RIVERS AND SALMON IN BC

BC has amazing diversity of freshwater habitats. Some of these rivers are arguably among the most pristine large river systems in the world. Reflecting the geographical diversity of the province, rivers in BC come in many shapes, sizes, and forms.

Hydrograph—the seasonal pattern of discharge in a river.

You can learn a lot about a river by knowing about where it gets most of its water. Not surprisingly, the dominant water source depends on the location of the river in BC, driven by gradients of distance from the ocean and latitude.

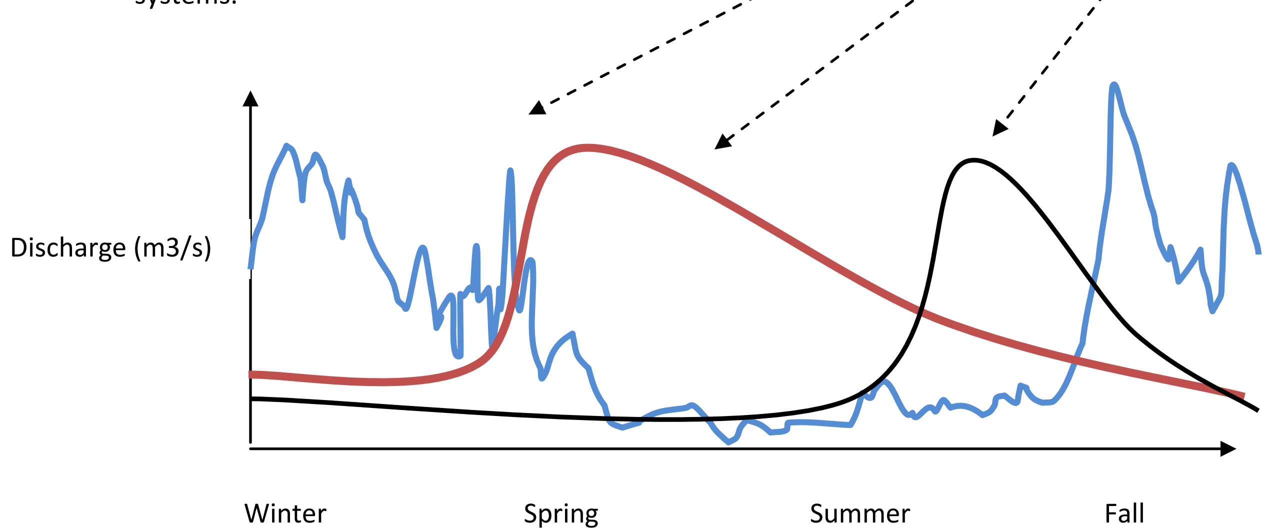
1. **Glacial**—generally are northern rivers. These rivers drain large glaciers. Not surprisingly, these rivers have the most flow towards the end summer during the hottest months. These rivers often have enormous sediment load and are really turbid, moving the sediments that were trapped and deposited by the glacier. They are also cold.

2. **Rainfall**—usually are coastal rivers. These systems are often fairly flashy, responding rapidly to a rain event. Without any storage of water in the form of snow, they can often get to very low flows during the summer when there is no rain.

3. **Snow melt**—often are interior rivers. These systems have highest flows during the spring or summer snow melt. This creates rivers that are often surprisingly cold and big during the warmest months of the year. Snow melt can allow rivers to maintain flow during the summer.

4. **Hybrid**—most rivers in BC are a mix, with a high-water period in the spring due to snow-melt and a high-water period in the fall due to the onset of the winter rains.

Below is a cartoon of three theoretical hydrographs of a **rainfall**, **snow-melt**, and **glacially** dominated systems.



The hydrograph sets the seasonality of rivers for both abiotic (non-living) and biotic (plant, animal, etc) dynamics.

The *phenology* (timing of life-history events) of stream plants and animals is often adapted to river hydrographs.

Timing of emergence—e.g., aquatic insects

Timing of seed release—e.g., cottonwoods

Timing of migration—e.g., salmon

PACIFIC SALMON AND RIVERS

Salmon evolved in the dynamic rivers that flow into the Pacific Ocean. The term *Pacific salmon* refers to species that are anadromous and are in the *Oncorhynchus* genus.

- Genus: *Oncorhynchus*
- Family: Salmonidae

Economic value

Commercial landings $390 million per year (1992 – 2001).

LIFE-HISTORY

Anadromy—when an individual is born in freshwaters, migrates to the ocean to grow large, and then migrates back to freshwaters to spawn. This life-history strategy is thought to have evolved to take advantage of the relatively predator-free freshwaters for the vulnerable life-stages (eggs/fry/parr) as well as the better growing conditions of the ocean. There are non-anadromous versions of salmonids, such as rainbow trout vs. steelhead and kokanee salmon vs. sockeye

Homing—salmon almost invariably return to spawn to the site where they were spawned. This has important consequences for salmon, such as strong local adaptations and population differentiation. However, there are often some small frequency of *straying*, individuals that go to different habitat, perhaps a bet-hedging strategy by the mother.

Semelparous—When an individual dies after spawning. Many salmon species are semelparous. This allows salmon to put everything into spawning (large eggs), and not save anything for the journey back out. Steelhead trout are not semelparous, instead they are *iteroparous*, having the ability to reproduce in multiple years. .

Stream-type vs. Ocean-type—many species have juveniles that either go out to the ocean early after they emerge (ocean-type) and other life-history that rear in streams or rivers for 1+ years (stream-type).

SPECIES DIVERSITY

Some of the West coast salmon species:

Steelhead—(*Oncorhynchus mykiss*) Anadromous version of rainbow trout. Anadromous and iteroparous. This species has incredible flexibility in their life-history.

Chinook (aka King or Tyee)—(*Oncorhynchus tshawytscha*). Largest of the Pacific salmon. Least abundant of the five semelparous salmon. Spawners can either be olive or maroon and black gums.

Coho (aka Silvers)—(*Oncorhynchus kisutch*). Spawn in small streams with moderate gradient along the coast. Spawners often have maroon/red sides and the males have exaggerated hooked noses. Spawners are ~ 2-5 kg.

Sockeye (aka Reds or Kokanee for the land-locked version)—(*O. nerka*). Bright red with green heads. Sockeye juveniles generally rear in lakes, so this species is dependent on connections between river and lake ecosystems. Second most abundant salmon species. Farthest migration of this species is 1600 km to Redfish Lake. Mature at 2-4 kg.

Chum (aka Dog or Keta)—(*O. keta*). Spawners are greenish, with white tips on fins, and vertical stripes. Generally spawn in lower reaches of rivers. All are anadromous and semelparous. Spawners are 3-6 kg.

Pink (aka Humpies or Humpback)—(*O. gorbuscha*). Males have exaggerated hump, often with dark brown backs and white bellies. Smallest of the Pacific salmon (~2 kg). Often spawn in low gradient coastal streams with smaller sediment. They mature at 2 years old. Most abundant salmon species. Are semelparous.

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IMPACTS OF SALMON ON FRESHWATERS

- Salmon are large and can reach extraordinarily high densities on spawning grounds relative to the size of the constrained freshwaters where they spawn.
- This is probably a function of their anadromous and semelparous life-history.
- Due to these high densities and sizes, salmon can have important impacts on coastal ecosystems.
- This has raised concerns that salmon population losses have had substantial ecosystem consequences.

Ecosystem engineering—Salmon, during digging their nests, physically modify stream ecosystems. Thus, they are an example of a ecosystem engineer.

Salmon nest-digging

- Physically shapes streams

- Exports fine sediments and nutrients

- Is a disturbance of benthic stream algae and invertebrates (reduces their abundance).

Salmon-derived nutrients

Salmon act as a "conveyor belt" of nutrients from the ocean to confined freshwaters. The adults bring back in more nutrients than their offspring. What about steelhead?

- Salmon-derived nutrients are dispersed to riparian areas via several pathways
    - Biotic
        - Direct (grizzly dragging carcass up into riparian area)
        - Indirect (grizzly excreting urea from salmon into riparian area)
    - Abiotic
        - Hyporheic flow transports dissolved nutrients
        - Floods deposit carcasses into floodplains

- The impacts of salmon-derived nutrients are fairly controversial and seem context-dependent.
    - Experiments that have experimentally added carcasses often see increased algal growth.
        - But these experiments don’t include ecosystem engineering impacts of salmon.
    - Paleolimnology studies have found that salmon population declines are associated with declines in primary productivity.
    - Direct consumption of salmon nutrients is probably important for growth of a variety of consumers (such as grizzly bears and rainbow trout).
    - Scientists have suggested that salmon declines have caused a “cultural oligotrophication” of coastal North America. Furthermore, there has been a suggested feedback loop for salmon populations, where nutrients from the parents increase future salmon production. To replace these nutrients, there have been many artificial fertilization attempts.