Alamitos Generating Station

Appendix C

Model Parameterization

C1. Estimating Total Entrainment

C2. Estimating Proportional Entrainment
and the ETM Calculations

C3. Demographic Model Calculations

Appendix C1
Estimating Total Entrainment

The following section describes calculations used for assessing entrainment effects at the Alamitos Generating Station (AGS). The equations are presented in a general form that is applicable to sample designs that may have differing numbers of stations, sampling periods, or replicates. The AGS entrainment study will sample two stations. While the summation signs over stations are presented in the equations they will be summing over an n of one in the actual calculations and therefore will drop out of the formulas.

A general form can be written for summing entrainment over stations at an intake or entrainment site using cycles within a day and days within time periods. Let

i = period $\left(i = 1, \ldots, N\right)$;

j = day within period $\left(j = 1, \ldots, N_i\right)$;

k = cycle within day $\left(k = 1, \ldots, N_{ij}\right)$;

l = station $\left(l = 1, \ldots, N_{ijk}\right)$;

m = volume at station within cycle $\left(m = 1, \ldots, N_{ijkl}\right)$.

The total larval entrainment at an intake source can be expressed as

$$E_T = \sum_{i=1}^{N} \sum_{j=1}^{N_i} \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \rho_{ijkl} V_{ijkl} \tag{A1}$$

where

ρ_{ijkl} = density of larvae at the lth station within the kth cycle on the jth day in the ith time period;

V_{ijkl} = volume of water passing the at the lth station within the kth cycle on the jth day in the ith time period.

This summation assumes that stations represent the total intake volume of the power plant. It also assumes that the larval density in the volume of water passing a station is constant over time and space over any cycle. An estimate of the total larval entrainment can be made by taking n_{ijkl} samples of the N_{ijkl} volumes passing a station as

$$\hat{E}_T = \sum_{i=1}^{N} \sum_{j=1}^{N_i} \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \frac{V_{ijkl}}{n_{ijkl}} \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \qquad \text{(A2)}$$

If we also assume that entrainment volume is constant and the same at all stations then

$$\hat{E}_T = \sum_{i=1}^{N} V_{ijkl} \sum_{j=1}^{N_i} \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \frac{1}{n_{ijkl}} \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \qquad \text{(A3)}$$

Strata will be defined as the stations and cycles with constant N_{ij} and N_{ijk}. In addition, we sample n_i days of the N_i possible during a period so that

$$\begin{aligned} \hat{E}_T &= \sum_{i=1}^{N} N_i N_{ij} N_{ijk} V_{ijkl} \frac{1}{n_i} \sum_{j=1}^{n_i} \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk} n_{ijkl}} \right) \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \\ &= \sum_{i=1}^{N} V_i \frac{1}{n_i} \sum_{j=1}^{n_i} \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk} n_{ijkl}} \right) \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \end{aligned} \qquad \text{(A4)}$$

where

$$V_i = \sum_{j=1}^{N_i} \sum_{l=1}^{N_{ij}} \sum_{k=1}^{N_{ijk}} V_{ijkl}$$

If only one day per period is sampled Equation A4 can be expressed as

$$\begin{aligned} \hat{E}_T &= \sum_{i=1}^{N} V_i \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk} n_{ijkl}} \right) \sum_{m=1}^{n_{ijkl}} \rho_{ijklm} \\ &= \sum_{i=1}^{N} V_i \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk}} \right) \hat{\rho}_{ijkl} \end{aligned} \qquad \text{(A5)}$$

with estimated variance

$$\widehat{Var}\left(\hat{E}_T\right) = \sum_{i=1}^{N} V_i^2 \sum_{k=1}^{N_{ij}} \sum_{l=1}^{N_{ijk}} \left(\frac{1}{N_{ij} N_{ijk}} \right)^2 \left(1 - \frac{n_{ijkl}}{N_{ijkl}} \right) \frac{\widehat{Var}\left(\rho_{ijkl}\right)}{n_{ijkl}} \qquad \text{(A6)}$$

where

$$\widehat{Var}\left(\rho_{ijkl}\right)=\frac{\sum_{m=1}^{n_{ijkl}}\left(\rho_{ijklm}-\hat{\bar{\rho}}_{ijkl}\right)^2}{\left(n_{ijkl}-1\right)};$$

$$\hat{\bar{\rho}}_{ijkl}=\frac{\sum_{m=1}^{n_{ijkl}}\rho_{ijklm}}{n_{ijkl}}.$$

Estimates of E_T based on Equation A5 will be used in *FH* and *AEL* calculations to estimate annual effects of entrainment on fishes and invertebrates. Equation A6 will underestimate the true variance because it does not include within-period variance. In practice, we ignore the finite population correction, $\left(1-\frac{n_{ijkl}}{N_{ijkl}}\right)$ because N_{ijkl} is large. Estimators similar to Equation A5 and Equation A6 are used for calculating survey period estimates of intake and source populations for use in ETM calculations.

Appendix C2
Estimating Proportional Entrainment and the *ETM* Calculations

The empirical transport model (*ETM*) is used to estimate the total mortality probability for larvae from power plant entrainment. The estimate is based on periodic estimates of the probability of entrainment mortality based on daily samples. In the following calculations we assume all larvae entrained die. Generally, sampling takes place over the course of a year so that larval mortality of various species is estimated.

The daily probability of entrainment can be defined as

$$PE_i = \frac{\text{abundance of entrained larvae}_\text{i}}{\text{abundance of larvae in source population}_\text{i}}$$
$$= \text{probability of entrainment in } i\text{th time period } \left(i = 1,\ldots,N\right).$$

In turn, the daily probability can be estimated and expressed as

$$PE_i = \frac{\widehat{E_i}}{\widehat{R_i}} \tag{B1}$$

where

$\widehat{E_i}$ = estimated abundance of larvae entrained in the ith time period $\left(i = 1,\ldots,N\right)$;

$\widehat{R_i}$ = estimated abundance of larvae at risk of entrainment from the source population in the ith time period $\left(i = 1,\ldots,N\right)$.

Estimating Daily Entrainment

The estimate of total Alamitos Generating Station (AGS) entrainment on day j in period *i* can be expressed from equation (A4) as

$$\widehat{E_{ij}} = \sum_{k=1}^{4}\sum_{l=1}^{1} V_{ijkl}\frac{1}{3}\sum_{m=1}^{3}\rho_{ijklm} \\ = V_{ij}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{12}\right)\sum_{m=1}^{3}\rho_{ijklm} \tag{B2}$$

with associated variance

$$Var\left(\widehat{E_{ij}} \middle| E_{ij}\right) = V_{ij}^{\ 2}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{12}\right)^2\left(1-\frac{3}{N_{ijkl}}\right)S_{\rho_{ijkl}}^2 \tag{B3}$$

which can be estimated by

$$\widehat{Var}\left(\widehat{E_{ij}}\right) = V_{ij}^{\ 2}\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{12}\right)^2\left(1-\frac{3}{N_{ijkl}}\right)s_{\rho_{ijkl}}^2 \ . \tag{B4}$$

The finite population correction [i.e., $\left(1-\frac{3}{N_{ijk}}\right)$] can be ignored because N_{ijkl} is exceedingly large. Only one day is sampled per period. The period estimated entrainment and variance are

$$\widehat{E_i} = V_i\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{12}\right)\sum_{m=1}^{3}\rho_{ijklm} \tag{B5}$$

$$\widehat{Var}\left(\widehat{E_i}\right) = V_i^2\sum_{k=1}^{4}\sum_{l=1}^{1}\left(\frac{1}{12}\right)^2 s_{\rho_{ijkl}}^2 \ . \tag{B6}$$

Estimating Numbers of Larvae at Risk

With the defined and agreed-upon sources of Alamitos Bay (S) larvae, the daily abundance of larvae at risk can be estimated by

$$\widehat{R_{ij}} = V_S \cdot \widehat{\bar{\rho}_{S_{ij}}} \tag{B7}$$

where V_S denotes daily exchanged and static volumes at Alamitos Bay (S), and $\widehat{\bar{\rho}}$ denotes an estimate of average density in each respective source water bodies. The variance of Expression B7 can be written as

$$Var\left(\widehat{R_{ij}} \mid R_{ij}\right) = V_S^2 \cdot Var\left(\widehat{\bar{\rho}_{S_{ij}}} \mid \bar{\rho}_{S_{ij}}\right) \tag{B8}$$

The individual variances within Formula B8 describe temporal-spatial variance in density within the source population during the day of sampling. Nine source water locations are sampled in Alamitos Bay and San Pedro Bay. Ideally, tow samples would be collected randomly through time and space during a sampling day over a potential source population. However, practical limitations due to sampling a large area required a directed and fixed time and location sampling scheme. Our source water estimates of population and variance are made for each period using only one day, i.e. $\widehat{R_i} = \widehat{R_{ij}}$ and $\widehat{Var}\left(\widehat{R_i}\right) = Var\left(\widehat{R_{ij}} \mid R_{ij}\right)$.

Period Entrainment and *ETM* Calculations

By dividing estimated period entrainment (B5) by the corresponding source population (B7) an estimate of entrainment mortality can be written as

$$\widehat{PE}_i = \frac{\widehat{E_i}}{\widehat{R_i}} \tag{B9}$$

Variance for the Estimate of PE_i

The variance for the period estimate of $\widehat{PE_i}$ can be expressed as

$$Var\left(\widehat{PE_i}\middle| PE_i\right) = Var\left(\frac{\widehat{E_i}}{\widehat{R_{ij}}}\middle| E_i, R_i\right).$$

Assuming zero covariance between the entrainment and source and using the delta method (Seber 1982), the variance of an estimator formed from a quotient (like $\widehat{PE_i}$) can be effectively approximated by

$$Var\left(\frac{A}{B}\right) \approx Var(A)\left(\frac{\partial\left[\frac{A}{B}\right]}{\partial A}\right)^2 + Var(B)\left(\frac{\partial\left[\frac{A}{B}\right]}{\partial B}\right)^2.$$

The delta method approximation of $Var(\widehat{PE_i})$ is shown as

$$Var\left(\widehat{PE_i}\right) = Var\left(\frac{\widehat{E_i}}{V_S \cdot \widehat{\rho_{S_i}}}\right)$$

where by the Delta method can be approximated by

$$\widehat{Var}\left(\widehat{PE_i}\right) \approx \widehat{Var}\left(\widehat{E_i}\right)\left(\frac{1}{V_S \cdot \widehat{\overline{\rho}_{S_i}}}\right)^2 + \widehat{Var}\left(V_S \cdot \overline{\rho}_{S_i}\right)\left(\frac{-\widehat{E_i}}{V_S \cdot \left(\widehat{\overline{\rho}_{S_i}}\right)^2}\right)^2 \tag{B10}$$

and is equivalent to

$$= PE_i^2\left[CV\left(\widehat{E_i}\right)^2 + CV\left(V_S \cdot \widehat{\overline{\rho}_{S_i}}\right)^2\right]$$

where

$$\widehat{R_i} = V_S \cdot \widehat{\overline{\rho}_{S_{ij}}} \text{ and}$$

$$CV\left(\hat{\theta}\middle|\theta\right) = \frac{\widehat{Var}\left(\hat{\theta}\middle|\theta\right)}{\widehat{\theta^2}}.$$

Regardless of whether the species has a single spawning period per year or multiple overlapping spawnings the estimate of total larval entrainment mortality can be expressed by

$$\widehat{P_M} = 1 - \sum_{i=1}^{N} \widehat{f_i}\left(1 - \widehat{PE_i}\right)^q \tag{B11}$$

where

q = number of days of larval life, and

$\hat{f}_i$ = estimated annual fraction of total larvae hatched during the *i*th survey period.

Formula (B11) is based on the total probability law where

$$P(A) = \sum_{i=1}^{N} P\left(A\middle|B_i\right) \cdot P\left(B_i\right).$$

In the above example, the event A is larval survival and event B is hatching with $P(B)$ estimated by $\widehat{f_i}$ where

$$\widehat{f_i} = \frac{\widehat{E_i}}{\widehat{E_T}},$$

where $\widehat{E_i}$ = estimated entrainment for the *i*th survey period. Then based on the Delta method

$$\widehat{Var}(\widehat{f}_i) = \widehat{Var}\left[\frac{\widehat{E}_i}{\widehat{E}_T}\right]$$

$$= \widehat{Var}\left[\frac{\widehat{E}_i}{\widehat{E}_i + \sum_{j \neq i}^{N} \widehat{E}_j}\right]$$

$$= \widehat{f}_i^{\,2}(1-\widehat{f}_i)^2\left[\frac{\widehat{Var}(\widehat{E}_i)}{\widehat{E}_i^{\,2}} + \frac{\widehat{Var}(\widehat{E}_T)}{\widehat{E}_T^{\,2}}\right].$$

The estimates of PE_i and f_i and their respective variance estimates can be combined in an estimate of the variance for $\widehat{P_M}$ following the Delta method (Seber 1982) for variance and covariance as follows:

$$\widehat{Var}(\widehat{P_M}) = \widehat{Var}\left(1 - \sum_{i=1}^{N} \widehat{f}_i (1-\widehat{PE}_i)^q\right)$$

$$= \widehat{Var}\left(\sum_{i=1}^{N} \widehat{f}_i (1-\widehat{PE}_i)^q\right)$$

$$= \sum_{i=1}^{N}\left[Var(\widehat{f}_i)(1-\widehat{PE}_i)^{2q}\right]$$

$$+ \sum_{i=1}^{N}\left[Var(\widehat{PE}_i)(\widehat{f}_i q(1-\widehat{PE}_i)^{q-1})^2\right]$$

$$+2\sum_{i=1}^{N}\sum_{j>i}^{N} \operatorname{cov}\left(\widehat{f}_i, \widehat{f}_j\right)(1-\widehat{PE}_j)^q(1-\widehat{PE}_i)^q \qquad \text{where}$$

$$\operatorname{cov}\left(\widehat{f}_i, \widehat{f}_j\right) = \left(\frac{1}{\widehat{E}_T}\right)^2\left[\widehat{f}_i\widehat{f}_j Var\left(\sum_{g \neq i,j}^{N} \widehat{E}_g\right) + \widehat{f}_i\left(1-\widehat{f}_j\right)\widehat{E}_i + \widehat{f}_j\left(1-\widehat{f}_i\right)\widehat{E}_j\right].$$

Appendix C3
Demographic Model Calculations

Fecundity Hindcasting (*FH*)

The estimated total larval entrainment for a species ($\widehat{E_T}$) was used to estimate the number of breeding females needed to produce the number of larvae entrained. The estimated number of breeding females ($\widehat{FH}$) whose fecundity was equal to the estimated total loss of entrained larvae is calculated as follows:

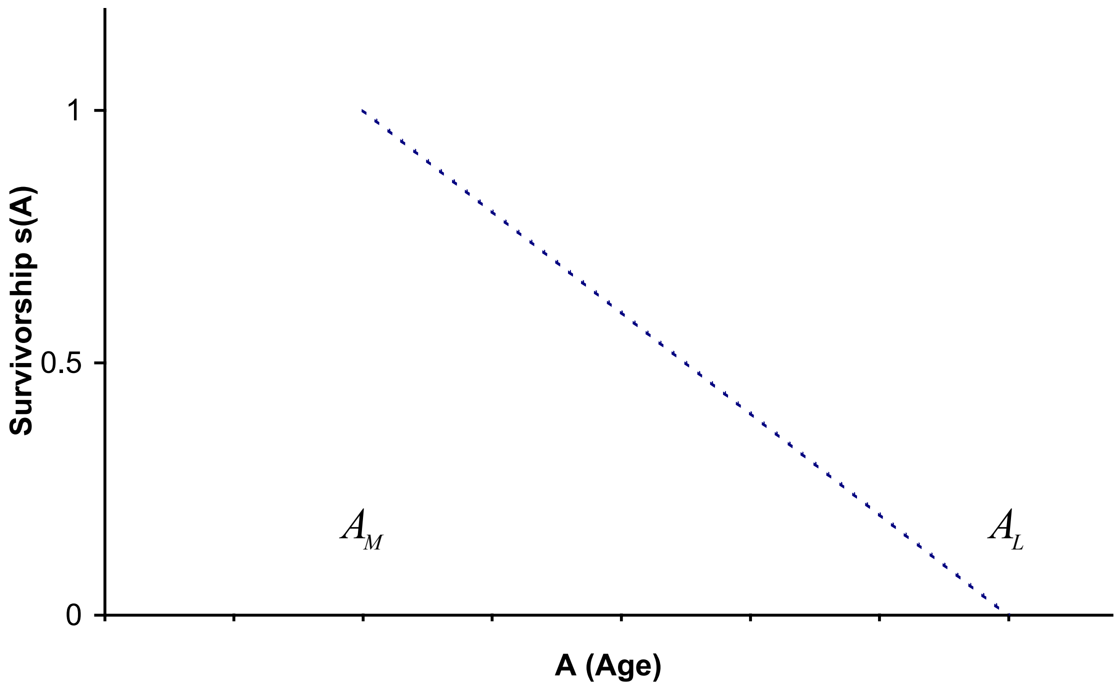
$$\widehat{FH} = \frac{\widehat{E_T}}{\widehat{TLF} \bullet \prod_{i=1}^{n} S_i} \qquad \text{(C1)}$$

where

n = number of larval stages vulnerable to entrainment,
$\widehat{E_T}$ = estimated total entrainment,
S_i = survival rate from eggs to larvae of the *i*th stage, and
$\widehat{TLF}$ = estimated total life time fecundity for females, equivalent to the average number of eggs spawned per female over their reproductive years.

Equation C1 is based on the simplified case of a single synchronized spawning by a species. For species with overlapping or continuous spawning, larval abundance would have to be specified by week and age class (i.e., $\widehat{E_{ij}}$). However, we used the mean size of all larvae entrained to estimate a representative age of larvae, and then estimated a survival rate to this representative age. Two input parameters in Equation C1 that may not be available for many species, and thus may limit the method, are lifetime fecundity (TLF) and survival rates (S_i) from spawning to entrainment.

In practice, survival was estimated by either one or several age classes, depending on the data source, to the estimated age at entrainment. The expected total lifetime fecundity $E(TLF)$ was approximated by modeling a linear survivorship for a female once she reached the age of maturity, and using a constant number of eggs produced per year.



The number of eggs produced per year was approximated as the average number of eggs per year. Thus

$$\begin{aligned}\widehat{TLF} &= \int_{A_M}^{A_L} F(A)s(A)\,dA \\ &= \overline{F}\int_{A_M}^{A_L} \frac{A_L - A}{A_L - A_M}\,dA \\ &= \overline{F}\left(\frac{A_L - A_M}{2}\right)\end{aligned}$$

where

$s(A)$ = survivorship of a female;

$F(A)$ = eggs produced;

A_M = age of maturity; and

A_L = age at death.

In other words,

$$\begin{aligned}\widehat{TLF} &= \text{Estimated Total Lifetime Fecundity} \\ &= \text{Average eggs/year} \cdot \text{Average number of years of reproductive life} \\ &= \text{Average eggs/year} \cdot \left(\frac{\text{Longevity - Age at maturation}}{2} \right).\end{aligned} \qquad \text{(C2)}$$

The expected length of reproductive life was approximated as the midpoint between the times of maturation and longevity. The approximation of linear survivorship between these events implies uniform survival. For exploited species such as northern anchovy and sardine, the expected number of years of reproductive life may be much less than predicted using this assumption.

Simulation, comparing exponential survival, shows that the calculation of $\widehat{TLF}$ will be negatively biased for species with short reproductive lifespans, and positively biased for those with longer durations.

The variance of $\widehat{FH}$ was approximated by the Delta method (Seber 1982):

$$\widehat{Var}(\widehat{FH}) = (\widehat{FH})^2 \left[CV^2(\hat{E}_T) + \sum_{j=1}^{n} CV^2(\widehat{S}_j) + CV^2(\hat{\hat{F}}) + \left(\frac{\widehat{Var}(A_L) + \widehat{Var}(A_M)}{(A_L - A_m)^2} \right) \right]$$

where

$CV(\hat{E}_T)$= CV of estimated entrainment (estimated by $CV(\hat{\hat{I}})$ when available),
$CV(\widehat{S}_j)$ = CV of estimated survival of eggs and larvae up to entrainment,
$CV(\hat{\hat{F}})$ = CV of estimated average annual fecundity,
A_M = age at maturation, and
A_L = age at maturity.

The behavior of the estimator for *FH* appears log-linear, suggesting that an approximate confidence interval can be based on the assumptions that ln($\widehat{FH}$) is normally distributed and uses the pivotal quantity

$$Z = \frac{\ln \widehat{FH} - \ln FH}{\sqrt{\dfrac{\widehat{Var}(\widehat{FH})}{\widehat{FH}^2}}}.$$

A 90% confidence interval for *FH* was estimated by solving for *FH* and setting Z equal to

+/-1.645, i.e.

$$\widehat{FH} \cdot e^{-1.645\sqrt{\frac{\widehat{Var}(\widehat{FH})}{\widehat{FH}^2}}} \quad \text{to} \quad \widehat{FH} \cdot e^{+1.645\sqrt{\frac{\widehat{Var}(\widehat{FH})}{\widehat{FH}^2}}}.$$

Adult Equivalent Loss (*AEL*)

The *AEL* approach uses estimates of the abundance of entrained or impinged organisms to forecast the loss of equivalent numbers of adults. Starting with the number of age class *j* larvae entrained ($\widehat{E}_j$), it is conceptually easy to convert these numbers to an equivalent number of adults lost ($\widehat{AEL}$) at some specified age class from the formula:

$$\widehat{AEL} = \sum_{j=1}^{n} \widehat{E}_j \widehat{S}_j \tag{C3}$$

where

$n =$ number of age classes,
$\widehat{E}_j =$ estimated number of larvae lost in age class j, and
$\widehat{S}_j =$ survival rate for the jth age class to adulthood (Goodyear 1978).

Age-specific survival rates from larval stage to recruitment into the fishery (through juvenile and early adult stages) must be included in this assessment method. For some commercial species, survival rates are known for adults in the fishery; but for most species, age-specific larval survivorship has not been well described.

When age-specific survival rates from larval stage to recruitment into the fishery were available, *AEL* was calculated using survival from a representative age of the entrained larvae at AGS. This age was calculated by dividing the average larval length at entrainment (minus hatch length) by a literature-based growth rate. Age-specific survivorship for any interval of time (t) was then calculated following the formula (Ricker 1975)

$$\frac{N_t}{N_0} = e^{-Zt}$$

where

$N_t =$ number of animals in the population at time t,

$N_0 =$ number of animals in the population at time $t = 0$,

$\frac{N_t}{N_0} = S$ (finite survivorship to time t),

$e = 2.71828...$(base of the natural log), and

$Z =$ instantaneous mortality rate.

Survivorship to recruitment, to an adult age, was apportioned into several age stages, and AEL was calculated using the total entrainment as

$$\widehat{AEL} = \hat{E}_T \prod_{j=1}^{n} \widehat{S}_j \tag{C4}$$

where

$n =$ number of age classes from entrainment to recruitment and

$\widehat{S}_j =$ survival rate from the beginning to end of the jth age class.

The variance of $\widehat{AEL}$ can be estimated using a Taylor series approximation (Delta method of Seber 1982) as

$$\widehat{Var}(\widehat{AEL}) = \widehat{AEL}^2 \left(CV^2(\hat{E}_T) + \sum_{j=1}^{n} CV^2(\widehat{S}_j) \right). \tag{C5}$$

An alternative analysis would be to compare $\widehat{AEL}$ with the size of the adult population of interest or with fishery harvest data. This method converts numbers of adult losses into fractional loss of the population of interest (e.g., stock assessment). However, information describing adult stocks is limited for many species, and independent field estimates of survival from time of entrainment to adulthood are not available for some species. For some species where such information is unavailable, we can estimate this parameter by assuming a stationary population where an adult female must produce two adults (i.e., one male and one female). Overall survival (S_T) can then be estimated from total lifetime fecundity (TLF) by the quantity

$$\widehat{S_T} = \frac{2}{\widehat{TLF}} = \hat{S}_{egg} \cdot \hat{S}_{larvae} \cdot \hat{S}_{adult},$$

which leads to

$$\hat{S}_{adult} = \frac{2}{\widehat{TLF} \cdot \hat{S}_{egg} \cdot \hat{S}_{larvae}}. \tag{C6}$$

Substituting Equation 11 into the overall form of the *AEL* equation where

$$\widehat{AEL} = \hat{E}_T \cdot \hat{S}_{adult} \tag{C7}$$

yields

$$\widehat{AEL} = \frac{2(\hat{E}_T)}{\hat{S}_{egg} \cdot \hat{S}_{larva} \cdot \widehat{TLF}}$$

where

$$\widehat{AEL} \equiv 2\widehat{FH} \;. \tag{C8}$$

Without independent adult survival rates and assuming a 50:50 sex ratio, $\widehat{AEL}$ and $\widehat{FH}$ are deterministically related according to Equation 13, with an associated standard error of $\widehat{SE}(\widehat{AEL}) = 2\widehat{SE}(\widehat{FH})$. Equation 13 should be aligned so that the average female age is also the age of recruitment used in computing $\widehat{AEL}$. This alignment is accomplished by solving the simple exponential survival equation (Ricker 1975)

$$N_t = N_0 \cdot e^{-Z(t-t_0)}$$

by substituting numbers of either equivalent adults or hindcast females, their associated ages, and mortality rates into the equation where,

$N_t =$ number of adults at time t,
$N_0 =$ number of adults at time t_0,
$Z =$ instantaneous rate of natural mortality, and
$t =$ age of hindcast animals (FH) or extrapolated age of animals (AEL).

This allows for the alignment of ages in either direction such that $2FH \equiv AEL$ since they are either hindcast or extrapolated to the same age.

The estimates of mortality calculated from the *AEL* and *FH* approaches can be compared for the same time periods for taxa where independent estimates are available for (1) survival from entrainment to recruitment into the fishery and (2) entrainment back to hatching. These comparisons serve as a method of cross-validation for the demographic approaches to impact assessment.

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