Techniques of Water-Resources Investigations
of the United States Geological Survey

Chapter A4

METHODS FOR COLLECTION AND ANALYSIS
OF AQUATIC BIOLOGICAL AND
MICROBIOLOGICAL SAMPLES

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LABORATORY ANALYSIS

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Acrina, acari (n, pl).—An Order of Arachnoidea that includes mites and ticks.

Accuracy (n).—A measure of the degree of conformity of a value generated by a specific procedure for the true value. The concept of accuracy includes precision and bias (American Society for Testing and Materials, 1980).

Aerobe (n). aerobic (adj).—An organism living or growing only in the presence of free oxygen.

Alga, algae (n), algal (adj).—A group of plants, mostly aquatic, single-celled, colonial, or multicelled, containing chlorophyll and lacking roots, stems, and leaves.

Algal bloom (n).—A large number of a particular algal species.

Alochthonous (adj).—Originating outside the area being studied. Also see autochthonous.

Amino acid (n).—A class of nitrogen-containing organic compounds, large numbers of which become linked together to form proteins.

Anaerobe (n), anaerobic (adj).—An organism living or growing in the absence of free oxygen.

Aquatic (adj).—Pertaining to water; aquatic organisms, such as phytoplankton or fish, live in or on water.

Assimilation (n).—The total rate of organic matter used by heterotrophs; secondary productivity plus respiration and other losses. Also see secondary productivity.

ATP (n).—Abbreviation for adenosine triphosphate, an organic, phosphate-rich compound, important in the transfer of energy in organisms.

Autochthonous (adj).—Originating within the area. Also see allochthonous.

Autotroph (n), autotrophic (adj).—An organism, such as an alga, in which organic matter is synthesized from inorganic substances, commonly by the process of photosynthesis.

Bacterium, bacteria (n), bacterial (adj). Microscopic unicellular organisms, typically spherical, rodlike, or spiral and threadlike in shape, often clumped into colonies. Some bacteria cause disease, and others perform an essential role in the recycling of materials; for example, by decomposing organic matter into a form available for reuse by plants.

Benthic invertebrate (n).—An invertebrate of the bottom.

Benthos (n), benthic (adj).—The community of organisms living in or on the bottom of an aquatic environment.

Bias (n).—A persistent positive or negative deviation of the average value of the method from the true value (American Society for Testing and Materials, 1980).

Bioassay (n).—The use of living organisms to test the effects of a substance. Also see toxicity bioassay.

Biology (n), biological (adj).—The science or study of life.

Biomass (n).—The quantity of living matter present at any given time, expressed as the number or weight per unit area or volume of habitat. Same as standing crop.

Biotic community (n).—All the plant and animal populations living together in a habitat and functioning as a unit by virtue of food and other relations.

Blackfly (n).—See simulididae.

Bloom (n).—See algal bloom.

Botany (n).—The science or study of plants.

Broth medium (n).—A liquid mixture of defined composition used to provide nourishment for the growth of microorganisms in culture.

Bryophyta (n, pl), bryophyte (n).—The division of the plant kingdom containing mosses and liverworts.

Carnivore (n).—An organism that obtains its nourishment by consuming animals, includes many types of fish and aquatic insects.

Chemosynthesis (n), chemosynthetic (adj).—A chemical synthesis of organic compounds in bacteria by energy derived from oxidation-reduction reactions of mineral compounds.

Chironomidae (n, pl), chironomid (n).—A family of the insect Order Diptera that includes midges.

Chlorophyll (n).—The green pigments of plants.

Closus (n).—The taxonomic category below phylum, consisting of orders. Also see taxonomy.

Coliform bacteria (n).—A particular group of bacteria used as indicators of possible sewage pollution. They formally are characterized as aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose and form gas at 35 °C within 48 hours.

Community (n).—Any naturally occurring group of different organisms inhabiting a common environment and interacting with one another through food relations.

Compensation level or depth (n).—The depth of water at which gross photosynthesis (oxygen production) balances respiration (oxygen uptake) during a 24-hour period.

Concentration (n).—The weight or number per unit volume or area of a water-quality constituent or characteristic.

Culture (n, v).—Cultivation of or act of cultivating living material, such as microorganisms, in nutrient medium; any inoculated nutrient medium whether or not it contains living organisms.

Culture medium (n).—See nutrient medium.

Denitritkation (n).—The biochemical reduction of nitrates and nitrites during the oxidation of organic matter and the evolution of gaseous nitrogen.

Detritivore (n).—An animal that obtains its nourishment by consuming organic detritus; includes many types of aquatic insects.

Detritus (n).—Fragmented material of inorganic or organic origin.

Diatom (n).—A unicellular or colonial alga having a siliceous shell.

Diel (adj).—Relating to a 24-hour period that usually includes a day and the adjoining night.

Diurnal (adj).—Relating to daytime or something recurring every day, commonly used as a synonym for diel.

Division (n).—The primary taxonomic category of the plant kingdom, consisting of classes. Also see taxonomy.

Dorsum (n), dorsal (adj).—The upper surface of an organism. Also see ventrum.

Dredge (n).—An instrument pulled across or through the bottom of a lake or stream to sample the benthos. Also see grab.

Ecology (n), ecologic(al) (adj).—The science or study of the relation of organisms or groups of organisms to their environment.

Ecosystem (n).—The community of plants and animals interacting together and with the physical and chemical environment.

Emerged plant (n).—A rooted, aquatic plant that has leaves or other structures extending above the water surface (sometimes called emergent plant).

Environment (n).—The sum of all the external physical, chemical, and biological conditions that affect the life and development of an organism.

Epipilimnion (n), epilimnetic (adj).—The upper, relatively warm, circulating zone of water in a thermally stratified lake. Also see hypolimnion.
metalimnion, and thermocline.

Euphotic zone (n).—That part of the aquatic environment in which the light is sufficient for photosynthesis, commonly considered to be that part of a water body in which the intensity of underwater light equals or exceeds 1 percent of the intensity of surface light.

Eutrophication (n), eutrophic (adj).—Enrichment of water, a natural process that may be accelerated by the activities of man; pertaining to water in which primary production is intense as a consequence of a large supply of available nutrients. Also see oligotrophic.

Facultative (adj).— Able to live and grow in many different environments. Also see obligate.

Family (n).—The taxonomic category below order consisting of genera. Also see taxonomy.

Fauna (n), faunal (adj).—A collective term for all the kinds of animals in an area. Also see flora.

Fecal coliform bacteria (n).—That part of the coliform group that is present in the gut or the feces of warm-blooded animals; they are indicators of possible sewage pollution.

Fecal streptococcal bacteria (n).—A particular group of bacteria found in the gut of warm-blooded animals; their presence in natural water verifies fecal pollution. They are formally characterized as gram-positive, cocci bacteria that are capable of growth in brain-heart infusion broth either at 45 °C and 10 °C (the enterococci species) or at 45 °C only (Streptococcus bovis and S. equinus).

Flagellum, flagella (n).—A fine, long, threadlike structure having lashing or undulating movement, projecting from a cell; it is used for locomotion.

Flora (n), floral (adj).—A collective term for all the kinds of plants in an area. Also see fauna.

Food chain (n).—The transfer of food energy from the source in plants through a series of organisms through repeated eating and being eaten (Odum, 1971). Also see food web.

Food web (n).—The interconnecting pattern of food chains. Also see food chain.

Formalin (n).—A clear, aqueous solution containing about 37 percent formaldehyde by volume and 5 to 10 percent methyl alcohol; when diluted with water, it is used as a general biological preservative.

Fungus, fungi (n).—Plants lacking chlorophyll, including molds, yeast, mildews, rusts, and mushrooms. Fungi derive their nourishment directly (saprophytic fungi) or from dead organic matter (parasitic fungi).

Genus, genera, generic (adj).—The taxonomic categories below family, consisting of species; the first part of the scientific name of organisms. Also see taxonomy.

Generation (n).—A group of organisms about the same age.

Generation time (n).—The period of time between the origin of a generation of organisms and the origin of their offspring.

Grab (n).—An instrument designed to bite into the bottom sediment of a lake or stream to sample the bottom. Also see dredge.

Greenhouse effect (n).—An increase in temperature within a glass or plastic enclosure ascribed to entrance of short-wave radiation into the enclosure; whereas, long-wave radiation from heated objects within the enclosure is thermally stratified lake in which temperature decreases rapidly with increasing depth. Also see epilimnion, metalimnion, and thermocline.

Incubation (n).—Maintenance of organisms in conditions favorable for growth and development.

Interpretive (adj).—A type of sampling program or study designed to collect information useful when describing a system and cause-and-effect relationships within the system.

Invertebrate (n).—An animal that does not have a backbone. Common aquatic examples include worms, insects, snails, and crayfish.

Kingdom (n).—The highest biological classification category. Also see taxonomy.

Larva, larvae (n), larval (adj).—An active, immature stage of an animal during which its bodily form differs from that of the adult. Also see nymph.

Lentic (adj).—Of or pertaining to nonflowing water; for example, a lake or pond.

Life history (n).—The environmental relations of an organism, including distribution, morphology, growth, reproduction, and behavior.

Light injury (n).—Physiological damage resulting from exposure of an organism, usually a plant, to a light intensity greater than that to which the organism was adapted.

Limnetic zone (n).—The open-water zone of a water body above the compensation level.

Littoral (n), adj. —Pertaining to the shallow zone of a body of water where light penetrates to the bottom.

Liverwort (n).—See bryophyta.

Lotic (adj).—Of or pertaining to flowing water; for example, a river or creek.

Macroinvertebrate (n).—An invertebrate, usually a benthic organism, that is retained on a U.S. Standard No. 30 sieve (0.959-mm mesh opening).

Macrophyte (n).—Large plants that can be seen without magnification; includes mosses and seed plants.

Medium (n).—See nutrient medium.

Membrane filter (n).—A thin, microporous material of specific pore size used to filter bacteria, algae, and other very small particles from water.

Metabolism (n).—The chemical processes of living cells by which energy is derived and material is assimilated.

Metalimnion (n), metalimnetic (adj).—The middle layer of water in a thermally stratified lake in which temperature decreases rapidly with increasing depth. Also see epilimnion, hypolimnion, and thermocline.

Metamorphosis (n), metamorphic (adj).—The period of rapid transformation from larval to adult form.

Microseston (n).—The suspended matter in water that will pass through a 150- to 350-μm mesh. Also see seston.

Midge (n).—See chironomidae.

Mite (n).—See acari.

Monitoring (n).—A type of sample or program designed to determine time trends.

Morphology (n), morphological (adj).—The study of a life form; the physical attributes of an organism.

Morphometry (n), morphometric (adj).—The measurement of external form.

Moss (n).—See bryophyta.

Nekton (n).—Actively swimming aquatic organisms, such as fish.
Net community productivity (n).—The rate of storage of organic matter not used by the organisms in the environmental area being studied during the period of measurement; net primary productivity minus heterotrophic use.

Net primary productivity (n).—The rate of storage of photosynthetically produced organic matter in plant tissues in excess of the respiratory use by the plants during the measurement period. The term is synonymous with apparent photosynthesis, net photosynthesis, and net assimilation.

Neuston (n).—Organisms living on or under the surface film of water.

Niche (n).—The location and ecological function of an organism in the environment.

Nitrification (n).—The biological formation of nitrate or nitrite from compounds containing reduced nitrogen.

Nutrient (n).—Any chemical element, ion, or compound that is required by an organism for the continuation of growth, for reproduction, and for other life processes.

Nutrient medium, nutrient media (n).—A chemical mixture of defined composition used to provide nourishment for the growth of microorganisms in culture. The medium may be in liquid form, called broth, or may be solidified using agar.

Nymph (n), nymphal (adj).—An immature stage of an insect that resembles the adult stage in body form. Also see larvae.

Obiligate (adj).—Restricted to living and growing in a single environment. Also see facultative.

Oligotrophic (adj).—Pertaining to water in which primary production is small as a consequence of a small supply of available nutrients. Also see eutrophic.

Order (n).—The taxonomic category below class, consisting of families. Also see taxonomy.

Organism (n).—Any living entity.

Pathogen (n), pathogenic (adj).—A disease-causing organism.

Periphyton (n), periphytic (adj).—The community of micro-organisms that are attached to or live on submerged surfaces.

Phaeopigment (n).—The degradation product of chlorophyll.

Photoperiod (n).—The duration of daylight during a 24-hour period.

Phoynthesis (n), photosynthetic (adj).—A biochemical synthesis of carbohydrates from water and carbon dioxide in the chlorophyll-containing tissues of plants in the presence of light.

Phylum, phyla (n).—The primary taxonomic category of the animal kingdom, consisting of classes. Also see taxonomy.

Phytoplankton (n).—An individual phytoplanktonic organism.

Phytoplankton (n), phytoplanktonic (adj).—The plant part of the plankton.

Plankton (n).—An individual planktonic organism.

Plankton (n), planktonic (adj).—The community of suspended or floating organisms that drift passively with water currents.

Polikilothermic organism (n).—An animal whose body temperature approximates that of the environment; commonly called cold blooded.

Pollution (n).—An undesirable change in the physical, chemical, or biological characteristics of our air, land, and water that may or will harmfully affect human life or that of other desirable species, our industrial process, living conditions, and cultural assets; or that may or will waste or deteriorate our raw material resources.

Production (n).—The total quantity of living matter produced in an area per unit time. Also see primary productivity and secondary productivity.

Profundal (adj).—Referring to the deep-water zone of a water body in which plant growth is limited by the absence of light.

Protein (n).—A complex nitrogenous substance of plant or animal origin formed from amino acids; essential constituent of all living cells.

Protozoa (n, pl), protozoan (n).—A biological kingdom consisting of unicellular (single-celled) organisms.

Protoplasm (n).—The living contents of a cell; the nucleus, cytoplasm, and plasma membrane that constitute a living unit.

Pupa, pupae (n), pupal (adj).—The inactive stage of certain insects during which the larva transforms into the adult. Also see larvae.

Random (n, adj).—The nonuniform, haphazard distribution of organisms in the environment.

Random sample (n).—A sample collected from a population or an area using an unbiased procedure so every part of the population or area has an equal chance of being sampled.

Reconnaissance (n, adj).—A type of sample or program designed to determine the present status of something; a preliminary survey.

Respiration (n).—A life process in which carbon compounds are oxidized to carbon dioxide and water, and the released energy is used in metabolic processes.

Rotifer (n, pl), rotifer (n).—The phylum containing microscopic organisms that swim and feed by means of a ciliated hand; also known as the wheel.

Sample (n).—A small, separated part of something that is representative of the whole.

Saproplankton (n).—The bacteria and fungi of the plankton.

Secondary productivity (n).—The rate of increase of organic matter in the heterotrophs of the community; assimilation minus respiration and other losses. Also see assimilation and primary productivity.

Sediment (n).—Fragmental material, mineral and organic, that is in suspension or is transported by the water mass or has been deposited on the bottom of the aquatic environment.

Seine (n).—A net used for collecting fish and other large aquatic animals.

Sessile (adj).—Pertaining to an organism that is attached to an object.

Seston (n).—The total particulate matter suspended in water.

Simuliidae (n, pl), simulid (n).—A family of the insect Order Diptera that includes blackflies.

Species (n, sing., n, pl).—The basic unit for the classification of organisms; the taxonomic category below genus, and the second part of the scientific name of an organism. Also see taxonomy. The biological concept of species, in contrast to the purely taxonomic concept, has been defined by Mayr (1940) as "*a group of actually or potentially interbreeding organisms reproductively isolated from other such groups of interbreeding organisms."

Specimen (n).—A part or individual used as a sample of a whole or group; an organism used for study.

Standing crop (n).—The quantity of living matter present at any given time, reported as the number or weight per unit area or volume of habitat. Same as biomass.

Statistical population (n).—The whole aggregate of something in an area being sampled.

Stratified water (n).—A body of water having a series of horizontal strata. Also see thermal stratification.

Submerged plant (n).—An aquatic macrophyte that completes its life cycle and lives entirely below the surface of the water (sometimes called submersed or submergent).

Substrate (n).—The physical surface on which something lives.

Suspended sediment (n).—Fragmental material, mineral and organic, that is maintained in suspension in water by turbulence and currents or by colloidal suspension.
Taxon, taxa (n).—Any classification category of organisms, such as phylum, class, order, or species.

Taxonomy (n).—The division of biology concerned with the classification and naming of organisms; synonymous with systematic biology. The classification of organisms is based on a hierarchical scheme beginning with the species at the base. The higher the classification level, the fewer the features the organisms have in common. Also see species.

As an example, the taxonomy of the common stonefly, *Pteronarcys californica* is as follows:

**Kingdom** | **Animal**
--- | ---
**Phylum** | **Arthropoda**
**Class** | **Insecta**
**Order** | **Plecoptera**
**Family** | **Pteronarcidae**
**Genus** | **Pteronarcys**
**Species** | **californica**

Scientific name | *Pteronarcys californica*

Thermal stratification (n).—A temperature distribution characteristic of many lakes in which the water is separated into three horizontal layers: a warm epilimnion at the surface, a metalimnion in which the temperature gradient is steep, and a cold hypolimnion at the bottom.

Thermocline (n).—The plane of maximum rate of temperature decrease in a thermally stratified lake, sometimes used as a synonym for metalimnion. See also epilimnion and hypolimnion.

Toxicity bioassay (n).—Determination of the potency of a toxic substance by measuring the intensity of a biological response. Also see bioassay.

Transect sampling (n).—A sampling scheme in which a longitudinal or transverse section of a stream or other area is marked off in equally spaced divisions, and samples are collected at predetermined division sites.

Vascular plant (n).—A multicellular macrophyte that possesses conductive tissues, including roots and similar plants and seed plants; aquatic representatives may be rooted or may float in or on the water.

Ventrum (n), ventral (adj).—The bottom surface of an organism. Also see dorsum.

Vertebrate (n).—An animal that has a backbone enclosing a nerve cord; aquatic examples include fish and amphibians.

Water pollution (n).—Variously defined as "***any thing which brings about a reduction in the diversity of aquatic life and eventually destroys the balance of life in a stream***" (Patrick, 1953, p. 33); "***the addition of something to water which changes its natural qualities so that the riparian owner does not get the natural qualities of the stream transmitted to him***" (quoted in Hynes, 1966, p. 1); "***any impairment of the suitability of water for any of the beneficial uses, actual or potential, for man-caused changes in the quality of water***" (Warren, 1971, p. 14). Also see pollution.

Water quality (n).—Kinds and quantities of matter dissolved and suspended in natural water, the physical characteristics of the water, and the ecological relations between aquatic organisms and the environment.

Water weed (n).—A popular term for an aquatic plant, usually one of the macrophytes.

Yield (n).—The quantity (weight or number) of biomass removed from a given aquatic area in a given time.

Zoology (n), zoological (adj).—The science or study of animals.

Zooplankter (n).—An individual zooplanktonic organism.

Zooplankton (n), zooplanktonic (adj).—The animal part of the plankton.

REFERENCES CITED


Part 3: Selected Taxonomic References

This section consists of references for the identification of aquatic organisms. The lists are not intended to be complete but rather to provide an introduction to the literature for the various taxonomic groups. Two types of references are included: (1) Keys and morphological descriptions for particular groups of organisms, mostly at the generic or higher taxonomic level; and (2) descriptions or lists of taxa for the various States or other geographic areas. North American freshwater taxa are emphasized.

Except for the general reference works, the listings are arranged by systematic or taxonomic category rather than by habitat or biological community. The analytical methods and their taxonomic groups, presented in part 1 of this chapter, are listed in table 22.

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