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of Alaska SeaLife Center (ASLC) Technical Report ASLC-0901

"Evidence for high natality rates among Steller sea lions in the Gulf of Alaska"

(Maniscalco, Hennen and Parker)

The ASLC authors are attempting to accomplish two things in this paper:

1. *To estimate the natality rate of naturally-marked female Steller sea lions (SSLs) observed on the Chiswell Island rookery in the eastern Gulf of Alaska (GOA).* The ASLC scientists used an ad hoc analytical method that does not properly take into account sampling biases inherent in the Chiswell study design. These biases are discussed in greater detail below. We reanalyzed the data in ASLC-0901 Appendix 1 using mark-recapture models specifically designed to estimate vital rates from the type of data (see attached report by D. Johnson). As a consequence, we estimate a natality rate approximately 10% lower than ASLC did, with a much wider confidence interval. We also see no justification to categorize stillbirths as live births. Eliminating stillbirths would lower the natality rate estimate slightly.
2. *To extrapolate the results of the Chiswell female natality study to the rest of the GOA SSL population.* The authors of ALSC-0901 assume that the Chiswell female group represents a random sample of all mature female sea lions in the Gulf of Alaska. As is explained in our detailed comments below and in the attached Johnson report, the natality rate calculated for the Chiswell females using the data in Appendix 1 is very likely higher than that of all mature female sea lions in the Gulf of Alaska. A fundamental part of the ASLC study is that in order to become part of the study population, a female sea lion had to be observed at least once at the Chiswell rookery where ASLC concentrated their observation effort. Adult females were not selected from haul-outs. Rookeries are where the vast majority of all sea lion births occur. Thus, Chiswell females have a higher probability of producing a pup than the average mature female in the GOA, and the ASLC observation effort is focused at a location where births are very likely to occur. Thus, it follows that to be included in the study population, a given female is very likely to be reproductive, and ASLC concentrated their observation effort at the location where she is likely to give birth. Females that are barren are not likely to become part of the study population. Furthermore, once entry into the Chiswell study population is noted, a female that does not breed or give birth in a particular year is not likely to be observed since she is less likely to appear on the rookery. Because of these sampling biases, it is not possible to estimate the average natality rate of mature female Steller sea lions in the GOA using the Chiswell data alone.

   The authors of ASLC-0901 attempt to apply the natality rate of the Chiswell group to the rest of the GOA by criticizing the methods of Holmes et al. (2007), who estimated a lower natality rate for female SSLs in the central GOA (west of the Chiswell Islands). The ASLC authors mischaracterize the methods of Holmes et al. (2007) in several significant ways (summarized below), but ultimately their criticism is unnecessary. There is considerable spatial variability in SSL population trends in the range of the western stock which the ASLC authors ignore, and contrary to their contention, there is *no* reason

not to suspect that there is local variation in vital rates. Local variation is particularly likely when the average natality rate at a single, relatively small and new rookery in the eastern GOA is compared to that of the entire central GOA SSL population that was modeled in Holmes et al. (2007). Compared with the single rookery analyzed in ASLC-0901, the modeled central GOA population in Holmes et al (2007) has five much larger rookeries and numerous haul-outs that collectively produce at least 24 times more pups than Chiswell Island.

Regarding their first objective, ASLC-0901 provides estimates of the natality rate of a select group of eastern GOA female Steller sea lions using an *ad hoc* method that has a number of limitations that can be avoided if standard mark-recapture models are used instead. The derivation of ASLC's equation 1 is not clear. This equation supposedly corrects the birth rate for the fact that sighting probability is biased toward the more productive females, but it is not clear how it was used to get the numbers in ASLC-0901 Table 1. In addition, $Be_{i,}$ the number of identified females who "belong" to the Chiswell population but gave birth elsewhere in year *i* (tracked by later observation of that animal with a pup, or a yearling), should be in the numerator of equation 1 as an addition; if the female is part of the Chiswell group and gave birth, the pup should count regardless of where it was actually born.

We used a full probability model to estimate Chiswell group natality rates that properly accounted for resighting probability and apparent survival (Johnson report). Apparent survival accounts for both the probability of surviving and the probability of *not* permanently emigrating from the Chiswell group (which are functionally equivalent in the analysis). For instance, the estimated natality rates in ASLC-0901 Table 1 do not account for females seen early in the 2003-08 period but are never seen again; these are the trailing blanks in the data in ASLC-0901 Appendix 1. If they are truly part of the Chiswell group, these 'unsighted' animals are much more likely to be unreproductive since they were not seen again at the rookery, while others may have died. Some may have permanently emigrated from the Chiswell group (and possibly reproduced elsewhere); in these cases, it is uncertain whether these females should be considered part of the Chiswell group but we have no more information about them.

Stillbirths and late term abortions are not live births and should be excluded from the analysis. The ASLC authors discuss how late-term abortions should be excluded, yet include still-births. It appears the only difference between them is that a stillbirth occurred on the Chiswells and was observed, while a late-term abortion occurred elsewhere and had a much lower probability of being observed. While it was possible to subtract stillbirths from the ASLC data, we conducted our reanalysis using the same assumption as in ASLC-0901.

The average natality rate estimated in the ASLC study is applicable only to the Chiswell study population and is not representative of all mature female Steller sea lions in the eastern GOA because:

1. *The Chiswell group of females is biased toward those likely to be reproductive*. Using primarily naturally-marked individuals initially identified at a rookery will inflate natality estimates, since females spending enough time at the rookery to be identified are more likely to be breeding or giving birth than females with lower natality rates. There are other females in the eastern GOA SSL population that do not breed regularly enough to be positively identified on the Chiswells and thus are far less likely to be observed at the Chiswell rookery during the breeding season.
2. *Effort to observe the reproductive state of identified Chiswell females is concentrated at the rookery.* By definition, if sighting effort primarily occurs where the vast majority of births occur, the observers are more likely to see breeding animals that gave birth to full term pups and less likely to see animals with lower reproductive rates.
3. *The data in ASLC-0901 Appendix 1 contain no information on female sea lions that never appear at the Chiswell rookery yet are 'mature' (old enough) and reside in the eastern Gulf of Alaska.* These females are likely to have a lower reproductive rate than those in the Chiswell study group because they have never been observed at the rookery, where the vast majority of breeding and births occur. As a consequence, the true natality of the eastern Gulf of Alaska population likely to use the Chiswell rookery is likely lower than both the AFSC and ASLC estimates. If a female is mature and breeds exclusively at another eastern Gulf of Alaska rookery (Seal Rocks or Fish Island), then they are not part of the Chiswell group at all and there is no information within the Chiswell data to estimate their natality. This third sampling bias precludes extrapolation of ASLC's or AFSC's Chiswell natality rate to the larger Gulf of Alaska Steller sea lion population; as such, it was inappropriate for the authors of ASLC-0901 to do so.

Regarding their criticism of the methods of Holmes et al. (2007), AFSC has the following comments:

1. *There is no evidence provided by ASLC for the hypothesized increases in female sightability and neonate pup mortality.* Regardless of spatial differences in population trends, the ASLC authors discount the conclusions of Holmes et al. (2007) regarding natality declines in the central GOA based solely on hypothetical increases in female sightability and/or increases in pup mortality rates. They speculate that female sightability changed due to regime shifts and greater prey availability now compared to the 70s, such that observers now see proportionally more females (they are hauled out more frequently or longer) since prey are supposedly easier to find. This then implies that while we perceive that the ratio of pups to non-pups has declined, ASLC argues that in fact it has remained constant, and that sightability has increased. There is also speculation that neonate pup mortality has increased due to an increase in storminess in late May through late June that killed pups and removed the evidence; this would also by itself give the impression that natality has declined. If there were evidence of increased neonatal mortality, it could explain an apparent decline in natality particularly if the

observations occurred after the pups had died. However, there is no evidence for either of these changes, and we are not aware of any that exist. The only data that apply to the issue of neonatal mortality are NMML's dead pup counts, which generally decreased as a proportion of live pups over this time period (with the exception of the rookery at Seal Rocks). Dead pup counts are admittedly coarse estimates of neonate mortality because of the potential for the bodies to be lost due to storms or scavengers. ASLC's claim that storms could take away the bodies or kill pups is plausible, but they provide no data to support their claim that storminess in late May through late June increased over the modeled time period, particularly in the central GOA where Holmes et al. modeled the SSL population. Instead, NMML's data suggest a density-dependent relationship between dead pups and population size, such that as rookery populations decreased, neonate pup survival increased (less chance of being trampled, perhaps). ASLC's statement that the leading cause of pup mortality is being washed away in high surf conditions may be true for the Chiswells, and it may also apply at Seal Rocks (perhaps due to high tides there rather than surf), but NMML has not observed this at Marmot and Ugamak where we have had field observes from late May through late July each year since 2000. The most recent paper on pup mortality in Steller sea lions suggests that an increase in pup mortality is not a likely cause of the lack of recovery in the Western stock (Maniscalco et al. 2008).

2. *If female sightability has increased, then the actual non-pup population decline in the GOA was greater than what NMML's counts indicate.* ASLC argues that we are currently seeing a larger proportion of the true population than we did before. If ASLC's assertions are true, then there were approximately 45% more sea lions in the central GOA in the 1970s, 1980s and early 1990s, and about 10% more in the mid-1990s than our counts would suggest; thus the decline was worse than we thought it was.

3. *If natality has remained 'high', why did the GOA population decline? We know based on our branding information that juvenile and likely adult survival has increased between the 1980s and the 2000s.* If natality has not changed as ASLC contends and survival increased, there is no reason the GOA population should have declined during the 1990s. Indeed, it was actually declining faster than our counts would indicate since ASLC contends that sightability was increasing.

4. *Holmes et al. did not use 2005 as an index of pup production for the entire 2000s.* They used non-pup and pup counts from 1998-2004 to estimate the best combination of 'step-changes' in vital rates necessary to fit the observed trends. 2005 was used only as an example later to test the model predictions against data not used in the model.

5. *Holmes et al. also did not use size differential to 'remove' juveniles from the population.* They used a time series of estimates of the proportion that were juveniles (1-3 years of age) as additional data to refine estimates of juvenile and adult survival. The proportion was scaled by a factor to account for including some adults in the 'juvenile' category. Using life history-based sex ratios (differences in survival of males and females) and sightabilities, they estimated the number of females alive at age and the number giving birth by changing vital rates to fit the time series of pup and non-pup counts.

6. *The logic on the bottom of page 13 and its relationship to the other criticisms of Holmes et al. in the rest of the paper are unclear.* ASLC claims that the 1970s collections of female SSLs were random, while the 1980s collections were biased toward reproductive animals. Despite this bias, the 1980s collections still showed a natality rate that was lower than the 70s, indicating that the true natality rate was lower still. Thus, ASLC argues that Holmes et al. over-estimated natality in the 1980s and under-estimated the natality decline between the 1970s and 1980s. However, for the period 1980s through the 2000s, ASLC claims that Holmes et al. did the opposite: they underestimated natality in the 2000s and over-estimated the natality decline. For the 1970s-1980s period, ASLC argues that Holmes et al. did not account for the biased 1980s collection methods, while presumably increases in female sightability and pup mortality (for which they provide no evidence) contributed to how Holmes et al. miscalculated natality changes in both time periods, but in opposite ways.
7. *Holmes et al. fit the life table for the 1970s by reanalyzing the original Calkins and Pitcher 1982 data that did not include the collections of Calkins and Goodwin 1988 (page 14).* The Holmes et al. life table was not designed to fit the 80s collection, only the 70s collection, which ASLC says was random. Holmes et al. tested their model predictions regarding the change in natality between the 70s and 80s by comparing them to the natality rates estimated from the 80s collection and found they were similar. However, ASLC argues here that Holmes et al. overestimated the 1980s natality rates because sampling in the 80s was biased and the actual natality was lower.
8. *On page 15, ASLC contends, with no evidence, that NMML's pup count methods are more likely to under-estimate than over-estimate pup production (or presumably even be accurate).* However, what is more important than accuracy is that there is no time trend in whatever bias there may be, such that pup counts in the 70s were more accurate, while those in the 80s, 90s, and 00s got progressively worse. This is the trend in pup-count accuracy that would be necessary to produce the declines in pup to non-pup ratios that drive the estimated natality declines in Holmes et al. Apparently, ASLC is suggesting in the conclusions that pup sightability bias may be on top of the female sightability and pup mortality trend issues that were discussed in the body of the paper. NMML believes that its pup counts provide a stable index of pup production albeit with counter error and there is no evidence that steadily worsening accuracy of the pup counts produced the observed declines in pup to non-pup ratios.
9. *ASLC contends that the sightability estimates used in Holmes et al. were biased because Holmes et al. used tagging data that were not adjusted for daylight hours.* Instead, ASLC presents an estimate of percent time on land (sightability) based on 'presence/absence' records. No details are provided on exactly how this calculation was done. The text would suggest that it is 'number of days sighted at least once' divided by 'total number of days'. This would grossly over-estimate the percent time on-land as it would count being sighted once as being on-land the whole day. In addition, the very high sightability estimates are not consistent with the degree to which SSLs engage in nocturnal versus diurnal feeding (calculated in other studies). ASLC's estimates would imply that SSLs are almost exclusively nocturnal foragers. Lastly, Holmes et al. used one estimate that was daylight adjusted – unfortunately, most studies only provided 24-hour estimates of percent time on-land.