PART 2 – MACROINVERTEBRATES & NUISANCE SPECIES

Part 2. Macro-flora and Fauna Section will include the identification (common name only) of immature and adult macroinvertebrates & aquatic nuisance organisms, their importance as indicators of water & wetland quality. FOR Division C ONLY students will also be expected to know the general ecology, life cycles, and feeding habits of all listed organisms.

- Class 1 Pollution Sensitive: Caddisfly, Dobsonfly, Gilled Snails, Mayfly, Riffle Beetle, i Stonefly, Water Penny, Water Scorpion
- Class 2 Moderately Sensitive: Aquatic Sowbug, Crane Fly, Damselfly, Dragonfly, Scuds Class 3 Moderately Tolerant: Blackfly, Flatworm, Leeches, Midge, Water Mite ii.
- iii.
- iv. Class 4 – Pollution Tolerant: Air Breathing Snail, Midge Fly Bloodworm, Deer/Horse Fly, Tubifex
- Class 5 Air Breathing: Back Swimmer, Giant Water Bug, Mosquito, Predacious Diving v. Beetle, Water Boatman, Water Strider, Whirligig Beetle
- vi. Aquatic Nuisance Plants: Purple Loosestrife, Eurasian Water Milfoil, and Water Hyacinth vii. Aquatic Nuisance Animals: Zebra Mussel, Spiny Water Flea, Asian Tiger Mosquito, & Asian Carp

Tips for learning indicator species

Power Point Slides - make power point slides for trees and use them so you can use them to study

Flash Cards – make a set of flashcards with pictures on the front and information on the back

Actual Specimens – collect and preserve actual specimens of leaves – put data on the back so you can use them for study. See the section following on collecting and preserving leaves

Study Binder - have a section for each part of water quality competition

- The most effective resources are the ones produced by the students.
- The process of producing the resources is a major learning tool. •
- Have a copy of the rules in your binder •
- Have a copy of the indicator species in your binder •
- Prepare and organize materials by major topic divisions.
- Place materials from many different sources into your topic divisions •
- Reduce the size of pictures where possible to get more information on a page. •
- Color code information to help you locate or emphasize key items.
- Put pages in sheet protectors two per protector to save space.
- Use tabs to separate sections.
- Label tabs so items can be located with ease.

Timer – prepare practice stations and use the timer to improve efficiency of your teamwork skills

It is very important to remember that when assessing macroinvertebrates, the use of other physical, chemical and biological data should also be considered. See the Handout for Part 3-Analysis.

Macroinvertebrates are sampled as indicators of water quality because they are useful biological indicators of change in the aquatic ecosystems.

The main advantages of using macroinvertebrates are that they

- live in water for all or most of their life time.
- stay in areas suitable for their survival.
- often have life span of up to a year and greater
- have limited mobility or are relatively sedentary
- They differ in their ability to survive in different type and amount of pollution.
- are easy to collect and identify
- they have varying sensitivities to changes in water quality

Freshwater habitats which support macroinvertebrates

- Streams and rivers
- Wetlands
- Lakes, ponds, and reserves



Plan view and crosssections of a pool, riffle and run varying flows and depths create a variety of habitats for macro-invertebrates. Source: TVA Clean Water Initiative, 1995

Edgewater habitats may have emergent plants, sheltered overhangs with suspended root mats and leaf packs in quiet back eddies. The composition of macro-invertebrates will tend to differ from that in riffles. Animals survive best in places that provide protection, camouflage and food sources.

Riffles are shallow rocky sections of streams with fast flowing turbulent water. The rocks provide a variety of living places and a large surface area onto which macro-invertebrates can attach. Food is continually swept along in the current from upstream. Since riffles provide a variety of living places, current conditions and food, they often support a diversity of macro-invertebrates.

Runs are generally deep and slow and the water surface is smooth. Smaller particles, like sand and gravel, tend to settle on the bottom. This limits the variety of living places for macro-invertebrates. In addition, occasional floods will wash sand and gravel and any macro-invertebrates downstream. Food is suspended in the water, deposited on the bottom or may grow in the stream bed. Since the physical habitat is not as stable as riffles, there are fewer and less of a variety of macro-invertebrates living in runs.

Pools usually have sandy or muddy bottoms with fewer types of macro-invertebrates present than in riffles. The habitat is less suitable so macro-invertebrates will attach to plant stems, roots, logs and other submerged objects.

Habitats of Macroinvertebrates



Freshwater habitats

Riparian vegetation above the water (stream, river, pond, etc.)

Water surface (in quiet back pools)

Edgewater includes overhanging vegetation Fast-moving bugs and beetles, freshwater shrimp from banks

On or among vegetation in the water

Under grasses and undercut stream banks Aquatic plants - plants under the surface as well as those growing through the water and floating

Riffles or water tumbling over rocks

Bottom under and among rocks-out of the swift current and tumbling debris

Bottom - mud, sand, silt, gravel, rocks

Flowing water - riffles, pools and runs

Pools – slow moving water at edges or behind rocks and logs

Macroinvertebrates that may be living there Macroinvertebrates as insects fall into water from foliage

whirligig beetles, water striders, springtails

Haliplid beetles, dragonfly larvae

Gripping insects, caddis flies, beetle larvae that have burrowed into logs and under rocks, mayflies and stoneflies

high in oxygen and especially rich in insect diversity –

caddis flies, stoneflies, mayflies, damselflies

Worms, fly larvae, bivalve mussels

Gripping insects, caddis flies, damselflies, shrimp, snails

Holding spot for organic material - shredders amphipods, isopods, freshwater crayfish and some caddis fly larvae

Special adaptations

Animals living in still or slow-moving water don't have to hang on and food is not brought to them in the current. Slow moving waters tend to house macroinvertebrates that are a wider range of sizes and shapes and are more mobile

Animals living in fast-moving water must be able to 'hang on' and, at the same time, catch their food. You can often find examples of adaptations in your sample. Some special adaptations include streamlined bodies, suction parts, special hooks and fine filters.

Factors indicating water quality as indicated by macroinvertebrate populations:

- Abundance: The number of macroinvertebrates present large numbers of macro-invertebrates tend to be found in water enriched with nutrients while small numbers may indicate erosion, toxic pollution or scouring by floodwaters.
- **Functional Group**: The presence and absence of certain feeding group of macroinvertebrates such as grazers and predators also indicates the water quality.
- **Taxa Richness**: Diversity of macroinvertebrates found in water. The more diversity in water, the better quality it is.
- **Composition:** the proportion of different types living together healthy communities contain a good number of mayflies, stoneflies and caddis flies while community contains a lot of worms and midge larvae usually indicates a degraded environment.
- **Pollution tolerance**: Different Macroinvertebrates have different level of sensitivity to pollution. The more number of pollution sensitive organisms, the better quality it is.

Group	Description	Food	Habitat
Collectors	Physically gather food or construct net like structure to catch it	Dissolved organic, algae, feces and plants	Stream bottom
Shredders	Shred, cut, bite or bore food	Leaves and vegetation fallen into water	Areas with tree cover
Scrapers	Use organs to scrape the food	Scrape algae and diatoms off the rock	Areas with enough light for algae growth
Predators	Hunt other organisms for food	Other organisms – other invertebrates & small fish	All types of habitat

Feeding types:

- Collectors/Filter feeders include mayfly nymph, mussels, water fleas, some fly larvae and worms
- Shredders include amphipods, isopods, freshwater crayfish and some caddisfly larvae
- Scrapers include animals such as snails, limpets and mayfly larvae.
- **Predators** include dragonfly and damselfly larvae, adult beetles and beetle larvae, some midge larvae and some stonefly larvae

Common Macroinvertebrates



Aquatic Insects with **complete metamorphosis** are alderflies, dobsonflies, beetles, moths, caddisflies, and true flies.

Aquatic Insects with **incomplete metamorphosis** are mayflies, damselflies, dragonflies, stoneflies, and waterbugs as waterboatman and backswimmer.

Macroinvertebrate Physical Properties and Life Cycles

Class 1-pollution sensitive

Mayfly

- Incomplete metamorphosis larval development can last 3 months to 3 years
- Nymphs have 3 tail filaments occasionally 2 tail filaments never paddle or fan-like
- Feathery gills line the sides of the abdomen on nymph
- Color of nymph can be green brown, gray but usually black
- Nymphs are flattened to reduce the force of fast currents
- Nymphs are collector-gathers or scrapers small plant and animal debris as algae, diatoms & plankton- they are found on underside of rocks
- Nymphs are a high proportion of the diet of many fish
- Adults do not eat



• Females deposit eggs on top of water where they drift to bottom – some deposit eggs underwater



on submerged objects

Caddisfly

- Complete metamorphosis
- Larvae are usually cylindrical and "C" shaped
- Some larvae are free-living (collector-filterers)
- The larvae are found beneath stones or rocks
- Some spin webs to trap food from the flowing water
- Others are case makers (shedders-detritivores & sheddersherbivores)
- Larvae transform into winged adults in the water
- Adults, they live only a few days and do not eat
- One generation per year





larva and cases





pupa





adult

Stonefly

- Incomplete metamorphosis
- Eggs are laid in the water or are placed in cracks near the water's edge.
- Nymphs hatch in early spring. Have two tails & no gills visible on the abdomen also 2 tarsal claws
- Nymphs usually live beneath stones in fast-moving, clean water.
- They feed on algae, lichens, and rotting vegetation. Some are predators
- As they grow the nymphs molt (often more than a dozen times.
- Some take a year to become adults, some take two years.
- Adults emerge near the edge of the stream, sometimes when the ice has just melted.
- Most appear to emerge at night.
- After emerging, the adults fly.
- They are not active fliers, usually remain near the ground.
- Many adult stoneflies do not have functional mouth, so they cannot eat and they live only a short time (about 2 to 3 weeks).
- Adult stoneflies are found near the streams and rivers from which they emerged.







Gilled Snails

- Rely on oxygen in the water for respiration
- Have gills for breathing
- Shell is made of calcium carbonate
- Soft body inside a hard, spiral shaped shell
- Plate-like door (called the operculum) protects the opening of the shell
- Shells usually open on the right side
- They are grazers found on a variety of substrates



Dobsonfly

- Complete metamorphosis
- Includes some of the largest larvae
- Larvae are most often found in clean rivers with rocky bottoms near soft rotting logs or stumps
- Larvae are carnivorous predators and may bite mouth has large chewing pinchers
- Larvae have 3 pr. of well-developed legs on the thorax
- Larva has many fleshy, filamentous lateral appendages on each side of the abdomen
- Gill tufts on the underside of the tail of larvae
- Abdomen of larvae ends in a pair of short spiny prologs each with 2 hooks
- Adult live only about 7 days



larva (larvae is plural)



female adult



pupa



male adult

Water Penny (beetle larva)

- Complete metamorphosis
- The water penny is the aquatic larva of a beetle The body is often stuck flat to surfaces as rocks and other flat substrates and looks like a tiny round leaf
- Larva is green, brown, black, or tan
- Segmented plate-like covering on larva
- Six tiny segmented legs beneath the round body
- Larva eat plant debris as algae and diatoms
- The adult of the species is not aquatic but found above water on rocks in riffles resembles extremely large riffle beetle







Riffle Beetle

- Complete metamorphosis
- Larvae body is long, stiff, and segmented (up to ³/₄ ")
- Larvae resemble small "torpedoes"
- Six segmented legs on upper middle section of larvae
- Back end of larva has two tiny hooks and short hairs
- Adults have small oval body only about ¹/₄" long
- Adult are aquatic and walks very slowly under water on the bottom
- Adults have only one pair of antennae
- Adults found more often than larva live longer
- Eat primarily plant material such as algae and





in water diatoms

Water Scorpion

- Incomplete metamorphosis
- Resemble elongated sticks with slender elongated bodies and long breathing tubes to take in oxygen from air as they move on surface of water
- Not good swimmers move very slowly
- They hang head down from twigs and weeds
- Aquatic predators grab the prey, hold it with their front legs and seem to suck the juices out of the victim, until its body is limp and shriveled.
- Adult is also aquatic predator



Nymph eating water mite



Adult

Damselfly

- Incomplete metamorphosis
- Nymphs have slender bodies with 3 long tail-like gills
- Nymphs have no abdominal gills and tail supplemental gills are paddle-shaped
- Long legs are close to the head
- Large compound eyes and extendable jaws fold under the head – very good vision
- Nymphs are grey, grey or brown in color
- Nymphs found among stones and in leaf litter at bottom
- Nymphs are predators and feed on other macroinvertebrates in the water may also be cannibals eating each other
- Nymphs have 10 to 12 stages of development to become adults
- Adults have long abdomens, 2 pr. wings held upright, and are very colorful reds, greens and blues
- Wings are held vertical when at rest







nymph

adult

Dragonfly

- Incomplete metamorphosis
- Most nymphs have oval and flattened robust, elongated bodies or spider-like bodies –
- Nymphs are usually grey, brown or green
- Often have algae growing on their backs
- No external gills on the nymph
- Nymphs have large eyes, are predators with distinct mouthparts used to capture prey
- Feed on aquatic macroinvertebrates, small fish and tadpoles
- 6 legs and a pair of small wings may be seen developing on the back
- Three anal structures (often appear as one)
- Adults similar to adult damselflies but the 2 pr. of wings are flat or horizontal when at rest rather than vertical as the damselflies
- Adults are agile predators eating mainly other insects-eating food equal to its own weight in 30 minutes





nymph



adult

Aquatic sowbug

- Crustacean and isopod
- Can be found on substrates or overhanging vegetation tend to crawl along surface
- Omnivorous
- Have 7 pr. of legs, 2 pr. antennae one much longer than the other
- Similar in appearance to terrestrial sowbugs or "roly-polys"



Scuds

- Are tiny Crustacean Amphipods
- Sometimes called freshwater shrimp
- Are laterally compressed side swimmers
- Have 2 pr. antennae and 7 pr. of legs
- Found in shallow water near overhanging vegetation
- Stay close to bottom use it to hide from predators
- Predators include tadpoles, aquatic insects, small fish
- Do not like light and are active at night
- Filtering collector scavengers eat dead plant and animal matter
- Help keep water clean by eating dead decaying material
- Primary food source for many varieties of fish including trout
- After mating, eggs are held by the female in a sac until they hatch





Cranefly

- Complete metamorphosis
- Larvae are worm-like with thick skinned segmented body somewhat transparent with digestive tract visible- may be greenish or grayish
- Larvae are rounded at one end and disc like spiracles at the other end
- Larvae are shredders eat plants and plant debris some are predators
- Adults nicknamed giant mosquitoes with long legs but are do not bite humans
- Adults normally do not eat and live only long enough to mate are food for birds, spiders and some carnivorous plants
- Females deposit eggs on submerged vegetation and other debris











Larvae

Pupa

Adult

Class 3-moderately tolerant

Water Mite

- Small Arachnids
- Have a complex life cycle egg, larva, nymph and adult
- Female attaches fertilized eggs to submerged plants
- Larvae hatch with only 6 legs
- Larva are usually parasitic on aquatic insects
- Nymphs called deutonymph resemble adults with 8 legs but are sexually immature
- Deutonymphs feed on aquatic insects, crustaceans, and other mites, and grows in size as it feeds
- Adults- round or globular with 8 legs.
- Bright red is common, but can be green, blue, orange, yellow, brown or black.
- Found in shallow water (1-2 meters beneath the water surface)
- Adults mostly piercer-predators preying on insect and fish eggs, insect larva, dead organisms and bivalves
- Water Mites are food for a wide variety of aquatic invertebrates





larvae parasitizing damselfly







Midge

- Complete Metamorphosis
- Eggs laid in a mass on surface of water in a gelatinous substance
- After hatching, larvae feed on gelatinous mass and then leave mass
- Larvae are cylindrical, thin, soft, and often curled with anterior and posterior prologs and hardened head capsule
- Larvae burrow in the mud and use salivary secretions to bind substrate particles into tubes or tunnels in which they live
- Larvae feed on suspended matter in water and organic matter in the mud gathering collector
- After the first molt, most midges take on a pink color then turn into a deep red "called blood-midges or blood worms" in low oxygen conditions (See blood midge under class 4-pollution tolerant)
- Larva turn into pupa and remain for about 3 days
- Adults usually swarm at night to mate and do not feed. They live only 3-5 days.
- Adults sometimes nicknamed "Blind Mosquitoes" but they do not bite



larva



pupa







Flatworm

- Body is soft, elongate, and flattened from top to bottom
- Two eyes are on the top of the head, looking cross-eyed.
- Flatworms do not undergo any metamorphosis as they grow and develop into adults
- Variety of ways of obtaining food, including piercer-predators, engulfer-predators, and collector-gatherers
- They are clingers, gliding slowly



planaria

Blackfly

- Complete metamorphosis (true fly)
- Eggs are deposited in shallow, fast-running water on suspended objects as rocks, leaves, or vegetation
- Larvae have brush-like mouthpart that collect tiny organisms or organic matter like a sieve out of water collectors/filterers
- Larvae tend to stay attached to substrate by producing a silk thread to adhere- tiny hooks on the abdomen help to attach
- Pupa usually found on downstream side of rocks or aquatic vegetation where current is slower
- Adults emerge at the same time in large numbers
- Adults many females require a special diet for egg maturation
- Adult females are blood-feeders and can be very aggressive not all adults feed on human targets most prefer other hosts
- Adult females can also transmit blood and skin parasites between mammals



Black fly. A, Adult. B, Larva. C, Cocoon. D, Pupa.





larvae

Black Fly

pupa

adult

Leeches

- Annelids
- Segmented, flattened and a sucker on both ends of the body
- Tan to brown in color
- Found in areas high in organic debris or mud in shallow, still water (ponds)
- Active at night
- Can be carnivores, detritivores, but mostly external parasites
- Free-living detritovores hid under stones or other objects and eat decomposing organic matter
- Predatory leeches eat frequently
- Parasitic species feed on host sucking blood from the host releasing an anesthetic

Class 4-pollution tolerant

Air Breathing Snail

- Left opening with no plate-like covering (operculum) over opening
- Respire via lungs so they are not dependent on dissolved oxygen in the water
- Found grazing on a variety of substrates
- Grazers

Deer/Horse Fly

- Complete metamorphosis (true fly)
- Larva are caterpillar-like and segmented
- Larva body is tapered on both ends with no appendages
- Usually milky, light brown or greenish with digestive tract often visible
- Larvae are predators, collectors and can be cannibalistic – usually eat small organisms as aquatic insects and other small invertebrates
- Larva found under rocks, overhanging vegetation, or in leaf-pack

- Adults emerge from pupa state, are good fliers, and immediately start mating with males and females feeding on nectar
- Females feed on blood and develop eggs
- Most species have only one generation per year

larva

Deer fly adult

Horse fly adult

Tubifex worms

- aquatic annelids
- slender segmented worms resemble slender earthworms
- color can be reddish, brown or gray
- often found in clumps in large numbers indicate poor water quality
- found in mud bottoms
- eat large quantities of mud and filter organic matter from it
- serve as food for fish and other bottom feeders
- reproduce similar to earthworms hermaphroditic and a cocoon serves during fertilization and development of embryos

Blood midge

- Complete metamorphosis
- Larva of the Midge (see midge above in Class 3)
- Midge Larva turn blood red under low oxygen conditions
- Contain a substance similar to haemoglobin which holds oxygen absorbed through gills at the base of the body
- Eat dead plant and animal matter (detritus)
- Serve as food for fish, water mites and insect larvae

Class 5 – Air Breathing Predacious Diving Beetle

- Complete metamorphosis
- Live in ponds, lakes and slow-moving streams
- Larvae are predators
- Adults are black or brown; some with markings
- Adults come to water surface to get oxygen from air
- Eat tadpoles and small fish
- Are food for fish, frogs, water spiders

adult

larva

Whirligig Beetle

- Complete metamorphosis -see similar life cycle under predacious diving beetle
- Larvae stay at the bottom and feed on microbes and plant matter
- Adults normally live on the surface of a "gentle" ponds or lakes
- Adults have short antennae and forelegs that are very long and mid and hind legs that are short and paddle-like
- Adults are oval-shaped and dark with a metallic sheen
- Adults are capable of trapping air bubbles so that they can submerge.
- Adults prey on insects and other creatures that fall on the water surface.
- Common name for adults comes from their habit of swimming rapidly in circles when alarmed.
- Divided eyes in adults allow them to can see both above and below water
- The adults are often found in groups to avoid predators larvae

Mosquito

- Complete metamorphosis
- Most mosquitoes lay eggs on surface of water as an egg raft but some species eggs are single
- Prefer water sheltered from wind
- Most eggs hatch within 48 hours
- Larvae are nicknamed "wigglers" or "wrigglers"
- Larvae stay near the water surface for feeding and breathing (collector-filterers or collector-gatherers)
- Larvae have siphon tubes for breathing and hang from the surface of the water
- Larvae feed on micro-organisms and organic matter in the water
- Mosquito larvae can live in almost every type of still-water habitat
- On the 4th molt the larva turns into a pupa
- Pupal stage is a resting, non-feeding stage where the adult develops
- Pupa takes in oxygen through two breathing tubes "trumpets"
- Male mosquitoes feed only on plant juices
- Only female mosquitoes bite humans and other animals using blood to allow her to develop eggs
- Female looks for movement of dark objects
- Female inserts its proboscis and probes for blood vessels where it injects saliva into the wound
- The saliva has an anticoagulant but also may contain pathogens such as malaria parasites or encephalitis viruses depending upon the type of mosquito and where the mosquitoes live

larvae and pupa

adult female

larvae

Giant Water Bug

- Incomplete metamorphosis (True Bug)
- Female deposit their eggs on the backs of males, which carry them until they hatch (common with other surface swimming water bugs as water boatman, backswimmer, and water strider)
- Mostly inhabit ponds, edges of lakes, and pools of streams
- Nymphs of water bugs molt several times before reaching adult
- Nymphs receive oxygen through their skin in pockets at the tip of the abdomen
- Adults breath air from the surface of the water (common with other surface swimming water bugs as water strider, backswimmer, and water boatman)

Bug Lifecycle

- Adults will inflict a painful bite with their beak in defense if they are handled carelessly.
- Nymphs and adults are fierce predators inject chemicals that kill prey and dissolve internal parts of prey feeding on tadpoles, small fish, salamanders and small frogs
- Front legs are greatly widened and elbowed for grabbing and holding prey. (piercer-predators)
- May be up to 3 inches long

adult

Egg mass

nymph

Water Strider

- Incomplete metamorphosis (True bug) see bug life cycle under Giant Water Bug
- Known to skate on the water surface (special adaptations that enable them to remain suspended on the surface film)
- Breathe from the atmosphere (when they occasionally dive or submerged, they trap air in the fine, water resistant hairs that cover their bodies
- Short, raptorial front legs to grasp their prey on the water surface (piercer-predator)
- A predator on other insects
- The front pair of legs is adapted for grasping prey

nymph

adult

Back Swimmer

- Incomplete metamorphosis (True Bug) see bug life cycle under Giant Water Bug
- Swims on its back paddling with long fringed hind legs
- Back is convex with wings white or lightly colored with cross striations can have green, brown or yellowish color (wings are lighter than the body area)
- Nymphs of water bugs molt several times before reaching adult
- Nymphs receive oxygen through their skin in pockets at the tip of the abdomen
- Adults breath air from the surface of the water
- Nymphs and adults are predators and attack prey as aquatic insects up to large as tadpoles and small fish
- Can inflict painful bite even to humans
- Adults are also good fliers with well developed wings attracted to lights and may invade home swimming pools

nymph

adult

Water Boatman

- Incomplete metamorphosis (True Bug)
- Adult swims upright back is dark
- Grayish, elongated oval body with large eyes
- Paddle along surface of water with oar-like back legs
- Nymphs of water boatman molt five times before reaching adult
- Nymphs receive oxygen through their skin in pockets at the tip of the abdomen
- Adults breath air from the surface of the water
- Can carry air bubble on body surface or under wings while they are under water
- Most species are herbivorous living on algae and plant matter
- They live in clusters or groups adults can fly
- Unlike other aquatic buds, they do not bite humans

Aquatic Nuisance Plants

- Purple loosestrife
- Eursian water milfoil
- Water hyacinth .

Aquatic Nuisance Animals

as 12 to 21 affens. The

Leaflet is 1/2 life size

- zebra mussel •
- spiny water flea •
- asian tiger mosquito •
- carp

Aquatic Nuisance Plants and Animals (Invasive Species)

Aquatic nuisance (or invasive) species are nonindigenous species that threaten the diversity and abundance of native species and the stability of the aquatic ecosystem

Have the following effects on Aquatic Environments

- threaten the ecological processes and natural resources of the waters
- loss of biodiversity greater threat than pollution, harvest, and disease combined
- changes in natural ecosystem their food chains and food webs
- compete with native species for available food while not having natural enemies to control them
- reduce the number and diversity of natural species
- impact economic enterprises such as agriculture, fisheries, forestry, power production and recreational activities of the waters
- severe and permanent damage to the habitats being invaded

Common Pathways of Introduction

- Ballast water operations
- Biofouling of ship hulls
- Transported on watercraft, fishing gear, and other recreational equipment/li>
- Escape from aquaculture facilities
- Escape from nurseries and water gardens
- Intentionally stocked as food or recreational sources
- Released as biological control of existing an existing invader
- Intentional release of unwanted pets
- Utilized for habitat restoration or erosion control efforts
- Accidental or intentional release of classroom and laboratory animals
- Fishing bait release
- Accidentally released with other species in the plant and animal trade

The table below provides a list of the 3 classes of adverse impacts caused by aquatic nuisance species: Types of Aquatic-Nuisance-Species Impacts

21 I		
Environmental Effects	Economic Impacts	Public Health
Predation	Industrial Water Users	Disease Epidemics
Parasitism	Municipal Water Supplies	West Nile Virus
Competition	Nuclear Power Plants	Cholera Risks
Introduction of new pathogens	Commercial Fisheries	Parasites
Genetic	Recreational Fishing	
Habitat Alterations	Shipping	

Aquatic Nuisance Species (ANS) Task Force

Resources:

EPA – Biological Indicators of Watershed Health Common Invertebrates of the Clinton River Watershed www.kidfish.bc.ca - for lifecycles Aquatic Nuisance Species (ANS) Task Force