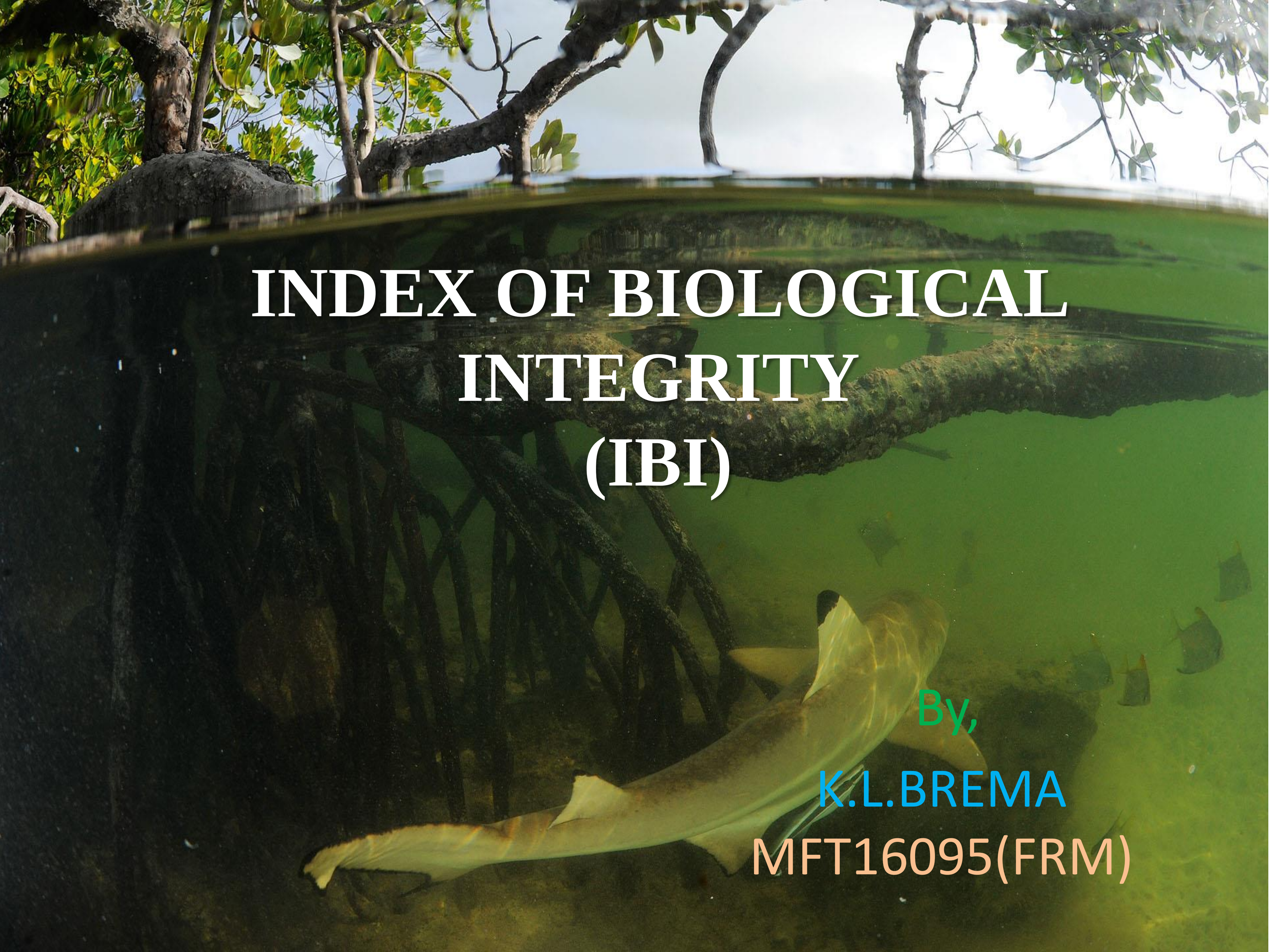


INDEX OF BIOLOGICAL INTEGRITY (IBI)

By,

K.L.BREMA
MFT16095(FRM)

OUTLINE OF THE PRESENTATION

a) Introduction
b) Biological integrity
c) Factors determine integrity of aquatic environment
d) Benthic macro-invertebrates
e) Classification and identification of macro invertebrates
f) Benthic index of biotic integrity
g) Invertebrates sampling & analysis
h) Index analysis
i) Calculation of the index (scoring basis)
j) Quality checking of water body
k) Summary
l) References

INTRODUCTION

- Clean water is essential to life, adverse changes to the water quality of one stream can impact all the bodies of water down streams rivers, lakes, even the ocean.
- When water quality degrades changes to plant, invertebrates and even fish communities may occur and affect the entire food chain

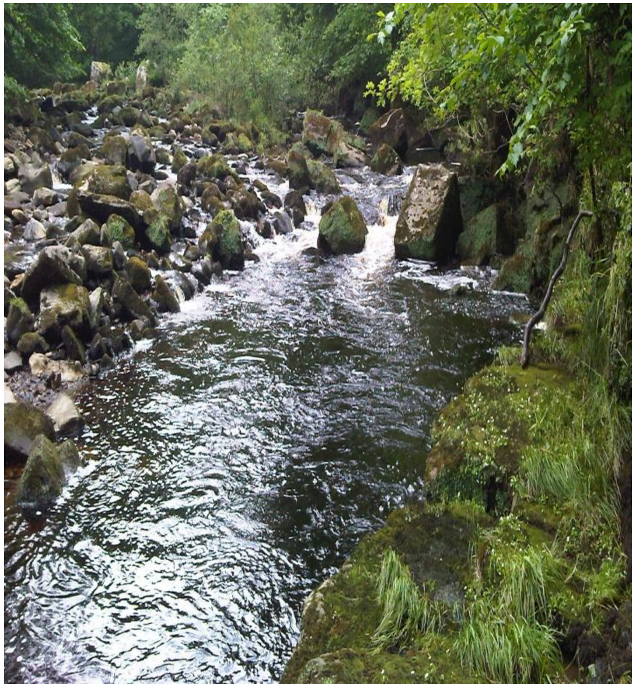


- Once baseline data of the health of the stream is collected, subsequently monitoring can help to identify when and where the pollution is occur.
- Water quality can be assessed using chemical sampling, though the water quality monitoring, communities can assess the health of their streams and rivers over time.

- Biological water quality = **Aquatic macro invertebrates**

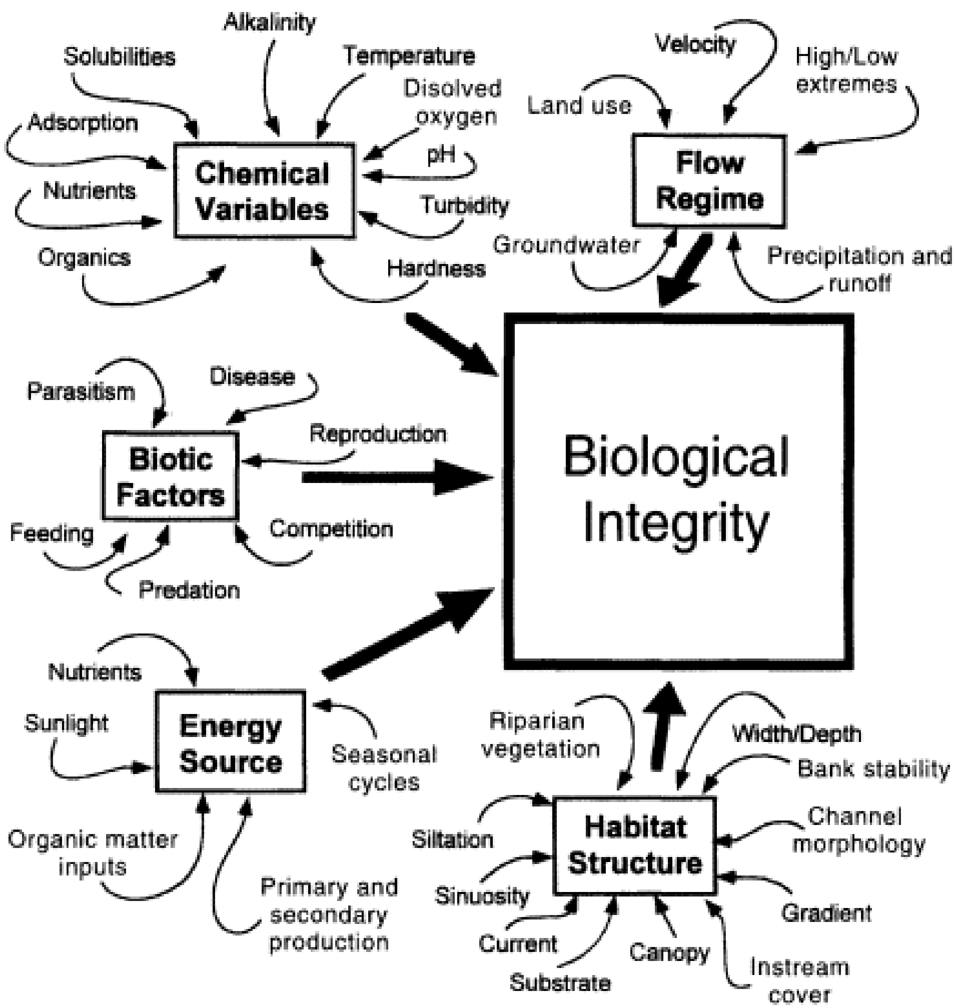
BIOLOGICAL INTEGRITY

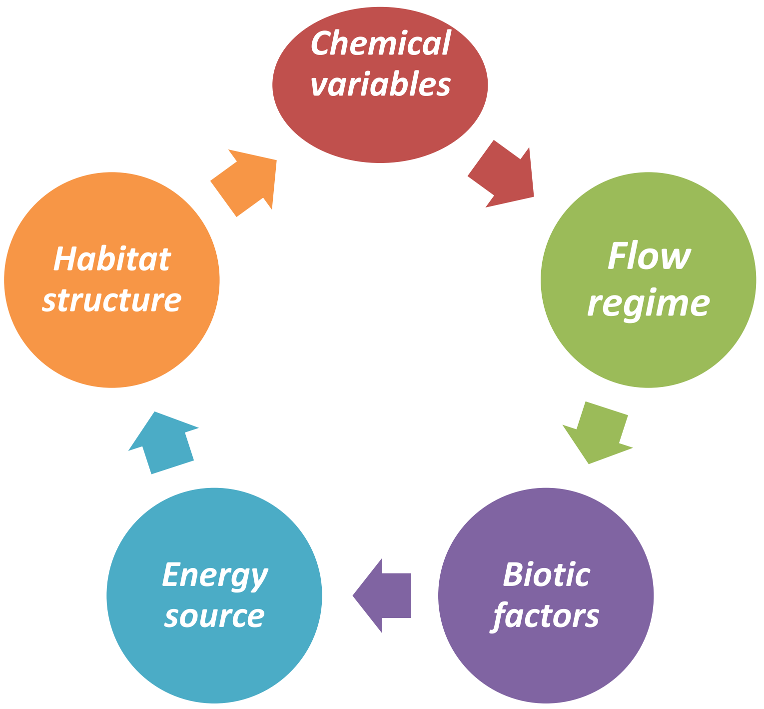
"The capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region."



- Developed by **DR. JAMES KARR**
- For sampling
- Biological integrity – clean water act (1972)
- Restoration and maintenance of Chemical, Physical and Biological integrity of the nation waters
- Goal: Make lakes &streams fishable and swimmable

FACTORS THAT DETERMINE THE INTEGRITY OF AQUATIC RESOURCES





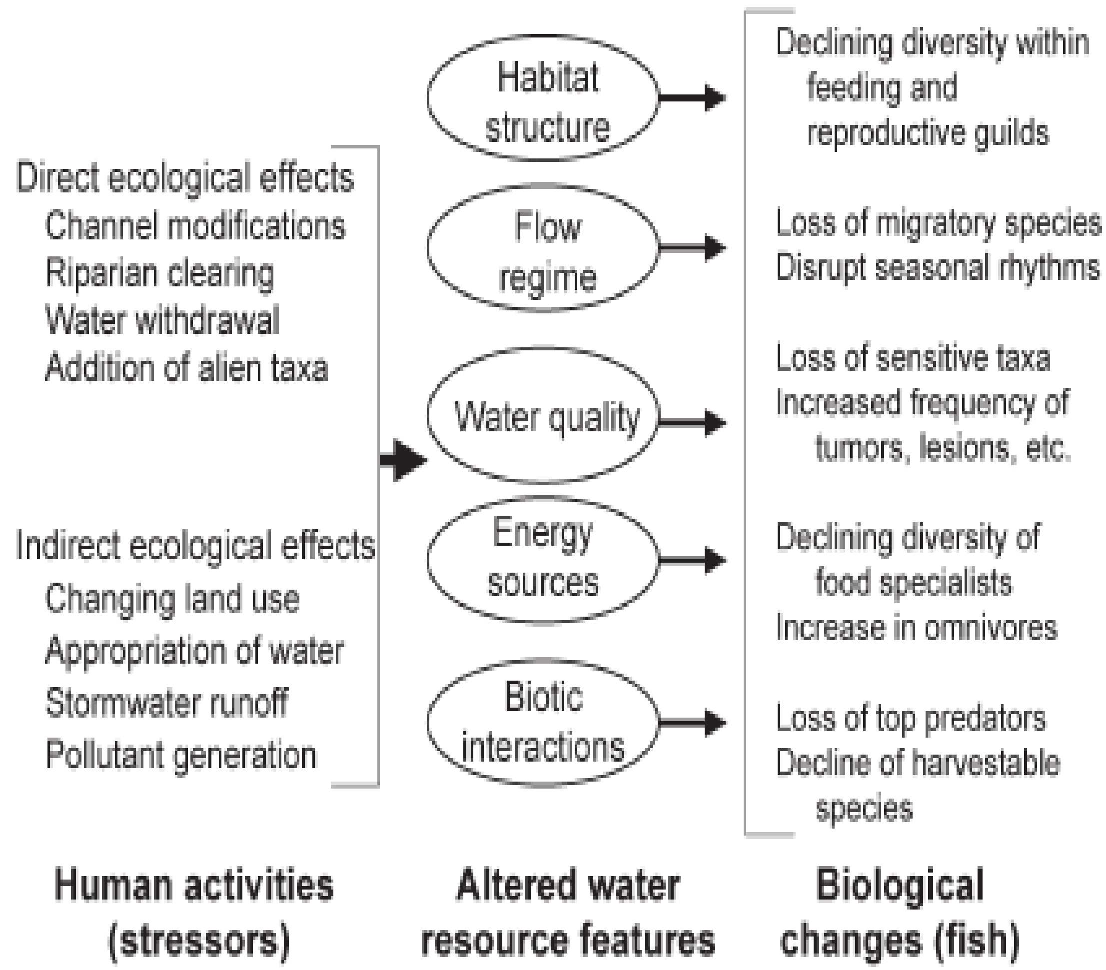
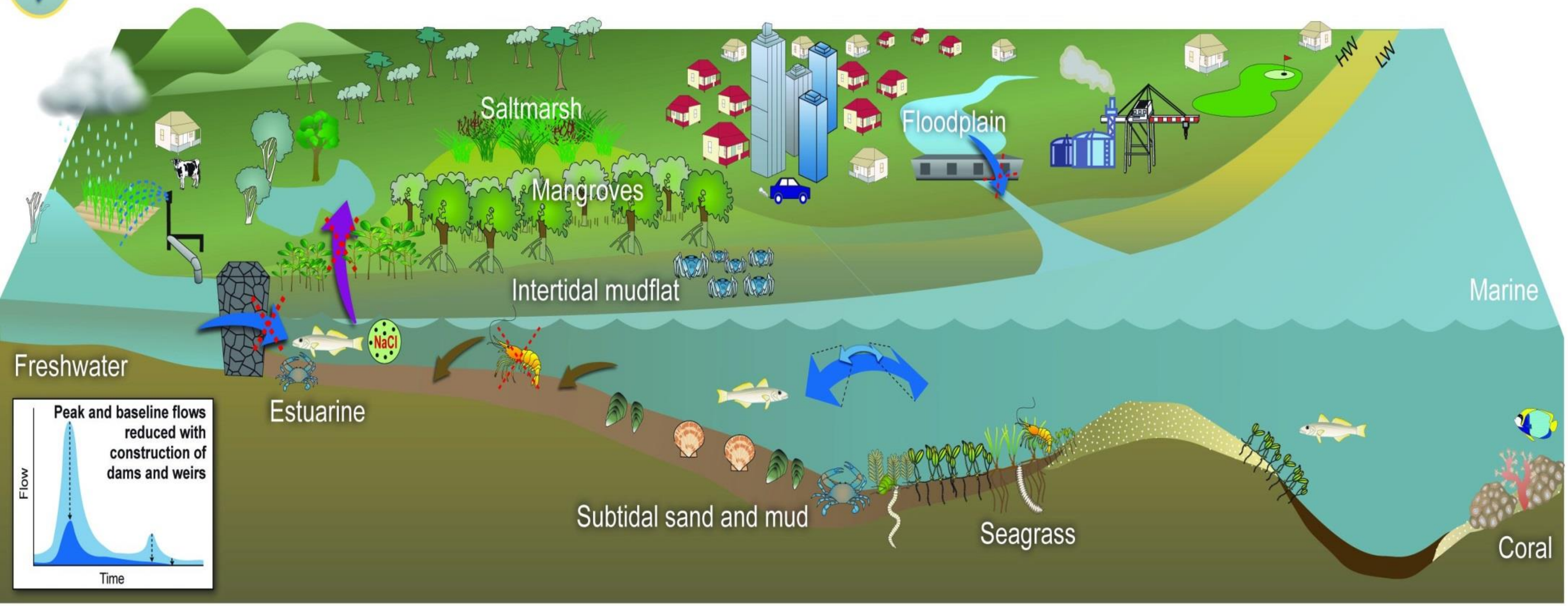


Fig. 1. Human activities alter five water resource features, resulting in specific changes in fish assemblages. (Modified from KARR and YODER, 2004)

Freshwater flow regime



Legend:

Construction of impoundments (e.g. dams and weirs) and water extractions ( ) reduce the inflow of freshwater ( ) into estuaries

Flushing is reduced in the upper and mid reaches of the estuary

Salinity increases upstream

Mangroves and other salt tolerant species (e.g. estuarine/marine fish) ( ) extend further upstream with increased salinity

Reduced freshwater inflows (i.e. reduced flooding) may result in a loss of connectivity ( ) with adjacent habitats (e.g. floodplain billabongs)

Siltation is increased in mid and upper estuarine reaches

The lack of freshwater pulses impacts on the spawning/reproduction, migration and production of estuarine species

Queensland Government
Environmental Protection Agency





BENTHIC MACRO INVERTEBRATES

Heptageniidae sp.
(Mayfly larva)

Hydropsyche sp.
(Caddisfly larva)

Perlodidae sp.
(Stonefly larva)

Aquatic macroinvertebrates are relatively immobile so they can't escape either short or long-term pollution exposure. This is important when assessing long-term pollution events within the stream.

Great candidates for biological monitoring…

WHY WE CHOOSE MACRO-INVERTEBRETES AS A INDICATOR

- Biological indicator of stream health and lotic ecosystems
- Limited migration behaviour- suit for assessing site specific effects
- Good performance in evaluating WQ, especially heavy metals and organic pollution
- Efficient to sampling
- Less sensitive to changes in hydrology and physical form(geomorphology)

- Have little mobility
- Generally abundant

- Primary food sources of many fishes
- Good indicator of localized conditions
- Diversity = healthy streams

Mayfly Adult

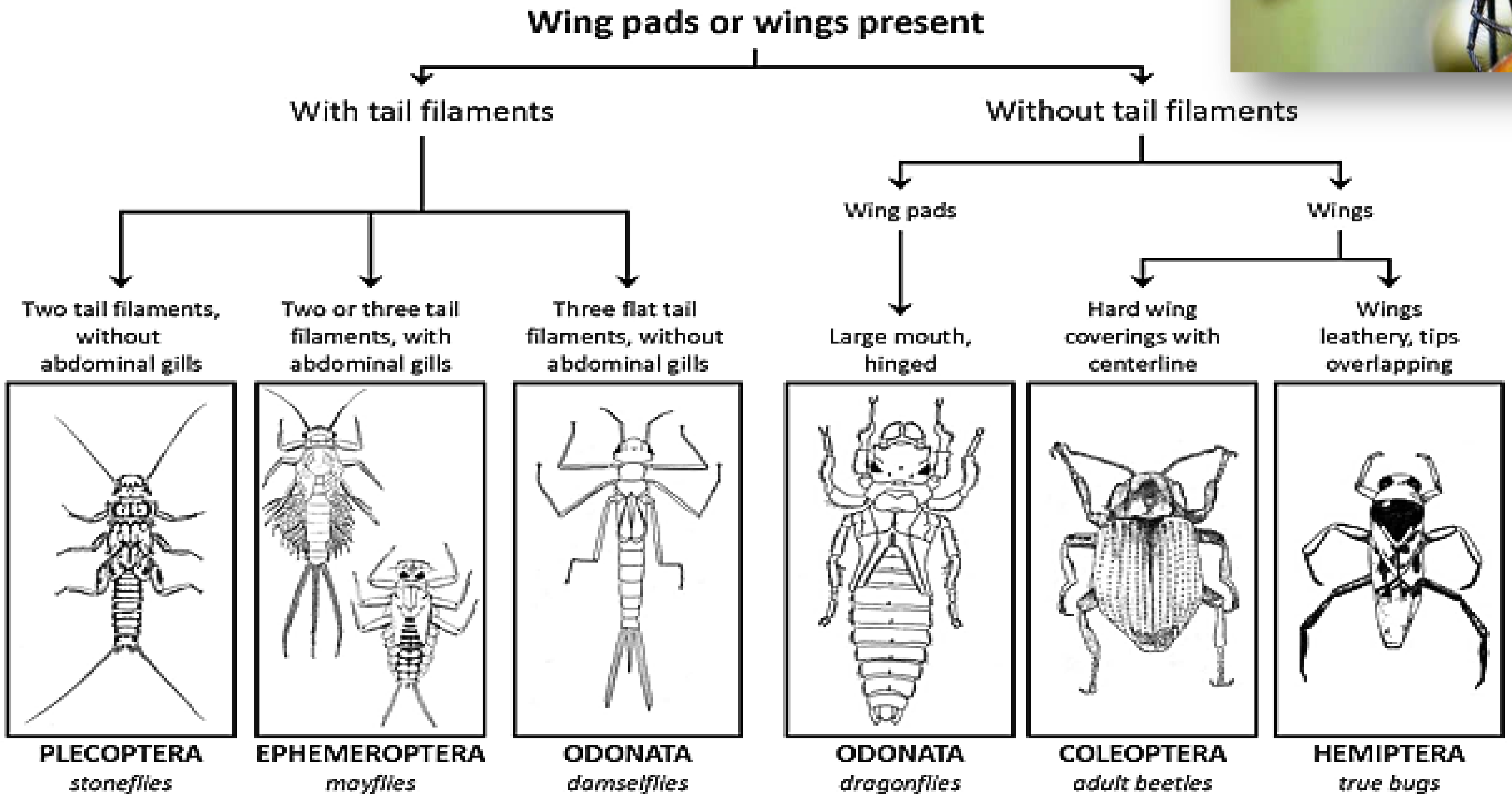
Brush-Legged Mayfly Nymph

Mayfly Nymph

POTENTIAL THREATS TO MACRO INVERTEBRATES DIVERSITY

- Sedimentation
- Habitat loss
- Chemical pollution

CLASSIFICATION OF FRESHWATER MACROINVERTEBRATES



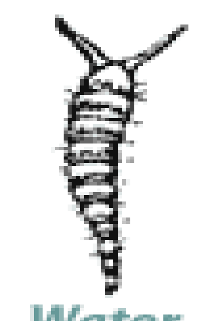
Types

Group 1: sensitive to pollution

- **DOBSONFLY**
  Dobsonfly larvae (Order Megaloptera) are often called hellgrammites.
- They are commonly found in oxygen-rich water, and obtain oxygen through their skin.
- They are equipped with hooks on the end of their body which help them to hold onto stable objects (such as rocks) in moving water.

WATER SNIPEFLY LARVAE

- Water snipefly larvae (Order Diptera) live in clean, fast-flowing water, which is oxygen-rich.
- Only one genus, *Atherix*, The larvae live for about one year, then pupate in the soil along stream banks, and emerge as adults in early summer.



ALDERFLY

- Alderfly larvae (Order Megaloptera)
- Have filaments along the sides of their bodies which help them to obtain oxygen from the water in which they live.
- They are carnivores and may live in the water in their larval stage for one to four years before emerging as adults.

STONEFLY

- It often found in fast-flowing water
- 2 tails
- 2 sets of wings pad, prominent antennae, and 2 claws at the end of the each leg, having steamlined flattened body
- Sometimes have branched gills between the legs
- Not tolerant to low DO

CADDISFLY

- Many different types of caddisfly larvae (Order - Trichoptera)
- Some types build cases, which they carry along with them as protection from predators and their environment.
- They live in nooks and crannies of rocks and materials along the stream bottom.
- They obtain their oxygen through their skin, though some have gills to help obtain oxygen
- Bio indicators of water purity.


golf caddy

MAYFLY

- (Order Ephemeroptera)
  can be found in numerous types of habitats within streams which still have adequate dissolved concentrations
- Two rows of long hairs growing on infornt legs are used for filtering the food particles
- 3 tails
- They eat detritus or algae within the water and obtain their oxygen through gills found along the sides of their abdomens.

Mayfly Adult

Brush-Legged Mayfly Nymph

Mayfly Nymph

WATER PENNY LARVAE

- Water Penny larvae (Order Coleoptera),
- Its being dependent upon food sources from the natural environment, such as leaves, their main food source is algae, which they scrape off rocks.
- Algal growth can increase when there are more nutrient sources within a stream

GROUP 2- WHO CAN LIVE WIDE RANGE OF WATER QUALITY

- **CRANEFLY**
  Cranefly larvae (Order Diptera) are often found in woody or rotting material and in algae along the bottom of streams.
- No legs, worm like body
- Head small, often hidden from view
- Fleshy protrusion at posterior ends
- Most usually breathe through openings at the end of their body called spiracles, but in well-oxygenated water can obtain oxygen through their skin.
- Colour: Brownish white
- Max length- 2 inch

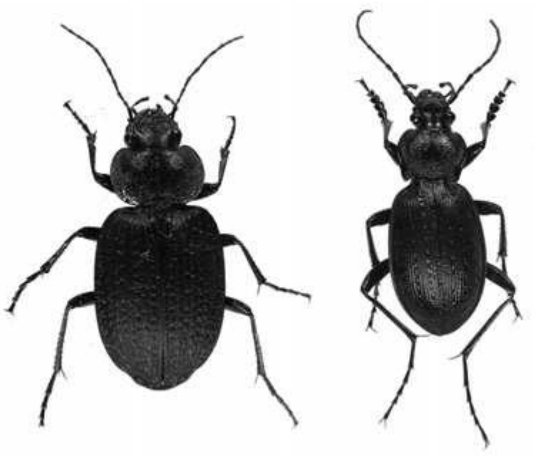
FRESHWATER MUSSEL AND FINGERNAIL CLAM

- Freshwater mussels and Fingernail clams (Order Pelecypoda), are filter-feeders; This makes them susceptible to pollution.

- They can be negatively affected by pollutants that are suspended in the water, which are filtered out as they feed.

BEETLES

- The Order Coleoptera is the largest order of class insecta and plays roles in maintaining soil quality, and contributes to the physical and chemical quality of soil formation.
- They also participate in biological control and biological monitoring of pollution from oil, Sulphur, Carbon dioxide and insecticides.



RIFFLE BEETLE

- Riffle beetles (Order Coleoptera)
- Both juveniles and adults live in the water, while for most organisms included in the index
- They can also be found in vegetated areas of fast flow.
- Larva breathe using gills, while adults use what is called a plastron.
- Body small, adults usually oval
- Legs are long
- Riffle beetles walk slowly underwater they do not swim on the surface

DRAGONFLIES AND DAMSELFLIES

- They are (known collectively as the “Odonata”)
- Having large eyes
- Two pairs of wings pads
- Large round or oval abdomen
- Abdomen terminates in three small point structures
- Prefer still water, often found among vegetation and leaf packs or burrowed in sediments

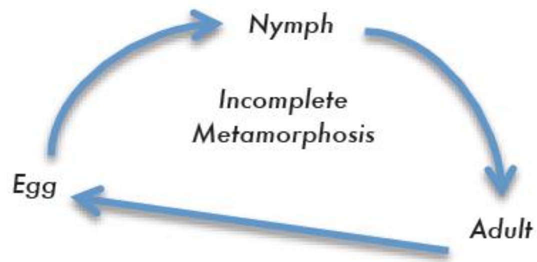


ISOPODS
(sow bugs)

- (Order Isopoda) are scavengers and they are known to eat a variety of plant and animal material
- They are generally found under leaves or other materials in small streams and in some ponds and lakes.
- They obtain most of their oxygen through the thin "skin" on their legs that are attached to their abdomen.

TRUE BUGS (HEMIPTERA)

Life Cycle



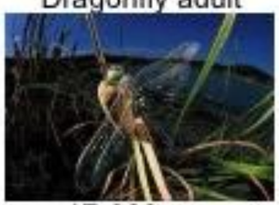
Fly fishing pattern resembling true bugs

Identifying True Bugs
Nymphs and Adults

- piercing mouthparts
- wings appear leathery and cover abdomen
- may confuse with beetle adults

Macroinvertebrate Identification Key

GROUP 2 **TOLERATE SOME POLLUTION**

Dragonfly larva  15-50mm	Damselfly larva  10-50mm	Water beetle larva  2-6mm	Whirligig beetle  3-15mm	Riffle beetle adult  2-4mm
Dragonfly nymph  30-50mm	Damselfly nymph  10-50mm	Water beetle  3-40mm	Whirligig beetle larva  3-12mm	Water strider  10-25mm
Dragonfly adult  17-200mm	Damselfly adult  25-55mm	Backswimmer  5-16mm	Waterboatman  5-16mm	Cranefly larva  10-25mm
Scud (amphipod)  5-21mm	Crayfish  10-150mm	Water scorpion  20-43mm	Sowbug  5-22mm	Freshwater clam  30-270mm

Group 3: Tolerate to pollution (GET O2 FROM AIR)

- **BLACKFLY**
  Blackfly larvae (Order Diptera) live in all types of stream habitats. These bowling pin-shaped organisms are found attached to substrate by their back ends.
- They eat by filtering organic materials from the water with fans that can be outstretched into the water column from their mouth.
- Larvae eat organic debris filtered from water and adult females of many species feed on blood
- It indicates nutrients presence in the water(nitrogen and phosphorous)
- Larvae:

Body shows cylidrical and widest abdomen(having disc)

Head have fan like appendages

OLIGOCHAETA (AQUATIC EARTHWORM)

- Size range: 1-30 mm
- Movement : crawl along bottom of the tray
- Colour: pinikish, light brown
- Similar appearance to the earth worm with bundles of hairs on each segment behind of hairs on each segement behind the first
- Segemented body with ciltellum (swollen, glandular region)

COLLEMBOLANS

- Collembolan are primitive insects that have influence on soil fertility by microbial activity stimulation.
- They are very sensitive to change in soil caused by pollutant such as heavy metals, pesticides and soil acidification in agricultural crops

TUBIFEX

- Tubifex worms are tube builders that eat decaying plant and animal materials, filamentous algae, and diatoms
- They live on or in the substrate of various waterbodies.
- Have hemoglobin in their bodies to hold and supply them with oxygen.
- They may also wiggle their bodies in the water to aerate it, thus helping to make more oxygen available to them.

LEECHES

- Leeches (Class Hirudinea, which has three Orders) are well-known for their interest in sucking blood from warm-blooded organisms,
- Scavengers or predators, not blood-suckers.
- 2cm to 5cm long
- Segmented body, fat tail region
- Undulated swimming pattern
- They obtain their oxygen through their skin, and some have been observed using their suckers to hold onto a solid surface and then undulating their body in the water, likely to aid in respiration.

EPT-index

- Biological: The following live only in unpolluted waters with high levels dissolved oxygen (Barbour et al., 1999)

E- Ephemoptera (Mayfly)

P- Plecoptera (Stonefly)

T- Tricoptera (Caddisfly)

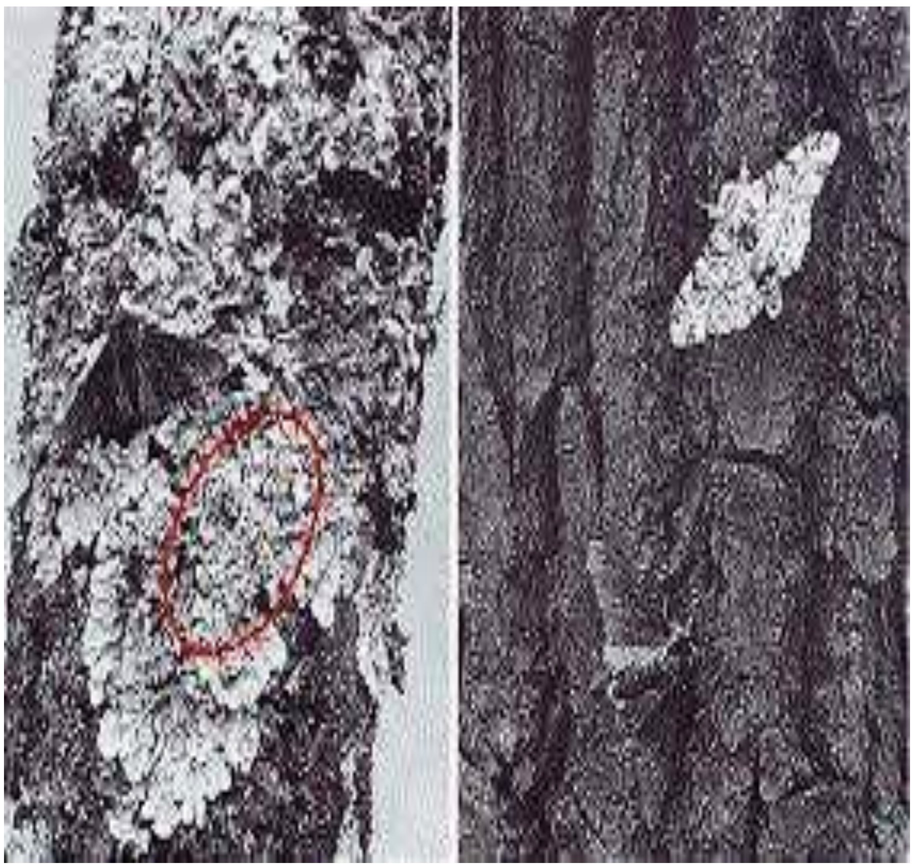
INSECTS AS SOUND POLLUTION INDICATOR

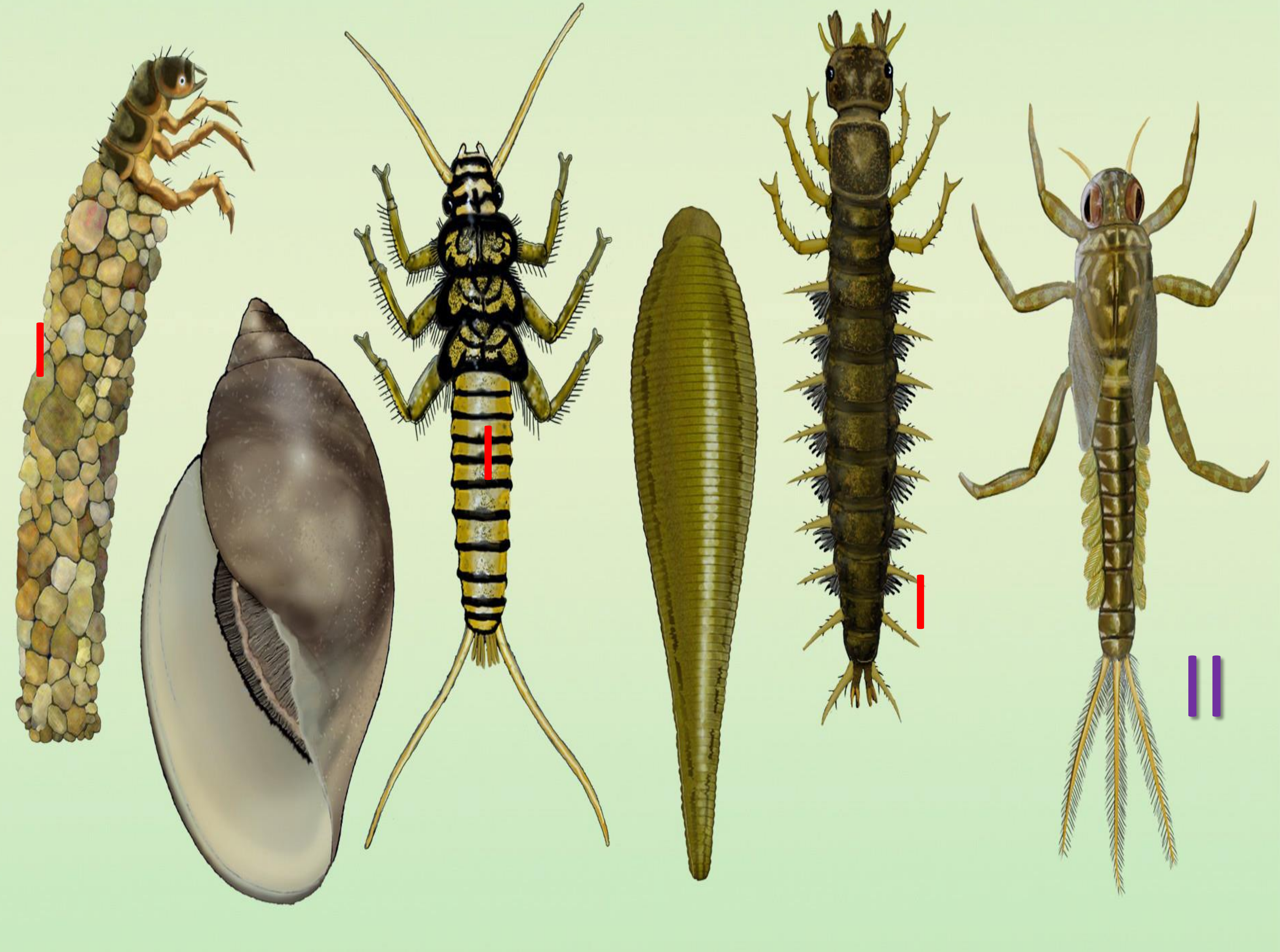
- Sounds are an important part of social insects life history.
- Generally males produce advertisement calls to attract females or to drive out competitive males out of their territory.
- Negative effect of vehicular horns, noise of moving vehicles and other sources suppress the advertisement call of male insects hence destroying their mating cycle and thus decreasing their numbers.
- Sound pollution has extreme negative effect on cicadas, crickets, locusts and grasshoppers mainly.

INSECTS AS INDUSTRIAL POLLUTION INDICATOR

- Unprocessed industrial output, when enters ecosystem leads to a phenomenon called **biomagnification**.
- **Biomagnification** – When a carcinogenic or toxic substance is consumed by primary trophic unit and consequently reached every trophic level in a food chain with increased potency. Thus, hampering the complete system.

- Famous example of effect of Industrial Revolution indicates - moths (*Biston betularia)*





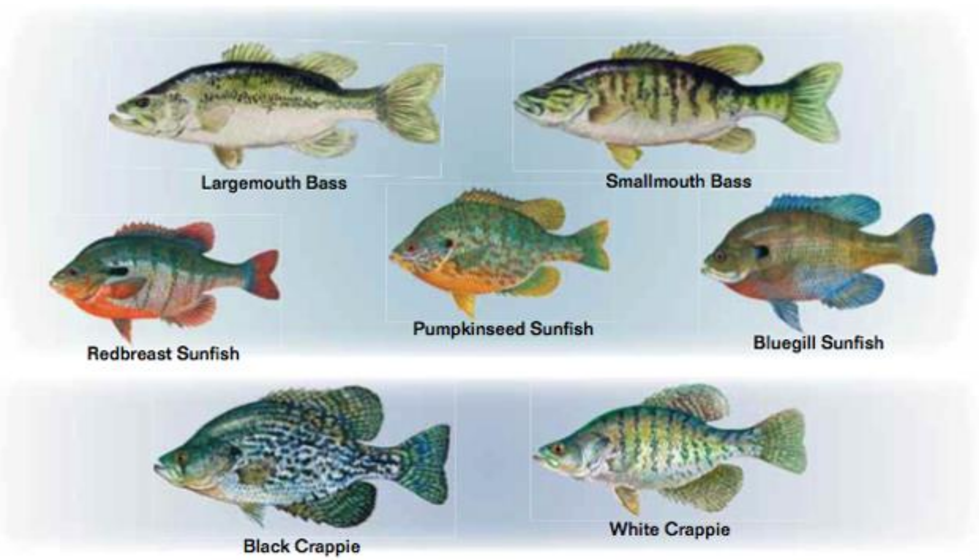
FISH BASED IBI

- NUMBER OF SPECIES OF SUNFISH

These species are particularly sensitive to silting in of pools and loss of in-stream cover.

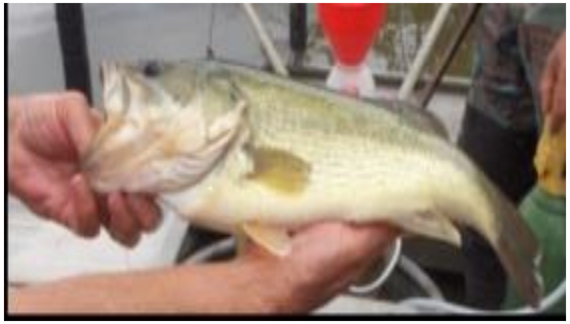
- NUMBER OF SPECIES OF SUCKERS

Suckers are intolerant of chemical and habitat degradation and because they are long lived provide a multiyear perspective



- NUMBER OF INTOLERANT SPECIES

Intolerant species are most affected by stream degradation and therefore would disappear by the time a stream is rated as ‘fair’.



- **PERCENTAGE OF TOLERANT SPECIES**

Tolerant species are present in moderate number but become dominant as stream degrades.

- PERCENTAGES OF OMNIVORES, INSECTIVORES AND PISCIVORES.

The cause of a greater number of omnivores than insectivores is nutrient enrichment.

‹20% of individuals as omnivores as good

›45% of omnivores to be badly degraded

- PERCENTAGE OF SPECIES WITH MULTIPLE AGE GROUPS

Determines reproductive success of the fish population.

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Development and evaluation of fish index of biotic integrity (F-IBI) to assess biological integrity of a tropical lake Veli-Akkulam, South India

UG Abhijna and A Biju Kumar

Abstract
Multimetric index of index of biotic integrity using fish community was developed for the first time in Indian lake using seven candidate fish metrics such as native species richness, native family richness, benthic species richness, water column species richness, % non-native individuals, % tolerant individuals and % herbivores were applied in addition to five original metrics such as intolerant species richness, % omnivores individuals, % top carnivore individuals, total number of individuals and % individuals with anomalies. Tolerant species and non-native individuals were abundantly recorded at Veli-Akkulam Lake mainly at downstream sites where the water quality was highly degraded which is clearly reflected in

value

Category	Metrics	Traditional scoring criteria			Continuous scoring criteria	
		5 (best)	3	1 (worst)	10 (best)	0 (worst)
Taxonomic richness	1. No. of native species	>24	12 to 24	<12	37	0
	2. No. of native families	>12	6 to 12	<6	21	0
Habitat composition	3. No. of benthic species	> 8	5 to 8	<5	14	0
	4. No. of water column species	>12	6 to 12	<6	14	0
	5. No. of intolerant species	>2	2	<2	2	0
	6. % Individual as tolerant species	<18	18 to 36	>36	14	50
Trophic composition	7. % Individual as omnivores	<24	24 to 48	>48	7	50
	8. % Individual as herbivore	>28	14 to 28	<14	37	0
	9. % Individuals as top carnivores	>48	24 to 48	<24	57	0
Fish health and abundance	10. Total no. of individuals	>1200	600 to 1000	<600	1587	0
	11. % Individuals as non-native	<1	1 to 10	>10	0.00	50
	12. % Individuals with anomalies or disease	NA	NA	NA	NA	NA

Open Access

Water Quality Assessment of Valapattanam River Basin in Kerala, India, using Macro-Invertebrates as Biological Indicators

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Water Quality Division, Centre for Water Resources development and Management, Kunnamangalam, Kozhikode-673571, Kerala, India

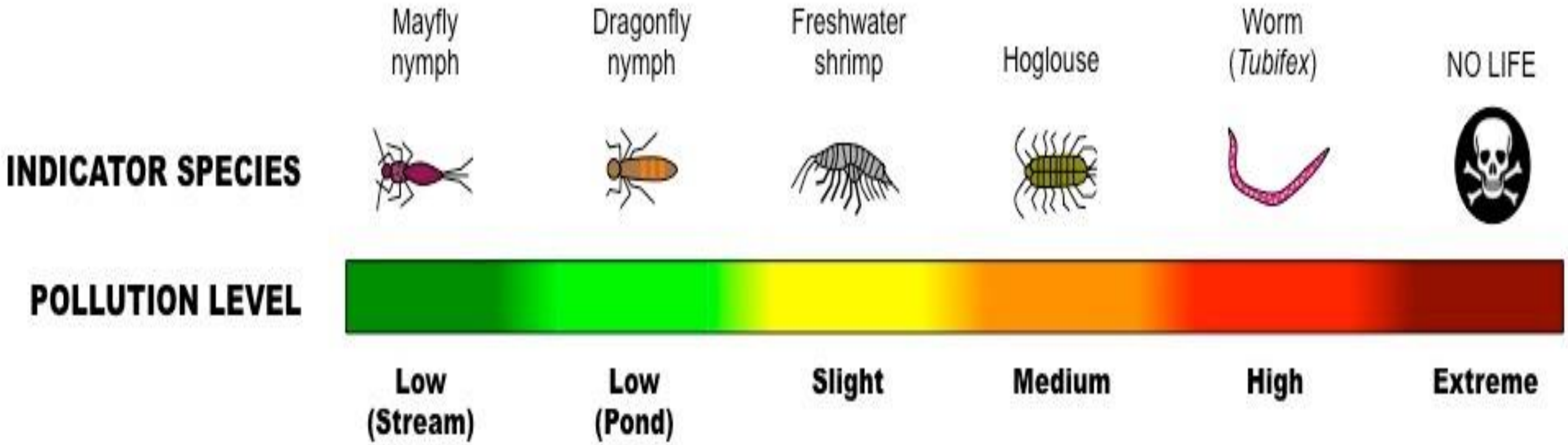
Abstract: Biomonitoring is a valuable assessment tool that is receiving increased use in water quality monitoring programs of all types. The study was to identify the freshwater Benthic Macro-invertebrates and to find out the biological water quality using BWQC developed by Central Pollution Control Board (New Delhi) in Valapattanam River, Kerala originating from Brahmagiri of Western Ghats. A total of 408 individuals belonging to 20 genera and 14 families were collected from the five stations of the River Valapattanam during pre-monsoon, monsoon and post-monsoon periods. *Chironomus sps* a pollution tolerant species were present in most of the stations showing high degree of organic pollution. The downstream stations showed moderate pollution during pre and post monsoon seasons and slight improvement during monsoon. The water quality of the Valapattanam River was deteriorated by sewage effluents and agricultural activities, diminishing the abundance of aquatic insects and macro-invertebrates.

Keywords: Benthic Macro-invertebrates, Biological indicators, Biological monitoring, Biological Water Quality Criteria (BWQC), Pollution.

During the present study were tolerant species according to the Fish Base data and the species were *Dayella malabarica*, *Hyporhamphus xanthopterus*, *Aplocheilus lineatus*, *Eleotris fusca*, *Mastacembelus armatus*, *Parambassis thomassi* and *Pseudosphromenus cupanus*. There was found a decline in the presence of a sensitive/intolerant species, *Anguilla bengalensis bengalensis* and emergence of non-indigenous species *Clarias gariepinus*

INDICATORS SPECIES

- **Indicators species** are sensitive to specific environmental conditions and consequently have a limited range of tolerance
- Their population growth or reduction indicates changes in the environment, making them a useful means of monitoring change
- Tubifex worms are sensitive to concentrations of heavy metals



Indicator species may be sensitive to a number of different environmental conditions:

Mosses: indicate acidic soil

Greasewood: indicates saline soil

Mayfly larva and certain aquatic invertebrates are sensitive to dissolved oxygen levels in water

Where as rat tail maggot can tolerate much lower level oxygen level

Clean water

Stone fly nymph

Freshwater shrimp

Sludge worm

Very polluted water

Lichen

- Lichens are sensitive to the amount of sulphur dioxide, some species more than others.
- The species present and number of different species give clues about **air pollution**.
- Lichens grow slowly, they indicate long-term purity of the air.
- Air pollution is also monitored daily with chemical tests

<u>Animals</u>

- Invertebrate animals are good indicators of **water pollution**. Some can live in very polluted water others can only live in clean water

high pollution

Crusty lichen

Leafy lichen

Shrubby lichen

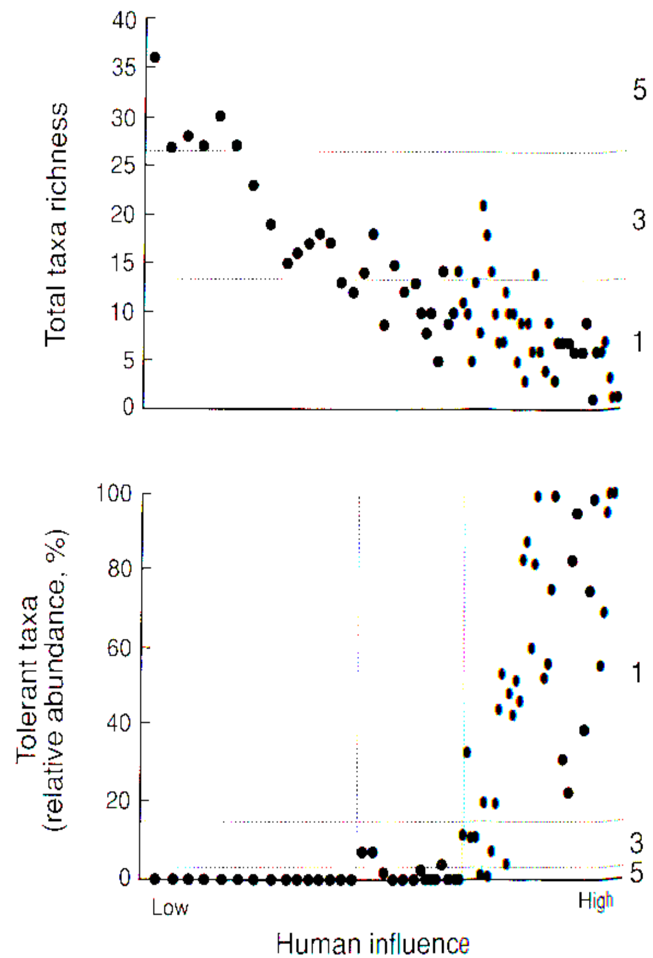
Low pollution

Lichen, along with mosses, are susceptible to air-borne pollutants dissolved in water (e.g. sulfur dioxide)

bushy lichens need really clean air	leafy lichens can survive a small amount of air pollution	crusty lichens can survive in more polluted air	no lichens air is heavily polluted with sulfur dioxide.
			

Benthic Index of Biotic Integrity (B-IBI)

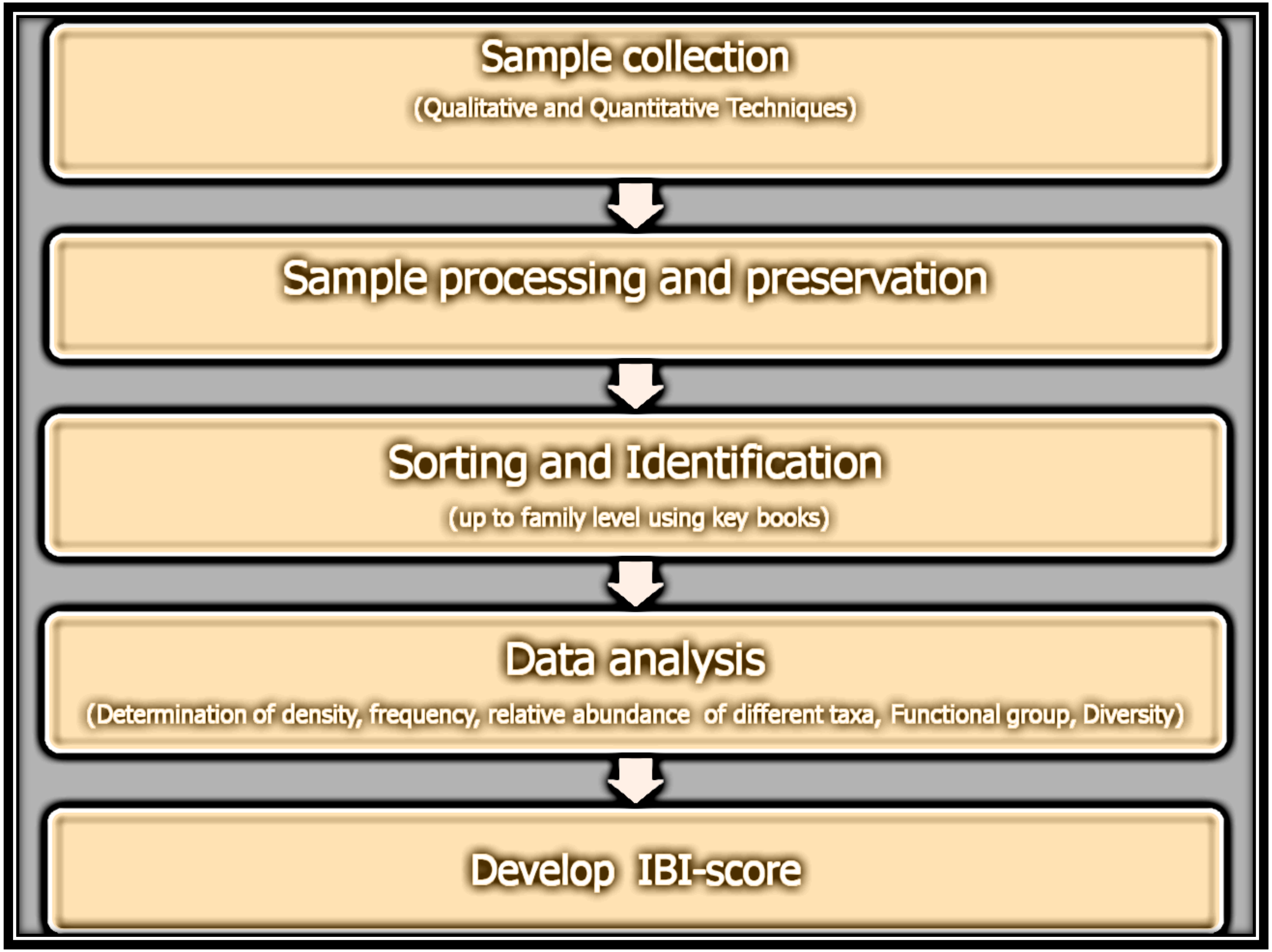
Generalized Plot of B-IBI Scores vs. Human Impact

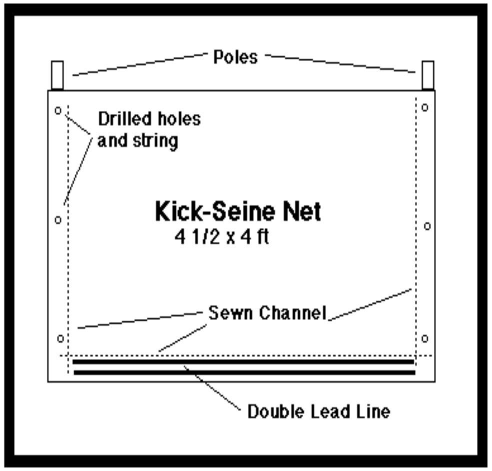


Index based on macro-invertebrates

- A rational or empirical of different measures and/or indicators, generally expressed in conventional units(range- 0-1,0-100)
- E.g – shanon index, environmenta benefits index ,IBI
- Result: Dose-response curves to human impact

A simple process flow chart for IBI of water quality





Time Needed:

Up to 45 minutes

Equipment Needed:

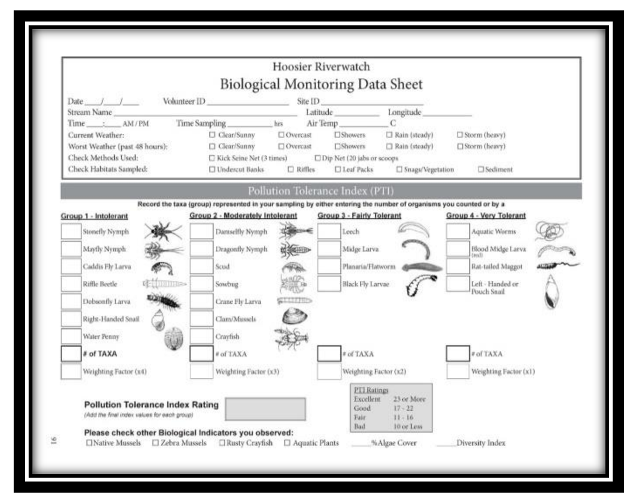
—D-frame kick net
—Two white basins buckets (important to have white background-helps to see the critters)
—White plastic spoons
—White ice cube trays
—Identification keys
—Form to record data
—Pen/pencil

Suggested equipment:

—Magnifying glass
—Tweezers
—Plastic cups
—Hip boots or old shoes
—Latex/plastic gloves

When:

Twice a year (once in spring, once in fall)



Hoosier Riverwatch
Biological Monitoring Data Sheet

Date ___/___/___ Volunteer ID __________ Site ID __________
Stream Name __________ Latitude ______ Longitude ______
Time ___:___ AM / PM Time Sampling ______ hrs Air Temp ______ C
Current Weather: ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)
Worst Weather (past 48 hours): ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)
Check Methods Used: ☐ Kick Seine Net (3 times) ☐ Dip Net (20 jabs or scoops
Check Habitats Sampled: ☐ Undercut Banks ☐ Riffles ☐ Leaf Packs ☐ Snags/Vegetation ☐ Sediment

Pollution Tolerance Index (PTI)

Record the taxa (group) represented in your sampling by either entering the number of organisms you counted or by a

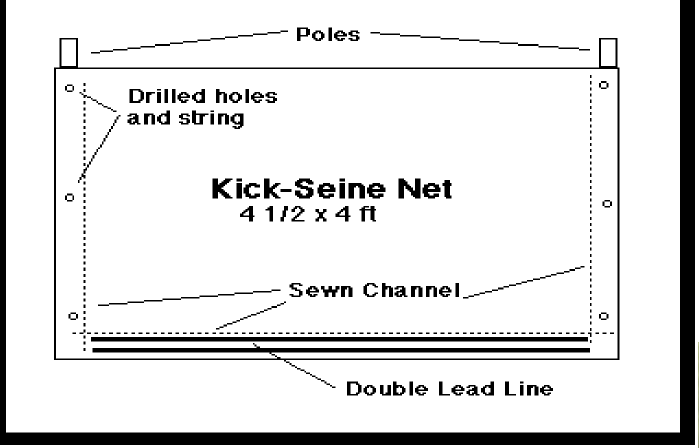
Group 1 - Intolerant	Group 2 - Moderately Intolerant	Group 3 - Fairly Tolerant	Group 4 - Very Tolerant
Stonefly Nymph	Damselfly Nymph	Leech	Aquatic Worms
Mayfly Nymph	Dragonfly Nymph	Midge Larva	Blood Midge Larva (red)
Caddis Fly Larva	Scud	Planaria/Flatworm	Rat-tailed Maggot
Riffle Beetle	Sowbug	Black Fly Larvae	Left - Handed or Pouch Snail
Dobsonfly Larva	Crane Fly Larva		
Right-Handed Snail	Clam/Mussels		
Water Penny	Crayfish		
# of TAXA	# of TAXA	# of TAXA	# of TAXA
Weighting Factor (x4)	Weighting Factor (x3)	Weighting Factor (x2)	Weighting Factor (x1)

Pollution Tolerance Index Rating
(Add the final index values for each group)

PTI Ratings	
Excellent	23 or More
Good	17 - 22
Fair	11 - 16
Bad	10 or Less

Please check other Biological Indicators you observed:
☐ Native Mussels ☐ Zebra Mussels ☐ Rusty Crayfish ☐ Aquatic Plants ____% Algae Cover ____ Diversity Index

16



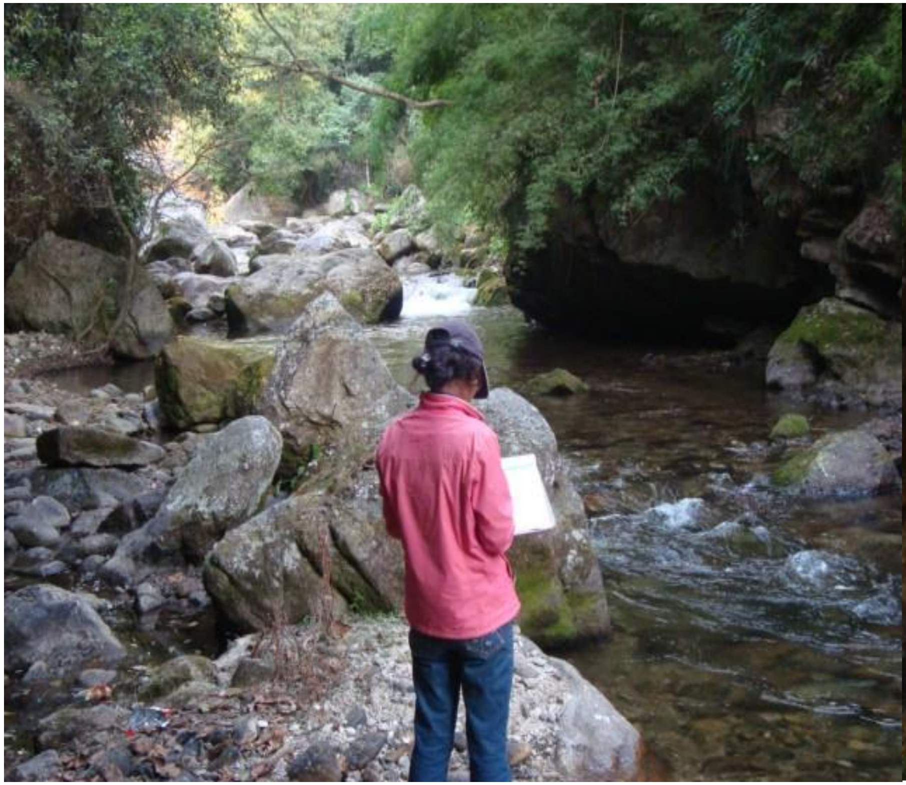
SAMPLING - KICK

1.Qualitative: To find out different taxa (mesh size hand net are used)

2.Quantitative: To find out number of organisms, abundance, density, frequency etc., Grab sampler and Multi-Habitat Sampler(MHS) are used.

Quantitative by Multi-Habitat Sampling (MHS) approach, this includes 20 sampling units taken from all habitat types at the sampling site, each with a share of at least 5 % coverage.

- A total of 20 samples are taken and a single composite sample is prepare.



SAMPLE PROCESSING AND PRESERVATION

- Stirred the sample in water filled bucket and sieve floated animals with net of mesh size 500 micrometer.
- Transferred into plastic bottles.
- Label the bottle with site location and date.
- Preserve at 4% formalin

SORTING AND IDENTIFICATION

After a week of preservation in formaldehyde.

- The sample is washed thoroughly by using mesh size of 0.5mm and kept in white enameled tray.

- Animals visible with necked eyes were picked and kept in various petridishes depending on various morphological forms.

- Finally the animals were identified up to the family level by using the key books.

10 METRICS INVOLVING THE INDEX CALCULATION

- Taxa richness
- Mayfly taxa
- Stonefly taxa
- Caddiesfly taxa
- Long-lived taxa
- In-tolerent taxa
- Tolerent taxa
- Pretators
- Clinger taxa
- % dominance(3 taxa)

A metric is a attribute of the biota that changes – human - disturbance

COMPUTING B.I.B.I SCORE

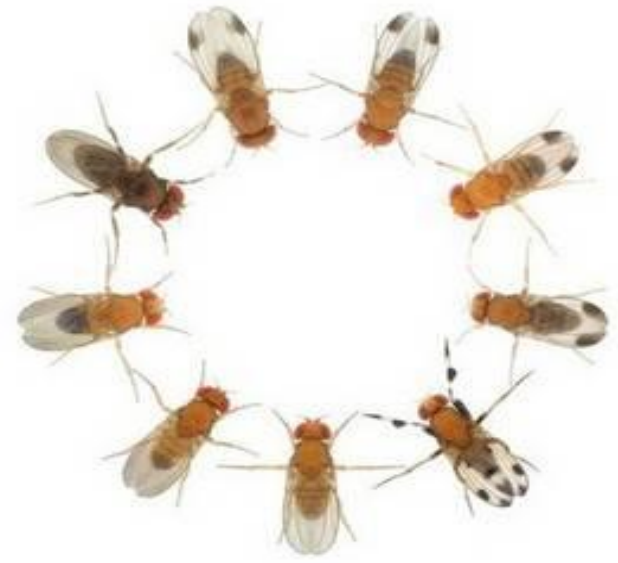
- Eg - Taxa richness (Random sampling- five-sq.m/100m)
- 0-20 taxa = Low (1)
- 21-40 taxa = Medium (3)
- 40+ taxa   = High (5)

- Taxa richness
- May fly taxa
- Stone fly taxa
- Caddies fly taxa
- Long-lived taxa
- In-tolerent taxa
- Tolerent taxa
- Pretator
- Clinger taxa
- % dominance(3 taxa)

- 1 3 5
- 1 3 5
- 1 3 5
- 1 3 5
- 1 3 5
- 1 3 5
- 1 3 5
- 1 3 5
- 1 3 5
- 1 3 5

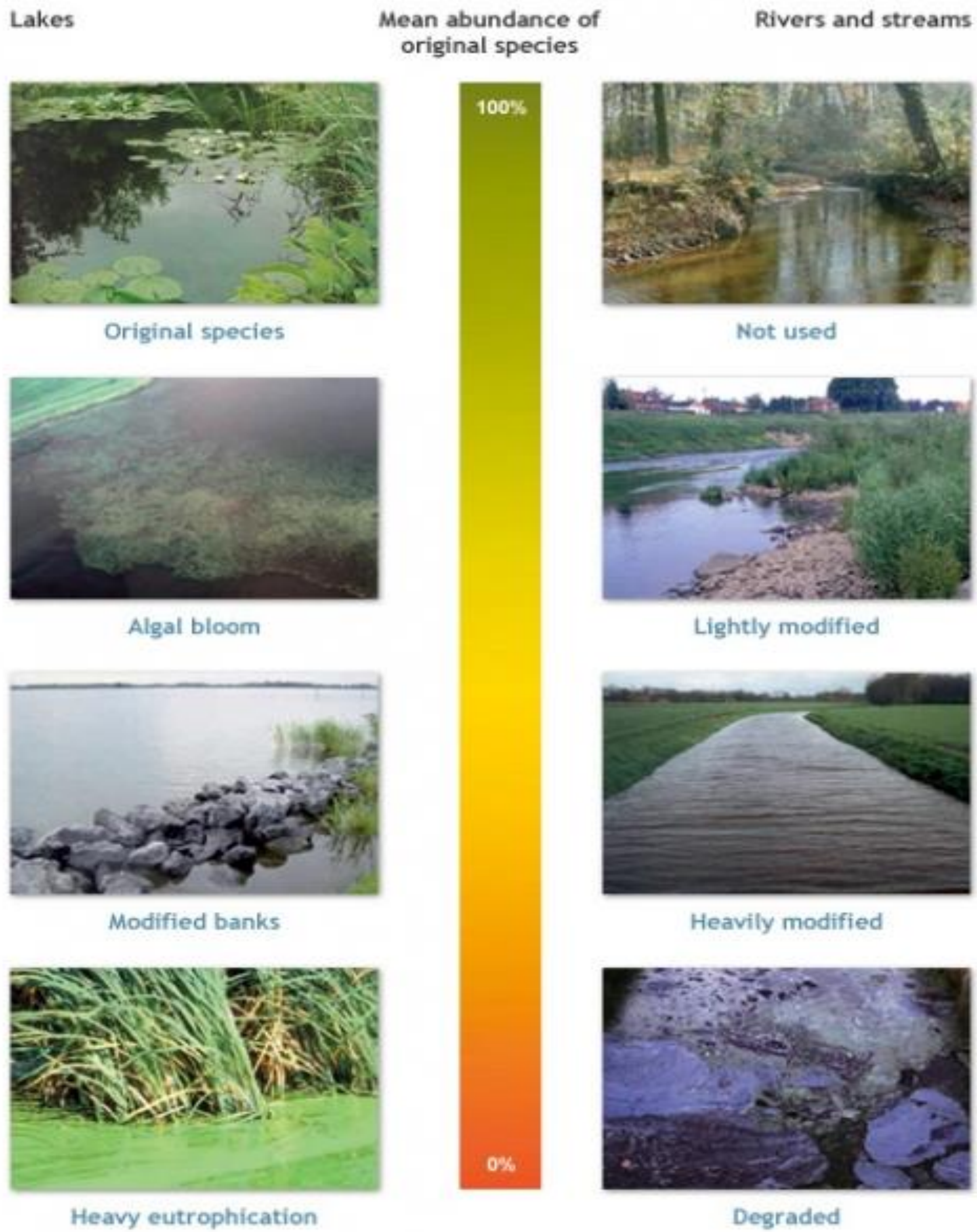
- Taxa richness 3
- Mayfly taxa 5
- Stonefly taxa 3
- Caddies fly taxa 1
- Long lived taxa 1
- In tolerent taxa 3
- Tolerent taxa 1
- Pretator 3
- Clinger taxa 5
- % dominance(3 taxa) 5

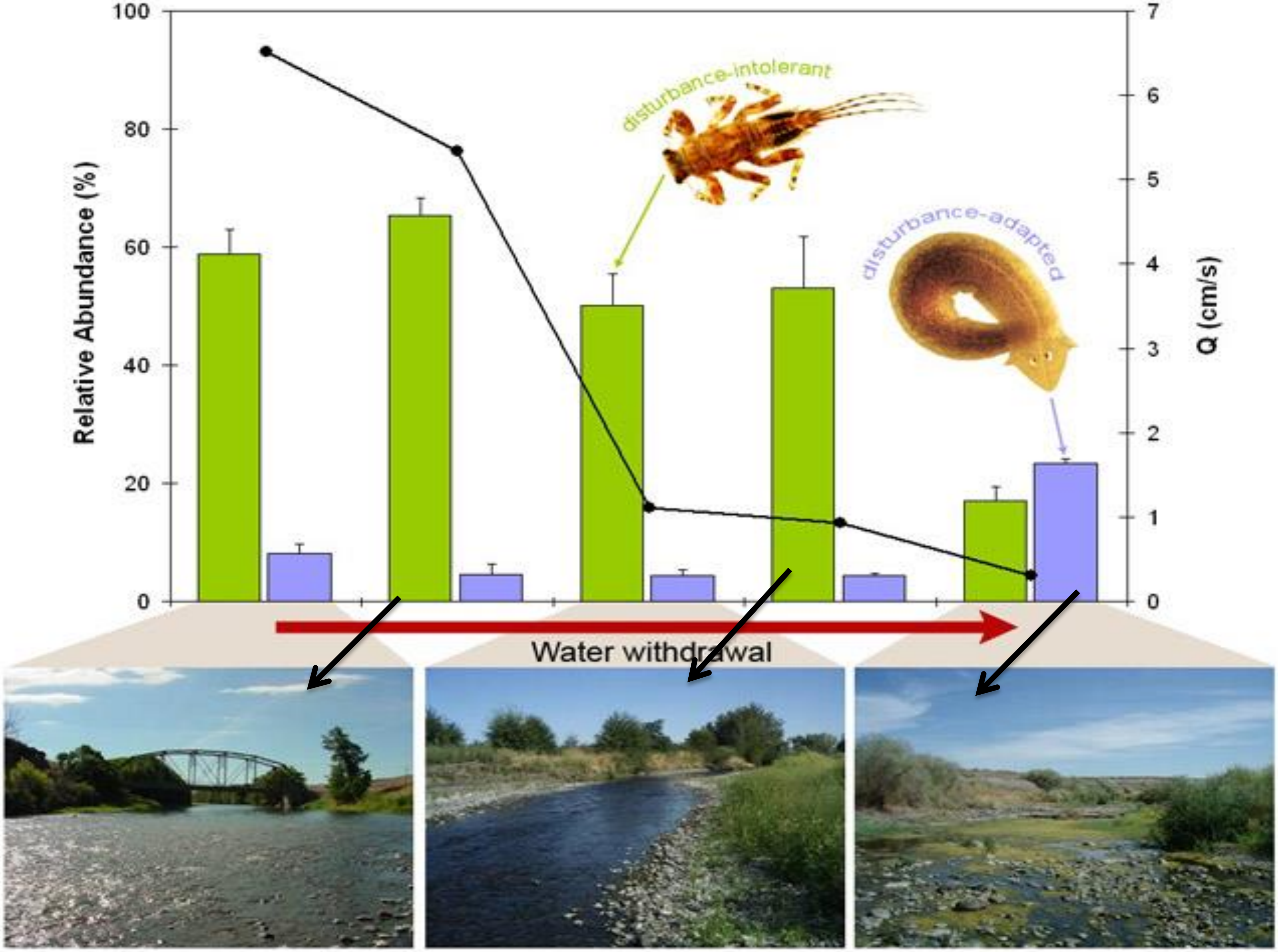
Total 30



Final B.I.B.I

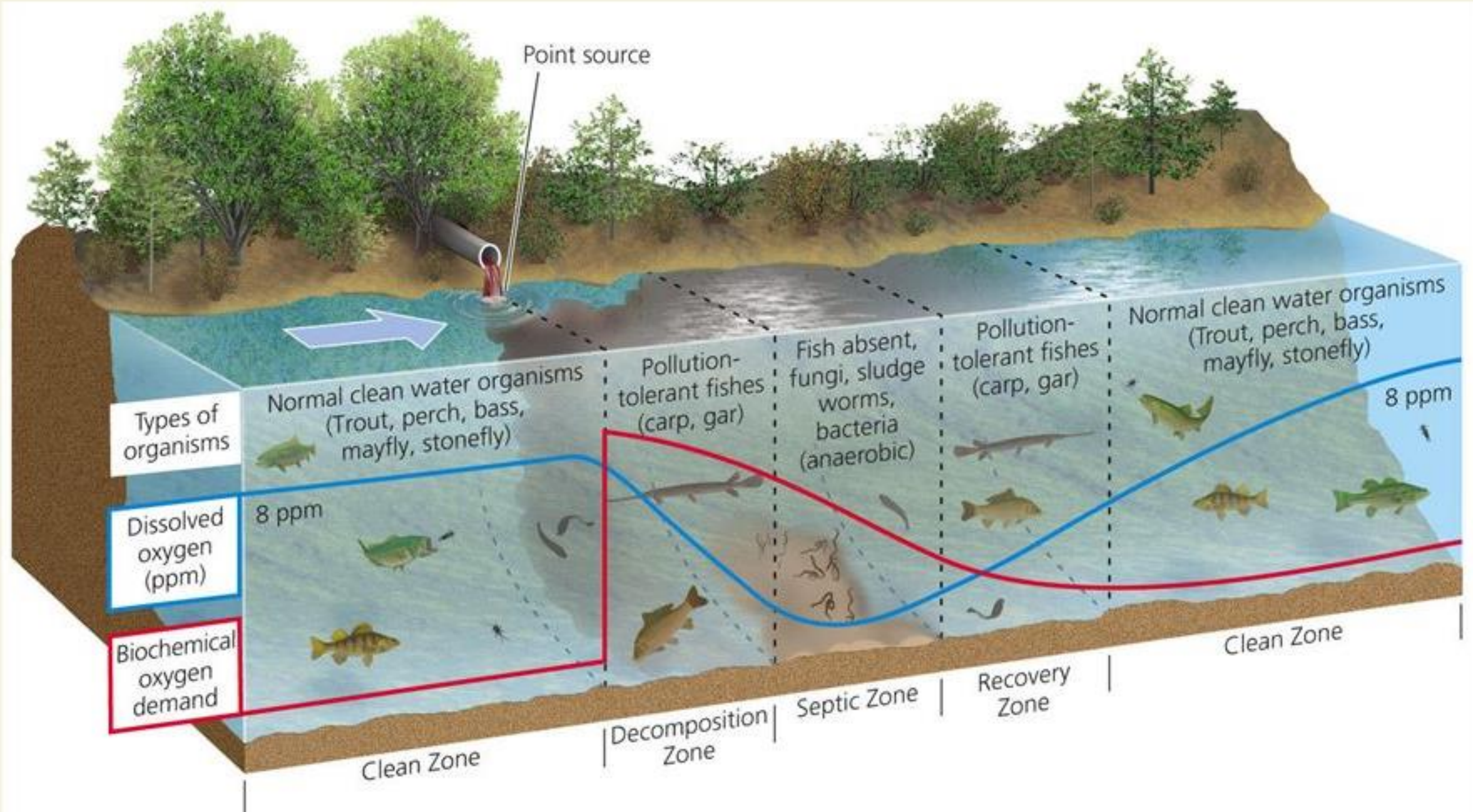
- 10-16 = VERY POOR
- 18-26 = POOR
- 28-36 = FAIR
- 38-44 = GOOD
- 46-50 = EXCELLENT





Relative Abundance (%)
Q (cm/s)
100
80
60
40
20
0
7
6
5
4
3
2
1
0
disturbance-intolerant
disturbance-adapted
Water withdrawal

Dilution and Decay of Degradable, Oxygen-Demanding Wastes in a Stream



Hoosier Riverwatch

Biological Monitoring Data Sheet

Date ____/____/____ Volunteer ID ____________________ Site ID _________________________

Stream Name ____ Latitude ___________ Longitude ____________

Time ____:____ AM / PM Time Sampling ___________ hrs Air Temp ____________ C

Current Weather: ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

Worst Weather (past 48 hours): ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

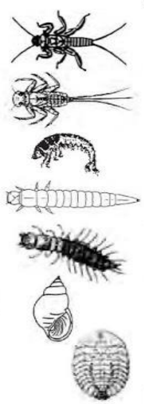
Check Methods Used: ☐ Kick Seine Net (3 times) ☐ Dip Net (20 jabs or scoops

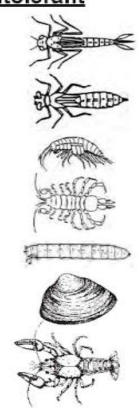
Check Habitats Sampled: ☐ Undercut Banks ☐ Riffles ☐ Leaf Packs ☐ Snags/Vegetation ☐ Sediment

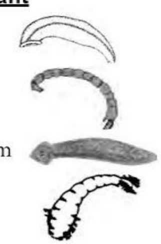
Pollution Tolerance Index (PTI)

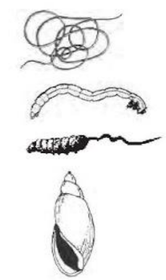
Record the taxa (group) represented in your sampling by either entering the number of organisms you counted or by a

Group 1 - Intolerant	Group 2 - Moderately Intolerant	Group 3 - Fairly Tolerant	Group 4 - Very Tolerant
☐ Stonefly Nymph	☐ Damselfly Nymph	☐ Leech	☐ Aquatic Worms
☐ Mayfly Nymph	☐ Dragonfly Nymph	☐ Midge Larva	☐ Blood Midge Larva (red)
☐ Caddis Fly Larva	☐ Scud	☐ Planaria/Flatworm	☐ Rat-tailed Maggot
☐ Riffle Beetle	☐ Sowbug	☐ Black Fly Larvae	☐ Left - Handed or Pouch Snail
☐ Dobsonfly Larva	☐ Crane Fly Larva		
☐ Right-Handed Snail	☐ Clam/Mussels		
☐ Water Penny	☐ Crayfish		
☐ **# of TAXA**	☐ # of TAXA	☐ # of TAXA	☐ # of TAXA
☐ Weighting Factor (x4)	☐ Weighting Factor (x3)	☐ Weighting Factor (x2)	☐ Weighting Factor (x1)









Pollution Tolerance Index Rating ☐

(Add the final index values for each group)

PTI Ratings	
Excellent	23 or More
Good	17 - 22
Fair	11 - 16
Bad	10 or Less

Please check other Biological Indicators you observed:

☐ Native Mussels ☐ Zebra Mussels ☐ Rusty Crayfish ☐ Aquatic Plants _____%Algae Cover _____Diversity Index

SUMMARY

- A parameter with predictable and empherical patterns when plotted against a gradient of human disturbances
- IBI = sum of metric scores
- Reference sites should be re-evaluated periodically
- Thresholds should be revisited occasionally or with specific regularity
- Should not be an one time process, particularly if overall condition improves overtime
- Since benthic macro invertebrates retain (bio-accumulate) toxic substance, chemical analysis will allow detection in them where levels are undetectable in the water resources

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Thank You