Appendix E

Method for Calculating Indirect Take for the Covered Species

Table of Contents

TERMINOLOGY USED IN THIS APPENDIX 1
INTRODUCTION 1
STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN HOARY BAT 2
CALCULATING EXPECTED INDIRECT TAKE ON PROJECTIONS OF FUTURE HAWAIIAN HOARY BAT DIRECT TAKE 4
Auwahi Wind 4
Kaheawa Wind Phase II 6
Kawailoa Wind 6
Pakini Nui Wind 6
Table E-4. Estimation for indirect take of Hawaiian hoary bats at Pakini Nui. 8
STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN GOOSE 9
CALCULATING EXPECTED INDIRECT TAKE ON PROJECTIONS OF FUTURE HAWAIIAN GOOSE DIRECT TAKE 10
Kaheawa Wind Phase II 10
Pakini Nui 10
STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN PETREL 11
Kawailoa Wind 13
Pakini Nui 14
LITERATURE CITED 15

List of Tables

Table E-1. Indirect take forecast for Hawaiian hoary bats at the four wind projects.....4
Table E-2. Indirect take estimate for Hawaiian hoary bat, combined with the new estimated future direct take (observed and unobserved) for the Auwahi HCP Amendment. 5
Table E-3. Variables Used for Calculation of Indirect Take for Hawaiian Hoary Bat at Kawailoa Wind.....7
Table E-4. Estimation for indirect take of Hawaiian hoary bats at Pakini Nui.....8
Table E-5. Calculation of indirect take of Hawaiian goose.....9
Table E-6. Indirect take forecast for Hawaiian goose at the two wind projects. 10
Table E-7. Variables used for calculation of indirect take of Hawaiian petrel. 12
Table E-8. Calculations for probability of indirect take of Hawaiian petrel. 12
Table E-9. Indirect take forecast for Hawaiian petrel at the two wind projects. 12
Table E-10. Variables for calculation of indirect take for Hawaiian petrel at Kawailoa Wind. 13
Table E-11. Calculation of Indirect Take for Hawaiian Petrel at Pakini Nui.....14

TERMINOLOGY USED IN THIS APPENDIX

Direct observed take. This refers to the number of fatalities (carcasses) found during fatality searches of a given species. This number is a known number entered into the model for each project and period.

Direct unobserved take. This represents the number of fatalities that *may* have occurred but that may have been missed or removed without being observed. It is an output of the model and should not be interpreted as the known number of unobserved fatalities that occurred.

Total direct take. The total of direct observed take plus direct unobserved take. The model provides a range of numbers inferred by the 1) number of observed fatalities and, 2) the imperfect detection. Each number in that output range has two associated probabilities; one that represents the probability that that number is the actual direct take, and the second is the probability that the number has not been exceeded.

Indirect take. This represents the *assumed* loss of a dependent young of the fatality.

Total take. This represents the sum total of the total direct take plus the total indirect take. Note that this does not represent the actual known total take. It is a value that the Service is confident has not been exceeded given imperfect detection. This is the value used for measuring compliance. Total take should always be stated as "we are X% confident that X total take has *not* been exceeded.

Credibility or assurance level. In reference to the Evidence of Absence modeling software, this represents the probability that an associated value has not been exceeded. The Service is conservative on the side of the species and uses the model output at the 80% credibility level.

INTRODUCTION

The fatality of an adult of a species during that individuals breeding season could result in the loss of dependent young. This potential loss is called indirect take because the death of the parent indirectly could cause the loss of the dependent young. It is rarely known if a fatality had dependent young at the time of death. For the purposes of indirect take assessment we need to determine the probability that adult fatalities taken during the breeding season period in which young were dependent, had dependent offspring. The criteria used to determine when indirect take should be applied to an adult of a species taken during the breeding season includes the age of the fatality, sex of the fatality, predicted activity during the time of take; number of offspring, and amount of parental contribution provided by the fatality.

Parental contribution differs between species. In the case of the Hawaiian hoary bat or ʻōpeʻapeʻa, indirect take is assessed on the total direct take of females taken during the breeding season using a standardized formula. In the case of Hawaiian goose or Hawaiian petrel, it is assessed for the observed take of female or male during the breeding season because it is assumed that both sexes contribute equally to the rearing of the dependent young. Indirect take is not an output of the model but is calculated separately and added to the total direct take based on the model's output value at the 80% credibility level.

STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN HOARY BAT

In June 2016, the wildlife agencies discussed the possibility for standardizing the incidental take calculations for Hawaiian hoary bat for projects that have incidental take permits or incidental take licenses. As a result of that discussion we recommended that permittees and their consultants consider using the following time periods and biological factors in their calculation of indirect take for observed Hawaiian hoary bat fatalities and for indirect take of unobserved Hawaiian hoary bats.

Calculation of observed and unobserved take will continue to be conducted with the Evidence of Absence ver 2.0.6+ software (Dalthorp and Huso 2014; Dalthorp et al. 2015). The 80% credibility output will be used as a *general* guide for what the agencies are 80% assured has not been exceeded. This output plus the indirect take converted to adult bats will represent total take that we are 80% certain has not been exceeded. This total take at the 80% credibility level will also be used as the value to guide the triggering of the next tier level. The next tier level shall be triggered when 75% of the estimated take of the existing tier is reached or exceeded based on the output at the 80% credibility level plus indirect take.

Female Hawaiian hoary bats may be pregnant or supporting dependent young from April 15 through September 15 (Tomich 1986ab; Menard 2001; Uyehara and Wiles 2009; C. Pinzari, pers. comm. 2015). This is based on best science for the Hawaiian hoary bats or North American hoary bat surrogates and information in our files. The wildlife agencies understand that exceptions to this range can occur. However, the need to be conservative on the side of the species is primary. Second, the use of lactation to determine whether or not a female has dependent pups has been challenging, given the condition of the carcasses that are found. Thus, for these reasons, the Service recommends using April 15 through September 15 as a period in which a female bat taken may have been pregnant or lactating and will result in indirect take assessment on the direct take during this time period. This range would apply to all female observed carcasses. The USGS has been authorized to conduct genetic testing on samples from the fatalities so that the sex of all fatalities found can be determined (Pinzari and Bonaccorso, 2018). The final resting place of the majority of the remains is the Bishop Museum, Honolulu, Hawai‘i.

The average number of pups attributed to a female that survive to weaning is assumed to be 1.8 which is based on Bogan, 1972 and Koehler and Barclay, 2000. The sex ratio of bats taken through unobserved direct take will be assumed to be 50% female, until the sex can be determined through genetic testing by the USGS. Sex determination based on observation has been shown to under-represent females, so all fatalities are to be sampled and sex determined with DNA testing.

The assessment of indirect take to a modeled unobserved direct bat take accounts for the fact that we do not know when the unobserved fatality may have occurred. The period of time from pregnancy to end of pup dependency for any individual bat is estimated to be 3 months. Thus the probability of taking a female bat that is pregnant or has dependent young is 25%, or 0.25.

The conversion of juveniles to adults has generally been 1 juvenile to 0.3 adults, though it has varied slightly from project to project in the past. Because we lack survival and mortality information for the Hawaiian hoary bat, the conversion of juvenile to adult equivalency is based on the estimated survival of the little brown bat (*Myotis lucifugus*) which is known and ranges from 20-48% (Humphrey & Cope 1976). The Service recognizes that this is a less than ideal surrogate for estimating Hawaiian hoary bat survival of a weaned pup to adult, but we have little other scientific evidence to base survival on, until it is established for the Hawaiian hoary bat. Thus, indirect take will be converted from juvenile to adult equivalency uses the 0.3 conversion.

Based on the rationale presented above, the wildlife agencies recommend estimated total take be calculated as follows:

Observed and Unobserved direct take should be calculated with Evidence of Absence ver 2.0.6 or better and the output at 80% credibility used as a basis for calculating indirect take.
Indirect take assessed for females taken between April 15 and September 15 shall be calculated as follows:

> The number of observed female bats taken between April 15 and September 15 x the average number of pups estimated at 1.8
>
> Indirect take assessed for observed males taken at any time or females taken from September 16 through April 14 would be 0.

Indirect take assessed for unobserved take shall be calculated as follows:

> The estimated number of unobserved bats taken x the proportion of unobserved take that is female, which is assumed to be 0.50 (until determined genetically) x the proportion of the calendar year in which a female may be pregnant or have dependent young which is 0.25 x the average number of pups estimated at 1.8.

To convert the indirect (juvenile) take to adults:

> (Total indirect take based on observed take + Total indirect take based on unobserved take) x the conversion of juveniles to adults, 0.30.

Example using the equations above:
Observed take 5 bats. Assume Evidence of Absence output at 80% for the 5 observed bats is 13. This means 8 unobserved bats.
Indirect take
2 of the observed bats were females taken between April 1 and September 15: 2 x 1.8 = 3.6
1 of the observed bats was a female taken between September 16 and March 31: 0
2 of the observed bats were males: 0
We assume 4 of the 8 unobserved bats taken were female: 4 x 0.25 x 1.8 = 1.8
Total indirect take of juveniles 3.6 + 0 + 0 + 1.8 = 5.4
Conversion of juveniles to adults 5.4 x 0.3 = 1.62
Total take based on 80% credibility basis: 13 +1.6 = 14.6 rounded up to 15 bats.

CALCULATING EXPECTED INDIRECT TAKE ON PROJECTIONS OF FUTURE HAWAIIAN HOARY BAT DIRECT TAKE

The formulas described above are used for take tracking and compliance monitoring. The amount of indirect take assessed is based on the number of observed and unobserved carcasses. In other words, we know how many carcasses have been observed and the model provides a range of values for the amount of unobserved take. Calculating the indirect take applicable to a projection of future take is conducted in a slightly different manner because we do not know exactly how many observed take we will have in the future. The general formula used for estimating indirect take on projections uses a value of 0.0675 which is derived from the proportion of direct take assumed to have dependent young * the portion of the future take expected to be female * the number of pups per female * the proportion of pups surviving to adulthood. It is applied as follows:

> (Projected direct take – current total take) * 0.25 (the proportion of direct take assumed to have dependent young) * 0.5 (the proportion of the future take expected to be female) * 1.8 (estimated pups per female) * 0.3 (proportion of pups surviving to adulthood) = indirect take amount estimated for future fatalities.

Slight variations in the calculations occurs between projects depending on the amount of current take and existing indirect take that applies to the observed take. The estimated indirect take each project is shown below (Table E-1). The specific breakdown of each projects' indirect take request is provided for each project in the sections that follow (Tables E-2, E-3, E-4).

Table E-1. Indirect take forecast for Hawaiian hoary bats at the four wind projects.

Project	Projected direct take	Estimated Indirect take
Auwahi	129	11
Kawailoa	246	19
Kaheawa Wind Phase II	36	2
Pakini Nui	23	3

Auwahi Wind

The indirect take estimate for Hawaiian hoary bat on the projected future take is shown in Table E-2. The Table shown is adapted from the Auwahi Wind HCP Amendment (Tetra Tech 2018).

Table E-2. Indirect take estimate for Hawaiian hoary bat, combined with the new estimated future direct take (observed and unobserved) for the Auwahi HCP Amendment.

Component	Calculation of Count	Number of Bats	Calculation of Indirect Take[1]	Indirect Take Assessment
Observed[2] male fatalities, or observed fatalities outside the breeding season	Observed	8	No impact to dependent young, multiply by 0	0
Observed[2] female fatalities within the breeding season	Observed	2	Multiply by estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.08
Observed[2] fatalities of unknown sex within the breeding season	Observed	6	Multiply by proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.62
Unobserved fatalities	38 estimated at 80% CI using EoA[3] minus 16 observed	22	Multiply by proportion of the population assumed to be taken with dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.49
Future direct take (unobserved)	129 predicted at the 80% CI using EoA[3] minus 38 current take estimated at the 80% CI	91	Multiply by proportion of the population assumed to be taken with dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	6.14
Future Indirect take	Sum the indirect take assessment for line numbers 1-5, rounded up to the nearest whole number	11	Sum the indirect take assessment for line numbers 1-5, rounded up to the nearest whole number	11
Total take estimated at the 80% CI	Sum the count for line numbers 1-6	**140[5]**		

1. Calculations based on USFWS Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take, unless otherwise noted.
2. Observed take counts only those fatalities observed during systematic monitoring. Carcasses found incidentally are accounted for through Evidence of Absence modelling.
3. Dalthorp et al. 2017.4. Calculations of future indirect take are based on USFWS guidance and actual estimates of indirect take will depend on the timing and gender of observed fatalities
5. The total take estimate includes 21 bats authorized under the approved HCP and 119 additional bats requested in the HCP Amendment.

Kaheawa Wind Phase II

Based on the three observed Hawaiian hoary bat fatalities, the estimated direct take at the 80% credibility level as of June 2018 was 12 bats. Base on the outputs of Evidence of Absence Model ver 2.0.6 (Huso *et al.* 2015, Dalthorp *et al.* 2017) the estimated 20-year (Tier 4) total direct take is no more than 35.2 bats with 80% credibility. The unobserved direct take not yet accrued for the remaining years estimated to be 23.2 bats (35.2 – 12 = 23.2).

Estimating Indirect Take

All three fatalities, two males and one of unknown sex, were documented at KWP II during the non-breeding season (April 1 through September 15) in February, March, and November, therefore, no indirect take (i.e., consideration of potential lost offspring) was assessed for the previously observed fatalities. For the purposes of estimating indirect take for the 20-year permit term the 32.2 of the 35.2 projected estimated direct take for the 20-year permit are considered unobserved direct take (35.2 total estimated direct take – 3 observed to date = 32.2 unobserved take). Indirect take is assessed to bats lost through unobserved direct take at the rate of 0.225 juvenile/bat. Based on these calculations, an indirect take totaling 7.25 juveniles (32.2 x 0.225 = 7.25), is estimated. For purposes of indirect take, juvenile bats are converted to adults based on a 30% survival rate of juvenile to adult. Hawaiian hoary bats are considered mature one year after their birth. This converts the total indirect take of 7.25 juveniles to 2.17 adults.

Adding these 2.17 adults to the estimated total direct take of 35.2 bats, results in an estimated total adjusted take of 37.4 adult bats for the 20-year permit period or 38 adult bats rounded up.

Kawailoa Wind

The indirect take estimate for Hawaiian hoary bat on the projected future take is shown in Table E-3. The Table shown is adapted from the Kawailoa Wind HCP Amendment (Tetra Tech 2018).

Pakini Nui Wind

The indirect take estimate for Hawaiian hoary bat on the projected future take is shown in Table E-4. The Table shown is adapted from the Pakini Nui Wind HCP Amendment (SWCA 2018).

Table E-3. Variables Used for Calculation of Indirect Take for Hawaiian Hoary Bat at Kawailoa Wind.

Component	Calculation of Count	Number of Bats	Calculation[1]	Indirect Take Assessment in Adult Equivalents
Observed males, or individuals outside the breeding season	Observed	19	No impact to dependent young, multiply by 0	0
Observed females within the breeding season	Observed	2	Estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	1.08
Observed unknown within the breeding season	Observed	11	Proportion of population assumed to be female 0.5* estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	2.97
Unobserved estimated by Evidence of Absence	62 estimated at 80% CI estimated by EoA[2] – 32 observed	30	Proportion of the year females are assumed to have dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	2.03
Future take (unobserved)	246 estimated total take at the 80% CI[2]- 62 current take estimated at the 80% CI[2]	184	Proportion of the year females are assumed to have dependent young 0.25 * proportion of population assumed to be female 0.5 * estimated reproductive rate 1.8 * proportion of offspring surviving to adulthood 0.3	12.42
Indirect take	Sum the indirect take assessment for lines 1-5, rounded up to the nearest whole number	19	Sum the indirect take assessment for Lines 1-5, rounded up to the nearest whole number	19
Total take estimated at the 80% CI	Sum the count for lines 1-6	265		

[1] Calculations based on USFWS guidance for calculation of Hawaiian hoary bat indirect take. The actual estimation of indirect take will depend on the timing and gender of observed fatalities.

[2] Output based on projections of future take from Evidence of Absence (Dalthorp et al. 2017).

Table E-4. Estimation for indirect take of Hawaiian hoary bats at Pakini Nui.

Component	Description/Rationale	Result
A. Total direct take requested	Estimated total direct take	23
B. Proportion of take that is adult	Erring toward a conservative estimate, it is assumed that 100% of take (observed and unobserved) will be adult individuals, despite the opportunity for first-year juveniles to pass through the Project Area.	1.00
C. Proportion of take that is female	Hawaiian hoary bats are assumed to have a ratio of 1:1. Furthermore, it is assumed there is no sex-based bias for differential susceptibility for fatal interaction with turbines. Therefore, approximately 50% of bats are assumed to be females.	0.50
D. Proportion of year that is the pupping period (24 of 52 weeks)	Adults are present in the Project Area throughout the year, but the pupping season is recorded as occurring from April to September 15, or 24 weeks. Indirect take of an offspring can only occur from direct take of an adult during these months.	0.46
E. Proportion of breeding adults taken with dependent young	Juvenile bats are completely dependent on females until they are weaned and therefore their survival depends on the mother bat's ability to provide care. Therefore, all direct take of females with young during the pupping season results in the offspring's indirect take.	1.00
F. Average offspring/breeding pair	Reproductive success is based on Bogan (1972) and Koehler and Barclay (2000)	1.8
G. Conversion of juveniles to adults	Juveniles are converted to adults by multiplying by 0.3, which is in accordance with the *Wildlife agency guidance for calculation of Hawaiian hoary bat indirect take* (USFWS 2016).	0.3
H. Total indirect take	Indirect take is estimated by multiplying the probabilities of lines A–G. This estimate is rounded up to the nearest whole number.	3

STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN GOOSE

Calculation of observed and unobserved take will continue to be conducted with the Evidence of Absence ver 2.0.6+ software (Dalthorp and Huso 2014; Dalthorp et al. 2015). The 80% credibility output will be used as a *general* guide for what the agencies are 80% assured has not been exceeded. This output plus the indirect take converted to adult Hawaiian goose will represent total take that we are 80% certain has not been exceeded. This total take at the 80% credibility level will also be used as the value to guide the triggering of the next tier level. The next tier level shall be triggered when 75% of the estimated take of the existing tier is reached or exceeded based on the output at the 80% credibility level plus indirect take.

Indirect take to account for loss of dependent young is assessed for adult Hawaiian goose only when mortality occurs during the breeding season which is August through April (Table E-5). Adults found during the months of October through March are assumed to have had a 60% chance of having been actively breeding because 60% of the population has been recorded to breed in any given year (Banko *et al.* 1999). Adult Hawaiian goose fatalities that occur in April, August or September are assumed to have had a 25% chance of breeding.

Male and female Hawaiian goose equally contribute to the care for their young (Table E-5). Thus, indirect take is assessed to the direct take of any male or female adult Hawaiian goose found during the breeding season. The number of young possibly affected by loss of an adult is based on the average number of fledglings produced per pair. The average number of fledglings produced annually per pair of Hawaiian goose is 0.3 (Hu 1998).

Based on these assumptions, the amount of indirect take that is assessed for each direct take of an adult Hawaiian goose during the months of October through March is 0.09. The amount of indirect take assessed for each direct take of an adult Hawaiian goose during the remainder of the breeding season is 0.04 (Table E-5).

Table E-5. Calculation of indirect take of Hawaiian goose.

Hawaiian goose	Season	Number of fledglings per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect (A*B*C)
Adult, any gender	Oct-Mar	0.3	0.6	0.5	0.09
Adult, any gender	Apr, Aug and Sep	0.3	0.25	0.5	0.04
Adult, any gender	May-Jul		0		0
Immature	All year		0		0

CALCULATING EXPECTED INDIRECT TAKE ON PROJECTIONS OF FUTURE HAWAIIAN GOOSE DIRECT TAKE

The formulas described above are used for take tracking and compliance monitoring. The amount of indirect take assessed is based on the number of observed and unobserved carcasses. Calculating the indirect take applicable to a projection of future take is conducted in a slightly different manner because we do not know exactly how many observed take we will have in the future. The general formula used for estimating indirect take on projections uses a value of 0.06. The formula assumes a Hawaiian goose could fly through the project any time of year. Based on breeding period of 4.5 months (a one-month incubation period followed by parental care for 3.5 months) the chance of an unobserved take during breeding is 4.5/12 = 0.375. Thus, 0.375 (proportion of time a nene is breeding)*0.3 (number of fledglings per pair)*0.50 (proportion of parental contribution) = 0.0563, rounded to 0.06. Total take and associated indirect take for Hawaiian goose for Kaheawa Wind and Pakini Nui are shown in Table E-6.

Kaheawa Wind Phase II

As of June 1, 2018, five Hawaiian goose mortalities have been documented within the search area at KWP II. These were observed on April 22, 2014; December 22, 2014; February 23, 2015; October 13, 2015, and February 6, 2018. Indirect take for the five observed take is assessed to be 0.31 fledglings (0.09 + 0.04 + 0.09 + 0.09 + 0.09 = 0.40). Projections based on these findings using the Evidence of Absence Model (versions 1.0 and 2.0; Huso *et al.* 2015, Dalthorp *et al.* 2017) results in a 20-year expected total direct take of not more than 42.3 adults with 80% credibility level. For the purposes of estimating indirect take the projection, we take the projection of 42.3 – 5 observed fatalities that have already occurred = 37.3. Then 37.3 * 0.06 (indirect take rate for unobserved) = 2.24 fledglings. Adding the indirect take of 0.40 fledglings from observed fatalities, the total fledglings indirectly taken is projected to be 2.64 fledglings.

Hawaiian goose mature at age two for males and age three for females and an annual survival rate is estimated to be 80%. One fledgling is thus the equivalent of 0.64 adults (1 * 0.8 * 0.8 = 0.64). Assuming all fledglings mature at age two and an annual survival rate of 80% for two years, 2.64 fledglings would be expected to yield 1.69 adults after two years (2.64* 0.64 = 1.69). The addition of indirect take to the expected total direct take of 42.26 individuals results in a total adjusted take with 80% credibility of no more than 44 adult Hawaiian goose (Table E-6).

Pakini Nui

For purposes of HCP, it is assumed that all birds taken, including unobserved take, will be adults. The direct take requested in 2 adults. Indirect take on unobserved direct take is 2.0 * 0.06 = 0.12 fledglings, rounded up to 1. Total take requested is 3 Hawaiian goose (Table E-6).

Table E-6. Indirect take forecast for Hawaiian goose at the two wind projects.

Project	Projected direct take	Estimated Indirect take
Kaheawa Wind Phase II	42	2
Pakini Nui	2	1

STANDARDIZED CALCULATION OF INDIRECT TAKE FOR HAWAIIAN PETREL

Calculation of observed and unobserved take will continue to be conducted with the Evidence of Absence ver 2.0.6+ software (Dalthorp and Huso 2014; Dalthorp et al. 2015). The 80% credibility output will be used as a *general* guide for what the agencies are 80% assured has not been exceeded. This output plus the indirect take converted to adult Hawaiian goose will represent total take that we are 80% certain has not been exceeded. This total take at the 80% credibility level will also be used as the value to guide the triggering of the next tier level. The next tier level shall be triggered when 75% of the estimated take of the existing tier is reached or exceeded based on the output at the 80% credibility level plus indirect take.

The incidental take of a Hawaiian petrel during the breeding season may result in the indirect loss or take of a dependent chick. Several variables are used in the assessment of indirect take (Table E-7). The age of the petrel at the time of fatality is one such consideration. If the petrel is newly fledged, the individuals' fatality is accounted for with direct take, but no indirect take is assessed because it would not have had a dependent egg or offspring. If it is not a fledgling, the petrel is considered adult. No distinction is made as to whether the bird is reproductively mature or not for the purposes of assessing indirect take. Another consideration is the time of year the fatality occurred and what type of activity characterizes that period. March-April is characterized predominantly by prospecting and exploring the colony, May-August 89% of the adults present are considering to be breeding, and the offspring is 100% dependent on both parents, by September only breeding petrels remain, by October the chick is considered dependent on only one parent (Simons and Hodges 1998). The remaining considerations include the likelihood that a given adult is reproductively active, the likelihood that the loss of a reproductively active adult results in the loss of its chick, and the average reproductive success (Table E-7).

Based on the assumptions described in Table E-7, there is an 89% probability that a male or female adult Hawaiian petrel fatality observed between May through August has a dependent chick and therefore is assessed the in direct take of 1, after rounding. There is a 100% chance that a male or female Hawaiian petrel fatality observed in September has a dependent chick and the indirect take assessed is 1. There is a 50% chance that a male or female fatality taken in October has a dependent chick, but the chick would likely be able to survive under the assumptions used to model the indirect take. (Table E-8)

Total take and associated indirect take for Hawaiian petrel at Kawailoa Wind and Pakini Nui are shown in Table E-9. Project specific calculations for Kawailoa Wind are shown in Table E-10. Project specific calculations for Pakini Nui are shown in Table E-11.

Table E-7. Variables used for calculation of indirect take of Hawaiian petrel.

Component	Rationale/Description	Parameter
	The impact of the loss of a single parent on a dependent chick varies within the breeding season (Simons and Hodges 1998).	
Proportion of parental contribution to dependent young	May to September, both parents are deemed critical to chick survival. Necessary for chick survival	1.0
	October, the chick is no longer dependent on both parents (100 percent breeding * 1 chick/pair * 50 percent parental contribution).	0.50
Proportion of breeding adults	May-August, only 89 percent of adults are breeding (89 percent breeding * 1 chick/pair * 100% parental contribution).	0.89
	By September, only reproductively active adults are present on the colony (100 percent breeding * 1 chick/pair * 100 percent parental contribution).	1.00
Reproductive success (average chicks/pair)	Average reproductive success for petrels on Maui (Simons and Hodges 1998).	0.63

Table E-8. Calculations for probability of indirect take of Hawaiian petrel.

Hawaiian petrel	Season	Number of fledglings per pair (A)	Likelihood of breeding (B)	Parental contribution (C)	Indirect (A*B*C)
Adult, any gender	May-Aug	1.0	0.89	1.0	0.89
Adult, any gender	Sep	1.0	1.0	1.0	1.0
Adult, any gender	Oct	1.0	1.0	0.5	0.5
Immature	All year		0		0

Table E-9. Indirect take forecast for Hawaiian petrel at the two wind projects.

Project	Projected direct take	Estimated Indirect take
Kawailoa	19	5
Pakini Nui	2	1

Kawailoa Wind

Calculation of the indirect take associated with the projected direct take of 19 Hawaiian petrels is shown in Table E-8. Indirect take of petrels associated with the projected take is estimated to be 0.95 petrels per year (Table E-8). Thus, over the remainder of the permit term, the total indirect take is calculated as 14 years * 0.34 chicks/year = 5 chicks (4.76 rounded upward) (Table E-10).

Table E-10. Variables for calculation of indirect take for Hawaiian petrel at Kawailoa Wind. Adapted from the Kawailoa draft HCP amendment.

Component	Supporting Evidence or Rationale	Parameter
A. Annual Direct Take (adults/year)	Annual direct take as estimated from Evidence of Absence (19 predicted over 20 years).	0.95
B. Proportion of take that is adult	Conservative assumption that 100 percent of direct take was of adult birds.	1.00
C. Proportion of "year" that is breeding period (6 of 8 months)	Although adult birds may be present at a breeding colony over an 8-month period (March-October), only six of these months (May – October) represent the breeding period (Simons and Hodges 1998).	0.75
D. Proportion of adults that breed	The proportion of adults attending the breeding colony that attempt to breed in a given year (Simons and Hodges 1998).	0.89
E. Proportion of taken breeding adults with dependent young	The impact of the loss of a single parent on a dependent chick varies within the breeding season: • During May to September, both parents are deemed critical to chick survival. • During May-August, only 89 percent of adults are breeding (89 percent breeding * 1 chick/pair * 100% parental contribution). • By September, only reproductively active adults are present on the colony (100 percent breeding * 1 chick/pair * 100 percent parental contribution). • In October, the chick is no longer dependent on both parents (100 percent breeding * 1 chick/pair * 50 percent parental contribution). The proportion of taken breeding adults with dependent young was calculated as: ((0.89*1*1*4 months) + (1.00*1*1*1 month) + (0.5*1*1*1 month))/6 months = 0.84.	0.84
F. Reproductive success (average chicks/pair)	Average reproductive success for petrels on Maui (Simons and Hodges 1998).	0.63
G. Annual Indirect Take (chicks/year)	Multiply Lines A through F.	0.34
H. Total Indirect Take (chicks)	Multiply Line G by 14 years and round up to nearest integer.	5
I. Total take estimated at the 80% confidence interval	Sum of total direct take as estimated from Evidence of Absence (19 adults) and total indirect take from Line H.	**24**

Pakini Nui

The 10-year fatality estimate of Hawaiian petrels at Pakini Nui is between 0.0437 and 0.2187, for 99% and 95% avoidance rates, respectively. Therefore, it is unlikely that a fatality will be detected during 8 years of operation and 2 years of decommissioning. However, to cover for the stochastic event of an incidental take of Hawaiian petrels, and allowing for unobserved direct take, the requested take is based on the direct take of two Hawaiian petrels. The indirect take is one egg/chick; therefore, the total requested take is three Hawaiian petrels. Calculations used are shown in Table E-11.

Table E-11. Calculation of Indirect Take for Hawaiian Petrel at Pakini Nui. Adapted from the Pakini Nui draft HCP.

Hawaiian Petrel	Season	Average No. of Chicks per Pair (A)	Likelihood of Breeding (B)	Parental Contribution (C)	Indirect Take (A × B × C)
Adult	March–April	–	0.00	–	0
Adult	May–July	1	0.89	1.0	0.89 egg
Adult	August	1	0.66	1.0	0.66 chick
Adult	September	1	1.00	1.0	1.00 chick
Adult	October	1	1.00	0.5	0.50 chick
Adult	November–April	–	0.00	–	0
Immature	All year	–	0.00	–	0

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