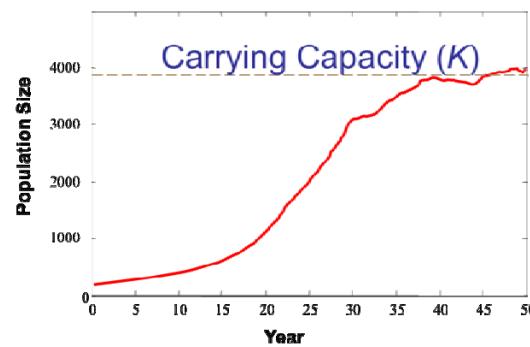


Sea Otters

History, Population Structure & Demography,
Threats, Trends and Status Relative to K:
California, Washington, and Southeast Alaska

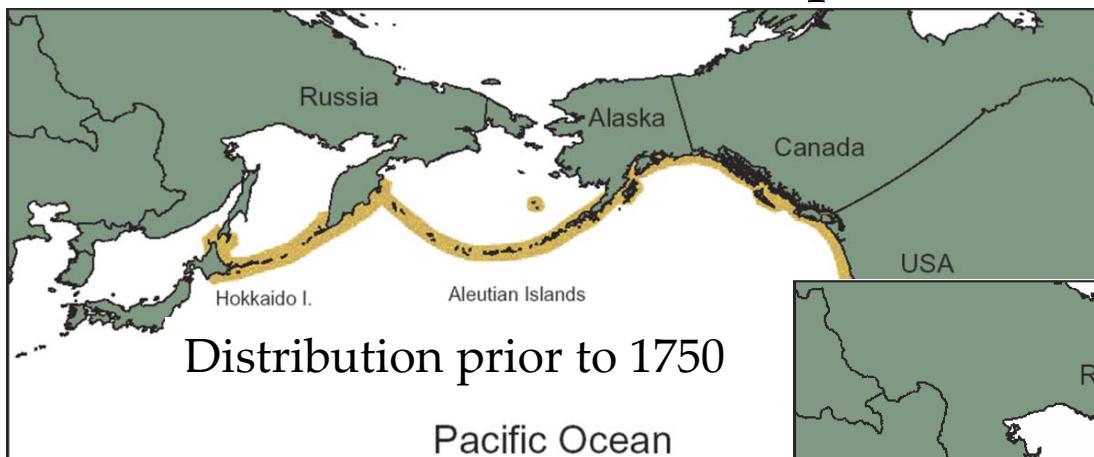
M. Tim Tinker^{1,3}, Deanna Lynch², James Bodkin³,
Brian Hatfield³, Joe Tomoleoni³ and Lilian Carswell⁴

1. UC Santa Cruz Dept. Ecology & Evol. Biology, and Nhydra Ecological Consulting
2. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office
3. U.S. Geological Survey (Alaska Science Center and Western Ecological Research Center)
4. U.S. Fish and Wildlife Service, Ventura California Office

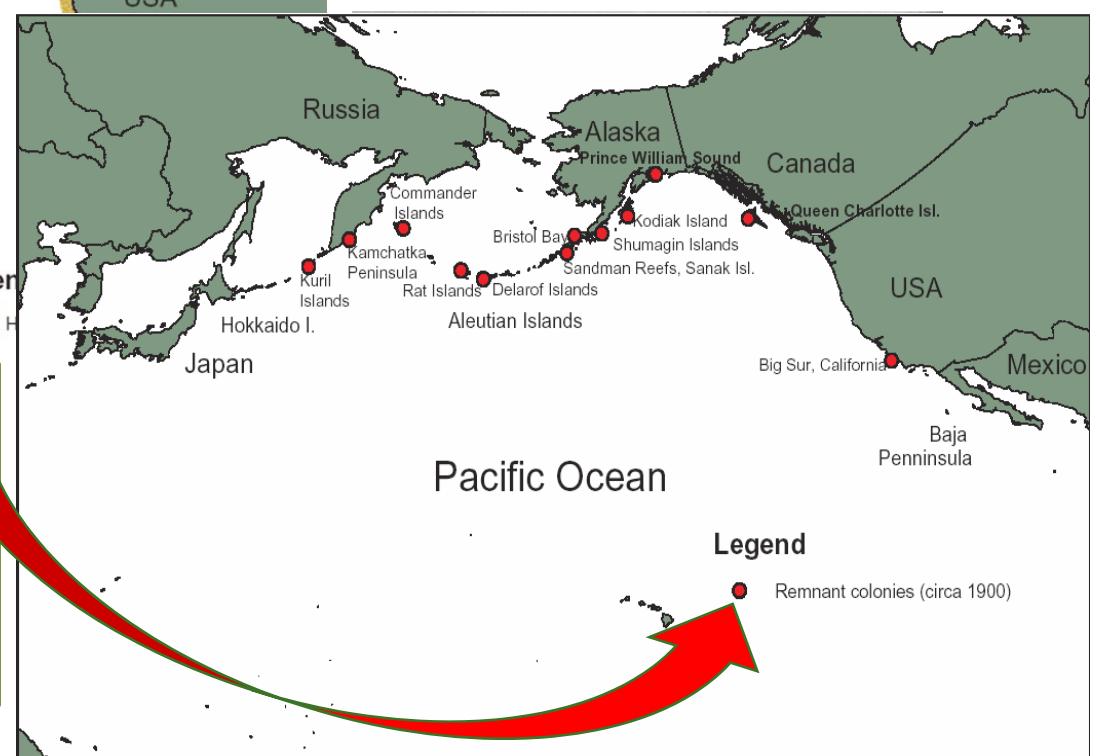


Overview: History of Sea Otters, NE Pacific

- Fur trade had catastrophic effect on all sea otter populations



Between 1750 and 1911....

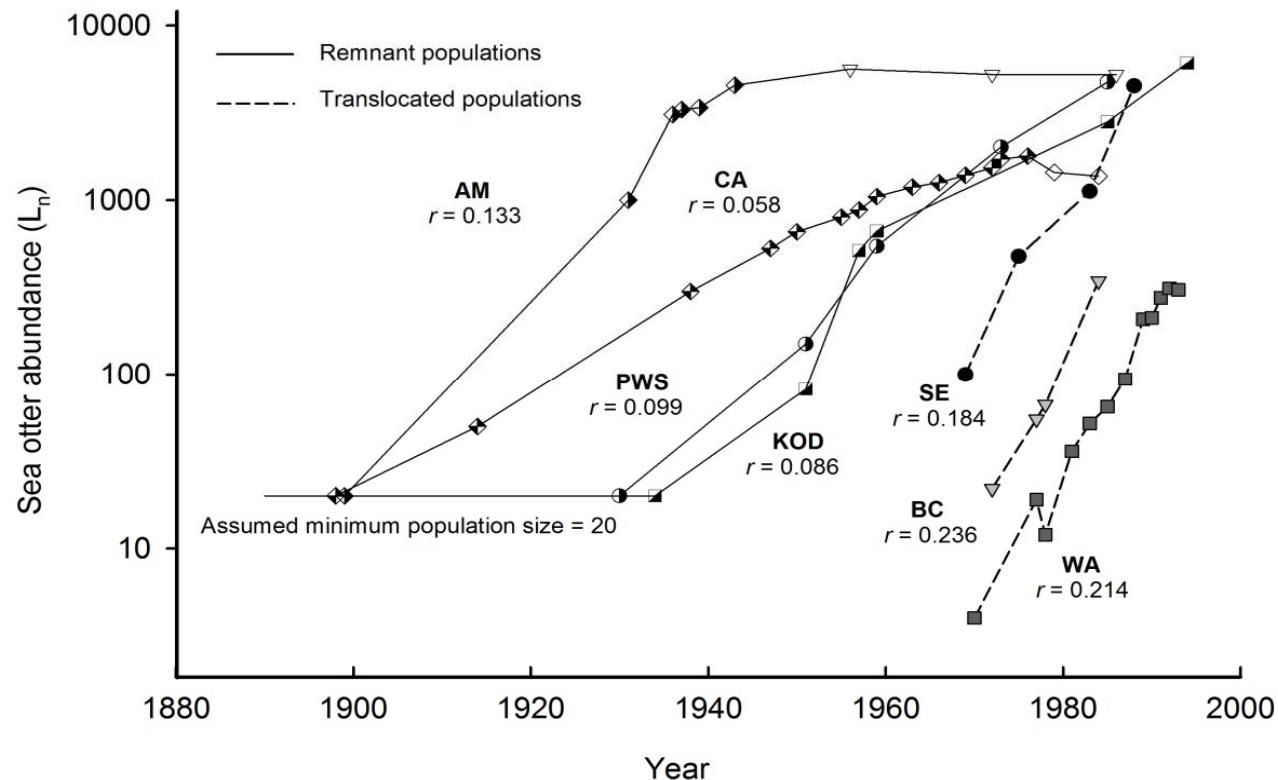


Recovery (piecemeal) over 20th century



Bodkin, J. L. 2015. Chapter 3 - Historic and Contemporary Status of Sea Otters in the North Pacific. Pages 43-61 in J. L. Bodkin, G. R. Vanblaricom, and S. Larson, editors. Sea Otter Conservation. Academic Press, Boston.

Mystery: Variable rates of recovery

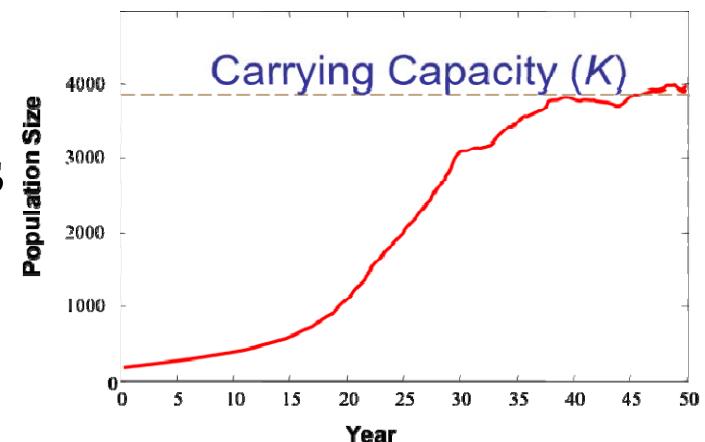


Mystery reflected a mis-understanding of scale,
and confusion over what a “sea otter population” was...

Bodkin, J. L., B. E. Ballachey, M. A. Cronin, and K. T. Scribner. 1999. Population demographics and genetic diversity in remnant and translocated populations of sea otters. Conservation Biology 13:1378-1385.

Overview: Population Structure & Demography

- Population growth & regulation in sea otters: carrying capacity (K) determined by prey resources
 - * *occasionally other factors*
- Question: what is relevant scale?
- Adult sea otters have small home ranges and limited dispersal
- Sea otter populations are regulated **locally**, due to
 - high site fidelity of females
 - fine-scale variation in abundance of invertebrate prey



Overview: Population Structure & Demography

How we used to think about regional sea otter populations:

Population grows rapidly at low density (max growth rate " r_{max} ")

Population growth slows at high density, " K " occurs at scale of entire region (e.g. California, SE Alaska)



WRONG!

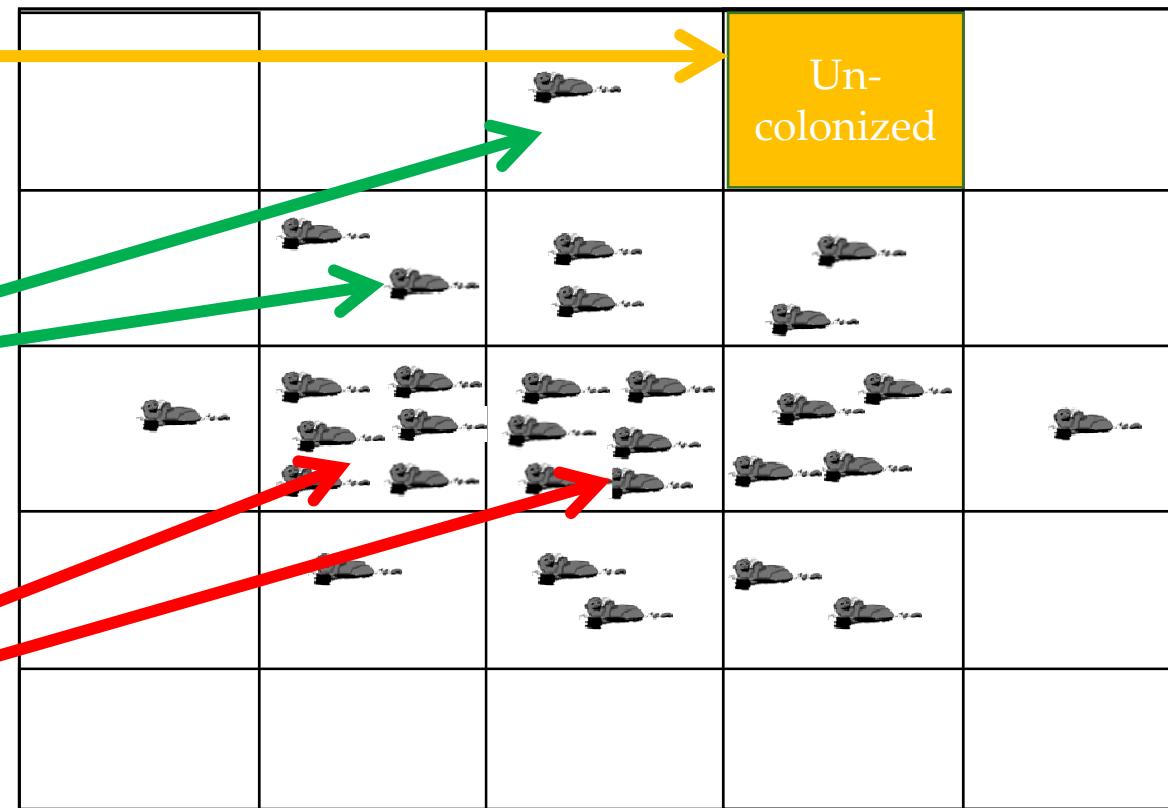
Overview: Population Structure & Demography

How we *now* think about sea otter population dynamics:

Un-colonized habitat:
rate of colonization
depends on mobility

Recently colonized
sub-populations,
high growth rate
(“ r_{max} ”)

Long-established
sub-populations,
at “K”: population
regulation occurs
at local scales



Spatially structured population (meta-population)

Summary: Population Structure & Demography

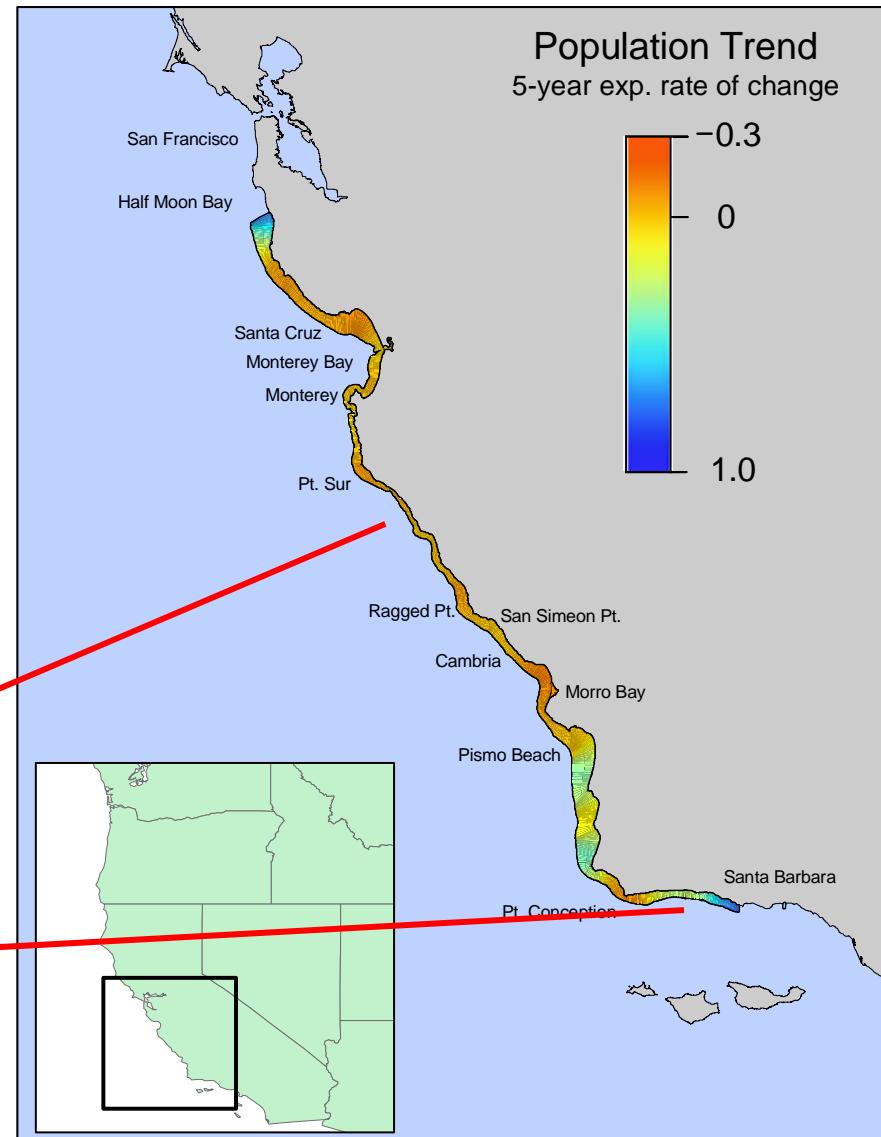
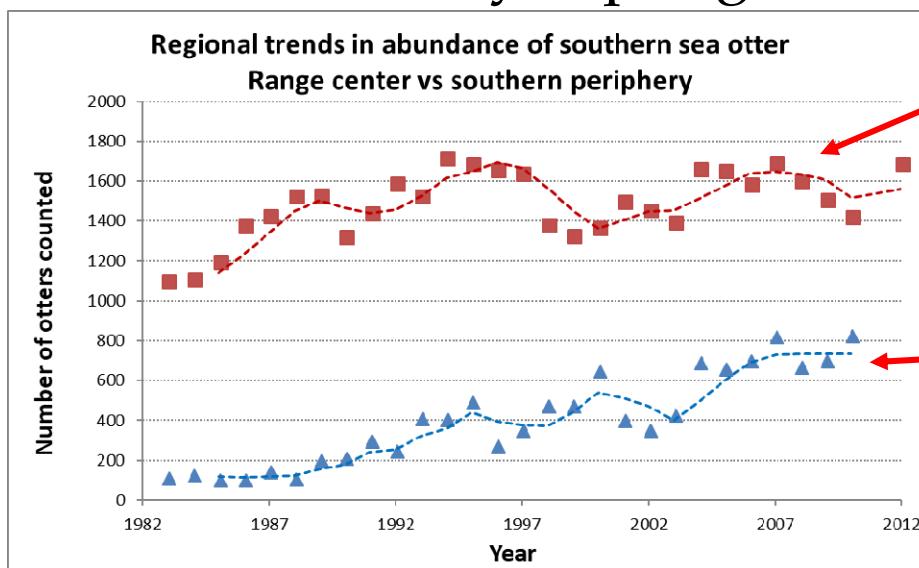
- Small-scale demographic structure supported by tagging studies and by recent genetic analyses (see Gagne et al 2018, Evolutionary Applications)
- Relevance for conservation and management:
 - population regulation occurs locally, not regionally
 - K density varies by habitat and prey productivity
 - Non-density-dependent threats (predation mortality, oil spills, fishing entanglements, harvest) can also have very strong local effects



© Nicole LaRonde

Recent Trends & Threats in California

- Variation in growth rates across range, pre-2013:
 - at range center, higher density & low growth: sub-pop's close to K
 - at range peripheries, low density/rapid growth



Status at range center vs peripheries

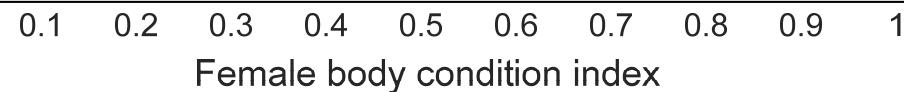
- In addition to survey data, several indices suggest that otters in range center are food-limited, at “K”

Survival vs. Condition, Female

Activity budgets, body condition, survival suggest nutritional limitation: also, increased dive depth/duration in range center (Thometz et al 2016), and higher rates of “end lactation” mortality in females (Chinn et al 2016)

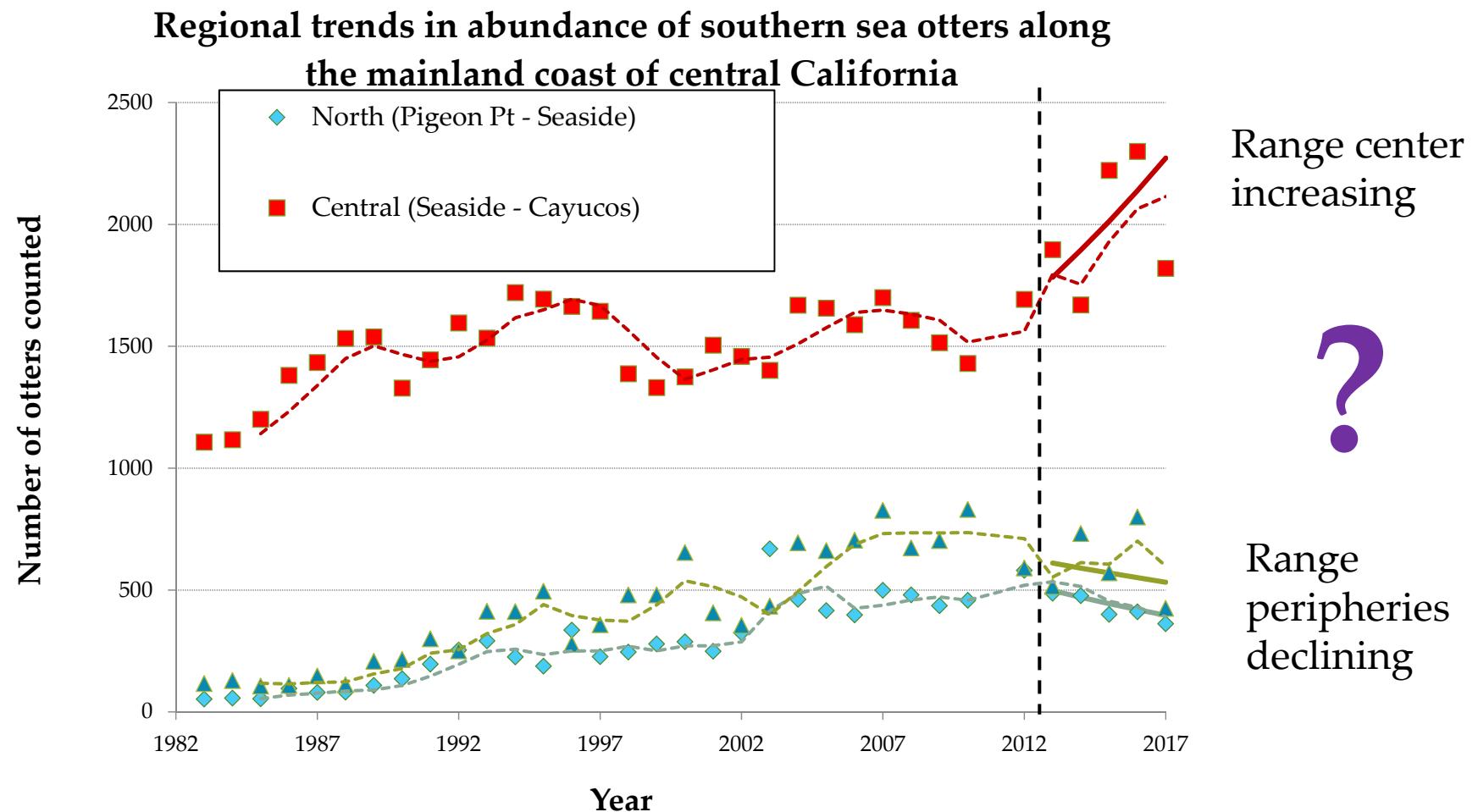
Thometz, N.M., Staedler, M.M., Tomoleoni, J.A., Bodkin, J.L., Bentall, G.B., Tinker, M.T., 2016. Trade-offs between energy maximization and parental care in a central place forager, the sea otter. *Behavioral Ecology*, 27(5): 1552-1566

Chinn, S. M., M. A. Miller, M. T. Tinker, M. M. Staedler, F. I. Batac, E. M. Dodd, L. A. Henkel. 2016. The High Cost of Motherhood: End-Lactation Syndrome in Southern Sea Otters. *Journal of Wildlife Diseases*, 52(2):307-318. doi: 10.7589/2015-06-158



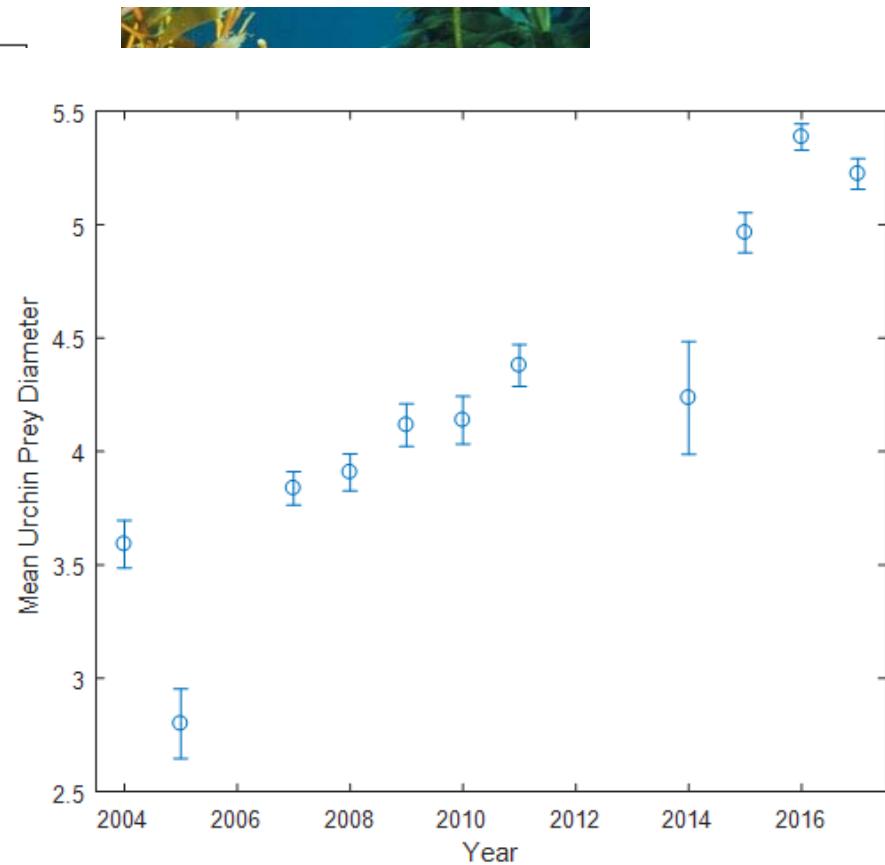
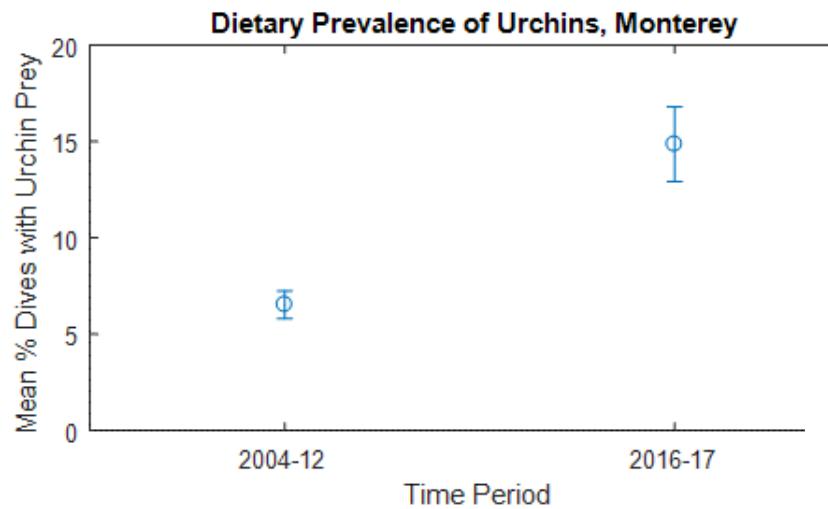
Tinker, M. T., J. Tomoleoni, et al. 2017. Southern sea otter range expansion and habitat use in the Santa Barbara Channel, California. USGS Open File Report 2017-1001, Reston, VA.

Last 5 years, trends have changed..



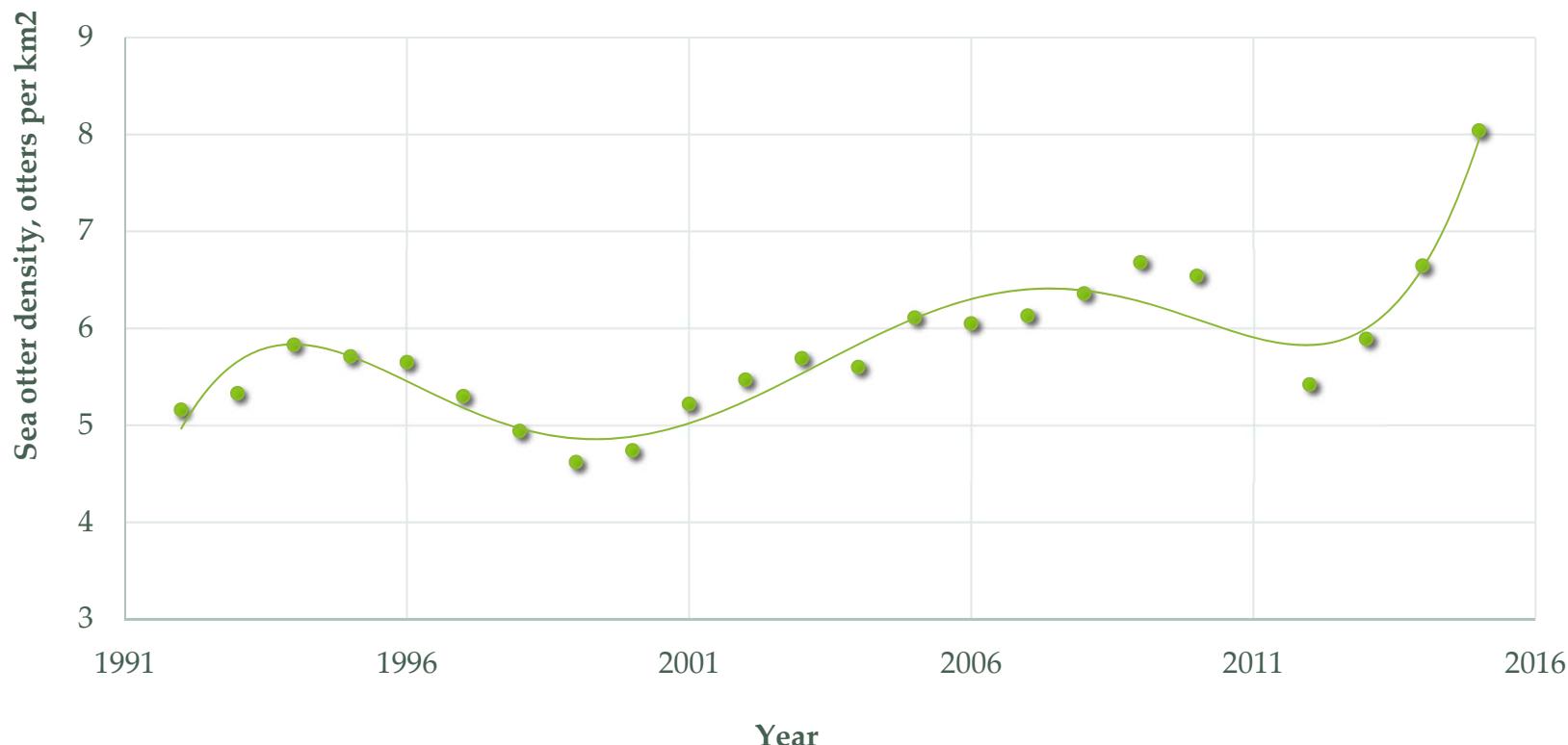
Tinker, M.T., and Hatfield, B.B., 2017, California sea otter (*Enhydra lutris nereis*) census results, spring 2017: U.S. Geological Survey Data Series 1067, 9 p., <https://doi.org/10.3133/ds1067>

In Range center, unexpected food subsidy: urchin boom starting 2013

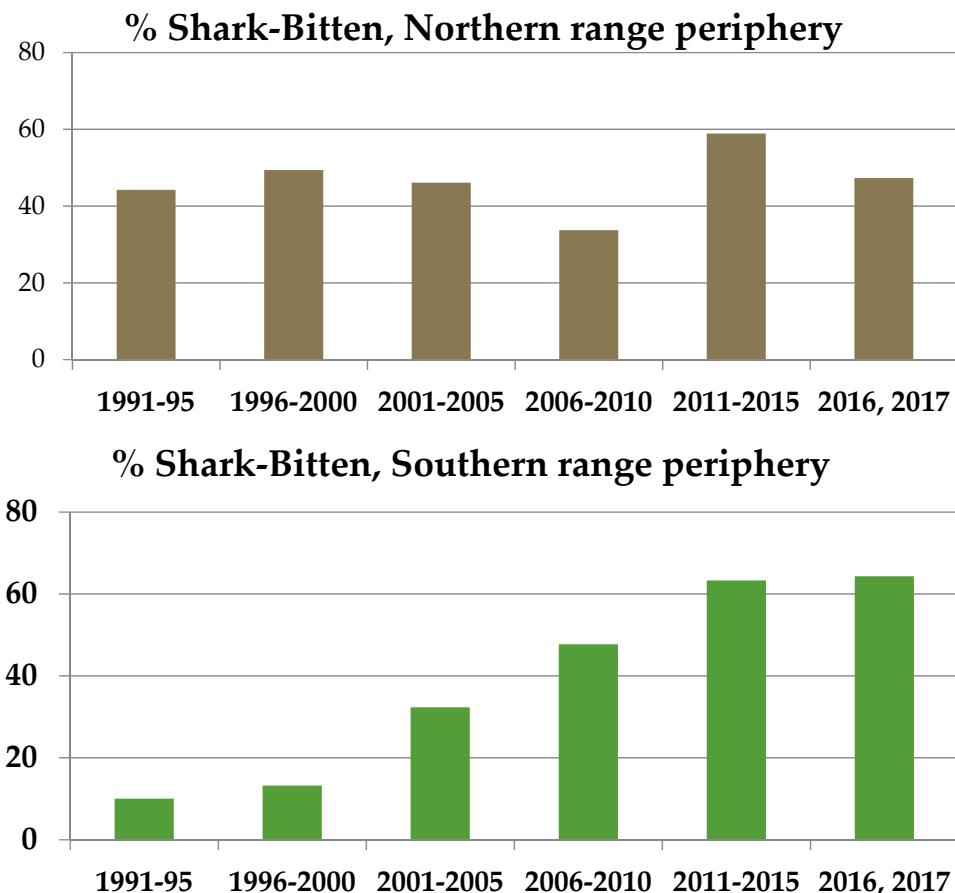
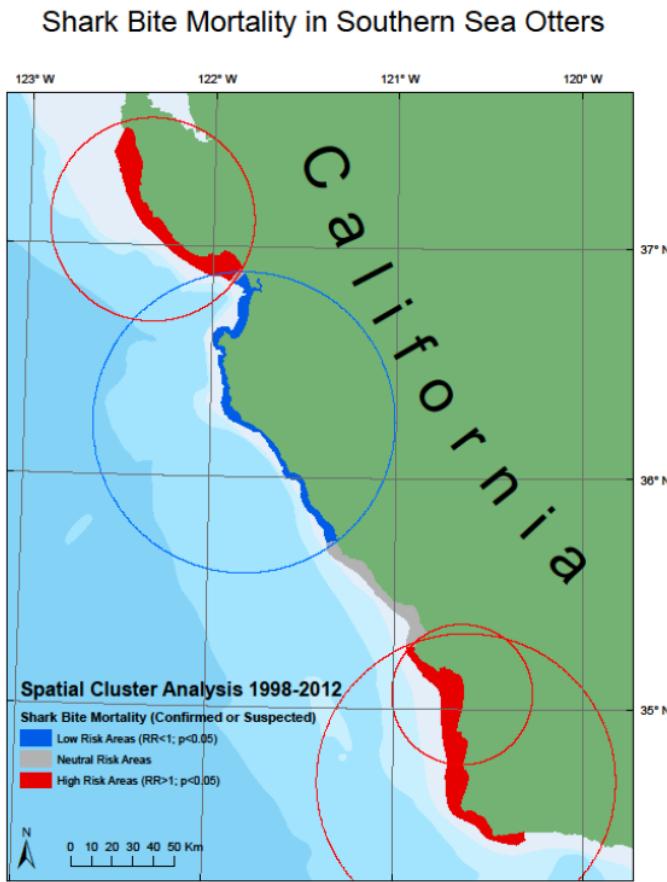


In Range center, unexpected food subsidy: urchin boom starting 2013

Uptick in sea otter density, Monterey:
increased juvenile survival (“urchin millennials”)



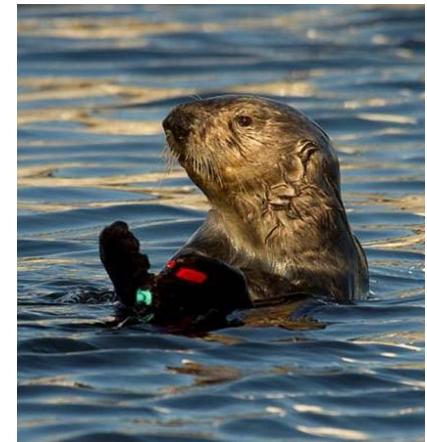
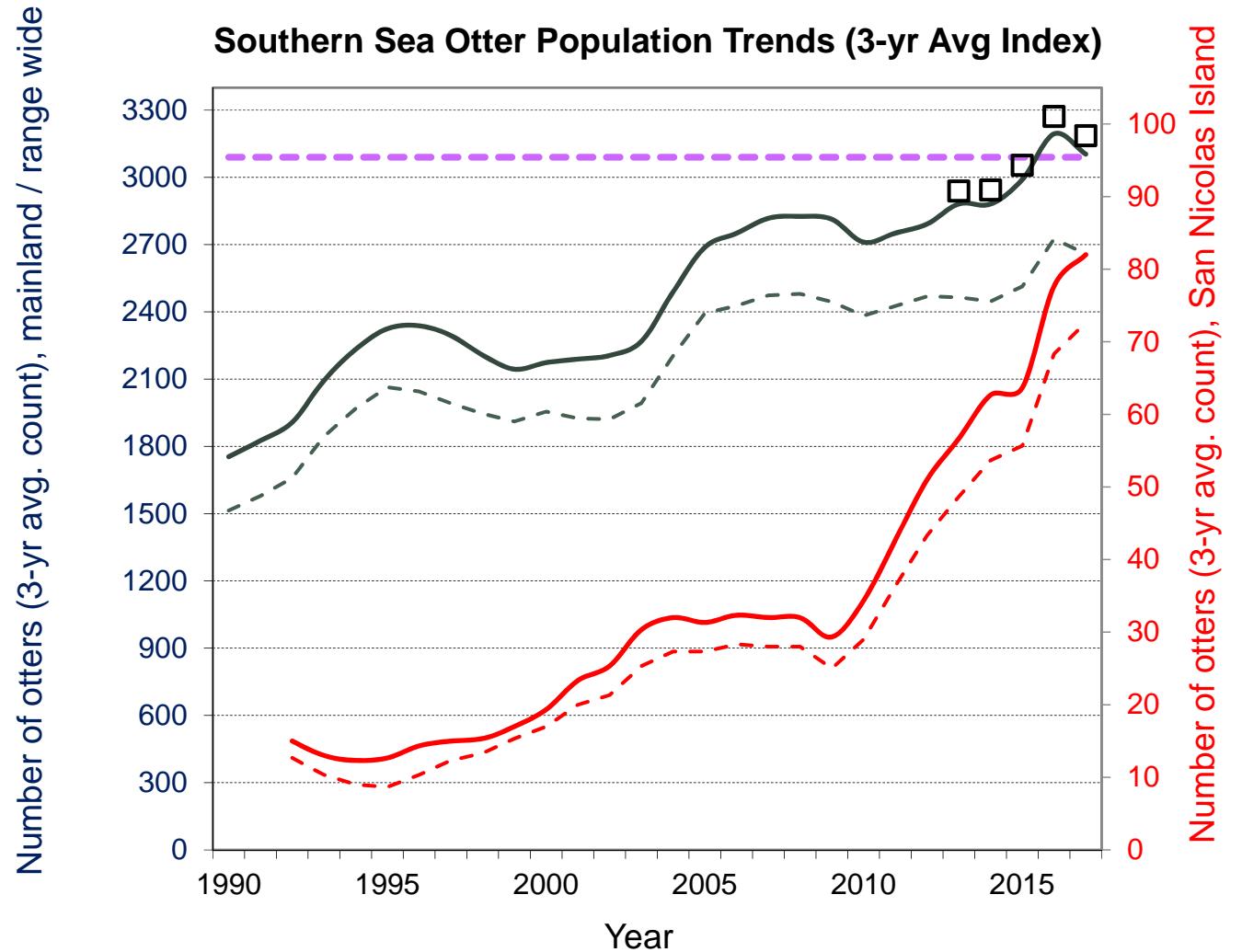
At range peripheries, shark-bite mortality is limiting growth/expansion



Tinker, M. T., B. B. Hatfield, M. D. Harris, and J. A. Ames.
Marine Mammal Science 32:309-326.

Hatfield, B. B., M. D. Harris, J. A. Ames, M. T. Tinker, and C. Young. 2017. Summary of stranded southern sea otters, 1985-2016: U.S. Geological Survey data release, <https://doi.org/10.5066/F71J98P4>.

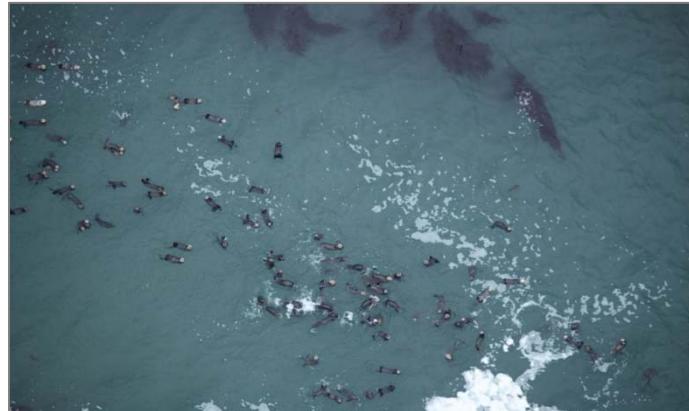
California Summary



- Total CA wide index
- - - Delisting Threshold
- Mainland Total
- - - Mainland Independents
- San Nicolas Total
- - - San Nicolas Independents

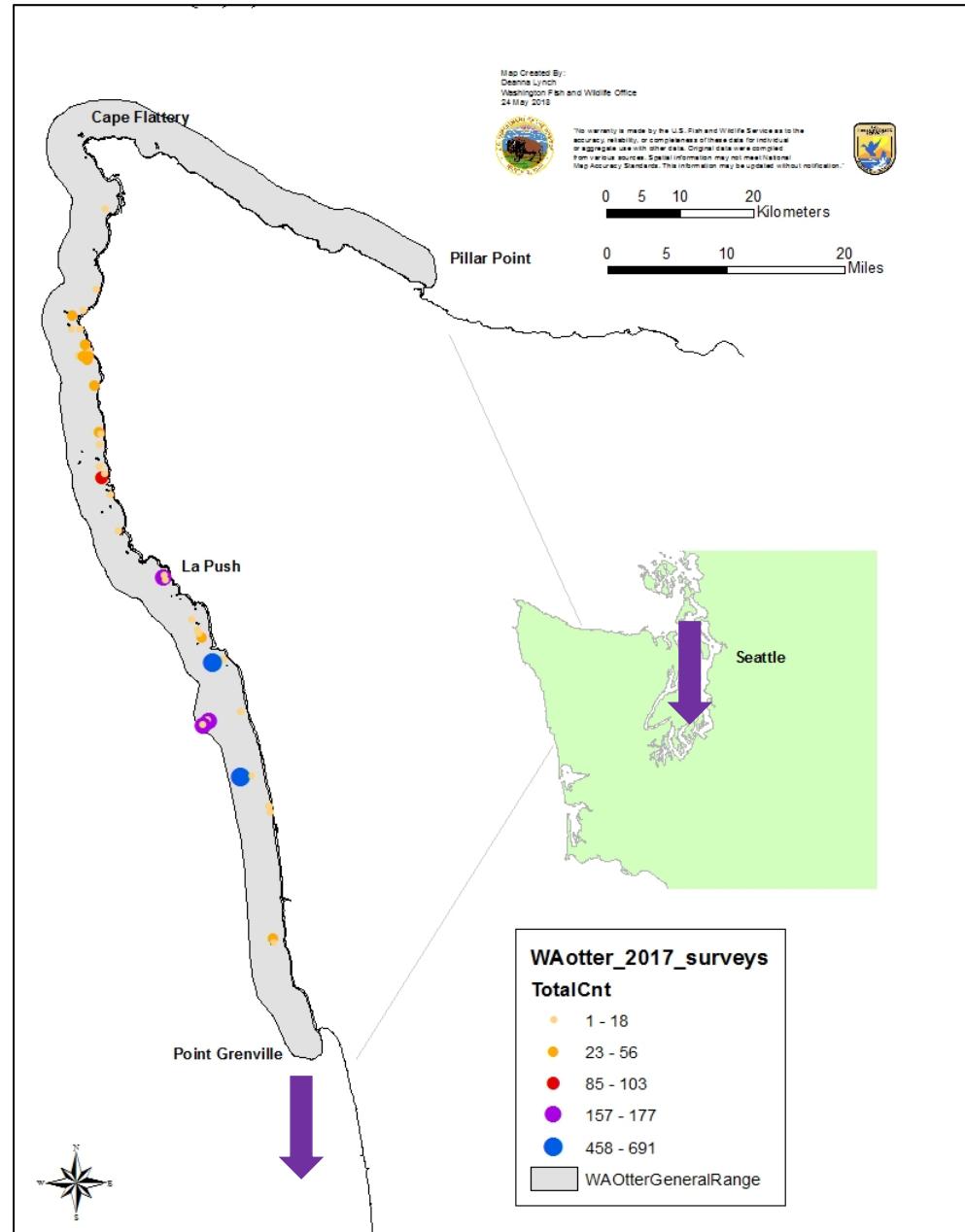
Tinker, M.T., and Hatfield, B.B., 2017, California sea otter (*Enhydra lutris nereis*) census results, spring 2017: U.S. Geological Survey Data Series 1067, 9 p., <https://doi.org/10.3133/ds1067>

Washington Primary Range



Credit: Sue Thomas, USFWS

↓ Individual sea otters sightings reported south to Newport, OR and east into Puget Sound



Population Estimate & Trend



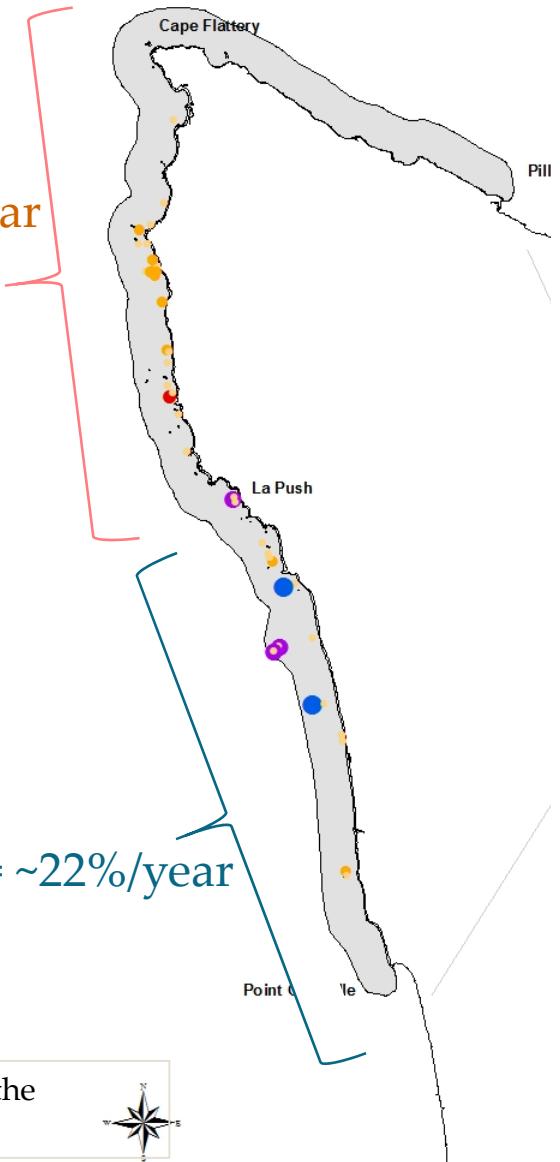
Growth = ~5%/year

Growth = ~9.5%/year 2,058 otters

Growth = ~22%/year

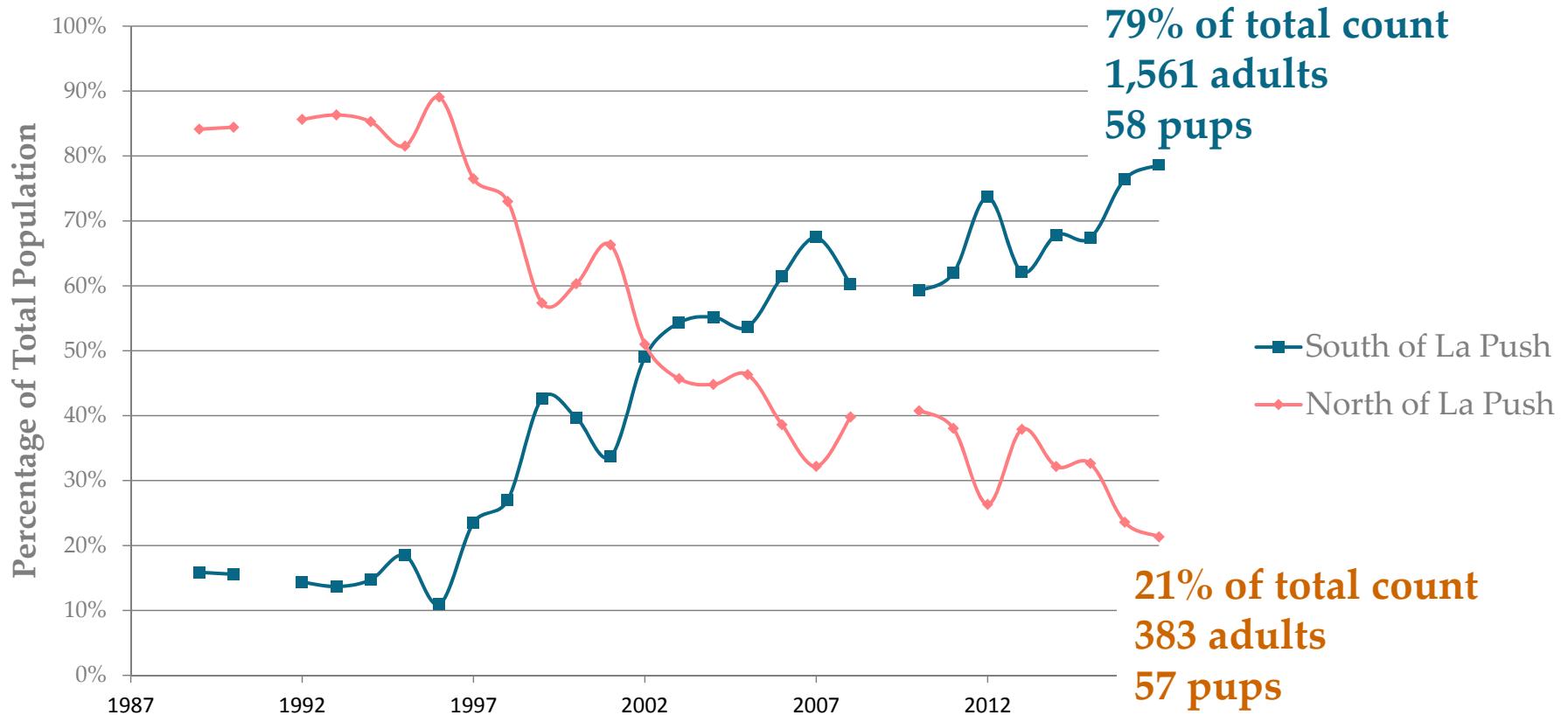


Jeffries, S., D. Lynch, S. Thomas, and S. Ament. 2017. Results of the 2017 Survey of the Reintroduced Sea Otter Population in Washington State. WDFW. 12 p.



Distribution within Primary Range

- Unequal distribution across range
- More otters/rapid growth; higher density?
- Pups produced in the north?



Distribution south of La Push

- Large Rafts: 685 adults, 39 pups
- Open Water
- Males, females, and pups



Credit:: Steve Jeffries, WDFW

Carrying Capacity

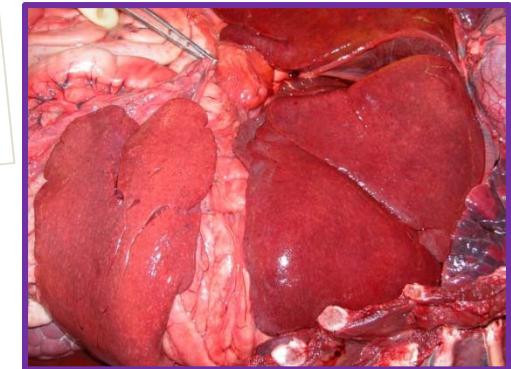
- No viable estimate of K
- Previous estimates: Laidre et al. 2002, 2011
 - Relied on otter WA population estimates from 1 habitat type (Rocky) taken before areas reached K
 - Used CA density estimates for sandy/mixed habitat types
 - Do not account for exponential growth in sandy/mixed habitats
- Research Needs
 - Prey availability
 - WA-specific densities for all habitat types
 - Why not expanding range southward or into Straits of Juan de Fuca?



Causes of Mortality 2002-2017*

Parasitic - *Sarcocystis neurona*
Toxoplasma gondii,
dual infections

> 50% of otters
examined
(2002-2017)



Bacterial – Leptospirosis, septicemia

Viral - Morbillivirus (canine)

Other - Oiling, Drowning, Birth complications,
Pneumonia, Severe head trauma,
Shark bite, Gunshot,
Poisoning (domoic acid, PSP)
Cardiac disease, Hepatitis



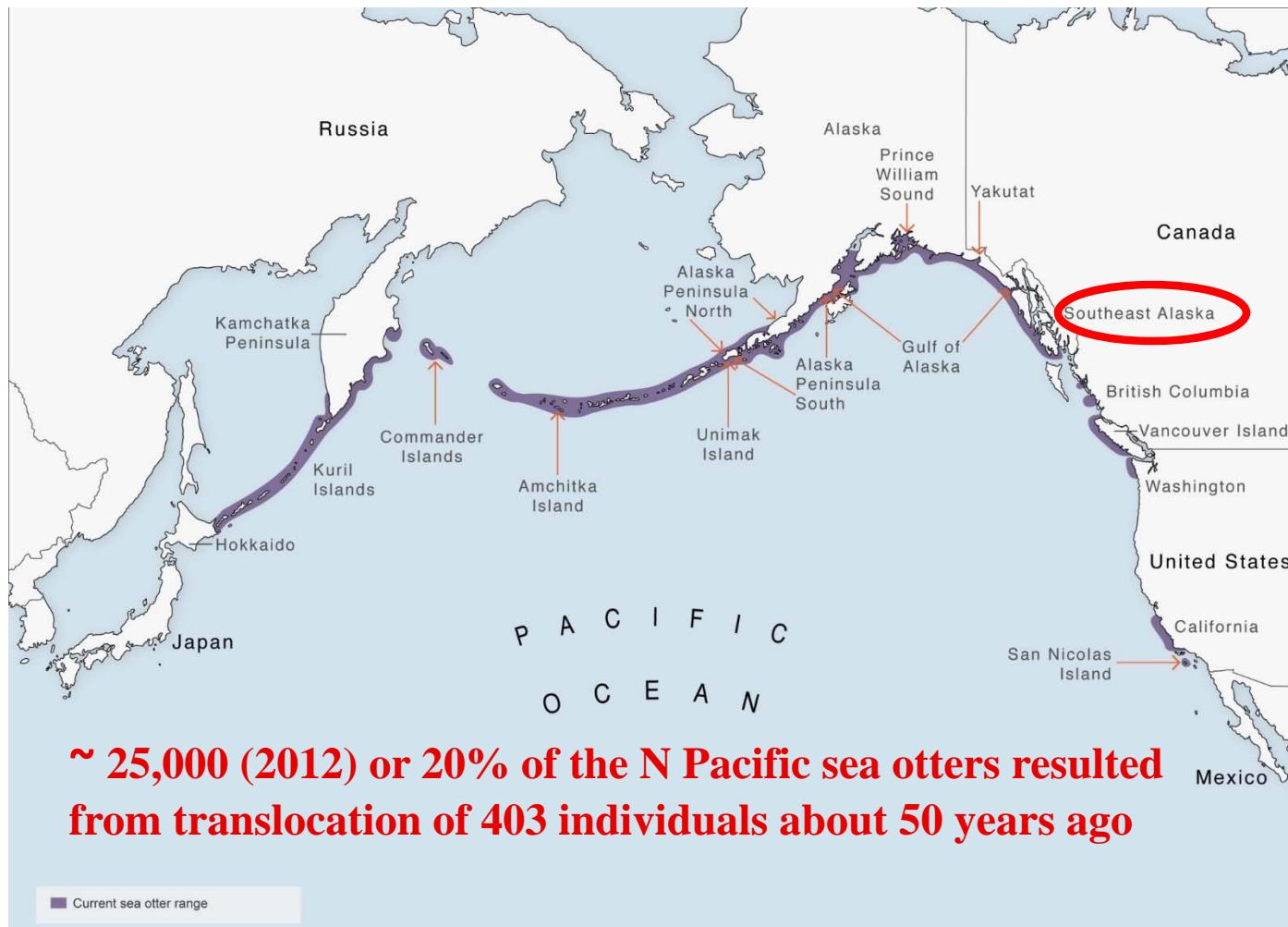
*Sources: White et al. 2018, Lynch unpublished

Threats & Emerging Issues

- Increased risk of catastrophic event (e.g., oil spill, disease) resulting from population concentration
- Fisheries interactions – increasing overlap with Dungeness crab and razor clam
- Continuation of population estimates
- Information Needs
 - Fisheries & Bycatch

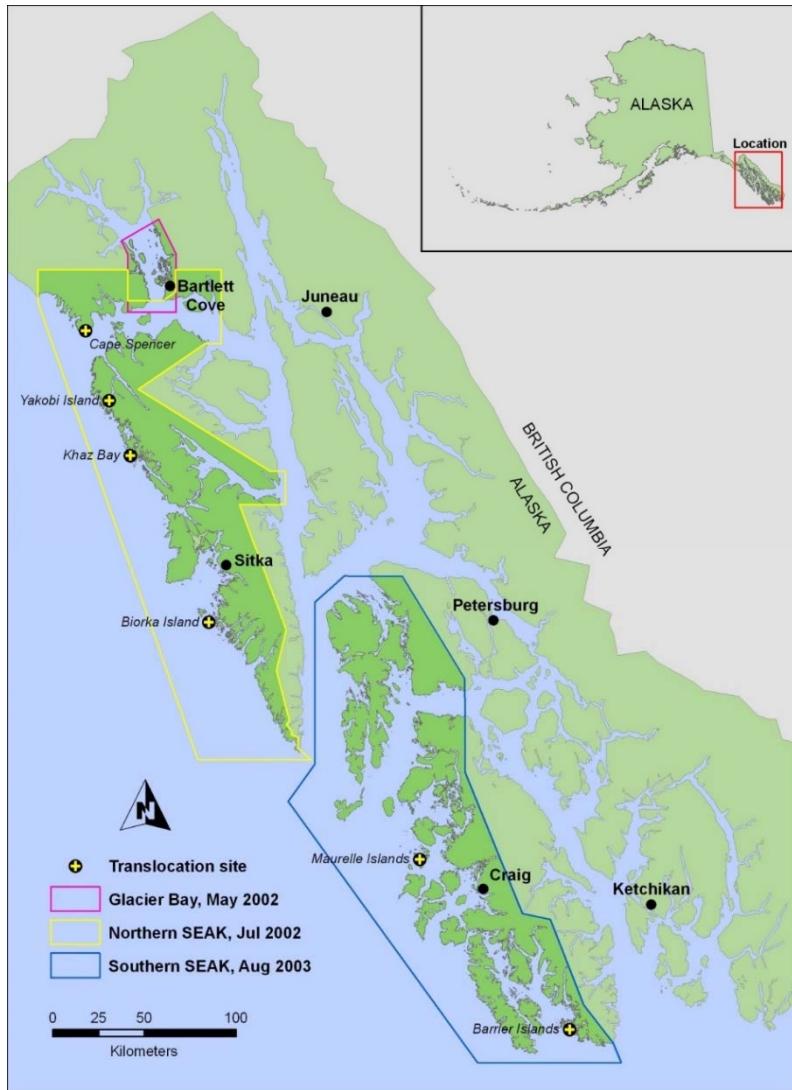


Southeast Alaska: Status and Trend



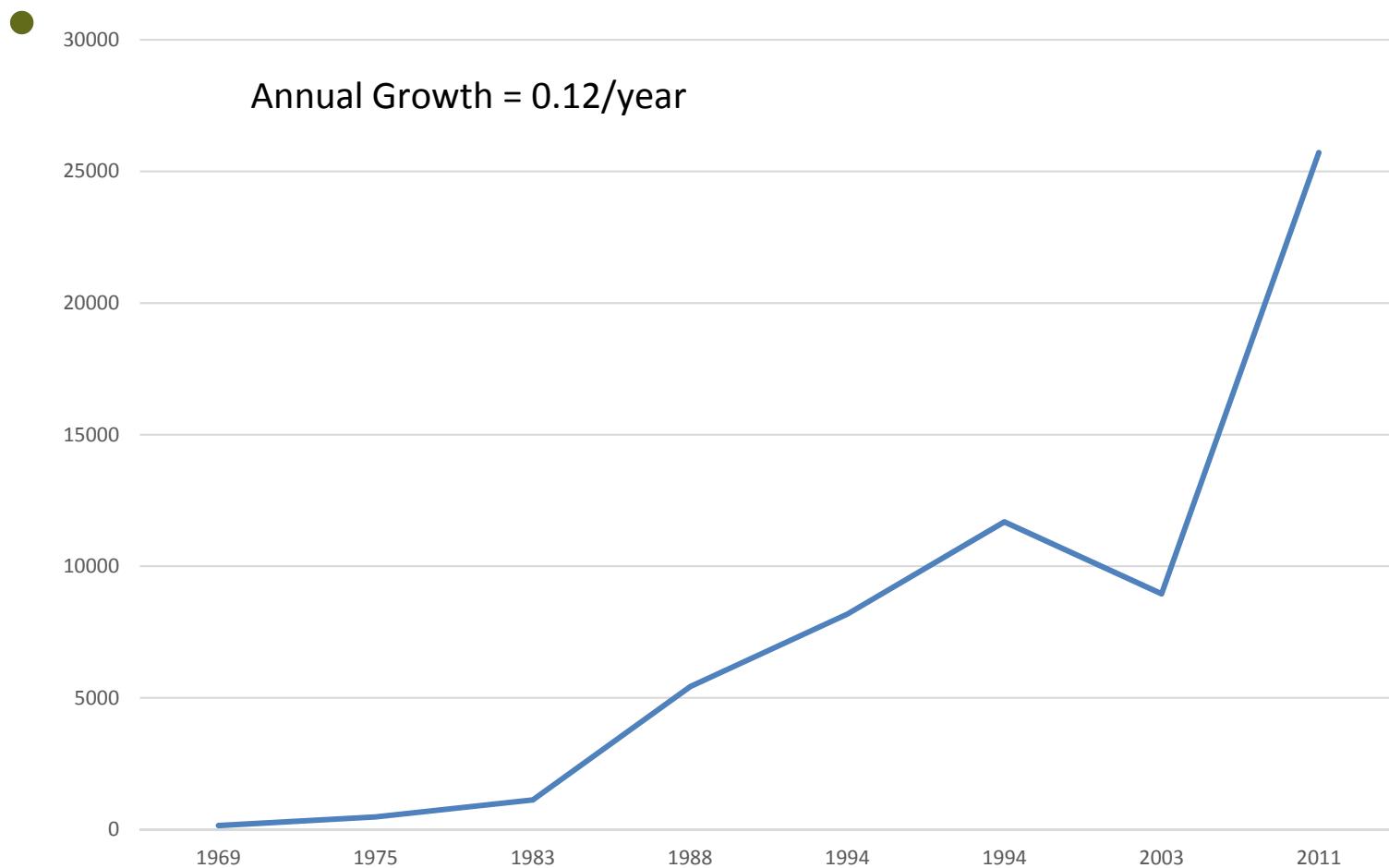
Bodkin 2015

History: SE Alaska

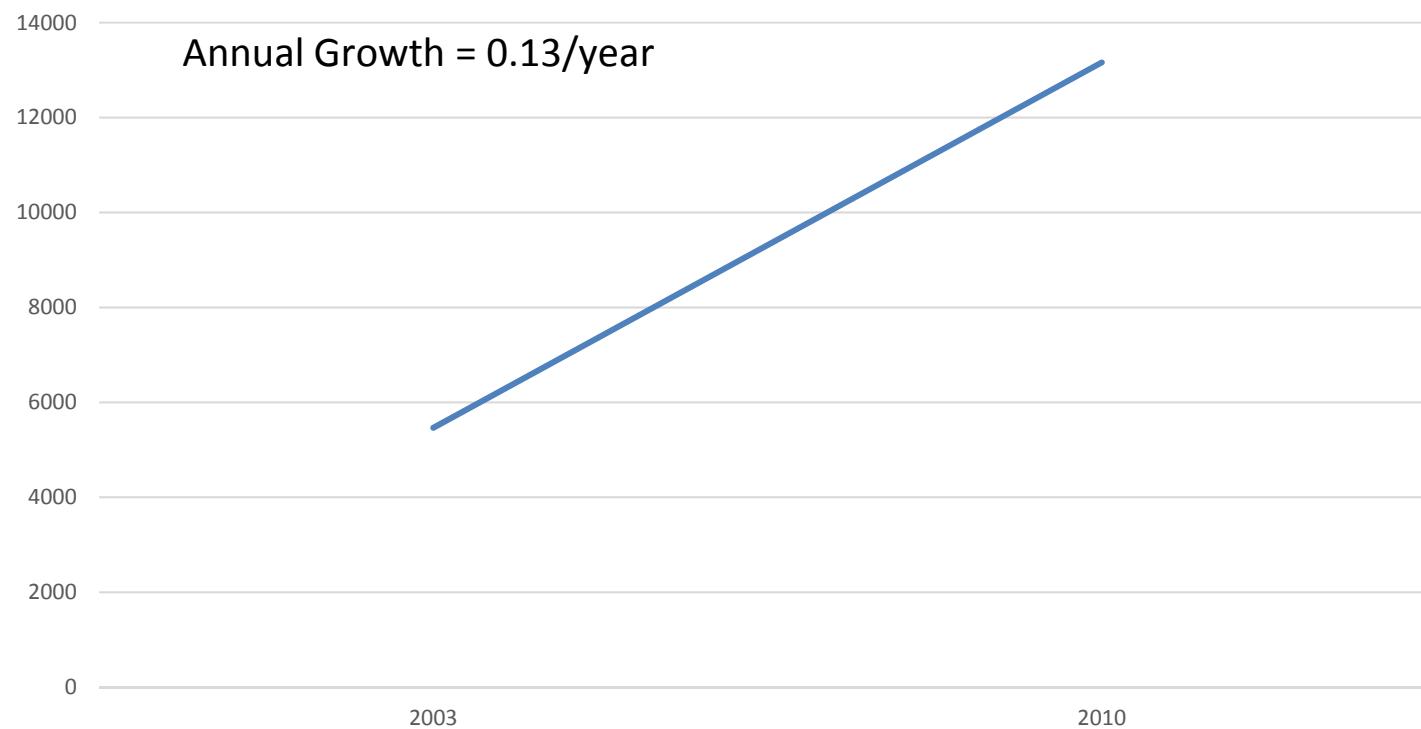


Esslinger, G. G., and J. L. Bodkin. 2009. Status and trends of sea otter populations in Southeast Alaska, 1969–2003. U.S. Geological Survey Scientific Investigations Report 2009-5045., Reston, VA.

Trend: SE Alaska 1969-2012



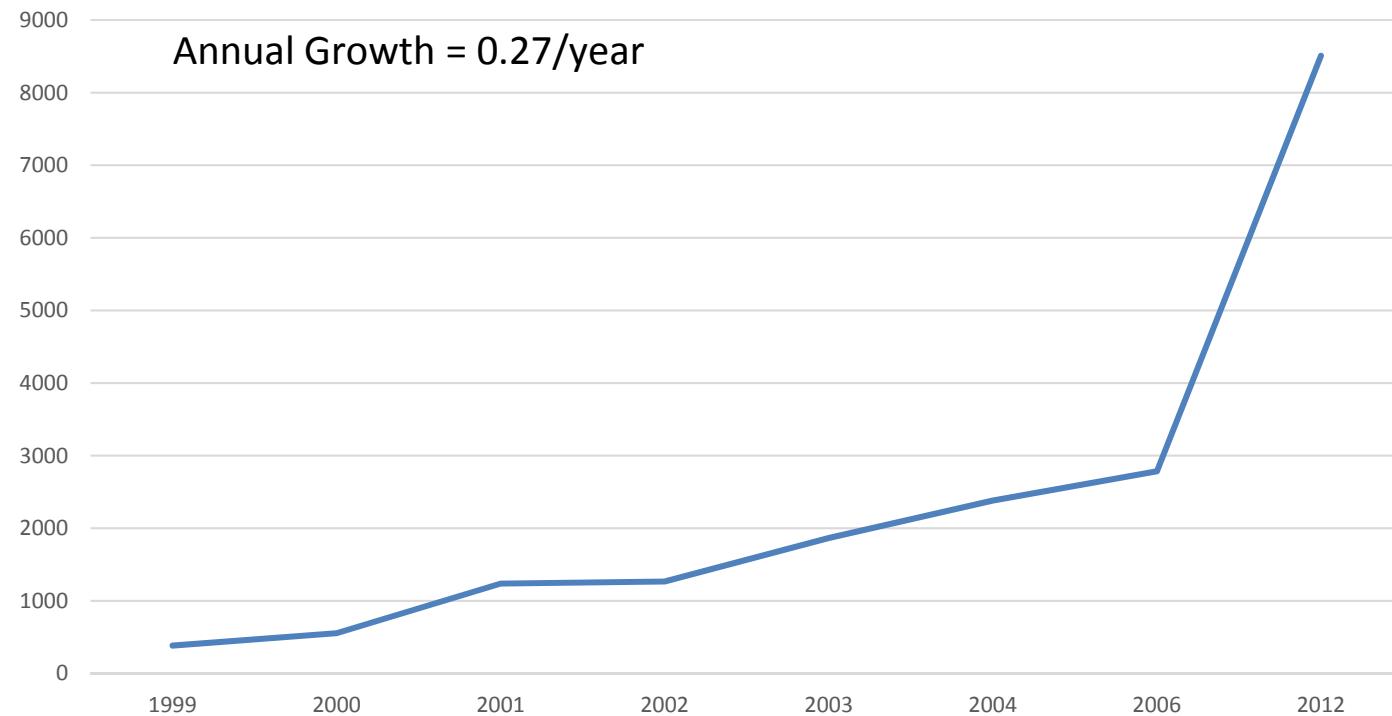
Trend SSE Alaska 2003-2010



Trend: NSE Alaska 2002-2012 (w/o GB)



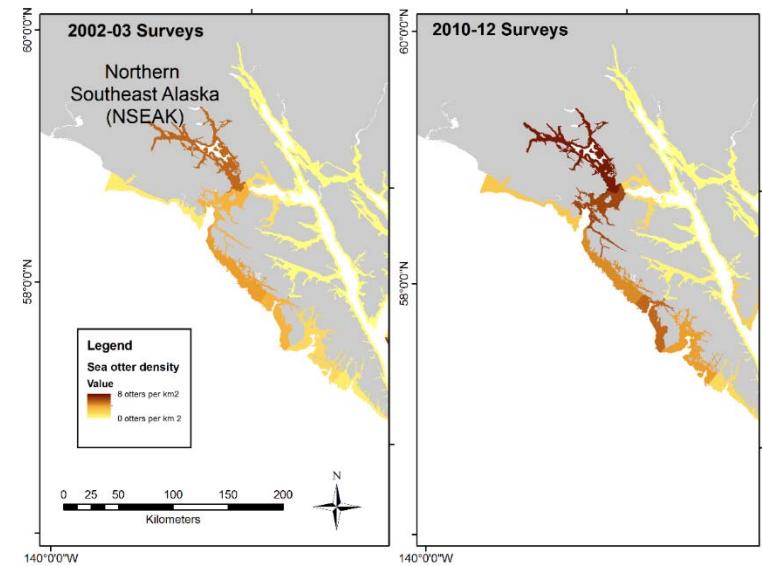
Trend: Glacier Bay 1999-2012





Carrying Capacity: Southeast Alaska

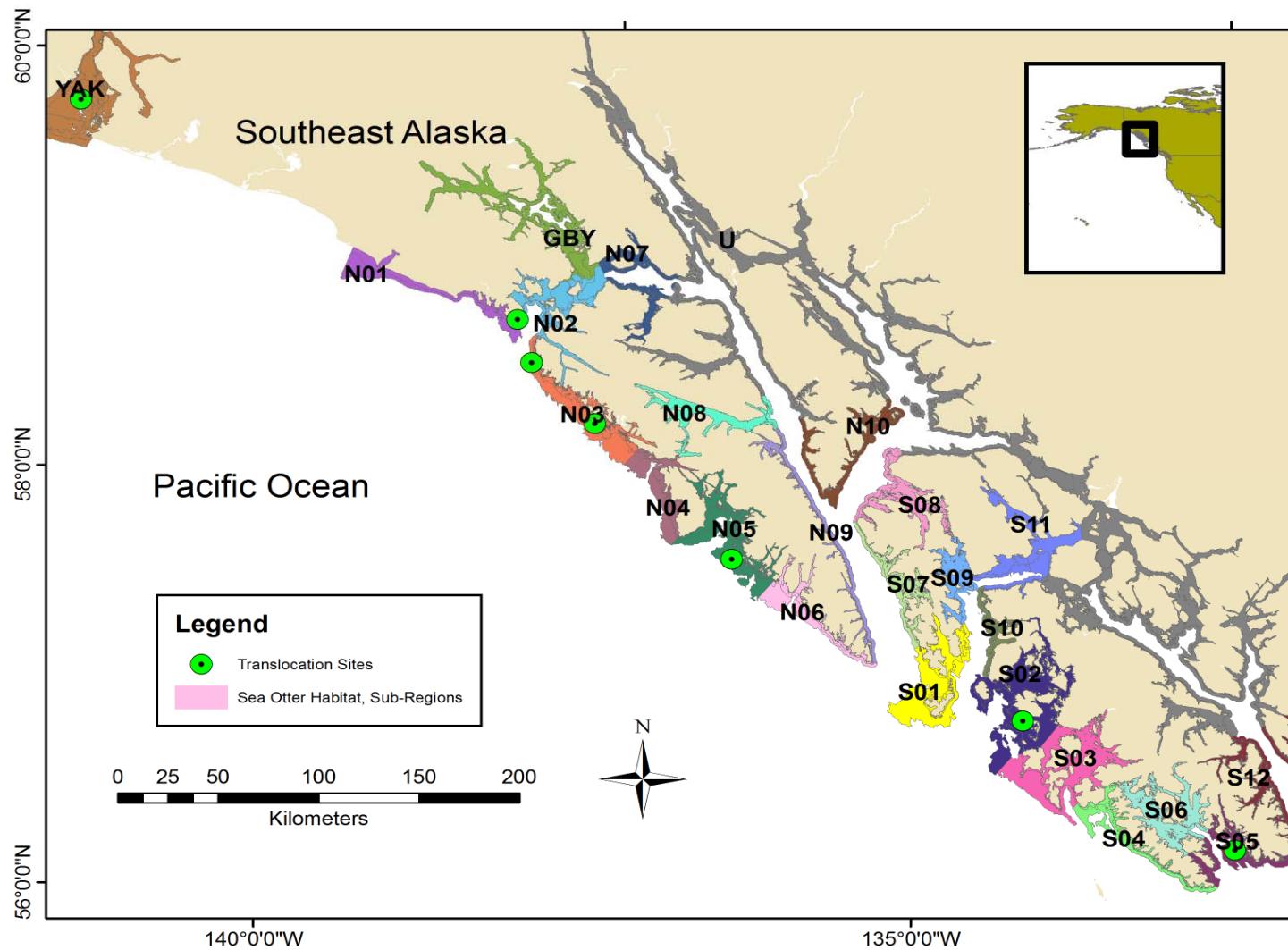
- Fit state-space model to survey data to estimate K at sub-regional scale



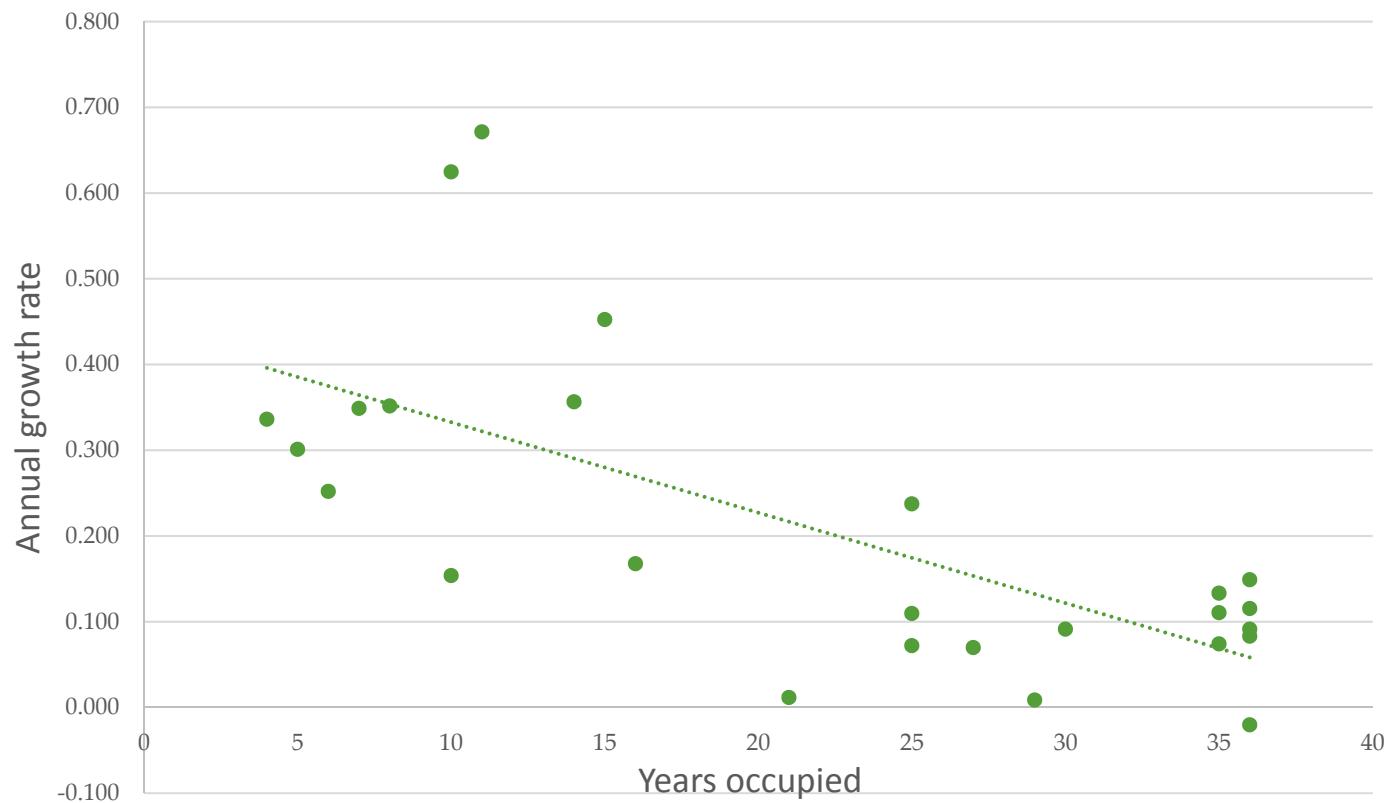
- No habitat covariates
- True abundance estimates
- Accounts for harvest mortality

Tinker et al. 2018 (in review, Journal of Wildlife Management)

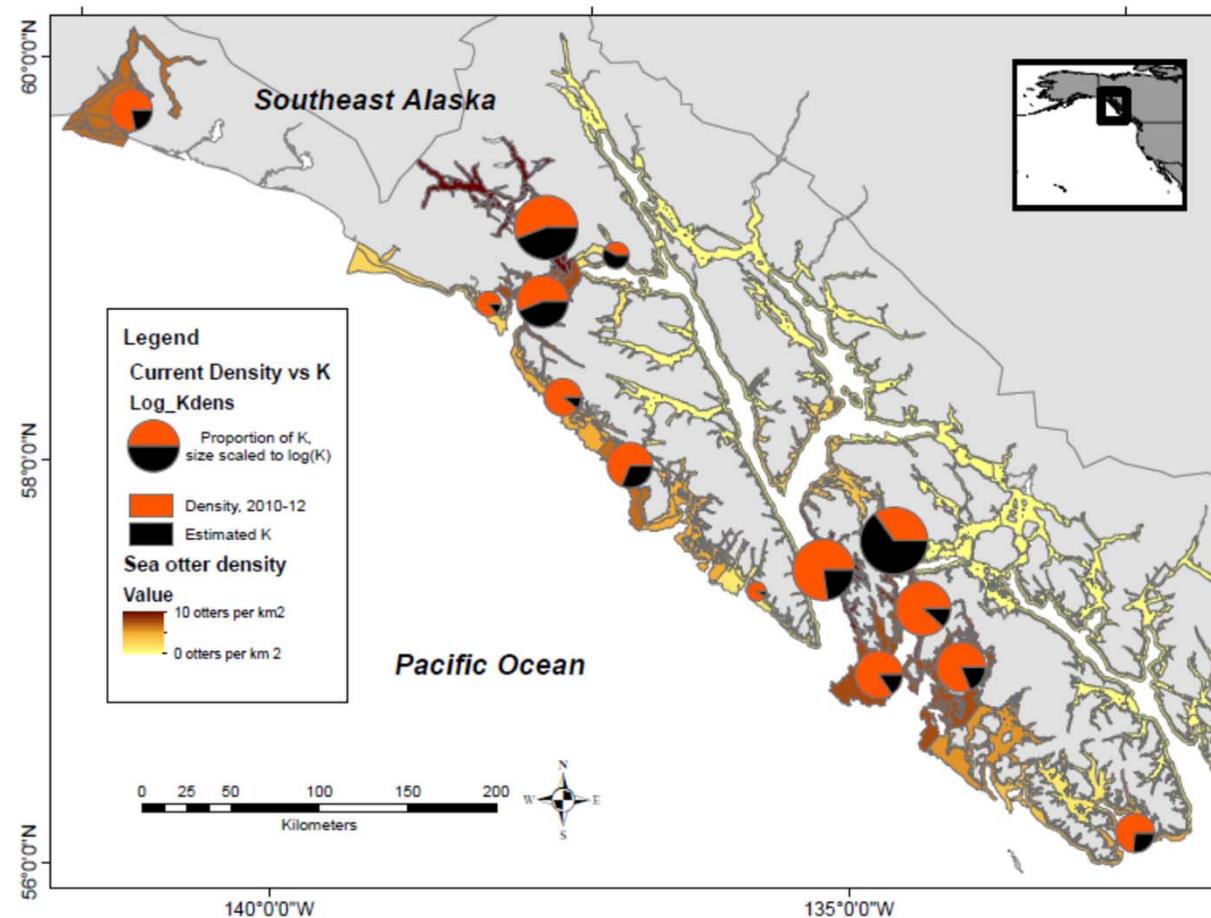
Demographically distinct sub-regions: SE Alaska



SE Alaska: Variation in sub-region growth rates



SE Alaska: Variation in Density at K



Summary

- Uncompromised habitat facilitated recovery of about $\frac{1}{2}$ of SE Alaska
- As sea otters recover in vacant habitat, population growth rates appear to moderate as densities approach “K”
- This is a prolonged process requiring decades
- Sea otter populations in SE Alaska (and elsewhere) appear demographically structured at spatial scales on the order of 100's of km² of nearshore habitat
- Recognizing appropriate spatial scales will enable more effective sea otter management and conservation
- Energy recovery rates (foraging studies) effective in evaluating population status

