

What Stable Isotopes Tell Us About Elwha Ecosystem Restoration

Stable isotopes are.....different forms of the same element but with different numbers of protons?

For instance C can have 15 or 14

Nitrogen can have 13 or

Different sources of C and N have different ratios of protons

A higher ratio of heavier to lighter sources is considered "enriched"

Marine sources of C and N are isotopically heavier than freshwater or terrestrial sources

Ratios of heavier to lighter isotopes are often used as natural tracers to determine

Because most salmon are anadromous (are born in freshwater, spend most of their life in the ocean, but return to spawn in their birth waters) Carbon (C) and Nitrogen (N) isotope ratios of their flesh changes over time

Young salmon out-migrating to the sea have relatively low ratios of C and N when they leave the Elwha. At sea, they put on (95%?) of their body mass. By consuming food sources of heavier C and N, their flesh also becomes enriched. You are what you eat.

When they return to their natal (birth) waters on the Elwha to spawn, their flesh contains higher C and N ratios thanwhat, anything else around?

These changes in C and N ratios can be used to trace the transfer of salmon nutrients throughout the Elwha food web

When their flesh, gametes (eggs and milt), or even just the dissolved nutrients released from their bodies is taken up or consumed by freshwater and terrestrial organisms, their isotopic ratio also goes up.....**You Are What You Eat**

By measuring changes in C and N isotopes in different organisms in the Elwha relative to the presence and absence of spawning adult salmon, we can trace where salmon nutrients go when they return to their natal waters to spawn.

Migratory salmon are a central part of the Elwha food web, sustaining human life also consumed by dozens of mammals and bird species, hundreds of invertebrate and plant species, and unknown numbers of microbes (bacteria, fungi, ??)

This nutrient transfer occurs from the headwaters to the ocean

From the river to the riparian zone to the uplands

And even beneath the river in the secret hyporheic zone

When adult salmon return from the ocean to spawn in their natal Elwha waters, they carry more of the heavier isotopes back into the freshwater

These heavier isotopes are released into the Elwha by gametes, decaying bodies, etc.

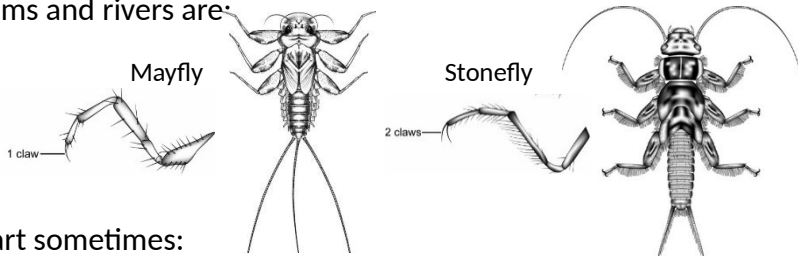
By measuring the ratios of heavy to light isotopes in different organisms, we can trace how salmon nutrients are being used across the entire Elwha food web

Benthic Macroinvertebrates (BMI) - The Basics

Benthic = bottom-dwelling, Macro = large (visible to the naked eye), Invertebrate = no backbone

There are **hundreds** of different species of BMI in the Elwha Watershed alone.

- BMI are important food source for fish and other animals, and play a big role in nutrient cycling.
- The most common and diverse types of BMI in streams and rivers are insects.
- Most aquatic insects spend their larval (immature) stage in water and their adult stage on land.
- The most common types of insects in streams and rivers are:
 - Mayflies (Order Ephemeroptera)
 - Stoneflies (Order Plecoptera)
 - Caddisflies (Order Trichoptera)
 - True Flies (Order Diptera)



Mayflies and stoneflies can be hard to tell apart sometimes:

- both have sclerotized bodies (hardened and shiny like a beetle)
- both have three sets of segmented legs on their thorax (chest) and long tails (called cerci), but
- mayflies always have one claw at the end of each leg, while stoneflies have two
- mayflies can have two or three cerci, while stoneflies always have two
- mayflies have leaf-like gills along their abdomens (belly); while stoneflies have finger-like gills on their thorax (chest) or none at all

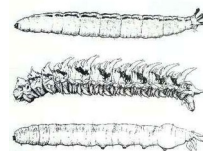


Caddisflies

- also have three sets of segmented legs (not always as obvious as on mayflies and stoneflies)
- head and part of thorax are sclerotized; abdomen is fleshy and more worm-like
- instead of cerci, caddisfly have "anal prolegs" (hooks at the end of their abdomen)
- often (but not always) live inside cases built of rock or plant material

True flies are soft-bodied

- never have three sets segmented legs
- may have one set of small prolegs or multiple fleshy suckers along body
- usually have a distinct head capsule (but sometimes difficult to make out)
- this order is very diverse in appearance but usually look worm-like



BMI's have varied body types and also different life-history strategies (ways of making a living)

- They are often classified into different "Functional Feeding Groups" such as:
 - Grazers - use their specialized mouth parts to scrape off algae from rocks
 - Shredders - tear apart leaves and other organic material into smaller particles
 - Collectors - dart along the river bottom collecting small particles of food
 - Filterers - similar to collectors but use a web or mouth parts to filters particles from water
 - Predators - eat all or some of the above - rawrrrr!

Other important differences between types of BMI's:

- Life-spans - some BMI's complete multiple life cycles in a year while others live for multiple years
- Sensitivity - BMI's vary widely in how much they can tolerate different types of disturbance

Researchers on the Elwha have been studying how the total numbers and types of BMI have changed before, during, and after dam removal. This information helps us better understand the ways dams impact rivers and how these ecosystems recover when dams are removed

Common name: “Little Green Stoneflies”

Scientific Name: Order = Plecoptera, Family = Chloroperlidae

How to tell it's a stonefly (Order Plecoptera)

- Sclerotized body (hardened and shiny like a beetle)
- Two long thick antennae
- Three sets of segmented legs
- Two claws at end of each leg
- Two segmented tails (NEVER three)
- No leaf-like gills along the abdomen (may have finger-like gills on thorax)



How to tell it's a Green Stonefly (Family: Chloroperlidae)

- Slender yellow/tan body, not patterned
- Younger instars may be very pale
- Fairly small (typical range is 7-12 mm long)
- No gills anywhere on the body
- Body may be covered with fine hairs
- Tails are shorter than the abdomen
- Relatively short legs

Fun facts

- Sensitive to human disturbance
- Predators



Where to find them

- Live under and between rocks, unlikely to find just by picking up a rock
- Pick these out of kick or Surber net sample collected in a riffle

Common name: “Flat-headed Mayflies”

Scientific Name: Order = Ephemeroptera, Family = Heptageniidae

How to tell it's a mayfly (Order Ephemeroptera)

- Sclerotized body (hardened and shiny like a beetle)
- Three sets of jointed legs
- One claw at end of each leg
- Two or three segmented tails
- Abdominal segments with gills

Family: Heptageniidae

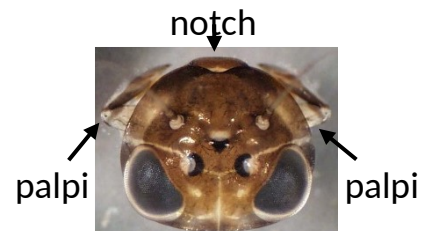
- Head is the widest part of the body
- Head and body flattened like a pancake
- Eyes pointed upward (dorsally)
- Outspread legs
- Plate-like gills along abdomen
- Range in size from small to medium

Where to find them

- Clinging to the surfaces of rocks
- Sucked onto the sides of your collection buckets]
- Swim poorly in collection tray in odd flopping motion

Fun facts

- These mayflies use their gills like a suction cup to attach to the surface of rocks
- They use their specialized mouthparts to scrape algae off rocks, like little cows!



Common name: "Green Rock Worm"

Order: Trichoptera

- Sclerotized (shiny) head, legs, some thorax
- Abdomen unsclerotized
- Three sets of thoracic legs (on chest)
- Anal prolegs that end in a single hook

Family: Rhyacophilidae

- Thick body with small head
- Second and third thoracic plate completely fleshy or only with small sclerotized plates
- Abdomen with deep constrictions between segments
- Anal prolegs long, largely free of abdomen (belly)
- Abdominal segment 9 with shiny dorsal plate
- Greenish, pink, or purplish - never bright white



Where to Find Them

- On top of rocks, clinging to the sides of your net
- Free-living (don't build cases)

Fun facts

- Very diverse-looking: bodies can be green, pink, or purple but never white
- Fierce predators!



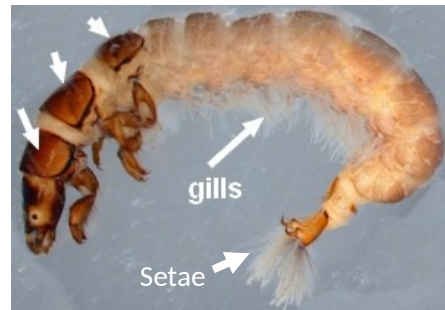
Common name: "Net spinner Caddisfly"

Order: Trichoptera

- Sclerotized (shiny) head, legs, and some thorax
- Abdomen unsclerotized (fleshy)
- Three sets of thoracic legs
- Anal prolegs that end in a single hook

Family: Hydropsychidae

- Three thoracic segments covered dorsally with well-developed sclerotized plates
- Abdomen with branched gills and scattered hairs
- Tuft of long setae at tip of each anal proleg
- Body generally curved



Where to Find Them

- On top of rocks
- Free-living (don't build cases) but make "retreats" (sloppy-looking tents)

Fun facts

- At one end of retreat they spin a web like a spider to collect food in the current
- Males are territorial and emit high-pitched "screches" at each other underwater



Common name: "Black Fly"

Order: Diptera

- Thorax lacks three sets of jointed legs

Family: Simuliidae

- Very small bodies shaped like bowling pins
- Sclerotized head external and clearly visible
- Head with fan shaped mouthparts
- Single proleg just below head
- Ring of tiny hooks on posterior end
- Typically 3-8 mm



Hooks

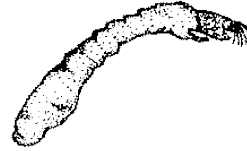


Where to Find Them

- In colonies on the leading edges of rocks in fast-flowing water

Fun facts

- Use their mustache fans to filter food out of the water column
- Use their anal hooks to attach to rocks
- Move like an inch-worm in the sampling tray
- Excrete sticky silk similar to spiders that makes them hard to remove from your forceps/paint brushes



Aquatic insects take many different shapes and sizes, but all have
Describe basic morphology (head, thorax, abdomen) – include schematic

- Some spend their entire life in water (e.g., water striders, water beetles)
- Others have a pupal stage (chrysalis) like a caterpillar/butterfly.

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- Anal prolegs long, largely free of last abdominal segment
- Abdominal segment 9 with dorsal plate
- Greenish, pink, or purplish - never bright white



Genus: Rhyacophila

- Without dense tufts of stout gills on each side of thorax and abdominal segments 1-8.
- Very diverse genus



Order: Ephemeroptera

- Sclerotized body
- Three sets of jointed legs
- Two or three segmented tails
- Abdominal segments with gills
- One claw at end of each leg



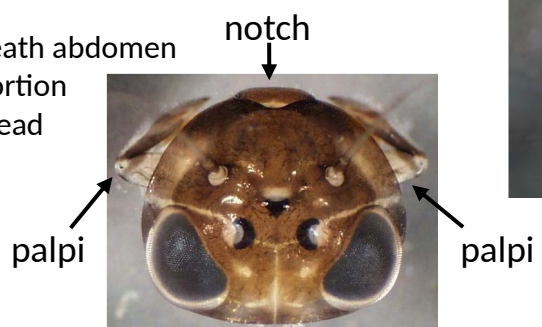
Family: Heptageniidae

- Body flattened, outspread legs
- Eyes pointed upward (dorsally)
- Gills on abdominal segments 1-7 platelike



Genus: Cinygmula

- Gills similar in size, do not meet beneath abdomen
- Gills do not have fibrilliform (frilly) portion
- Maxillary palpi protrude at sides of head
- Small notch in front margin of head



Order: Diptera

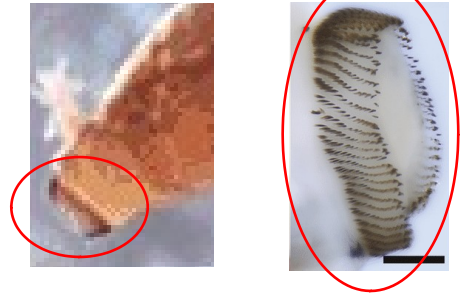
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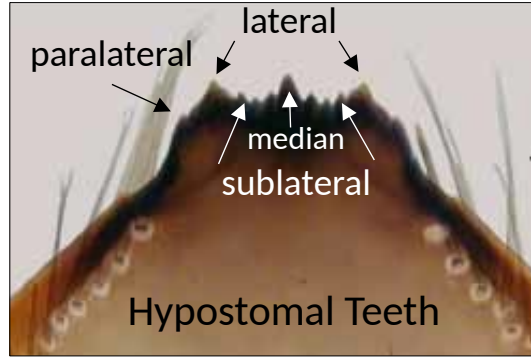
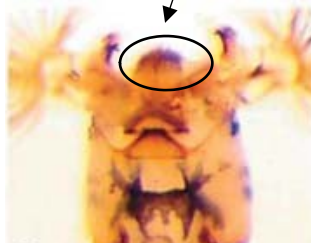


Genus: Simulium

- Head with fan shaped mouthparts
- Body pigmented
- Antenna never transparent with dark brown tip
- Hypostoma with paralateral teeth
- Hypostoma with median tooth taller than lateral teeth; sublateral teeth shorter than median and lateral teeth



Hypostoma



Order: Plecoptera

- Sclerotized body
- Three sets of jointed legs
- Two segmented tails
- Two claws at end of each leg

Family: Capniidae

- Slender light-colored body
- Long tails and antennae
- No visible gills
- Glossa and paraglossa ~ same length
- Wing pads long and narrow, essentially parallel to body
- Extended hindlegs reach far short of end of abdomen
- Membranous pleural folds on abdominal sternum 1-9
- Metathoracic wingpads about as wide as long, reduced, or absent
- Abdominal usually widest posteriorly



Order: Diptera

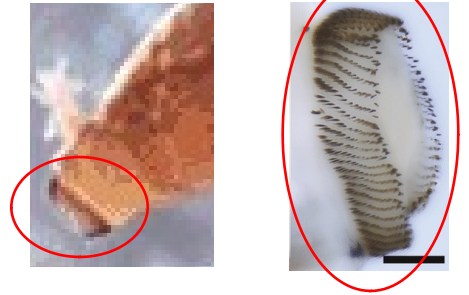
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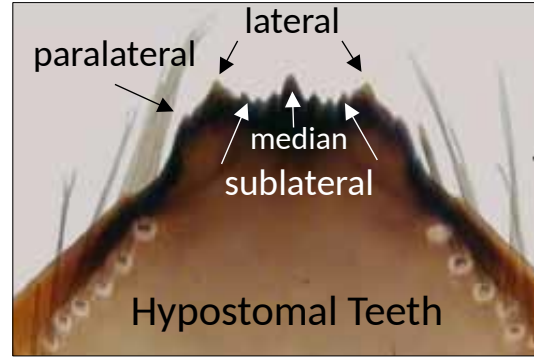
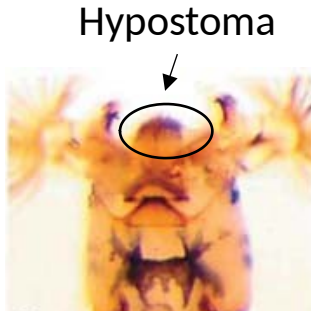


Hooks



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