist of sampling a randomly selected subset of six turbines (Fig 3B) with a search area radius of 75% of maximum turbine height. Turbines are randomly chosen to reduce possible bias. The subsequent week, the other set of six turbines will be searched to 75% maximum turbine height (Fig. 3C). The random selection of turbines will only be done once, prior to searches commencing at the project. The same subset of turbines will then be alternated each week for the remaining duration of the intensive sampling. In essence, each turbine will be searched to 75% turbine height at 2 week intervals. As the rate of mortality for all Covered Species at Kahuku Wind Power is expected to be low, sampling all turbines twice weekly at the 50% maximum turbine height and a subsample of six with a search area radius of 75% of turbine

height will ensure a high probability that most of the mortality will fall within the search areas. The short search interval at 50% maximum turbine height will also increase the probability that any carcasses will be found before they are removed by scavengers.

#### Plot Maintenance

All search plots will be mowed monthly out to 75% turbine height and maintained throughout the life of the project.

#### Determining Spatial and Temporal Variation on Site

The twice weekly search frequency is anticipated to accurately describe variation in mortality rates at different turbines within the site, as well as identify periods when Covered Species that potentially occur year round on site (e.g., Hawaiian short-eared owl, Hawaiian hoary bat) are at greater risk of collision. Each turbine will be sampled 108 times a year, resulting in a total of 1296 turbine searches per year for the entire facility.

#### Intensive Sampling During the Second Year

Sampling intervals after the first year will be adjusted to reflect seasonal carcass retention rates measured by the carcass removal trials. In addition, if sufficient data is collected and a reliable correction factor is obtained for the search area between 50 -75% maximum turbine height, all search plots may be reduced to 50% radius. The change in sampling regime will be determined by Kahuku Wind Power in consultation with DLNR, USFWS and members of the ESRC .

However, the same sampling regime as Year 1 will be continued if data indicates that more sampling is needed before any change can be made.

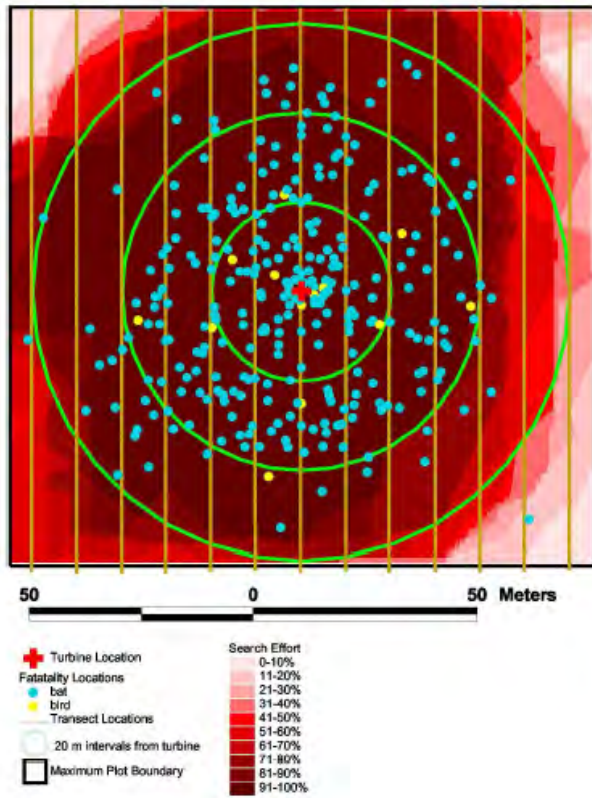


Figure 1a. Bat and bird fatalities (n=466 bats) at all turbines combined at Meyersdale Wind Energy Center in Pennsylvania, 2 August to 13 September 2004 (Arnett 2005). The maximum turbine height was 115 m.

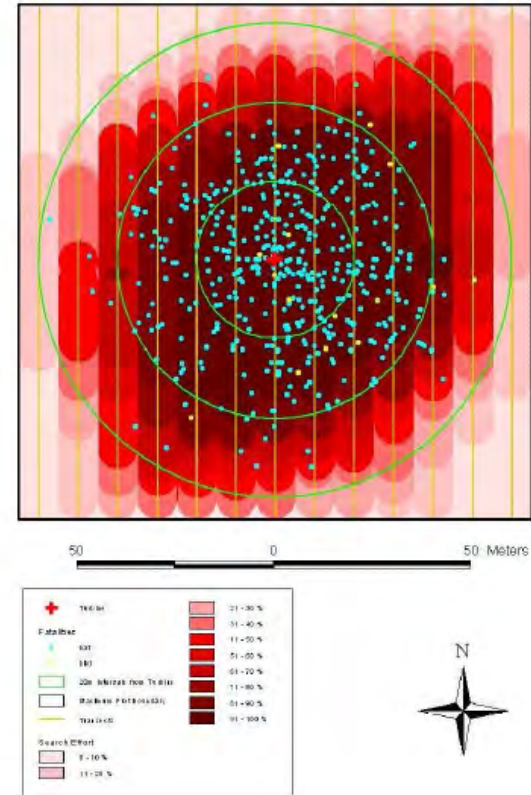
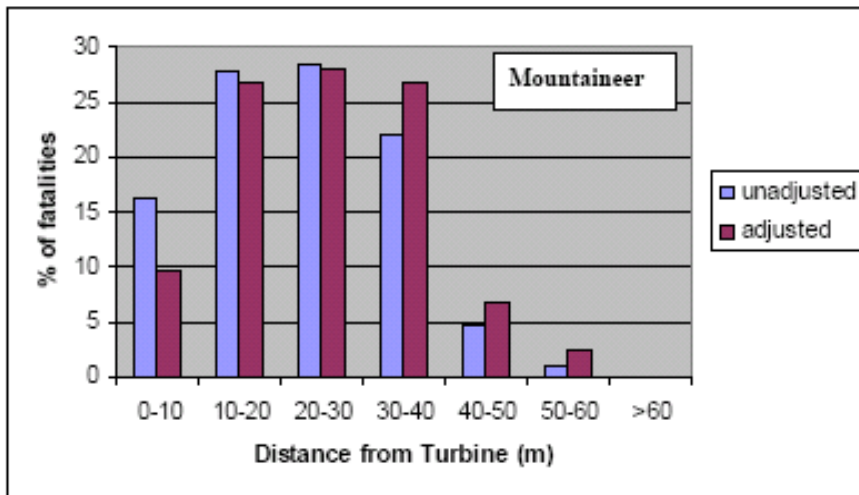
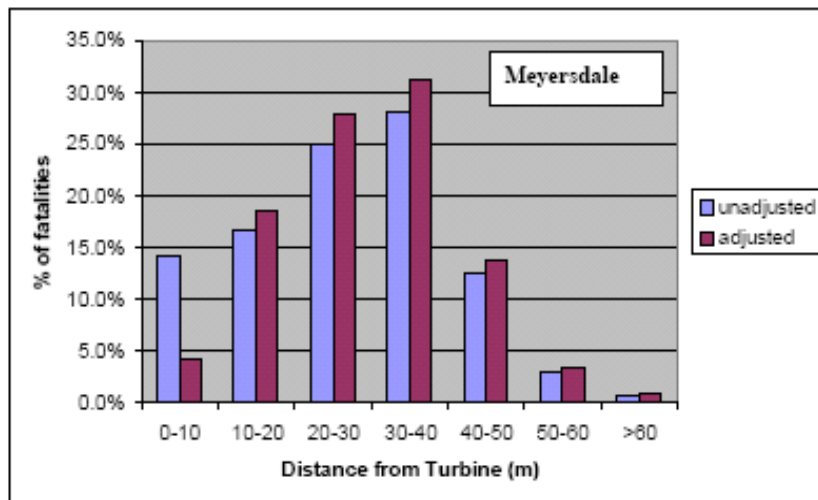


Figure 1b. Bat and bird fatalities (n=499 bats) at all turbines combined at Mountaineer Wind Energy Center in West Virginia, 31 August to 11 September 2004 (Arnett 2005). The maximum turbine height was 104.5m.

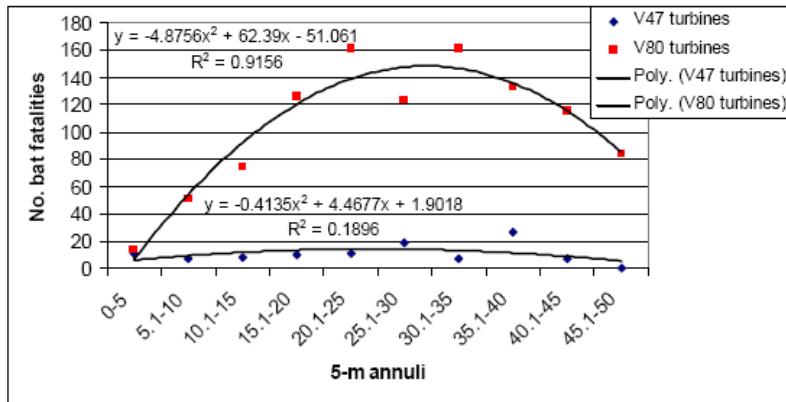


a

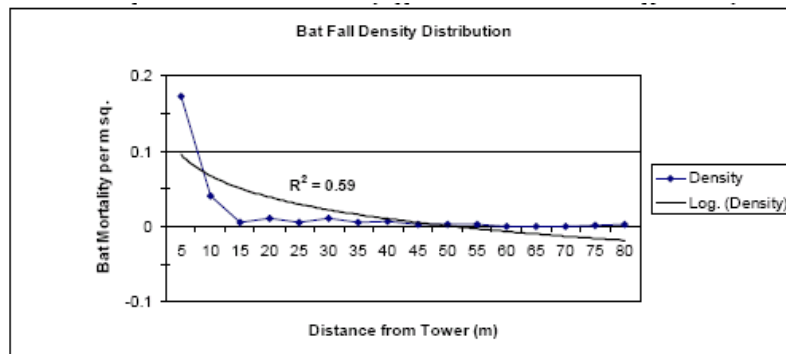


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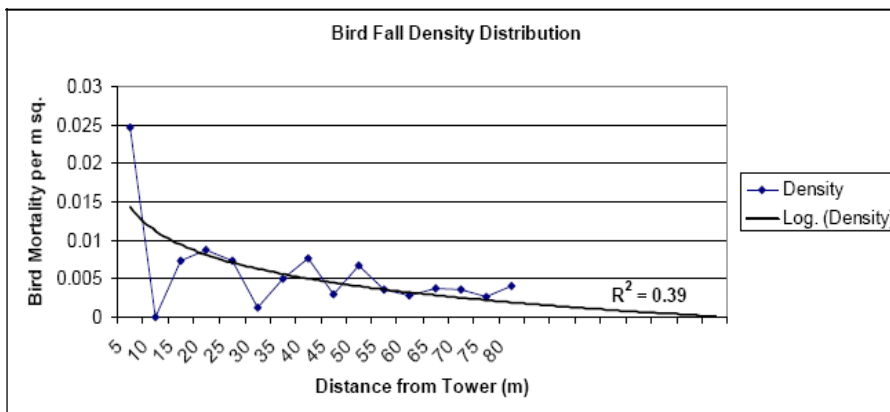
Figure 2a, b. Distribution of fatalities (birds and bats) as a function of distance from a turbine for Mountaineer and Meyersdale sites based on unadjusted counts, and counts adjusted for searcher detection and sampling effort (figures from Arnett 2005). The maximum turbine height was 104.5 m.



c



d



e

Figure 2c. Number of bats found within 5m annuli around V47 turbines (n = 20) and V80 turbine (n=243) from 5 April to 20 December 2005 and associated trend line for Buffalo Mountain, Tennessee (figure from Fielder et al 2007). The trend line for the V80 predicts that bat fatalities would reach zero at 59.6 m from the turbine (maximum turbine height is 120m). Data from the V47 is not considered in this report due to small sample sizes.

Figure 2d,e. Maple Ridge Wind Power, New York bat and bird fatality density distributions from September 1 to November 15, 2006, in relation to distance from towers with associated trend lines. The maximum turbine heights were 122 m (figures from Jain et al 2007). The trend lines predict that bird carcass densities approximate zero at 110m and at 45m for bats. The maximum turbine height was 122 m.



**A**

**B**

**C**

**Legend**

- Turbine Locations
- ⊕ Met Tower
- 50 % (64 Meter Radius) Maximum Turbine Height Search Plots
- 75 % (96 Meter Radius) Maximum Turbine Height Search Plots
- Met Tower Search Areas
- Project Parcels

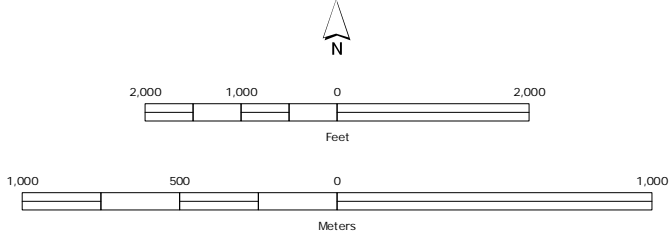


Fig 3 Search areas

### Post Two-Year Intensive Sampling Period

Spatial and temporal trends on site should also be well understood at the end of the two-year intensive sampling period, enabling correction factors to be appropriately applied. Depending on findings, the correction factors may enable a decrease or modification of sampling effort (e.g. increase in search intervals or decrease in the number of turbines searched), identify specific turbines or times of the year when sampling effort should be concentrated, and inform adaptive management considerations. Discussion with ESRC, USFWS and DLNR has indicated a preference for the reallocation of effort whereby mitigation efforts are increased in exchange for a reduction in fatality monitoring. It is expected that the systematic monitoring effort will be scaled back by about 50%. It is also proposed that systematic fatality monitoring after the post two-year intensive sampling period be conducted at the beginning of 5-year bins; years 6, 11 and 16, resulting in a total of 5 years of systematic monitoring during the life of the project (Table 2). SEEF trials and carcass removal trials will be repeated during these years to determine if any of the variables have changed over time (Table 2). All adjustments to direct take will use the most recent estimates from the SEEF and carcass removal trials.

In addition to this reduced monitoring effort, regular rapid assessment (RRA) of each search plot will be conducted in the interim years. This may consist of personnel searching each plot to 75% turbine height on an ATV (all terrain vehicle). The frequency at which the surveys take place will be determined at the conclusion of the carcass removal trials for that 5-year period. SEEF trials will also be conducted to determine the searcher efficiency of the chosen RRA method. All adjustments to direct take found in the interim years will use the estimates from the SEEF and carcass removal trials for that 5-year time period.

The systematic monitoring during the first year of the 5-year period and the subsequent 4-year rapid assessment is designed to inform the Applicant if the take is still occurring at Baseline levels or whether take has moved to a Higher or Lower tier based on 5-year and 20-year take limits outlined in the HCP. Five-year total direct take levels will be determined for each 5-year bin while 20-year total direct take levels will be a cumulative total from the start of project operation.

This long-term sampling regime will be refined by Kahuku Wind Power in consultation with ESRC, USFWS, statisticians and wind energy experts after the initial 2-year intensive sampling period.

Years																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IM1	IM2	RRA	RRA	RRA	SM	RRA	RRA	RRA	RRA	SM	RRA	RRA	RRA	RRA	SM	RRA	RRA	RRA	RRA
SEEF trials	SEEF trials	SEEF trials			SEEF trials	SEEF trials				SEEF trials	SEEF trials				SEEF trials	SEEF trials			
CRT					CRT					CRT					CRT				
1 <sup>st</sup> 5-year bin					2 <sup>nd</sup> 5-year bin					3 <sup>rd</sup> 5-year bin					4 <sup>th</sup> 5-year bin				

IM1 = intensive monitoring for year 1; IM2 = intensive monitoring for year 2; RRA = regular rapid assessment; SM= systematic monitoring  
 CRT= carcass removal trials

Total direct take for 1st 5-year bin = total direct take for IM1 + total direct take for IM2 + total direct take for RRA years

Total direct take for subsequent 5-year bins = total direct take for SM + total direct take for RRA years

**Table 2. Timetable for SEEF and scavenger removal trials and search techniques**

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