POESTEN KILL AQUATIC MACROINVERTEBRATES

WHAT IS AN AQUATIC BENTHIC MACROINVERTEBRATE?

An aquatic benthic macroinvertebrate is an organism that lacks a vertebra (i.e., spine) and inhabits the bottom substrate of a waterbody. In the case of aquatic benthic invertebrates, macroinvertebrates are organisms that can be seen by the naked eye, without the aid of a microscope. While they can be seen without the use of a microscope, a microscope is often needed to identify them to a certain taxonomic level (e.g., family, genus, and species).

DEFINITION BREAKDOWN

AQUATIC: pertaining to water

BENTHIC: pertaining to the bottom of a waterbody

MACRO: large-scale (from the Greek word makros, meaning 'long' or 'large')

INVERTEBRATE: organism lacking a spinal cord, or vertebra

Aquatic macroinvertebrates include insects, snails, mussels, worms, crustaceans (e.g., crayfish), and leeches.

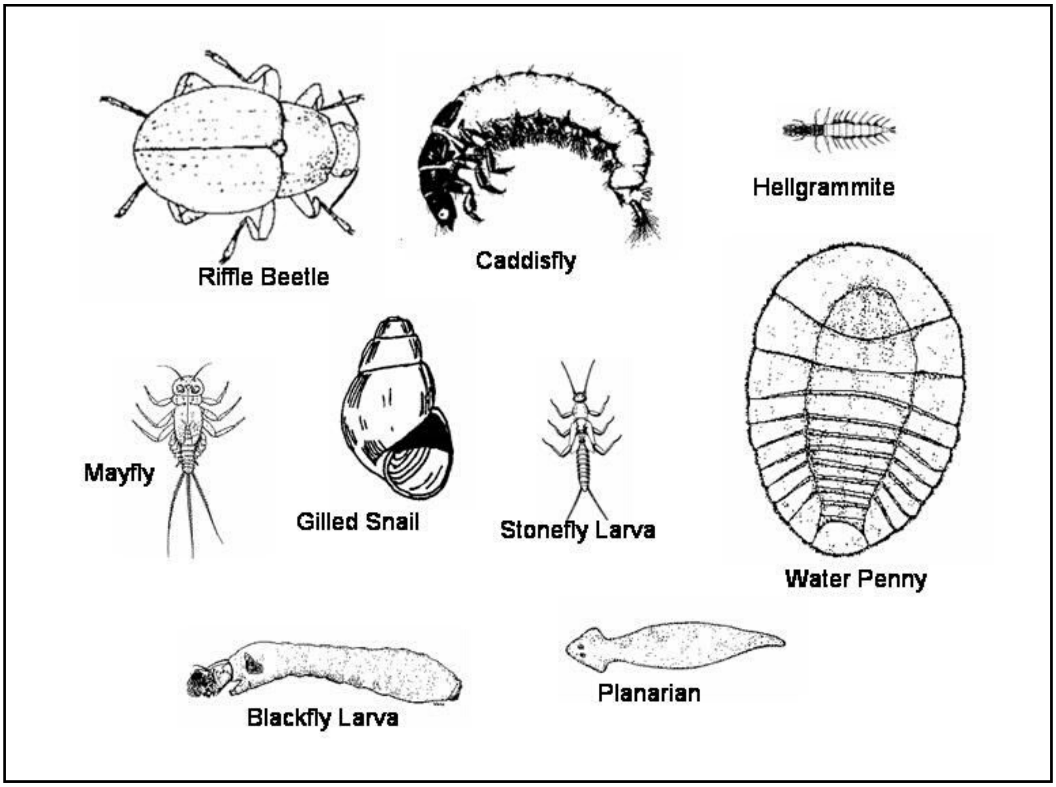


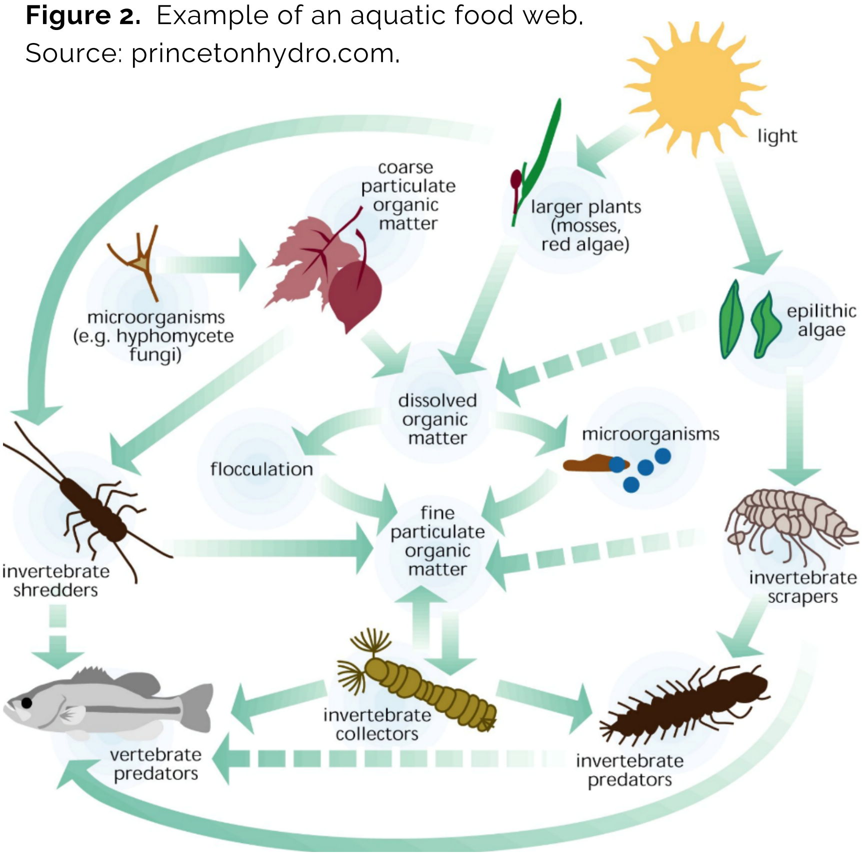
Figure 1. Examples of aquatic macroinvertebrates. Source: techalive.mtu.edu. 251

WHAT IS THE ECOLOGICAL ROLE OF AQUATIC MACROINVERTEBRATES?

Benthic macroinvertebrates play a significant ecological role in the structure and function of aquatic systems. As an intermediate level on the food chain, between other biological groups such as algae, zooplankton, and fish, aquatic benthic macroinvertebrates are key members of anaquatic community that can be used in understanding trophic, or food web, relationships. As a vital food resource for many species of fish, the study of macroinvertebrates is a critical component in developing a comprehensive understanding of aquatic systems (Voshell, 2002). By understanding changes in the macroinvertebrate community and/or their responses to stream impairments, scientists can make inferences about those effects on the larger aquatic community and how overall stream "health" is affected.

Up until the last several decades, aquatic organisms were considered vital components to only aquatic systems. It is now known that aquatic systems are inextricably linked to the surrounding terrestrial environment and, in fact, many interactions between the two environments are continuously taking place.

Figure 2. Example of an aquatic food web. Source: princetonhydro.com.



Just as the surrounding landscape can shape a stream and affect the organisms within them, the stream system can have an equally profound impact on the terrestrial environment. Aquatic macroinvertebrates have been shown to be a vital component of not only aquatic food webs, but terrestrial ones as well (McDowall et al. 1996, Nakano et al. 1999a, Nakano et al. 1999b, Kawaguchi and Nakano 2001, Nakano and Murakami 2001, Kawaguchi et al. 2003).

WHAT IS THE LIFE CYCLE OF AQUATIC INSECT?

Aquatic insects are a subset of macroinvertebrates that have been shown to serve an especially important ecological role to terrestrial ecosystems because of their unique life history. It is, therefore, worthwhile to discuss the lifecycle of aquatic insects.

Like frogs and butterflies, aquatic insects undergo metamorphosis, whereby they undergo distinctive changes in form and structure at discrete stages during their life cycle. Some species of aquatic insects undergo complete metamorphosis, like for example,butterflies, and have a pupal stage. Others, however, undergo incomplete metamorphosis and lack a pupal stage – changing directly from larvae to adult. Within each stage of development, aquatic insects may periodically shed their exoskeleton to allow for increases in size and shape. This is known as molting. The periods between molts are known as instars. Most species have four to six instars, while some species may undergo between more than 30 instars!

While some species of aquatic insects can spend their entire lives in the water, many species grow wings and emerge from the water, spending their adult stage in terrestrial environments as flying insects.

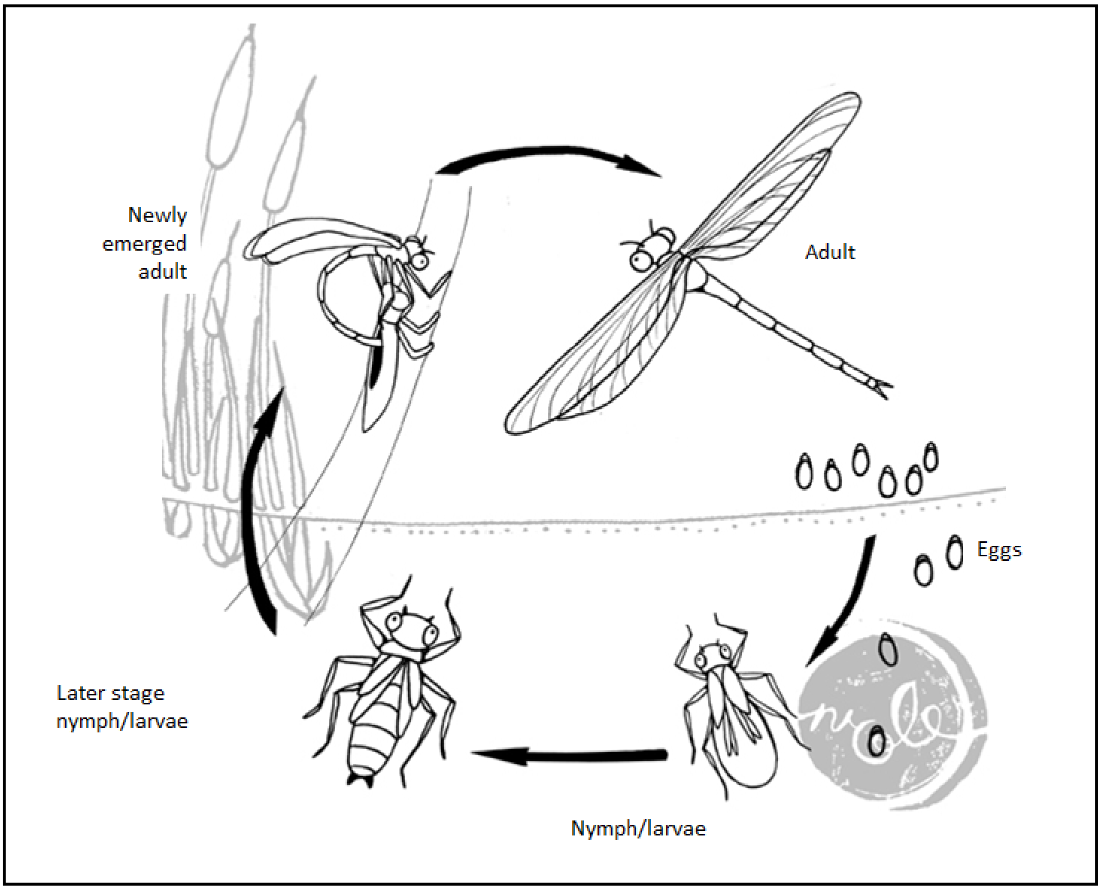


Figure 3. Example of the aquatic insect lifecycle.

WHAT IS BIOMONITORING?

Biomonitoring (biological monitoring, bioassessment) is the use of living organisms and/or their responses to ambient (surrounding) conditions and environmental stressors to make assessments of water quality, or stream health. There are two types of general biomonitoring surveys: 1) before and after an impact occurs, and 2) regular sampling on a routine basis (e.g., annually) to measure changes in condition over space and time. The former type of biomonitoring survey is a commonly used approached involving the use of aquatic macroinvertebrates. The latter type of survey can help scientists better understand long-term changes in water quality over time and along a stream gradient (i.e., upstream to downstream).

STREAM HEALTH: The structure, function, and sustainability of an ecosystem (Rapport et al. 1998)

Traditional approaches to measuring water quality were largely accomplished from a chemical-concentration approach, whereby the amount of a chemical pollutant(s) was/were measured for a given waterbody. While this approach helps to identify the causes of impairment to a waterbody, it does not identify the effects. And equally important, chemical tests do not identify ambient environmental factors that may be affecting water quality or compounding impairments. Aquatic organisms, however, are affected by both chemical pollution and environmental conditions. Therefore, their use in water quality surveys can provide extremely valuable information about the integrated effects of pollution and environment on stream health.

WHY ARE AQUATIC MACROINVERTEBRATES USED IN STREAM SURVEYS?

Bioassessments using aquatic macroinvertebrates has been a well-documented and widely accepted method for assessing water quality and impairment for many decades (Barbour et al. 1999, Rosenberg and Resh, 1993; Bode et al. 2002; Voshell, 2002; Davis and Simon, 1995). Through countless studies and surveys over many decades and in waterbodies across the globe, scientists have been able to describe the life history, habitat requirements, feeding habits, and pollution tolerances of thousands of aquatic macroinvertebrate species. This readily available, well-established information can then be applied to stream surveys where aquatic macroinvertebrates have been collected in order to make inferences about stream health. Traditional studies have used aquatic macroinvertebrates to assess the effects of organic pollution (Hilsenhoff 1987), non-point source pollution (Bode et al. 1995), and decreased habitat diversity (Erman and Erman 1984, Schmude et al. 1998) on stream health. While such studies continue today, the effects of land use and climate change on aquatic systems have become forefront issues and prime objectives of water quality monitoring programs today.

WHY AQUATIC BENTHIC MACROINVERTEBRATES MAKE GOOD BIOINDICATORS

(1) They are abundant in most streams.

(2) They are found in a wide range of habitats.

(3) They are reasonably easy and inexpensive to collect (Bode et al. 2002; Voshell, 2002.

(4) They are relatively stationary animals, in comparison to fish. Therefore, aquatic macroinvertebrates can provide valuable information about water quality at a specific location or area within a waterbody (Merritt and Cummins, 1996).

(5) They are sensitive to various environmental and anthropogenic impacts, such as chemical pollution, agricultural runoff, changes in temperature and habitat modifications (Bode et al, 2002).

(6) They allow for rapid assessment of stream conditions based on the presence or absence of certain species, as the sensitivity to various impacts varies between species (Merritt and Cummins, 1996; Barbour et al. 1999; Bode et al. 2002).

(7) They have comparatively long life cycles, making observations in temporal changes to population and abundance possible (Merritt and Cummins, 1996).

WHAT ARE THE DIFFERENCES BETWEEN POLLUTION TOLERANT AND POLLUTION INTOLERANT MACROINVERTERBATE COMMUNITIES?

Pollution occurs when a substance, chemical, or condition harms, contaminants, and/or poisons an ecosystem. Because aquatic macroinvertebrates have been repeatedly studied across a wide range of habitat types and water quality conditions all around the world, scientists have been able to describe the responses of aquatic macroinvertebrate species to varying degrees and types of pollution. As a result, a scale of pollution tolerance has been developed that helps categorize aquatic macroinvertebrates into distinctive groups: 1) species that are intolerant of pollution (i.e., pollution-sensitive), 2) species that are moderately tolerant to pollution (i.e., semi-tolerance), and 3) species that are very tolerant to pollution (i.e., pollution-tolerant). Depending on the study, the number of pollution-rating groups may vary, but all follow this general gradation. As a result, scientists can make predictions of water quality and pollution levels based on the macroinvertebrates found at a given location within a waterbody.

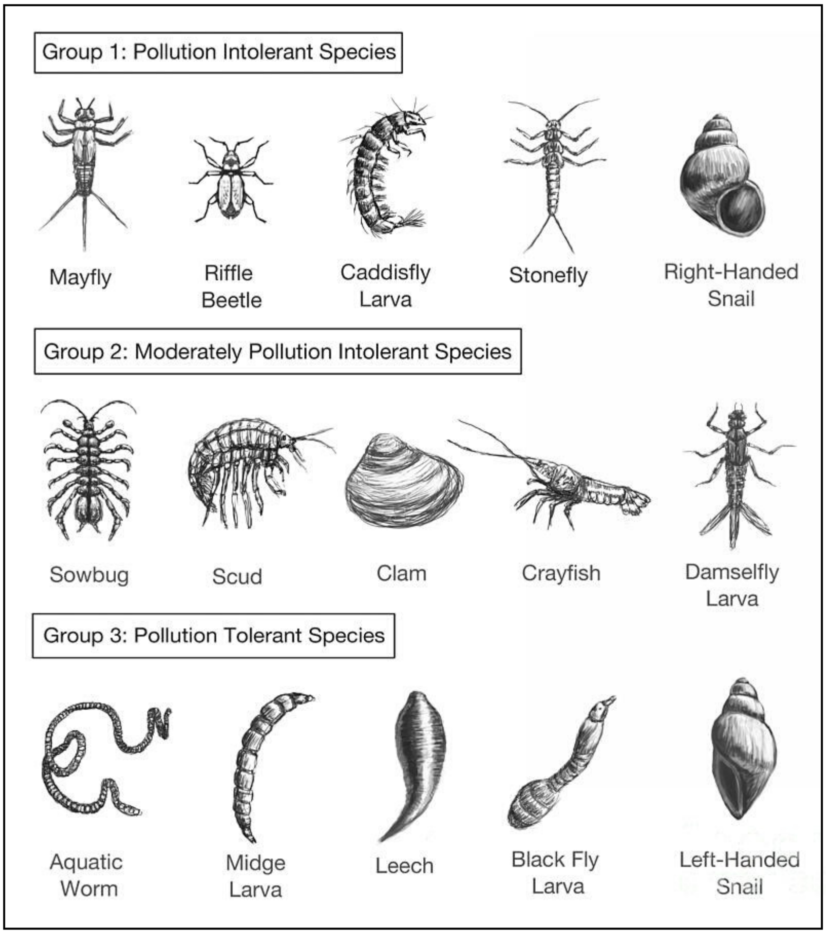


Figure 4. Example of macroinvertebrate pollution tolerance groupings. Source: fineartamerica.com, Artwork by Spencer Sutton.

For example, groups such as Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are generally considered pollution-sensitive taxa, whereas groups such as Annelida (worms), Chironomidae (midges), and Hirudinea (leeches) are considered pollution-tolerant. Therefore, if a stream sample contains a mixture of pollution-tolerant taxa, but lacks pollution-sensitive taxa, then it can be deduced that the site/waterbody is impacted by pollution, and is therefore, considered impaired.

HOW DOES MONITORING AQUATIC MACROINVERTEBRATES IN NEW YORK STATE HELP WITH UNDERSTANDING WATER QUALITY?

The New York State Department of Environmental Conservation (NYSDEC) relies heavily on aquatic macroinvertebrate monitoring to make assessments of water quality in streams, rivers, and lakes across New York. The NYSDEC Stream Biomonitoring Unit performs surveys of water quality each year throughout the state using aquatic macroinvertebrates, which ultimately help to develop and implement watershed plans, develop numeric criteria for nutrient pollution assessments, classify waterbodies under the NYS 303(d) List of Impaired Waterbodies, and to inform the State Permit Discharge Elimination System (SPDES) process.

The NYSDEC provides an interactive mapping service on their website that allows for interested parties to review the data and results collected during current and historical biomonitoring surveys.

MAPPING RESOURCE

https://nysdec.maps.arcgis.com/apps/webappviewer/index.html?id=692b72ae03f14508a0de97488e142ae1

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