Consummate and consumed predators:

Assessing killer whale predation on juvenile Steller sea lions in the Gulf of Alaska

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ABSTRACT (updated December 2011)

This project addresses **PCCRC Priority #1**, and was designed to allow us to directly quantify predation on juvenile Steller sea lions in the Gulf of Alaska. We have deployed newly developed, satellite linked Life History Transmitters in 36 juvenile Steller sea lions to date (December 2011). All animals except one were also monitored immediately after their release through conventional, externally attached short duration satellite tracking devices. We currently do not have any further new deployments pending or planned. However, we anticipate continuing the monitoring for LHX tag data return through at least December of 2014 through PCCRC (through 2012) and separate funding (through 2014). Life History Transmitters (LHX tags) allow the determination of individual animal survival and allow distinction of predation from non-traumatic causes of mortality, from satellite-transmitted post-mortems. Data returns from four of fifteen initial deployments proved the viability of the concept at the time of proposal submission. These early returns also suggested that predation by killer whales may be the single greatest cause of juvenile sea lion mortality, and that more than 50% of females may be consumed by predators before primiparity. To date we have detected 14 mortality events from the 36 deployments. At least 13 of 14 constitute predation events. Placing our preliminary findings into the context of a conceptual framework developed to integrate bottom up and top down effects, our data suggests the implications of this level of predation on recovery of the species may be profound. From the PCCRC, we had requested support for the continuation of satellite monitoring for LHX tag data returns for three years from April 2009 through March 2012.

PROJECT OBJECTIVES

The specific objectives of the work proposed here were to:

- **Quantify the predation proportion of juvenile Steller sea lion mortality, in the PWS – KF region of the Gulf of Alaska.**
- **Determine season (time of year) of greatest incidence of mortality and predation in juvenile Steller sea lions.**
- **Contribute to the testing of predictive powers of health and condition assessment parameters on individual survival.**
- **Contribute to the assessment of the proportion of female sea lions consumed by predators before primiparity.**

<u>Specific activities conducted:</u>

By the time of the original PCCRC proposal submission in the Fall of 2008, we had released 15 juvenile Steller sea lions with LHX tag implants, and had detected 4 mortality events. By the onset of PCCRC funding for satellite monitoring in April 2009 we had released a total of 21 juvenile Steller sea lions with LHX tag implants under NOAA SSLRI funding (including 6 still being tracked externally at that time), and we had detected 5 mortality events. Since the release of PCCRC funds and through December of 2011, we released an additional 15 juvenile Steller sea lions with funding from the Alaska SeaLife Center and the North Pacific Research Board. The most recent group of 4 animals was released in June of 2011. All 15 animals were released with dual LHX tag implants and 14 of the 15 received external satellite trackers. In total, 36 juvenile Steller sea lions were released with LHX between November of 2005 and December of 2011. Fourteen mortality events were detected during this time frame, of which 9 occurred after release of PCCRC funds. Sixteen of 18 tags from these 9 events successfully uplinked via the ARGOS system. In addition, we conducted 8 control tests using LHX tags deployed in carcasses of dead sea lions since April 2009. Fifteen of the 16 LHX tags from these carcass tests successfully uplinked via ARGOS. In summary, PCCRC funds have supported satellite tracking and data recovery fees for the external tracking of 20 animals (including a portion of the tracking time and fees for the 6 animals released between the submission of the proposal and the release of PCCRC funds), and for tracking and data recovery fees from 31 LHX tags (16 from animals, 15 from carcasses). This is a combined total of 51 satellite transmitters. All of these satellite tags had been previously purchased under NOAA SSLRI funds. Continued monitoring for ARGOS data returns through December 31st, 2011 brought the combined number of 'exposure days' (when subjects are at risk of mortality) to 30,269 days (20,059 under PCCRC funding). We have analyzed our data to provide updated contemporary vital rates for Steller sea lions in the eastern Gulf of Alaska, including specifically juvenile survival rates, the proportion of mortality by predation, and estimates of female recruitment.

SUMMARY OF RESULTS

Results as of January 2012. From November 2005 through December 2011 we monitored 30,269 exposure days from 36 juvenile Steller sea lions released with LHX implants and external tracking devices. LHX tags were surgically implanted under gas anesthesia as previously described (Horning & Mellish 2008). For all 36 animals post-surgical survival was confirmed beyond the 45 day study inclusion criterion previously established through a combination of external post-release tracking, re-sight confirmation using hot-iron brands, or LHX tag data (Mellish et al. 2007, Thomton et al. 2008, Horning & Mellish 2009). Mean post-release satellite tracking duration was 86 days (+/- 9.2 s.e.m., n=35). Mean confirmed post-surgery survival was 526 days (+/- 85.3 s.e.m., range 47 – 2072, n=36). 14 mortality events were detected during the study, to date. From the ratio of dual to single tag returns from n=14 carcass events (11 dual returns, 3 single returns) and n=9 carcass events (n=8 dual returns, 1 single return), we estimated LHX tag uplink failure probability at p=0.095 and mortality event detection probability for dual tag deployments at p=0.991 (for details see Horning & Mellish *In Press*). The corrected number of mortality events was estimated at 14.128 mortalities, but since animals cannot partially die this actually suggests that to date not a single event was undetected within the study group.

One of the 14 detected events yielded no data other than confirmation and date of mortality, due to a technical failure in the only tag of the implanted pair that successfully uplinked. The remaining 13 events yielded data. All 13 of these latter events were classified as acute death at sea by massive trauma, likely due to predation (for details and classification methods see Horning & Mellish 2009). To place these high levels of juvenile predation into context, we developed a density-dependent, qualitative conceptual population model for Steller sea lions (Horning & Mellish *In Press*). The two most recent events occurred in December of 2011. All four LHX tags from these two events are currently still transmitting, and data analysis from these four tags has not been completed yet. The summary results reported below are therefore still based on the 12 mortality events detected through November 30th, 2011, as reported in Horning & Mellish (*In Press*), except when indicated in parentheses.

Findings and Conclusions:

(1) Cumulative juvenile survival rates for ages 13 through 48 months was 0.472 (95% C.I. 0.38-0.54), (based on all 14 mortalities through December) in the study area and period (see Horning & Mellish *In Press* for calculation details). This rate is identical to control values supplied by the NMFS based on re-sights of n=255 animals branded in PWS in 2001, 2003 and 2005 (re-sights 2002-2008), supporting the notion that captivity, surgery or tags do not affect post-release survival within the data set. This cumulative survival rate is below pre-decline estimates and within uncertainties of peak-decline estimates for this age class for the nearby central Gulf of Alaska region (Holmes et al. 2007), suggesting that contrary to the hypotheses advanced by the referenced model, juvenile survival has not recovered to pre-decline levels in the Gulf of Alaska region (Horning & Mellish *In Press*).

(2) We used our data to provide an updated contemporary regional survivorship schedule, from which minimum natality can be estimated for conditions of stable or increasing populations, as is currently assumed. This schedule supports the natality estimate of at least 69% provided by Maniscalco et al. (2010) for the Chiswell Island rookery in our study area (see Horning & Mellish *In Press* for details).

(3) The contemporary regional proportion of mortality by predation for juveniles is >= 0.917 (95% C.I. 0.78 – 1.0) – see Horning & Mellish *In Press* for details.

(4) There is no distinct seasonality to when mortality or predation events occur - see Horning & Mellish *In Press* for details.

(5) The updated survivorship schedule combined with our estimate of the proportion of mortality by predation yields a contemporary estimate for female recruitment of 32%, with 61% of female pups that are born likely consumed by predators before reaching reproductive age (Horning & Mellish *In Press*).

(6) Our density-dependent model suggests predation as the single largest impediment to recovery of the population in the study region (Horning & Mellish *In Press*). The model further suggests the effect of predation on female recruitment as a key mechanism for constraining the potential population growth: from a modeled recruitment of 51% at the highest population densities, increasing predation pressure at lower densities may depress recruitment below 25%, in effect more than halving the reproductive potential of the population through predation without any changes in the birth rate amongst reproductively mature females (Horning & Mellish *In Press*).

Publications with PCCRC contribution:

Horning M, Mellish JE (*In Press*) Predation on an Upper Trophic Marine Predator, the Steller Sea Lion: Evaluating High Juvenile Mortality in a Density Dependent Conceptual Framework. PLoS ONE. *To be published and released January 17, 2012*.

Remarks and Requests:

We would like to request approval for using a portion of the remaining funds to defray publication costs, and for travel to cover attendance of the co-P.I. M. Horning at the annual meetings and the AMSS in Anchorage in January of 2013. We have chosen to publish our findings in PLoS ONE, a highly rated, peer-reviewed Open Access journal. We believe it is advantageous to publish our main findings in Open Access journals to enhance availability of our results to the lay public. However, the Open Access model requires authors to cover publication fees (ranging from approximately $1k to $3k per publication, depending on the journal). No additional funds are requested, we are only request a re-allocation of remaining funds (approximately $5,500 plus $5,000 pending final installment) within the existing budget.

We also request that this annual report not be distributed to the general public until after January 17th, 2011. This is because the report contains some data and findings from our upcoming PLoS ONE publication, which is under a press embargo until 5p.m. (EST) on January 17th 2011.

TIMELINE (updated December 2011)

April 2009: First installment of PCCRC funds ($5,000) awarded.

October 2009: Support for ARGOS fees begins.

January 2010: Presentation by M. Horning to PCCRC annual meeting in Anchorage.

April 2010: Second installment of PCCRC funds ($5,000) awarded.

November 2010: Annual report to PCCRC.

January 2011: Presentation by J. Mellish to PCCRC at annual meeting in Anchorage.

April 2011: Anticipated third and final installment of PCCRC ($5,000) to be awarded (pending as of January 2012).

January 2012: Annual report to PCCRC and presentation at annual meeting in Anchorage. Peer-reviewed publication of PCCRC-supported data in PLoS ONE.

January 2013: Final report and presentation to PCCRC at annual meeting in Anchorage.

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