Functional Morphology of Locomotion and Feeding

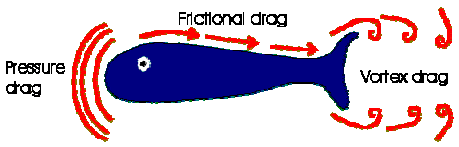
- Structure and Function – tied together
- Locomotion:
- Terrestrial = gravity
- Aquatic = density of water and drag exerted by it – remember 800xdense and 50x viscous. Energetically it is more expensive to move through water – also lower O2 in water

Functional Morphology of Locomotion and Feeding

- Locomotion: Forces and control
  - Forward progress
  - Directional Control

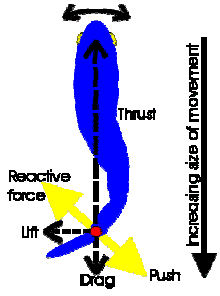
Functional Morphology of Locomotion and Feeding

- Drag = viscous or frictional drag (friction between water/body) + inertial or pressure drag (displacement of water as fish moves through it) + induced drag (vortices)
- Viscous = smoothness of body and surface area.



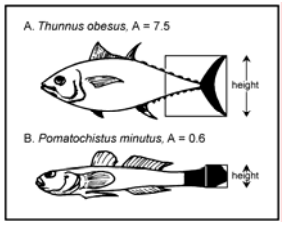
Locomotion – Swimming and Drift

- Drift – also important in larval forms
- Swimming
- Undulation – waves passing up/down body or fin
- Oscillation = structures move back and forth
- Propulsive effort = forward thrust
- Increase velocity – increase thrust – increase tail beat freq and amplitude

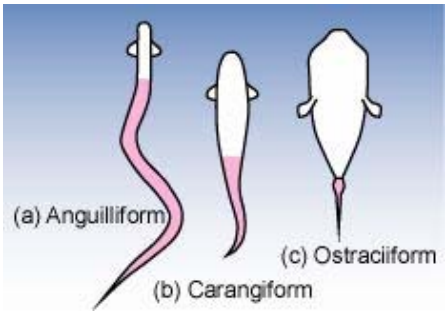


Functional Morphology of Locomotion and Feeding

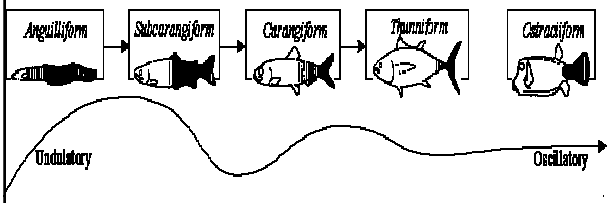
- Aspect Ratio (A.R.)= height/width relationship = square root height/area
- High A.R. = reduced drag and flex in caudal and narrow caudal peduncle: rapid sustained propulsion
- Low aspect ratio = broad surface area powerful thrust; but high frictional drag



Ten Types of Swimming



Body/Caudal Fin Propulsion



Ten Types of Swimming

- Via trunk and tail – all but head
  - (1) Anquilliform (eels, larval fish, lamprey, shark = ½ sine wave; dense vegetation, sediments, swim backwards = self-braking; Wave length less than body length
  - Contraction of body musculature – undulations – s-shaped curves
  - Bi-lateral symmetry
  - To Stop – hold body rigid

Ten Types of Swimming

- Via Trunk/Tail – via Tail – smaller part of body – reduce yaw (movement of head)
- Obtain greater speeds
- (2) Subcarangiform – posterior 2/3 – ½ half of body; forebody reduced flex;
- Low aspect ratios = better for rapid acceleration from dead stop; also good for hovering; Fast start predators; LM Bass = 1.5 A.R.; Brown trout = 2, Salmon = 2.7
- Salmonidae (salmon and trout), Cyprinidae (minnows and carp) and Gadidae (cods)

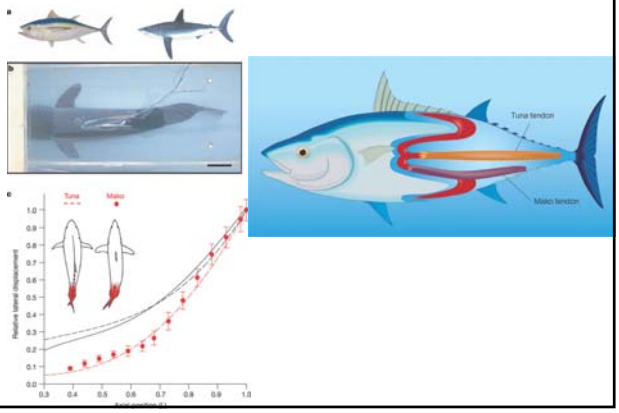
Functional Morphology of Locomotion and Feeding

- Ten Types of Swimming- Functional Hinge to connect tail to body (this and next)
- (3) Carangiform – A.R. ~ 3.5; Posterior third of body flexible; Some Clupeidae, Some Characidae, Mackerels

Ten Types of Swimming

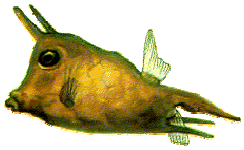
- Functional Hinge to connect tail to body
- (4) Thunniform – caudal peduncle and tail
- Narrow caudal peduncle = narrow necking
- High aspect ratio = less drag, minimize vortices
- 4 – 8.5 Tunas; 10 in Marlin/Sailfish
- 20 m/sec burst; 4 m/sec sustained

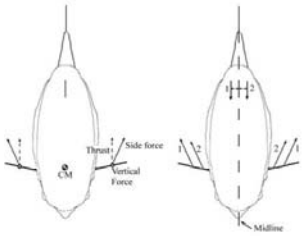
Thunniform



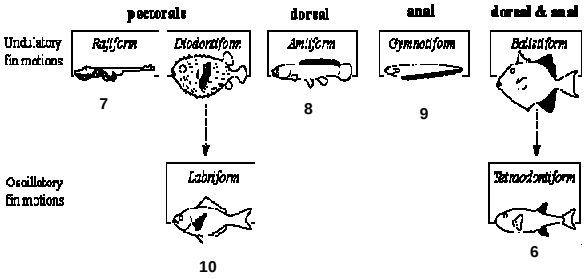
10 TYPES SWIMMING

- Via Tail
  - (5) Ostraciiform – cannot move body, lots of drag





Median/Paired Fin Propulsion



Functional Morphology of Locomotion and Feeding

- Via Median and Paired Fins
  - (6) Tetradontiforms – dorsal and anal fins synchronously
  - (7) Rajiform – slow undulation of pectoral fins
  - (8) Amiiform – undulation along dorsal fins; seahorses
  - (9) Gymnotiform – undulation along anal fin
  - (10) Labriform – row with pectoral fins.

Functional Morphology of Locomotion and Feeding

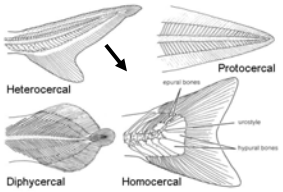
- Specialization for one function involves compromises in other functions – therefore most fish are generalists in locomotion
- Few fish use only one mode
- Not all fish fit into these “neat” categories
- For example - Sharks – undulations of body (sharks) or pectoral rays (skates and rays) – Most sharks = anguilliform – but three other aspects of morphology/swimming have attracted a lot of attention

Functional Morphology of Locomotion and Feeding

- Median fins – use as additional interacting thrusters
- Skin – 2 layers of collagen; reinforced cylinder; internal hydrostatic pressure (10x greater in fast vs. slow swimming); skin attached to muscle and skin elastic

Functional Morphology of Locomotion and Feeding

- Tail – heterocercal so thrust up and head down??? Can adjust angle of attack of tail and pectoral and other fins.



Other Locomotion

Walk along bottom on modifies pelvic and pectoral fins

Terrestrial locomotion – fins

Aerial locomotion – jumping to flapping flight; greater speed in air - Flying fish – vibrate fins = paired and tail fins

- Most swimming = very rapid acceleration – lasts few seconds or minutes
- Burst speeds:
- Aanguilliform
  - Eel = 2/lengths/sec
  - Flounder = 4 l/s
- Subcarangiform
  - Salmonidae (6 – 10 l/s = 300/500 cm/sec)
  - Rainbows – 1000 cm/sec = 36 km/hr
  - Carp, Suckers, Cod = 100-3000 cm/sec = 5-8 l/sec

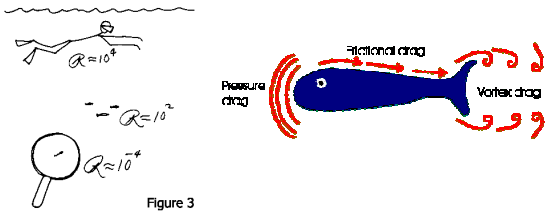
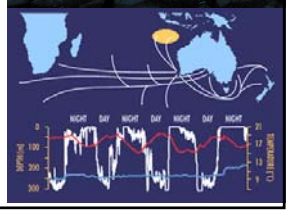


Figure 3

- Drag Reduction – Drag pressure and frictional
- Reynolds number = R = LV – laminar vs turbulent flow along body layer
- Drag proportional to sq rt velocity
- Flexible fish body – 2 to 5 X more drag than rigid – kick-glide; gliding fish = ~ 1/3 drag of swimming

Reduce Drag??

- Tunas – Great drag reducers;
  - Streamlined bodies; 'shoulder' back – increase laminar flow; Fins in grooves/slots; eyes, nostrils, jaws in fairings/smooth; Body straight
  - lateral movement confined to caudal peduncle; Increase aspect ratio; Small finlets on caudal peduncle – direct flow to minimize separation of boundary layer;
- Mucous coatings
- Schooling



Fins

- Unpaired Fins – dorsal, anal and caudal
  - Stabilizers – control yawing (horizontal axis) and rolling (vertical axis)
- Paired – pectorals and pelvics
  - Pitching (vertical axis)