WF4313/6413-Fisheries Management

Class 6

In the news

washingtonpost.com/national/energy-environment/17-tons-of-dead-fish-cleared-from-beaches-due-to-red-
e/2018/09/10/5187c47a-b539-11e8-ae4f-2c1439c96d79_story.html

The Washington Post

The Washington Pos

Three new species of fish discovered in the extreme depths of the Pacific Ocean

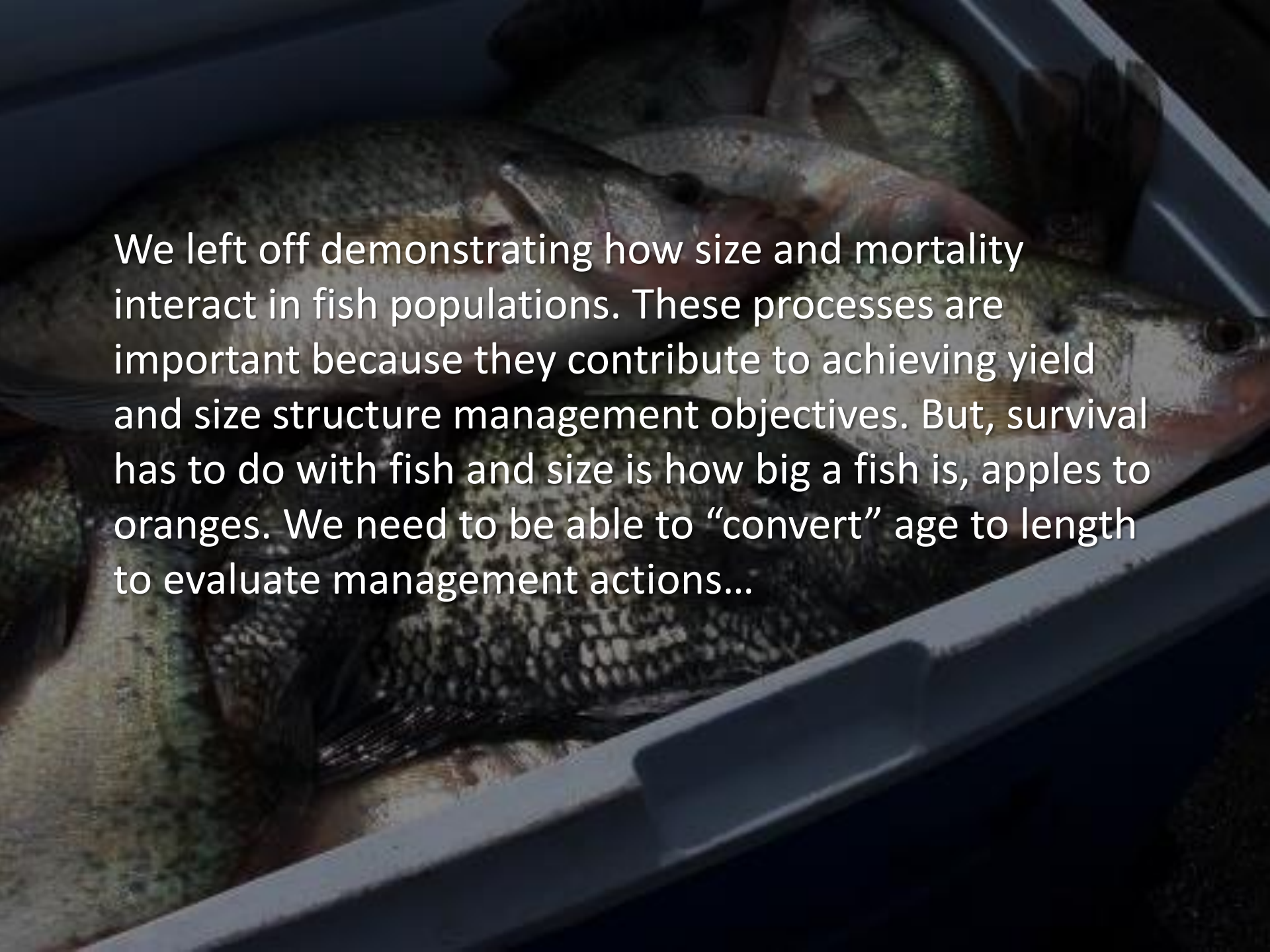
sciencedaily.com/releases/2018/09/180910142440.htm

FULL STORY

Three new species of snailfish were discovered at great depths in the Atacama Trench.

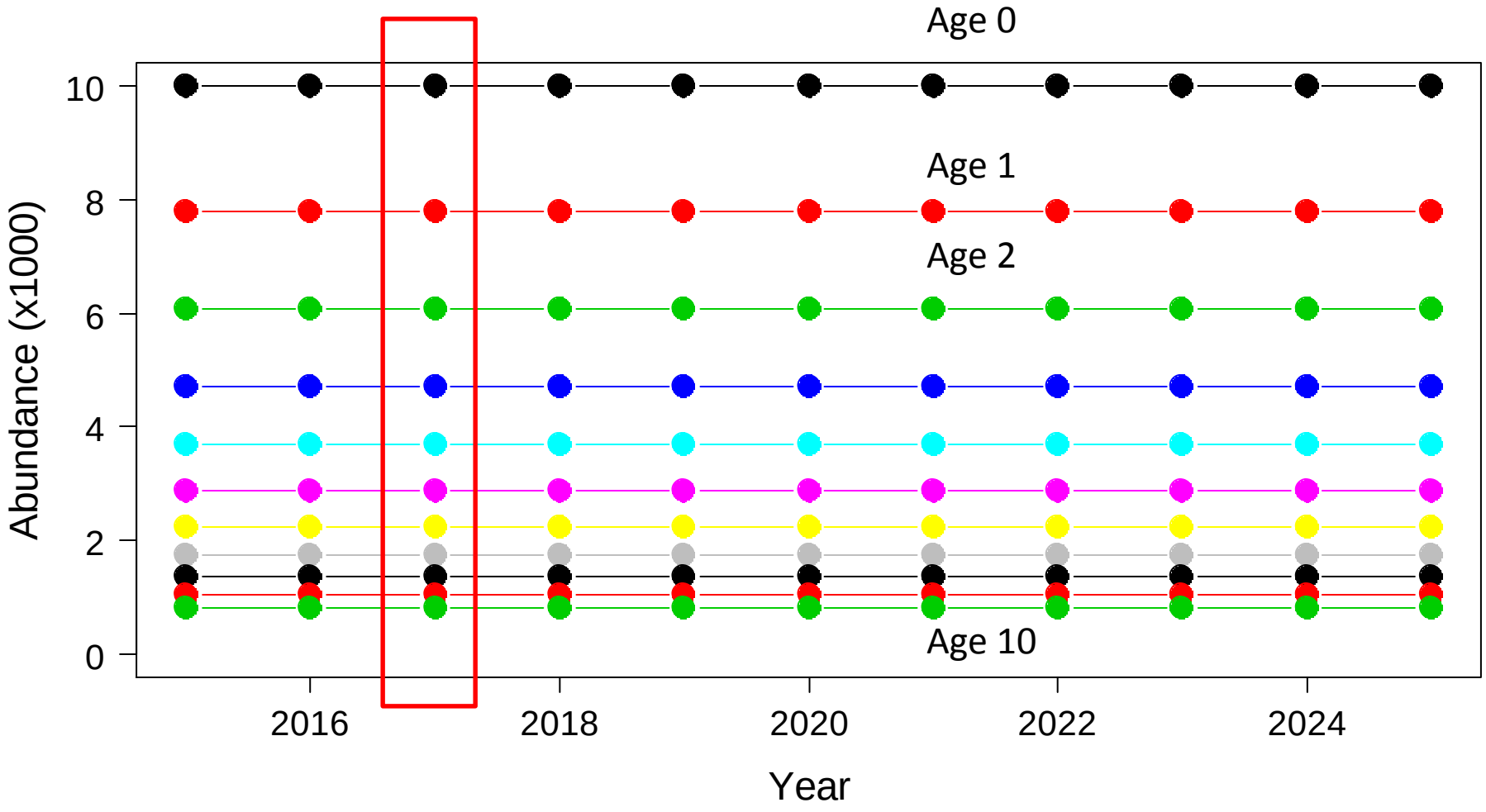
Credit: Image courtesy of Newcastle University

An exploration to one of the deepest places on earth has captured rare footage of what is believed to be three new species of the elusive Snailfish.

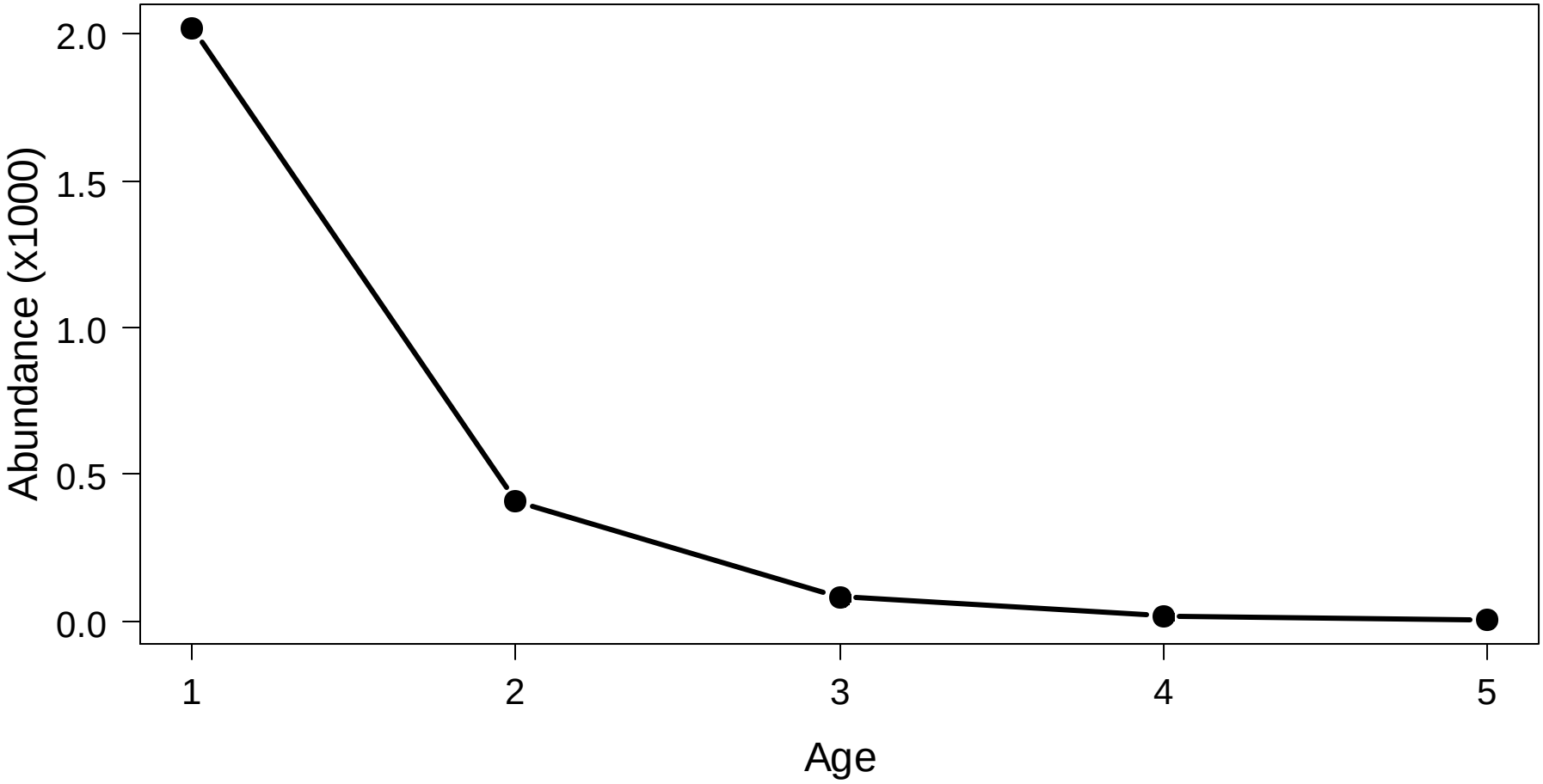


We left off demonstrating how size and mortality interact in fish populations. These processes are important because they contribute to achieving yield and size structure management objectives. But, survival has to do with fish and size is how big a fish is, apples to oranges. We need to be able to “convert” age to length to evaluate management actions…

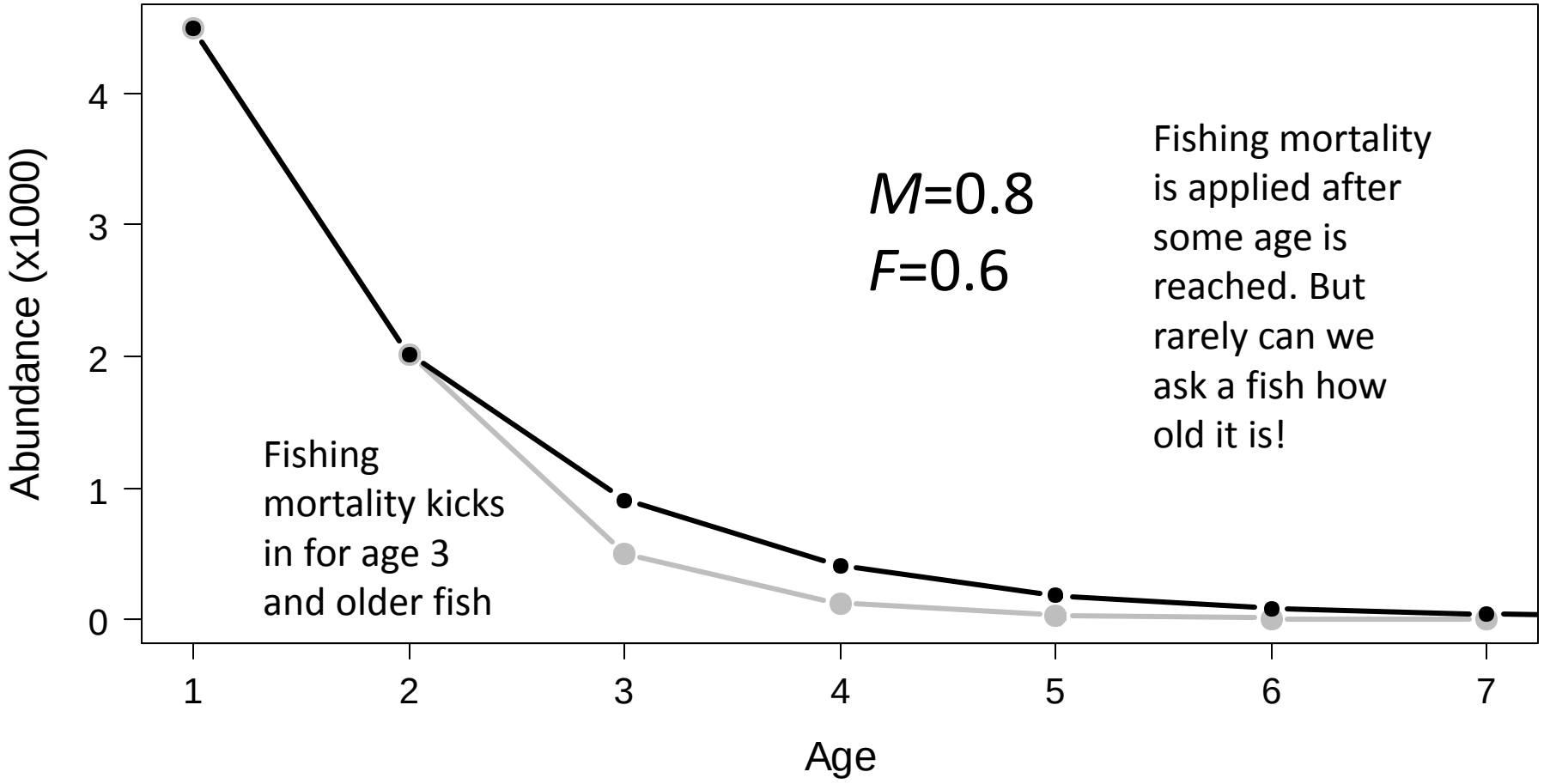
Population age structure



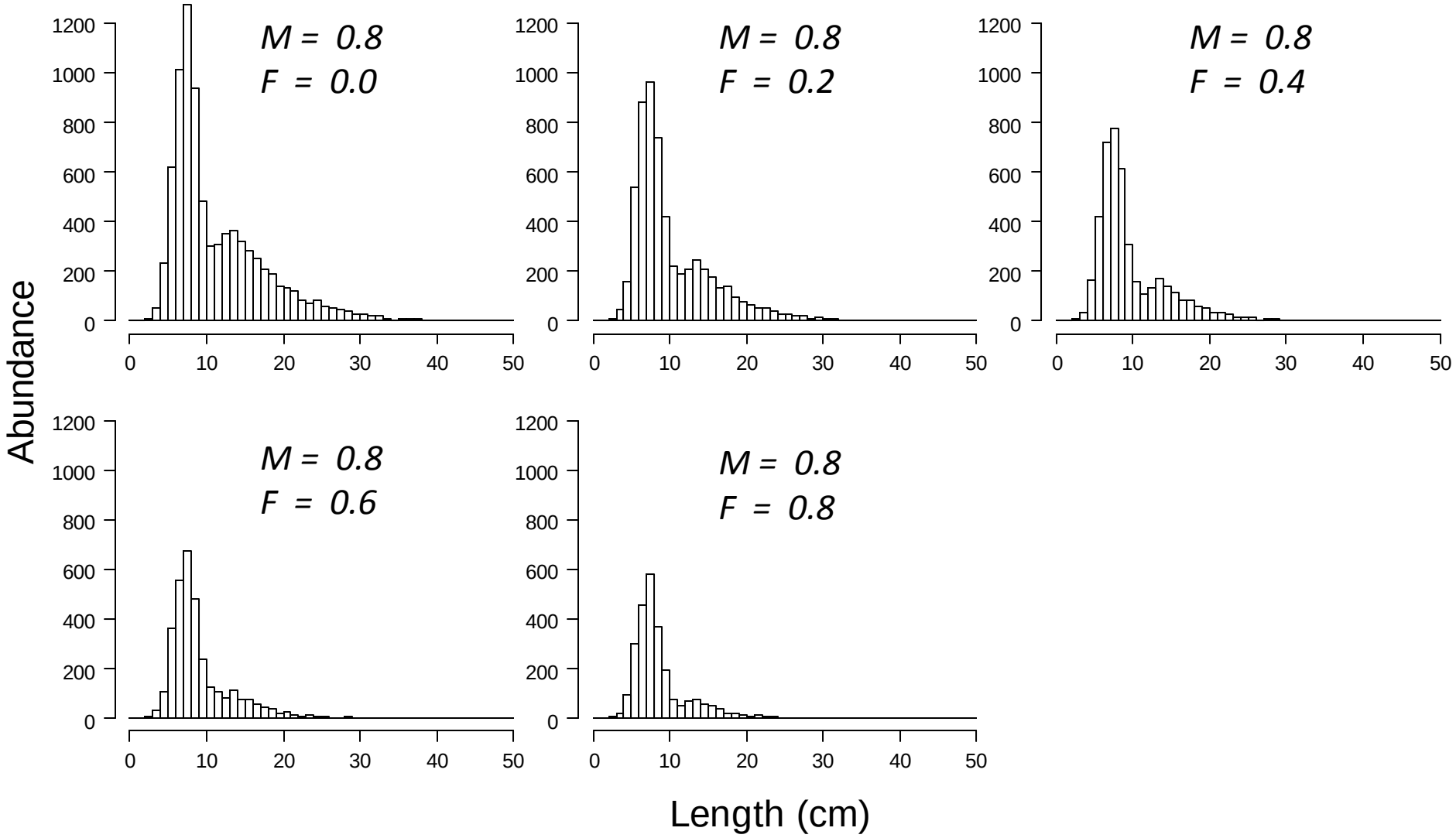
Population age structure



Effect of fishing



Size structure results from age structure



Fish get bigger as they get older…but grow slower as they get older

HELP CREATE WORLD CLASS SMALLMOUTH BASS FISHING

It Takes a Long Time to Grow a Big Smallmouth!

Special Regulations May Apply

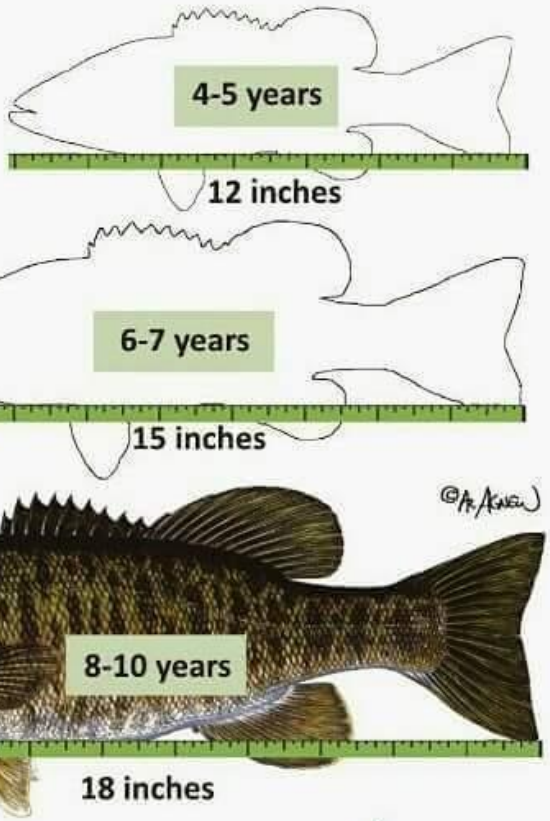
- Consult the *Wildlife Code of Missouri* for details

Release all Sublegal-Sized Fish Immediately

Release of Legal-Sized Smallmouth Bass Can Also Improve Angling Quality

Handle With Care

- Bend down hook barbs; remove hooks carefully; never squeeze fish
- If fish deeply hooked, cut the line
- Play fish quickly; minimize handling



Missouri Smallmouth Alliance
Catch and Release

www.missourismallmouthalliance.org

Practice Catch & Release

CONSERVATION DEPARTMENT MISSOURI TM

In Cooperation with the Missouri Department of Conservation

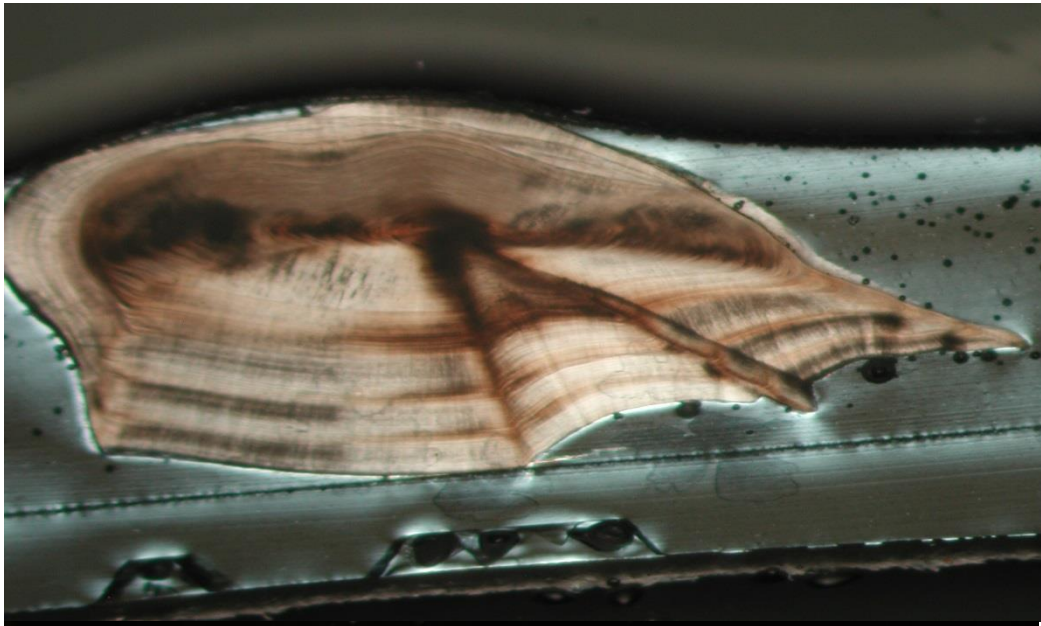

LINKING AGE TO SIZE…GROWTH!

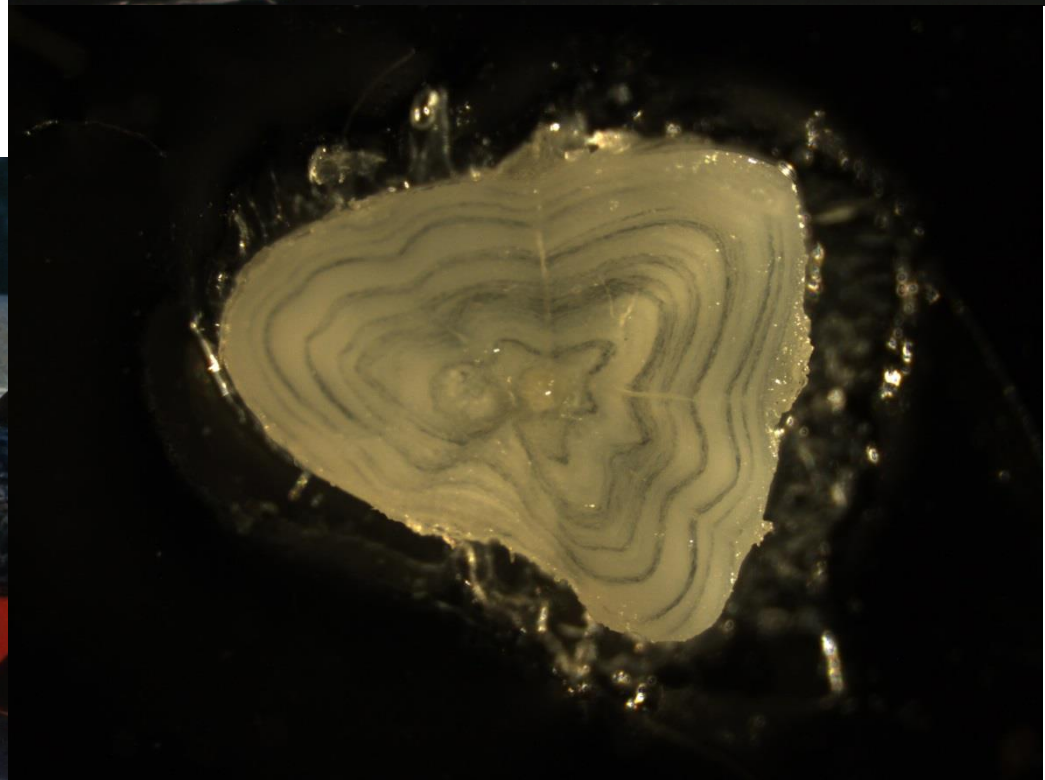
Growth process in fish

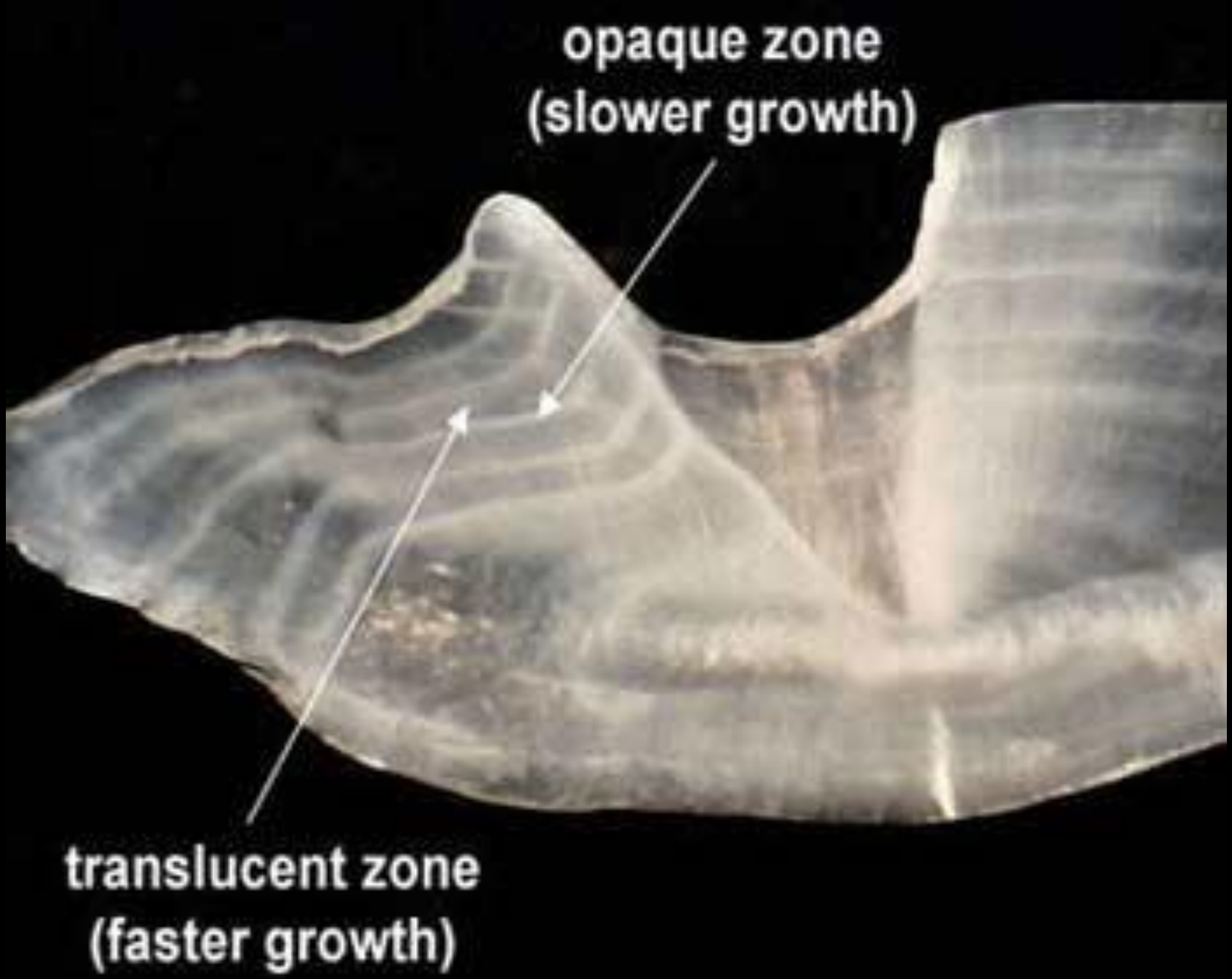
The assimilation of food as biomass (i.e., tissue). Primarily refers to somatic tissue but also includes gonad tissue.

- Fish adding **length** and **weight** over **time**
  1. **Estimate age**
  2. **Relate time (age) to length**
  3. **Relate length to weight**

Age & Growth





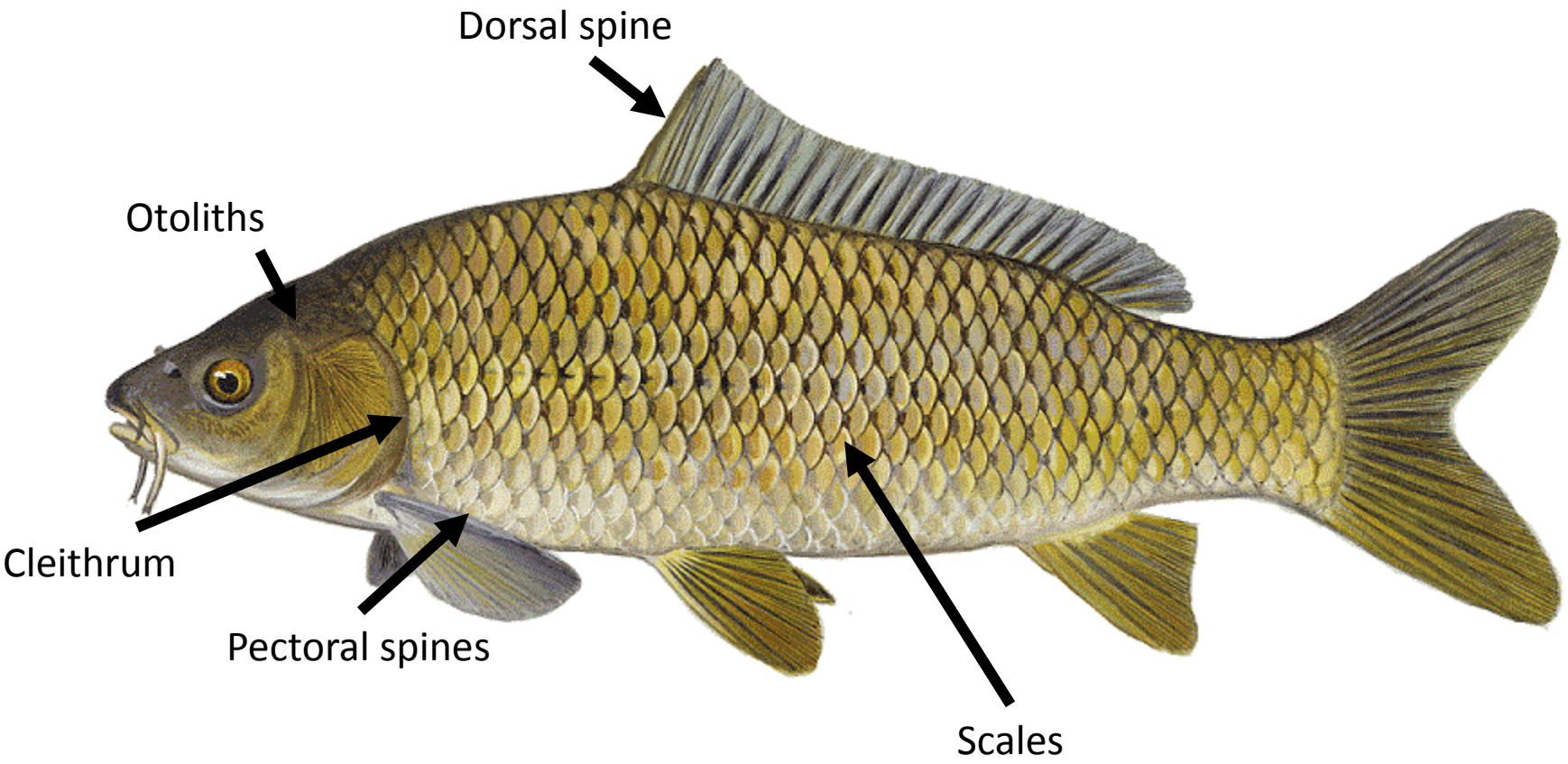


Credit: Florida Fish and Wildlife Conservation Commission

How do annuli form

- Daily ring deposition
- Circadian rhythm (24 hour period)
- Daily rings are closer together in winter
- Faster growth & rings are further apart

Common Aging Structures



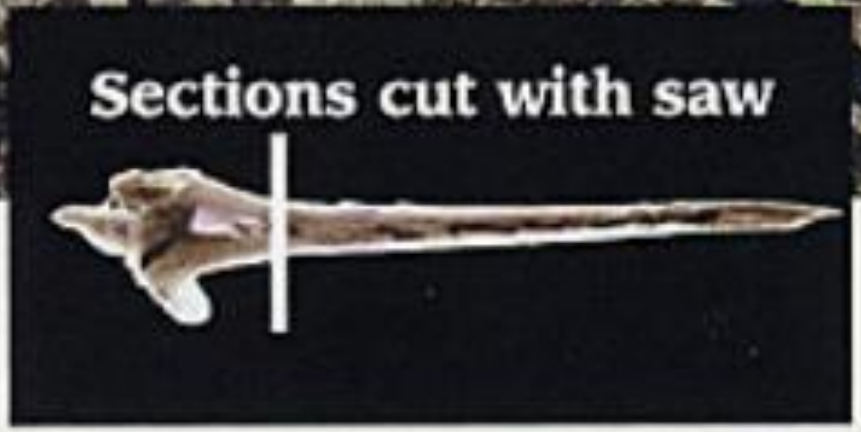
Common Aging Structures

- Otoliths: Lethal to sample, the gold standard, located at the base of the brain
- Fin rays & spines-hard rays: Non-lethal to sample, usually first of the dorsal or pectoral fin. Accuracy decreases with age.
- Scales: Non-lethal, Accuracy decreases with age.

Rules of thumb-older slow growing fish are harder to accurately age

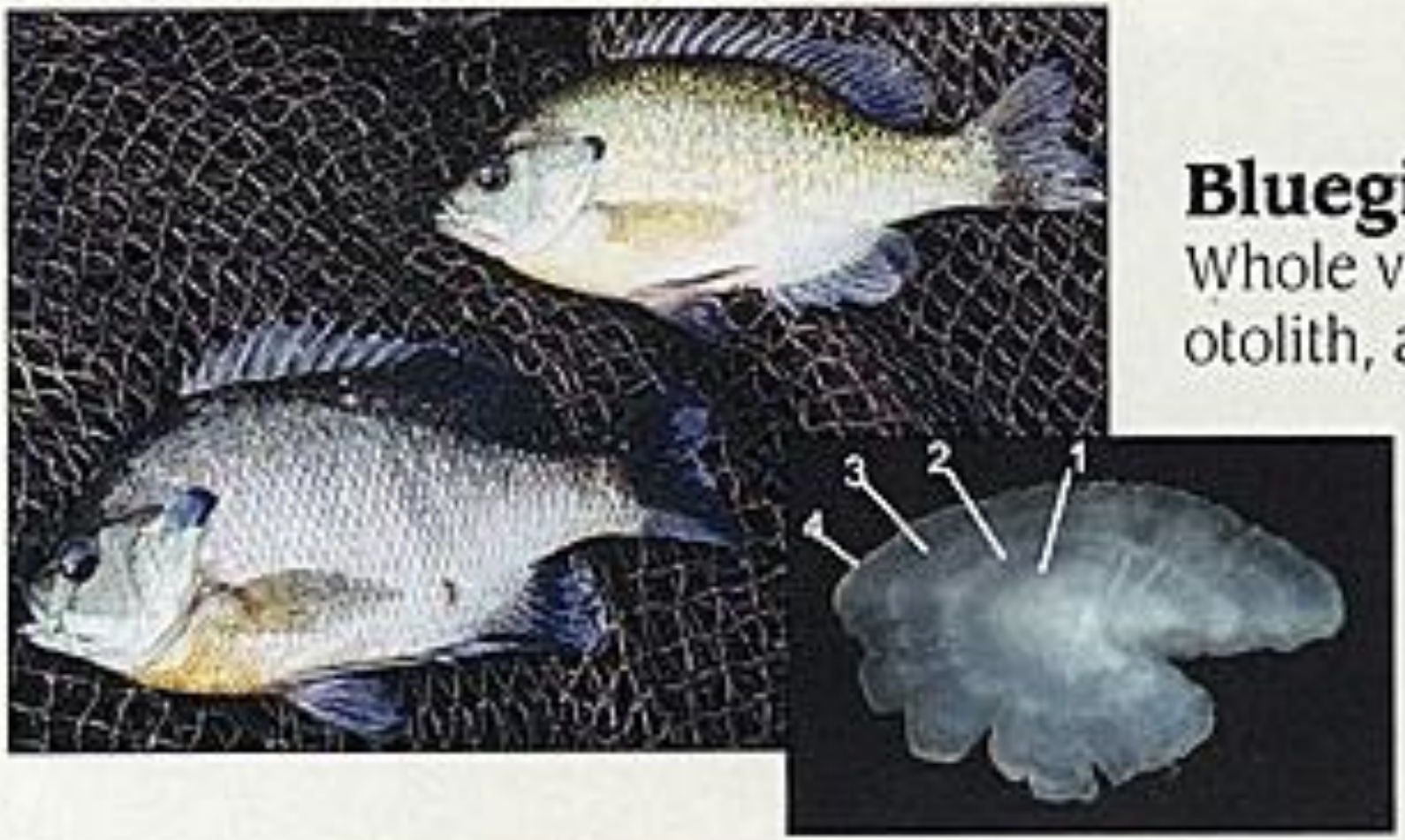
Black Bullhead

Pectoral spine removed and sectioned, age 6



Common Carp
Pectoral fin ray
section, age 5

White Bass
Cracked (half)
otolith, age 12



Bluegill
Whole view -
otolith, age 4

Walleye

Cracked otolith (right), age 5;
(below) dorsal spine, age 7

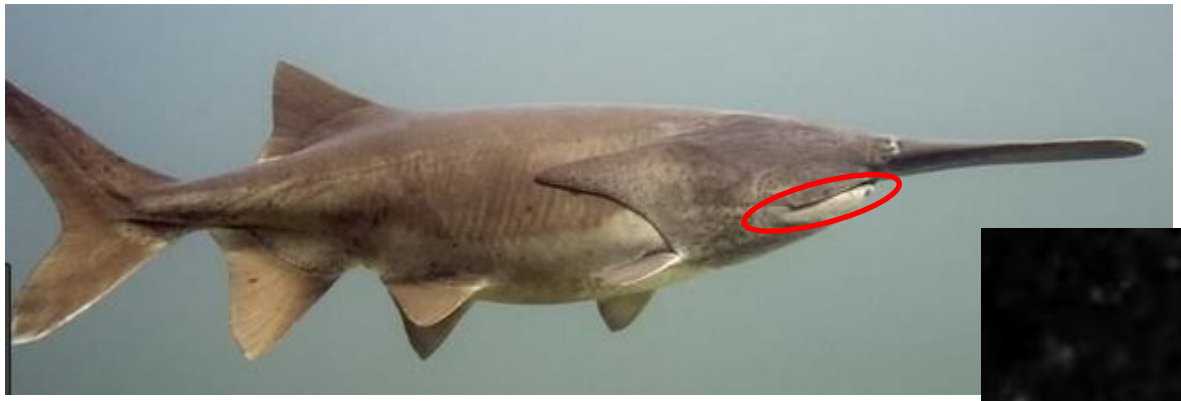
White Crappie

Scale collected in fall, age 2, would be 3 on Jan 1 of next yr

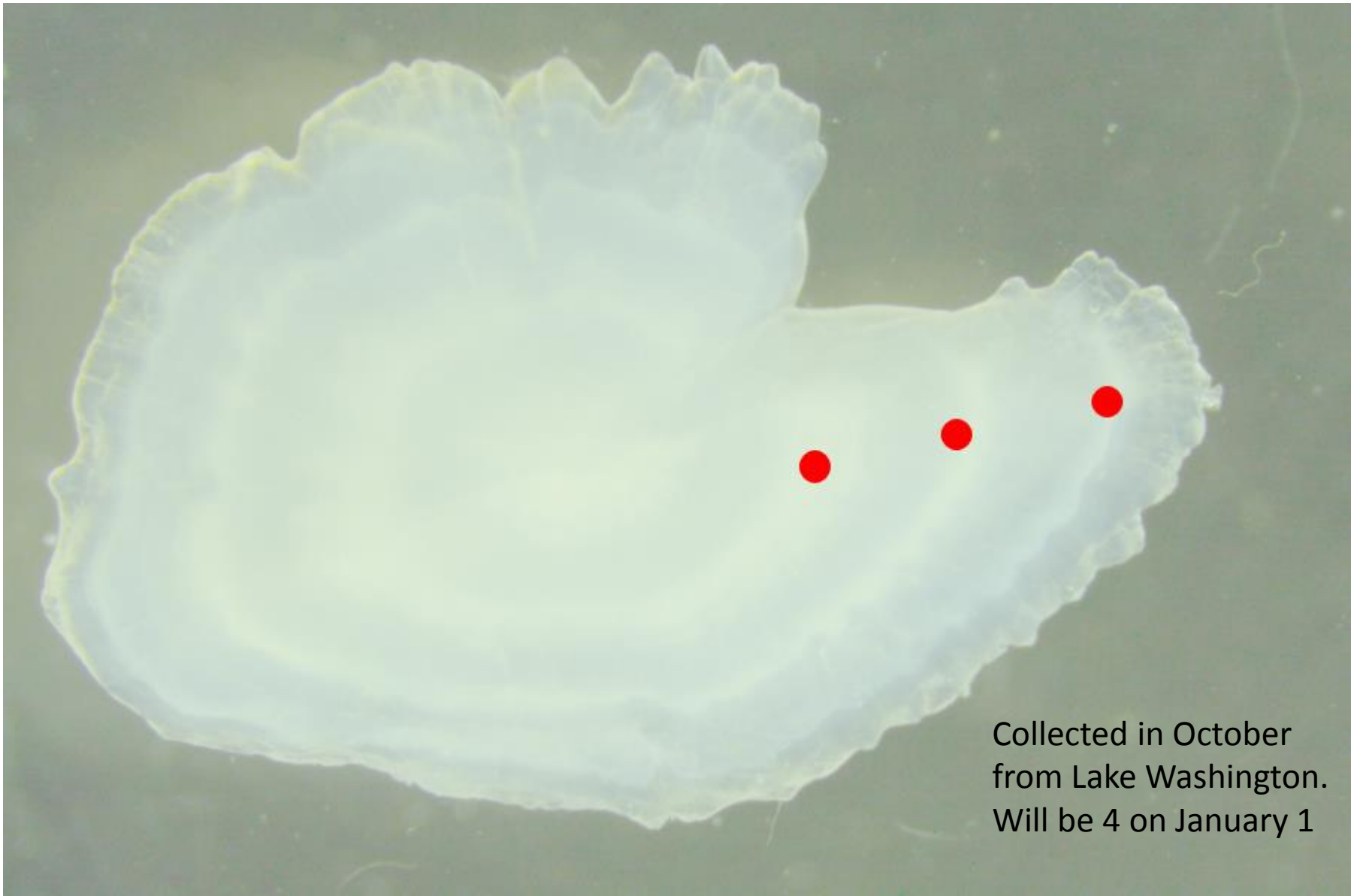
Cleithrum

Dentary (Jaw bone)

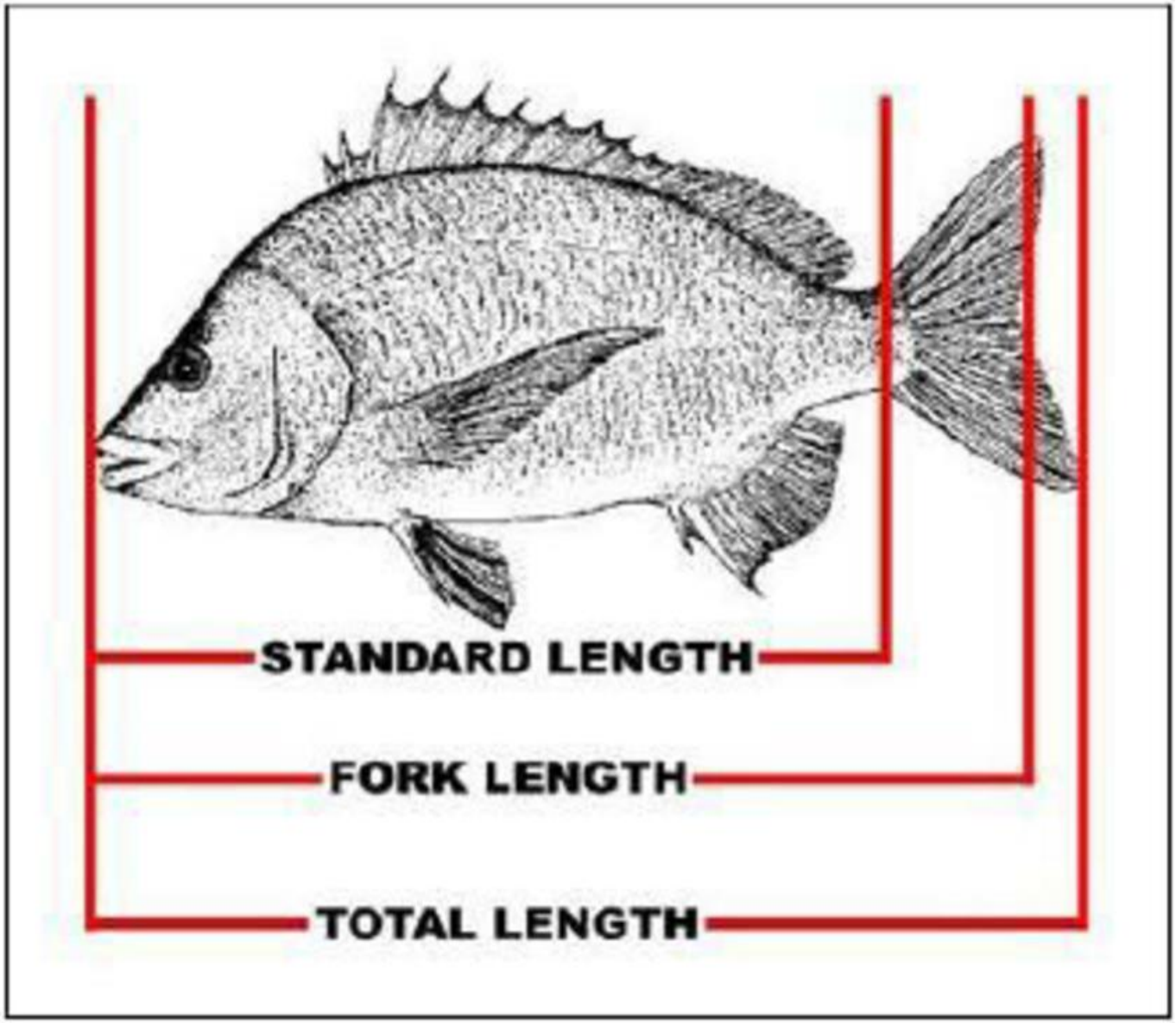
- Paddlefish
- One of few hard structures



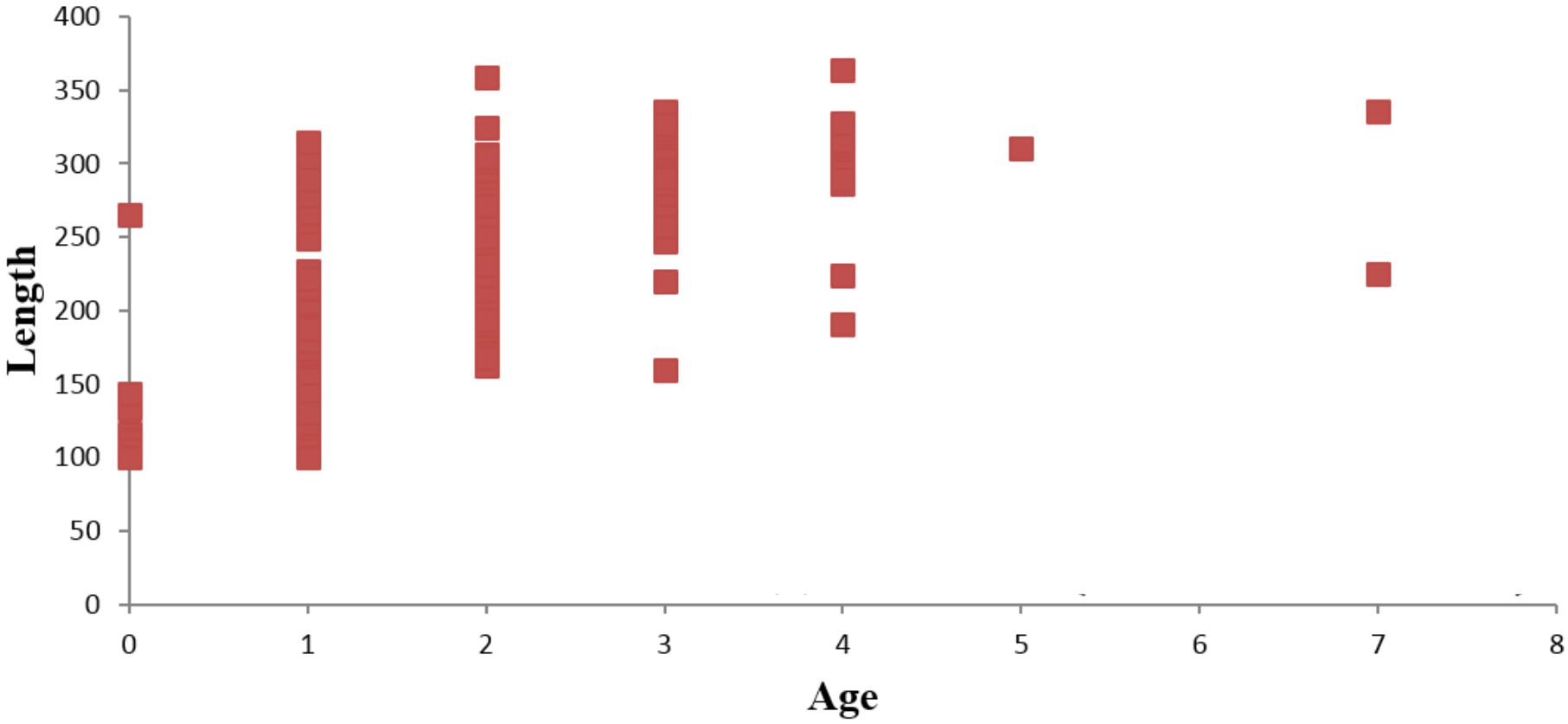
Age-3 Black Crappie



How to Measure Fish Length



Crappie Length at Age



Growth models

- Relate the age of fish in a population to their length or weight
  - Provide equations that describe growth using parameter estimates that can be used to make comparisons within and among populations
  - These equations are regression models of the size of the fish over time
  - Model selection should be based on fit and interpretability.

Alternative length at age models

1. Von Bertalanffy
2. Gompertz
3. Logistic
4. Power

The von Bertalanffy growth model

Widely used in fisheries science – many alternative forms, but the basic model for length is:

$$Length = Length_{\infty} \cdot (1 - e^{-K \cdot (age - t_0)})$$

Where:

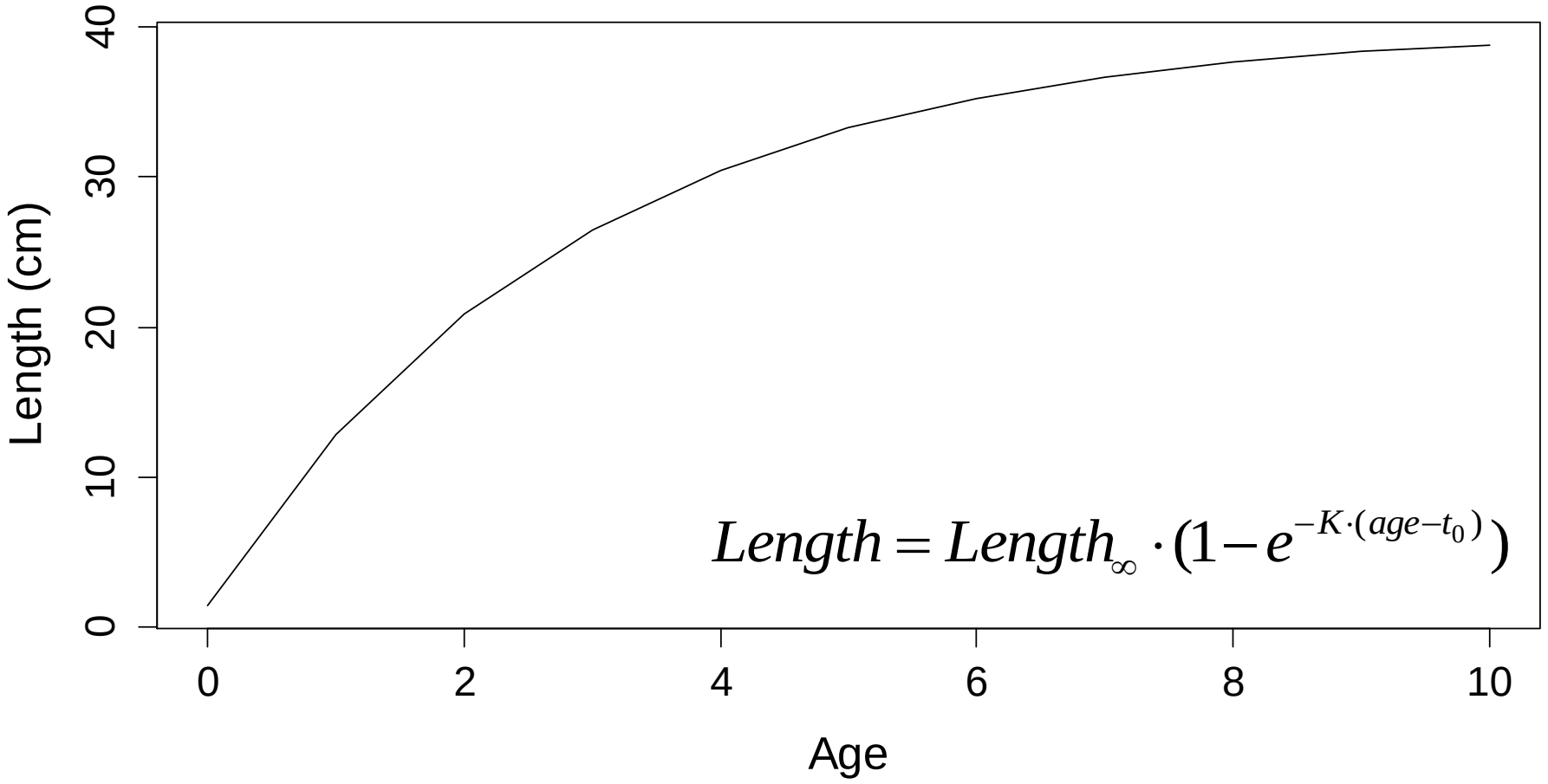
$Length_t$ is the estimated *mean* length at time t,

$Length_{\infty}$ is the asymptotic or theoretical *mean* maximum length,

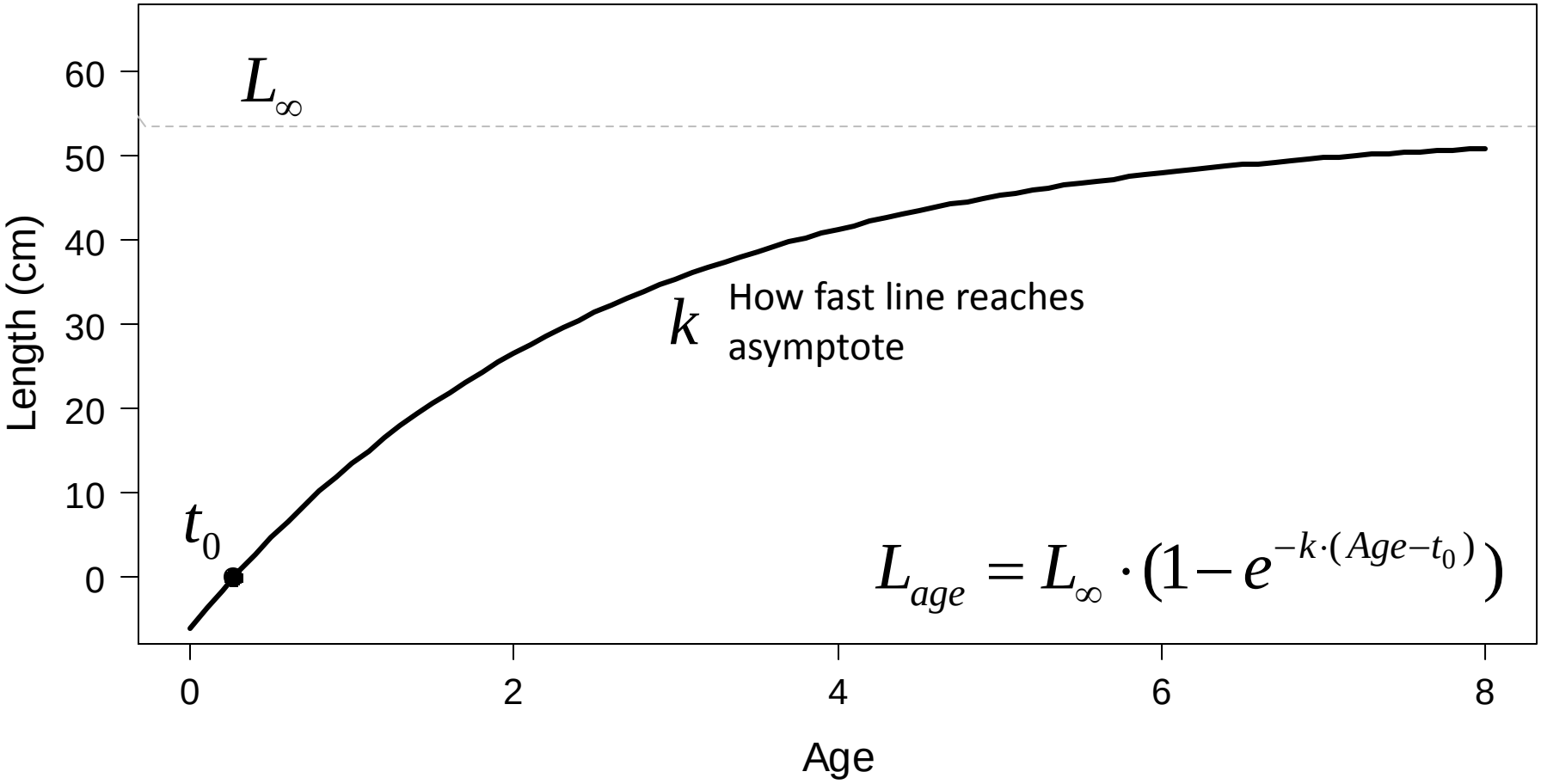
K is a growth coefficient; describes how quickly L_{∞} is reached, and

t_0 is the theoretical age when length equals 0; fixes curve position on axis.

The von Bertalanffy growth model



von Bertalanffy Growth Function



The Gompertz growth model

Rarely used in fisheries science

$$L = L_{\infty} \cdot \mathrm{e}^{(-e^{-k_2 (age - t_2)})}$$

Where:

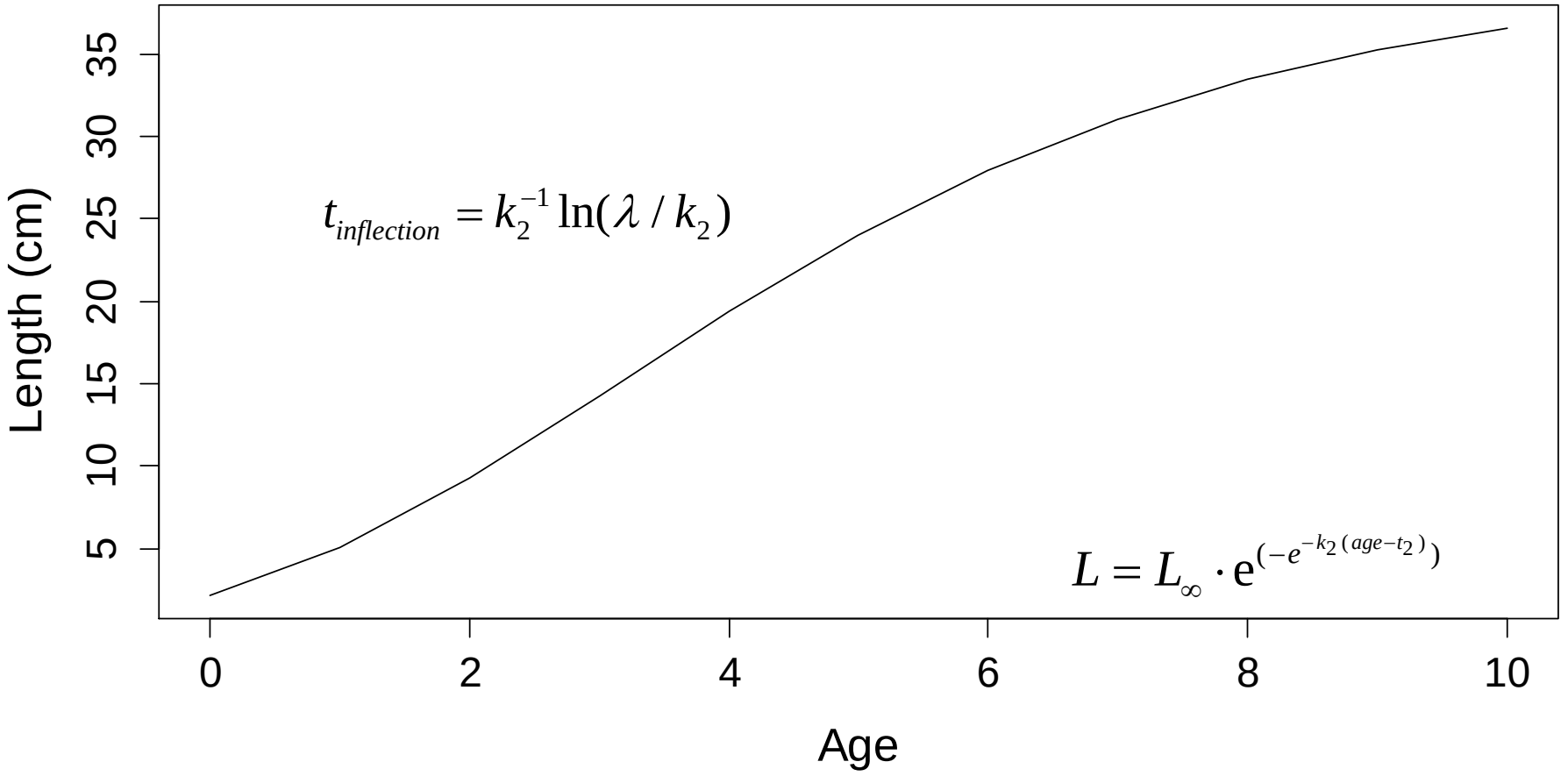
L is the estimated *mean* length at age,

L_{∞} is the asymptotic or theoretical *mean* maximum length,

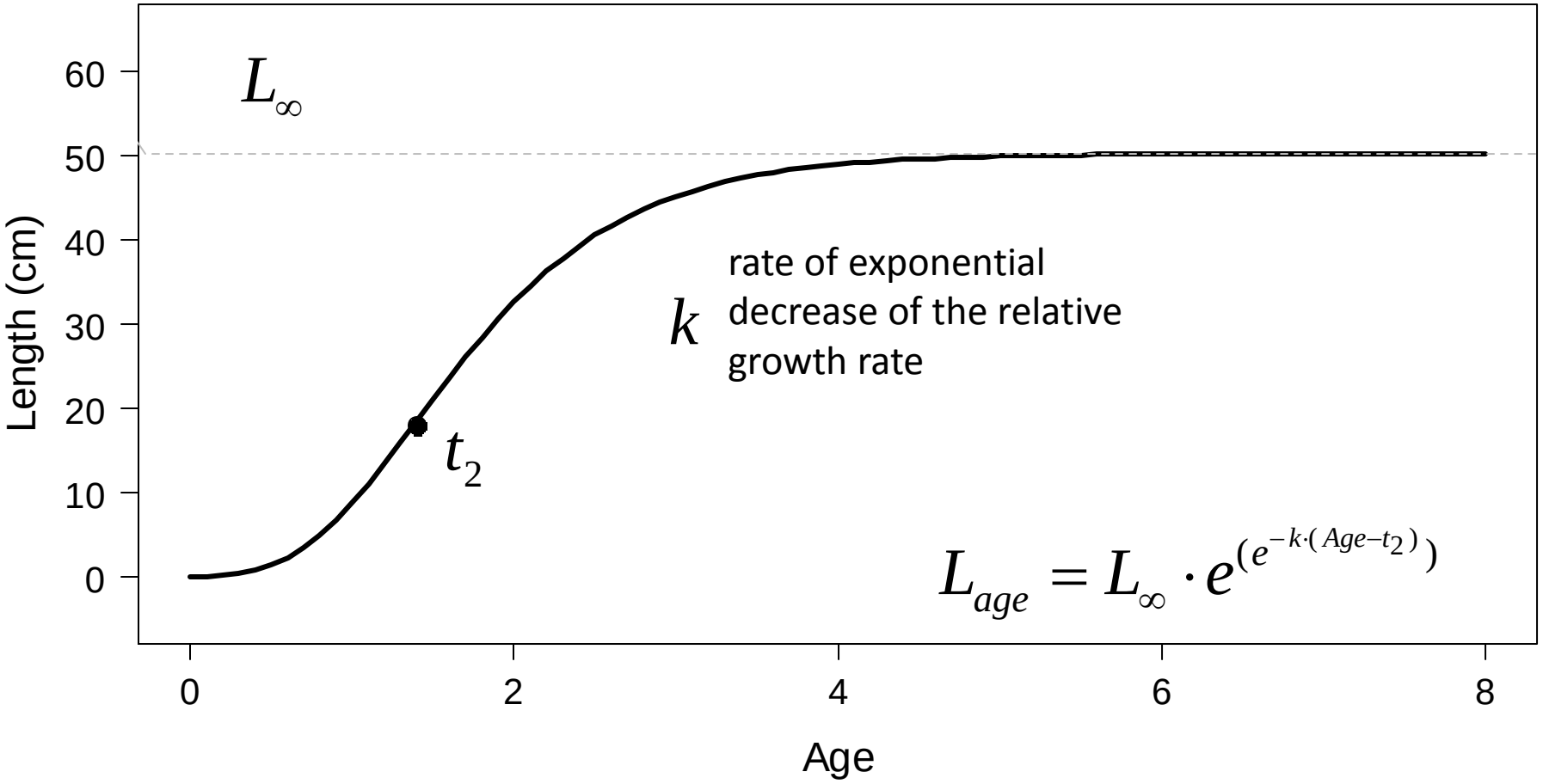
k_2 is the exponential decrease of relative growth rate & age

t_2 is related to lambda as $t_2 = (\ln \lambda - \ln k_2) / k_2$

The Gompertz growth model



Gompertz


L_∞
60
50
40
30
20
10
0
Length (cm)
k
rate of exponential
decrease of the relative
growth rate
t_2
$L_{age} = L_\infty \cdot e^{(e^{-k\cdot(Age-t_2)})}$
0
2
4
6
8
Age

The Logistic growth model

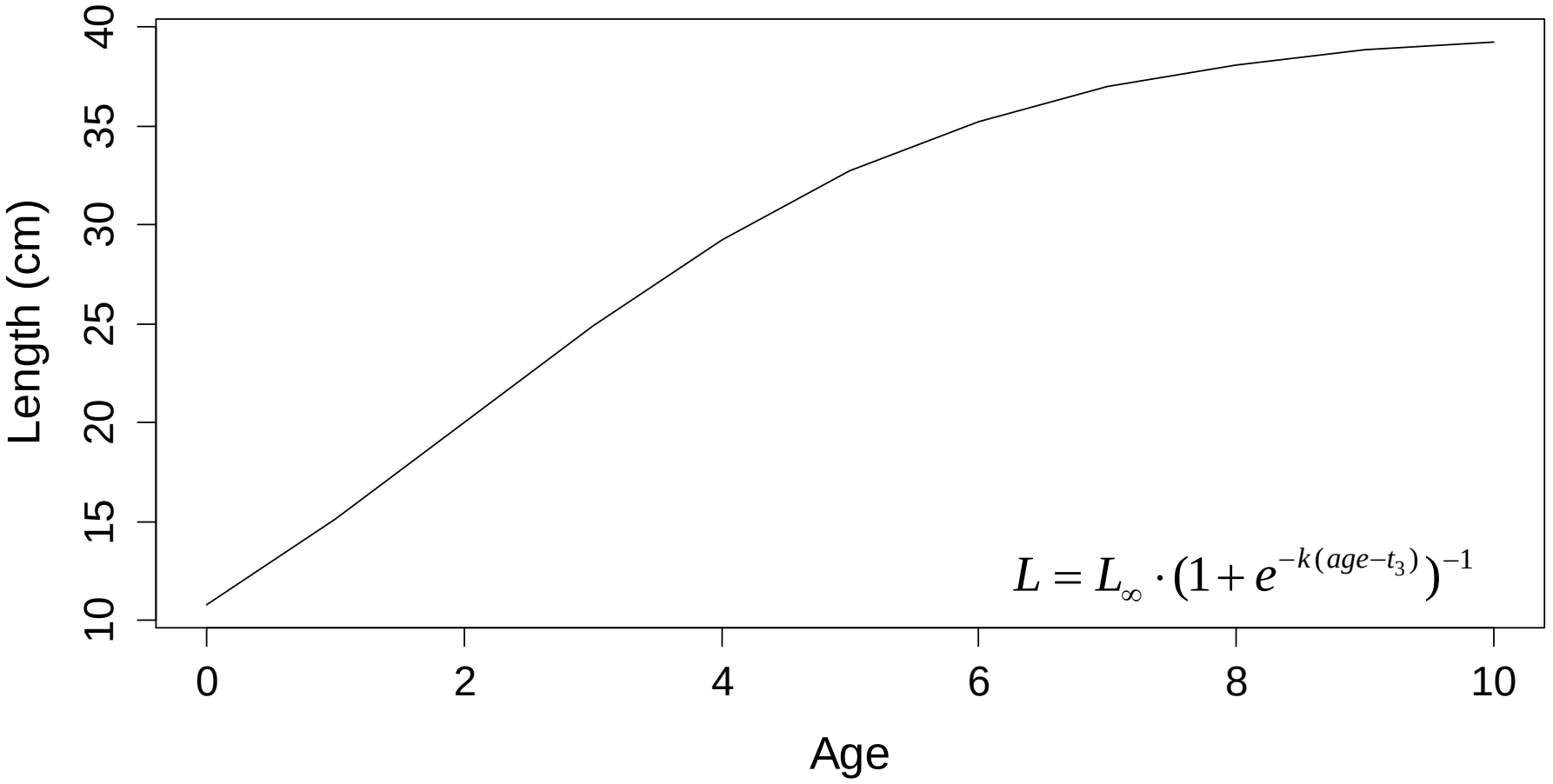
Widely used in fisheries science – many alternative forms, but the basic model for length is:

$$L = L_{\infty} \cdot (1 + e^{-k(age - t_3)})^{-1}$$

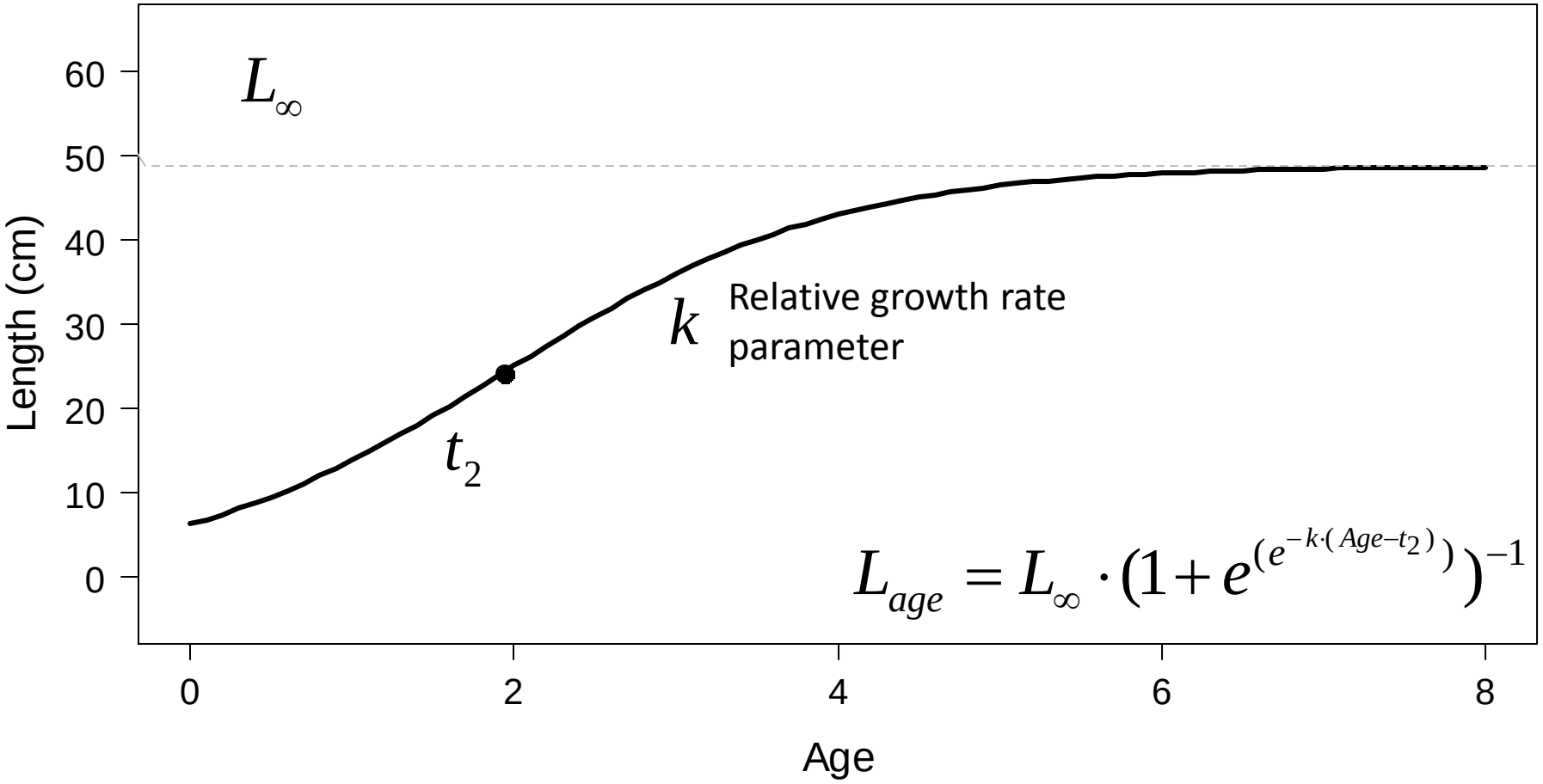
Where:

L	is the estimated *mean* length at age,
L_{∞}	is the asymptotic or theoretical *mean* maximum length,
k	is a relative growth rate, and
t_3	is the inflection point of the curve

The Logistic growth model



Logistic


L_∞
k
Relative growth rate parameter
t_2
$L_{age} = L_\infty \cdot (1 + e^{(e^{-k \cdot (Age - t_2)})})^{-1}$
Length (cm)
0
10
20
30
40
50
60
0
2
4
6
8
Age

The Power growth model

Not common, but reasonable

$$Length = \beta_0 + \beta_1 \cdot Age^{\beta_2}$$

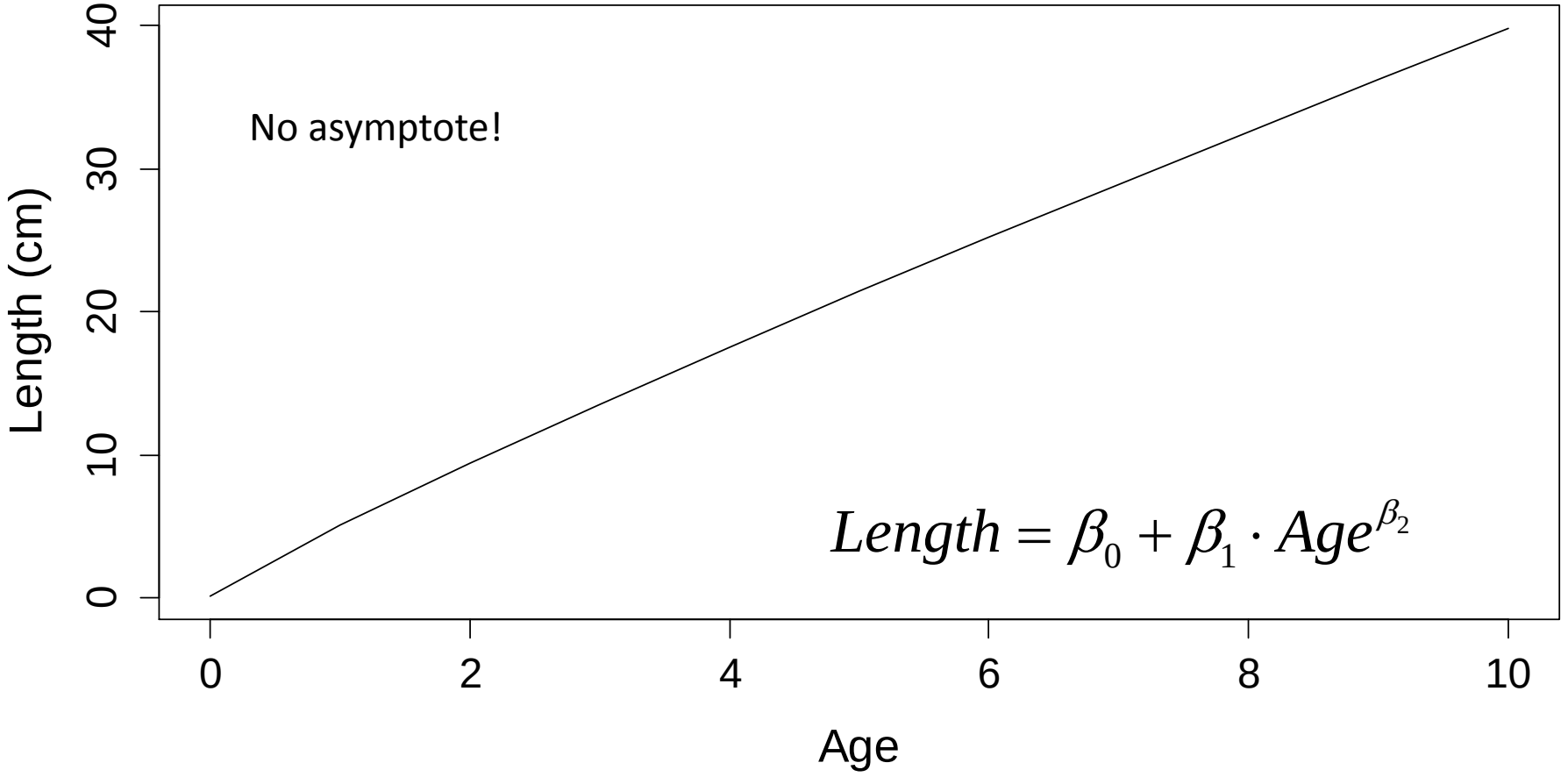
Where:

β_0 is the intercept

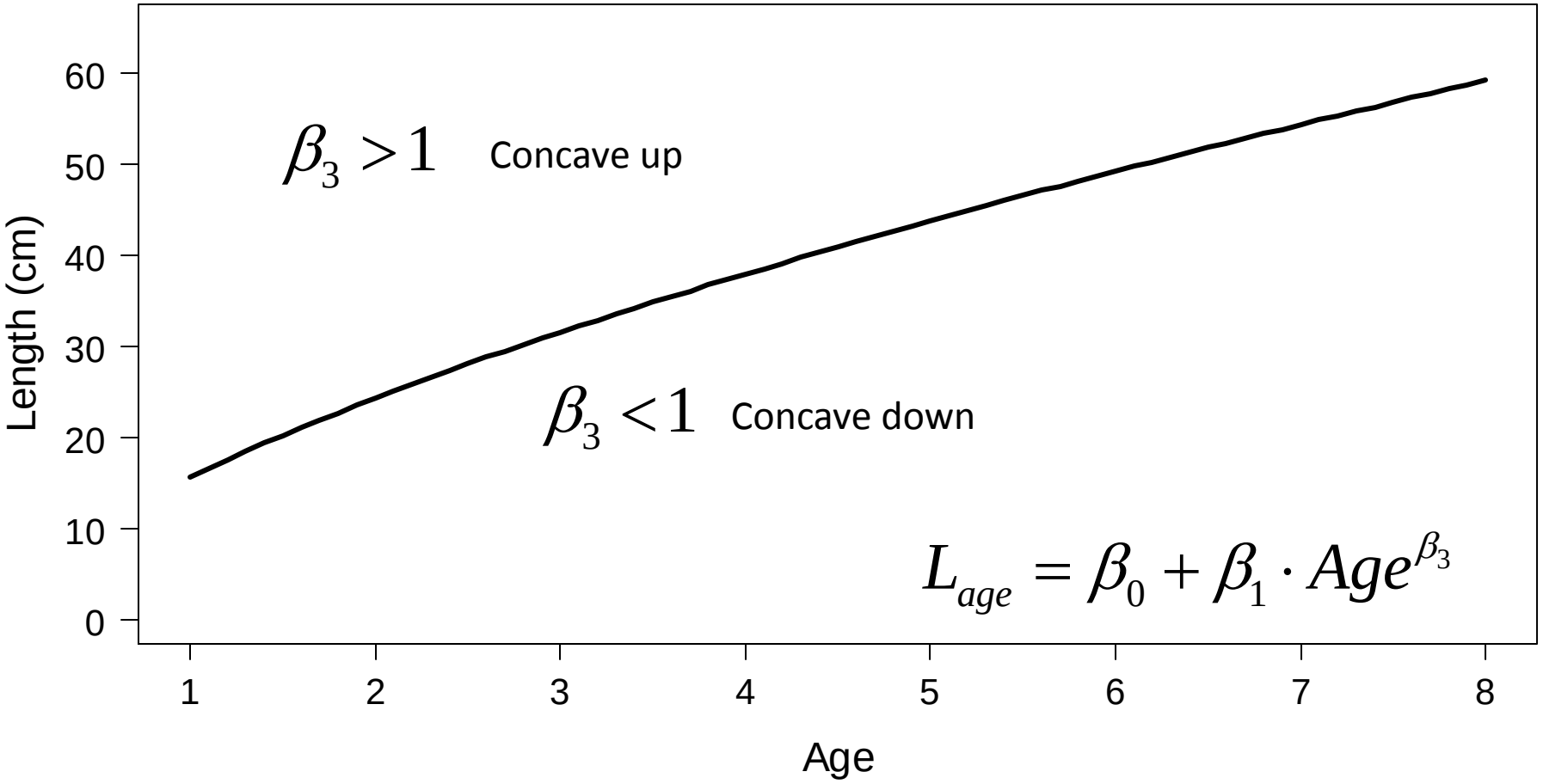
β_1 is the slope

β_2 is the power term, concave down when < 1

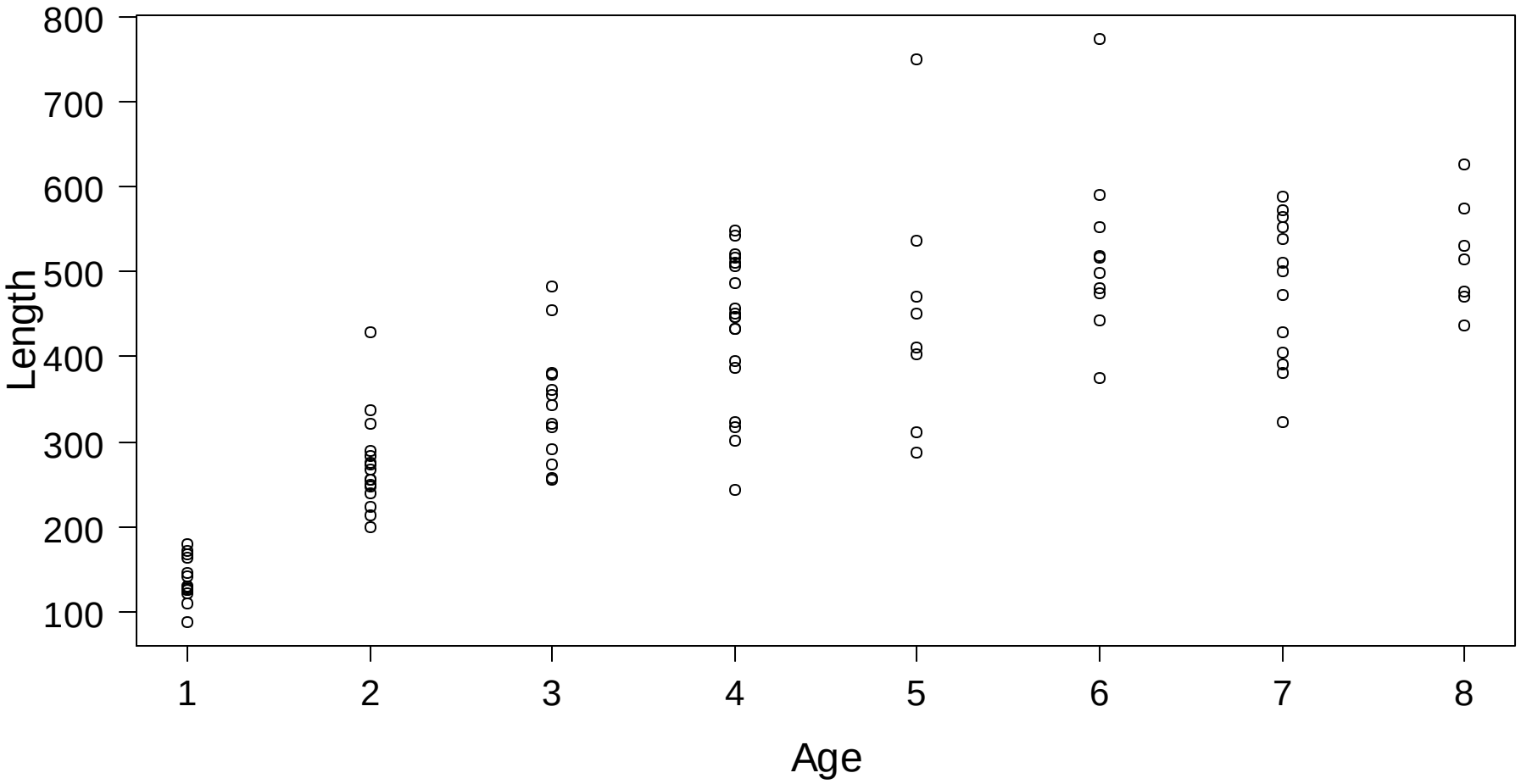
The Power Model



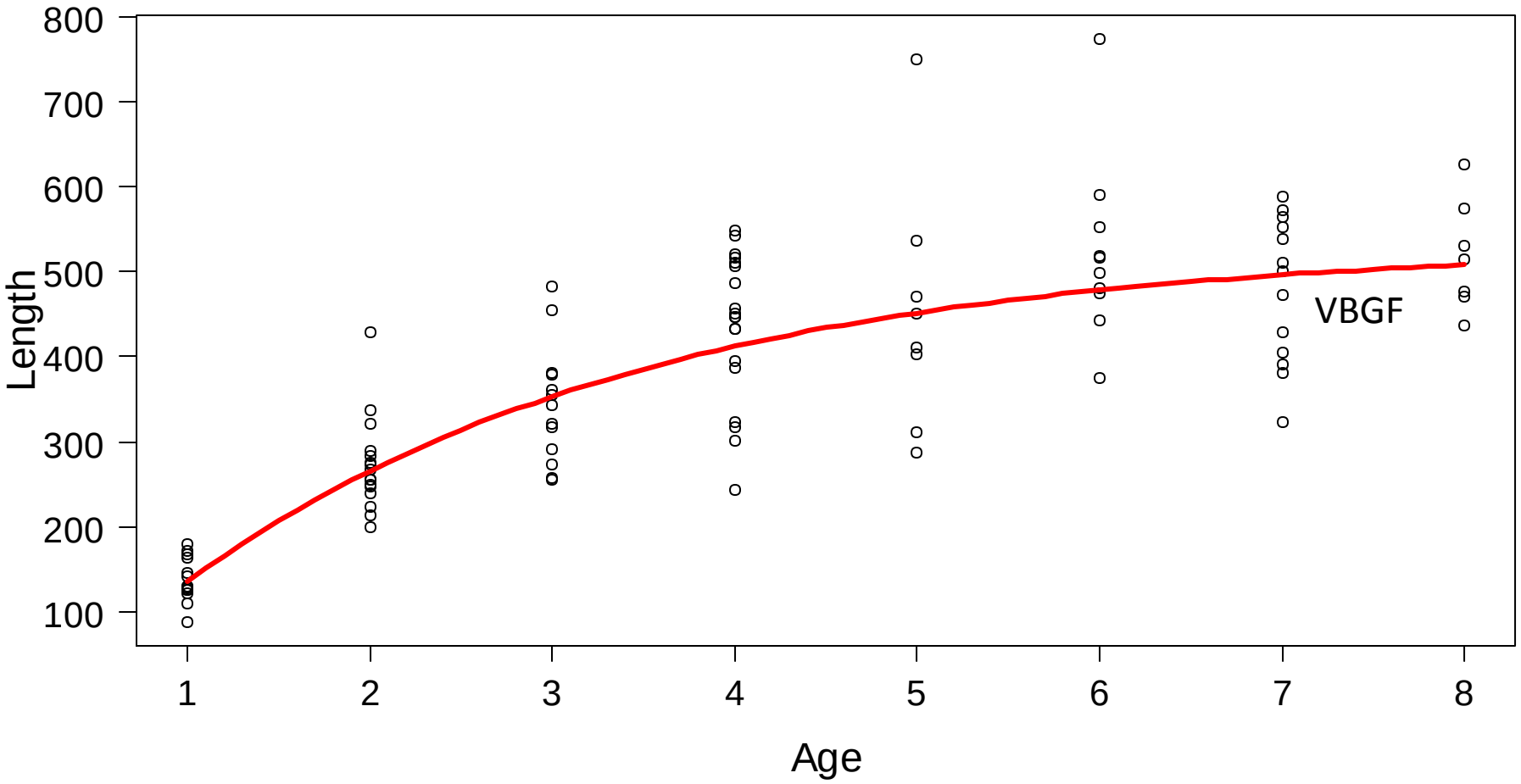
Power


60
50
40
30
20
10
0
Length (cm)
$\beta_3 > 1$ Concave up
$\beta_3 < 1$ Concave down
$L_{age} = \beta_0 + \beta_1 \cdot Age^{\beta_3}$
1
2
3
4
5
6
7
8
Age

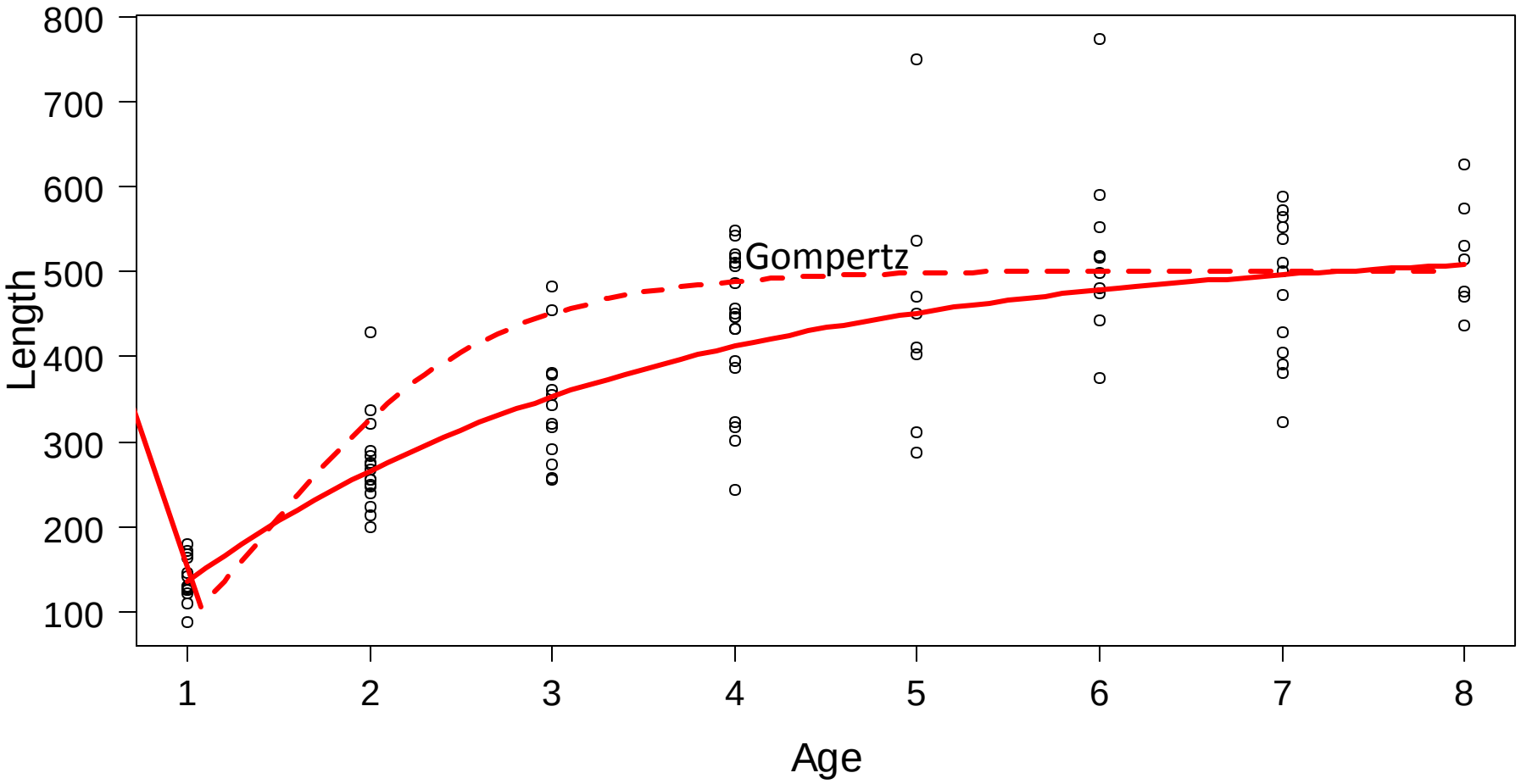
Some Age-Length Data



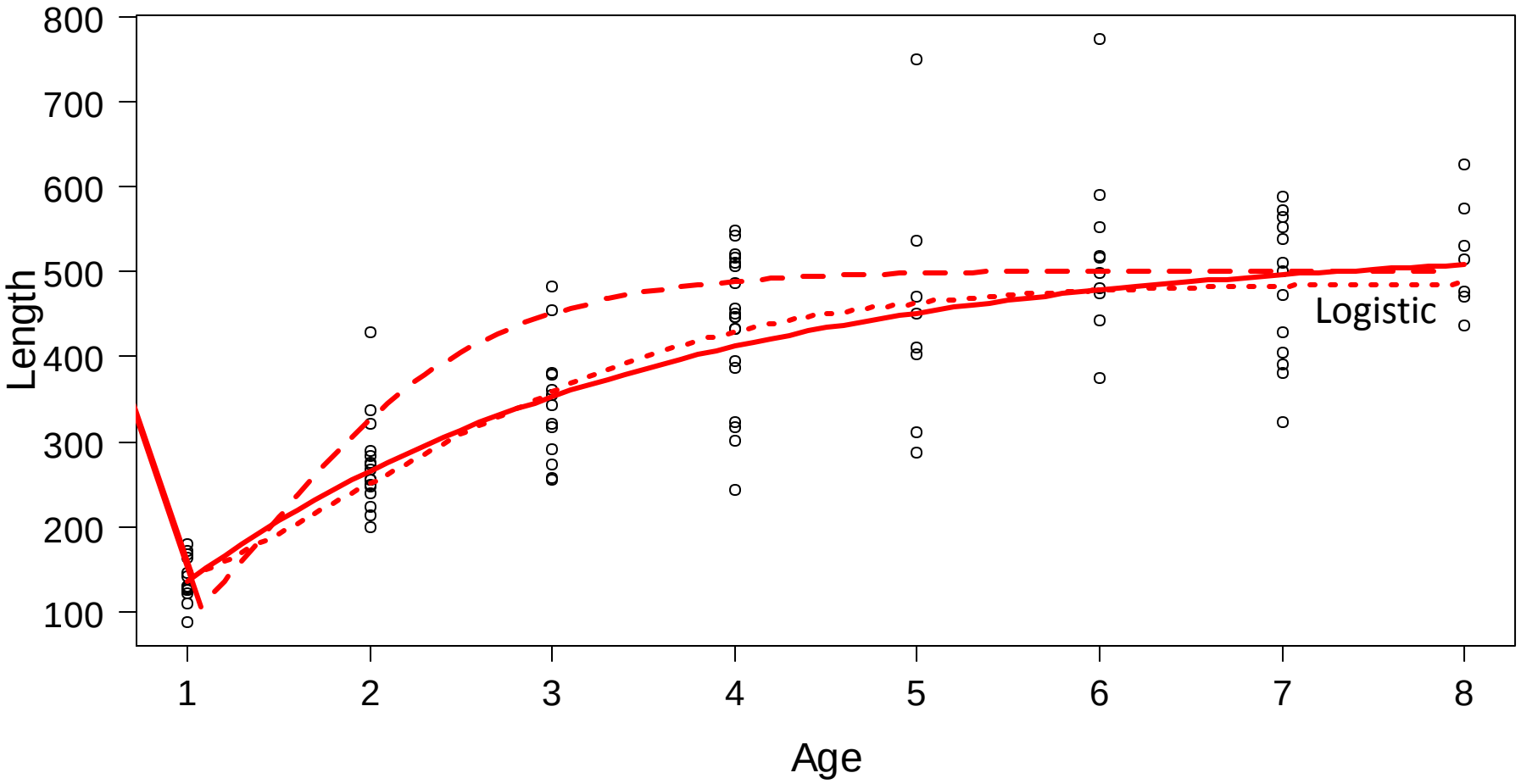
vonBertalanffy



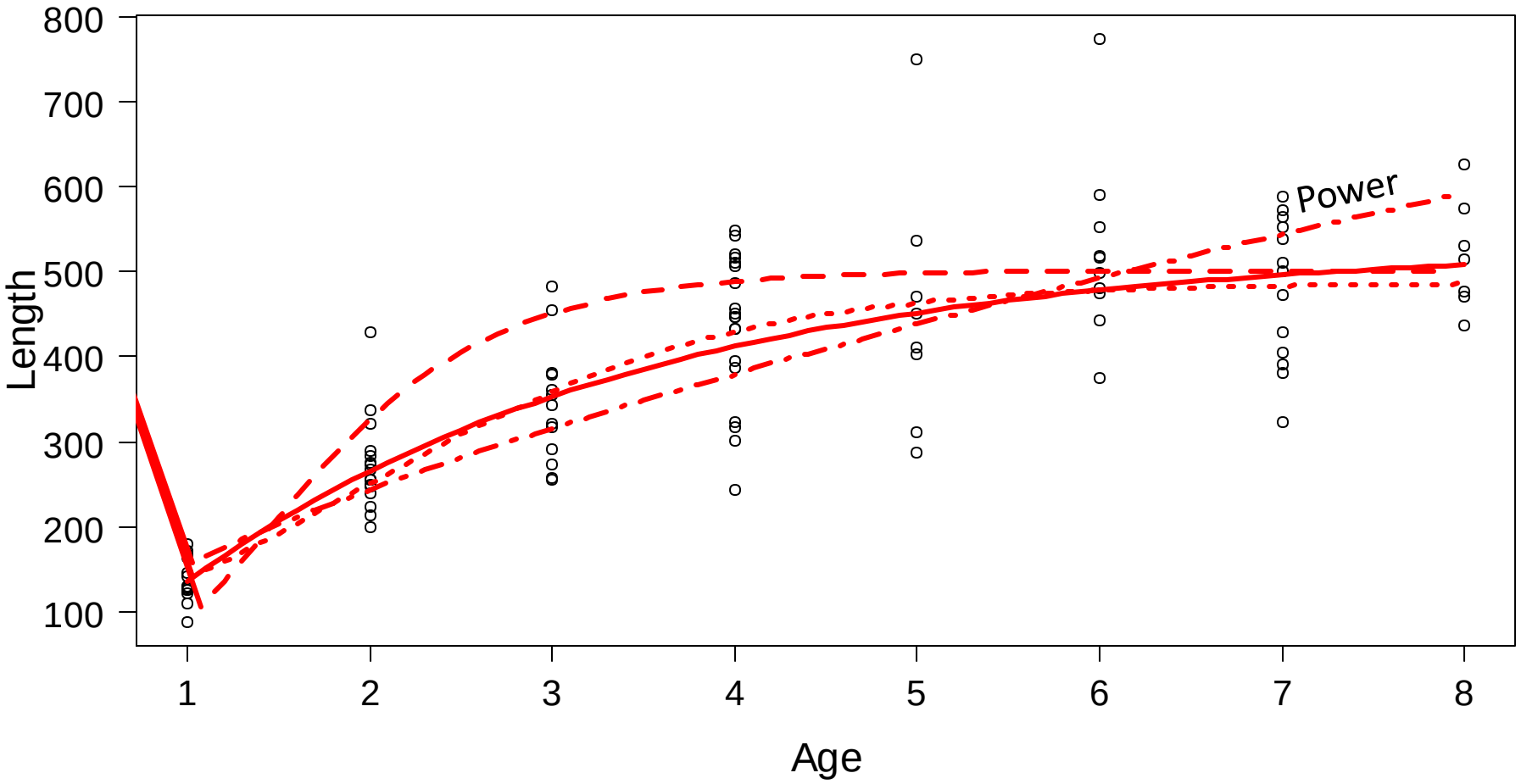
+Gompertz



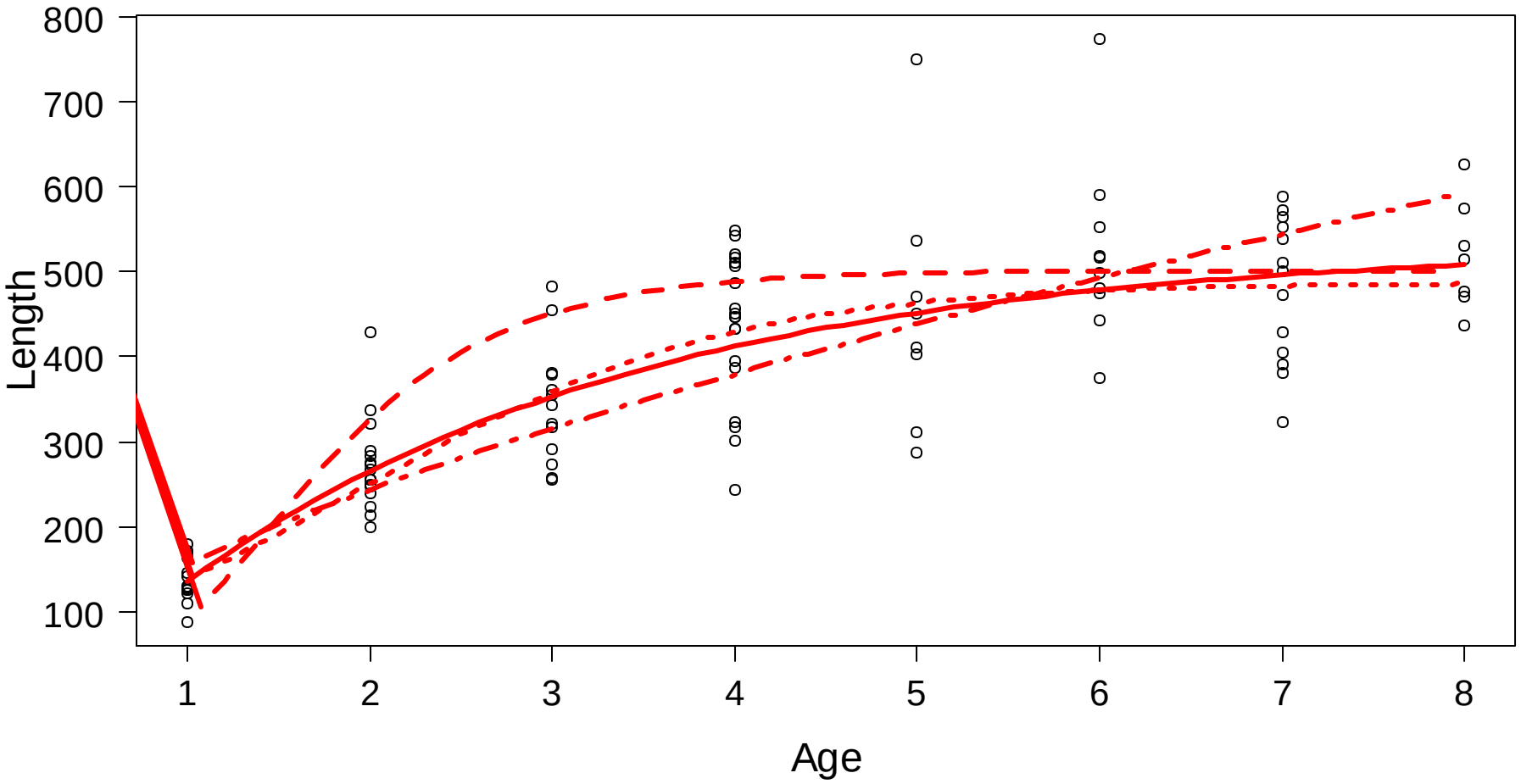
+Logistic



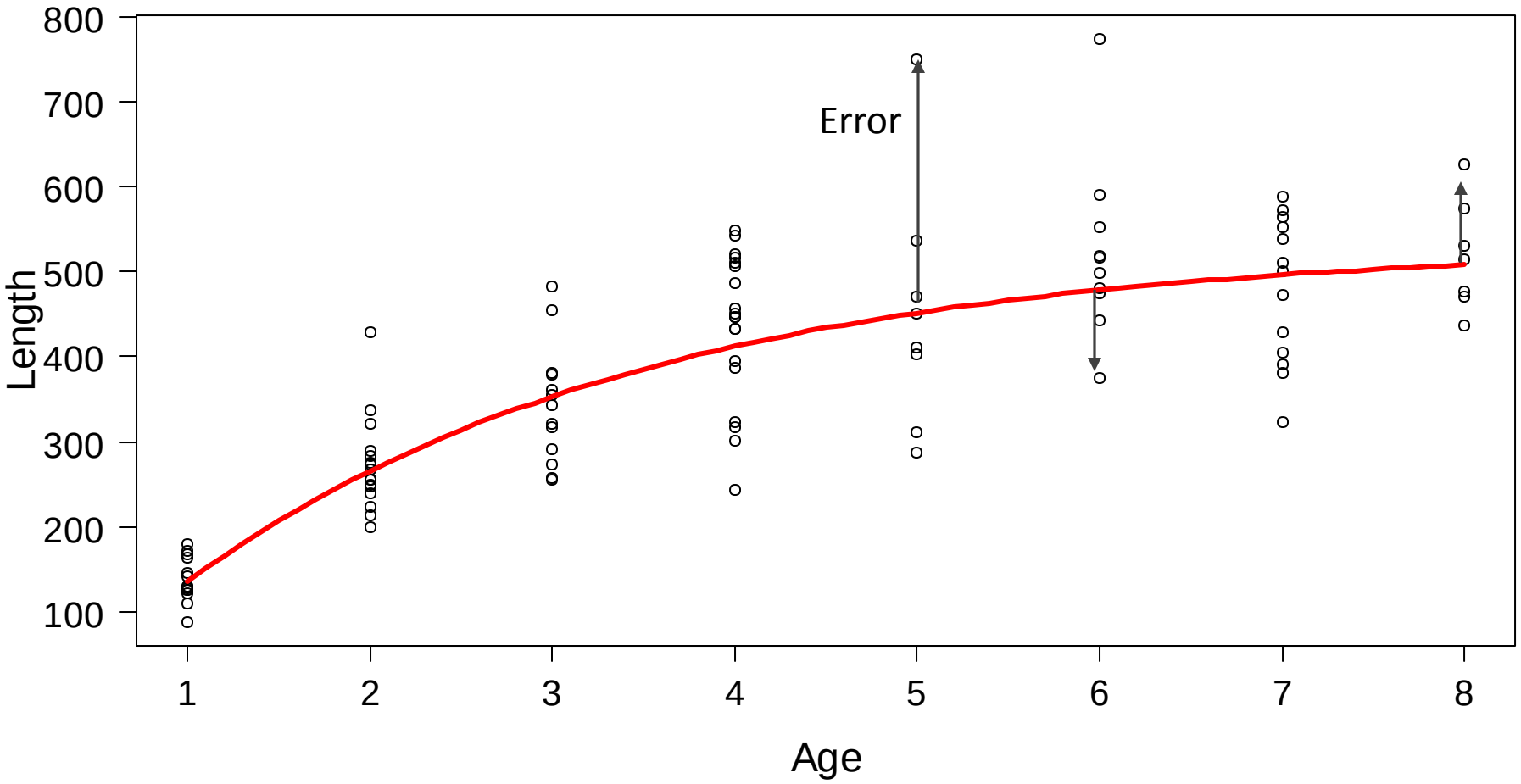
+Power



How to decide?



How to decide?



How to decide?

- Best fitting model
  - Mean absolute error (MAE)
  - Mean squared error (MSE)

Model	MAE	MSE
VBGF	58.5	**6526.2**
Gompertz	76.1	9306.283
Logistic	**58.3**	6565.2
Power	66.2	8065.2

So which one is Best?

Science Influences Management

FISH and FISHERIES

FISH and FISHERIES, 2008, **9**, 178–187

Modelling fish growth: multi-model inference as a better alternative to *a priori* using von Bertalanffy equation

Stelios Katsanevakis & Christos D. Maravelias

Institute of Marine Biological Resources, Hellenic Centre for Marine Research (HCMR), 46.7 km Athens-Sounio, P.O. Box 712, 19013 Anavissos, Attica, Greece

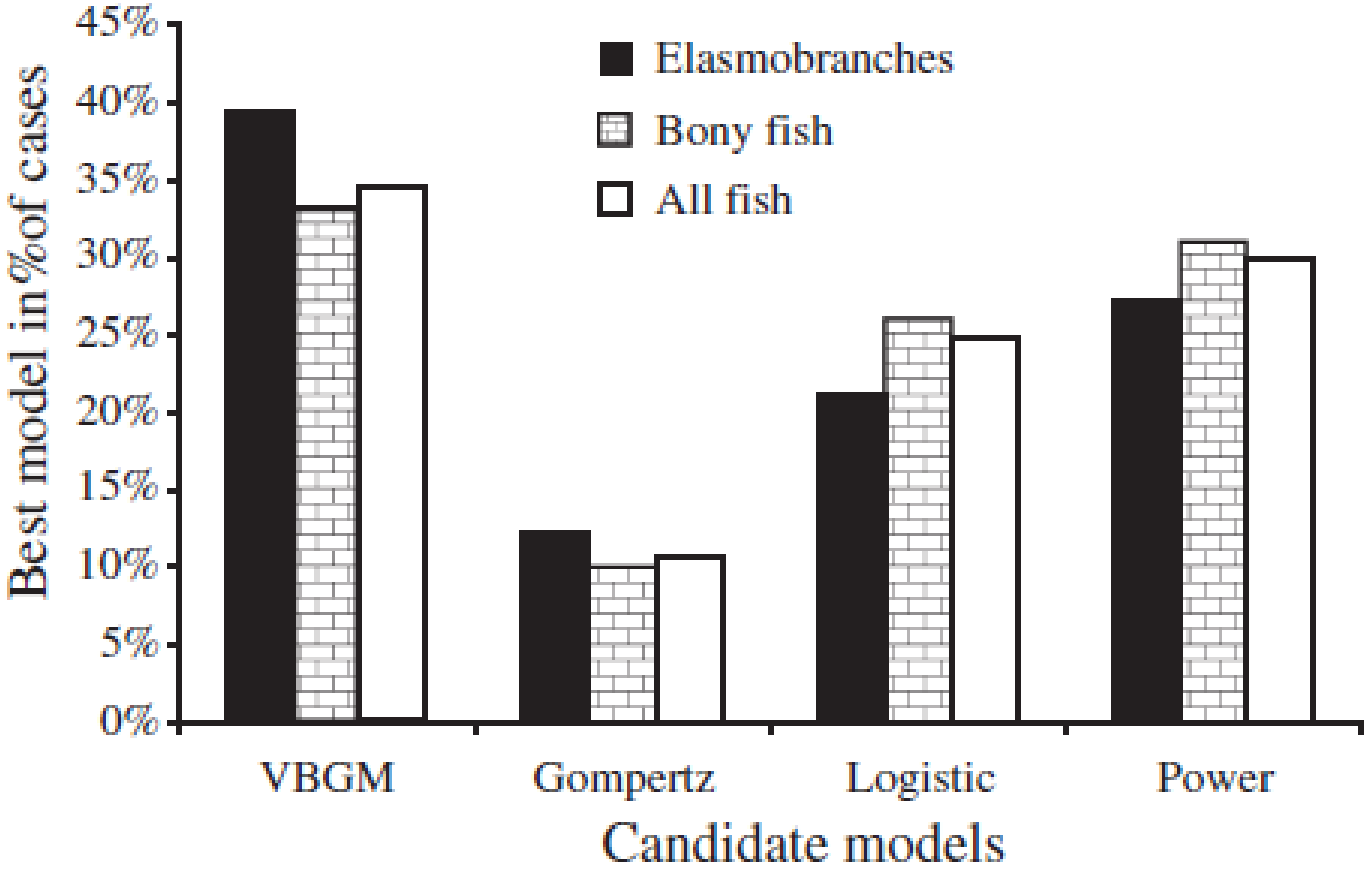


Figure 1 Percentage selection of each of the four candidate models of this study as the 'best' model, separately for elasmobranchs, bony fish and all fish combined.

Katsanevakis, S., and C. D. Maravelias. 2008. Modelling fish growth: multi-model inference as a better alternative to a priori using von Bertalanffy equation. Fish and Fisheries 9(2):178-187.

Multi Model selection

Likelihood of model given data and penalized for complexity

Model	AIC	ΔAIC	Model weight
VBGF	**1137.9**	**0**	**0.49**
Gompertz	1138.5	0.57	0.37
Logistic	1140.4	2.65	0.132
Power	1160.5	22.57	<0.001