Aquatic Ecosystems

BI 201 Natural History of Guam

Class Presentation 34

General Characteristics

- Aquatic ecosystems are comprised of surface waters inhabited by plants and animals
- Aquatic ecosystems differ from terrestrial ecosystems in their primary limiting factors
  - In aquatic ecosystems, the primary limiting factors are dissolved oxygen (**DO**) and light
  - In terrestrial ecosystems, the primary limiting factors are water and warmth

- The concentration of O_2 varies little in the atmosphere, but DO concentrations in water vary widely
  - The **saturation concentration** is the maximum amount of O_2 that will dissolve in water at a given temperature
    - The saturation concentration of DO in water is 9 ppm (parts per million), or 0.0009% by weight at 24 ˚C, but only 0.000763% at 30 ˚C
    - Compare DO in water to atmospheric O_2, which is about 21% by volume
  - DO concentrations below 3–5 ppm are lethal to many aquatic organisms

- Sources of DO
  - Turbulence at the air-water interface
  - Photosynthesis by aquatic plants

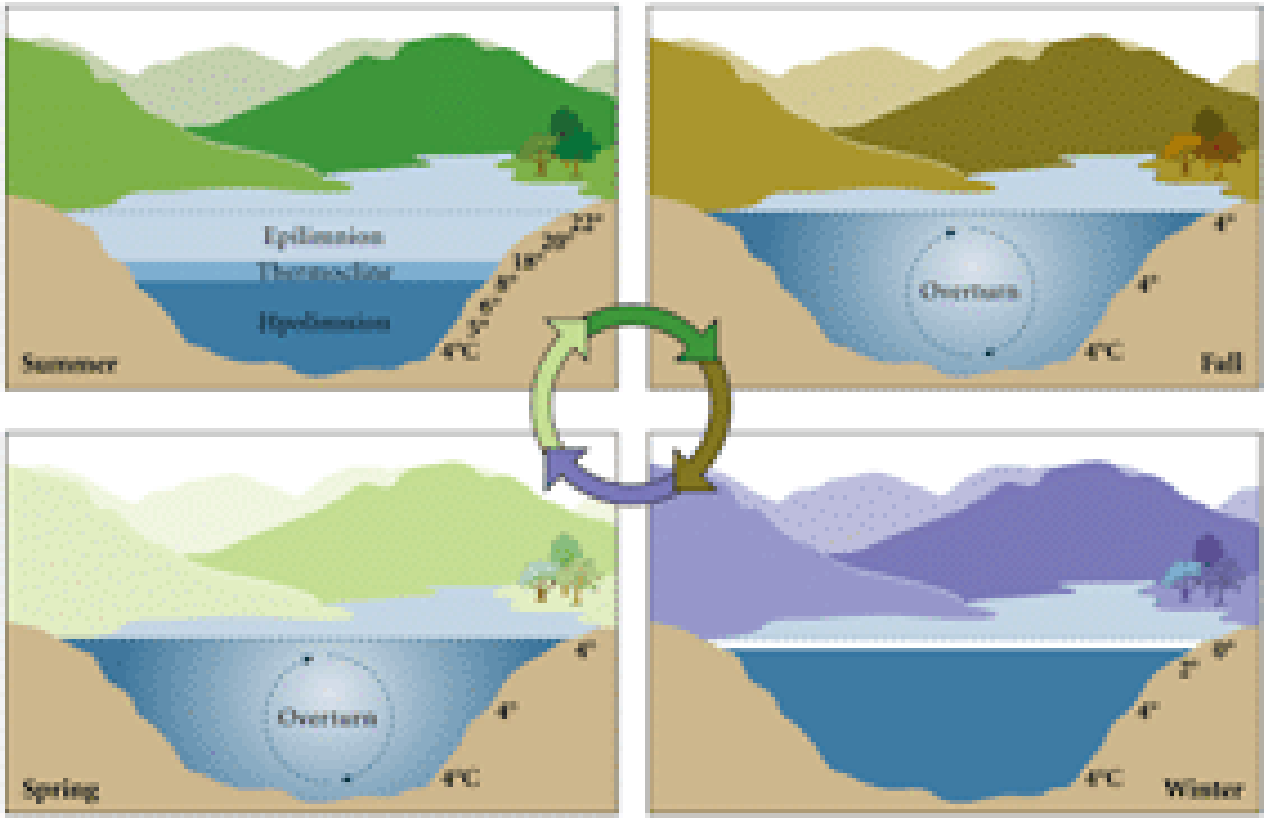
- Temperature varies less in aquatic ecosystems than it does in terrestrial ecosystems, and it changes more slowly because water has a higher *heat capacity* than air
- Sunlight is another limiting factor in aquatic systems, because light can penetrate only to a depth of about 100 m even in clear water and less in silty water
  - Therefore, photosynthesis is confined to the upper layer of water receiving sunlight

Freshwater Ecosystems

A. Lakes/ponds/ponding basins

- General characteristics
  - These bodies of water differ mainly in size
  - All three refer to bodies of relatively static water

Thermal Stratification in Lakes



- **thermocline**
  - The thermocline is a narrow transition zone between the epilimnion and the hypolimnion
- When stratification occurs, the DO of the upper layer is affected very little, because wind action and phytoplankton maintain average levels of DO
- However, DO in the hypolimnion may become reduced by respiration of fishes and decomposers; the hypolimnion would eventually become anaerobic if the lake remained stratified
- Stratification breaks down when cooler air temperatures reduce the temperature of the surface water, causing it to sink, mixing DO downward and dissolved nutrients upward

- **eutrophication**
  - Eutrophication is the process of aging of lakes by nutrient enrichment
  - All lakes are relatively short-lived, in geological terms
    - They all fill in by

      1) sedimentation from rivers and streams depositing sediments

      2) accumulation of plant remains, especially where nutrient-rich waters favor luxuriant plant growth

- Examples from Guam
  - Fena Lake
    - Fena Lake is the largest open body of freshwater in Guam

- This is a manmade reservoir created when U.S. Navy dammed the Mahlac River in 1951
- Fena Lake is 3 km long and up to 600 m wide, covering an area of 81 ha and holding some 9.7 million m3 when full
- The average outflow is about 62 million liters/day
- The average water temp in the lake ranges from 27˚ to 31˚C
- The Maulep, Almagosa, Sadog Gaso and Imong Rivers drain into Fena Lake

- The maximum depth of Fena Lake is 20 m during the rainy season, but it may drop 2–9 m in the dry season or more during severe El Niño-Southern Oscillation droughts
- DO in the concentrations at the bot ing concentra
  - Strati decomposition of org
- A massiv *mbicus* or tilapia (>2300 fis ril 1984 when stress cau O levels resulted i *monas* sp.
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[Fur ramme – Fe

- Masso Reservoir
  - Masso Reservoir is about 2 ha in area, of which about 75% is open water
  - This is a manmade pond built as a potable water reservoir
  - Masso Reservoir was created by damming the Masso River
  - The reservoir has large beds of aquatic plants, and dense stands of *Phragmites karka* grow along SE and NE shores

  [Further information: Protected Areas Programme – Masso Reservoir]

B. Rivers/streams

- Rivers are associated with flowing water
  - Therefore, the water is more turbulent than in lakes and ponds
- Rivers are relatively shallow compared to lakes
  - Therefore, rivers have a greater surface:volume ratio than lakes
- Because of turbulence, the DO varies little along the length of a river channel unless large amounts of organic matter are emptied into the river
  - Therefore, DO is not a limiting factor in rivers

- Current speeds vary along the length of a river
  - Near the source, the river channel is narrow and currents are swift
    - Cascades and waterfalls are common in the source waters
    - Aquatic animals and plants must be adapted to survive turbulence by holding onto the substrate
  - Downstream, the river channel broadens, cascades disappear, and the current slows
    - Sediment layers may build up in the lower reaches

- Zonation of rivers in Guam
  1) **source zone**
     - Generally, species diversity is reduced in this zone compared to the lower zones
     - Because large, highly motile predatory fishes are excluded from this zone by cascades and waterfalls, freshwater prawns and shrimps are abundant
     - The source zone is inhabited by mountain gobies, e.g., *Awaous guamensis*
       - These fishes have pelvic fins that are modified into a suction disk to hold on to rocks in the rapidly flowing water

2) cascade zone

- Species above cascades are similar to those of the source zone
- Below the cascades, predatory fishes, e.g., flagtails *Kuhlia rupestris*, are commonly found
  - Therefore, there are fewer prawns, shrimps and gobies found below the cascade zone

3) lower graded zone

- Species diversity increases in this zone, because the river channel is open to brackish and marine species that can tolerate freshwater

4) estuarine and mangrove zone

- This zone is characterized by brackish water with freshwater species upstream and marine species at the seaward fringe

- There are 45 rivers and streams in Guam, all of which are south of the Adelup Fault Zone
  - The Talofofo River drains the largest watershed (7,300 ha) in Guam
  - The lower Agana and Talofofo River channels are covered by the floating aquatic plant *Pistia stratiotes*, or water lettuce

C. Springs

- Springs are areas where groundwater flows to the surface
- Agana Springs are located on the south side of the Agana Swamp [marsh] at the base of a limestone ridge
  - A pair of retaining walls and a low dam are present
  - These structures were one part of a municipal water pumping station from 1937–1957, with 3.8 – 3.95 million liters of water pumped daily
  - Efforts to establish the Agana Springs Nature Preserve have failed, and the ponded water is choked with the water hyacinth *Eichhornia crassipes* and *Ipomoea aquatica*

- Almagosa Springs and Bonya Springs are utilized as a source of potable water at present by the Navy
  - After purification, some the water from these springs enters the municipal water supply, especially for residents of Agat and Santa Rita

Freshwater Organisms

- Except for some introduced species, Guam has no truly freshwater organisms
  - Freshwater organisms are those whose entire life cycles are completed in freshwater
- Therefore, aquatic organisms in Guam's rivers and streams are described as being **diadromous** species
  - Diadromous species are those that migrate between freshwater (FW) and seawater (SW) to complete their life cycle

- Diadromous species may be further grouped as either,
  - **Catadromous**
    - Adults of catadromous species live in FW ecosystems but migrate from FW to SW to spawn
      - e.g., anguillid FW eels: larvae/young then migrate back to FW to mature
  - **Amphidromous**
    - Maturity of adults of amphidromous species occurs in freshwater, but they do not migrate to spawn
    - Instead, spawning occurs in freshwater and river currents carry larvae to the estuary where larval development takes place
  - **Anadromous**
    - Anadromous species are those that migrate from SW to FW to spawn; e.g., salmon
    - Guam has no anadromous species

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- *Pistia stratiotes* ma
  for mosquitoes

- Water hyacinth, *Eicchornia crassipes*
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  - Be nting swimming and fishing, water hyacinth infestations also prevent sunlight and oxygen from getting into the water

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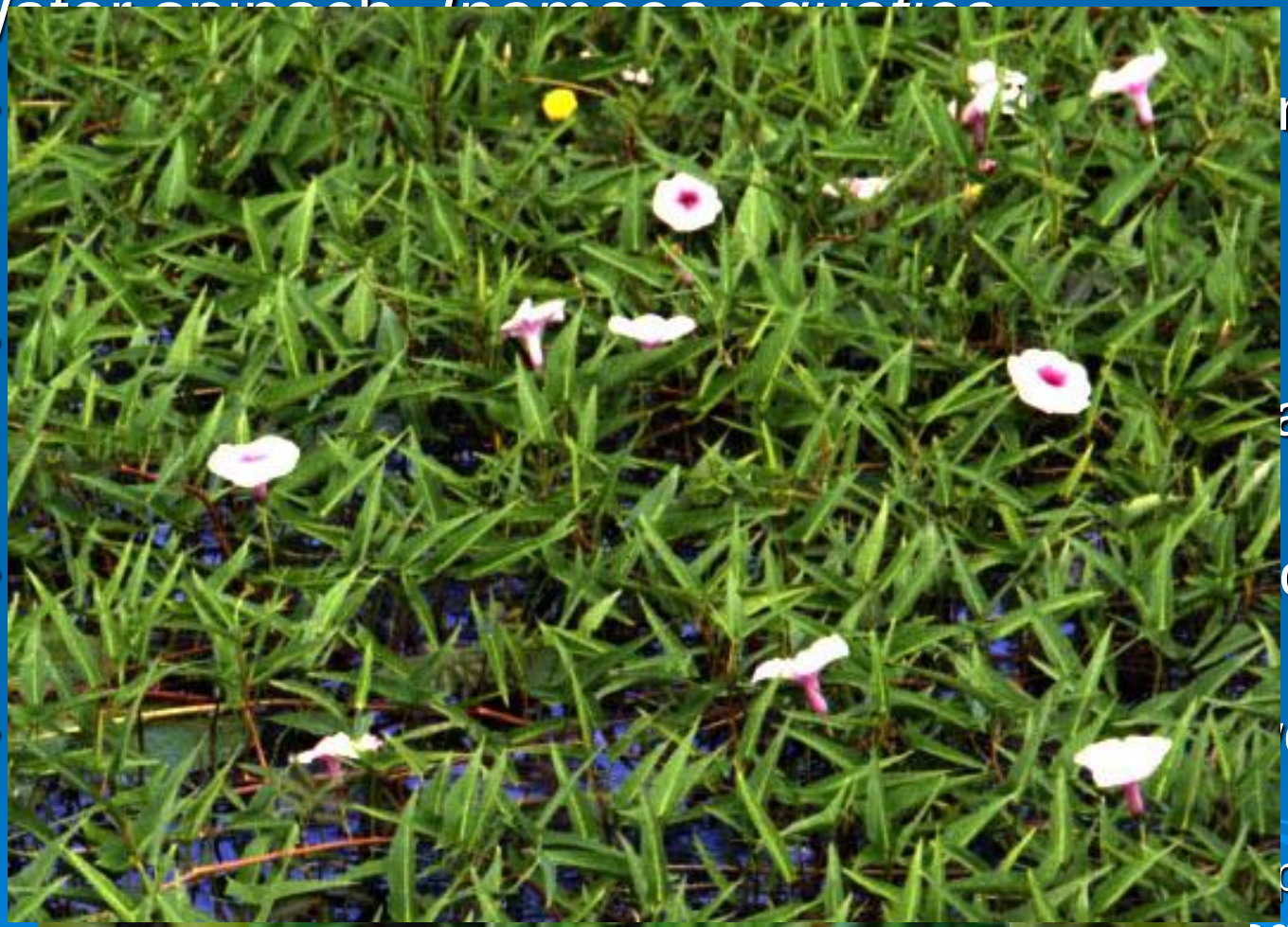
    water flow, interfere with fisheries, and inhibit passage in fresh water



- Molluscs:
  - Family Neritidae
    - Nerites are herbivorous snails that browse on algae-covered rocks of streams & rivers from sea level to the headwaters
    - They deposit their eggs in white, oval capsules that are firmly attached to the surface of shells and rocks
    - Some members of this family are restricted to estuarine or to marine waters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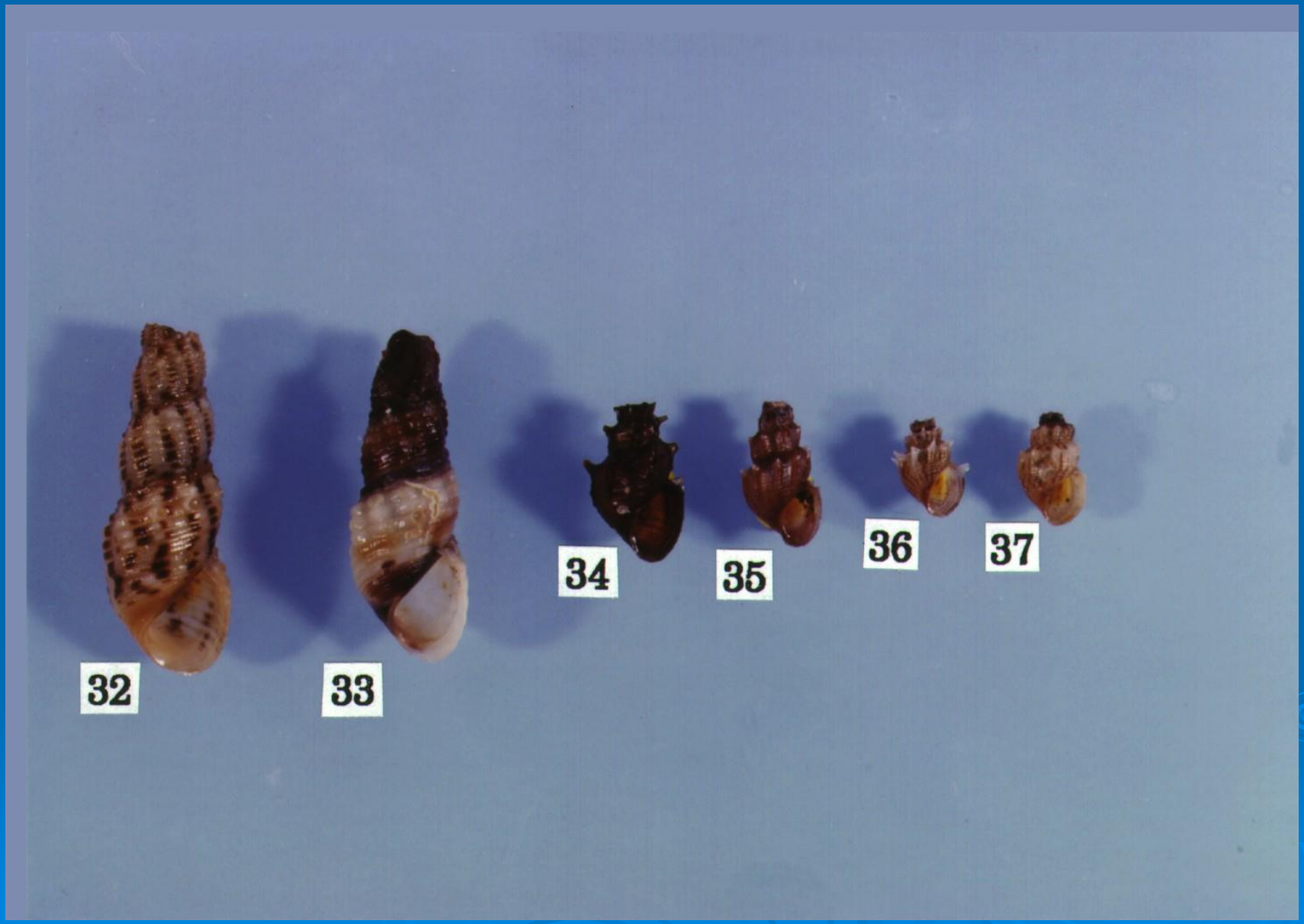
- Family Thiaridae
  - Thiarid snails are parthenogenetic, i.e., females produce eggs that undergo embryological development without first being fertilized by sperm
  - Males are entirely absent in some species, and the few that do occur are sterile
  - Females often brood the developing young in a special brood-pouch organ, and the young snails crawl away from the mother
  - Thiarids may be found on hard or soft stream substrates, as their herbivorous or detritivorous diet dictates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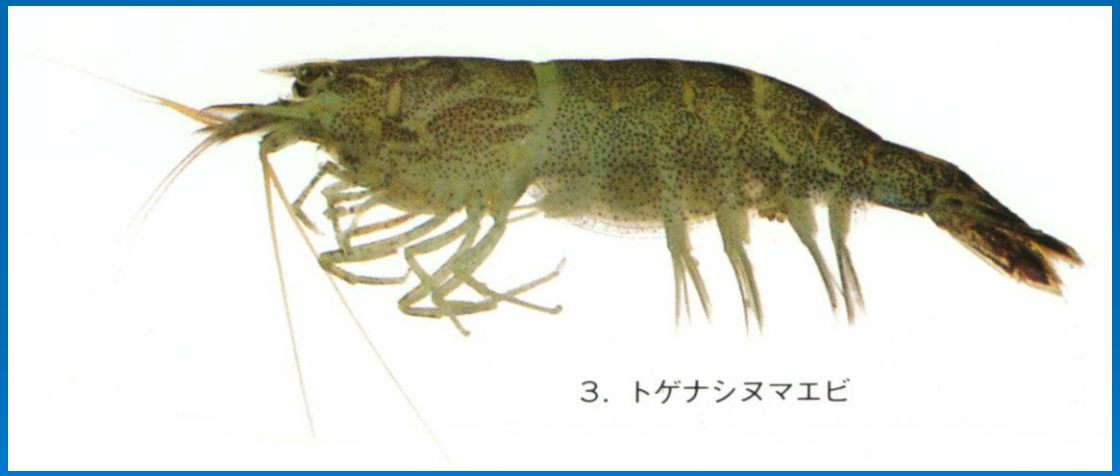
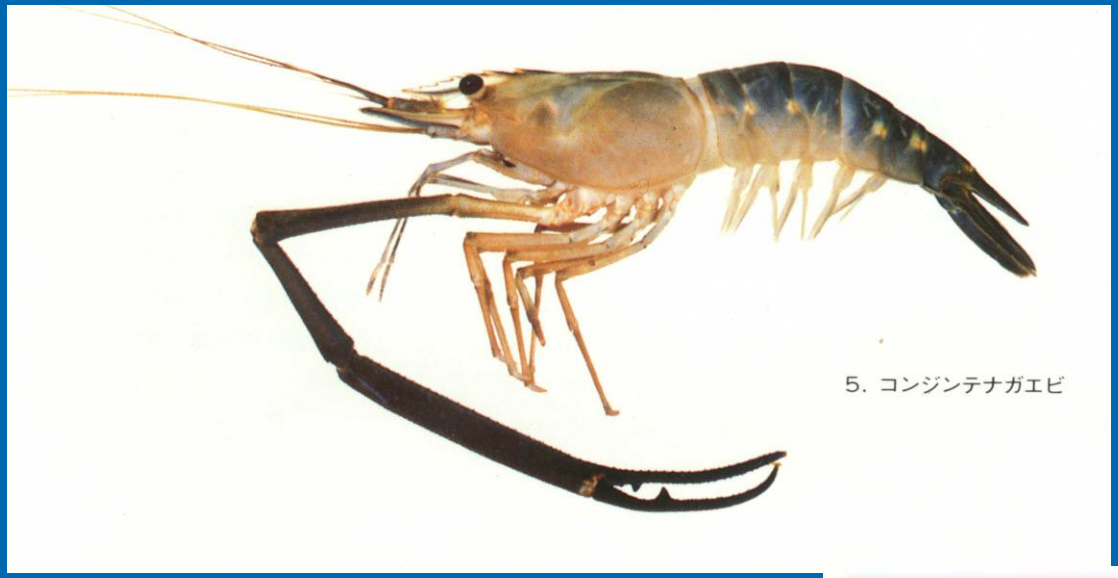
- Crustaceans:
  - Family Atyidae
    - These small freshwater shrimps are detritivores of streams and rivers
    - They reach their greatest abundance in flowing waters upstream of barriers that prevent predators from penetrating upstream

Atyoida pilipes



Caridina typus

- Family Palaemonidae
  - These freshwater prawns are much larger than the atyids
  - They are carnivores preying upon small fishes, but they are also opportunistic scavengers
  - Prawns are sexually **dimorphic** (i.e., males and females are morphologically distinct), with males possessing larger **chelipeds**, or claws



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- Fishes:
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- Gobies exhibit a wide range of feeding habits
- Some species are herbivorous, feeding on periphyton
- Carnivorous species may have a diet composed of crabs, prawns, smaller crustaceans (e.g., copepods), molluscs, worms, and small fishes

- Family Eleotridae
  - Gudgeons are close relatives of the gobies, and

  - Hatching times range from 24 hr for some species to 10 days for others

- Gudgeons feed on a wide variety of organisms, including insects and their larvae, crustaceans, snails, worms, and fishes
- Some species also consume algae and other plant material.

- Family Gobioidae
  - Worm gobies are unusual, eel-like fishes that are found on soft, muddy bottoms, and they are adept burrowers
  - Diagnostic features include an upturned mouth with small, sharp teeth, small rudimentary eyes, pelvic fins forming an adhesive disc, and long dorsal and anal fins that are often continuous with the caudal fin
  - Because of their cryptic habits, worm gobies are seldom seen unless flushed from the bottom by toxic chemicals

- Family
  - Flag esemble the sun
  - *Kuh* brackish wat
  - *Kuh* may be fou cascade or wat
  - Flagtails feed on insects and their larvae, prawns, crabs, and small fishes.

- Family Anguillidae
  - Freshwater anguillid eels are slender, snake-like fishes that possess small, fan-shaped pectoral fins but lack pelvic fins

Anguilla marmorata

- When sexual maturity is reached, eels migrate downstream
- Spawning occurs in the Philippine Sea west of Pagan
- The tiny, leaf-shaped larvae, known as leptocephali, are carried by ocean currents to coastal areas where metamorphosis occurs

Leptocephalus larva of *Anguilla marmorata*

- The young semi-transparent eels, sometimes called glass eels, gradually assume the appearance of adults and begin their migration upstream
- Migrating eels are extremely adaptable in their ability to reach remote headwaters of streams and rivers
- They use their muscular bodies to slither up rapids, waterfalls, and spillways of dams

- Eels may require 10–20 yr to attain sexual maturity before beginning their migration to the sea
- Anguillids feed mainly on fishes, crustaceans, and molluscs.