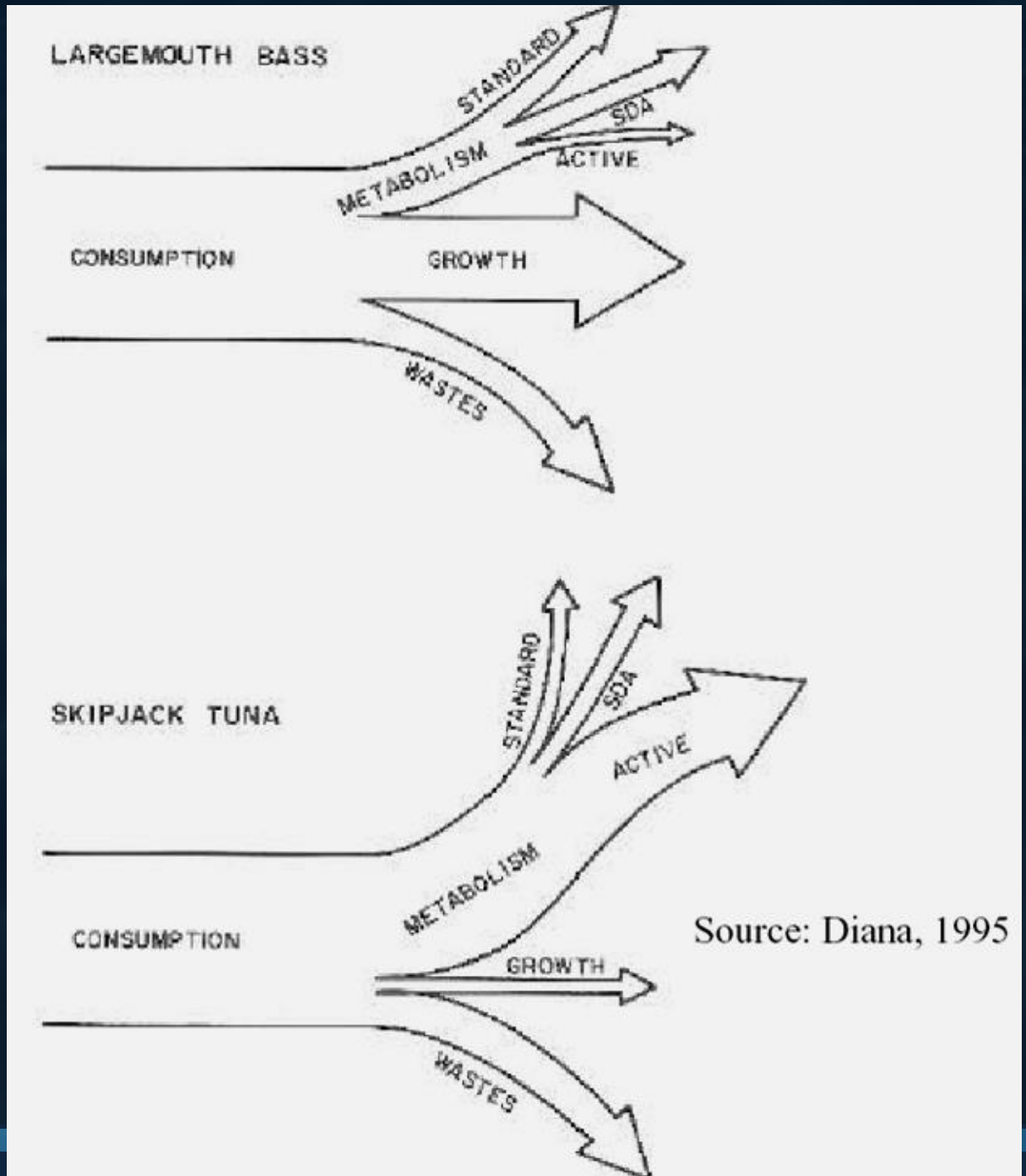
Feeding/Nutrition/Growth of Fish

Fundamentals of Fisheries Biology

3/2/2015



Source: Diana, 1995

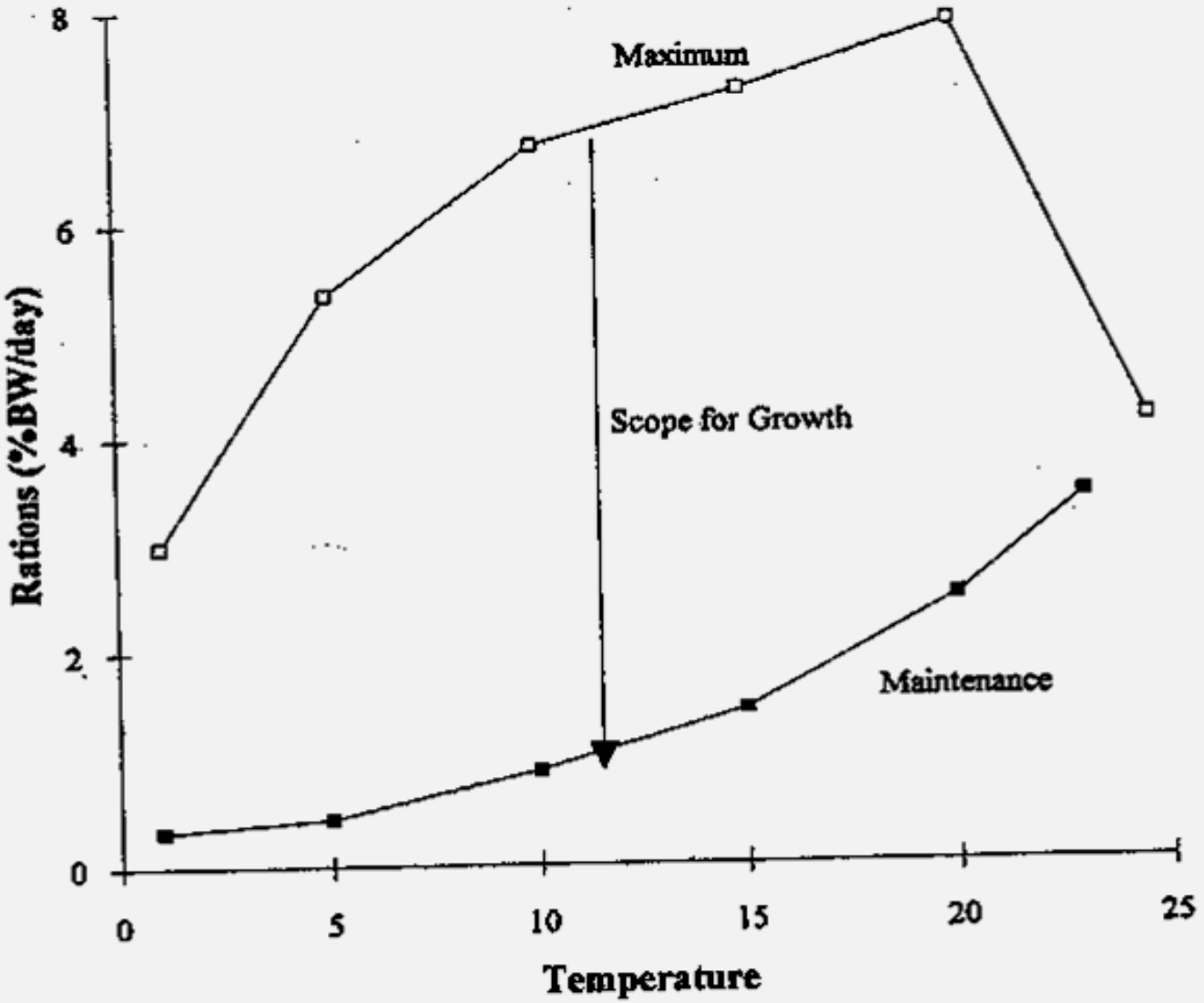
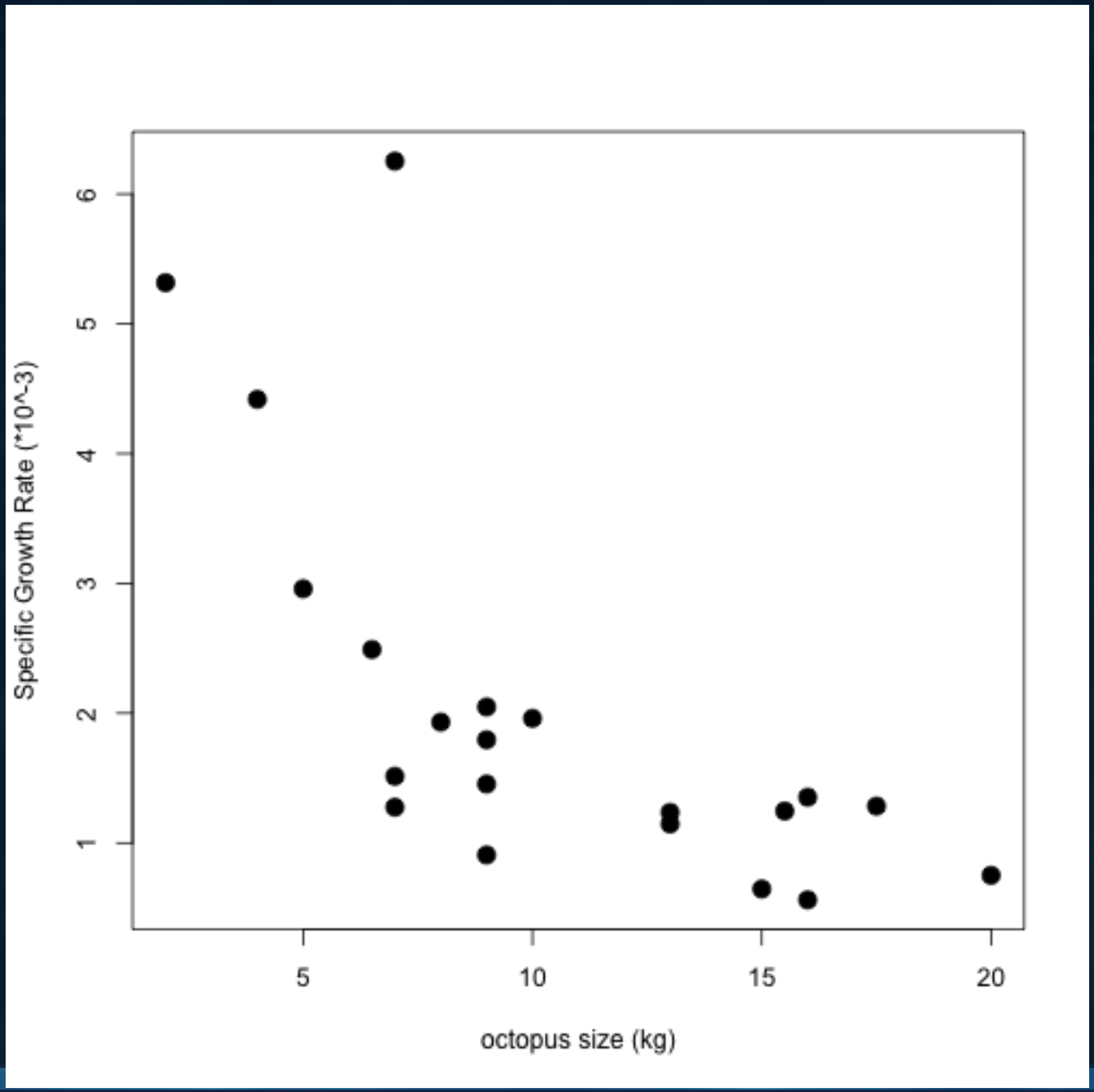


Figure 5-7. *Maintenance and maximum ration at each temperature for fingerling sockeye salmon. Redrawn from Brett et al. (1969).*


Specific Growth Rate (*10^-3)
1
2
3
4
5
6
5
10
15
20
octopus size (kg)

Part I. Fill in the blank (2 points each)

1. Ostracoderms means ___shell skinned____.
2. Osteichthyes means ____bony fish_____.
3. Fish like halibut and skates have a flattened body shape called __depressiform__.
4. Sharks commonly have __placoid___ scales.
5. The swimming style of eel-like fish (snake-like) is called __anguilliform_____.
6. A fish tail is also called the ___caudal___ fin.
7. A mouth pointed down, as seen in skates and rays, is called __inferior__ mouth.
8. __Red_ muscle is used by fish for slow continuous swimming (hint: it's a color).
9. _Counter Current Exchange_ is the efficient extraction method that fish use where water flow over the gill goes one way and direction of blood flows the other.
10. The term ___hypoxia_____ means reduced oxygen content of air or a body of water detrimental to aerobic organisms

Part II. TRUE/FALSE (2 points each; circle one)

1.	TRUE	FALSE	Systematics is the study of the evolutionary relationship among organisms.
2.	TRUE	FALSE	Many sharks have paired spiracles on their head that they may use to aerate the gills.
3.	TRUE	FALSE	The bony fishes have evolved light weight and flexible scales in comparison to their ancestors.
4.	TRUE	FALSE	Salmon are anadromous fishes.
5.	TRUE	FALSE	Meristic traits are standard measurement of fish size (length or width) anatomical
6.	TRUE	FALSE	Sharks have a homocercal tail hetercercal
7.	TRUE	FALSE	Ram gill ventilation is a passive form of gill aeration achieved by swimming with the mouth open.
8.	TRUE	FALSE	Fish need oxygen to digest food.
9.	TRUE	FALSE	Body weight is a major factor affecting oxygen consumption rate
10.	TRUE	FALSE	The name of the instrument used to measure respiration in fish is called a respirometer.

Part III. SHORT ANSWER (5 points each)

1. Compare allopatric and sympatric speciation

   Allopatric - causes different selection pressures that when combined with intrinsic factors such as original size and makeup of gene pool of isolated population results in development of genetically distinct populations. GEOGRAPHICALLY SEPARATED

   Sympatric – new species evolve from a single ancestor despite overlap. NOT GEOGRAPHICALLY SEPARATED

2. Provide three alternate strategies (not normal) that fish use for respiration. Provide a brief description of how it works (1 sentence or phrase so I know you can associate it with use).

   Skin Breathers – Diffusion of oxygen through the epidermis. Important in larval fish, Black Bullhead is the only fish that can supply up to 5% of their total oxygen demand, European eels move at night when cooler and usually through wet grass

   Respiratory Trees – Widely spaced lamella allow for terrestrial exposure. Walking catfish

   Mouth Breathers – Greatly reduced gills, most of the oxygen is taken through the mouth at the surface. Electric eels

   Gut Breathers – Swallow water and extract in the stomach. CO_2 dumped at the gills. Tropical catfish

   Lungs/Swimbladders – Have true lungs or breath with a modified swimbladder. Lungfish, Bichirs, Bowfin, Gars

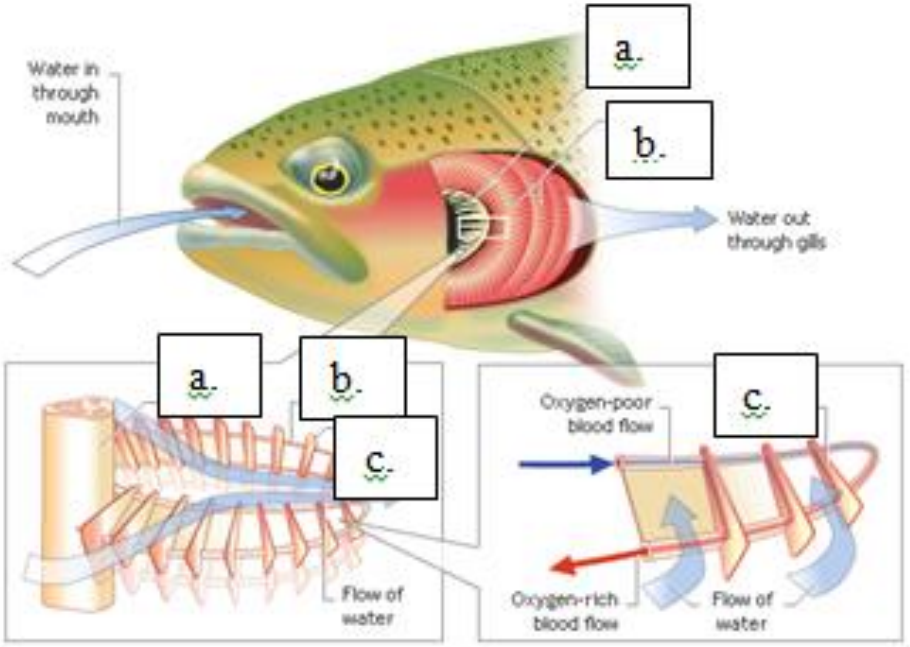
3. What are the two type of fish blood cells and what is the function of each?

Leukocytes – white blood cells, provide ability to clot blood and rid body of foreign material. Several types found in fish blood though less abundant than RBCs.

Erythrocytes – red blood cells, most abundant in fish blood, contain hemoglobin, carry oxygen from the gills to the tissues.

4. List the appropriate parts of the fish gill

a. __gill arch_____
b. __gill filament___
c. ___lamella_____



Part IV. SHORT ESSAYS (20 points each)

1. Fishes have six basic and broad defining body shapes. List the six shapes; include what they are and what the defining characteristics are of each shape and give an example of a fish with this shape.

Rover-predator – classic fish –fusiform, pointy headed terminal mouth, evenly distributed fins, narrow caudal peduncle, capture prey by pursuit – bass, tuna, mackerel, salmon

Ambush-predators – torpedo streamlined, flattened head to present narrow profile, large mouth, prominent teeth, cryptic coloration, large caudal fin, fins set back on body in a row, secretive, lunging – pike, gar, barracuda, needlefish

Surface-oriented fish – usually small, upward, superior mouth position, dorsovent flat head, large eyes, dorsal fin toward rear of body – feed in surface waters – flyingfish killifish, mosquitofishes

Deep bodied fish – wider than long, dorsal and anal fins long, pec fins high on body,some fins w/ sharp spines, mouth small and protrusible, eyes large, snout short - bluegill

Eel and eel like fish – elongate bodies, blunt wedge shaped heads, crevice and hole dweller, macro beds, anal and dorsal fins may run into caudal fin

Bottom feedeing fishes – no or reduced swim bladder, flattened dorsoventrally, variety of feeding habits

2. Describe the fish circulatory system and how air travels from the water to the tissues. (Don't forget to mention type of heart, type of blood pigment, oxygen affinity, etc.)

Fish have a two chamber heart and a closed circulatory system.
Fish blood is composed of plasma, Erythrocytes (RBCs) and Leucocytes (WBCs).
When a fish opens its mouth oxygenated water is extracted at the gills.
As the flow of blood in the lamella is in the opposite direction of the flow water, oxygen is extracted via counter-current-exchange.
The Erythrocytes contain hemoglobin which have a high oxygen affinity and can bind four molecules.
As blood flows in though the body and as tissues produce CO_2 as part of metabolism, the oxygen molecules are driven off of the hemoglobin.
The oxygen in the plasma transfers to the tissues while the CO_2 is carried in the blood back to the gills where it is released.

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Fundamentals of Fisheries Biology

3/2/2015


50 LBS. NET
PURINA
TROUT
CHOW
50 LBS. NET
PURINA
TROUT
CHOW
50 LBS. NET
PURINA
TROUT
CHOW

Classification of Feeding Habits

- Detritivores
- Herbivores
- Carnivores
- Omnivores

Classification of Feeding Habits

- Detritivores - feeding on dead material off the seafloor
- Herbivores - feeding on live plant materials
- Carnivores - feeding on living animals
- Omnivores - feeding on a mixture of plant and animal material

Food Selectivity in Fishes

- Euryphagous
- Stenophagus
- Monophagous

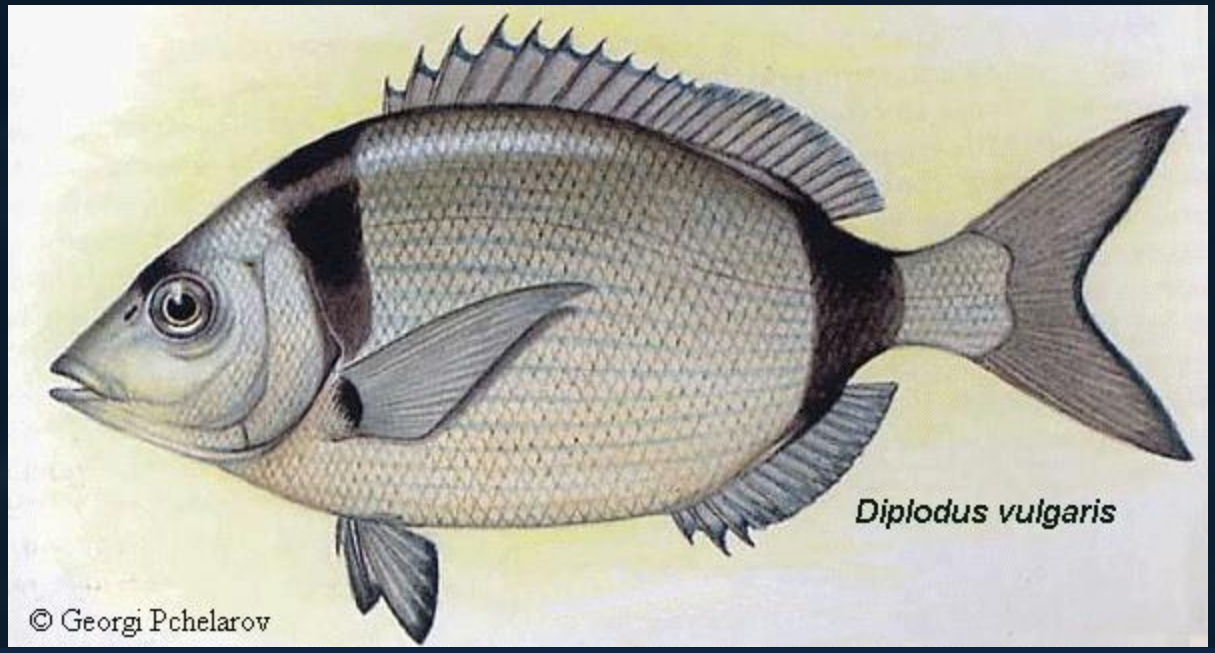
Food Selectivity in Fishes

- Euryphagous (Eury =many) – feeding on wide variety of organisms
- Stenophagus (Steno =narrow) – feeding on a small variety of organisms
- Monophagous (one food) – feeding on only one species or type of food
- Most fish are …….

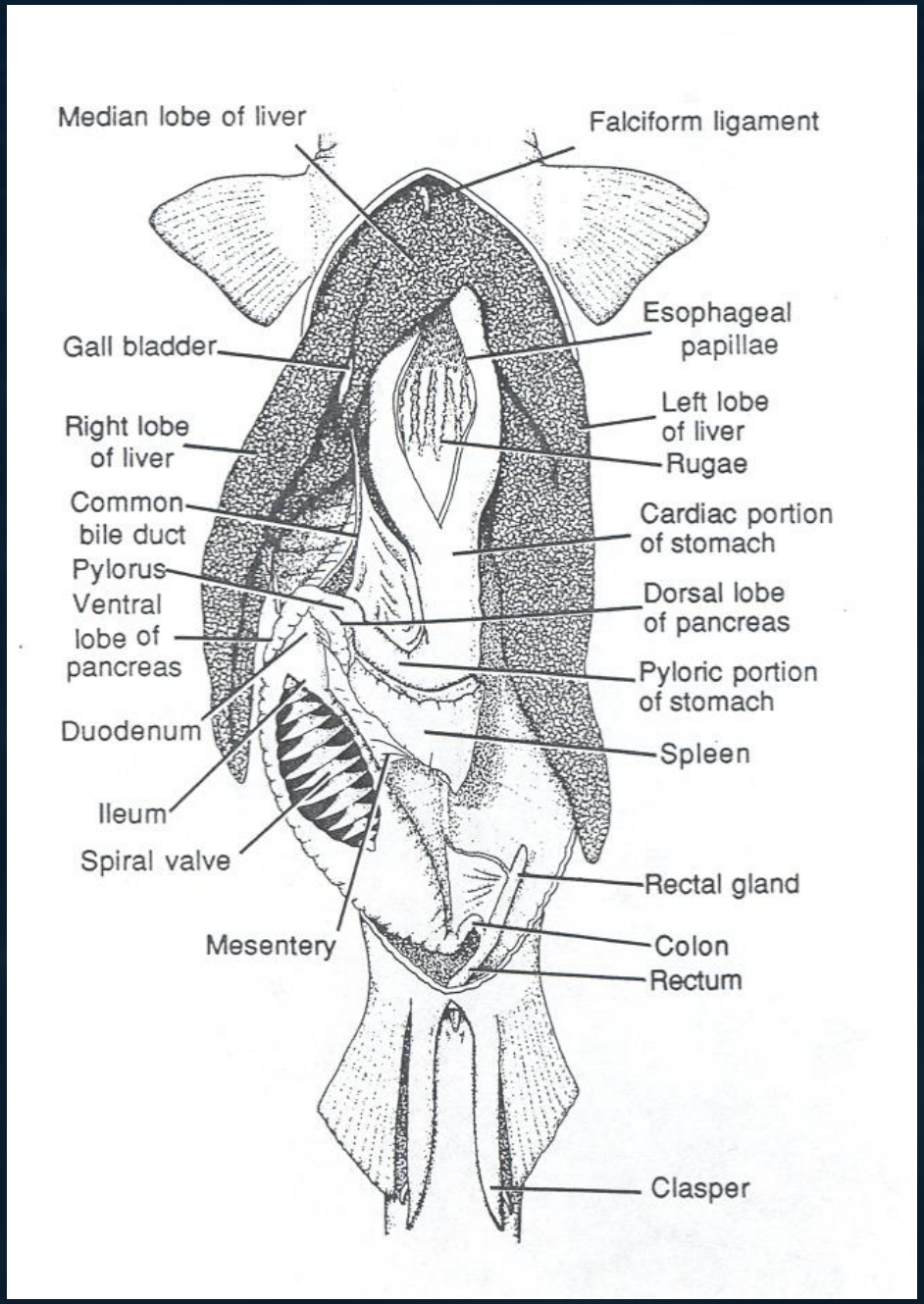
Gut length and feeding

Correlation between gut length and food type

- Longer gut = detritus/algae
- Intermediate gut = zooplankton…
- Short gut = carnivore



Dietary Type	Ratio of body length to gut length
Carnivore	0.7 to 0.9
Omnivore	1.1 to 2.2
Herbivore	5.4 to 28.7


Median lobe of liver
Falciform ligament
Esophageal papillae
Gall bladder
Left lobe of liver
Right lobe of liver
Rugae
Common bile duct
Cardiac portion of stomach
Pylorus
Dorsal lobe of pancreas
Ventral lobe of pancreas
Pyloric portion of stomach
Duodenum
Spleen
Ileum
Spiral valve
Rectal gland
Mesentery
Colon
Rectum
Clasper

Gut Length

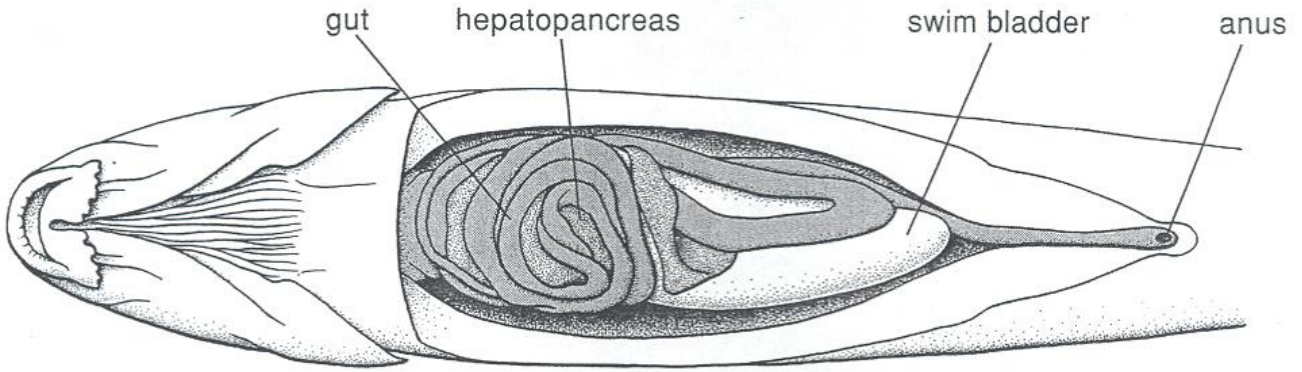


FIGURE 25–5 Elongate gut of sucker (*Catostomus macrocheilus*), a microphagous fish.

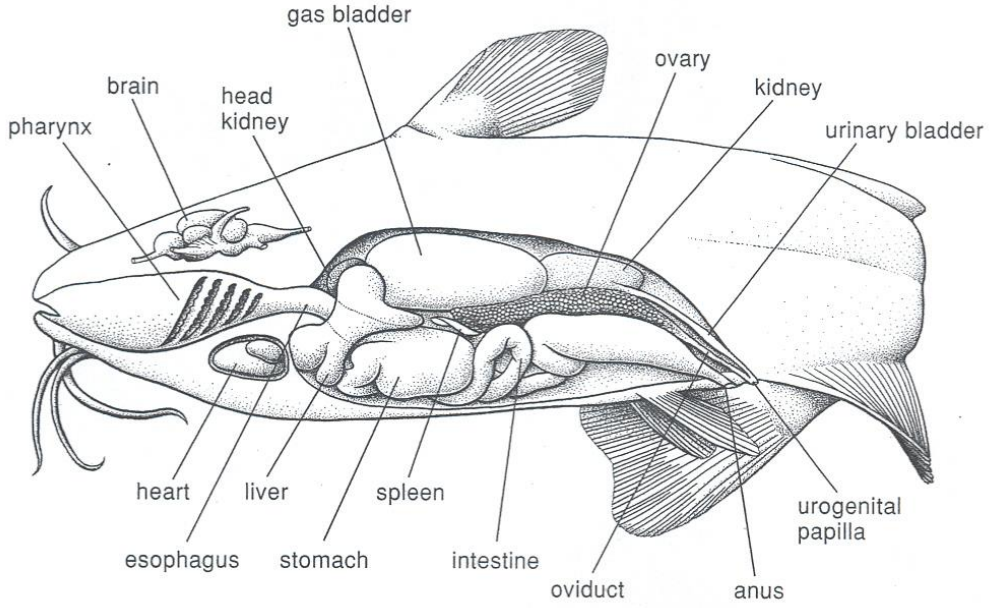
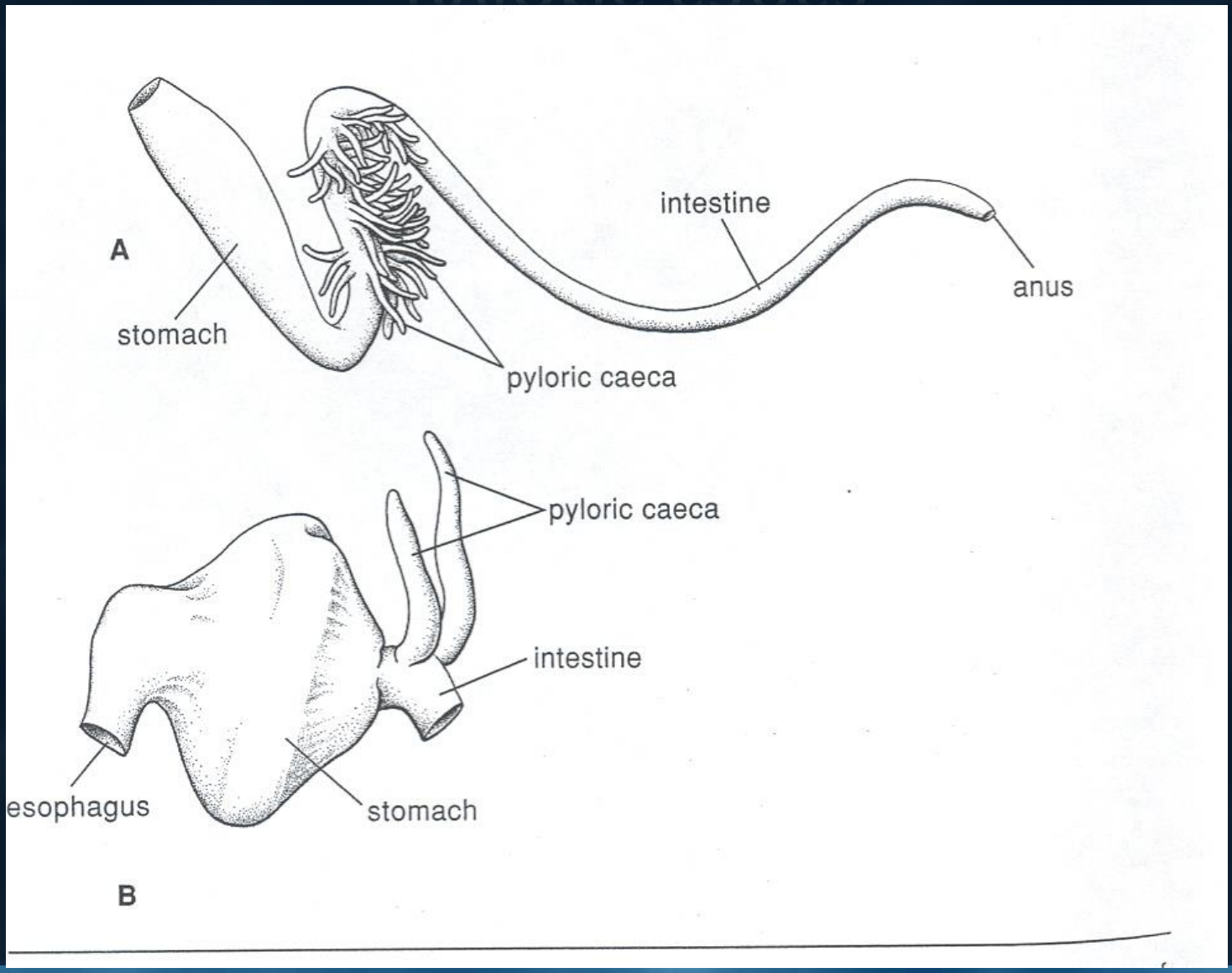


FIGURE 25–6 Bullhead (*Ameiurus*), head sectioned slightly to left of midline, body cavities opened to show

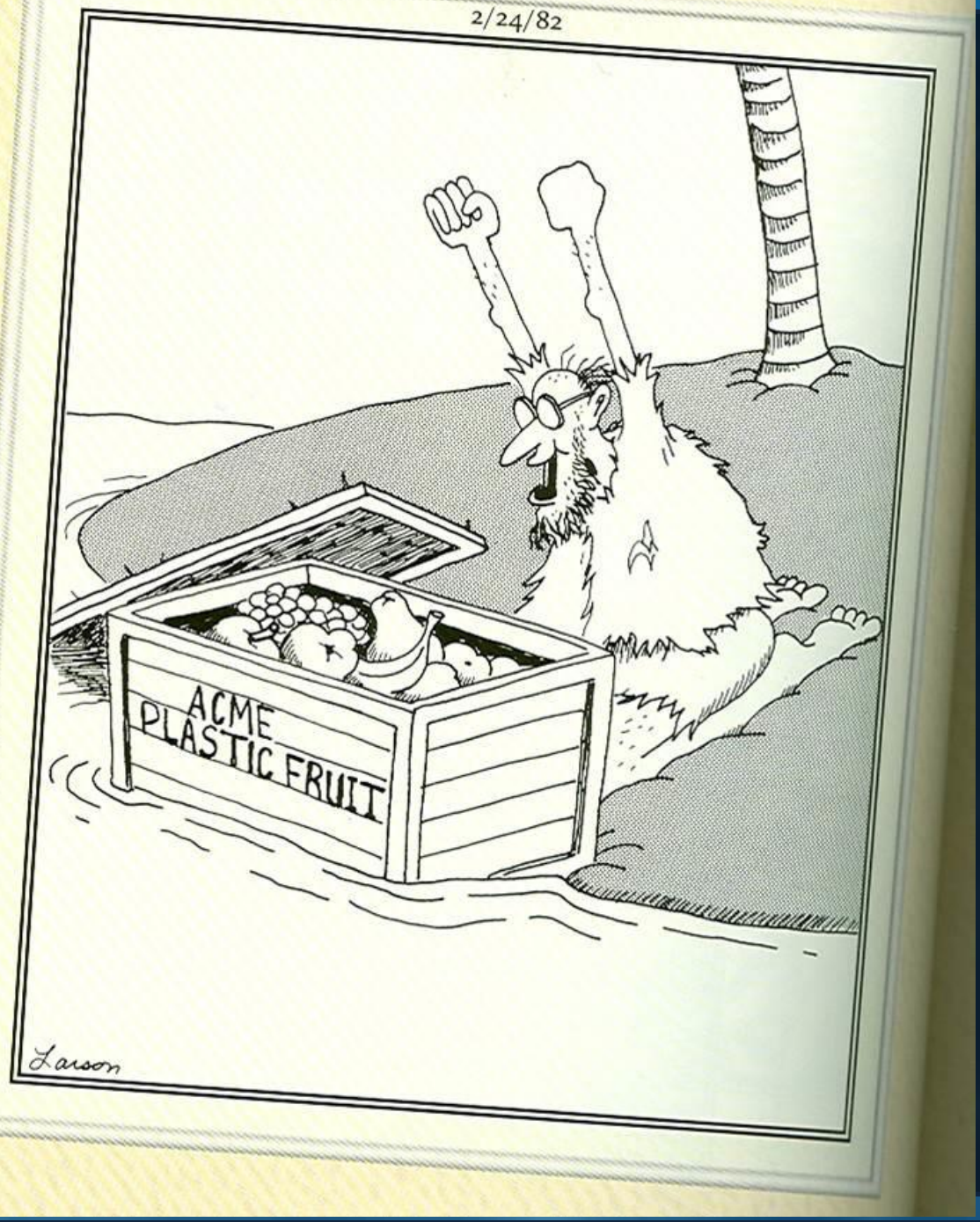
Pyloric caeca



Palatability and shape

- Friability

2/24/82



Prey capture

Methods

Functional anatomy

Food capture

Ram feeding: overtakes prey by rapid swimming, has mouth open when prey approached.

Suction feeding: creates vacuum in buccal cavity, opens mouth and extends mouthparts when prey encountered.

Manipulation: biting, scraping, clipping


© Leanne&David Atkinson

Mouth structures can help

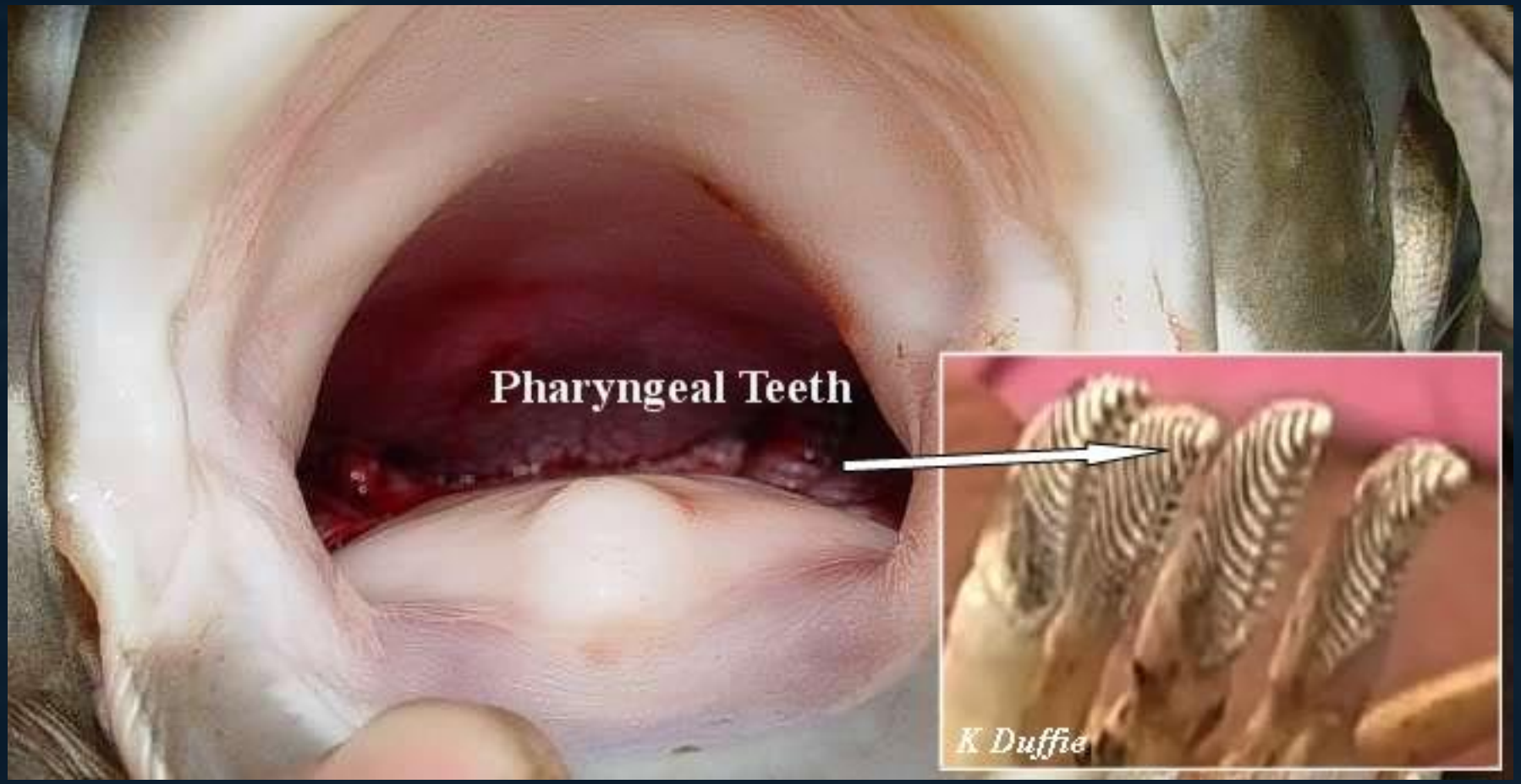
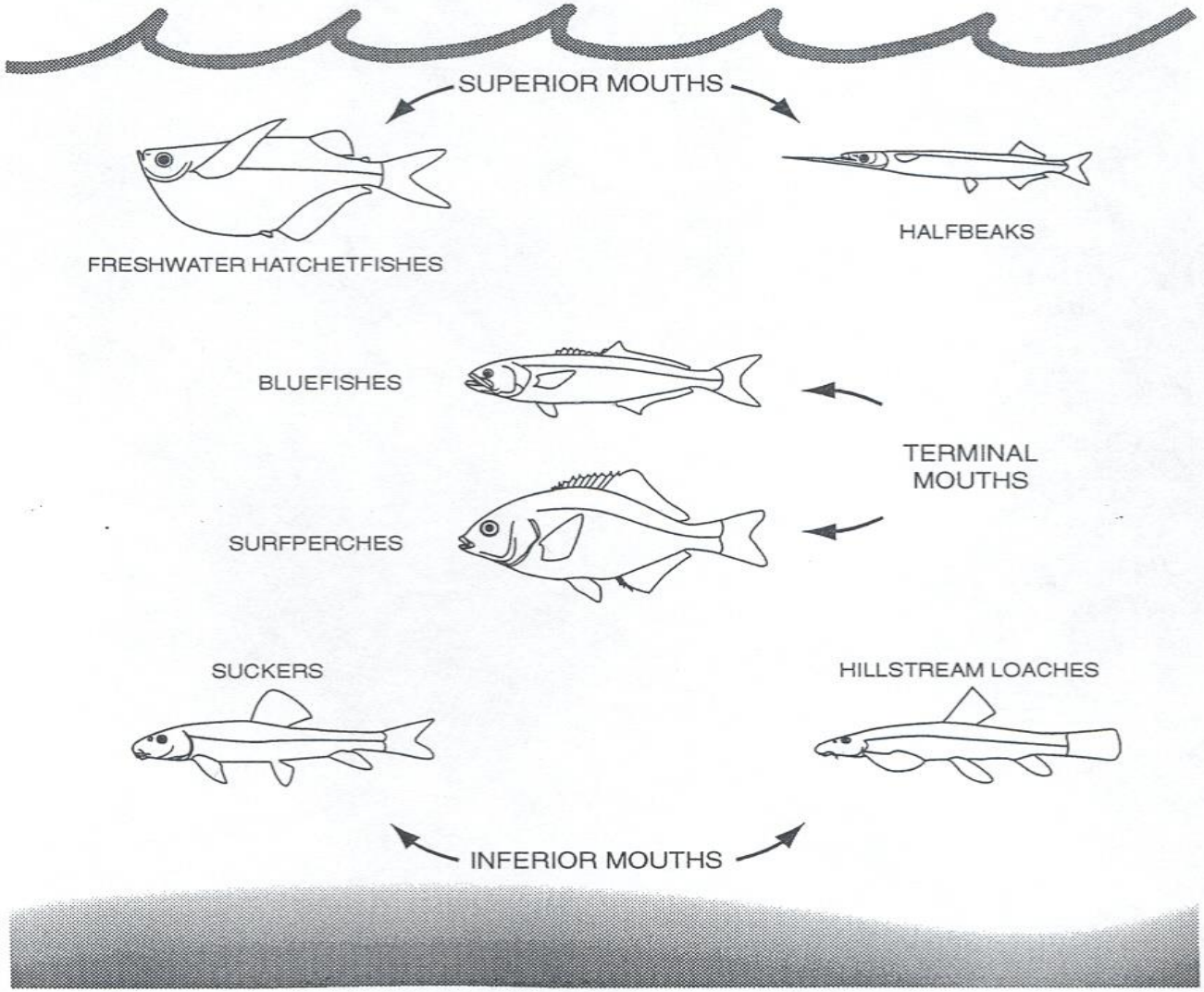
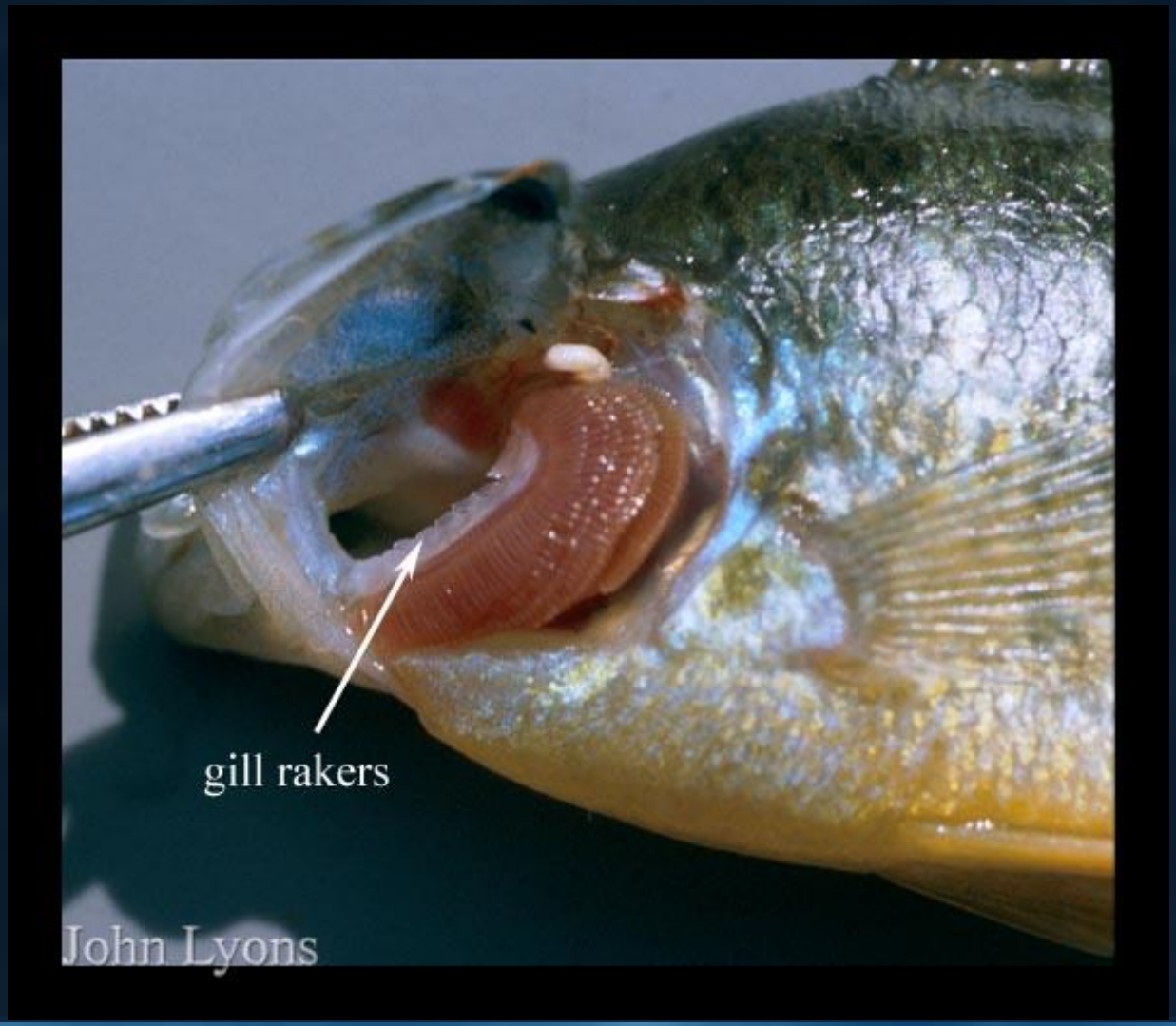


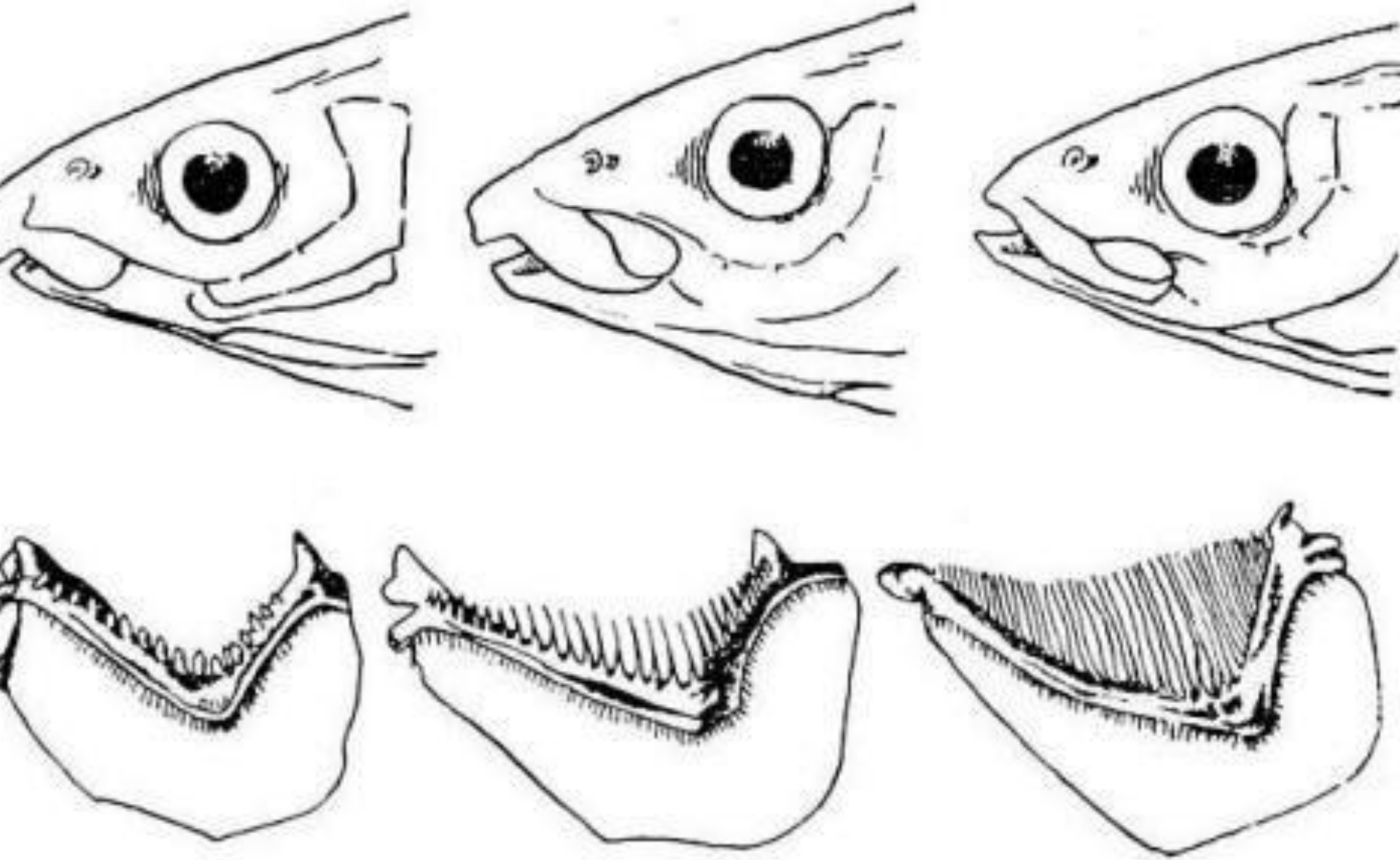
FIGURE 8.7. *Correspondence among mouth position, feeding habits, and water-column orientation in teleosts. Fishes with supraterminal mouths frequently live near and feed at the surface, whereas fishes with subterminal mouths often scrape algae or feed on substrate-associated or buried prey. Fishes with terminal mouths often feed in the water column on other fishes or zooplankton but are also likely to feed at the water's surface, from structures, and on the bottom. See also Fig. 23.3*



Fish drawings from Nelson 1994; used with permission.

Gills can help too !





A
Round Whitefish

B
Lake Whitefish

C
Shallowwater Cisco

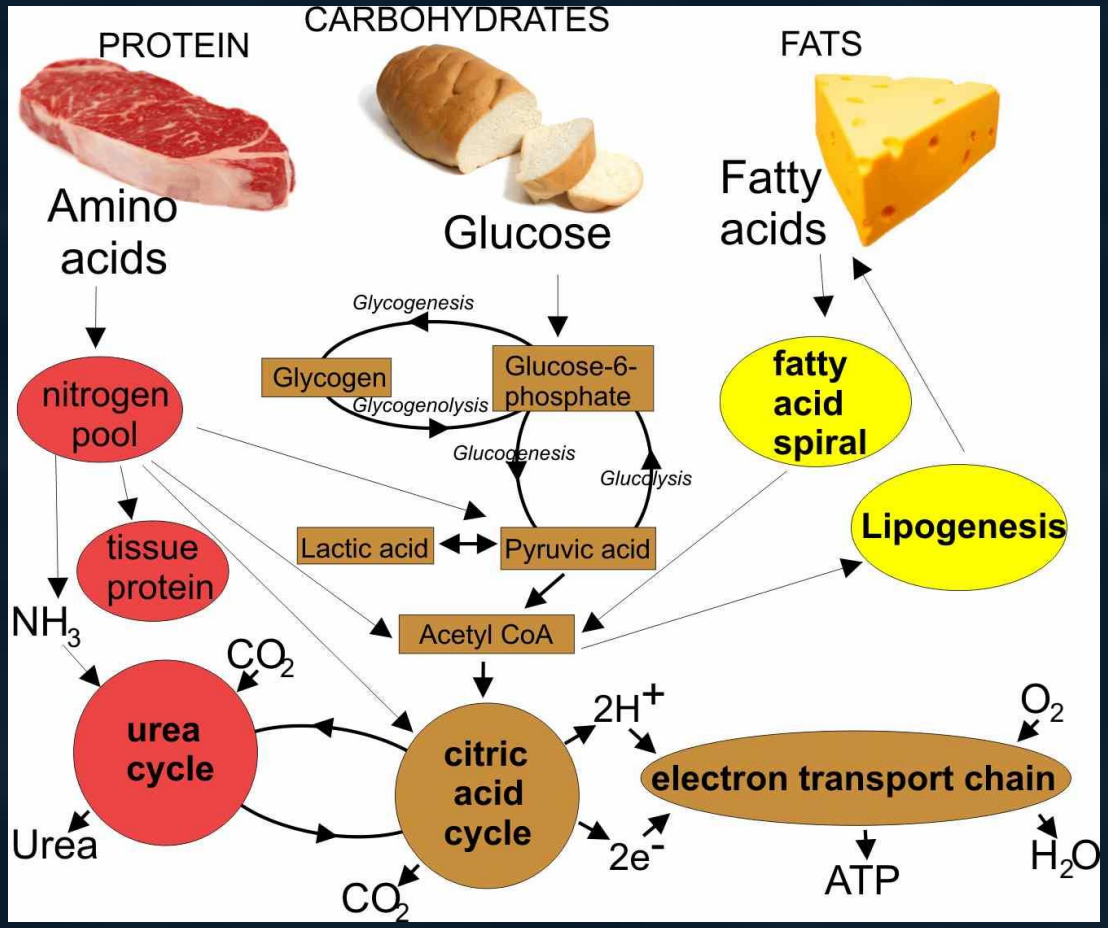
Food depends on activity

Break 2

NUTRITION

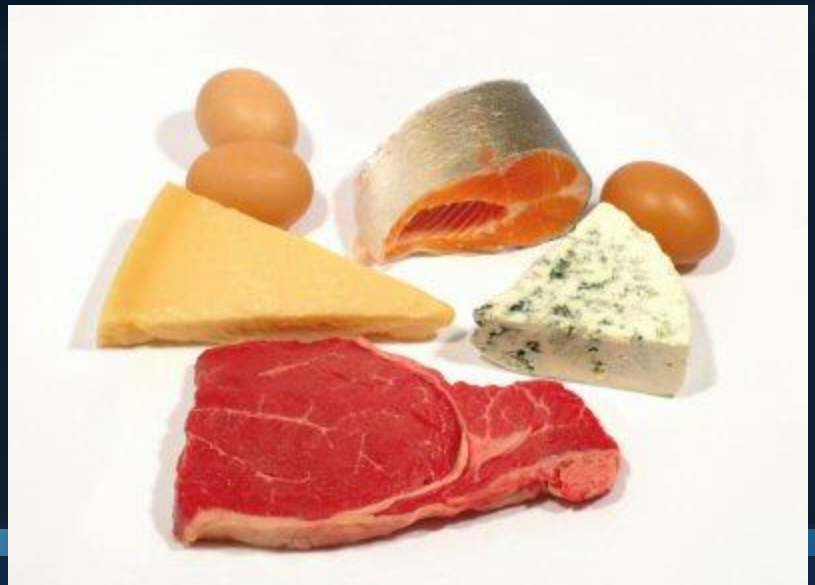
Nutritional needs

- Proteins
- Lipids
- Carbohydrates



Proteins

- Important for growth and metabolism
- Important and expensive part of fish meal
- Catabolism – break down of molecules into smaller units to release energy
- Anabolism – using energy to create molecules – lead to growth in tissues



Carbohydrates

- Found primarily in plants
- Low digestibility = low energy gained
- Herbivirous and Omnivorous fish have elongated guts or guts with microbes to break down cellulose

Lipids

- Found in both plants and animals
- Rich energy source (up to 50% of the total fuel)
- Can be stored for later use
- Important in predacious fish

Starvation

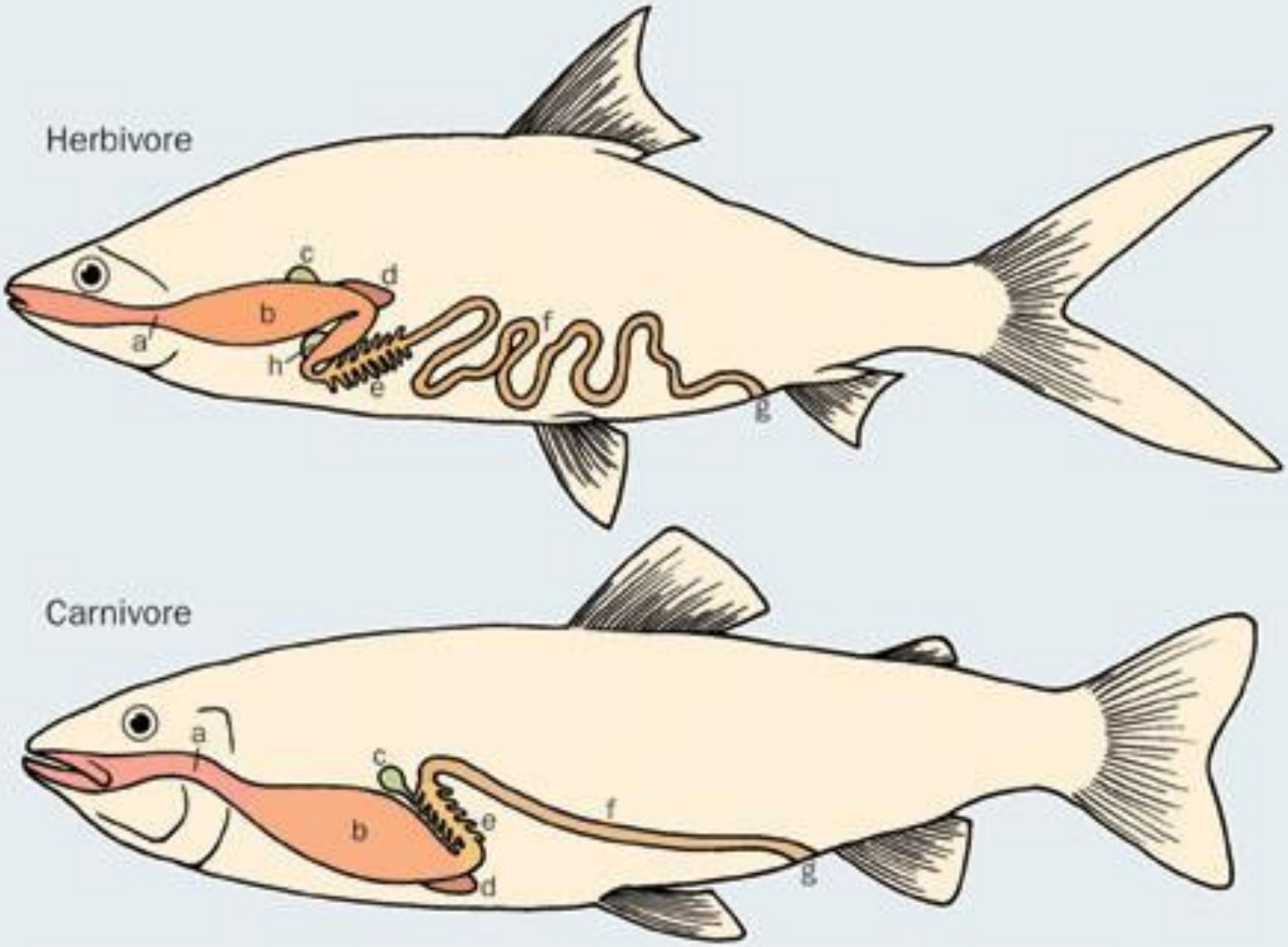
- Occurs during life cycle (winter conditions, reprod.)
- Mobilizing protein and lipids during starvation
- While fish are fasting no intake
- Water will often replace reduced tissues
- Degeneration of digestive tract

Unlimited food

- Growth rate and feeding frequency
- Growth rate and age

DIGESTION and ABSORBTION

- Breakdown of body foods by enzymatic and often acidic excretions in the gut
- Absorption of nutrients…..
- Excretion



a) Esophagus
b) Stomach
c) Gall bladder
d) Spleen
e) Pyloric caeca
f) Intestine
g) Anus
h) Gizzard

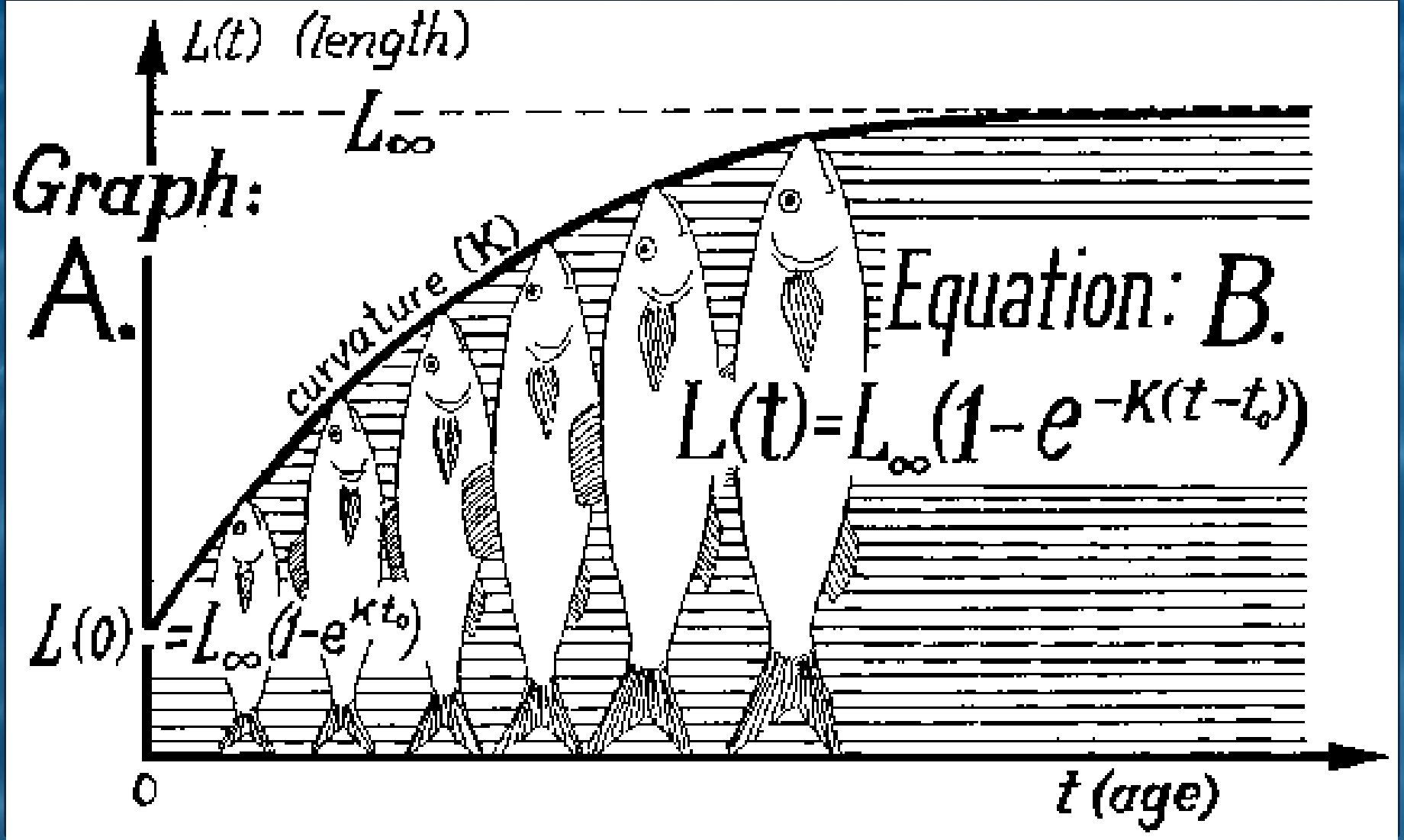
EXCRETION

- Teleosts – nitrogenous waste -> ammonia
- Elasmobranchs and Coelacanths -> urea

http://www.farnorthscience.com/2007/03/18/marine-mammals/sea-lions-and-junk-food-ocean/

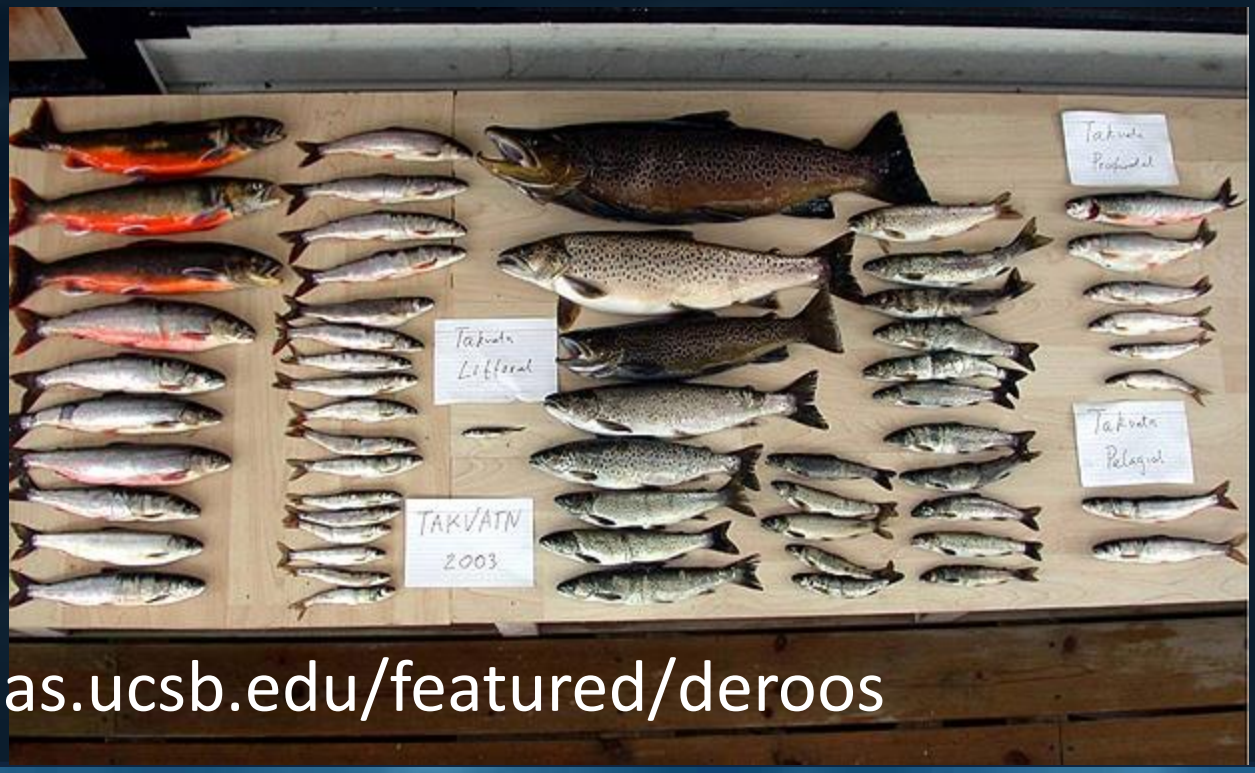
Break 3

GROWTH


L(t) (length)
L_∞
Graph:
A.
curvature (K)
Equation: B.
$L(t)=L_\infty(1-e^{-K(t-t_0)})$
$L(0)=L_\infty(1-e^{Kt_0})$
0
t (age)

Growth

- A change in size (length or weight)
- A change in calories stored in somatic and reproductive tissues



http://www.nceas.ucsb.edu/featured/deroos

I=M+G+E

I=Ingested Food Energy M=Metabolism G=Growth E=Energy Expended

Growth of Fish…..Indeterminate or Life Long

Manifested in Two Ways

Factors affecting growth

Metabolism = Anabolism + Catabolism

If Anabolism > Catabolism = growth

Growth is mediated by hormones secreted by the pituitary gland and steroids by gonads

Factors affecting growth

Growth depends on:

Temperature	Dissolved Oxygen
Salinity	Photoperiod
Age	Maturity
Activity	Conditioning

Temperature

Optimal temperature for maximum growth

Fish can maximize by moving in water column

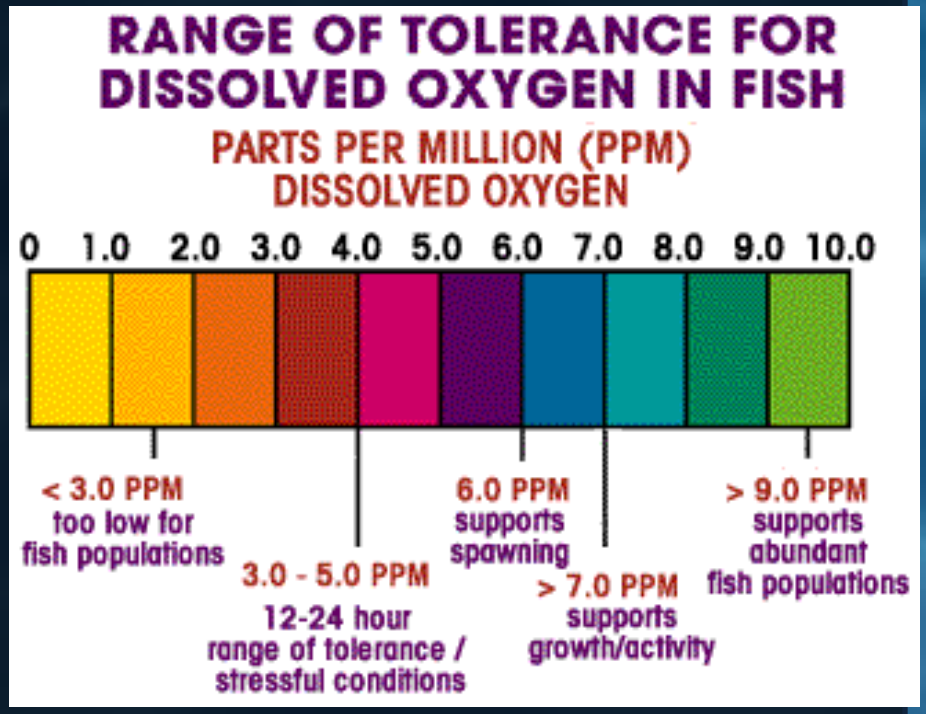
Bear Lake Sculpin

Increased metabolism at warmer temps

http://utahspecies.com/bearlakesculpin.html

Dissolved Oxygen

- Temperature dependant
- Reduced oxygen available = reduction in food conversion = reduced growth
- May swim to other areas



Ammonia

- If present in high concentrations can slow growth
- Problematic in non-circulating fish culture programs

Ammonia Controller Neutralizer Remover

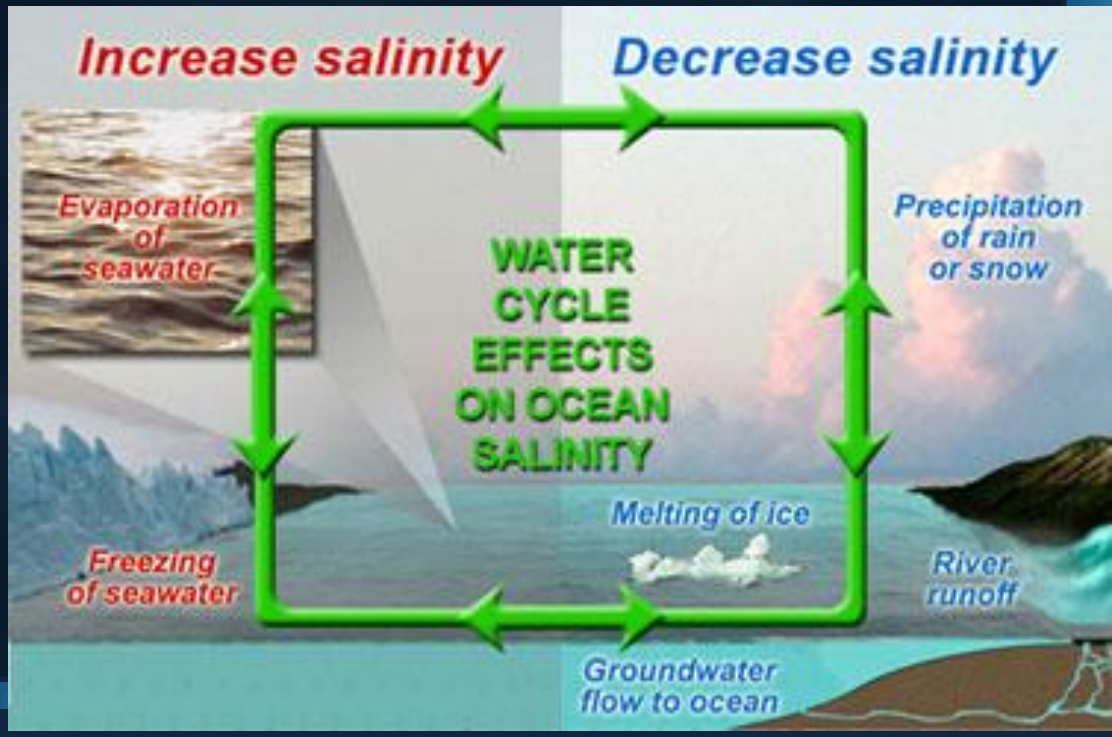
Our quality product ZERO – AMM, strong and efficient ammonia neutralizer removes ammonia gas completely to nil concentrations and and restores the pond with suitable living environment for aquatic life. Our ZERO – AMM product can be used in shrimp, prawn, and fish farming. On regular usage of ZERO – AMM on aqua culture farming maintains ammonia to nil level. For more information please contact us.

Zoom

Salinity

- Euryhaline can handle a range for max growth
- If fish are working active pumps the either add or remove salt ions there is less energy available for growth

$$I=M+G+E$$

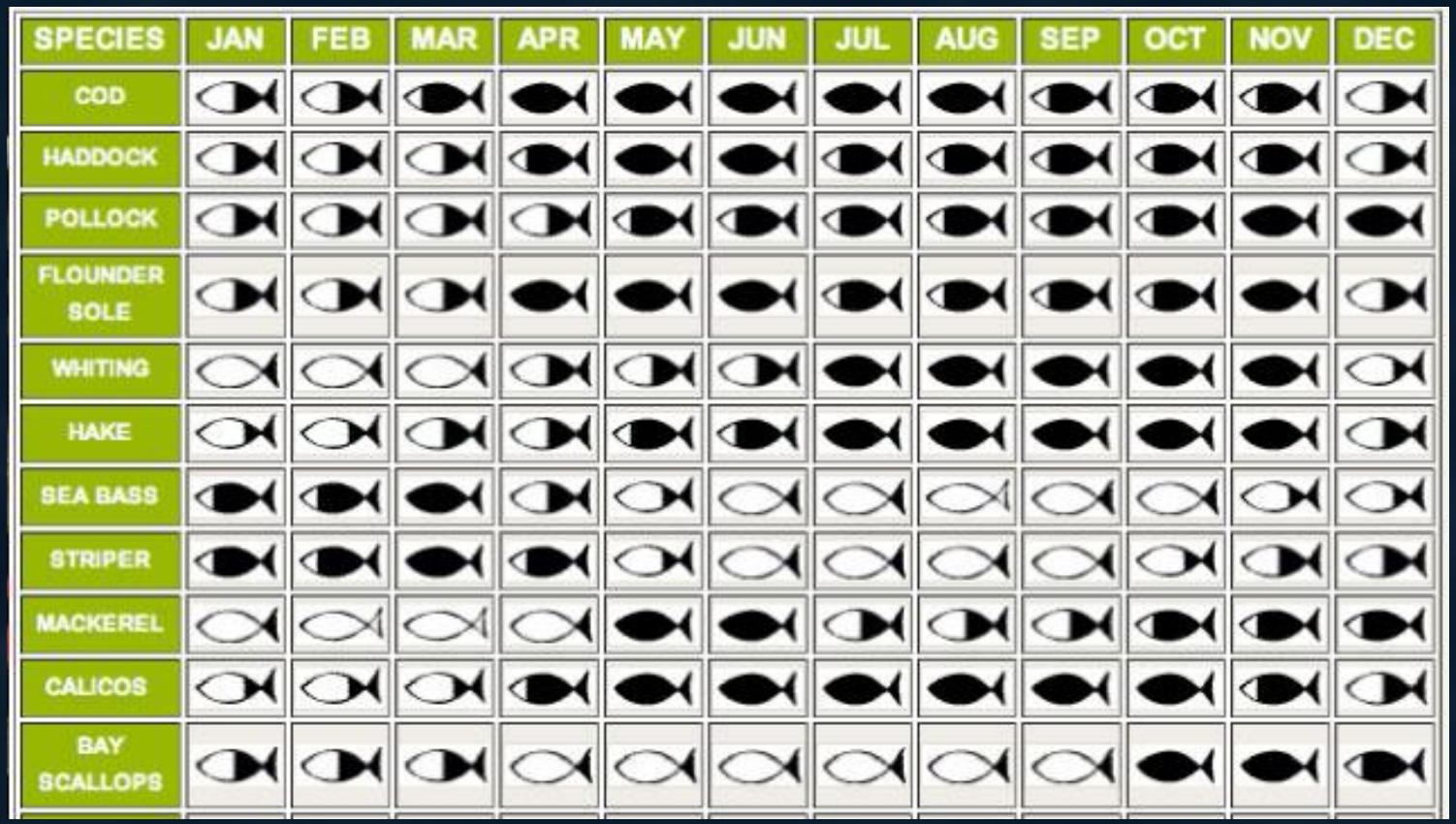


Competition

- Limited food = less growth
  May limit size at maturity or future
  prey populations

Food Availability

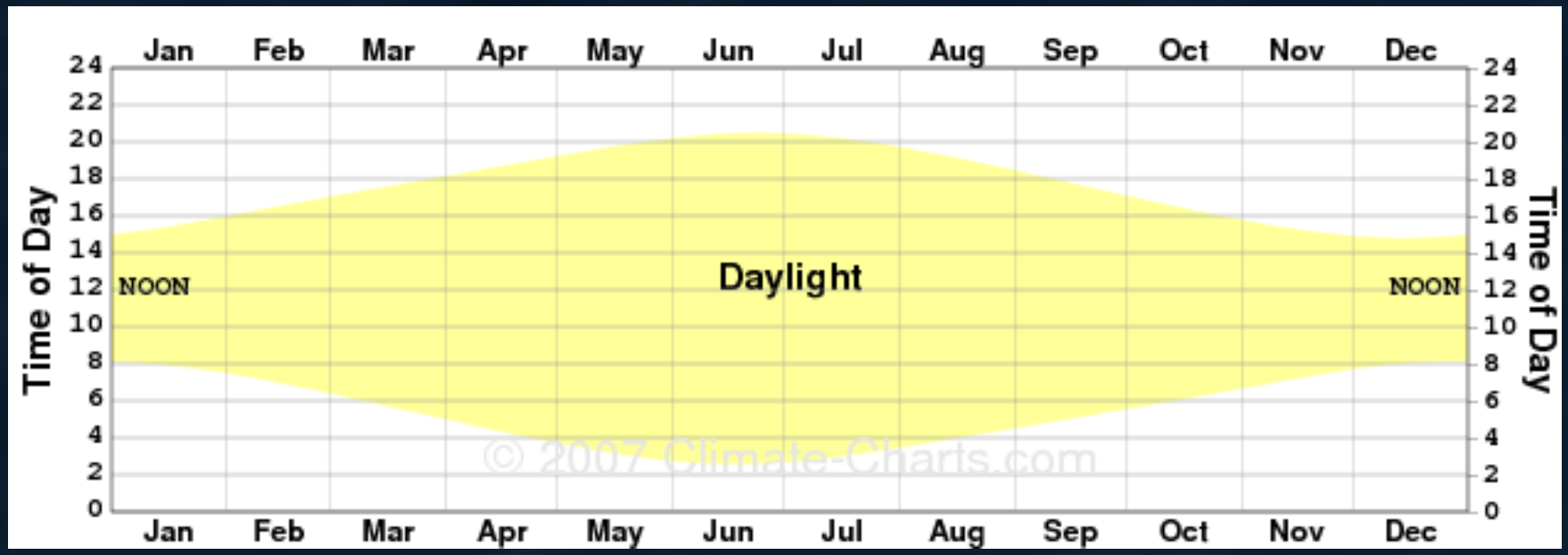
Seasonal availability



SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
COD	◐	◐	●	●	●	●	●	●	●	●	●	◐
HADDOCK	◐	◐	◐	●	●	●	●	●	●	●	●	◐
POLLOCK	◐	◐	◐	◐	●	●	●	●	●	●	●	●
FLOUNDER SOLE	◐	◐	◐	●	●	●	●	●	●	●	●	◐
WHITING	◔	◔	◔	◐	◐	◐	●	●	●	●	●	◔
HAKE	◔	◔	◐	◐	●	●	●	●	●	●	●	◔
SEA BASS	●	●	●	◐	◔	◔	◔	◔	◔	◔	◔	◔
STRIPER	●	●	●	◐	◔	◔	◔	◔	◔	◔	◐	◐
MACKEREL	◔	◔	◔	◔	●	●	◐	◐	◐	●	●	●
CALICOS	◔	◔	◔	●	●	●	●	●	●	●	●	◔
BAY SCALLOPS	◐	◐	◐	◔	◔	◔	◔	◔	◔	●	●	●

Photoperiod

May impact seasonal growth



Age and maturity

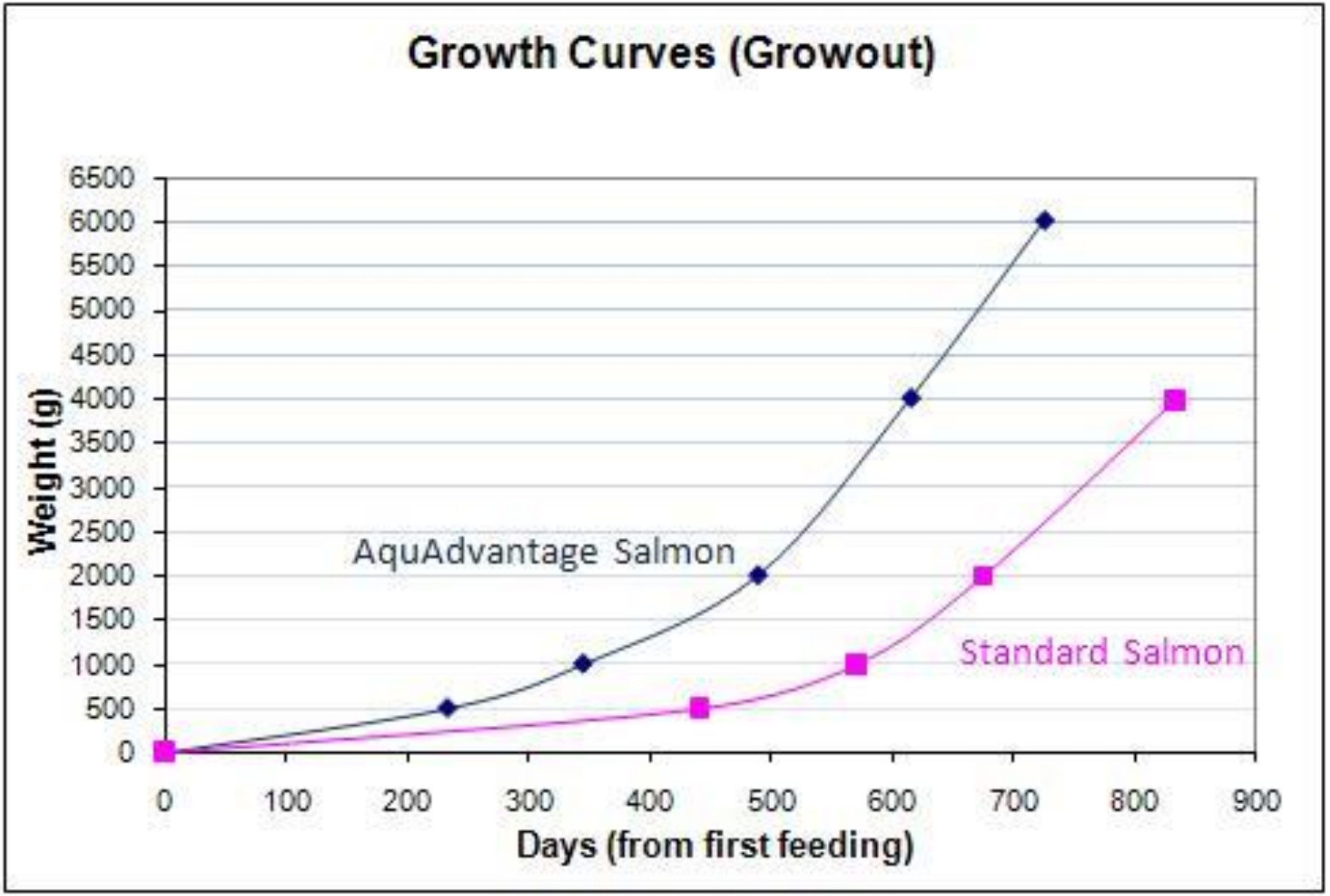
- Fish typically grow fast during first few months to years
- As increasing energy is diverted to gonads during maturity less is available for growth

Exercise conditioning

- Can increase growth for fish
  - Better food conversion efficiency
  - Increased growth hormones
  - Increased protein synthesis
  - Decreased stress

How do we measure growth rates?

1. Raise fish in controlled environment
2. Mark and recapture methods
3. Length-Frequency Distributions
4. Back Calculations


Growth Curves (Growout)
Weight (g)
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
AquAdvantage Salmon
Standard Salmon
0
100
200
300
400
500
600
700
800
900
Days (from first feeding)

1. Raise fish in a controlled environment

2. Mark and Recapture

Long-term retention of internal elastomer tags in a wild population of North Pacific giant octopus (*Enteroctopus dofleini*)

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Enteroctopus dofleini
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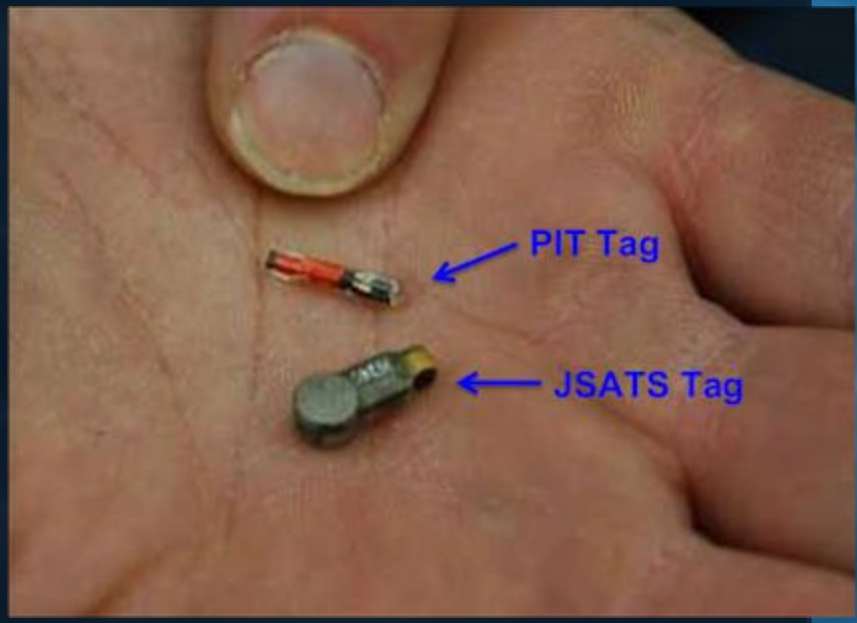
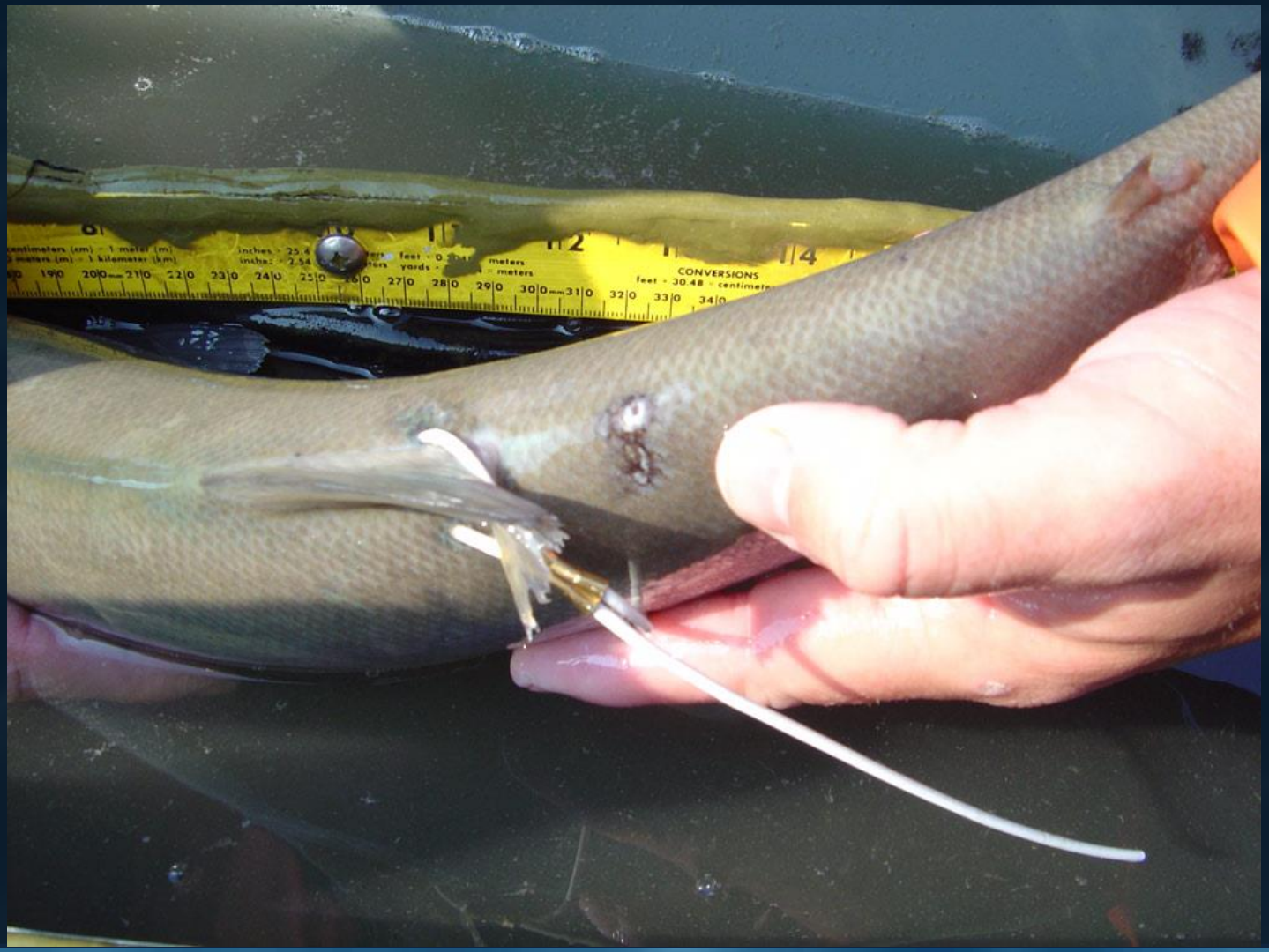
ABSTRACT

Visible Implant Elastomer (VIE) tags represent a viable approach for long-term tracking of North Pacific giant octopus (*Enteroctopus dofleini*) in Alaska. Over a two year period, 1730 *E. dofleini* were tagged with individually identifiable VIE tags and 238 *E. dofleini* were recaptured in a 25 km^2 area. Of the 238 *E. dofleini* recaptured, 31 were at liberty for 60 days or more with a maximum time at liberty of 374 days. This study shows that long-term retention of VIE tags may prove to be a vital tool in determining important life-history information for octopus species.

PIT tags

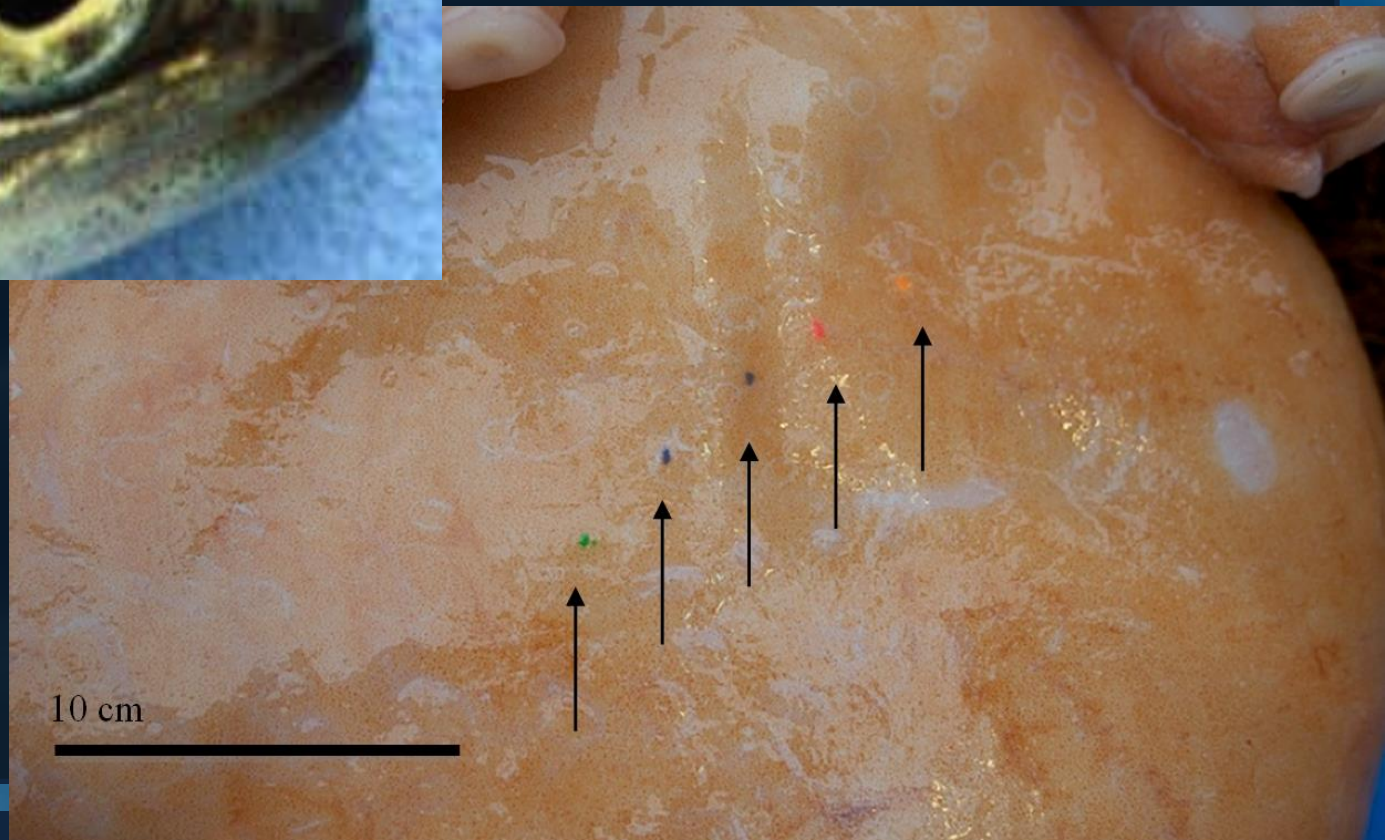


Spaghetti tags



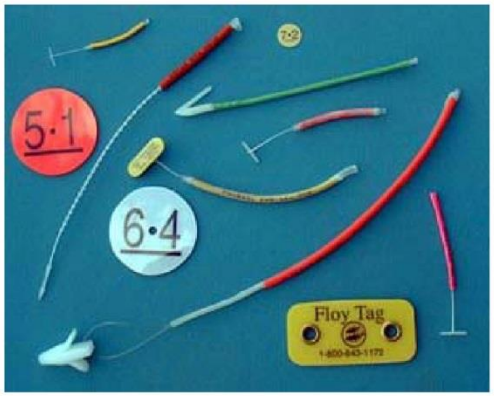
Satellite tags

Visible Implant Elastomer tags

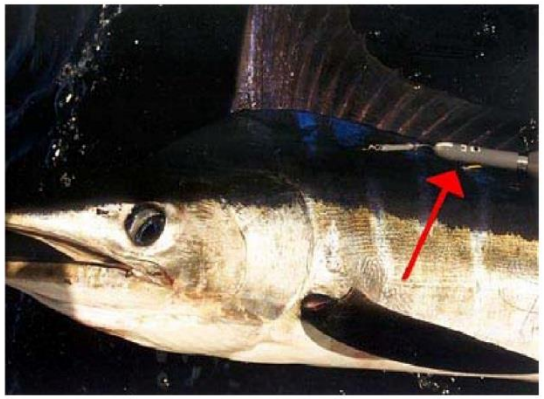


Other tags

a



b

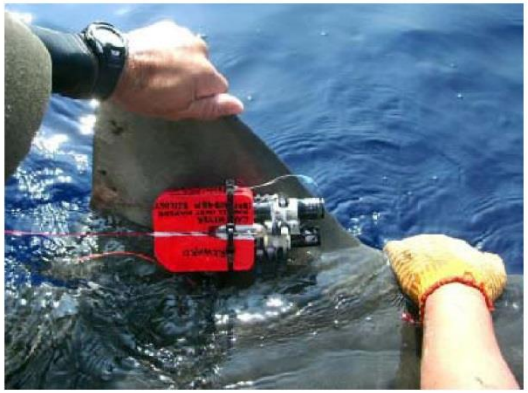


c

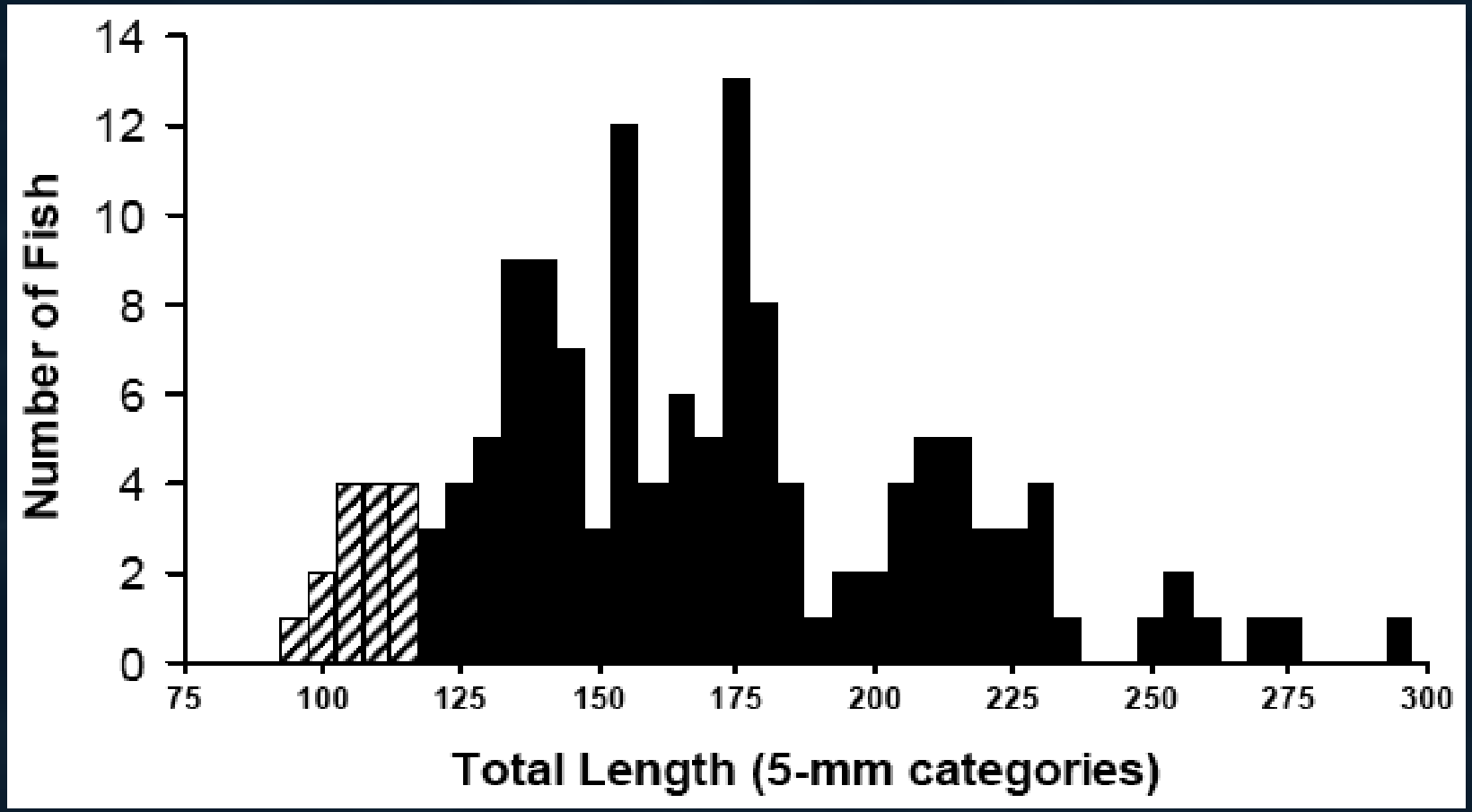
d

e

f



3. Length Frequency



4. Back Calculation from hard structures

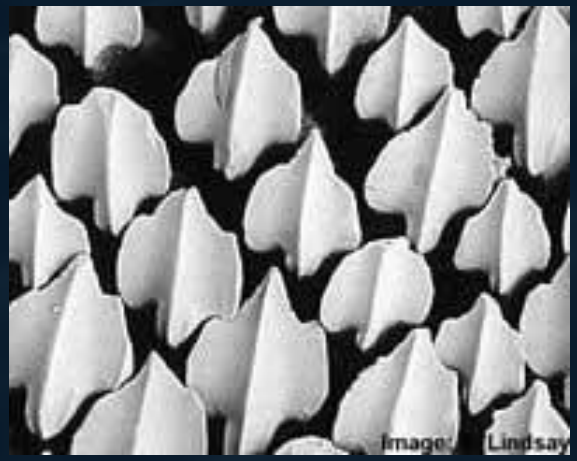
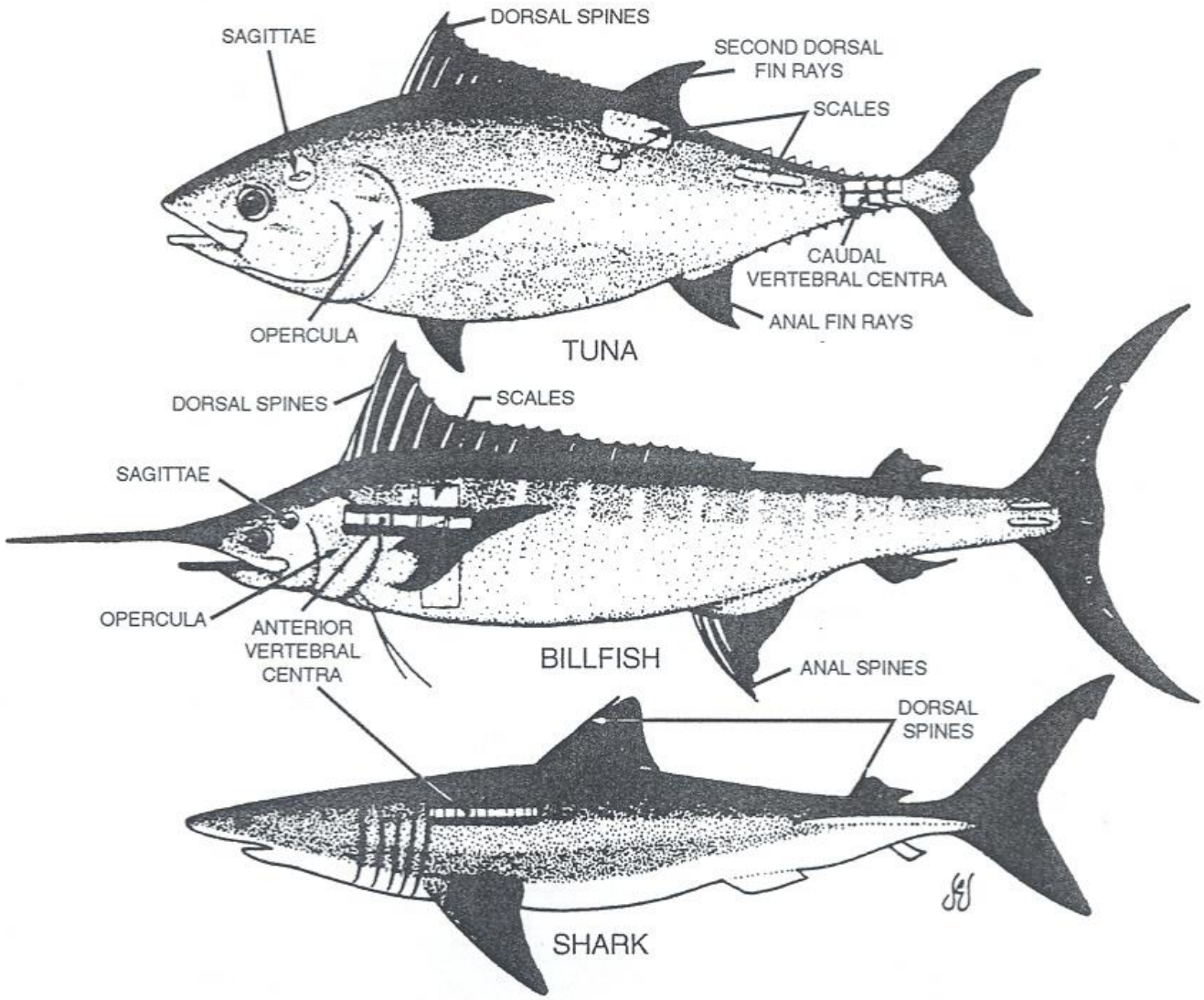
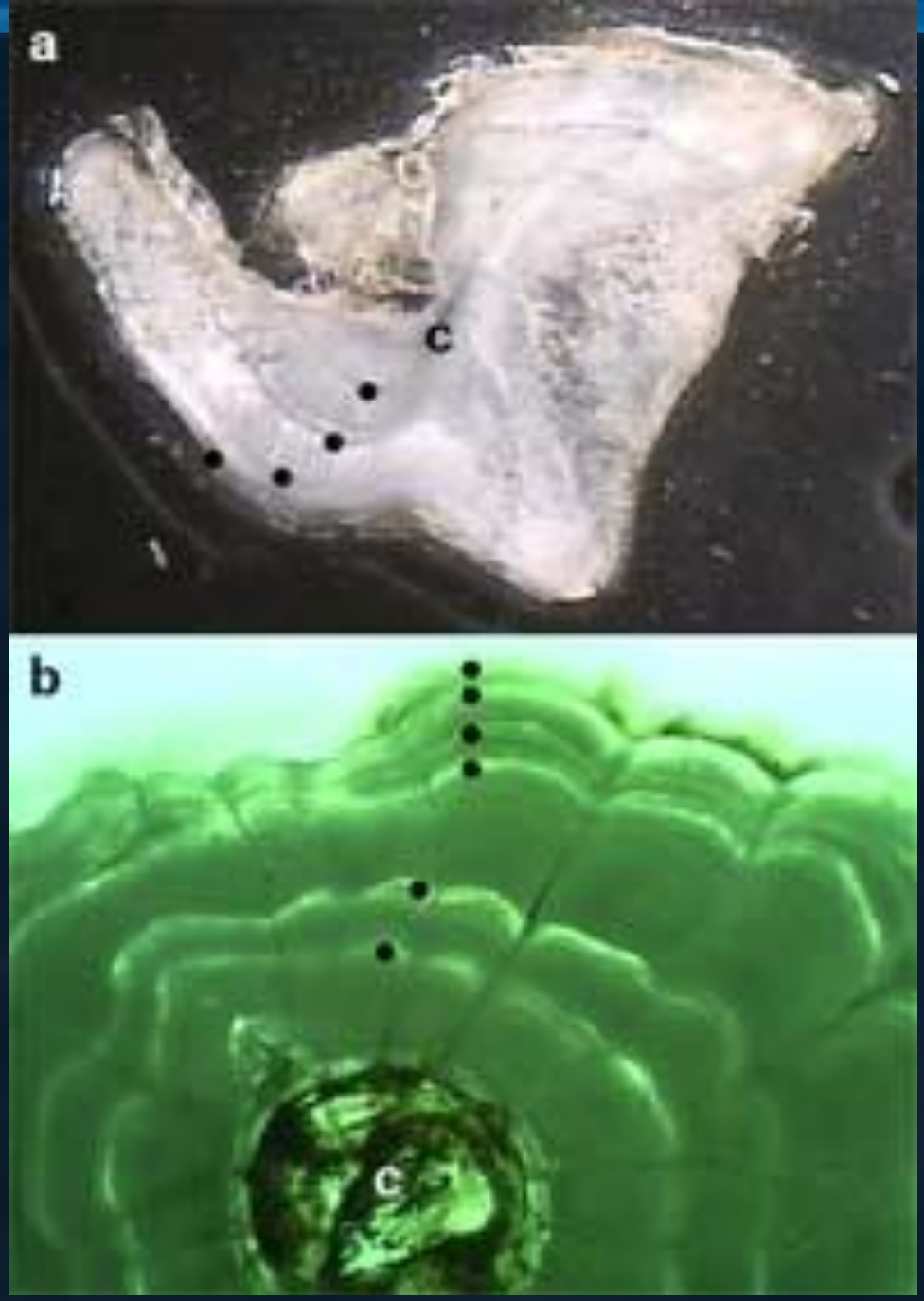
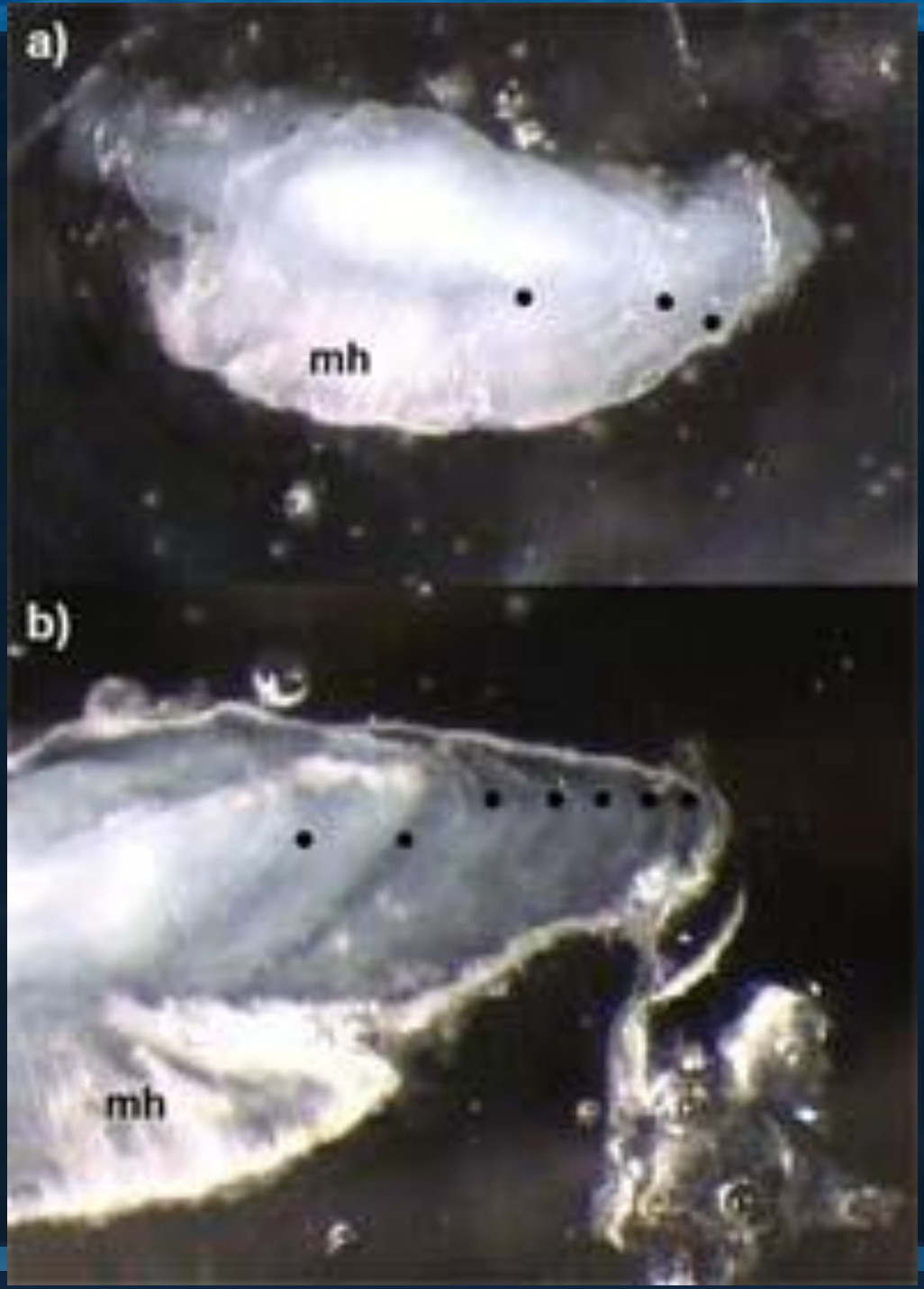


FIGURE 10.3. *Methods for determining fish age. Growth lines are added periodically to hard body parts, but the best part to count differs among taxa. Scales, otoliths, fin rays, and vertebrae are the most commonly investigated structures. The body parts used for growth determination of oceanic pelagic fishes are shown in the figure.*




a
c
b
c


a)
mh
b)
mh

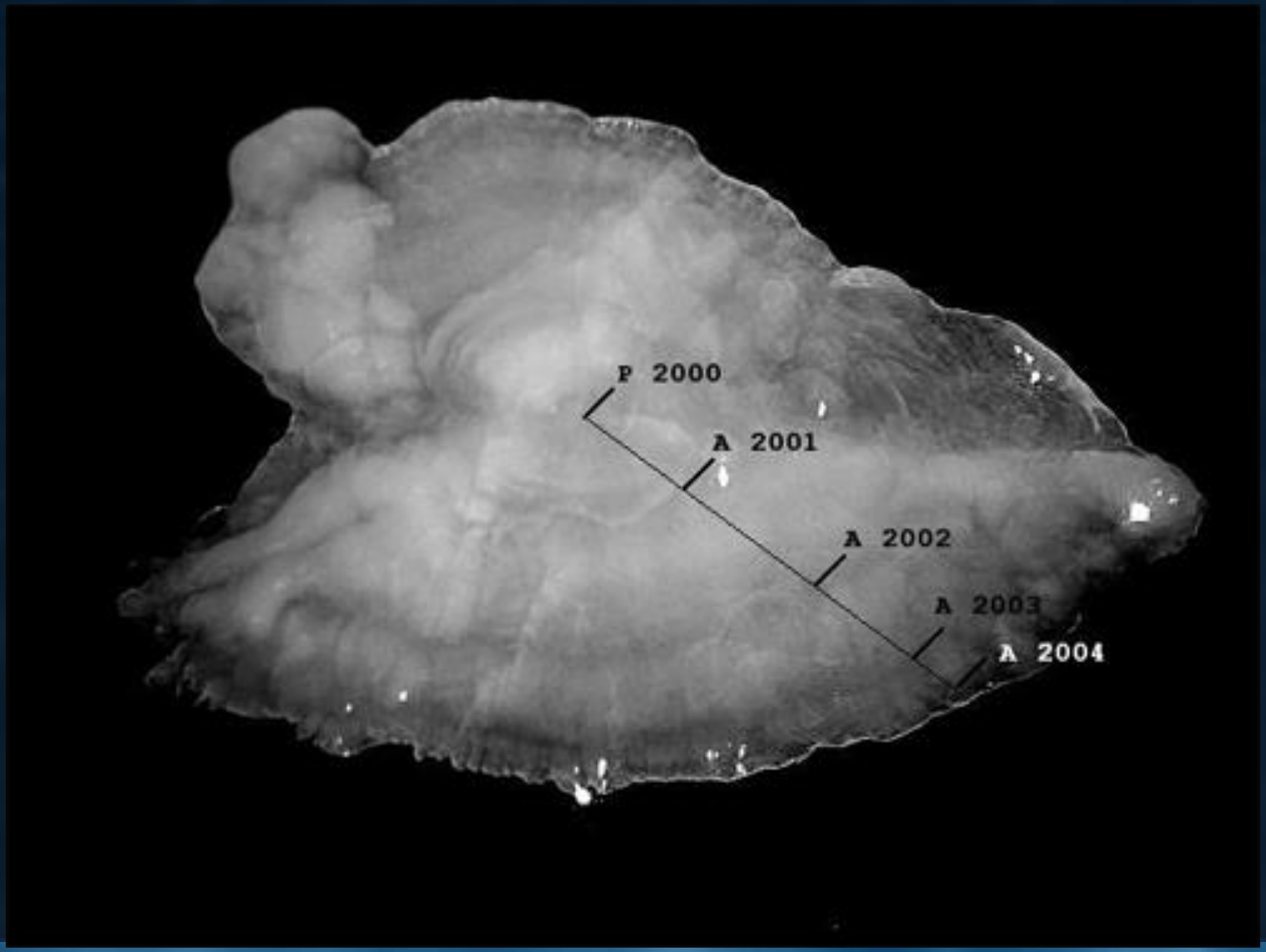
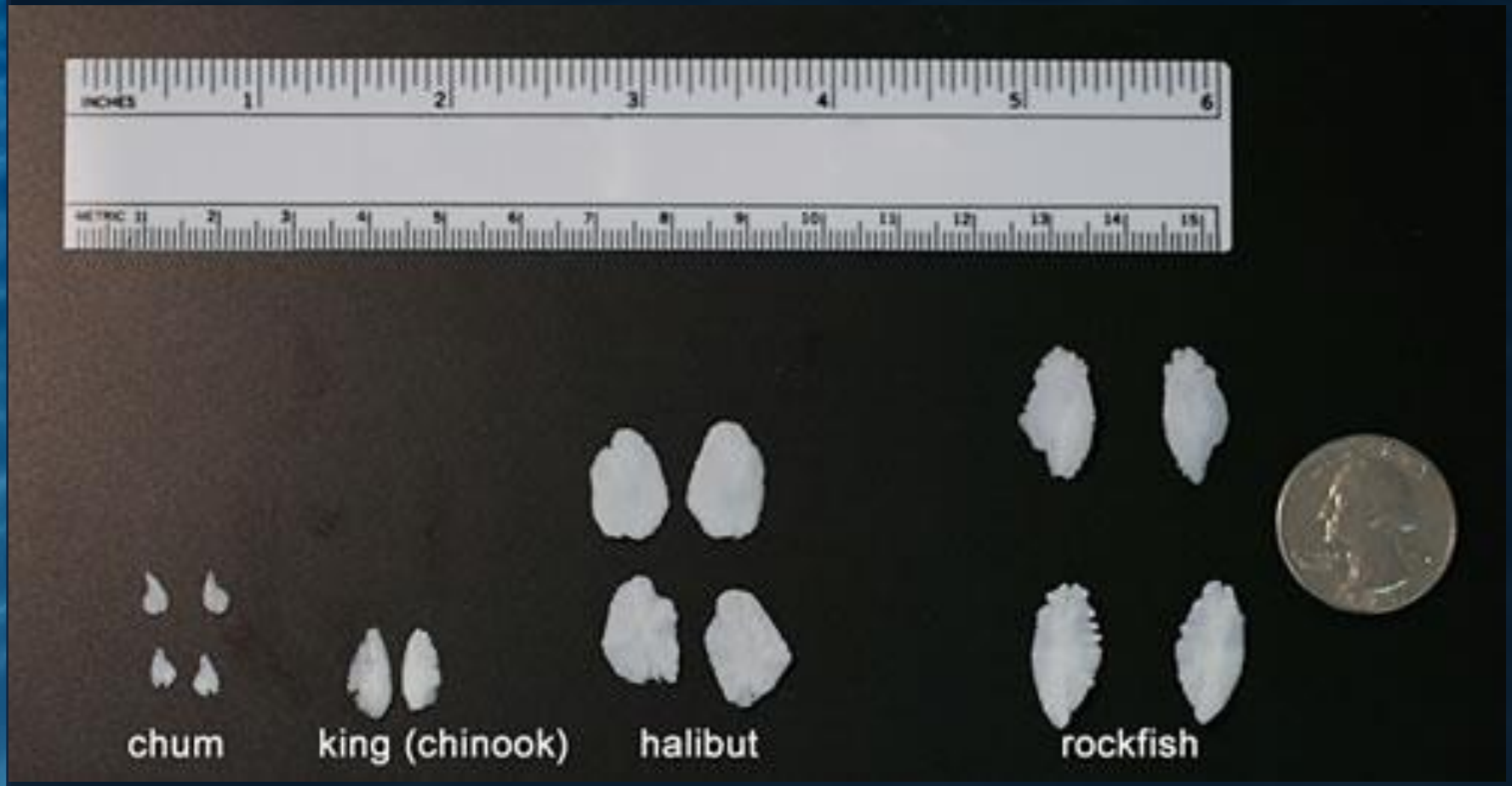
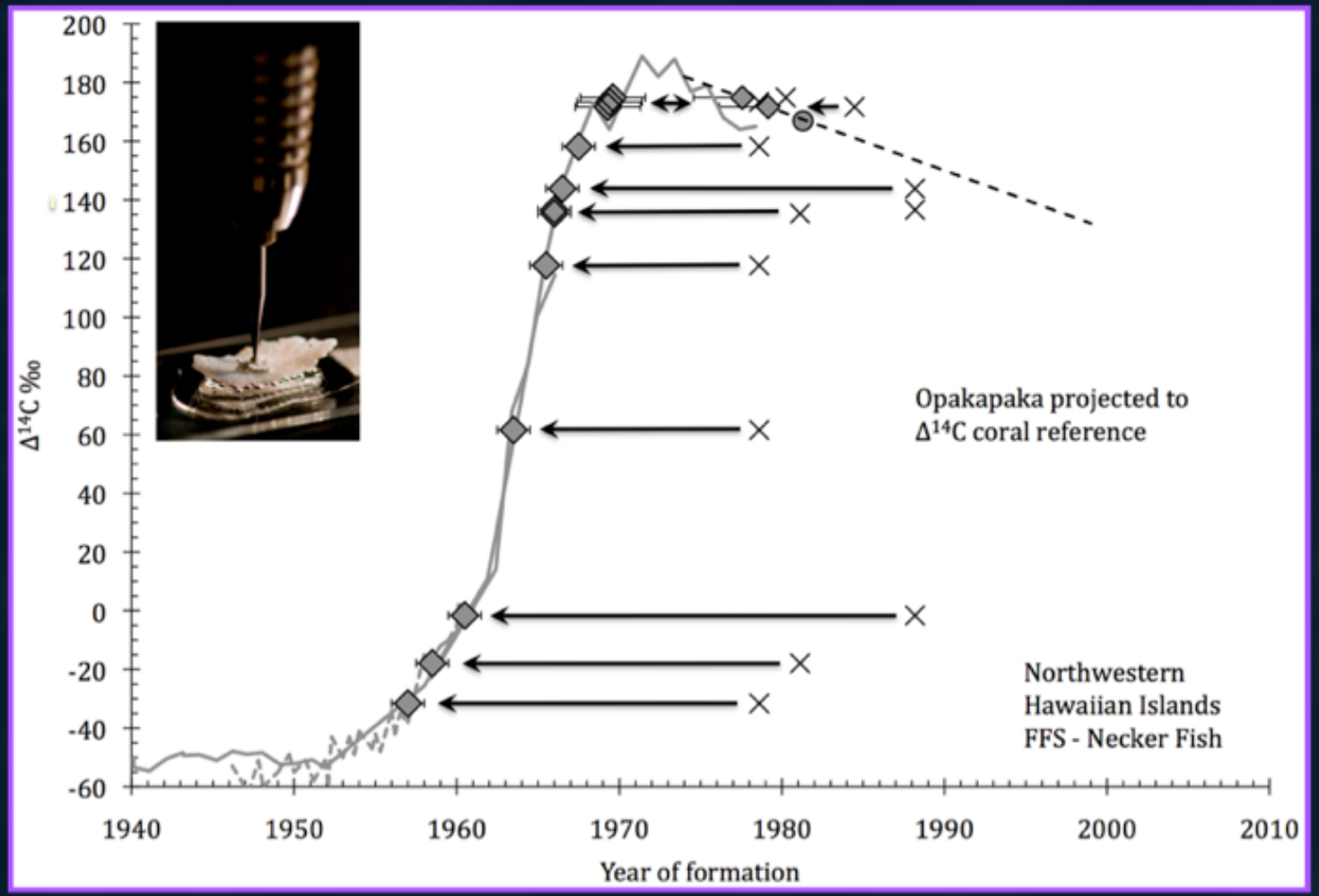

P 2000
A 2001
A 2002
A 2003
A 2004

Image courtesy of
www.marinebiodiversity.ca


chum
king (chinook)
halibut
rockfish

Radiocarbon Uptake methods



RNA/DNA

- Ratio of Nucleic Acids in a Cell
- Amount of DNA remains constant
- RNA is directly proportional to the amount of protein produced…more protein =more growth.