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The Impact of Sample Size Reduction on the Precision of Biomass Estimates in the Gulf of Alaska

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Abstract

The sample sizes of the two most recent (2011 and 2013) Gulf of Alaska bottom trawl surveys were reduced by 20% and 33% (to 670 and 548 from 825 stations), respectively because of lack of funding and logistical reasons. In this study we examine the potential impact these sample size reductions has on the precision of the biomass estimates of 11 common species assessed by this survey. Surveys of sample sizes ranging from 300 to 825 stations were simulated by randomly sampling stations without replacement from the 2007 Gulf of Alaska survey. The coefficient of variance was plotted against sample size for each of the 11 species, and the rate of decline of the slope of the fitted curve was used to determine whether the reduced sample sizes of the two most recent surveys resulted in adequate precision. A threshold value of the slope (70% of its value at N = 300) was used to decide whether the reduced sample sizes of the 2011 and 2013 surveys were adequate for each species. The sample size of the 2013 (N = 548) survey resulted in none of the 11 species meeting the threshold, suggesting that the sample size that year was too low. In contrast, 3 species met the threshold at the sample size of the 2011 survey (N = 670) and 10 species met the threshold for a traditional full-scale survey (N = 825).

Contents

Introduction

Biennial bottom trawl surveys conducted in the Gulf of Alaska have traditionally used three charter vessels for 75 days each, resulting in a total survey effort of approximately 820 stations (von Szalay et al., 2010). However, due to limited funds in recent years, the survey effort has been reduced to 548 and 670 stations in the two most recent surveys (2011 and 2013).

The high cost of surveys necessitates prudent sampling. It is therefore important that each additional station that is sampled beyond some minimum total sample size contributes toward the reduction of variance in a meaningful way. The rationale for maximizing the survey effort is based on the assumption that biomass variance estimates are inversely correlated with sample size; the more stations sampled, the higher the precision of biomass estimates ought to be. However, at some point, the law of diminishing returns dictates that more stations do not result in a sufficient variance reduction to justify the marginal expense.

There are no definitive or even objective criteria for establishing the smallest sample size that would not have an overly negative impact on the precision of biomass estimates, but it may be possible to make an informed decision by carefully examining the relationship between the precision of biomass estimates and sample size. The objective of this study was to examine how the coefficient of variation for 11 common species in the Gulf of Alaska varies with sample size and attempt to establish the minimum number of survey stations that does not result in unacceptably high coefficients of variation for the majority of these species. A simulation study was conducted and compared with actual variances from surveys with highly contrasting effort.

Methods

Simulations

Catch per unit of effort (CPUE) data for 11 common species from the 2007 biennial Gulf of Alaska bottom trawl survey were processed and analyzed. The species were selected from three major categories of commercially important fishes encountered during the Gulf of Alaska trawl survey. Flatfishes were represented by arrowtooth flounder (*Atheresthes stomias*), rex sole (*Glyptocephalus zachirus*), flathead sole (*Hippoglossoides elassodon*), northern rock sole(*Lepidopsetta polyxystra*), and southern rock sole (*Lepidopsetta bilineata*); rockfishes were represented by Pacific ocean perch (*Sebastes alutus*) and northern rockfish (*Sebastes polyspinis*); and miscellaneous roundfishes were represented by walleye pollock (*Gadus *chalcogrammus*), Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*), and yellow Irish lord (*Hemilepidotus jordani*).

Twenty-two simulations were conducted with the number of stations varying between 300 and 820 hauls (in increments of 25 hauls). Simulations were conducted for each species with an *R* program. All simulations were based on CPUE data from the 2007 Gulf of Alaska survey, which consisted of 820 hauls. In each simulation a random sample of hauls was drawn without replacement for each of the 59 strata comprising the survey area. The number of hauls sampled for stratum *i* (n_i) was proportional to both the number of hauls sampled in that stratum during the 2007 survey ($n_{i,2007}$) and the sample size of the simulated survey (N_{SIM}) relative to sample size of the 2007 survey ($N_{2007} = 820$):

$$n_i = \frac{N_{SIM}}{N_{2007}} \times n_{i,2007} \quad .$$

The sample sizes of individual strata were subject to the constraint that each stratum had to be assigned a minimum of two stations so that biomass variance estimates could be calculated. This constraint, which was applied most often to simulated surveys with the smallest sample sizes (e.g., 300-500), necessitated the removal of previously assigned stations to other strata in order to keep the total number of stations of the simulated survey fixed. Assigned stations were randomly removed from strata based on the number of stations assigned to the different strata. Accordingly, the stratum with the largest number of assigned stations was the first candidate for station removal. When more than one station had to be removed (because more than one stratum was assigned fewer than two hauls), the stratum with the second largest number of stations was next in line, and so forth.

Mean CPUE values and variances of these means were calculated for each stratum and iteration of the simulated survey. The biomass of stratum *i* was calculated as:

$$B_i = A_i \times \boldsymbol{CPUE}_i \quad ;$$

where A_i is the area of stratum *i* and $\boldsymbol{CPUE_i}$ is the mean CPUE of stratum *i*. The biomass variance of stratum *i* was calculated as:

$$varB_i = A_i^2 \times \frac{varCPUE_i}{n_i} \quad ;$$

where var $CPUE_i$ and n_i are the sample variance and sample size in stratum *i*, respectively.

The survey biomass and variance estimates were calculated as the sum of the 59 strata biomasses and variances:

$$B_{TOT} = \sum_{i=1}^{59} B_i$$

$$varB_{TOT} = \sum_{i=1}^{59} varB_i \ .$$

The coefficient of variation (CV) of the total biomass estimate was calculated as follows:

$$CV(B_{survey}) = \frac{\sqrt{varB_{TOT}}}{B_{TOT}} \ .$$

This procedure for generating the total survey biomass estimate (B_{TOT}) and its associated variance and coefficient of variation was replicated 100 times for each simulated survey. The mean values of B_{TOT},varB_{TOT}, and CV(B_{survey}) generated from the 100 iterations were used in the subsequent analysis.

Analysis of Simulations

The simulated CVs were plotted against sample size (N) and were fitted with an exponential regression line for each species. The slope of the regression was calculated at 7 sample sizes between N = 500 and N = 820, and these values were subsequently divided by the slope of the regression line at N = 300 to express the slope as a percentage of its value at the lowest viable sample size (N = 300) for a survey. The value of 300 was based on a projection that with two vessels operating for 50 days (a traditional full-scale survey uses three vessels for 75 days), each vessel should average at least three stations per day. This ratio, which is expected to decrease with increasing sample size, was used as an indicator of the level of variance reduction achieved at a particular sample size relative to the variance of the smallest viable survey sample size. At sufficiently high sample sizes the marginal rate of decrease of this ratio with further sample size increases becomes too small to justify the additional costs. A ratio of 0.70 (70%) was used as a threshold to decide whether the sample size was adequate for each species. This value was considered to be low enough to avoid missing out on any substantial precision improvements with further increases in N, because at this level, all but 1 of the 11 species examined in this study meets the threshold in a traditional full-scale survey consisting of 820 stations.

Results

Observed CVs

The sample sizes of the first two surveys (2007 and 2009) were at or close to what has been traditionally regarded as a full-scale three-vessel survey in the Gulf of Alaska (820 and 823 stations, respectively). However, the sample sizes of the subsequent two surveys were substantially smaller. The 2011 survey was reduced to 670 stations because of budgetary constraints, and the 2013 survey was reduced to only 548 stations due to our inability to secure a third charter vessel.

The observed coefficients of variance were calculated in the same manner as the simulated CVs described in Methods. The CPUEs used to calculate the biomass and variances, in turn, were obtained from the four consecutive biennial Gulf of Alaska bottom trawl surveys between 2007 and 2013 and are listed in the respective Data Reports (e.g., von Szalay et al., 2008). The first two of these surveys were traditional full-scale surveys with three vessels chartered for 75 days each, sampling a total of 820 or more stations. The latter two surveys (2011 and 2013) only had two vessels chartered for 75 to 85 days each, sampling a total of 670 (2011) and 548 (2013) stations.

Despite the considerably smaller sample sizes of the 2011 and 2013 surveys, the coefficient of variation for either of these surveys was only the highest for 6 of the 11 species under consideration (arrowtooth flounder, rex sole, northern rock sole, sablefish, walleye pollock, and northern rockfish), with five of the species associated with the 2013 survey (Table 1). Of these six species, only four were also associated with the second highest CV for the reduced surveys. Furthermore, the full-scale 2009 survey (N = 823) was, like the reduced 2013 survey, also associated with the highest CV for five species. Combined, these observations indicate only a weak correlation between CV and N for the range of stations during the 2007-2013 surveys.

More importantly, of the five species that the 2013 survey was associated with the highest CV, the CV was substantially greater (>10%) than that of the survey with the second highest CV for three species (rex sole, walleye pollock, and northern rockfish). By comparison, of the five species that the 2009 survey was associated with the highest CV, the CV was also substantially greater than that of the survey with the second highest CV for three species (flathead sole, southern rock sole, and Pacific cod). These findings also suggest that the correlation between CV and sample size is weak and not consistent across species even at the relatively low sample size of the 2013 survey.

CVs Based on Simulated Surveys

The CV monotonically decreased with sample size throughout the 300 to 820 sample size range for all species (Fig. 1). The reduction in the CVs ranged from 31% (Pacific ocean perch) to 49% (yellow Irish lord). Although these reductions are substantial on a proportional basis, the magnitudes of the CVs were relatively low throughout the sample size range: less than 0.15 for all but one of the flatfishes and sablefish, and less than or equal to approximately 0.25 for all but one of the other species (northern rockfish is the exception).

The relatively small magnitudes of the simulated CVs are generally consistent with the observed CVs of the four surveys. The magnitudes of the CVs at the sample size of a traditional full-scale survey (820 stations) were between approximately 0.07 and 0.15 for all species except northern rockfish. The slope of the *CV* vs. *N* curve also decreased monotonically with sample size throughout the sample size range for all species (Fig. 1 and Table 2).

Table 2 presents the slope of the exponential fitted to the *CV* vs. *N* data, expressed as a fraction of the slope at N = 300, for select sample sizes between 500 and 820. The boldfaced values indicate the sample size at which the slope drops below the 70% slope threshold for an acceptable survey result. At N = 548 used for the 2013 survey, none of the 11 species considered in this study had a CV below the 70% threshold, suggesting that the 2013 sample size was unacceptably low. However, at N = 670 used for the 2011 survey, three of the species (southern rock sole, walleye pollock, and sablefish) met the "acceptable" threshold, and another six species (arrowtooth flounder, rex sole, flathead sole, northern rock sole, Pacific ocean perch, and yellow Irish lord) were very close (71-73%).

The rate of decline in the slope with sample size was relatively low for northern rockfish, whose slope only dropped by 16 percentage points to 73% at the sample size of a traditional full-scale survey (N = 820). This contrasts with a drop of 20-24 percentage points for the other species, which generally reached a slope ratio of 60-65% at N=820. Assuming the exponential fit still applies at sample sizes greater than 820, a sample size of approximately 900 would be necessary to meet the "acceptable" threshold for this species.

Table 1. -- Estimates of biomass, variance, and coefficient of variation for 11 common Gulf of Alaska species derived from four consecutive biennial bottom trawl surveys (2007-2013). The boldface CV values indicate the survey associated with highest CV for each species.

YEAR	SPECIES	# HAULS	BIOMASS	VARIANCE	CV	YEAR	SPECIES	# HAULS	BIOMASS	VARIANCE	CV
2007	ATF	820	1,939,055	22,517,724,741	0.077	2007	YIL	820	15,721	5,575,852	0.150
2009		823	1,772,029	25,409,008,475	0.090	2009		823	25,219	16,128,573	**0.159**
2011		670	1,747,339	32,328,164,491	**0.103**	2011		670	15,771	5,218,324	0.145
2013		548	1,290,727	16,990,783,870	0.101	2013		548	19,841	9,895,080	0.159
2007	FHS	820	280,290	565,403,295	0.085	2007	PCOD	820	233,310	1,046,472,635	0.139
2009		823	225,377	627,027,305	**0.111**	2009		823	752,651	52,005,965,774	**0.303**
2011		670	235,639	498,571,410	0.095	2011		670	500,975	4,642,992,280	0.136
2013		548	201,233	346,553,145	0.093	2013		548	506,362	5,640,361,654	0.148
2007	REX	820	103,776	93,050,007	0.093	2007	PLK	820	316,225	1,917,504,750	0.138
2009		823	124,744	92,309,110	0.077	2009		823	703,644	11,507,462,171	0.152
2011		670	95,134	52,002,759	0.076	2011		670	708,092	9,741,811,348	0.139
2013		548	100,978	193,837,033	**0.138**	2013		548	1,014,846	42,127,999,171	**0.202**
2007	NRS	820	102,303	145,110,447	0.118	2007	POP	820	688,180	13,035,283,284	0.166
2009		823	95,846	258,170,234	0.168	2009		823	649,449	13,867,565,648	**0.181**
2011		670	72,875	154,424,036	0.171	2011		670	778,670	18,361,868,452	0.174
2013		548	74,586	184,601,647	**0.182**	2013		548	1,298,443	45,589,096,333	0.164
2007	SRS	820	161,617	138,382,979	0.073	2007	NRF	820	227,069	7,306,887,158	0.376
2009		823	191,765	510,368,369	**0.118**	2009		823	89,896	834,489,465	0.321
2011		670	120,573	106,467,961	0.086	2011		670	173,642	4,504,728,201	0.387
2013		548	131,441	195,811,086	0.106	2013		548	370,454	48,669,985,128	**0.596**
2007	SABF	820	202,736	207,398,512	0.071						
2009		823	202,209	261,820,876	0.080						
2011		670	136,420	336,893,470	0.135						
2013		548	81,858	126,808,521	**0.138**						

Table 2. -- The slope of *CV* vs. *N* at select sample sizes, expressed as a fraction of the slope at N = 300. The boldfaced values indicate the sample sizes at which the slope is less than 33% of its value at N=300. The 33% threshold would have been met at N = 870 for Pacific ocean perch (POP).

N	ATF	REX	FHS	NRS	SRS	POP	NRF	PLK	COD	SAB	YIL
500	0.84	0.84	0.83	0.85	0.82	0.85	0.89	0.83	0.87	0.80	0.84
548	0.81	0.80	0.80	0.81	0.78	0.81	0.86	0.79	0.84	0.76	0.80
600	0.77	0.76	0.76	0.78	0.74	0.78	0.84	0.75	0.81	0.72	0.77
670	0.72	0.72	0.71	0.73	**0.70**	0.73	0.80	**0.70**	0.76	**0.66**	0.72
700	0.71	**0.70**	**0.69**	0.72	0.68	0.71	0.79	0.68	0.75	0.64	**0.70**
800	**0.65**	0.64	0.63	**0.66**	0.61	**0.66**	0.74	0.62	**0.70**	0.58	0.64
820	0.64	0.63	0.62	0.65	0.60	0.65	0.73	0.61	0.69	0.56	0.63

Discussion

Although the threshold for what constitutes an "acceptable" survey in terms of the precision of biomass estimates for a number of select species is necessarily arbitrary, the one chosen in this study can be justified as follows. First, because of constraints such as availability of qualified personnel, ability to secure charter vessels and the finite length of the survey season, future surveys are not likely to be larger in scope than the traditional full-scale survey of the past. Consequently, the coefficients of variation associated with a sample size of 820-825 (assuming that all other factors that influence the CV are equal) are likely the lowest that can be achieved in practice. Second, an appropriate choice for a threshold should therefore reflect this reality by ensuring that the vast majority of commercially or ecologically important species encountered during the survey meets this threshold at that sample size. At the 70% threshold chosen for this study, nearly all of the species satisfied the threshold (10 out of 11). The only exception was northern rockfish, which would have met the 70% threshold at a sample size of 900.

Based on the simulation results and a 70% slope threshold, it is clear that the sample size of the 2013 survey (548) was too low because none of the 11 species considered in this study met the threshold. On the other hand, with a sample size in the 670-700 range (2011 survey), just over half of the species (3 at N = 670 and 6 at N = 700) met the threshold. Of the remaining five species that do not meet the threshold at N = 700, four do so at N = 800 (Table 2). These findings suggest a survey with a sample size of 670 may qualify as "acceptable" when funding is constrained.

The results from the observational part of this study were unanticipated. We noted that two surveys were associated with the highest CV for almost all of the species (10 out of 11). As expected, one of these was the 2013 survey, which had by far the lowest sample size (548), but surprisingly, the other was the 2009 survey, which had the highest sample size (823) of all surveys. Both of these surveys were associated with the highest CV for five species each, and for three of the five species the CV was substantially higher (>10%) than the survey with the second highest CV. In terms of minimizing the CV, based on these observations there appears to be no advantage in a full-scale 820 station survey compared to a reduced 548 station survey. However, the observational part of this study was very limited as it was based on only four surveys. Furthermore, several factors other than sample size, such as fish distribution (both vertical and geographical) and catchability (e.g., skipper, vessel, and net effects) also influence the CV. It is possible that one or more of these factors had an undue influence during the 2009 survey, which resulted in the higher than expected relative CVs that year. For example, there was an exceptionally large catch of cod (over 13 tons) in one haul during the 2009 survey, which was more than six times larger than the second largest cod catch in any of the four surveys between 2007 and 2013. This haul was highly influential and resulted in a very high CV for cod that year as indicated by the outlier shown in Figure 1i. In addition, the four largest catches of southern rock sole during the four surveys were all caught during in 2009. Two of these catches were more than twice as large as the biggest catch in a survey other than the 2009 survey, resulting in an unusually large CV (Fig. 1e). Finally, compared to the simulated study, the observational CV values were limited to the second half of the range of sample sizes, where the reductions are considerably smaller than in the first half.

Conclusion

The findings from the observational part of this study provided little, if any, evidence that a sample size of 548 stations (2013 survey) consistently resulted in higher CV values than a traditional full-scale 820 station survey. In contrast, the finding of the simulations part of the study demonstrated that a sample size of 548 is inadequate because none of the 11 species met the 70% slope threshold at that sample size. This compares to 6 and 10 species, respectively, which met the threshold at N = 700 and N = 820. At least a part of the discrepancy between the two methods may be attributed to the limited scope of the observational study, which was based on only four surveys, and that factors other than sample size may have had an undue influence on the 2009 survey data. Consequently, with a preference on erring on the side of “too many” stations to define an acceptable survey, we recommend a minimum sample size of 670 for all future Gulf of Alaska bottom trawl surveys.

Citations

von Szalay, P.G., N.W. Raring, F.R. Shaw, M.E. Wilkins, and M.H. Martin. 2010. Data Report: 2009 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech Memo. NMFS-AFSC-208, 245 p.

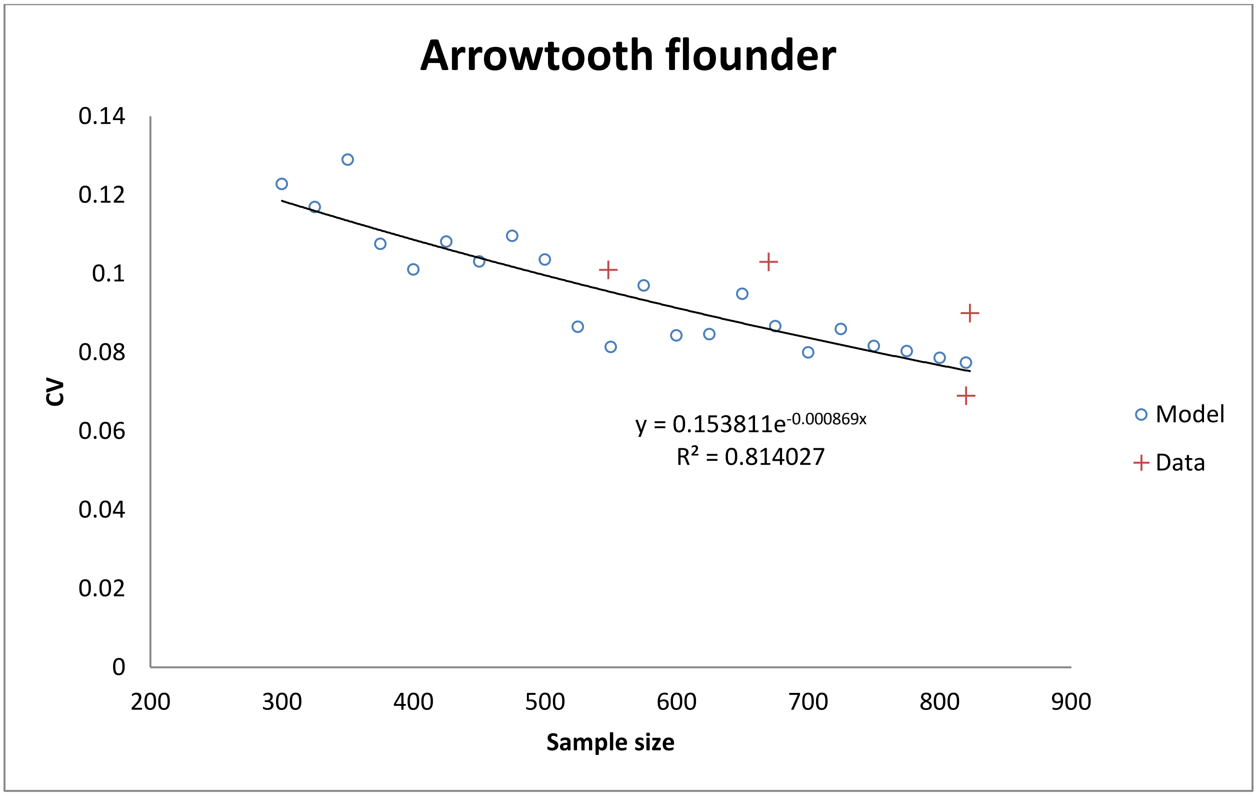

Figure 1a. -- Observed (2007-2013) and simulated CVs as a function of sample size for arrowtooth founder.

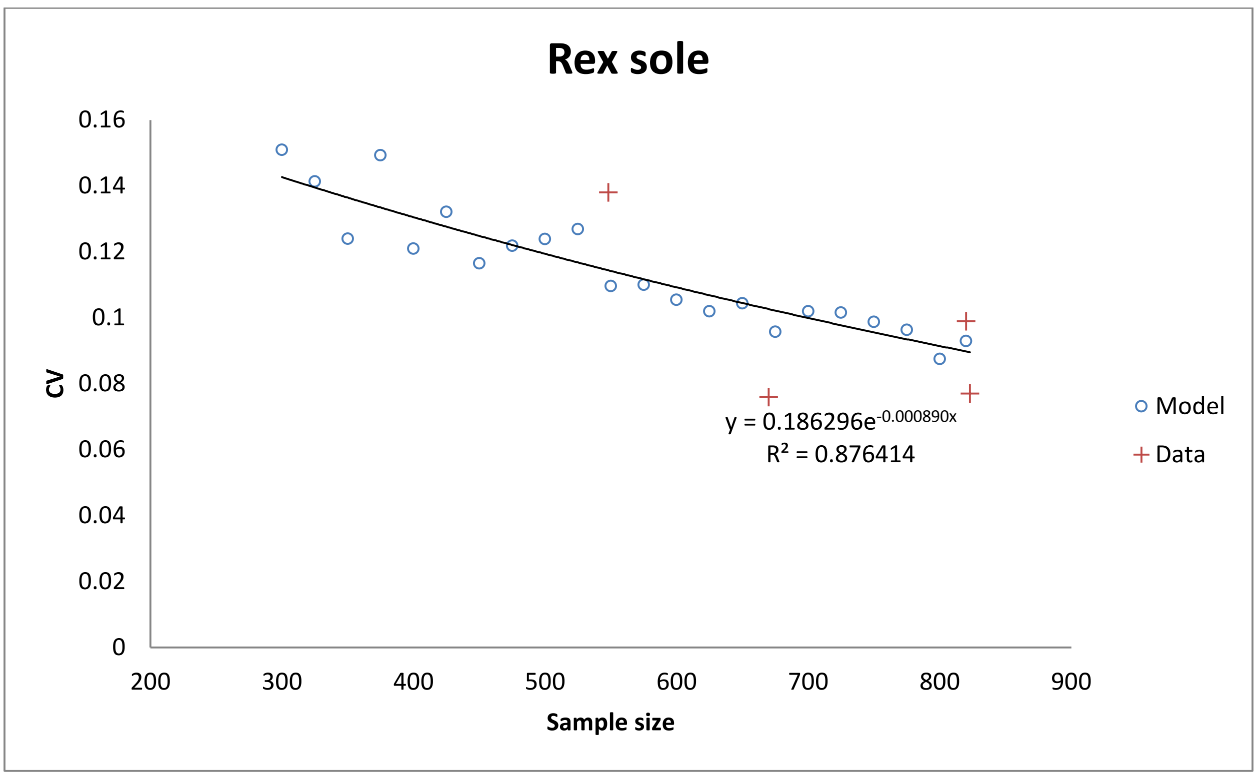

Figure 1b. -- Observed (2007-2013) and simulated CVs as a function of sample size for rex sole.

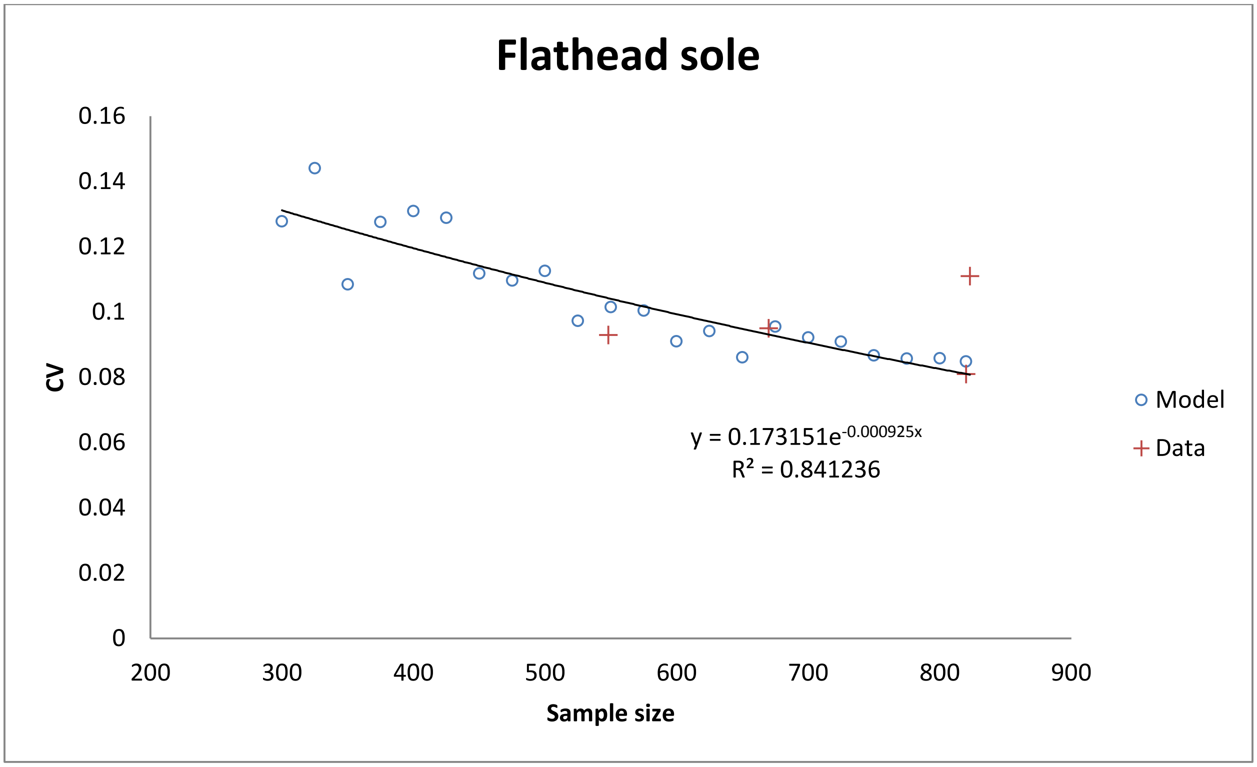

Figure 1c. -- Observed (2007-2013) and simulated CVs as a function of sample size for flathead sole.

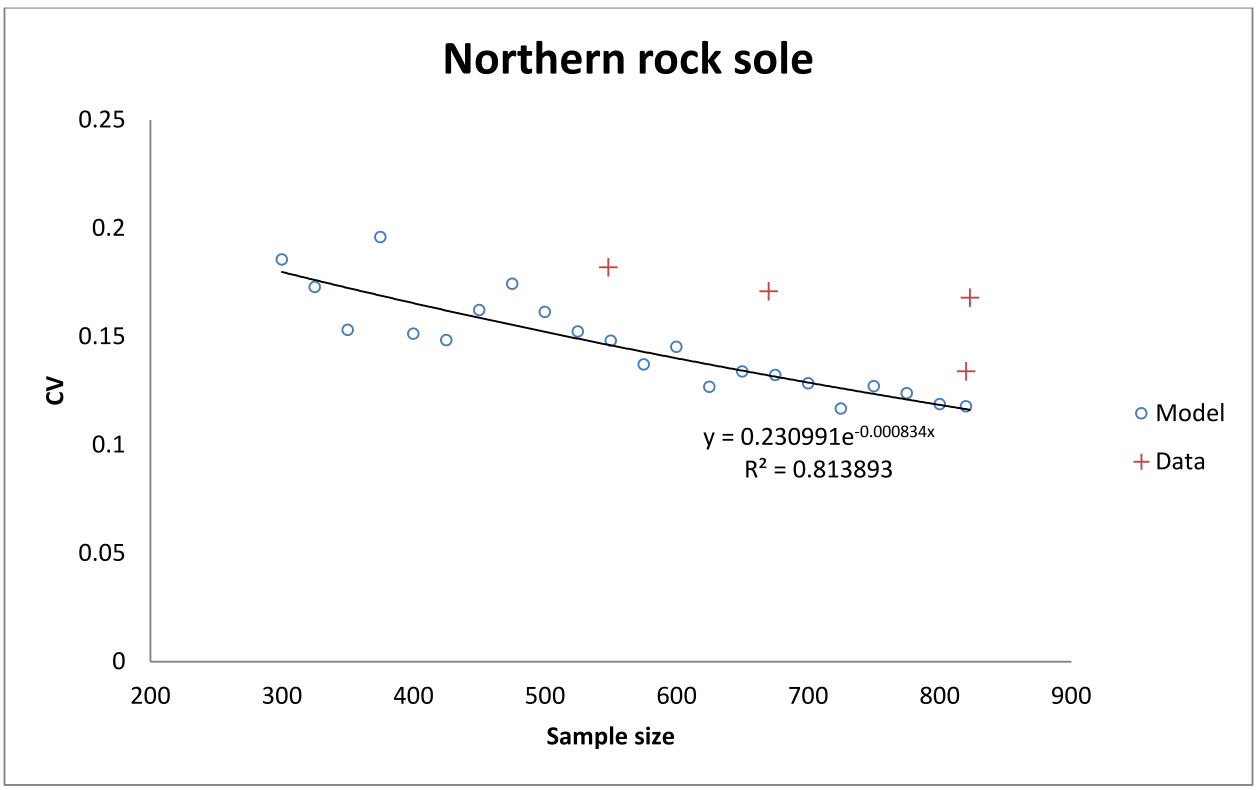

Figure 1d. -- Observed (2007-2013) and simulated CVs as a function of sample size for northern rock sole.

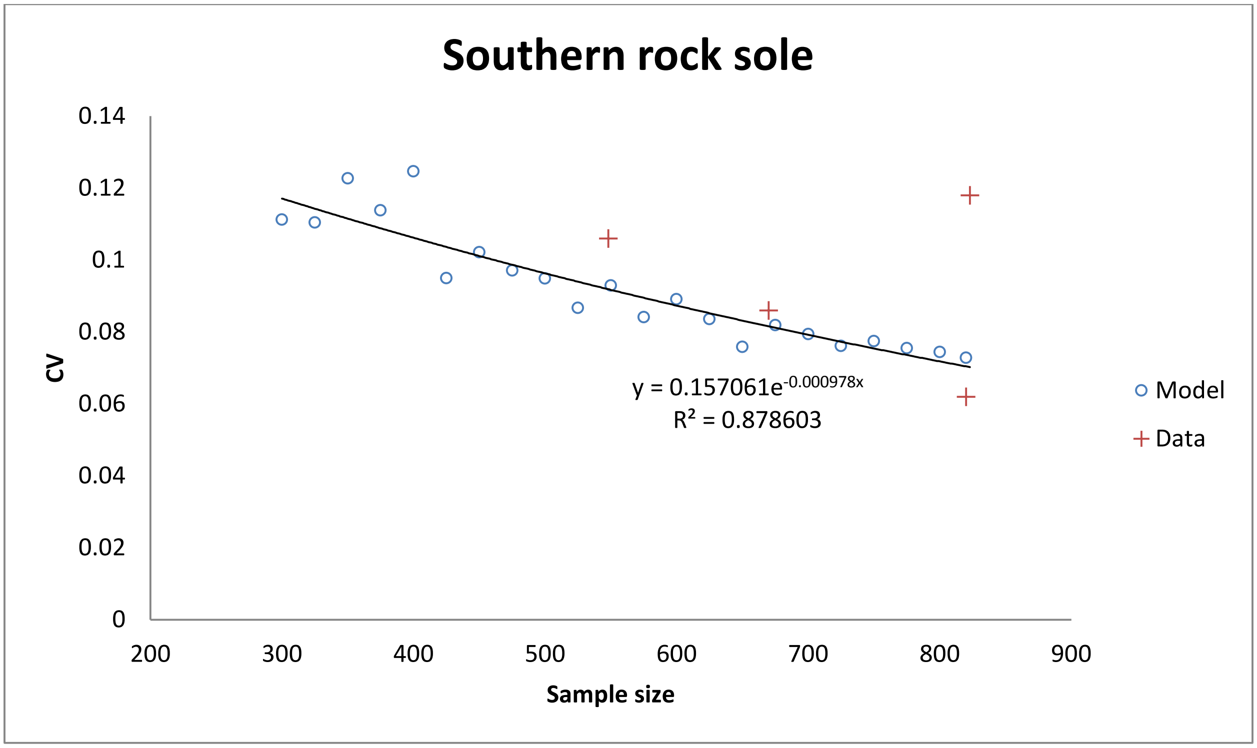

Figure 1e. -- Observed (2007-2013) and simulated CVs as a function of sample size for southern rock sole.

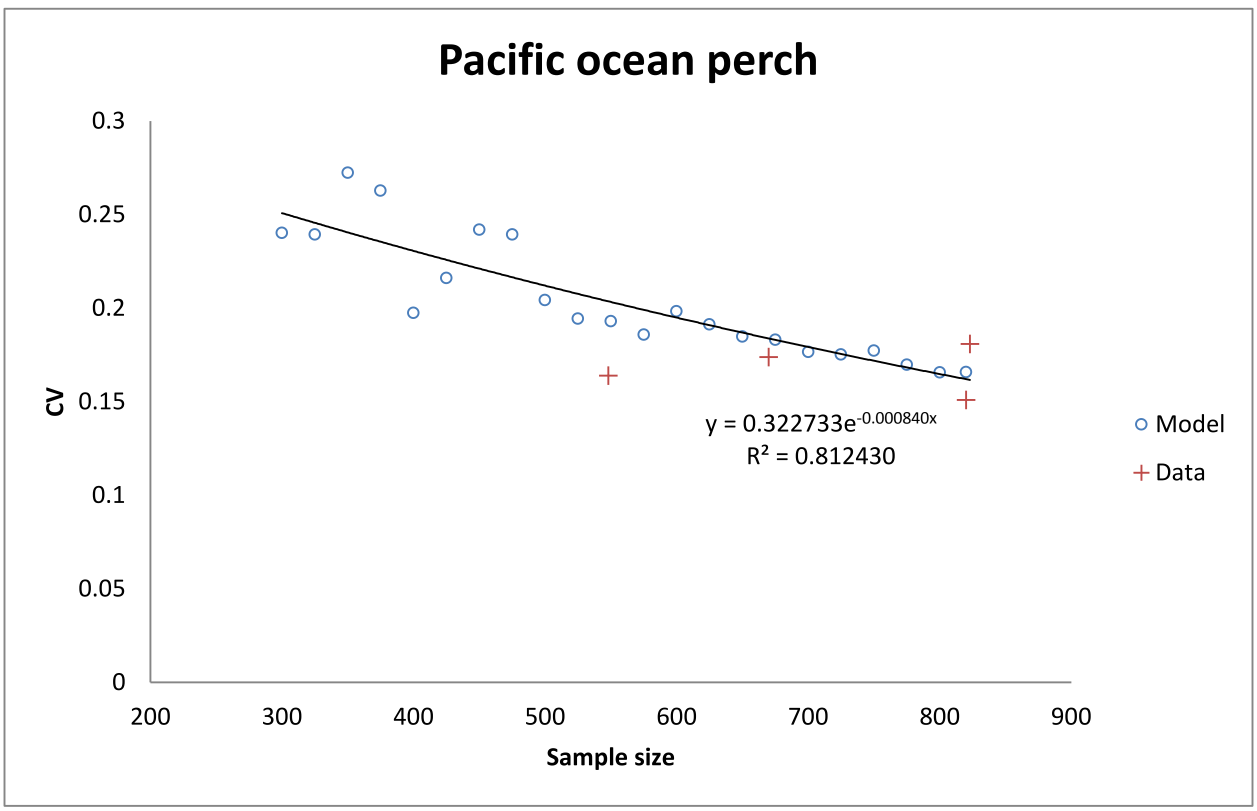

Figure 1f. -- Observed (2007-2013) and simulated CVs as a function of sample size for Pacific ocean perch.

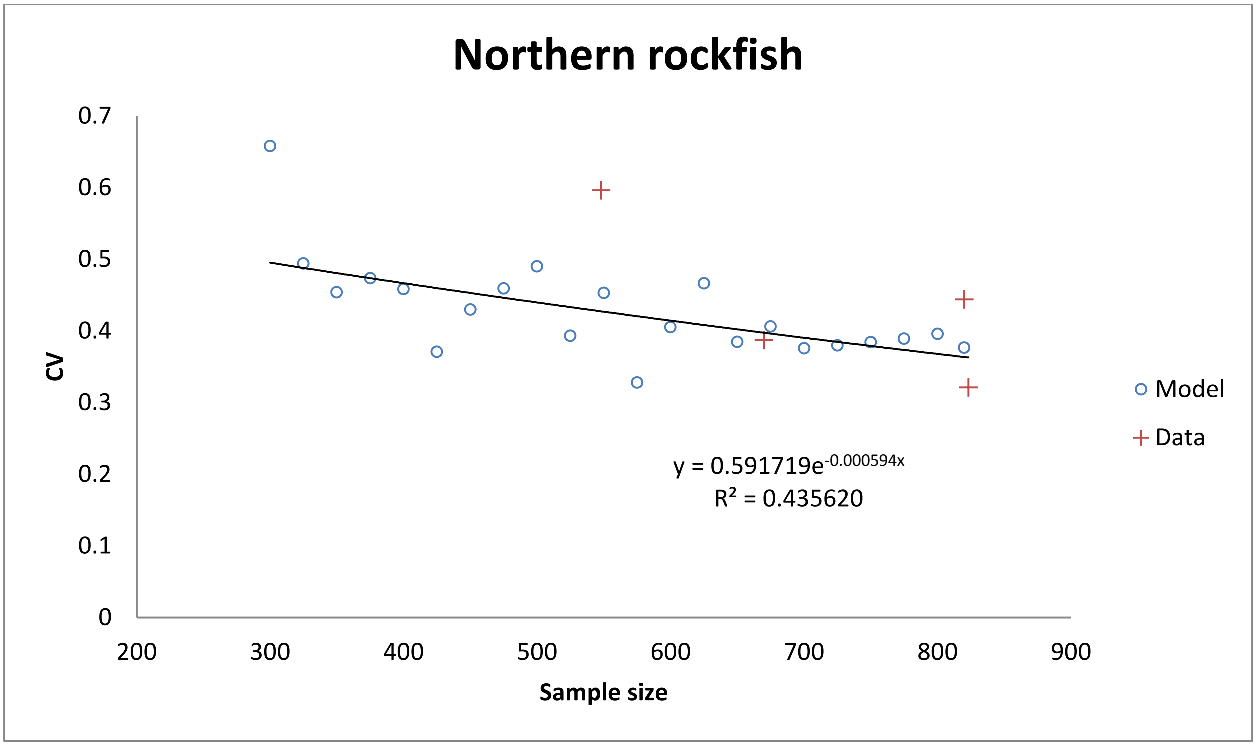

Figure 1g. -- Observed (2007-2013) and simulated CVs as a function of sample size for northern rockfish.

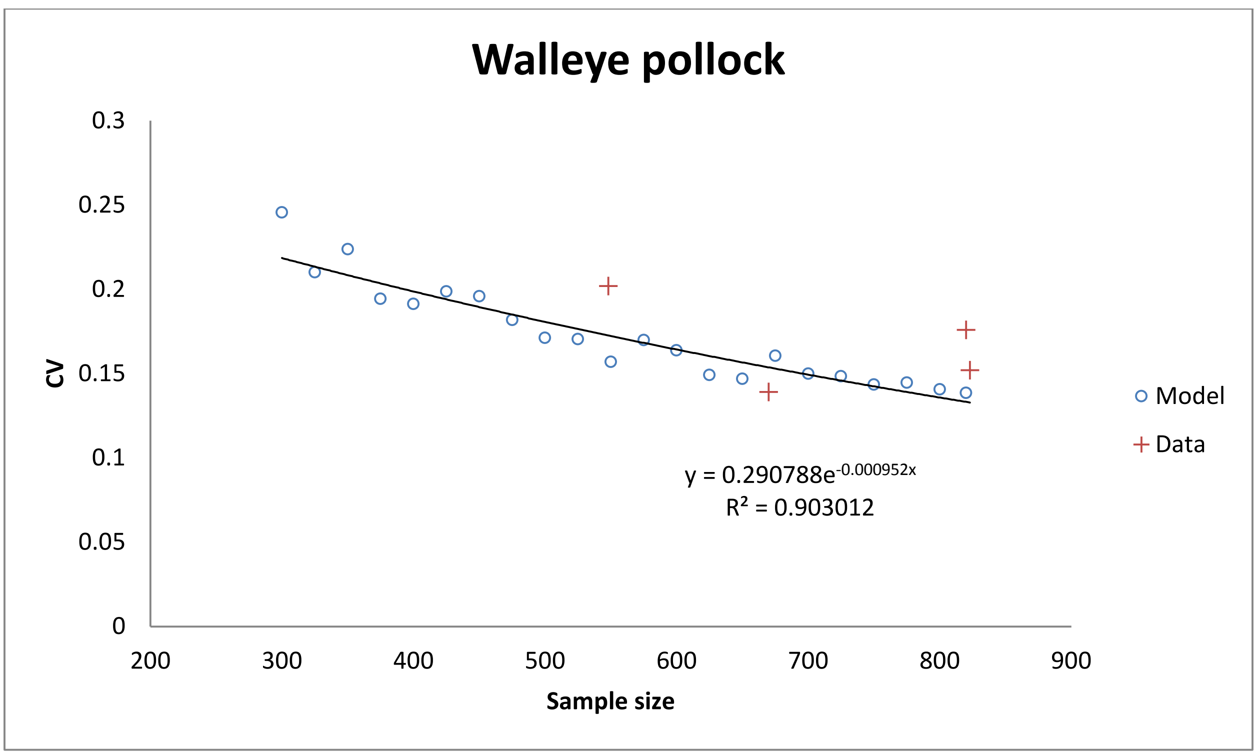

Figure 1h. -- Observed (2007-2013) and simulated CVs as a function of sample size for walleye pollock.

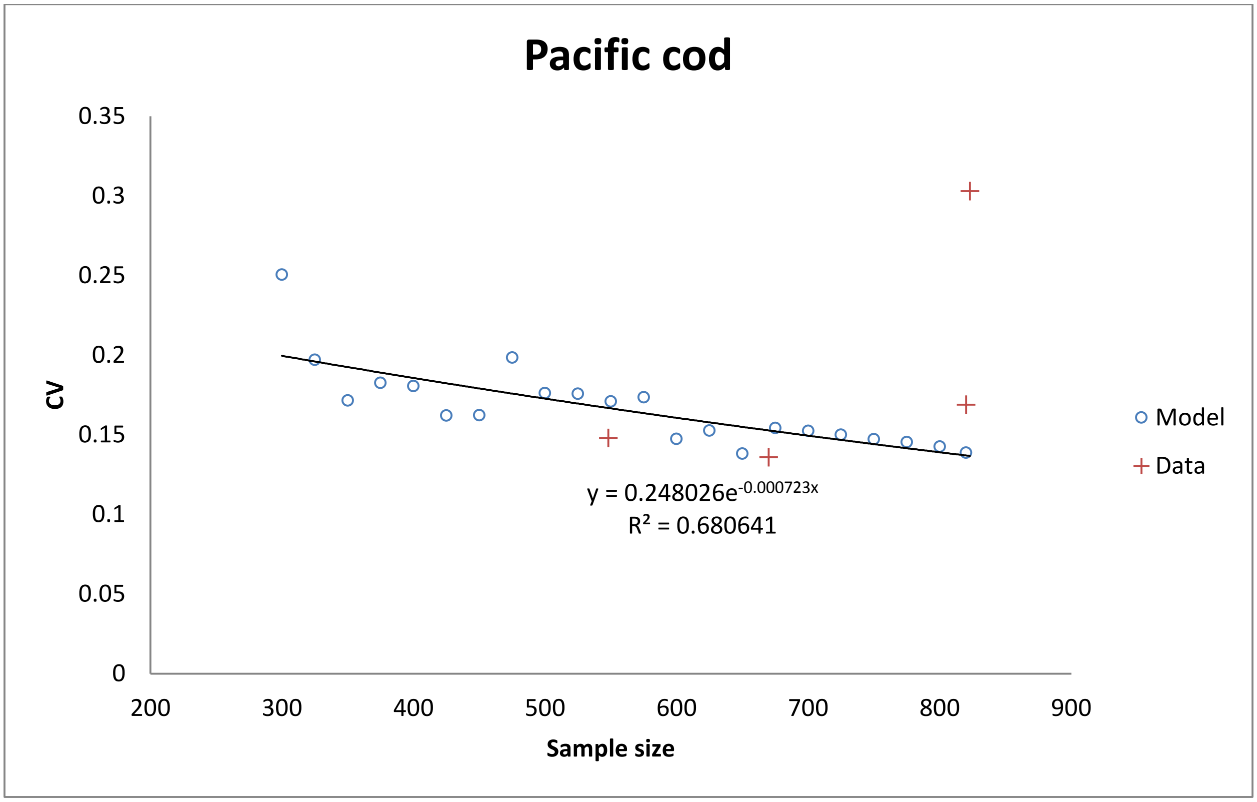

Figure 1i. -- Observed (2007-2013) and simulated CVs as a function of sample size for Pacific cod.

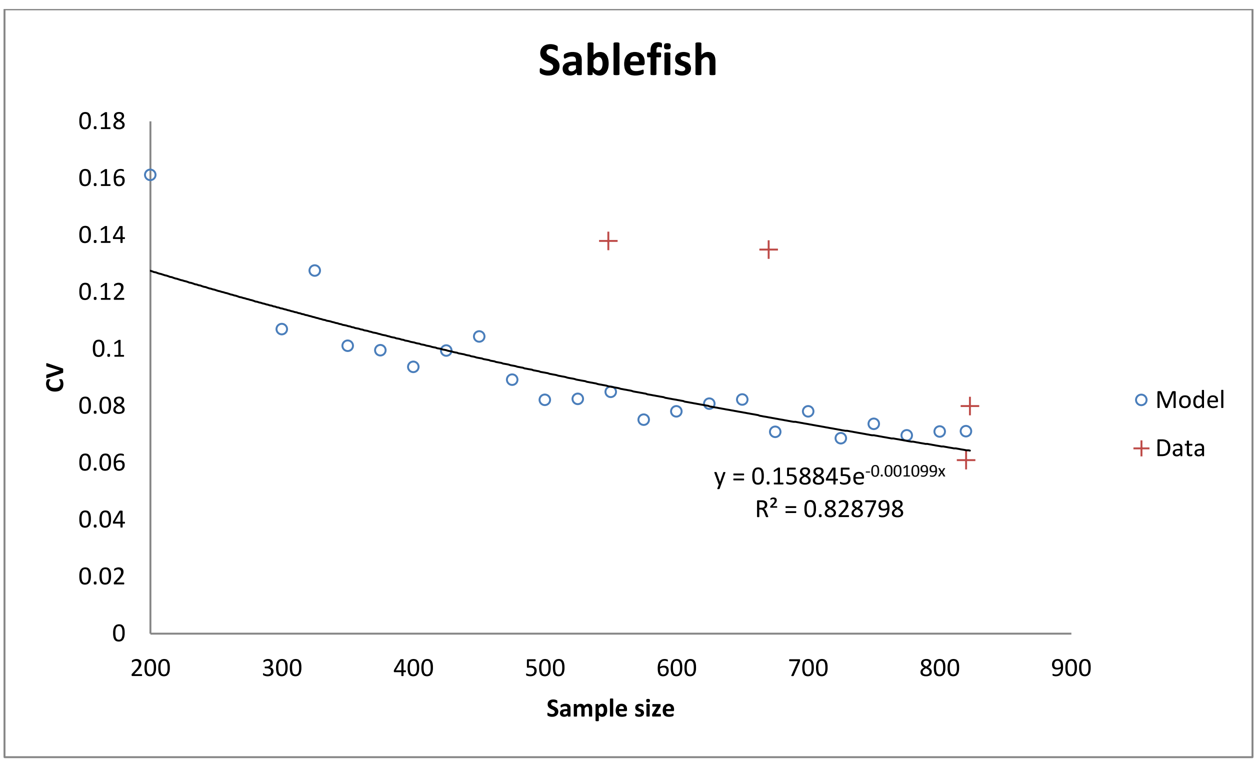

Figure 1j. -- Observed (2007-2013) and simulated CVs as a function of sample size for sablefish.

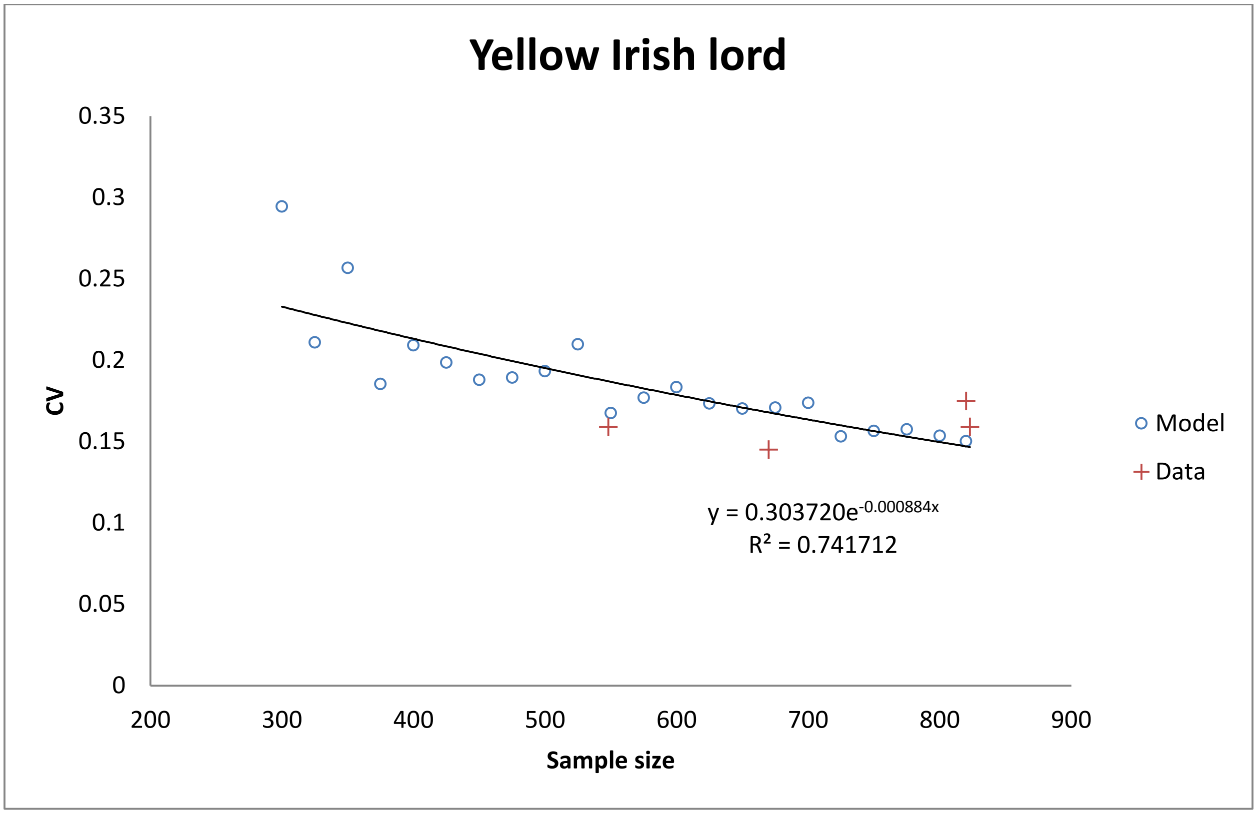

Figure 1k. -- Observed (2007-2013) and simulated CVs as a function of sample size for yellow Irish lord.

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291 GUYON, J. R., C. M. GUTHRIE III, A. R. MUNRO, J. JASPER, and W. D. TEMPLIN. 2015. Genetic stock composition analysis of the Chinook salmon bycatch in the Gulf of Alaska walleye pollock (*Gadus chalcogrammus*) trawl fisheries, 26 p. NTIS number pending.

290 GUTHRIE, C. M. III, HV. T. NGUYEN, and J. R. GUYON. 2015. Genetic stock composition analysis of the Chinook salmon bycatch from the 2013 Bering Sea walleye pollock (*Gadus chalcogrammus*) trawl fishery, 21 p. NTIS number pending.

289 GUYON, J. R., HV. T. NGUYEN, C. M. GUTHRIE III, J. BONNEY, K. MCGAULEY, K. HANSEN, and J. GAUVIN. 2015. Genetic stock composition analysis of Chinook salmon bycatch samples from the rockfish and arrowtooth flounder 2013 Gulf of Alaska trawl fisheries and the Gulf of Alaska salmon excluder device test, 19 p. NTIS number pending.

288 FAUNCE, C. H. 2015. Evolution of observer methods to obtain genetic material from Chinook salmon bycatch in the Alaska pollock fishery, 28 p. NTIS number pending.

287 ZIMMERMANN, M., and M. M. PRESCOTT. 2015. Smooth sheet bathymetry of the central Gulf of Alaska, 54p. NTIS number pending.

286 CAHALAN, J., J. GASPER, and J. MONDRAGON. 2014. Catch sampling and estimation in the federal groundfish fisheries off Alaska, 2015 edition, 46 p. NTIS number pending.

285 GUYON, J. R., C.M. GUTHRIE III, A. R. MUNRO, J. JASPER, and W. D. TEMPLIN. 2014. Extension of genetic stock composition analysis to the Chinook salmon bycatch in the Gulf of Alaska walleye pollock (*Gadus chalcogrammus*) trawl fisheries, 2012, 26 p. NTIS number pending.

284 HIMES-CORNELL, A., and K. KENT. 2014. Involving fishing communities in data collection: a summary and description of the Alaska Community Survey 2011, 171 p. NTIS number pending.

283 GARVIN, M. R., M. M. MASUDA, J. J. PELLA, P. D. BARRY, S. A. FULLER, R. J. RILEY, R. L. WILMOT, V. BRYKOV, and A. J. GHARRETT. 2014. A Bayesian cross-validation approach to evaluate genetic baselines and forecast the necessary number of informative single nucleotide polymorphisms, 59 p. NTIS number pending.

282 DALY, B. J., C. E. ARMISTEAD, and R. J. FOY. 2014. The 2014 eastern Bering Sea continental shelf bottom trawl survey: Results for commercial crab species, 167 p. NTIS No. PB2015-101255.