Food & Feeding

I. Food types (fish diets)
II. Morphology of feeding structures
III. Feeding tactics & Mechanics
IV. Diversity of feeding in fishes
V. Trophic structure

Importance of Feeding

- must eat to survive
- size often influences susceptibility to predators
- fish never stop growing
- maturity is a function of size
- more food → more energy for **growth** & **reproduction**
- higher foraging rate → higher **fitness**

A healthy cod and one that has been starved for three months in the laboratory
The condition of the laboratory subject resembles that of Gulf of St. Lawrence cod caught during the spring fisheries in the mid-1990s

I. Diets of Fishes

General Food Habits

Herbivores: opaleye, halfmoon (<10% of spp. in CA)
Detritivores (scavengers): mullet
Omnivores: killifish, topsmelt
Carnivores:
- primary - anchovy, gobies
- secondary - various spp. surfperches
- tertiary - basses, bonito, mackerel

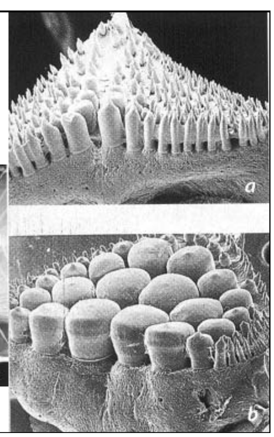
Most fish are opportunistic though

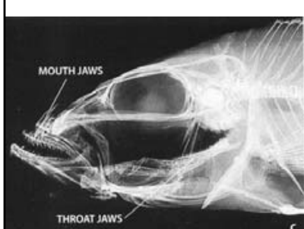
Feeding types (another way of classifying fishes)

1. **Predators** - take large whole (or part) items grasping, pointed teeth
2. **Grazers** (browsers) - plant and animal - small bits – algae
3. **Plankton feeders**
   - ***Strainers*** (filterers) - small and large
     - – herring, anchovies, whale sharks
   - ***Pickers*** – protrusible jaws
     - – blacksmith, kelp perch, pipefishes
7. **"Suckers"** - large amount detritus, but plant also long gut
   - – mullets, suckers (FW)
9. **Parasites** - lampreys, pearlfish, candiru

II. Morphology of Feeding Structures

- great diversity of feeding modes is allowed by complex feeding structures





Parts of the feeding & digestive system

- mouth
  - —structure
    - lips
    - key bones: premaxilla & maxilla, mandible
    - pharyngeal jaws
    - teeth
  - —placement
- gill rakers
- stomach
- intestine

Lips

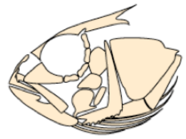
- "form follows function"
  - thin in planktivores (e.g., *Chromis sp.*)
  - thick, fleshy, tactile, w/ taste buds in bottom foragers
  - thick & tough in many large predators (e.g., giant seabass, sheephead)

Mouth Bones

- premaxilla, maxilla, dentary (mandible), several other skull bones

primitive – fused maxilla & premaxilla

advanced – separate maxilla & premaxilla



Mouth Bones

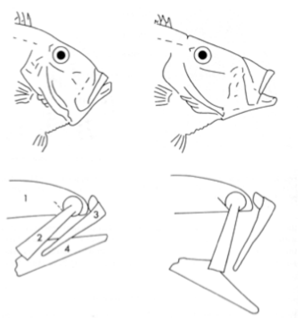
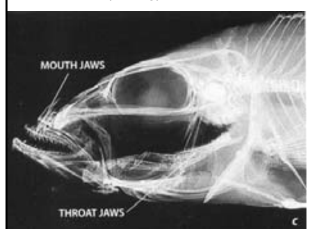
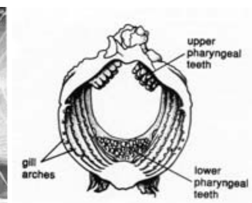


Fig. 3.8 Jaw structure in suctorial feeders. Note the loose connection between the premaxilla (3) and the cranium (1), which enables the premaxilla to rotate as the mouth opens due to the movements of the lower jaw (4) and maxilla (2). In many species of suctorial feeders the premaxilla will both rotate and slide outwards and downwards as the mouth opens.

Pharyngeal Jaws

- "throat jaws" – bones plates w/ projecting teeth
- second set of jaws allows different uses of primary jaws – increased range of food types
  - evolved as modified gill arches
  - morphology varies with diet





Teeth

- hugely variable in shape and size (absent in many "advanced fishes)
- found on many structures
  - jaw bones, pharyngeal jaws, roof of mouth, etc.

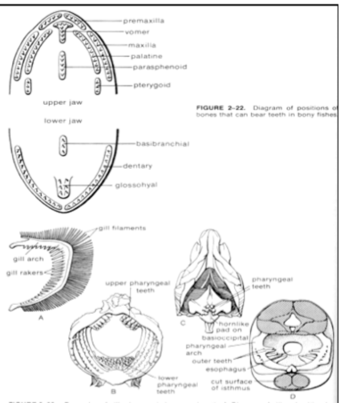
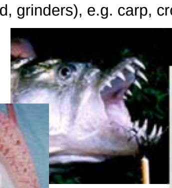


FIGURE 2–22. Diagram of positions of bones that can bear teeth in bony fishes.

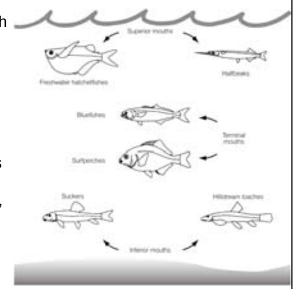
Teeth

- types
  - **viliform** (elongate, needlelike), e.g. gars, n
  - **blade-like**, triangular, e.g. sharks, piranhas
  - **caniniform** (fang-like), e.g. snappers
  - **cardiform** (numerous, small, pointed, sand paper-like), e.g. snook, bass, billfish
  - **molariform** (flattened, grinders), e.g. carp, croakers, eagle rays



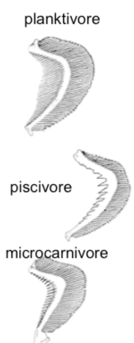
Mouth Placement – reveals much about diet

- **superior** mouths: fishes that ambush prey from below (e.g., stargazers, hatchetfishes, frogfishes
- **terminal** mouths: highly mobile predators that feed on highly mobile (often schooling) prey (e.g., tunas, sea basses)
- **inferior** mouths: demersal predators that feed on bottom-dwelling prey items such as crustaceans, bivalves, etc. (e.g., horn sharks, catfishes, suckers)
- **tubed-snout** fishes: fishes that feed on prey items that dwell or hide in crevasses, under substrates,etc. (e.g., elephantnoses, butterflyfishes)



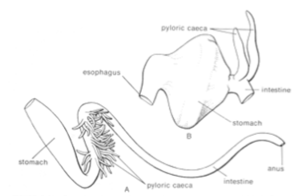
Gill rakers

- form follows function:
  - long, fine, closely spaced in filter feeders
  - shorter, stout, sharp, & widely spaced in piscivores
  - short and stubby in eaters of shelled invertebrates
  - intermediate (length, spacing, thickness) in fishes w/ mixed diets



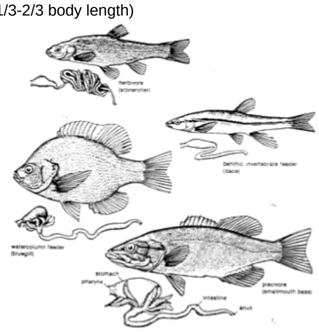
Stomach

- most fish have stomachs, but some lack them (e.g., plankton feeders, herbivores, parasitic fishes)
- some highly muscular, gizzard-like (mollusk eaters, some herbivores)
- acidic: HCl and pepsin (digestive enzyme) break down proteins, spacing, thickness) in fishes w/ mixed diets



Intestine

- length correlated with diet
  - herbivores: long & coiled (2-15x body length)
  - carnivores: short (1/3-2/3 body length)



Intestine

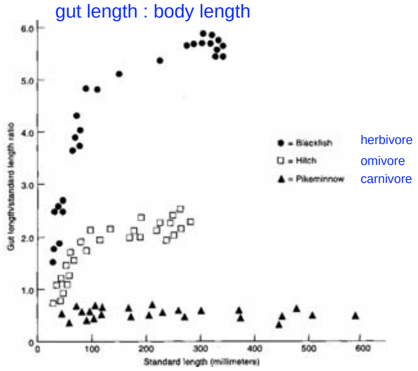
- intestine length in various fishes

Table 14–1. RATIO OF INTESTINE LENGTH (I) TO BODY LENGTH (B) IN SELECTED FISH SPECIES

Species	I/B	Remarks
Atlantic salmon *(Salmo salar)*	0.73–0.80	Carnivorous
Cod *(Gadus morhua)*	1.05–1.50	Carnivorous
Silver carp *(Hypophthalmichthys molotrix)*	4.6–7.1	Herbivorous
Tui chub *(Gila bicolor)*	1.0–1.3	Omnivorous
Northern squawfish *(Ptychocheilus oregonensis)*	0.7–0.9	Carnivorous
Calbasu *(Labeo calbasu)*	3.75–10.0	Herbivorous
—*(Labeo horie)*	15.0–21.0	Detritivorous
Flagfish *(Jordanella floridae)*	2.5–2.7	Herbivorous
Largemouth bass *(Micropterus salmoides)*	0.7–0.9	Carnivorous

Specializations for herbivory: herbivores have long guts

gut length : body length



III. Feeding tactics: how fishes feed

A. Oral manipulators

1. *scrapers*, e.g. parrotfish, surgeonfish, Plecostomus
2. *biters*, e.g. piranha, some sharks
3. etc.

B. Ram feeders: swim mouth around prey

1. Continuous swimmers
   a. *strain* small food, e.g. whale shark
   b. *chase* down prey, e.g. tunas, jacks
2. Sit and wait or stalkers, e.g. pike, lizardfish, barracuda

C. Suction Feeders ("inertial suction")

- most fishes
- allows great diversification of diet
- the key to evolutionary success of many fish groups?

Oral Manipulators

cutting: tiger shark

rasping: damselfish

crushing: wrasse

grasping: lizardfish

chiseling: parrotfish

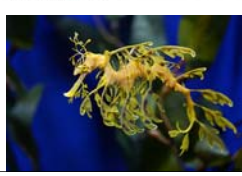
tearing: eel

Ram Feeders

Suction Feeders

sit & wait predators

planktivores

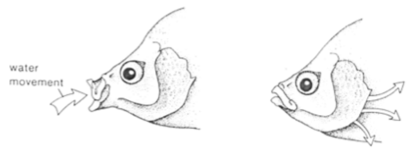


Suction feeding & jaw protrusion – keys to evolutionary success of fishes

- suction depends in part on jaw protrusion
- allowed by freeing of premaxilla and maxilla
- generates negative pressure in mouth (buccal cavity)
- most fish use it at some point during feeding
- especially important to planktivores and piscivores
- mechanics -- increase volume of buccal cavity by:
  - elevate neurocranium
  - drop "floor" of mouth
  - move sides of mouth out (laterally)
  - lower mandible & protrude premaxilla

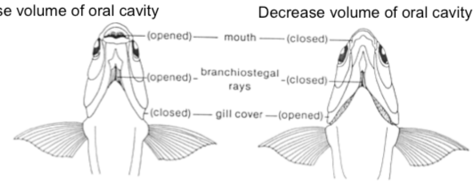
http://www.amnh.org/learn/pd/fish/fish_skull/

Suction feeding

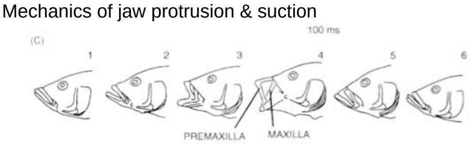


Increase volume of oral cavity

Decrease volume of oral cavity



Mechanics of jaw protrusion & suction



(A), (B) slightly modified from Lauder 1985; (C) from Lauder 1985 after Liem 1978; used with permission.

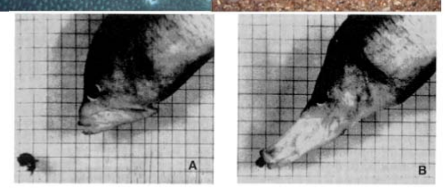
A Red Hind rapidly expands its mouth creating suction to draw in prey.

Functional advantages of jaw-protrusion

1. **Prey can be sucked in** from as far away as 25-50% of head length
2. **Increases attack velocity** by up to 40%: mouth can surround a prey much faster than if by ram feeding
3. **Increased handling ability and swallowing ability**

Jaw Protrusion in the Sling-Jaw Wrasse

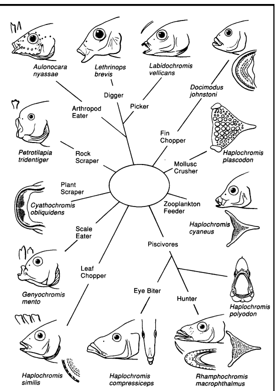
- jaw protrudes up to 65% of head length
  (twice that of any other fish)



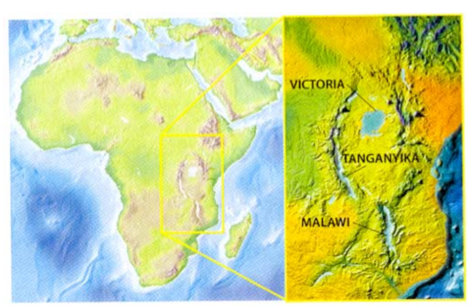
From Westneat and Wainwright 1989; used with permission of John Wiley & Sons, Inc.

IV. Diversity of Feeding in fishes

- African cichlids as an example
- about 1000 species evolved from a single body plan & a handful of ancestral species



Diversity of Cichlid species (~1000+) in African Great Lakes **allowed by flexibility in foraging habits**



EAST AFRICAN LAKES Tanganyika, Malawi and Victoria contain the greatest diversity of cichlid species. The family is spread, however, over the warm waters of much of the globe.

African Cichlid foraging habits: examples & convergent evolution

V. Trophic Structure

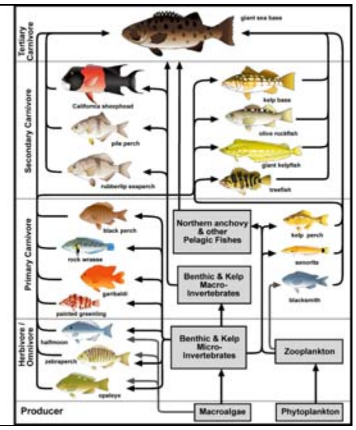
-- who eats whom

Kelp forest fish assemblage trophic structure

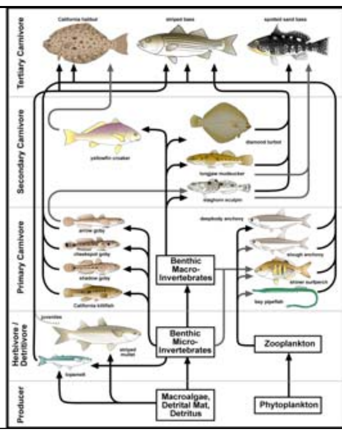
megacarnivore

mesocarnivore

microcarnivore



Bay/estuary trophic structure



Epipelagic trophic structure

- **Six trophic levels!**
- **No herbivorous fishes**