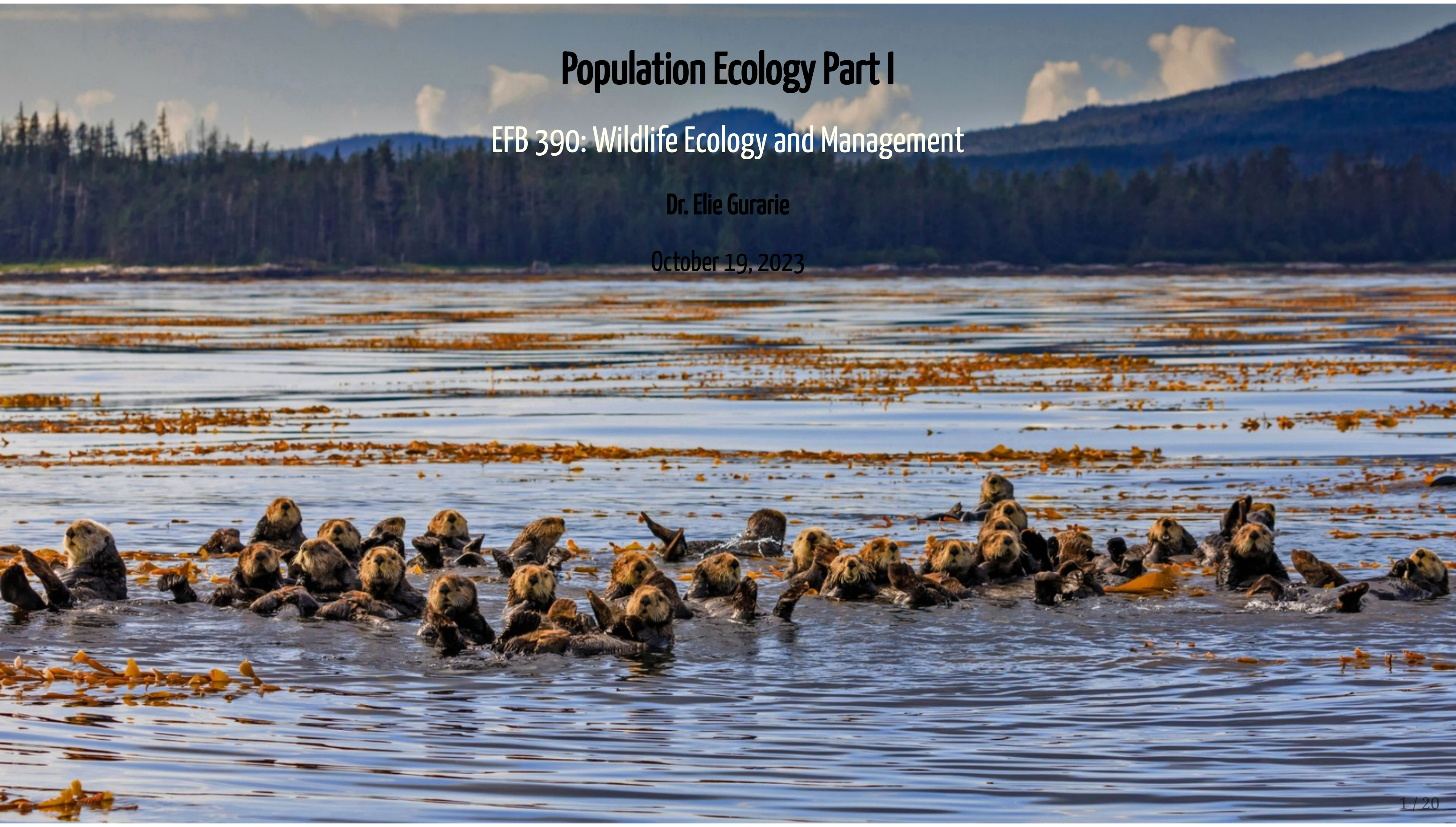
Population Ecology Part I

EFB 390: Wildlife Ecology and Management

Dr. Elie Gurarie

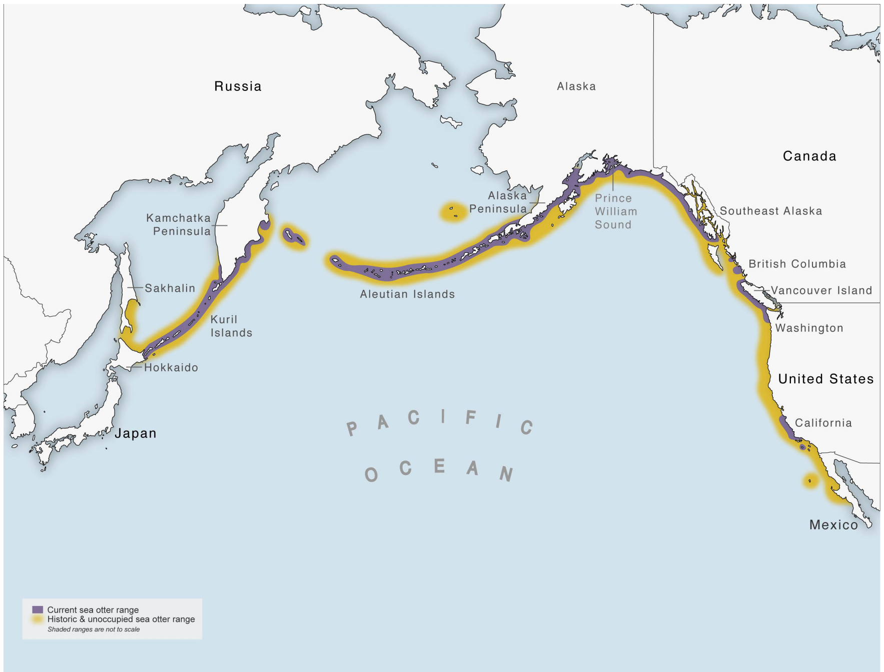
October 19, 2023



Meet ... *Enhydra lutris*

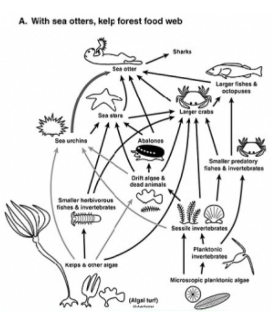
- The largest ...
- The smallest ...
- The furriest ...
  - guess how may hairs per in^2^? (*hint, humans are born with ~100,000 TOTAL.*)

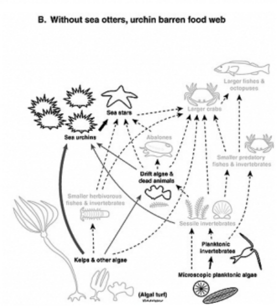
Sea otters: Range



Littorally the entire North Pacific

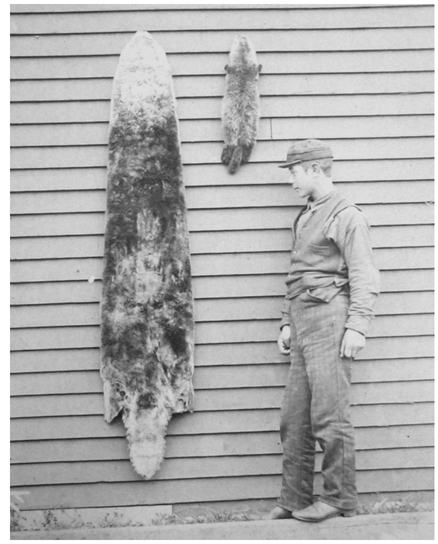
Sea otters: Keystone Species





(Estes et al. 1974)

Sea otters: Furriness > Cuteness



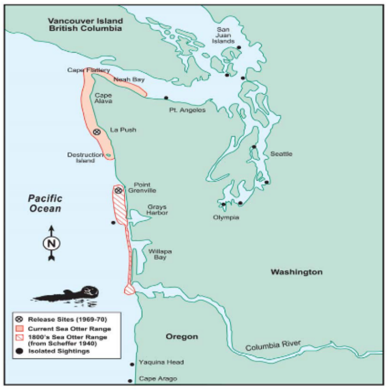
- Fur trade (Russian -> British -> American) leads to near **extirpation** across the entire range.
- **> 300,000 in 1740 … < 2,000 in 1900**.
- Displacement and indenturing of Indigeneous fishermen (esp. Aleut)

> *… the rush for the otters' "soft gold" was a predictable boom and bust … a cautionary example of unsustainable resource use, and a socioeconomic driver of Western — mainly American — involvement in the Pacific region,* (Loshbaugh 2021)

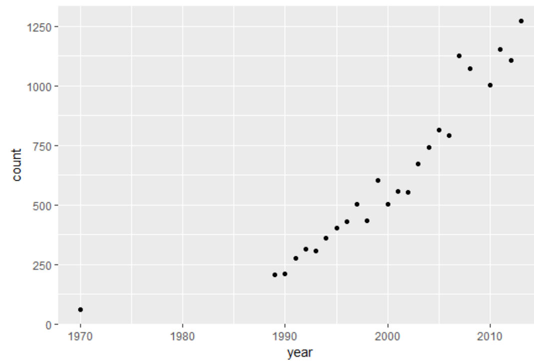
Sea otter reintroduction: Pacific NW

Remnant populations from Aleutian Islands … released in OR, WA, BC and SE-AK 1969 – 1972.

Sea otter reintroduction: Washington State ...



1970: 60 otters



2010's: over 1000

Successful!

Population ecology is all about ...

$$N$$

but where? when?

Here! Now! ..

$$N_t$$

but how many were there?

That many, then Δt ago!

$$N_t = N_{t-\Delta t} + \Delta N$$

slight rearrangement:

$$N_{t+1} = N_t + \Delta N$$

For now, $\Delta t = 1$, i.e. it's the discrete unit that we measure population change. VERY TYPICALLY - whether because of biology or field seasons:

$$\Delta t = 1 \text{ year}$$

.

How does population change?

$$N_{t+1} = N_t + (B - D) + (I - E)$$

Birth

Death

Immigration

Emigration

Assumption 1: no one's getting on or off the bus

$$N_{t+1} = N_t + B - D$$

Birth

Death

Immigration

Emigration

This is a **closed population** ...

Assumption 2: the important one

The number of *Births* and *Deaths* is proportional to *N*.

$$N_{t+1} = N_t + bN_t - dN_t$$

What does that mean?

- Every female gives birth to the same number of offspring?
- Every female has the same *probability* of giving birth?
- Every female has the same *probability* of giving birth to the same *distribution* of offspring?

- A fixed proportion of all individuals dies?
- Every individual has the same *probability* of dying?
- the *distribution* of probabilities of dying is constant?

Some math ....

Define

$$r_0 = b - d$$

r_0: **discrete growth factor**,

$$N_{t+1} = N_t + r_0 N_t$$

$$N_{t+1} = (1 + r_0) N_t$$

$$N_{t+1} = \lambda N_t$$

λ is **rate of growth (or decrease)**

- If $d > b$, $\lambda < 1$.
- If $b > d$, $\lambda > 1$.

Cranking this forward

$$N_{t+1} = \lambda(N_t)$$

$$N_{t+2} = \lambda(N_{t+1}) = \lambda^2 N_t$$

$$N_{t+3} = \lambda^3 N_t$$

Solution:

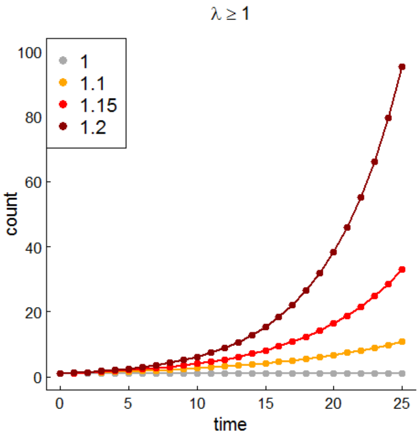
$$N_{t+y} = \lambda^y N_t$$

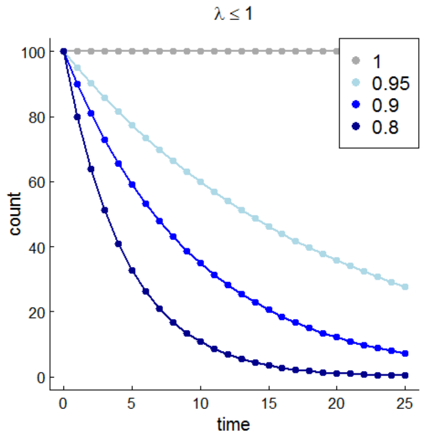
or

$$N_t = \lambda^t N_0$$

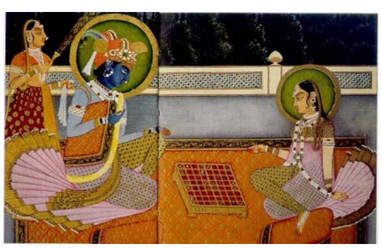
Geometric (same as ***Exponential***) growth.

Some examples





How fast is exponential/geometric growth?

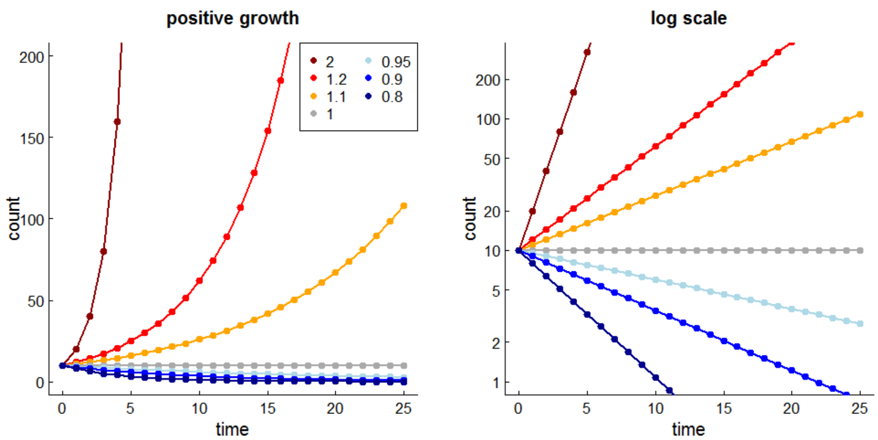


Legend says the inventor of chess (in India) so delighted the raja, he was offered anything he wanted.

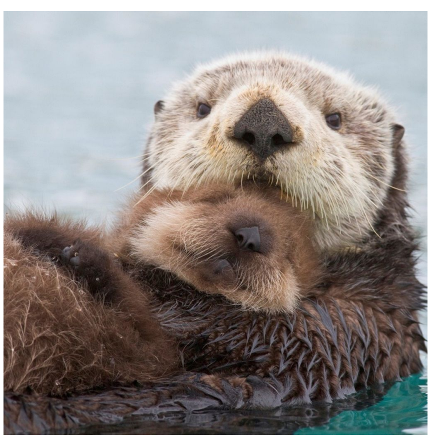
Inventor said, not much. One grain of rice on one square, 2 on the next, 4 on the next and so on till the board is filled.

Not only is there not enough rice in India to fill such a chessboard, **there are not enough atoms on earth**.

Note what the log-scale does



Estimating some rates ... discrete



The amazing thing is, if you have an equation "solved", you only need 2 points on the curve to compute.

Let's use the discrete equation:

$$N_{t+y} = \lambda^y N_t$$

$$1000 = 60 \times \lambda^{40}$$

$$16.7 = \lambda^{40}$$

$$2.81 = 40 \times \log(\lambda)$$

$$0.07025 = \log(\lambda)$$

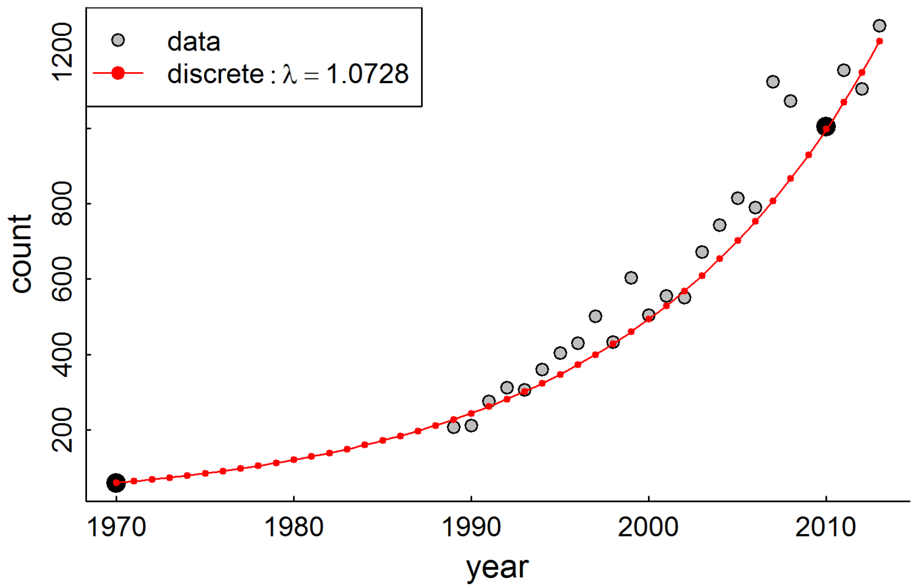
$$\lambda = \exp(0.07025) = 1.0728$$

i.e. population increase about

$$7.28\%/year$$

.

Washington sea otter fit to data (7.025% discrete growth)



This is an EXCELLENT fit

but why isn't it *perfect*?

What are some potential sources of **variation**?

Sea otter references

- J. A. Estes, J. F. Palmisano. 1974. Sea otters: Their role in structuring nearshore communities. Science 185, 1058–1060.
- Loshbaugh S. 2021. Sea Otters and the Maritime Fur Trade. In: Davis R.W., Pagano A.M. (eds) *Ethology and Behavioral Ecology of Sea Otters and Polar Bears. Ethology and Behavioral Ecology of Marine Mammals.*
- Gilkinson, A.K., Pearson, H.C., Weltz, F. and Davis, R.W., 2007. Photo-identification of sea otters using nose scars. *The Journal of Wildlife Management*, 71(6), pp.2045-2051.
- Veltre, D.W. "Unangax̂: Coastal People of Far Southwestern Alaska"