• Updated results through July 31st 2012 (Nov 2011)
• Clarify intent of PLoS ONE model
• Present one additional model output
METHODS

**Life History Transmitters – LHX tags**

- Life-long implants that monitor vital signs

- *Post-mortem* satellite-linked data retrieval

- *Known fate data* w. spatio-temporally unlimited re-sight effort

- 2 tags per animal to increase and determine event detection probability

- Determination of causes of mortality from temperature, light and dielectric sensors
  *Predation vs other causes*
  (Horning & Mellish, Endangered Species Research 2009)
The impact of predation on Steller sea lions in the Gulf of Alaska

**Timeline**

**METHODS**

- 36 (8f + 28m) weaned sea lions (age 13-25 months) released with LHX tags from 2005 through 2011
  
  *(Mellish et al. Aquatic Mammals 2006)
  Horning et al. BMC Veterinary Research 2008)*

- > 34,000 exposure days monitored through July 2012 (29,500)

- 10 carcass simulations (9)
The impact of predation on Steller sea lions in the Gulf of Alaska

CONTROLS

• LHX tags - *studies in quarantined captivity @ASLC*: low morbidity, zero mortality, **full recovery in 45 days**

• Survival confirmed >45d for all released animals

• No differences in dive behavior from LHX tags or captivity
  (Mellish et al., JEMBE 2007; Thomton et al., ESR 2008)

• $P_{detect} > 0.98$ (carcass simulations & live returns) (0.99)
  $\rightarrow$ **likely no mortalities undetected in study group**
  (Horning & Mellish, PLoS ONE 2012)

• No differences detected in survival to brand re-sight controls (NMFS) - **Survival ages 1-5 years (1-3):**
  LHX 0.413 (0.26 – 0.64)
  NMFS 0.413 (0.27 – 0.55)
  *(updated from Horning & Mellish, PLoS ONE 2012)*
The impact of predation on Steller sea lions in the Gulf of Alaska

**RESULTS**

- **16 mortalities detected** (12) from 14 mo to 4.1 yrs age
- **All 14 events with data** (11) were due to predation (circles)
- None near rookeries, only 1 in summer
- Predation risk is highest for 12-24 months (after weaning) and declines for older animals
  
<table>
<thead>
<tr>
<th>Age Range</th>
<th>Predation Risk</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-23</td>
<td>41.5%</td>
<td>(17-63)</td>
</tr>
<tr>
<td>24-35</td>
<td>16-20%</td>
<td>(3-35)</td>
</tr>
<tr>
<td>36-47</td>
<td>5.4%</td>
<td>(0-16)</td>
</tr>
<tr>
<td>48-59</td>
<td>7.4%</td>
<td>(0-22)</td>
</tr>
</tbody>
</table>

Where did this happen? What happened, and where?

M Horning & J Mellish
Oregon State University & Alaska Sea Life Center
The impact of predation on Steller sea lions in the Gulf of Alaska

**RESULTS**

- At least 3 in 14 predation events *could* be attributed to Pacific sleeper sharks.
- *Lamnid* sharks (white shark, salmon shark) are 8-16°C above ambient.
- Most of the other 11 events were likely transient killer whales.

**What predators?**

- Pacific sleeper sharks
- Lamnid sharks
- Transient killer whales

---

M Horning & J Mellish
Oregon State University & Alaska Sea Life Center
RESULTS

Updated contemporary survival schedule for region: (survival rate for each year-class – by sex)

- Cumulative juvenile survival rates (12-60 months) 0.413 (0.26 – 0.64) controls = 0.413 (0.27 - 0.55) do not support hypothesized recovery and still appear below pre-decline rates

BUT: age-bias and gender balance!

- Holmes et al. 2007 (females!):
  Pre-decline estimate: 0.64
  Peak decline estimate: 0.36 (0.33-0.40)
  Modeled post-decline: 0.61 (0.59-0.66)
Updated contemporary *survival schedule* for region: *(survival rate for each year-class – by sex)*

- **50.3%** of females born are consumed before primiparity
  **32.7%** survive to primiparity

- Survival schedule supports *natality* $\geq 0.69$
  *(Maniscalco et al. *PLoS ONE* 2010)*
  for a steady or increasing population

- We find no support for the hypotheses advanced by Holmes et al. (Ecol. Appl. 2007) of recovered juvenile survival, and depressed natality – *right now, in this region*. 
A density-dependent *qualitative* model using the updated survival schedule to evaluate:

- How may predation be linked to the reproductive output of the population?
- How would that affect other vital rate metrics and the population trajectory?
The impact of predation on Steller sea lions in the Gulf of Alaska

THE MODEL

Conceptual predation model

Modified birth-pulse *Leslie Population Matrix* using updated contemporary survival schedule

No fecundity schedule, not time variant!

3 key assumptions:

- Constant natality! *(held at 0.69)*
- Non-predation mortality held constant
- *Age-structured* consumption by predators *varies with density*!
Assumptions:

- Age structured, density dependent consumption of sea lions! As there are fewer sea lions, predators shift to eating more younger animals!
The impact of predation on Steller sea lions in the Gulf of Alaska

**THE MODEL**

**THE INTENT OF THE MODEL**

- Pup difference = *Potential trajectory*, matches decline data <70%
- J/T matches retrospective analysis (Holmes et al. 2003, 2007)

*ONLY to support age structured, density dependent predation idea!*

- Female recruitment **cut in half** without any changes in natality
- P/nP is lowest at fastest drop in density
The impact of predation on Steller sea lions in the Gulf of Alaska

CONCLUSIONS

• Predation *could* effectively reduce the reproductive potential of the population by 50% @ const. natality

• Even theoretical natality = 1 would only shift equilibrium density from current 20% to 30%

• Predation may be biggest constraint on the recovery of the species in the region

• Escape from ‘*predation-driven productivity*’ pit may only be possible at reduced predation
CONCLUSIONS

• Our findings apply to the present time and the Gulf of Alaska only

• With predators focus on juveniles, population age structure has to change as sea lion density changes. *This is not accounted for in Holmes et al. model.*

• Recruitment, potential trajectory and P/nP are *all* linked to and affected by predation and how it might change with density. *This is also not accounted for in Holmes et al. model.*

• Holmes et al. 2007 model predictions are unrealistic within GOA and certainly outside

• P/nP is a poor estimator of birth rates
The impact of predation on Steller sea lions in the Gulf of Alaska

Thank you to:

- Vets: Marty Haulena, Pam Tuomi, Carrie Goertz
- Support: ASLC capture and husbandry teams
- OSU students: Norma Vazquez, Stephen Meck
- Ships: MV Norseman I & II crew
- LHX tags: Wildlife Computers Inc, Redmond, WA

Funding: NPMRP, PCCRC, NOAA SSLRI, ASLC, NPRB

Permits: NMFS # 1034-1685; 881-1668; 881-1890, 14335, 14336
Gradual cooling:

- allows estimation of mass at time of death (Horning & Mellish, ESR 2009)
- with delayed light, air, uplinks: death by disease, starvation, entanglement, drowning...

![Graph showing temperature over time for different masses of carcasses.](image-url)