FISH STRUCTURE AND FORM

Fundamentals of Fisheries Biology

FT 273, 2 February 2015

MAJOR DETERMINANTS OF BODY SHAPE/FORM:

- Locomotion
- Camouflage
- Communication
- Habitat
- Protection
- Phylogeny

SPECIFIC OBJECTIVES

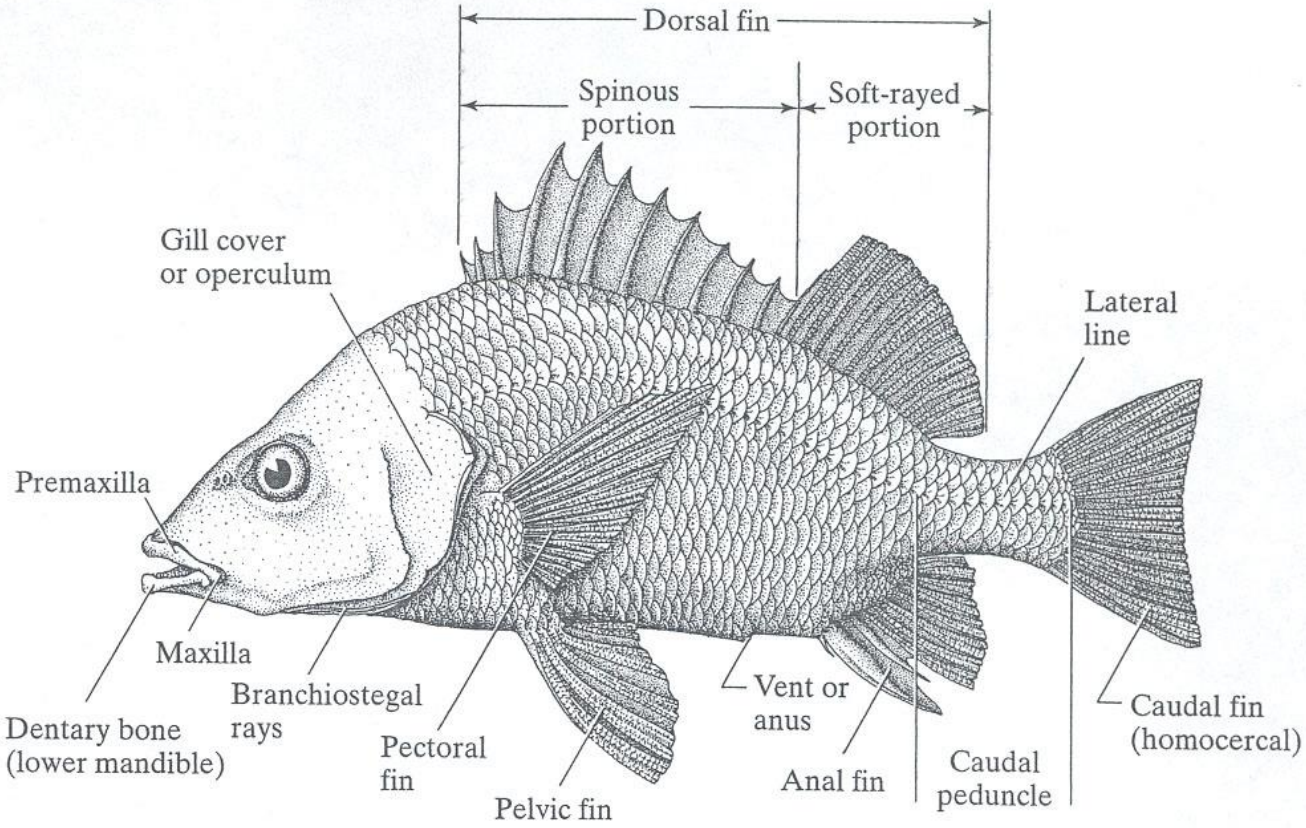
1. describe the six basic categories of fish body shape

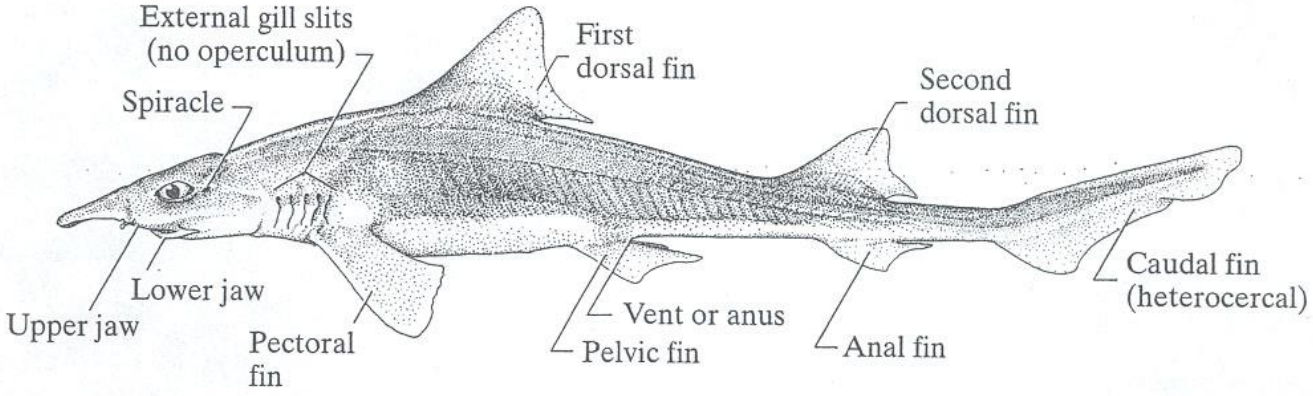
2. differentiate the different types of scales and which belong to which fish

3. describe the purpose of each fish fin and how fins play an important role in fish ecology

4. differentiate the function of white vs. red muscle

5. describe three different types of swimming


Dorsal fin
Spinous portion
Soft-rayed portion
Gill cover or operculum
Lateral line
Premaxilla
Maxilla
Branchiostegal rays
Dentary bone (lower mandible)
Pectoral fin
Pelvic fin
Vent or anus
Anal fin
Caudal peduncle
Caudal fin (homocercal)


External gill slits (no operculum)
Spiracle
First dorsal fin
Second dorsal fin
Lower jaw
Upper jaw
Pectoral fin
Vent or anus
Pelvic fin
Anal fin
Caudal fin (heterocercal)

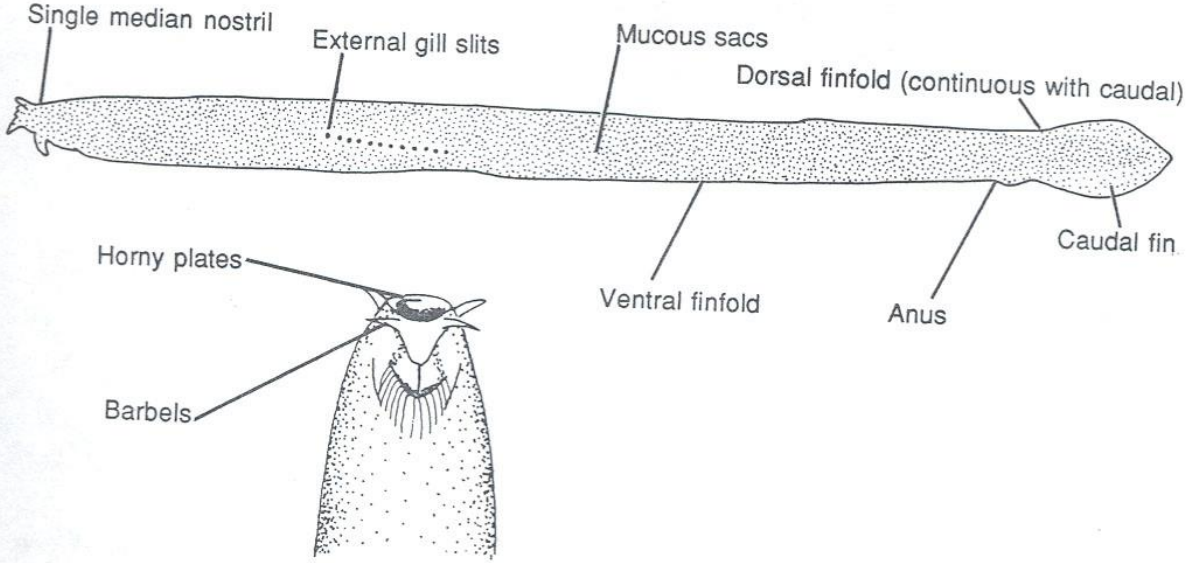


Figure 1.1 The external anatomy of the Pacific hagfish (*Eptatretus stoutii*) with details of the suctorial mouth. (Miller and Lea 1972)

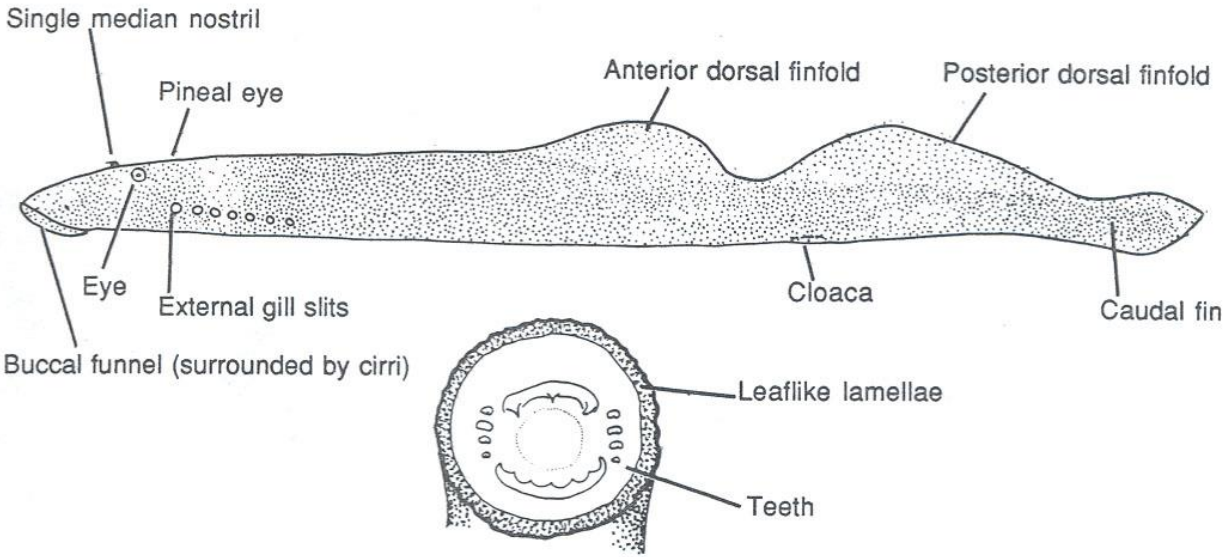


Figure 1.2 The external anatomy of the Pacific lamprey (*Lampetra tridentata*) with details of the suctorial mouth. (Miller and Lea 1972)

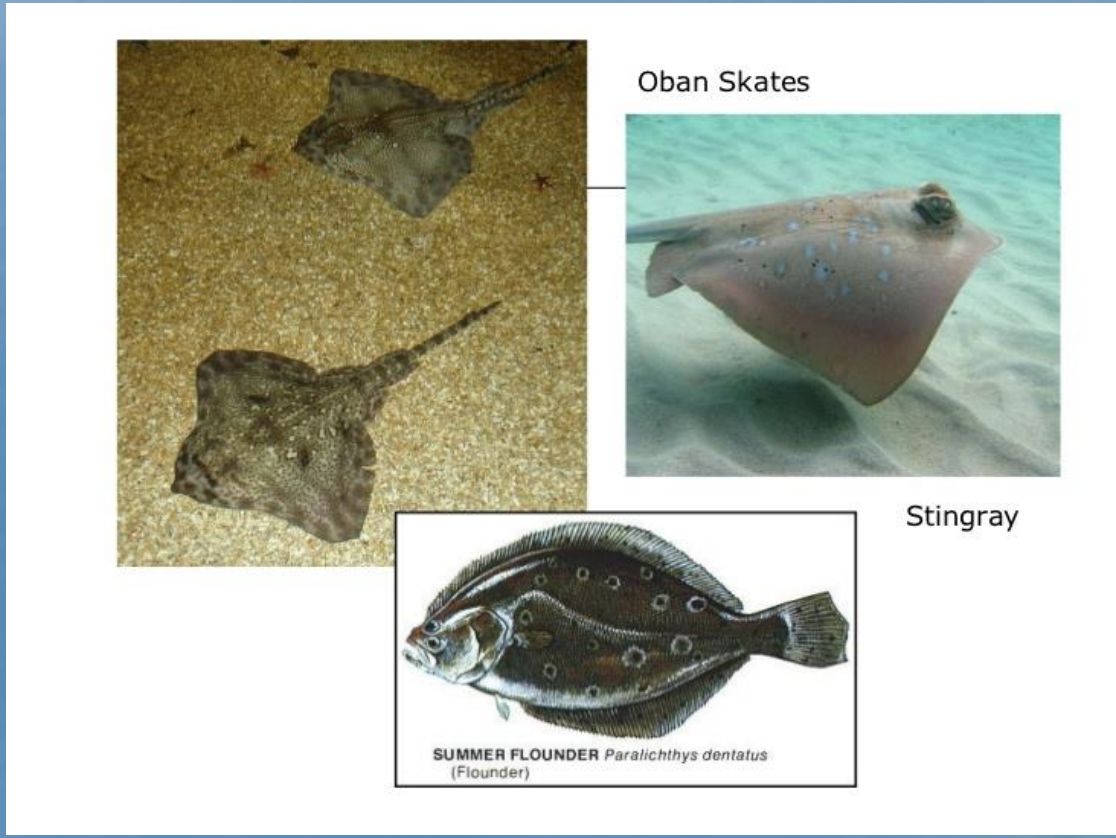
DIVERSITY

BODY SHAPES

- Depressiform
- Filiform
- Fusiform
- Compressiform
- Sagittifrom
- Taeniform
- Globiform
- Anguilliform

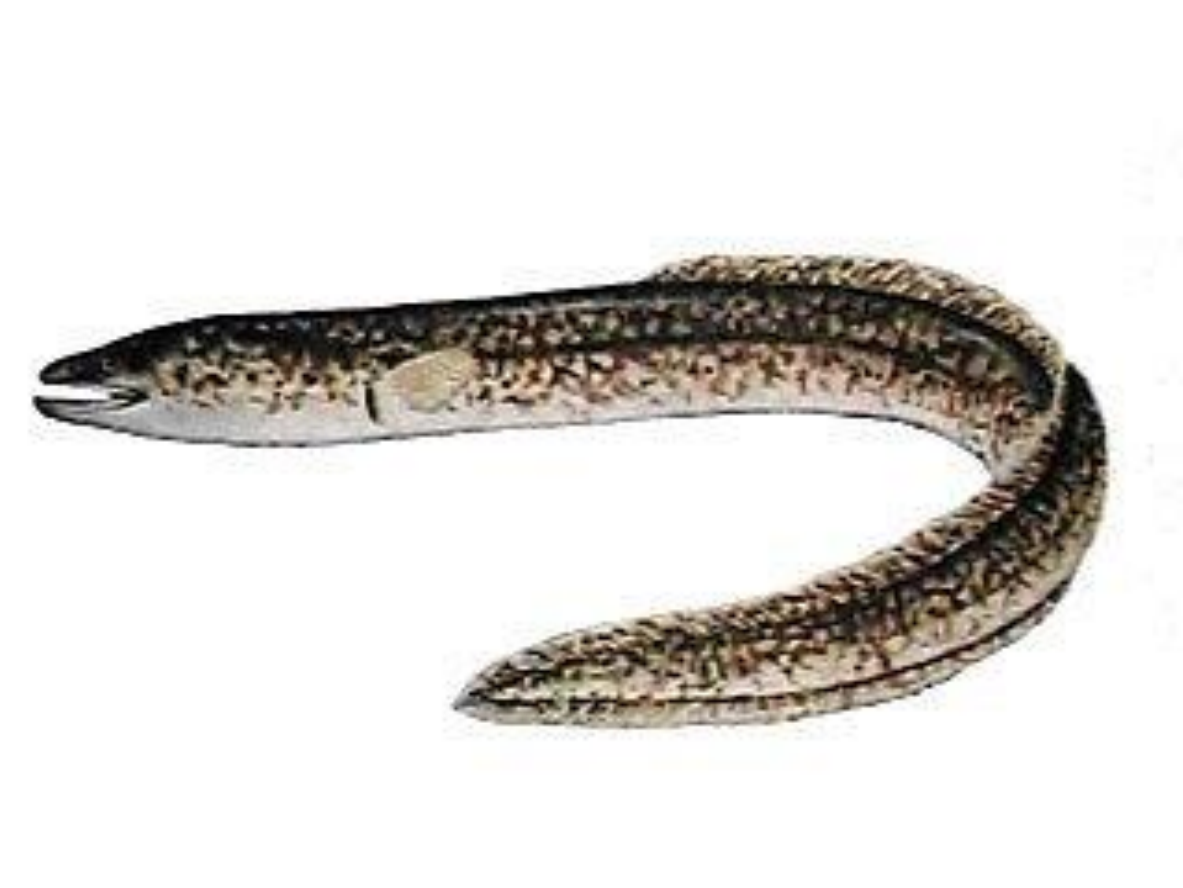
DEPRESSIFORM

- Normally life on the bottom
- Flap fins up and down to swim
- Skate and flounder



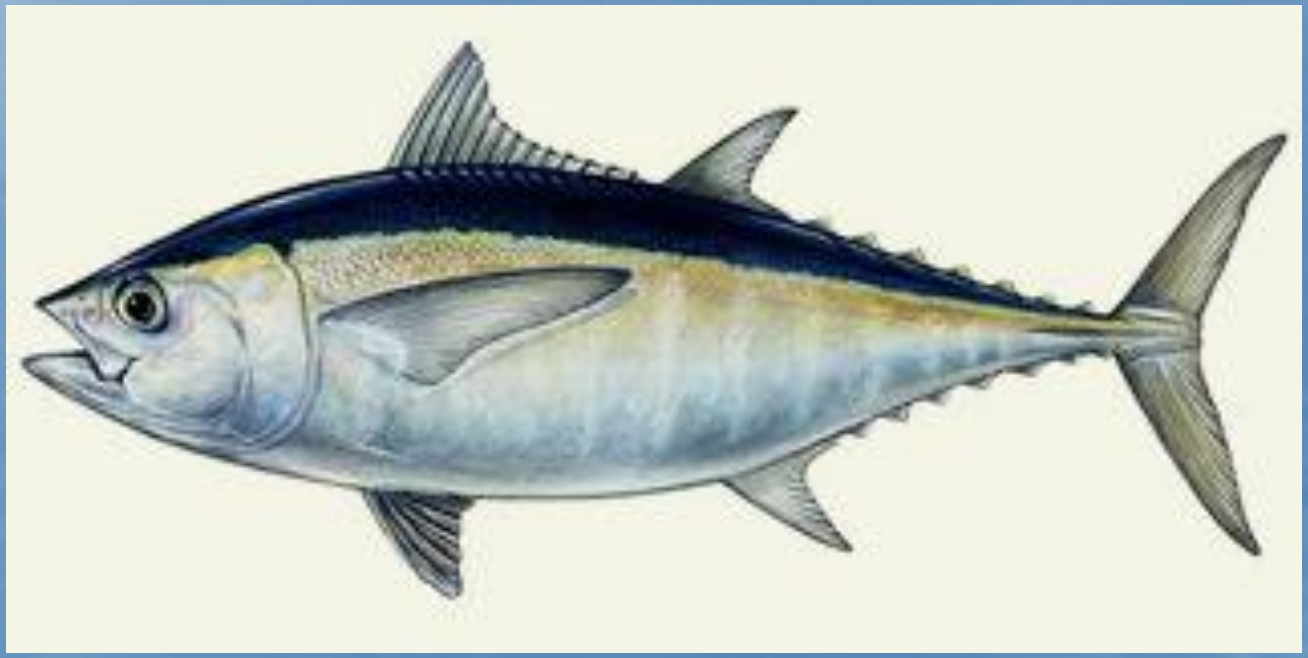
FILLIFORM

- Slither through the water like a snake
- Snake eel, American eel



FUSIFORM

- Torpedo shapped
- Oval cross section
- Usually live in open water



COMPRESSIFORM

- Looks thin when viewed from the front
- Made for sharp turns and quick bursts of speed
- Live near refuges – lakes, ponds, reefs
- School when together in open water

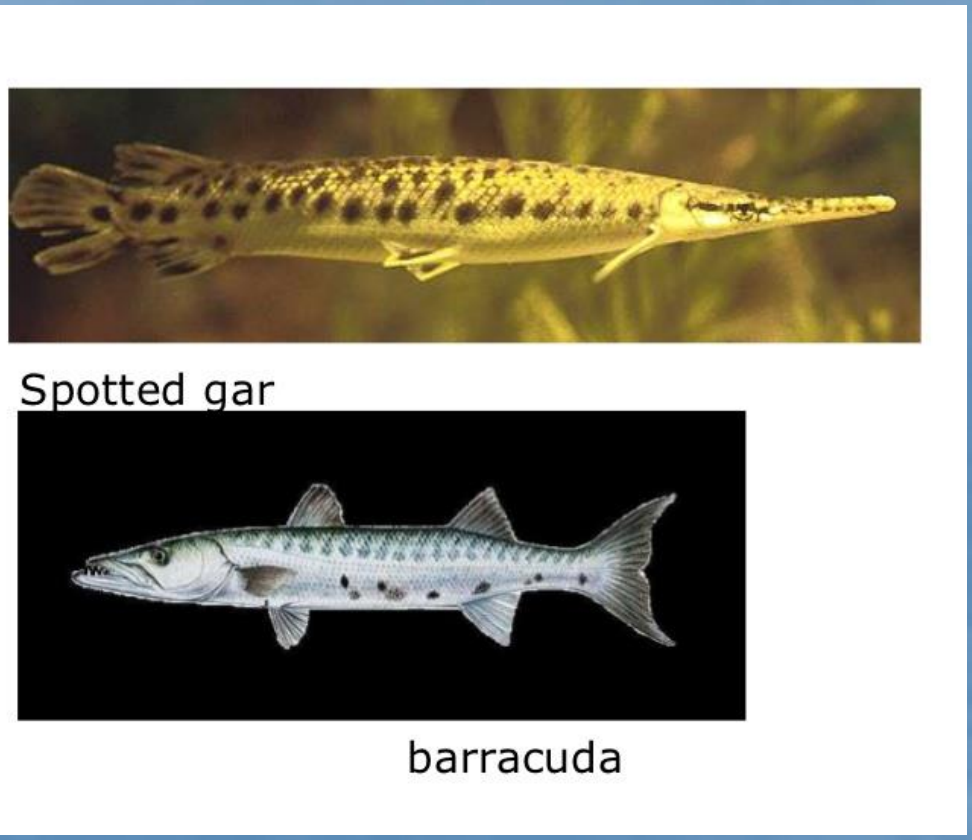
Angelfish

Yellow-faced Angelfish

Holacanthus bermudensis

SAGITTIFORM

- Arrow-like in appearance
- Fins usually back on body



TAENIFORM

- Ribbon-like
- Good shape for hiding in cracks and crevases
- Not fast swimmers

GLOBIFORM

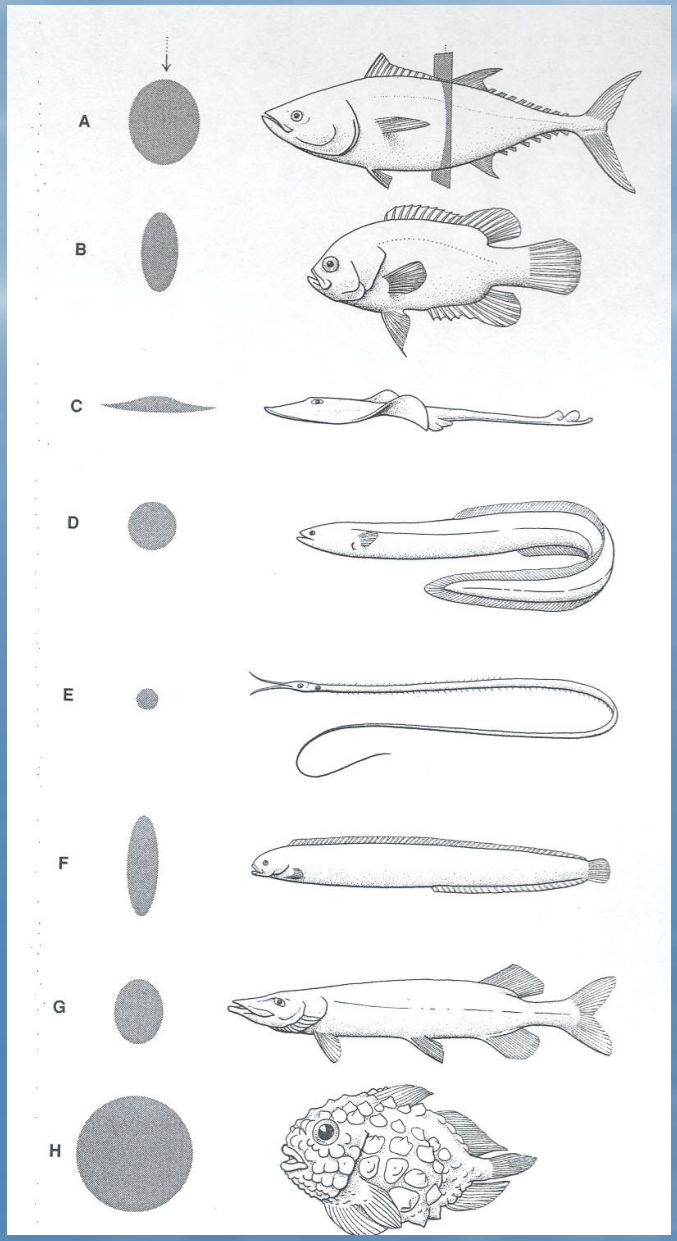
- “globe-like”
- Lumpsuckers and puffers

ANGUILLIFORM

- “Eel-like”
- Allows fish to enter very narrow openings
- Also allows fish to resist force of currents

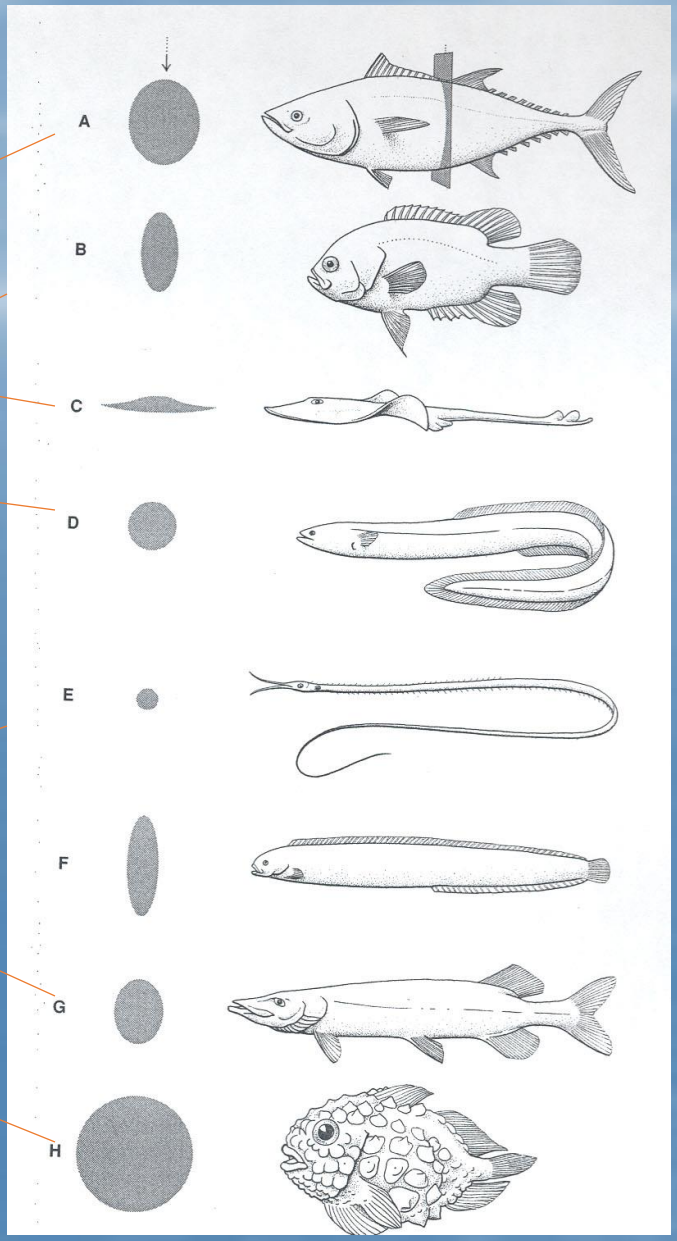
BODY SHAPES

- Depressiform
- Filiform
- Fusiform
- Compressiform
- Sagittifrom
- Taeniform
- Globiform
- Anguilliform



BODY SHAPES

- Depressiform
- Filiform
- Fusiform
- Compressiform
- Sagittifrom
- Taeniform
- Globiform
- Anguilliform



BREAK 1

MOST FISH FALL INTO ONE OF SIX BROAD BODY SHAPE AND LIFESTYLE CATEGORIES:

1. Rover-predator
2. Ambush predators
3. Surface oriented fish
4. Deep bodied fish
5. Eel and eel like fish
6. Bottom feeding fishes

1. ROVER-PREDATOR – THE "CLASSIC FISH"

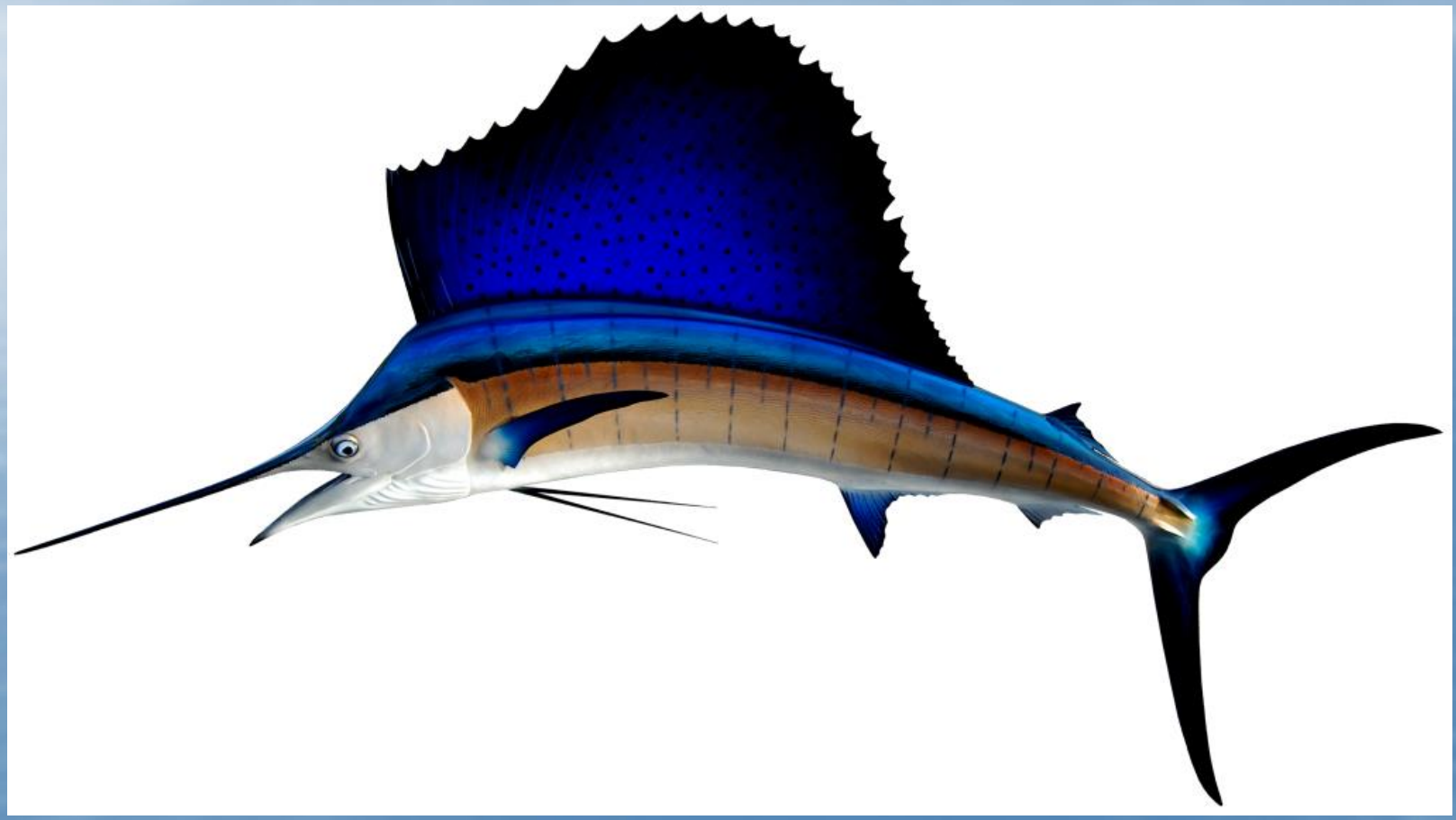
ROVER PREDATOR

- Fusiform (torpedo-shaped)
- Streamlined
- Forked sometimes lunate tail
- Fins distributed evenly
- Some have narrow caudal peduncles

BLACKFIN TUNA

SWORDFISH

KING SAILFISH



2. AMBUSH PREDATORS (LIE-IN-WAIT)

AMBUSH PREDATORS

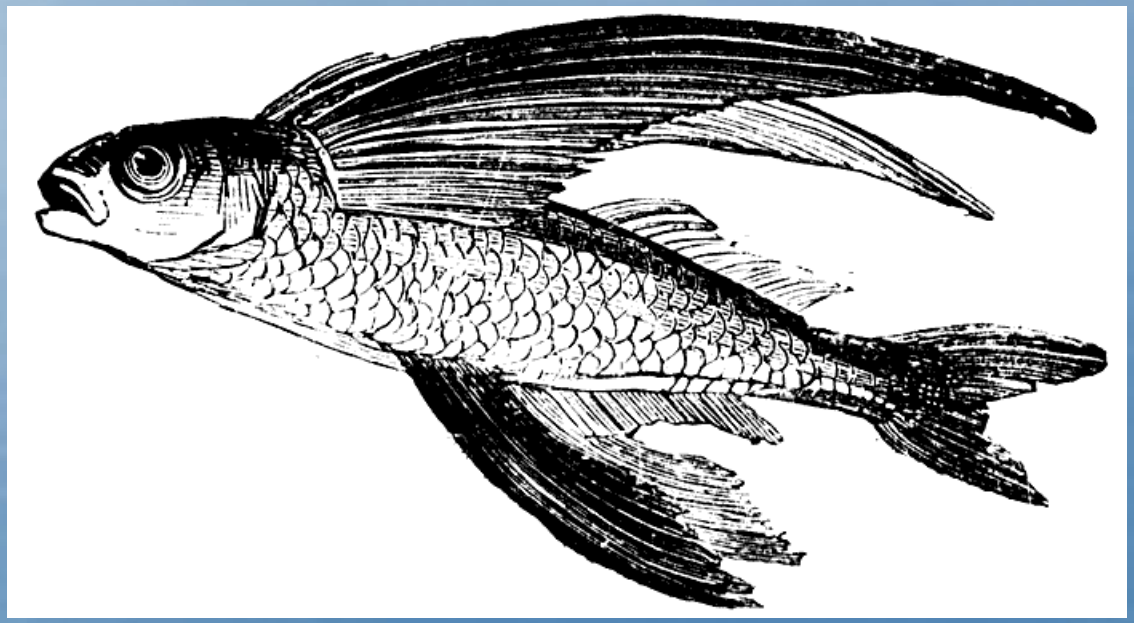
- Streamlined – very torpedo like (sagittiform)
- Have a flattened head, present a narrow frontal profile
- Have a large mouth and obvious teeth
- Pointy snouts large mouth
- Cryptic coloration
- Large caudal fin
- Fins set back on body and all in a row – iads in thrusting ability)

NORTHERN PIKE

BARRACUDA

NEEDLEFISH

3. SURFACE ORIENTED FISH



SURFACE ORIENTED FISH

- Usually small sized
- Upward pointed mouth
- Dorsoventrally flattened head with large eyes
- Fins toward rear of body
- Morphology well suited for capturing plankton and small fishes living in the surface waters.

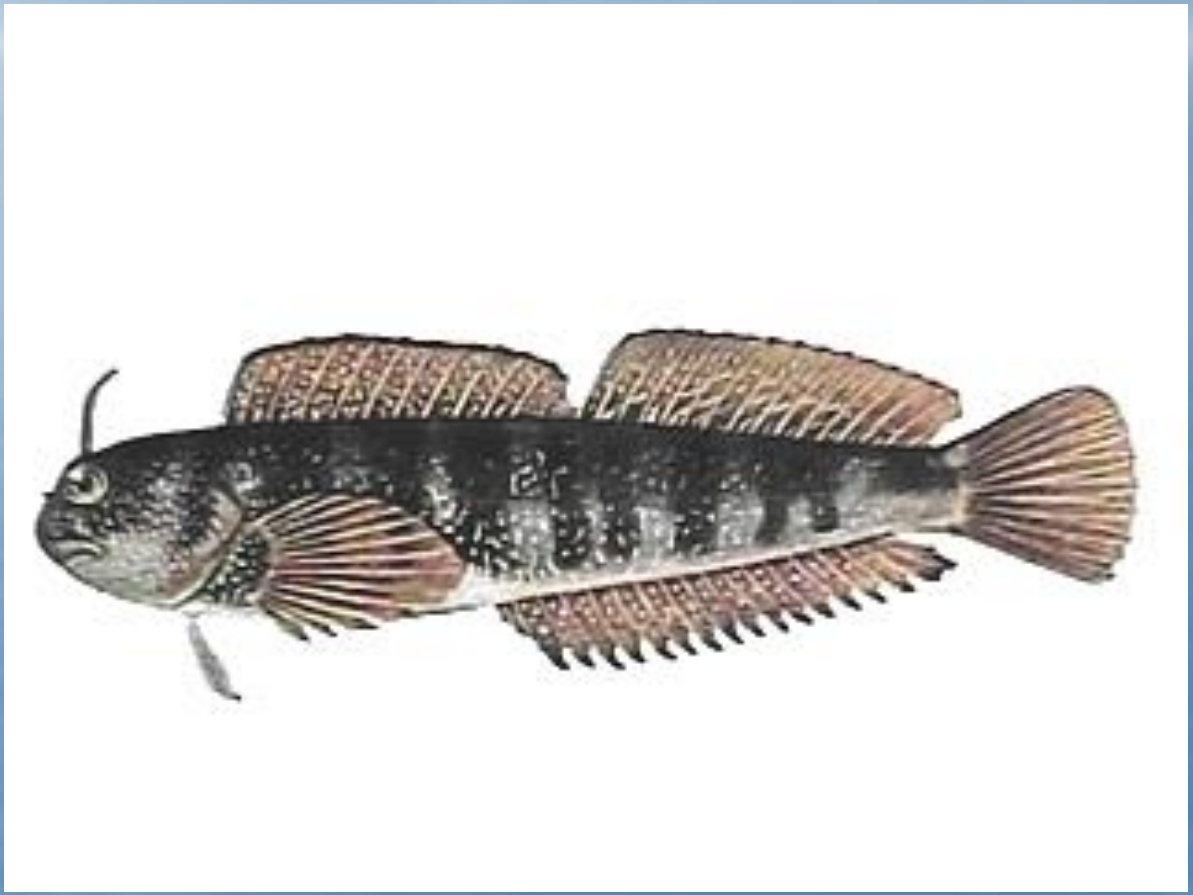
MOSQUITO FISH

KILLIFISH

FLYING FISH

HALFBEAKS

4. BOTTOM FEEDING FISHES



BOTTOM FEEDING FISHES

- Swim bladder absent or greatly reduced
- Most body shapes flattened dorsoventrally
- Bottom fish exhibit several types of feeding behaviors:
  - bottom rovers
  - bottom clingers
  - bottom hiders
  - flatfish
  - deep bodied
  - eel like
  - rattails

BLUE LINED GOATFISH

CATFISH

MANDARINE GOBY

SCULPIN

NOPOLI GOBY

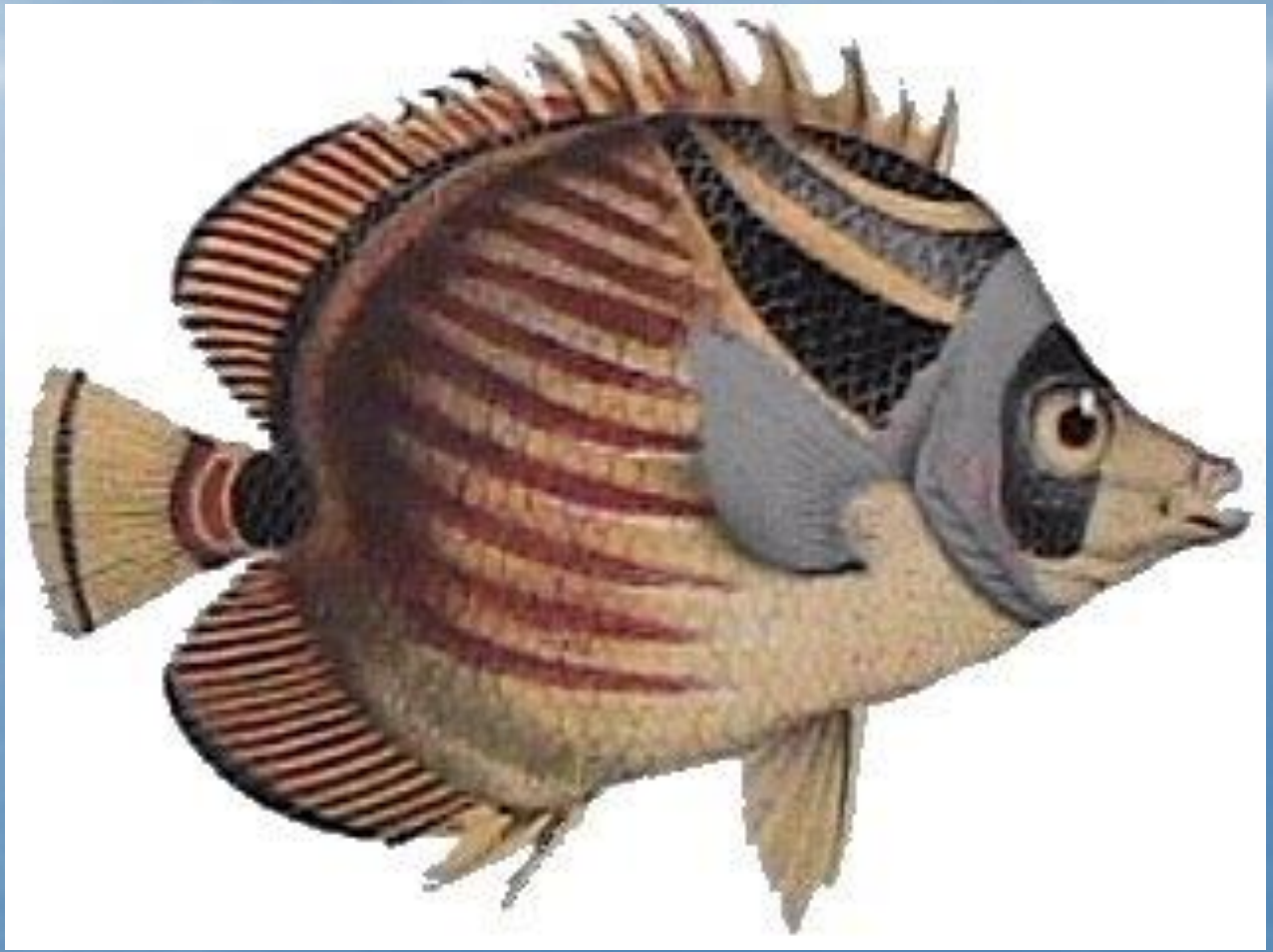
HALIBUT

SOUTHERN STING RAY

BROAD SKATE

RATTAILS

5. DEEP BODIED FISH



DEEP BODIED FISH

- Laterally compressed
- Deep bodied
- Dorsal and anal fins are relatively long
- Pectoral fins high on the body
- Pelvic fins moved forward
- Some have ventral keel

6. EEL-LIKE FISH

- Snake-like form
- Blunt or rounded heads
- Small or absent pectoral fins
- Dorsal and anal fins may be elongated

SADDLED SNAKE EEL

EUROPEAN EEL

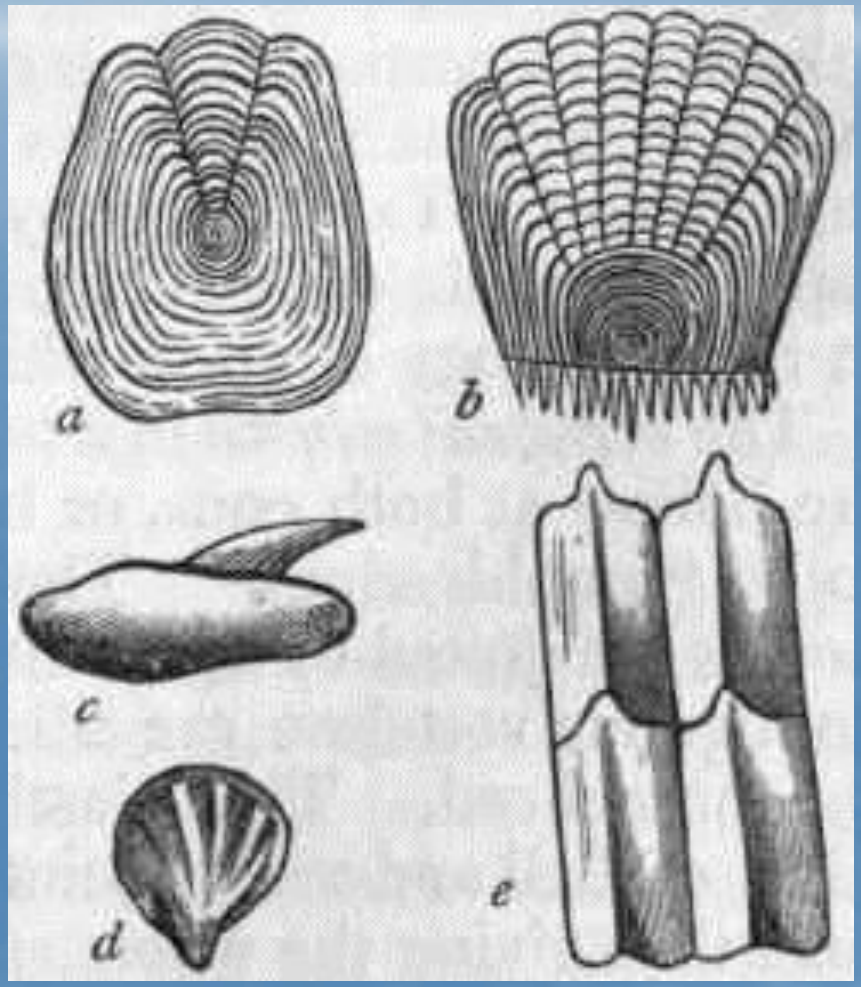
BREAK 2

TYPES OF SCALES

- Fish scales are dermally derived
- Vary greatly on bony fishes
- Can be armor like to no scales at all
- Bony plates – slow movers
- Protection
- Weight issues

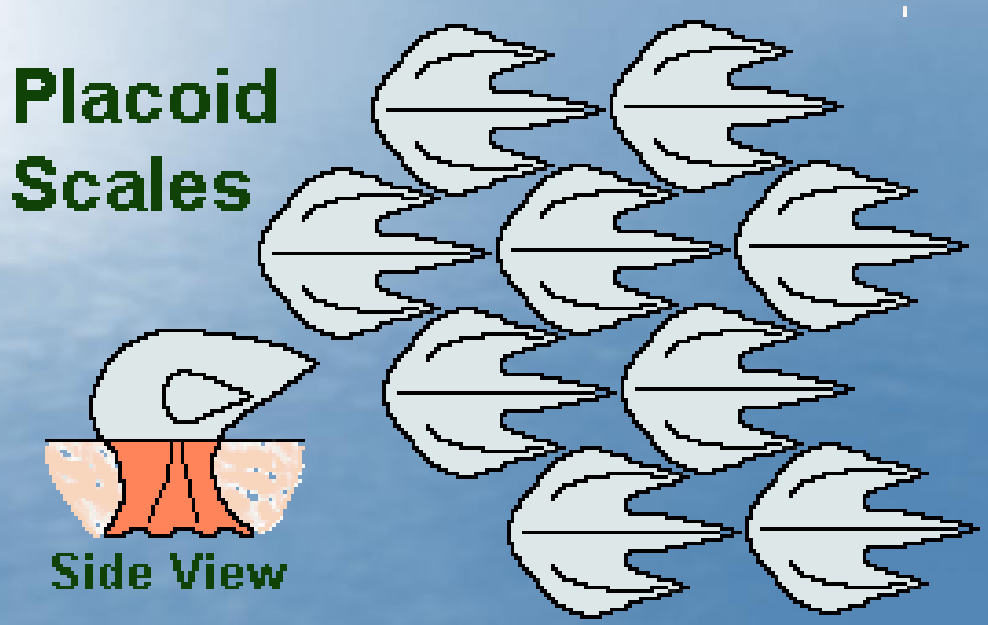
FOUR MAIN TYPES

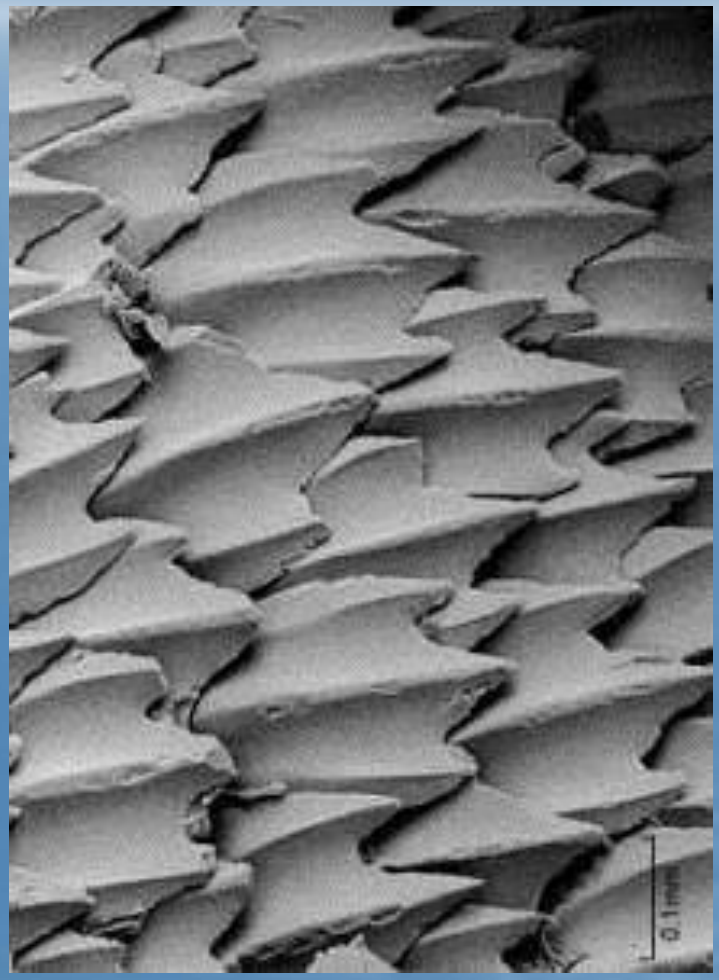
- Placoid
- Ganoid
- Cycloid
- Ctenoid



PLACOID SCALES

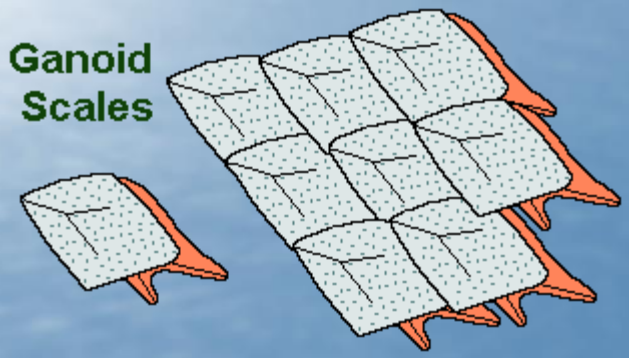
- Also called “dermal denticals”
- Common in sharks





GANOID SCALES

- Bichirs, Bowfin, gars, sturgeons
- Usually rhomboid in shape

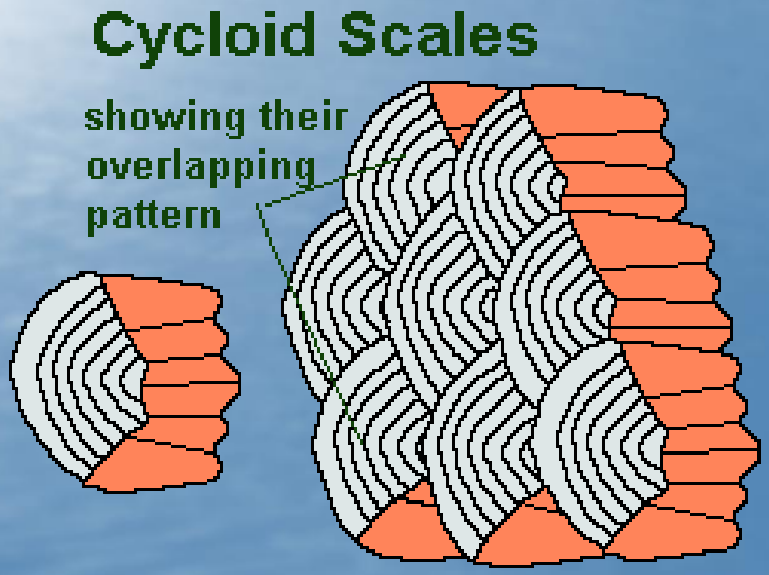


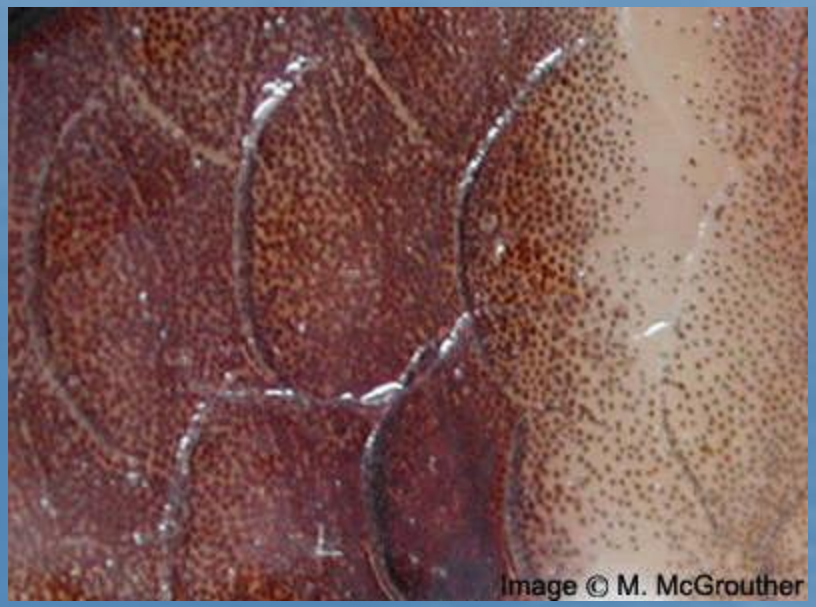
CYCLOID AND CTENOID SCALES

- Found in majority of bony fishes (Teleostei)
- Anterior usually overlapped by posterior of scale in front
- Gives fish more flexibility than fish with ganoid or cosmoid scales
- As a fish with cycloid or ctenoid scales grows, its scales also grow
  - results in a pattern of concentric growth rings on the scale

CYCLOID SCALES

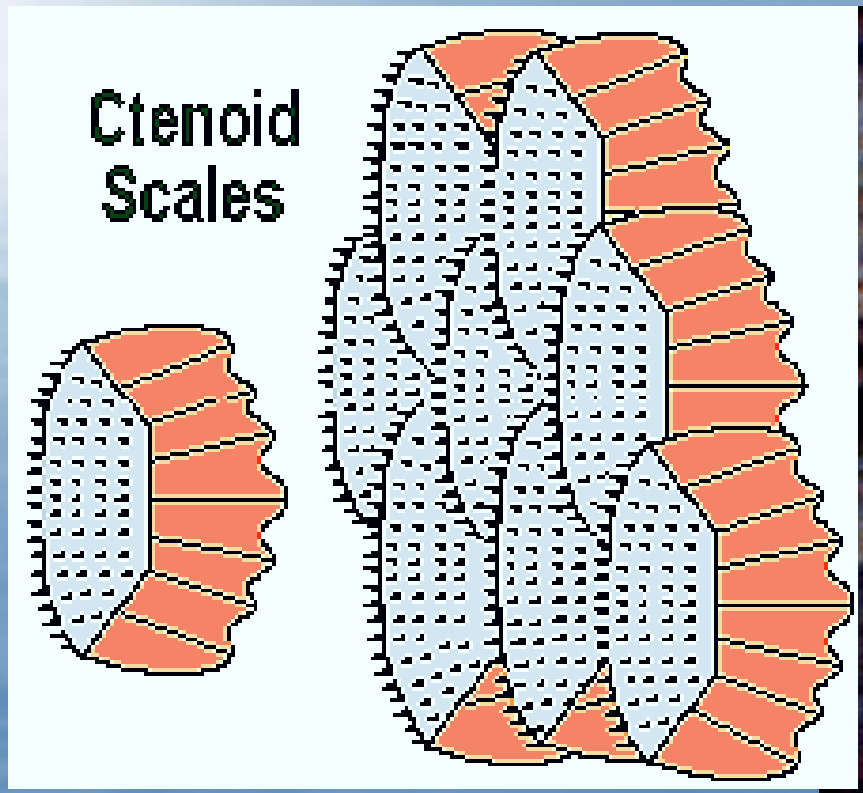
- Are often round flat and thin

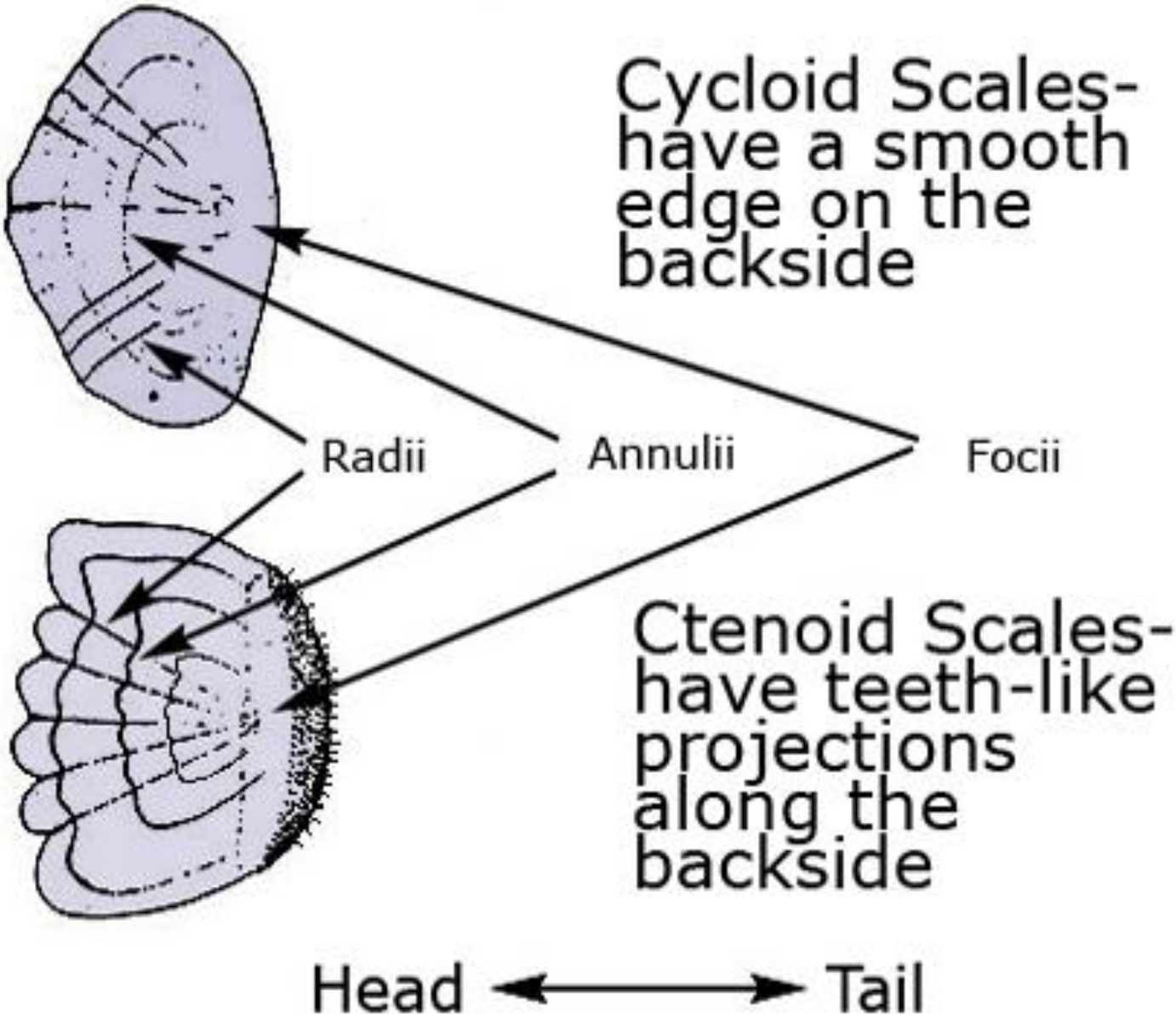


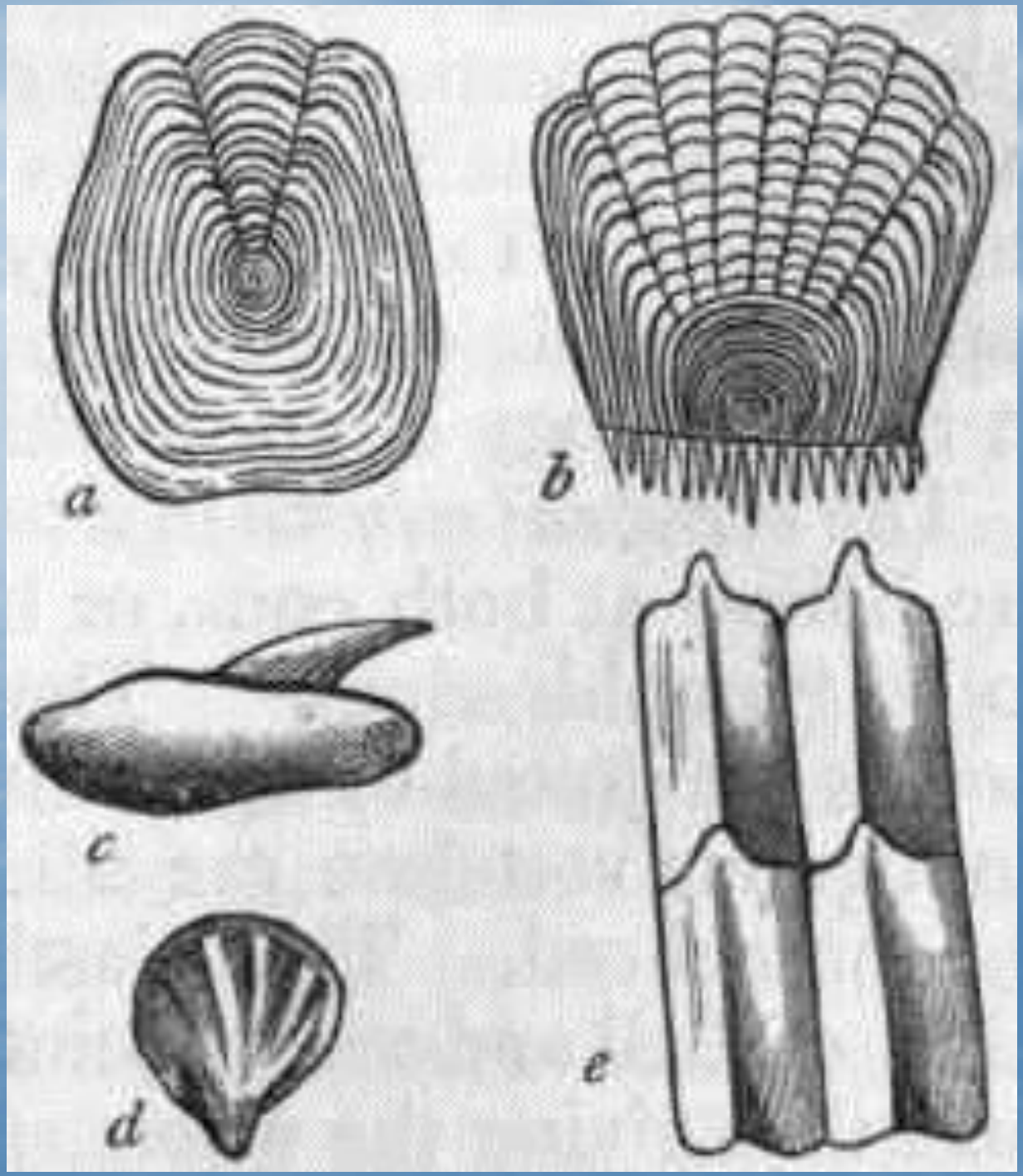


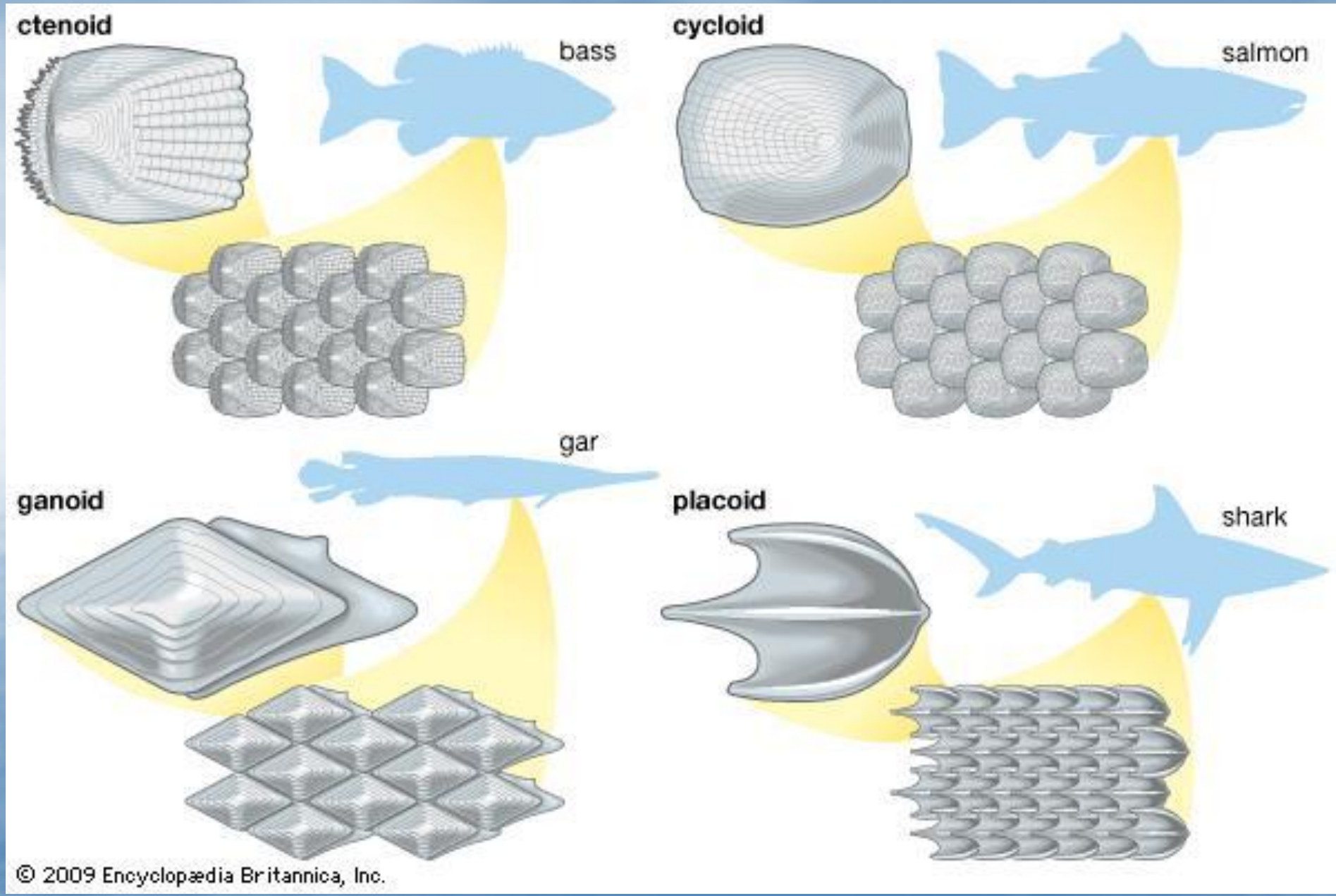
CTENOID SCALES

- Often found on spiny fish
- Similar to cycloid except for tiny projections




Cycloid Scales- have a smooth edge on the backside
Radii
Annulii
Focii
Ctenoid Scales- have teeth-like projections along the backside
Head
Tail


a
b
c
d
e


ctenoid
bass
cycloid
salmon
gar
ganoid
placoid
shark
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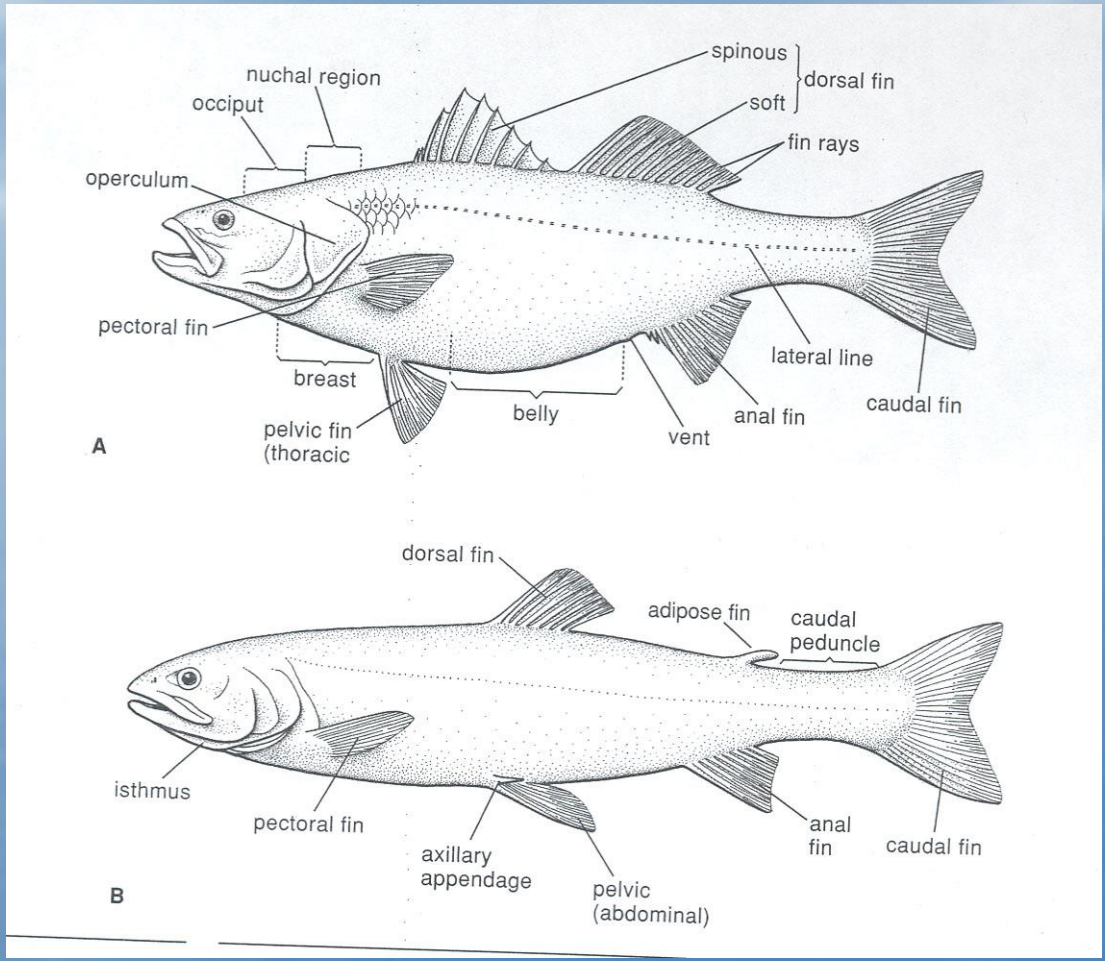
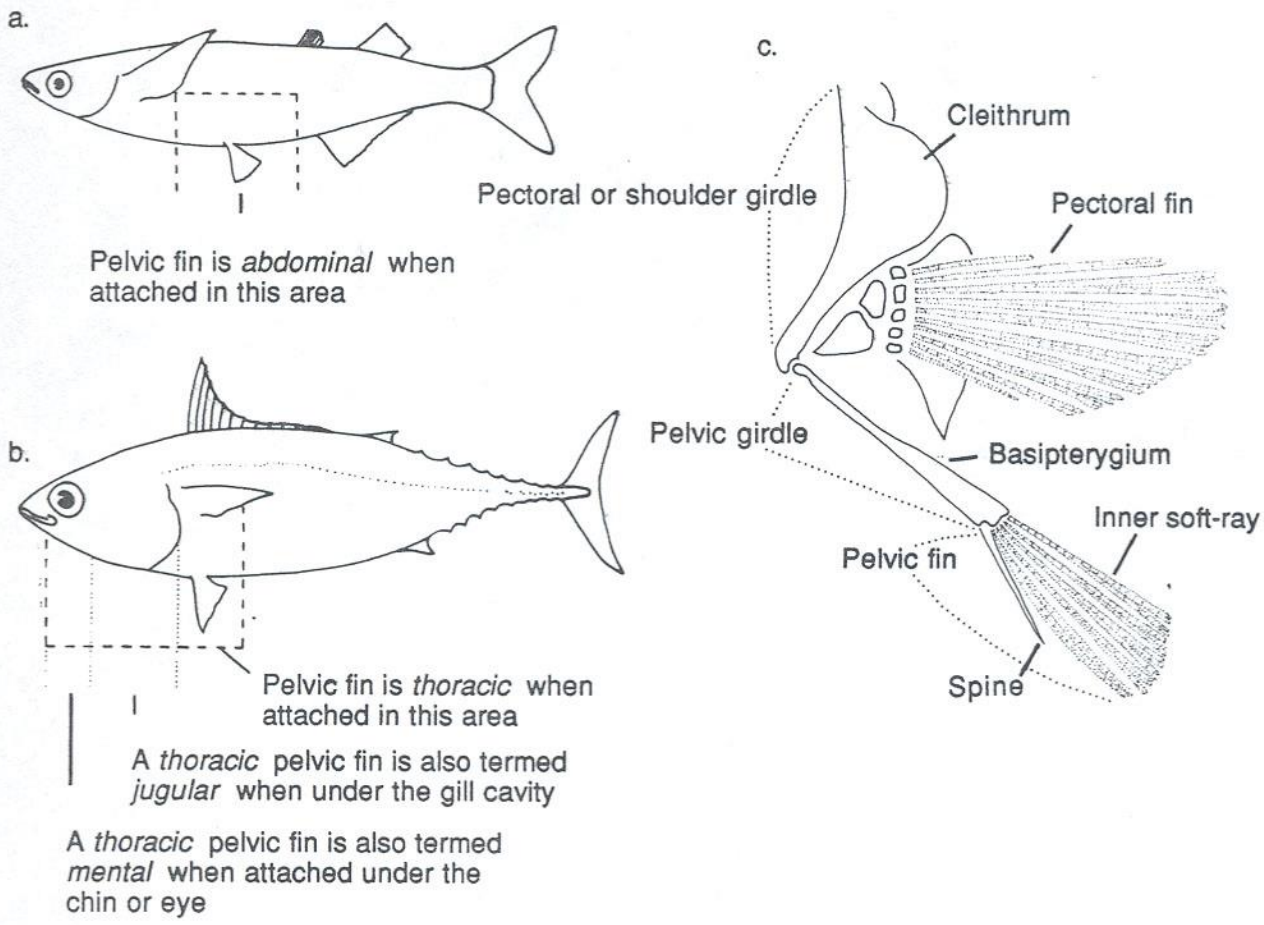
FISH ANATOMY

- Fins
- Other Structures
- Skeletal System
- Muscular System
- Locomotion

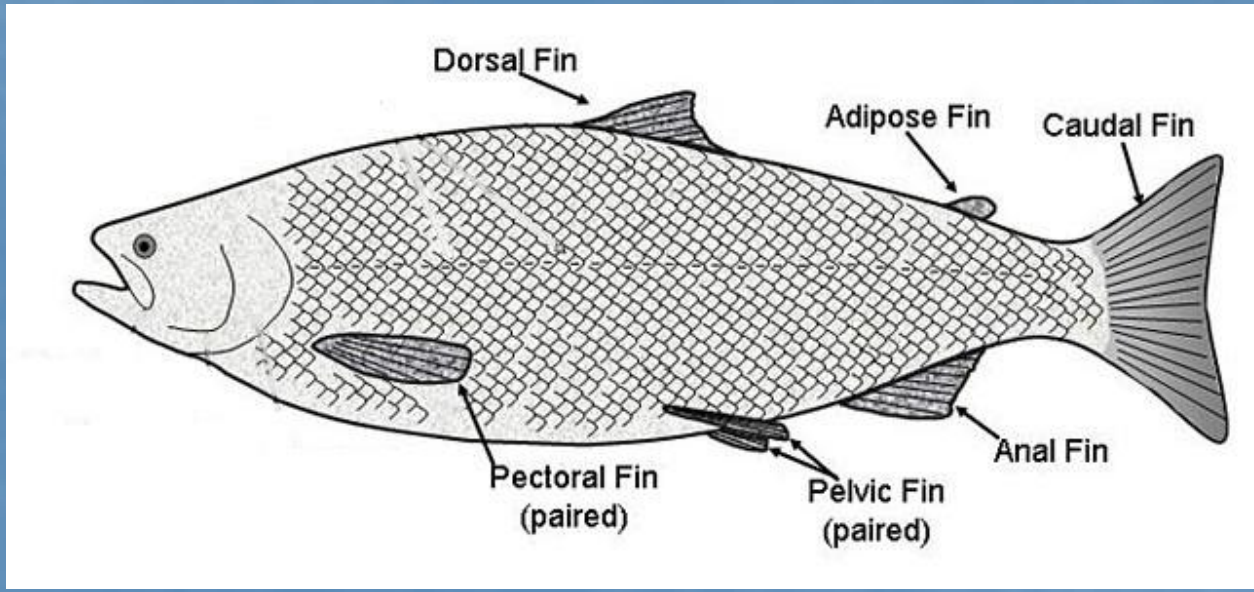

spinous
dorsal fin
soft
fin rays
nuchal region
occiput
operculum
pectoral fin
breast
pelvic fin
(thoracic
belly
vent
anal fin
lateral line
caudal fin
A
dorsal fin
adipose fin
caudal
peduncle
isthmus
pectoral fin
axillary
appendage
pelvic
(abdominal)
anal
fin
caudal fin
B

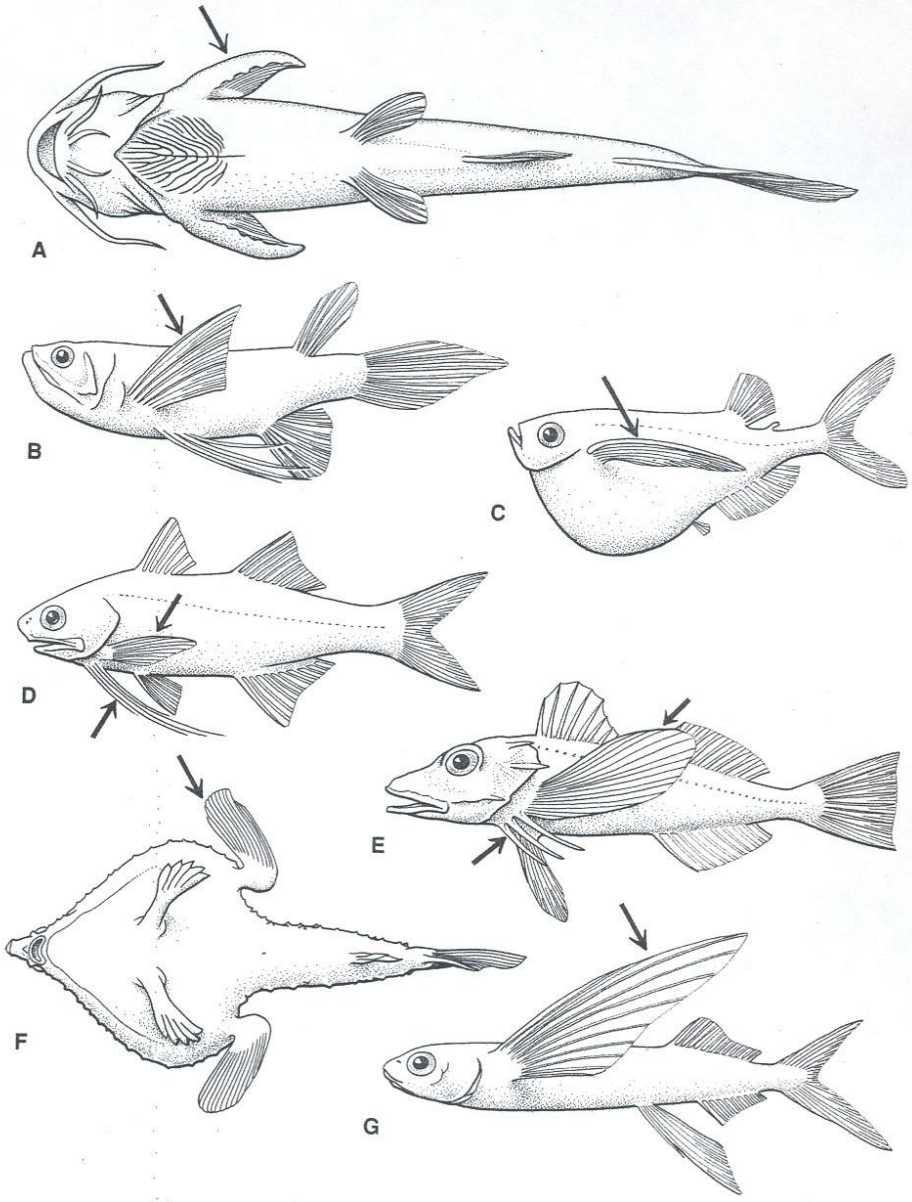

a.
Pelvic fin is *abdominal* when attached in this area
b.
Pelvic fin is *thoracic* when attached in this area
A *thoracic* pelvic fin is also termed *jugular* when under the gill cavity
A *thoracic* pelvic fin is also termed *mental* when attached under the chin or eye
c.
Cleithrum
Pectoral or shoulder girdle
Pectoral fin
Pelvic girdle
Basipterygium
Inner soft-ray
Pelvic fin
Spine


2cm

PECTORAL FINS

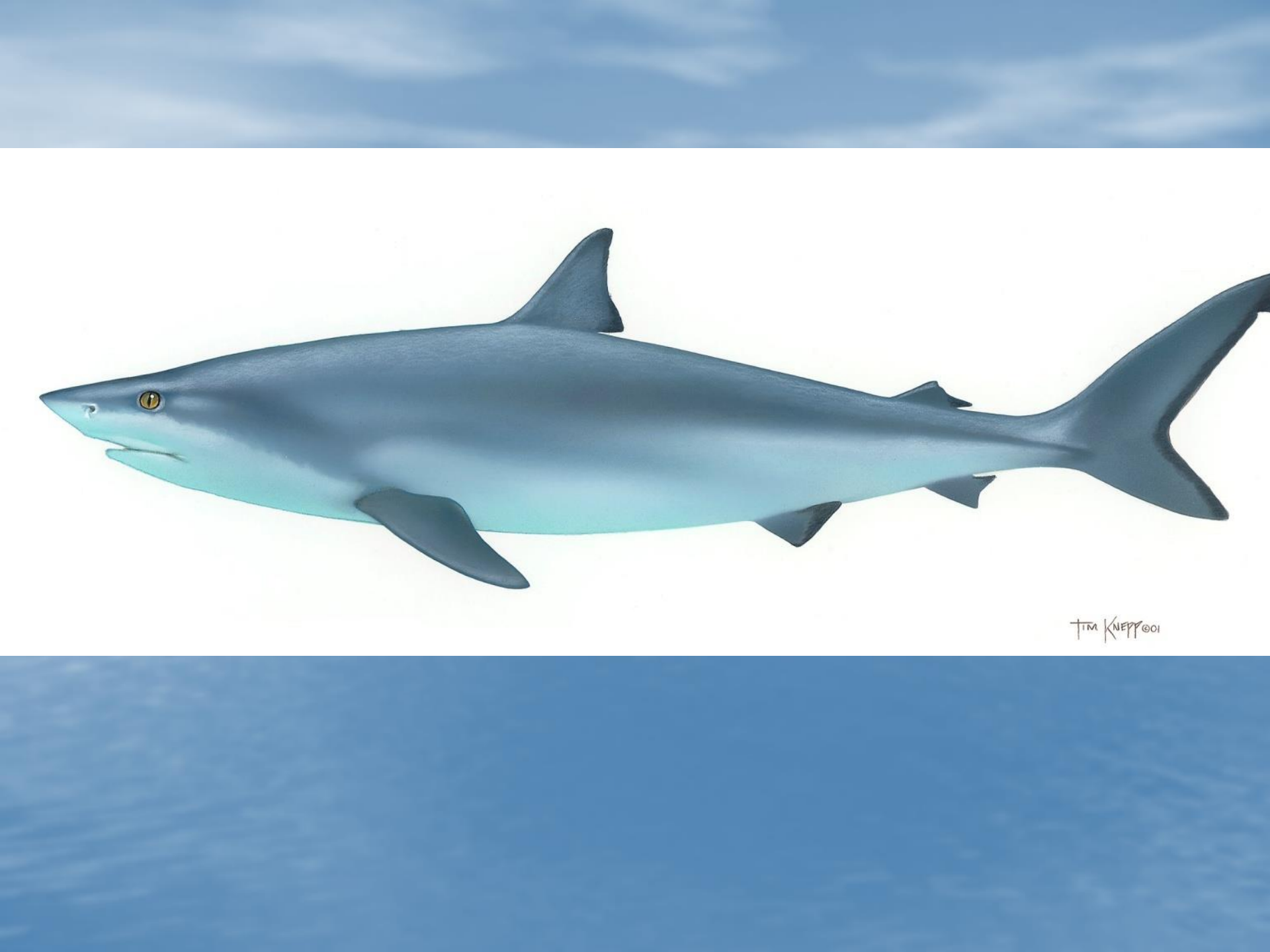
- Varied and many forms
- Aid in locomotion, stability
- Generally located high up on sides of deep bodied fish which rely on precise movement to pick up food from bottom or in water column
- In rover predators these fins tend to be more toward or below the midline
- In slower moving rover predators or fish needing more surface area for stablility fins tend to be more rounded





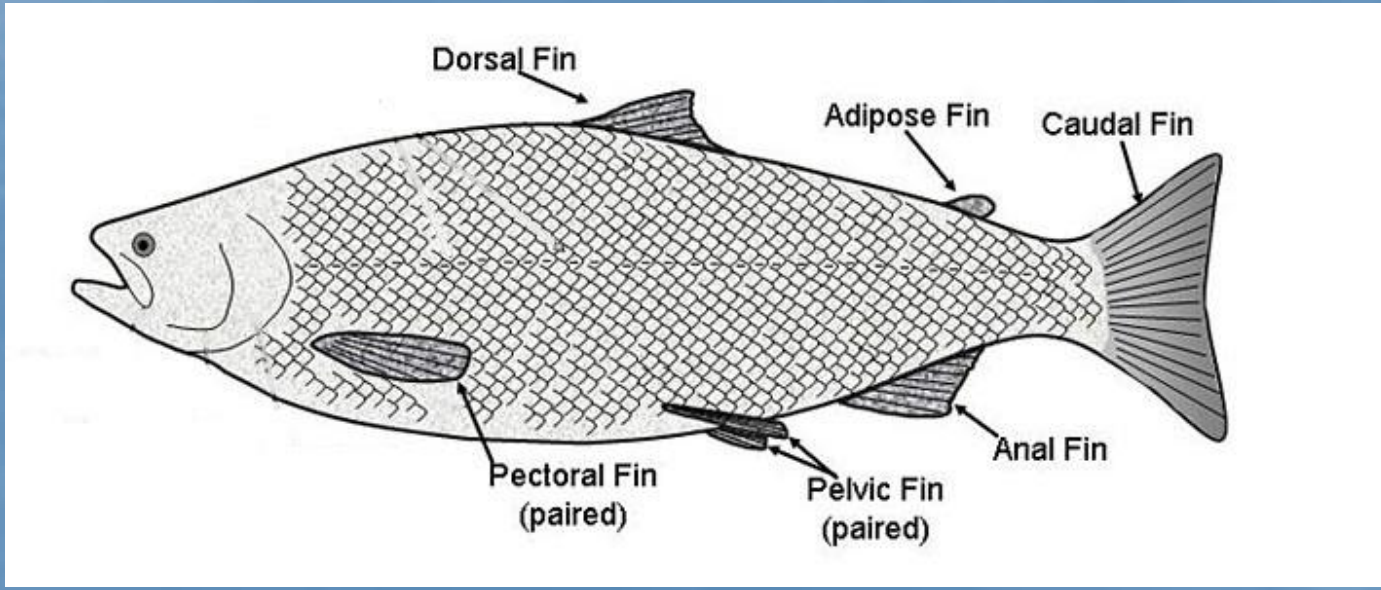
Examples of fish with modified pectoral fins. **A,** Ventral view of sisorid catfish (*Glyptothorax*); **B,** freshwater butterflyfish (*Pantodon*); **C,** hatchetfish (*Gastropelecus*); **D,** threadfin (Polynemidae); **E,** gurnard (Triglidae); **F,** ventral view of batfish (Ogcocephalidae) with armlike pectorals well behind pelvics; **G,** flying fish (Exocoetidae). (**B** based on Herald, 1961; **D, E,** and **G** based on Jordan and Evermann, 1900.)


Slimy Sculpin- *Cottus cognatus*
averages 3-5 inches


TIM KNEPP©01

DORSAL AND ANAL FINS

- Generally long on rover predators and deep bodied fish to provide stability while swimming
- Modified for swimming, reproduction (mosquitofish)
- May be continuous in eel like fish

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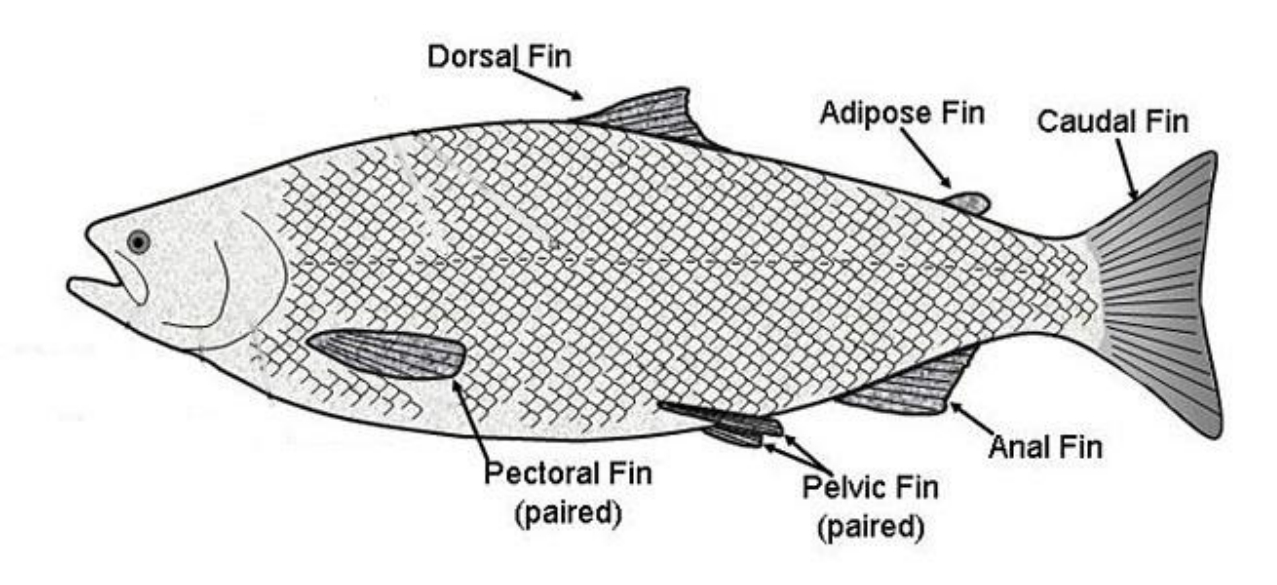
NATURFOTO

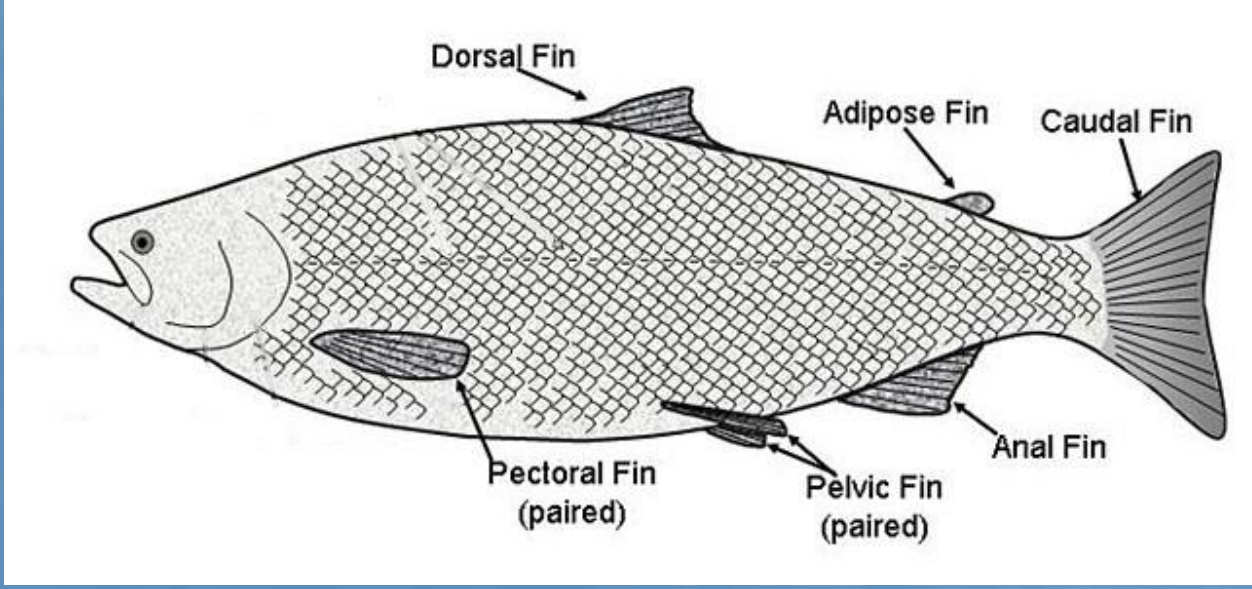
ADIPOSE FIN

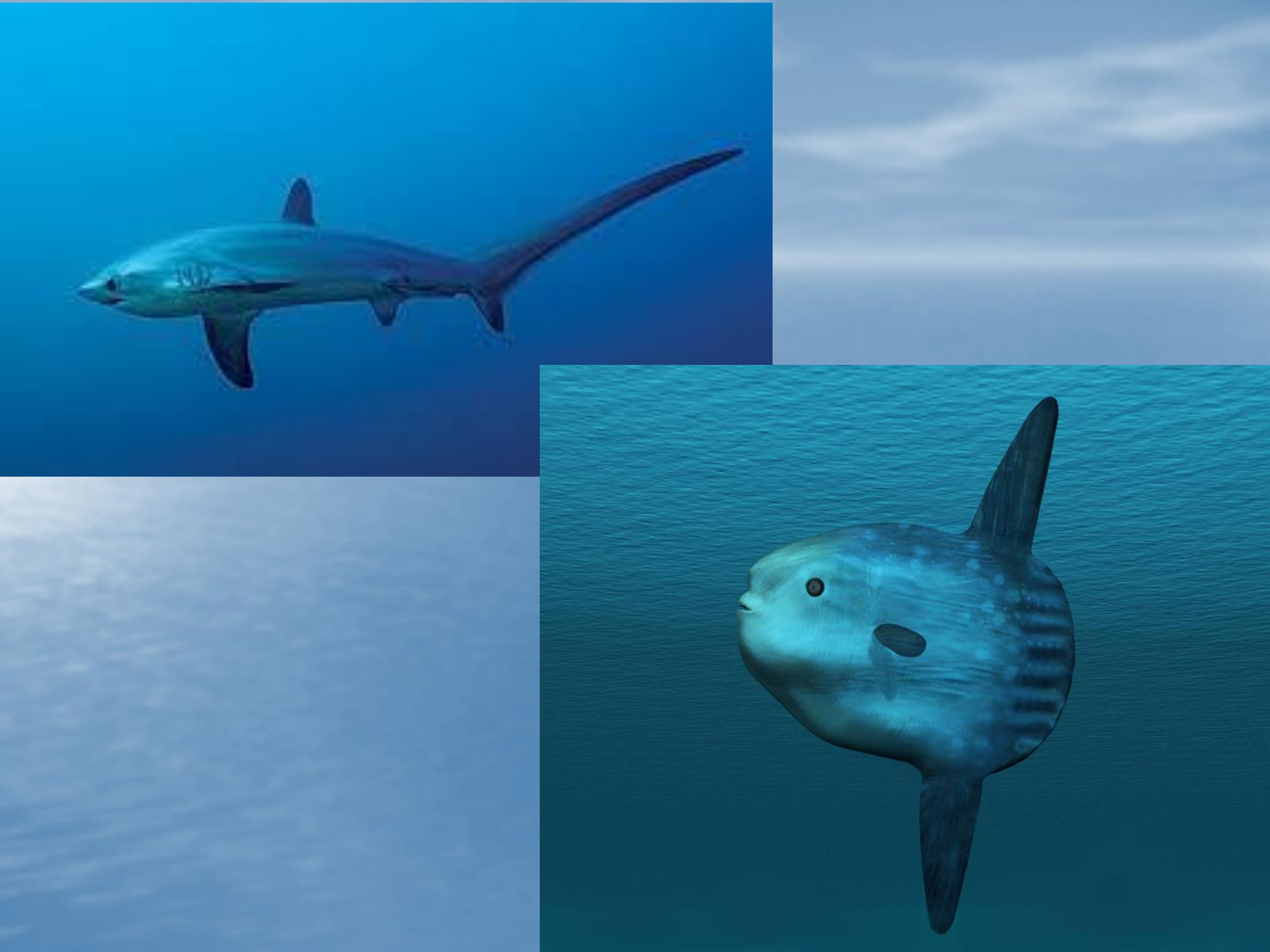
- Fleshy dorsal found in Salmonidae, smelts (Osmeridae), lanternfish (Myctophidae), catfish and CHARACINS
- Small size and lack of rays make it a mystery fin
- May be important post-larval when other fins poorly developed



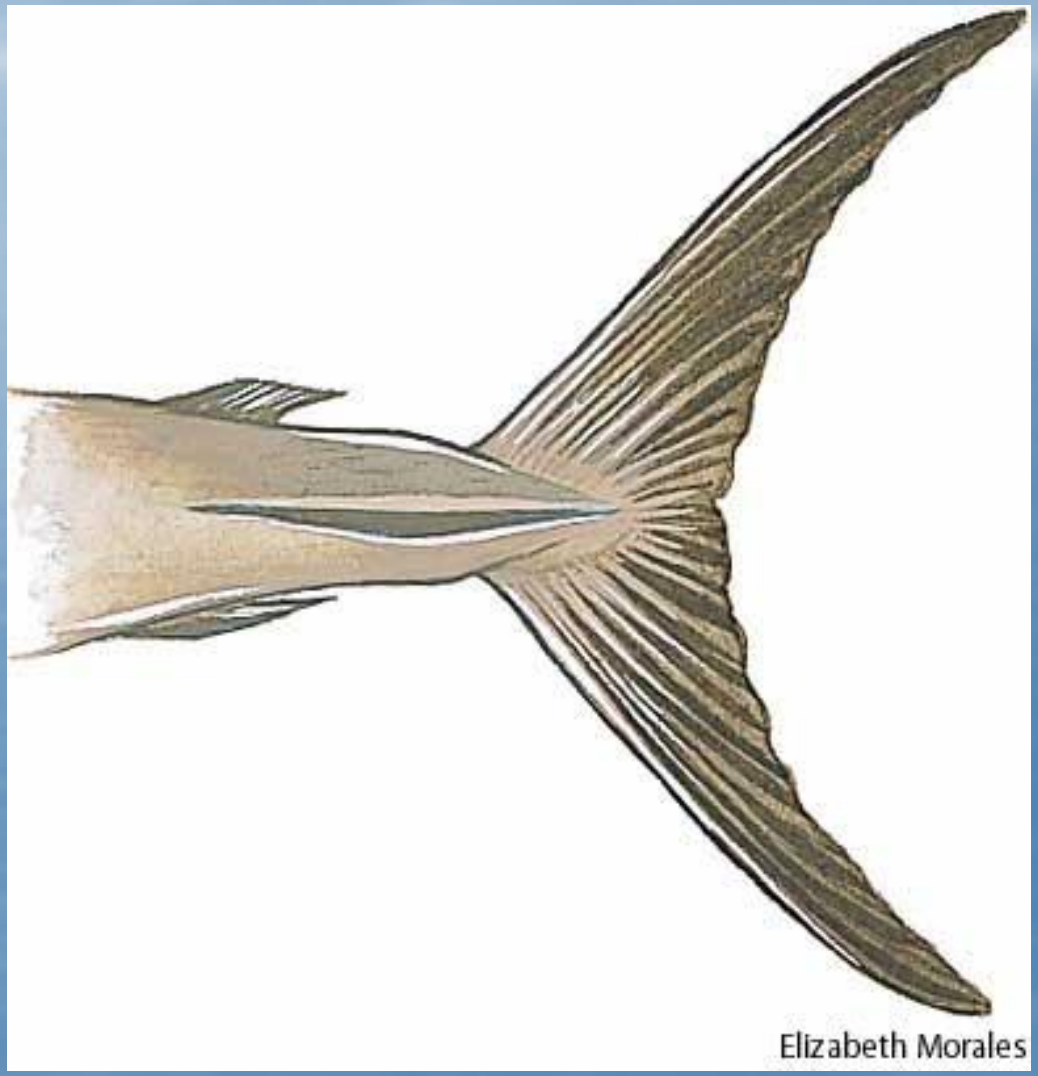
CAUDAL FINS

- “tail fins”
- Size and shape is dependent upon ecology and lifestyle

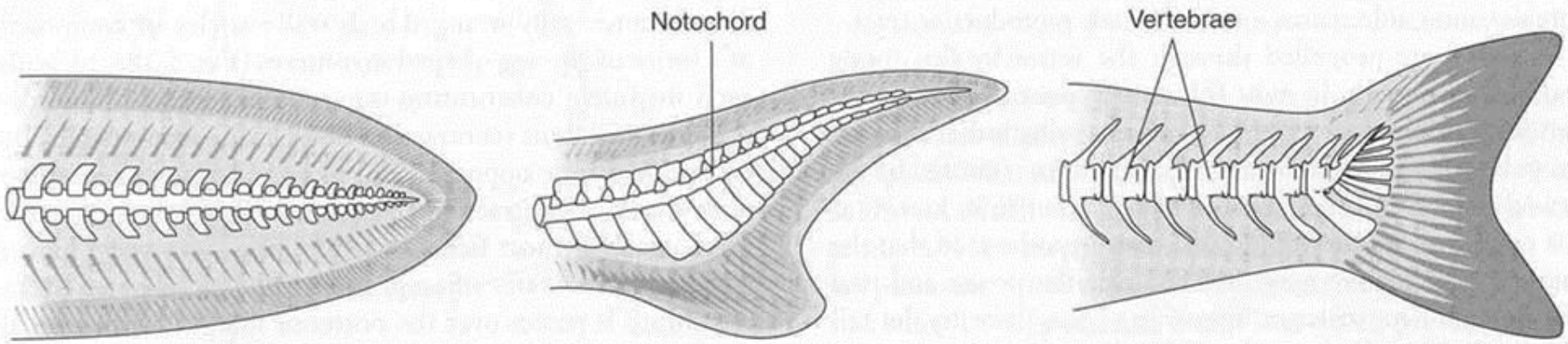




HOMOCERCAL

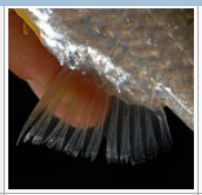
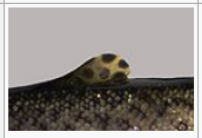
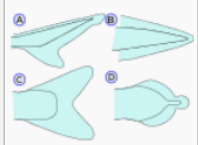
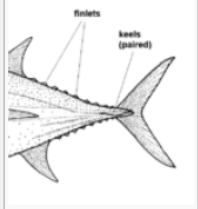


HETEROCERCAL TAIL



Major caudal fin (tail) modifications in fishes: (*a*) diphycercal (lungfishes and bichirs); (*b*) heterocercal (sharks); (*c*) homocercal (most bony fishes).

Pectoral fins		The paired **pectoral fins** are located on each side, usually just behind the operculum, and are homologous to the forelimbs of tetrapods. • A peculiar function of pectoral fins, highly developed in some fish, is the creation of the dynamic lifting force that assists some fish, such as sharks, in maintaining depth and also enables the "flight" for flying fish. • In many fish, the pectoral fins aid in walking, especially in the lobe-like fins of some anglerfish and in the mudskipper. • Certain rays of the pectoral fins may be adapted into finger-like projections, such as in sea robins and flying gurnards. • The "horns" of manta rays and their relatives are called **cephalic fins**; this is actually a modification of the anterior portion of the pectoral fin.
Pelvic fins (Ventral fins)		The paired **pelvic** or **ventral fins** are located ventrally below and behind the pectoral fins. They are homologous to the hindlimbs of tetrapods. The pelvic fin assists the fish in going up or down through the water, turning sharply, and stopping quickly. • In gobies, the pelvic fins are often fused into a single sucker disk. This can be used to attach to objects. • Standen EM (2009) "Muscle activity and hydrodynamic function of pelvic fins in trout *(Oncorhynchus mykiss)* *The Journal of Experimental Biology*, **213**: 831–841. doi:10.1242/jeb.033084
Dorsal fin	 Dorsal fin of a shark	Dorsal fins are located on the back. A fish can have up to three of them. The dorsal fins serve to protect the fish against rolling, and assists in sudden turns and stops. • In anglerfish, the anterior of the dorsal fin is modified into an **illicium** and **esca**, a biological equivalent to a fishing rod and lure. • The bones that support the dorsal fin are called *Pterygiophore*. There are two to three of them: "proximal", "middle", and "distal". In spinous fins the distal is often fused to the middle, or not present at all.  Dorsal fin of a chub *(Leuciscus cephalus)*

Anal fin		The **anal fin** is located on the ventral surface behind the anus. This fin is used to stabilize the fish while swimming.
Adipose fin	 Adipose fin of a trout	The **adipose fin** is a soft, fleshy fin found on the back behind the dorsal fin and just forward of the caudal fin. It is absent in many fish families, but is found in Salmonidae, characins and catfishes. Its function has remained a mystery, and is frequently clipped off to mark hatchery-raised fish, though data from 2005 showed that trout with their adipose fin removed have an 8% higher tailbeat frequency.[1][2] Additional released in 2011 has suggested that the fin may be vital for the detection of, and response to, stimuli such as touch, sound and changes in pressure. Canadian researchers identified a neural network in the fin, indicating that it likely has a sensory function, but are still not sure exactly what the consequences of removing it are.[3][4]
Caudal fin (Tail fin)	 	The **caudal fin** is the tail fin (from the Latin *cauda* meaning tail), located at the end of the caudal peduncle and is used for propulsion. *See body-caudal fin locomotion.* (A) - **Heterocercal** means the vertebrae extend into the upper lobe of the tail, making it longer (as in sharks). • **Reversed heterocercal** means that the vertebrae extend into the lower lobe of the tail, making it longer (as in the Anaspida) (B) - **Protocercal** means the vertebrae extend to the tip of the tail and the tail is symmetrical but not expanded (as in amphioxus) (C) - **Homocercal** where the fin appears superficially symmetric but in fact the vertebrae extend for a very short distance into the upper lobe of the fin (D) - **Diphycercal** means the vertebrae extend to the tip of the tail and the tail is symmetrical and expanded (as in the bichir, lungfish, lamprey and coelacanth). Most Palaeozoic fishes had a diphycercal heterocercal tail.[5] Most modern fishes have a homocercal tail. These appear in a variety of shapes, and can appear: • **rounded** • **truncated**, ending in a more-or-less vertical edge (such as salmon) • **forked**, ending in two prongs • **emarginate**, ending with a slight inward curve. • **lunate** or shaped like a crescent moon
Caudal keel **Finlets**	 Drawing by Dr Tony Ayling	Some types of fast-swimming fish have a horizontal **caudal keel** just forward of the tail fin. Much like the keel of a ship, this is a lateral ridge on the caudal peduncle, usually composed of scutes (see below), that provides stability and support to the caudal fin. There may be a single paired keel, one on each side, or two pairs above and below. **Finlets** are small fins, generally behind the dorsal and anal fins (in bichirs, there are only finlets on the dorsal surface and no dorsal fin). In some fish such as tuna or sauries, they are rayless, non-retractable, and found between the last dorsal and/or anal fin and the caudal fin.

Break 3

SPINES

- Developed independently in several groups
- Spines are effective, lightweight means of protection
- Increase the effective size of a fish
- May be poisonous (scorpionfish)

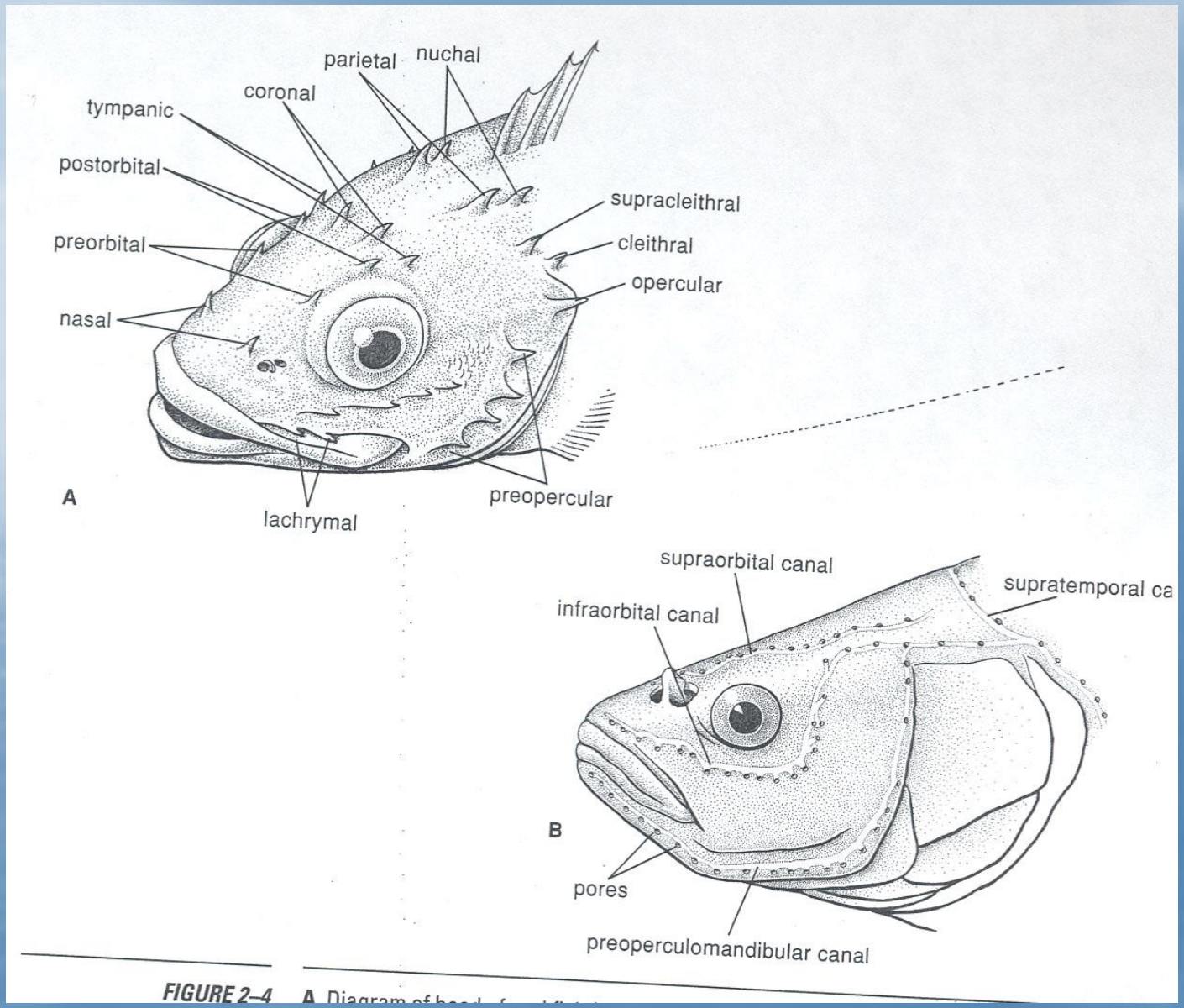
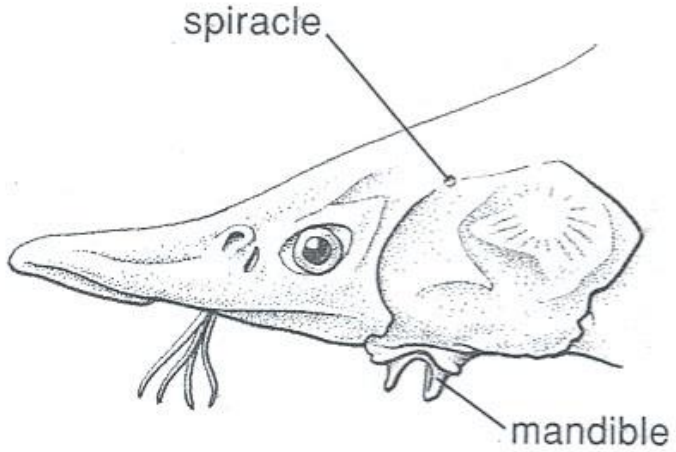


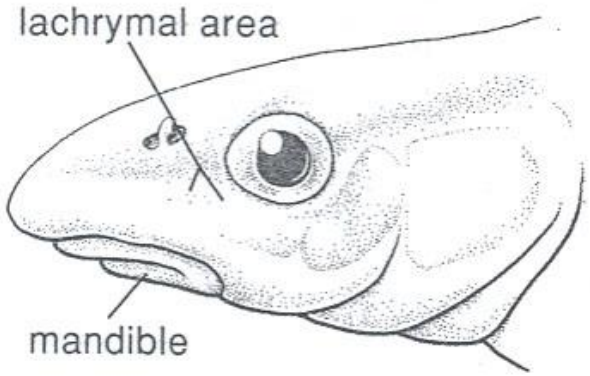
FIGURE 2–4 A Diagram of head

MOUTH STRUCUTRES

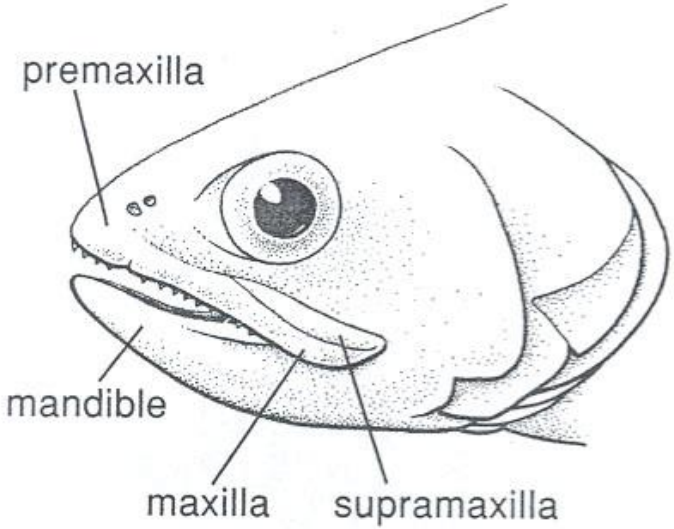
- Reveals much about fish and its habit
- Position, shape size all related to what fish do
- Bottom feeding fish have downward pointing mouth – inferior
- Surface oriented fish have upward on superior pointing mouth
- Most fish however fall into the category of terminal mouth – that is location at end of snout
- Size and shape of mouth usually reflects shape of preferred food organism



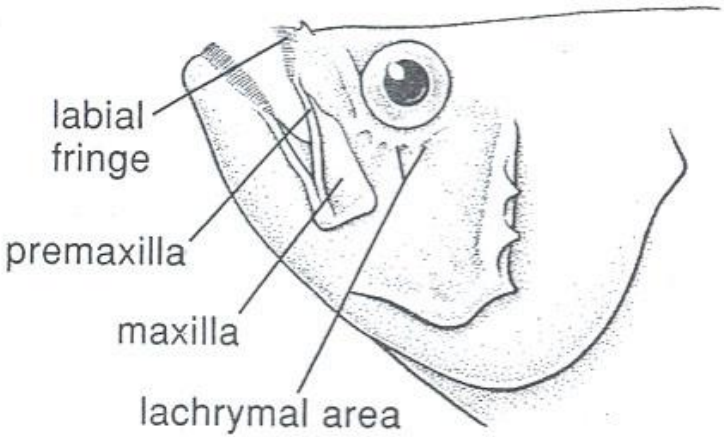
A INFERIOR



B SUBTERMINAL



C TERMINAL



D SUPERIOR

GILL OPENINGS

- are covered in most bony fish by thin flexible bony structure called the operculum
- little variability – but size varies

  (bigger on active fish; smaller on less active fish)

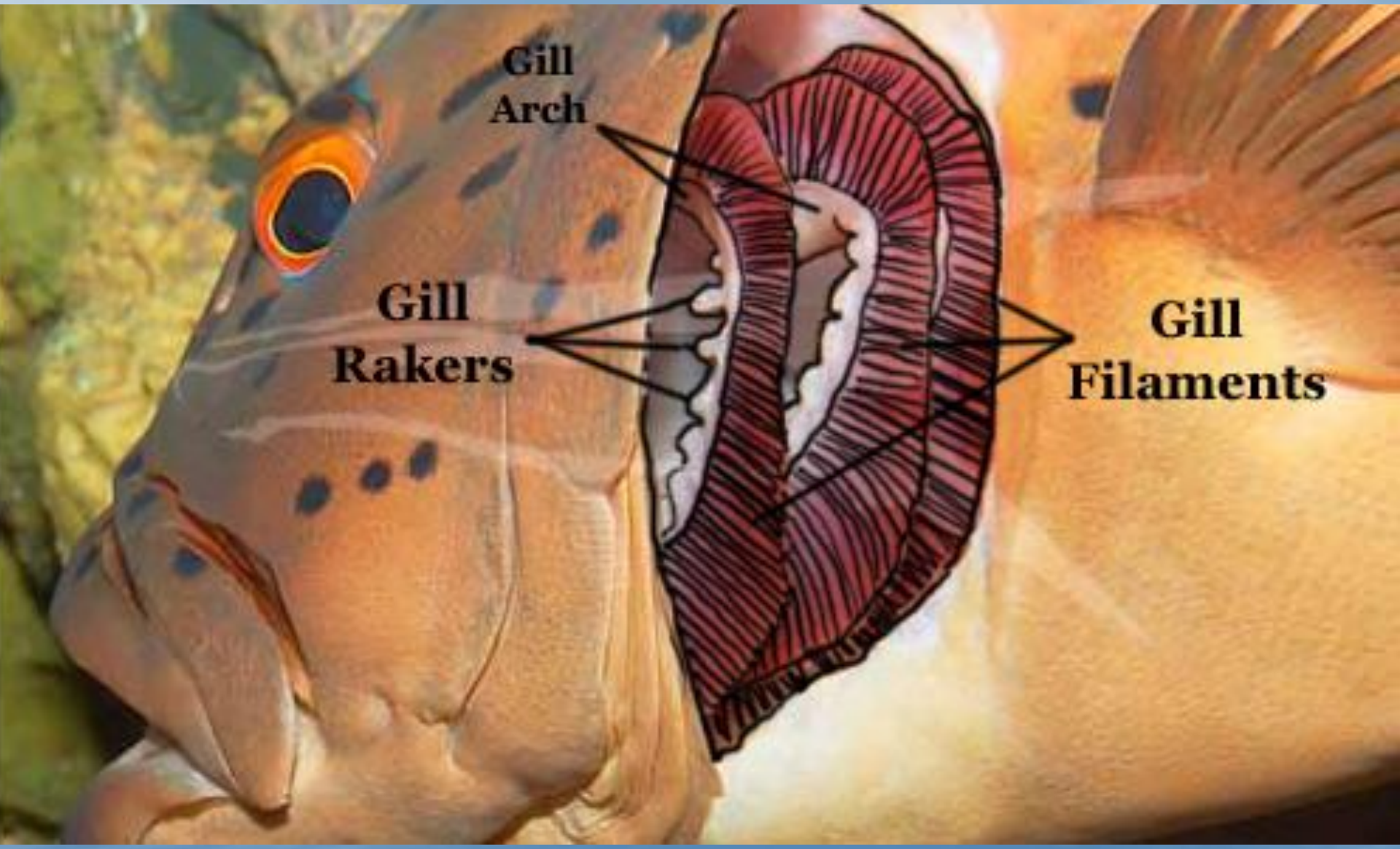
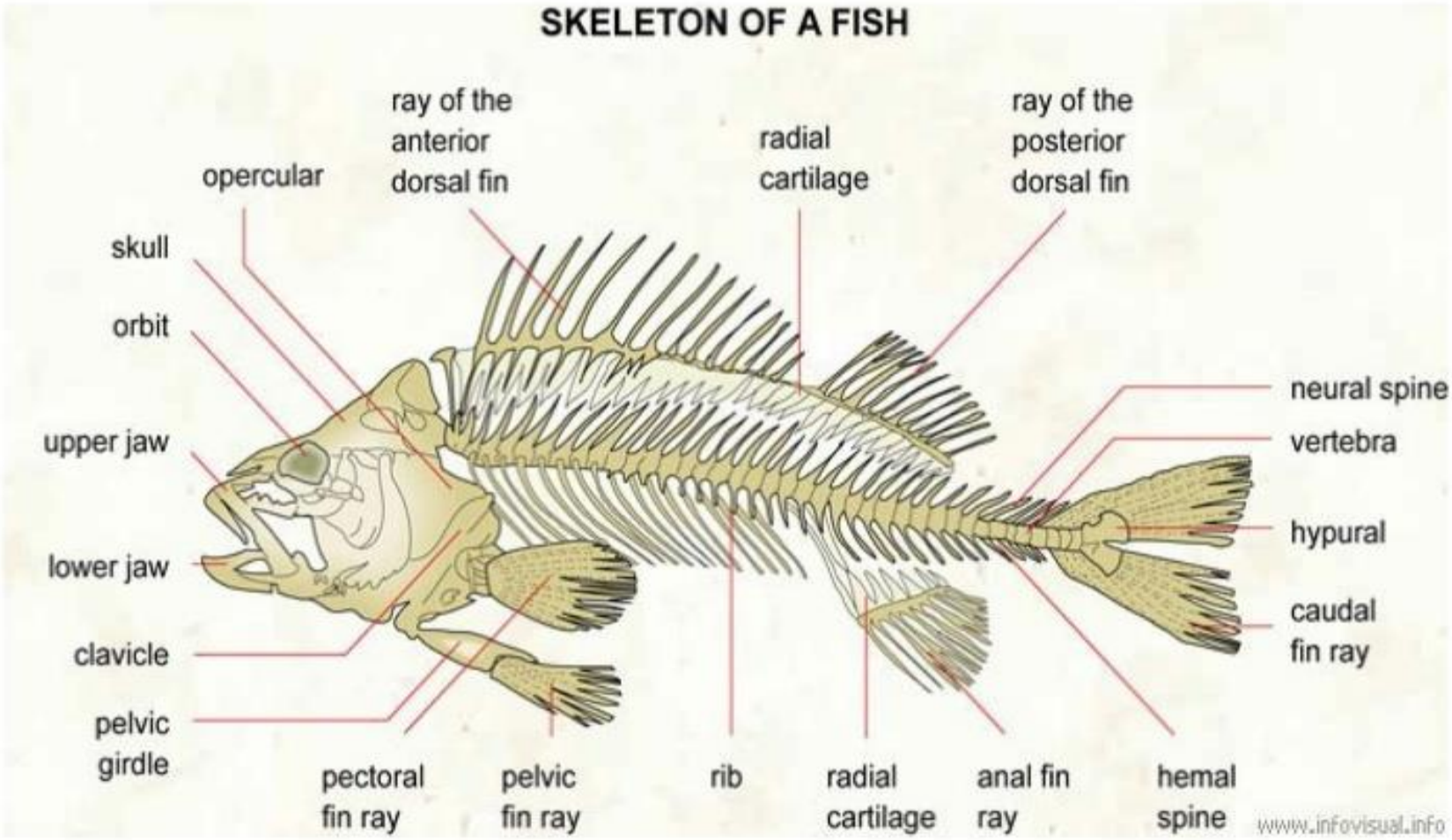

Gill
Arch
Gill
Rakers
Gill
Filaments


Image © T. Trnski


© OceanwideImages.com

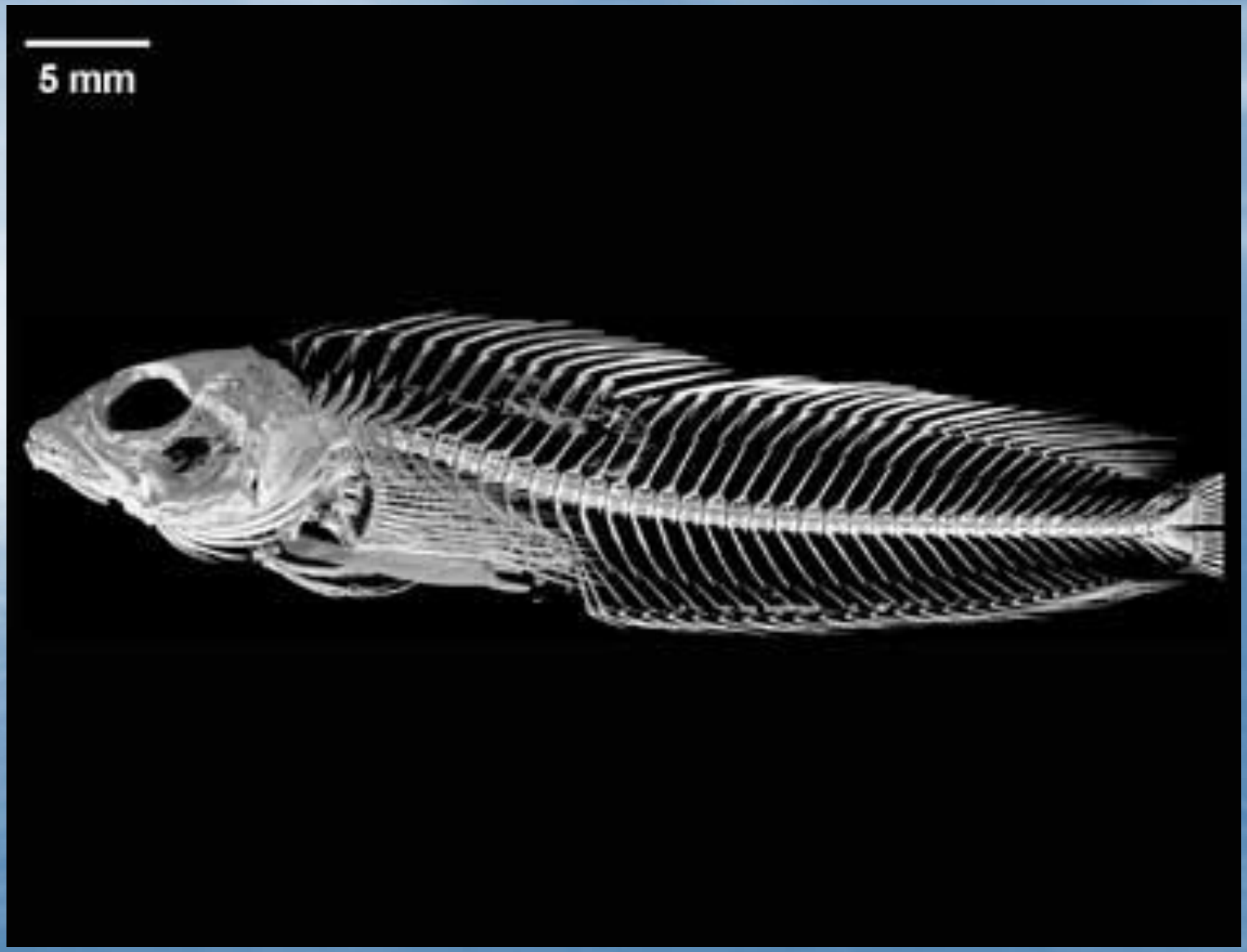
EYES

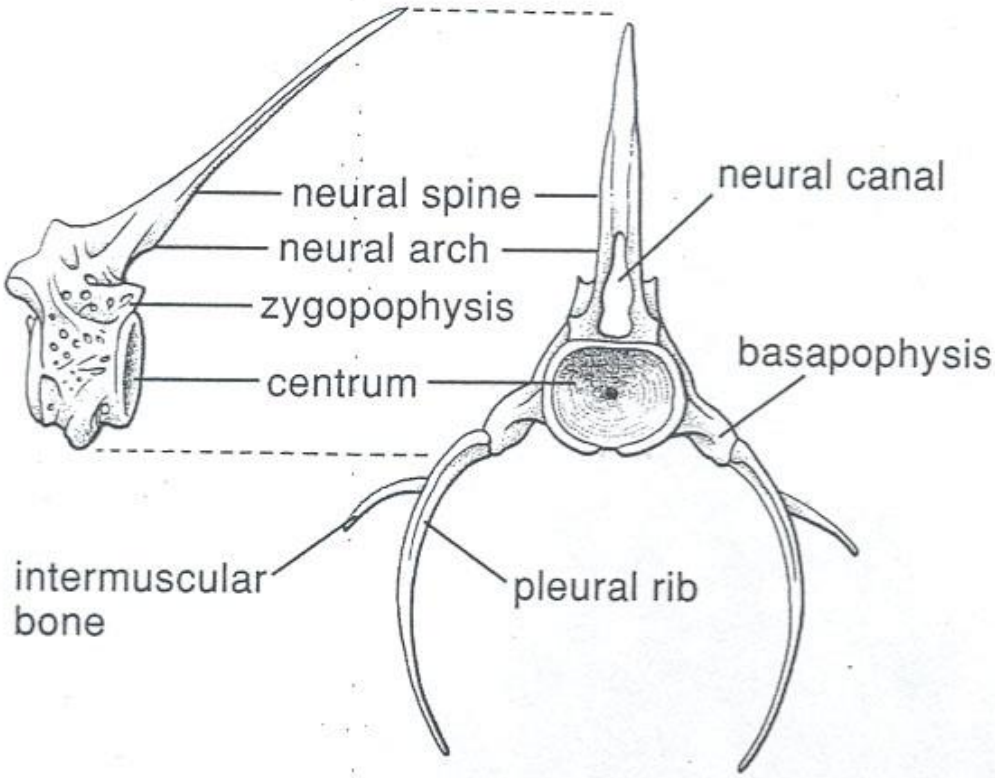
SKELETAL SYSTEM



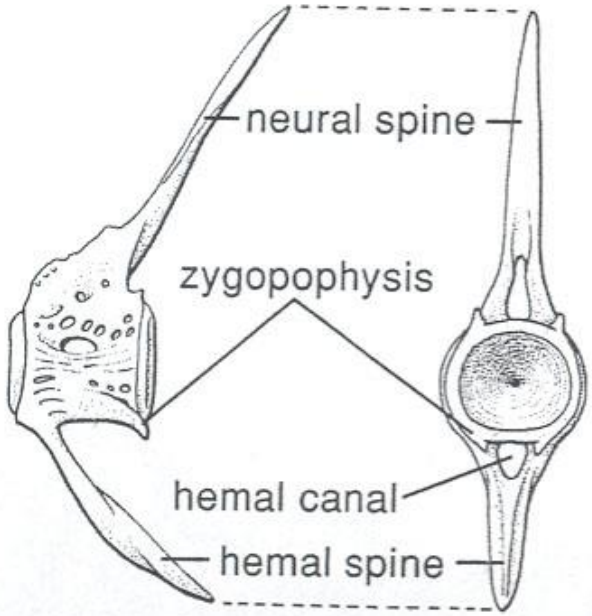
VERTEBRAL COLUMN -

- The vertebral column of fishes ranges in complexity from the very primitive notochord found in hagfishes, the cartilaginous vertebral column of the Chondrichthyes to the totally ossified vertebrae of the Osteichthyes
- The vertebral column provides fish with the basic structural basis for swimming and there is generally one vertebra per body segment


5 mm



A ABDOMINAL



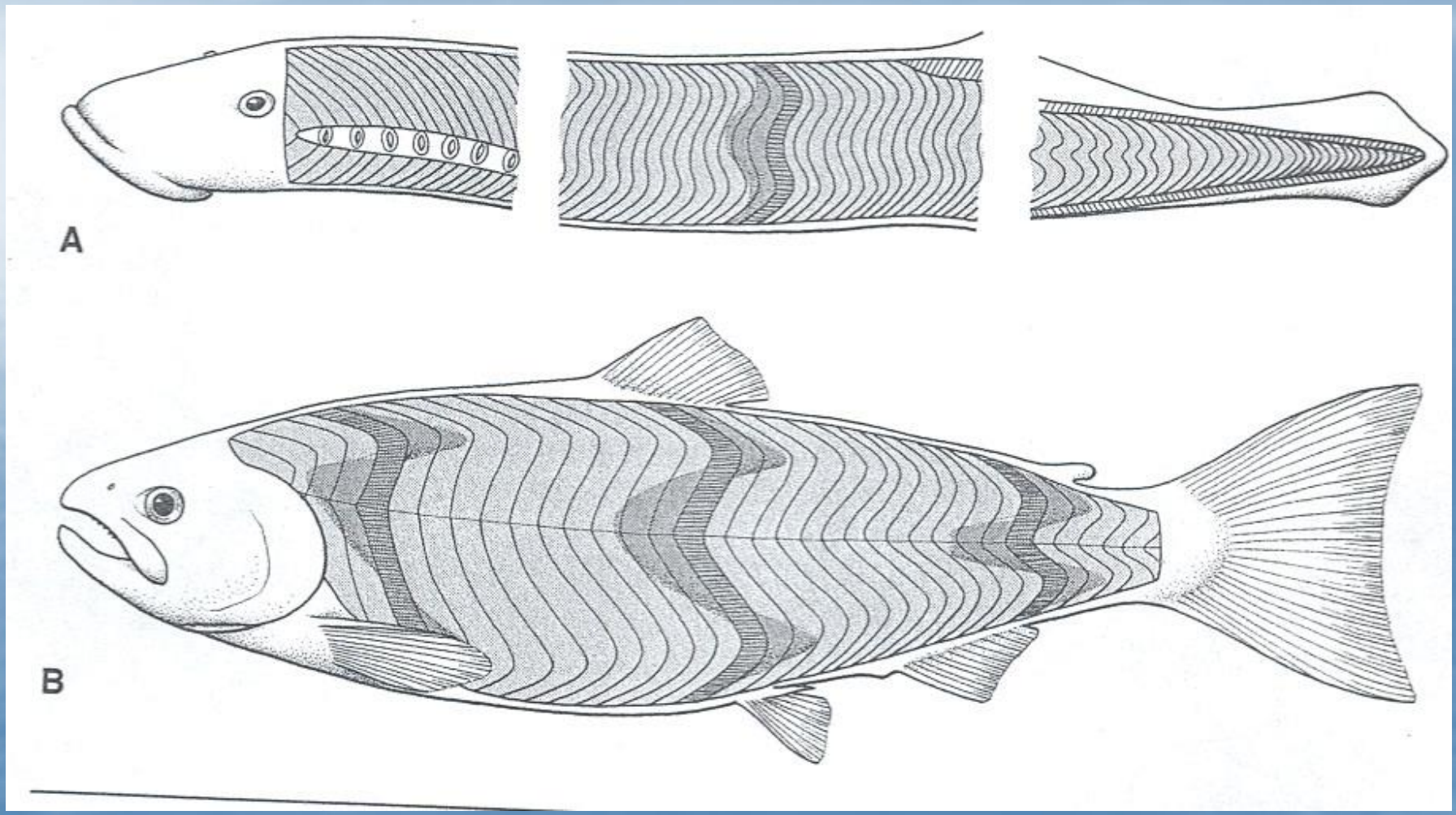
B CAUDAL

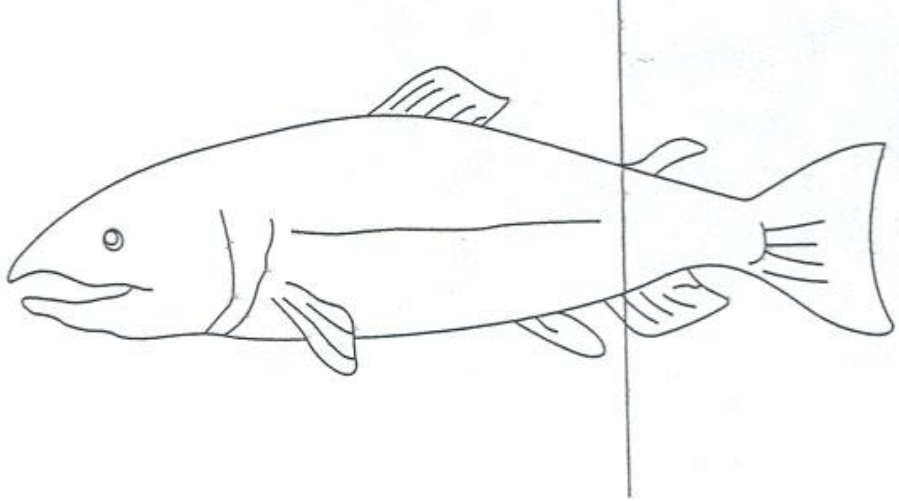
THE SKULL:

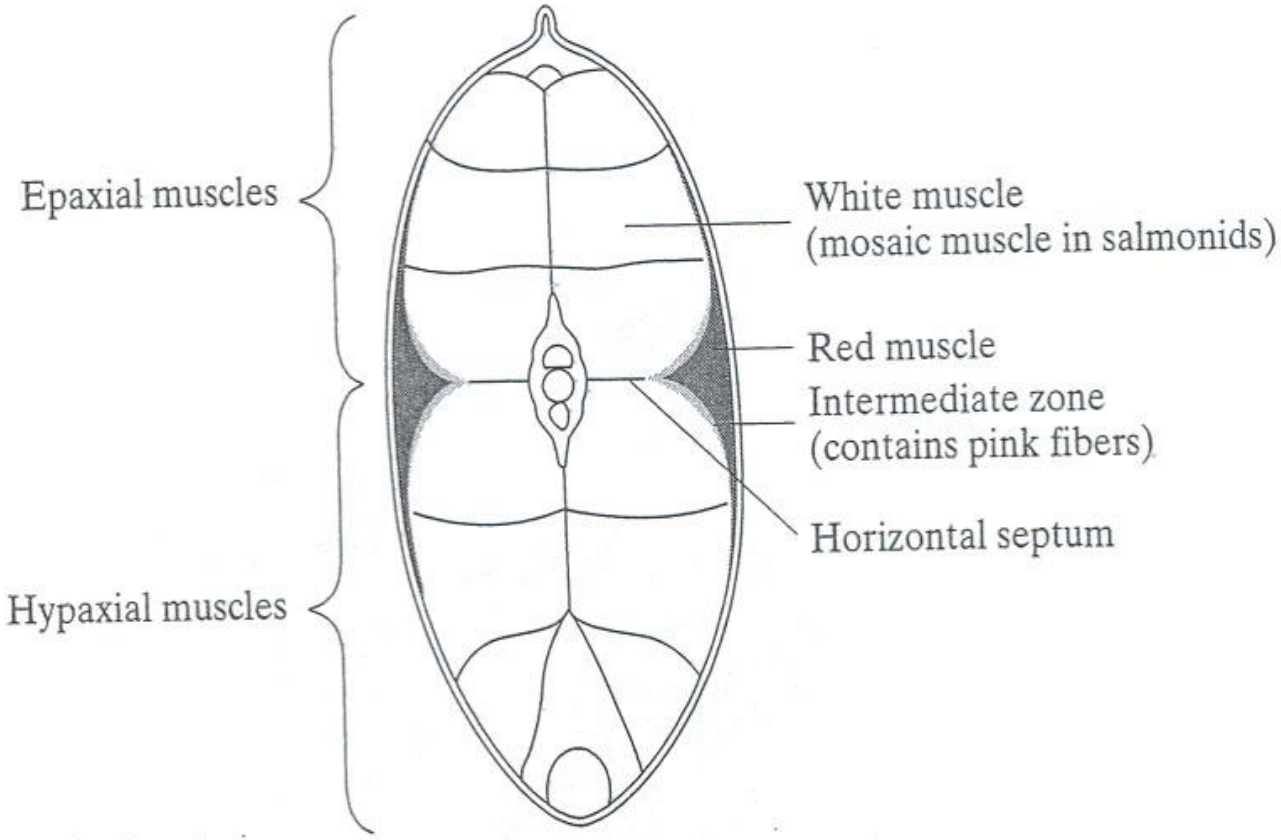
- Compared with the vertebral column, the skulls of fishes are much more variable
- Functions of the Skull:
  - Entry point for food
  - Entry point for water needed in respiration
  - Site of major sensory organs
  - A protective structure for the brain, gills, eyes, etc.
  - The attachment site for many major muscle groups
  - A streamlined entry point for forward swimming

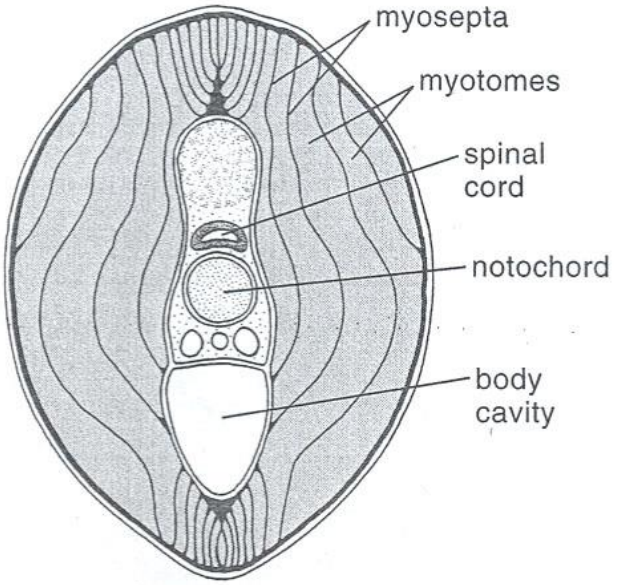
BREAK 4

MUSCULAR SYSTEM

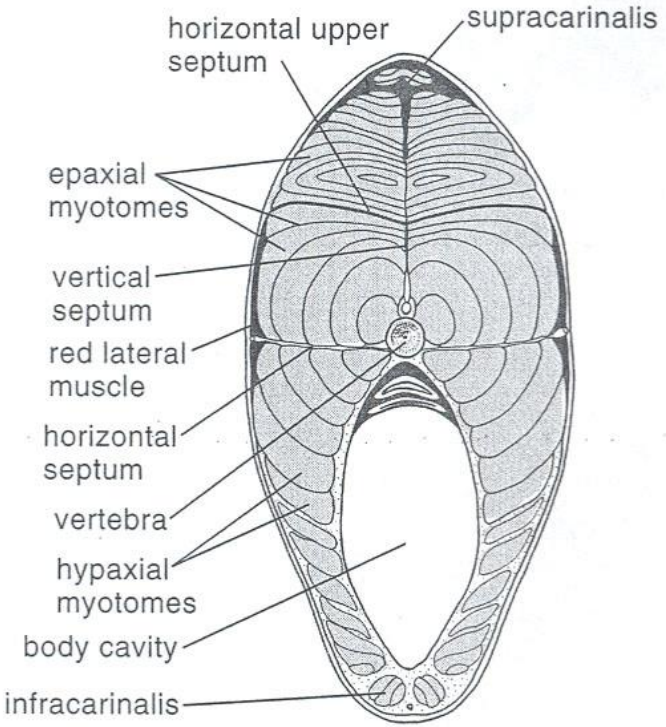




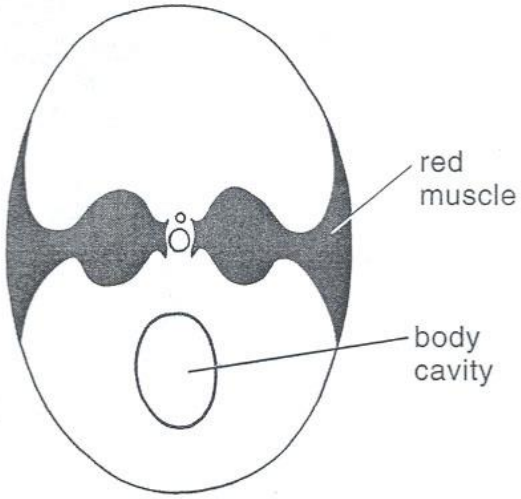

Epaxial muscles
Hypaxial muscles
White muscle
(mosaic muscle in salmonids)
Red muscle
Intermediate zone
(contains pink fibers)
Horizontal septum


myosepta
myotomes
spinal cord
notochord
body cavity

A


horizontal upper septum
supracarinalis
epaxial myotomes
vertical septum
red lateral muscle
horizontal septum
vertebra
hypaxial myotomes
body cavity
infracarinalis

B


red muscle
body cavity

C

TEMPERATURE AND RED MUSCLES

- Red muscles, at low temperatures show:

1. increased capillary densities
2. increased mitochondrial densities
3. increased lipid droplet densities

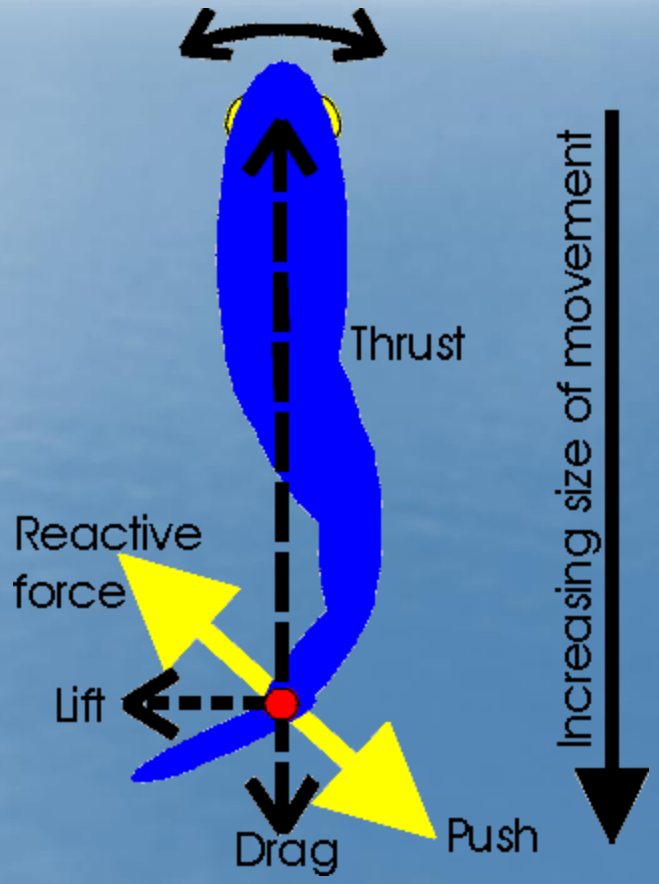
WHITE MUSCLES –

- Thicker than red ones
- Poorer blood supply
- Lack myoglobin and other red oxygen carrying pigments
- White muscle most useful for short bursts and more abundant in medium active to slow fishes

PINK MUSCLE

- Intermediate
- High velocities and very low speeds
- Some fishes will intermix muscle uses; others keep uses separated

LOCOMOTION IN FISH



LOCOMOTION CONTINUED

- To increase speed, a fish can increase the amplitude or number of tail beats.
- Water moves along the body as it undulates as result of flexing body muscles – when water is shed at posterior margin of caudal fin, it produces thrust
- The more udulating waves a fish can exert against the surrounding water and the faster and more exaggerated the waves are, the more power the fish has

SWIMMING METHODS

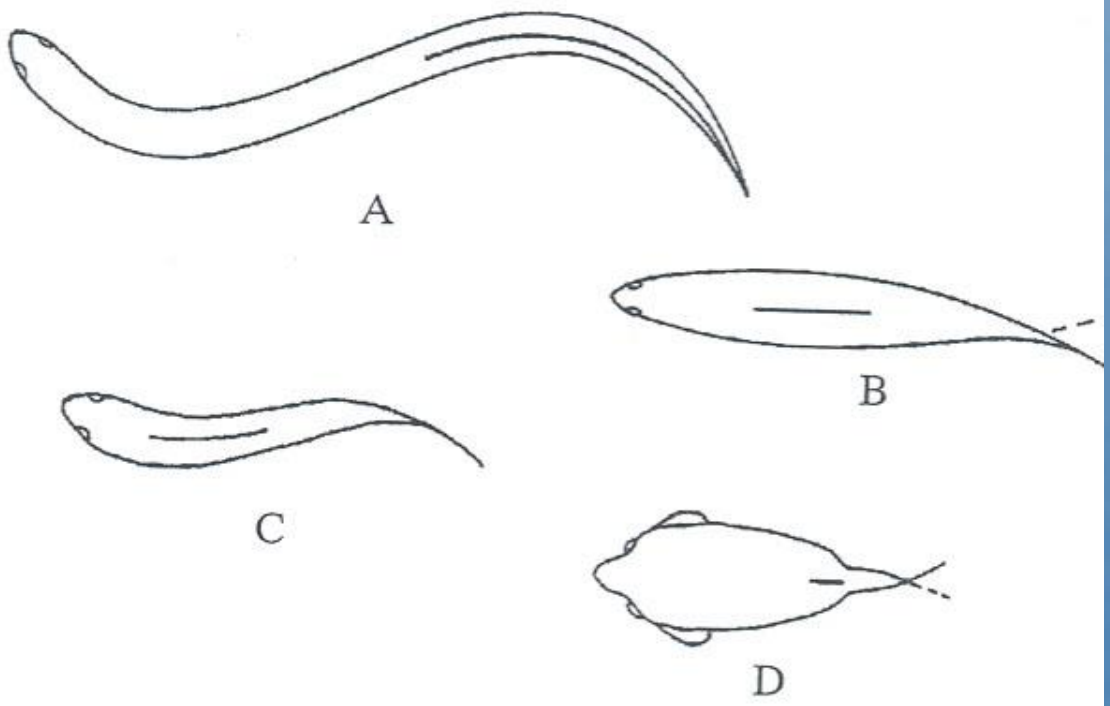
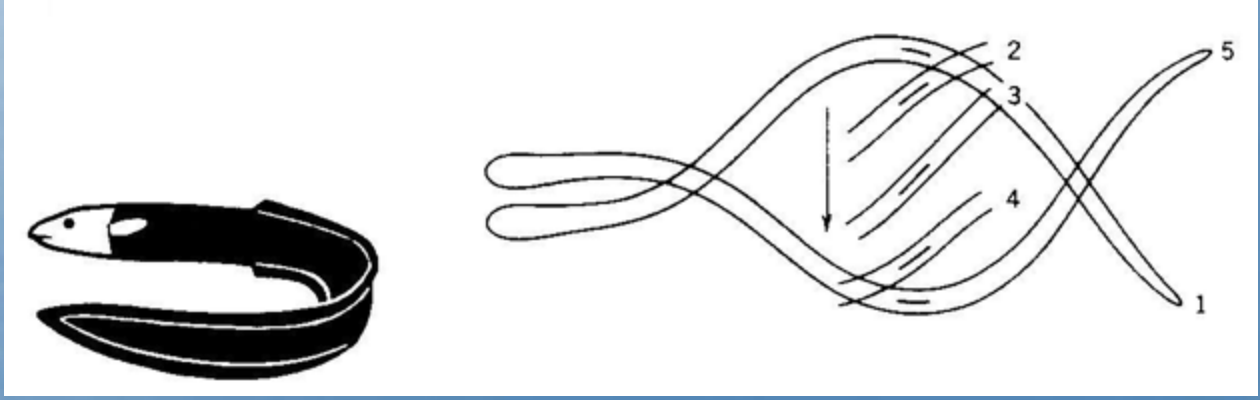


FIGURE 2.8 Swimming modes of fishes: (**A**) anguilliform; (**B**) carangiform; (**C**) subcarangiform; (**D**) ostraciform.

Anguilliform

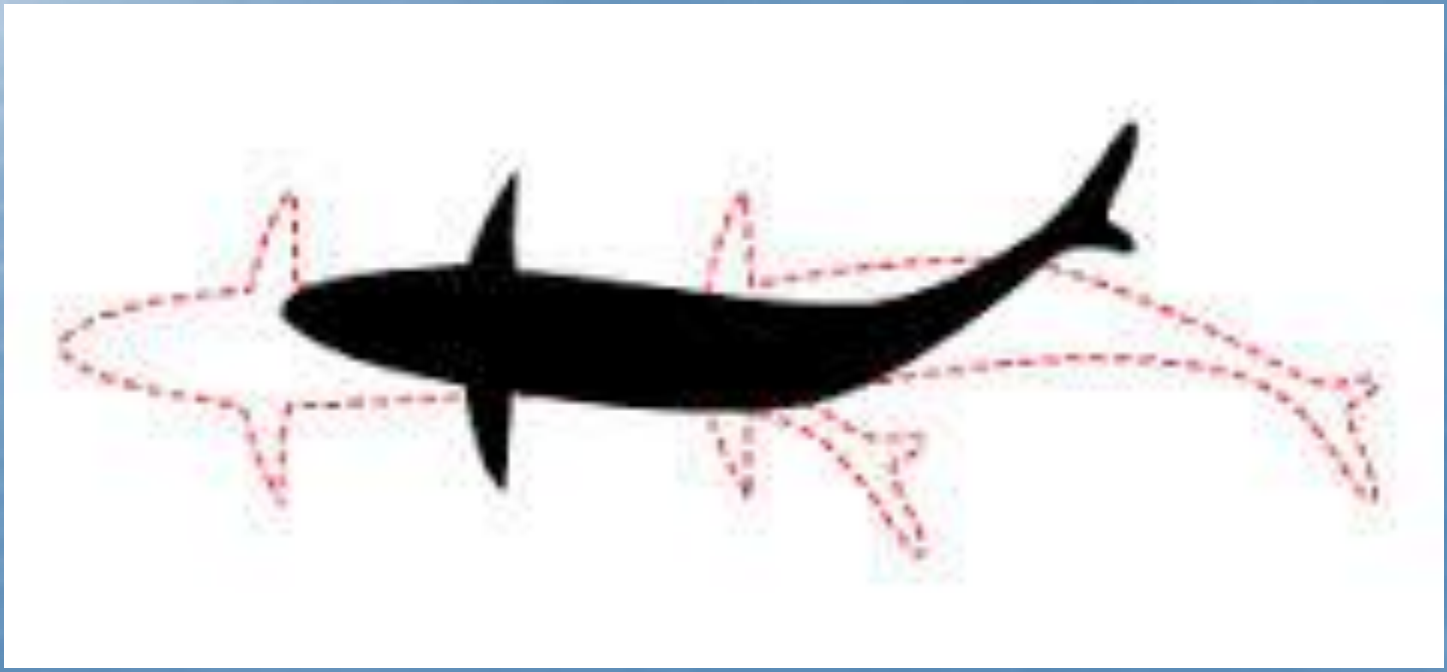
This form of swimming is characteristic of extreme long-bodied fishes such as the eels. The whole body is flexed in a wavelike motion. The continuous dorsal-caudal-anal fins of these fish as as fins on an oar.



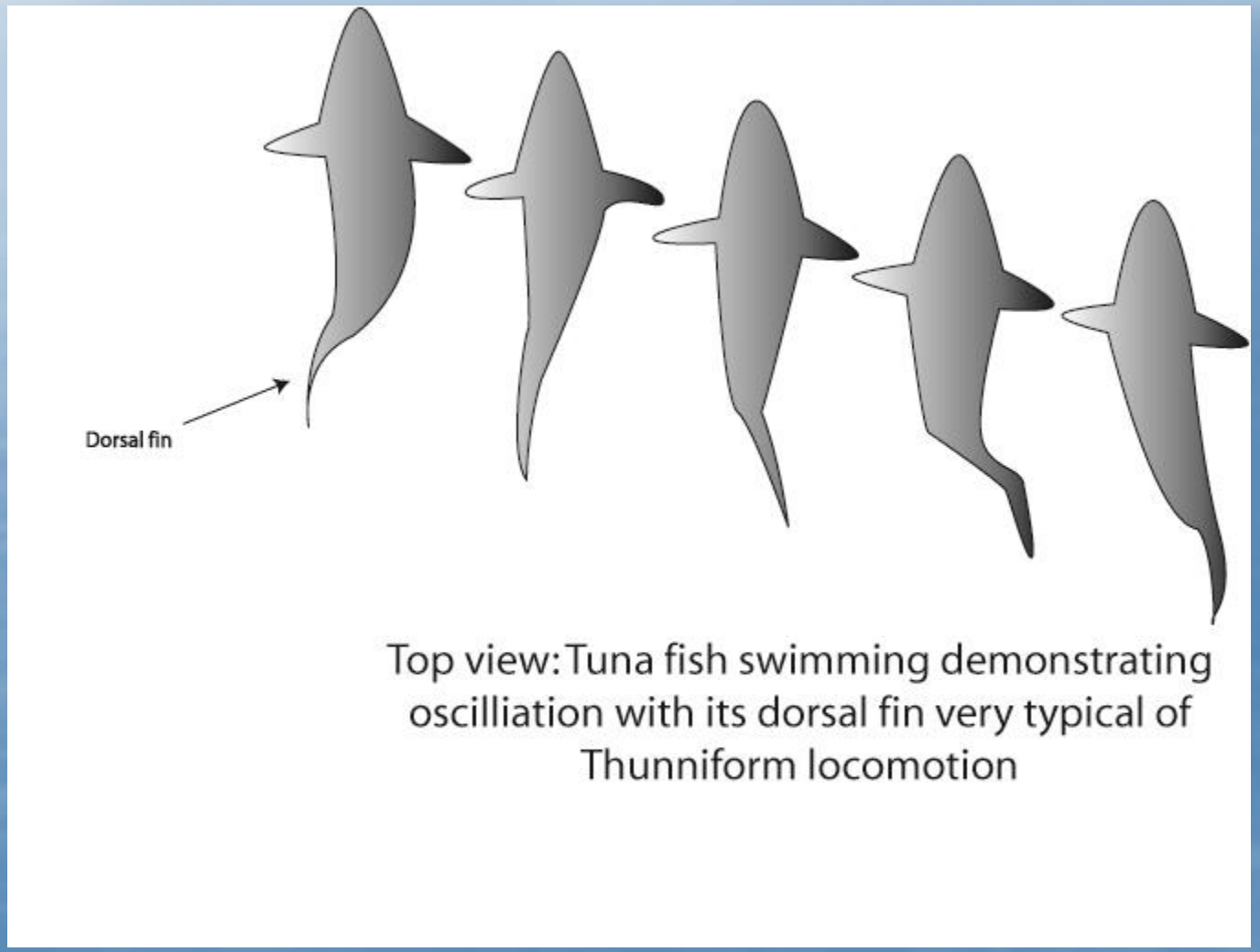
Carangiform

This type of swimming is an intermediate between anguilliform and ostraciform. The body is moved in a shallow wave, more so in the tail region.

Slower moving fishes swim in a subcarangiform fashion



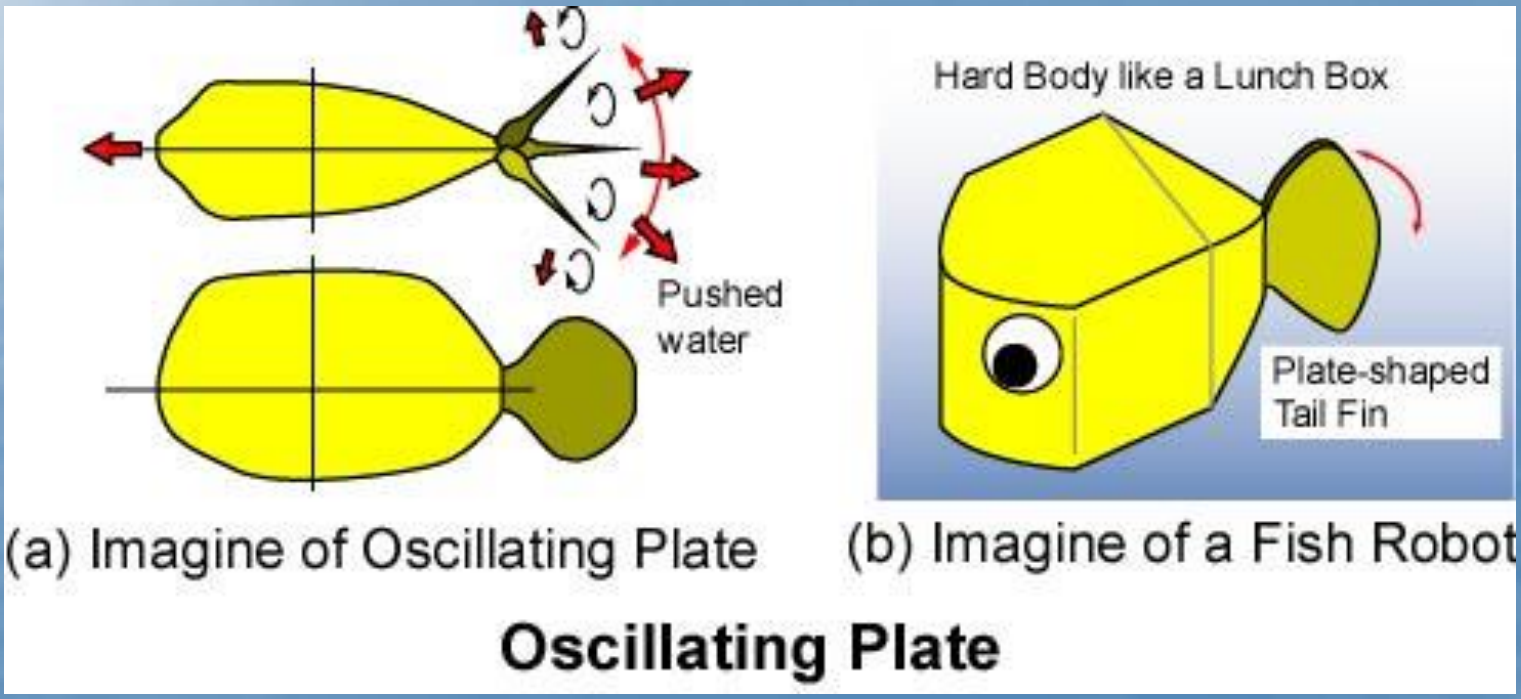
Thunniform swimming is found in the fast, continuous moving fishes such as tuna where the large, lunate tail moves at a small amplitude but at high speeds

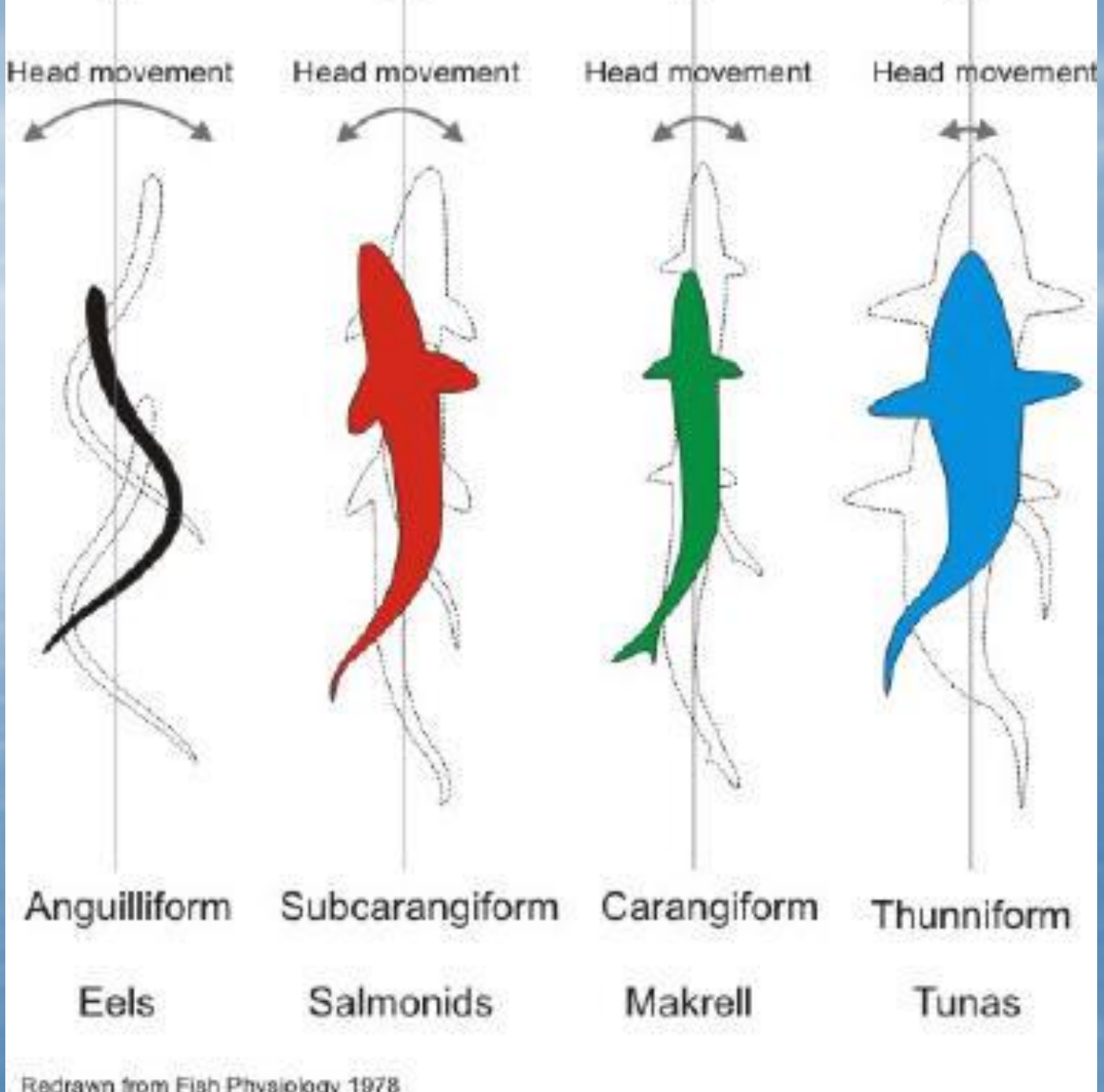


Top view: Tuna fish swimming demonstrating oscilliation with its dorsal fin very typical of Thunniform locomotion

Ostraciform

These fishes have boxlike bodies and move the caudal fin in a “sculling” motion. These fish do not usually move quickly and depend on spines and/or toxins for protection.





Redrawn from Fish Physiology 1978