General thesis ideas that need to be rearranged:

From spatial chapter, some needs moving to intro chapter:

Pacific salmon species have complex life history strategies that can impact survival from smolts to adults, and species interactions during the early marine phase are still not well understood (\*). Pink salmon are the smallest smolts to begin the marine migration (as small as 0.2 g \*), due to their short, obligate life cycle of two years. Chum salmon are the second smallest species when leaving freshwater habitats, with various amounts of time spent rearing in estuaries (\*). Smaller salmon smolts are often the most vulnerable to predators and require sufficient food resources to grow to a critical size during this period to survive their first winter in the ocean (\*). Salmon growth during the early marine period has been shown to affect adult survival in all five species of Pacific salmon (\*), therefore, prey quality and quantity are crucial. The variability in early marine growth of different species and stocks of salmon make predicting adult returns challenging, resulting in many returns being much lower or higher than expected (\*). Salmon have to cope with multiple stressors in freshwater and oceanic environments, such as warming, disease, predation, fishing, habitat loss, pollution, and more, and achieving sufficient food for growth and resilience in order to overcome these challenges is paramount. As scientists and managers who hope to understand salmon dynamics, these relationships between species, their prey and environmental interactions must be viewed very holistically. Therefore, studies investigating multiple species potentially competing for prey resources in various environments are required to learn more about the challenges that young salmon face.

… The data was transformed using an arc sine square root transformation, common for proportional data metrics to correct skewed data. Bray-Curtis dissimilarity metrics were then calculated for clustering and ordination analyses, to determine and visualize the differences in diets between the salmon species, sites and regions.

**Chapter 2: From gauntlet to refuge: Juvenile pink and chum salmon dietary overlap**

**Chapter 2: Salmon resource partitioning under high and low foraging opportunities**

**Chapter 2: Pink and chum salmon prey partitioning decreases with foraging intensity**

**Chapter 3: Prey phenology influences juvenile salmon interactions and trophic niches**

**Chapter 3: Salmon dietary overlap depends on prey phenology and migration timing**

Pacific salmon are opportunistic foragers, shifting their diets according to the available prey fields, environmental conditions, and potential interspecific competition. Physical and biogeochemical properties of the ocean facilitate phytoplankton production, which stimulates zooplankton blooms, which then become prey for higher level predators. Availability of prey in the dynamic ocean environment can influence the trophic niches of predators such as salmon and occupying the same niche can lead to competitive exclusion. Two species that coexist can either occupy different niches and consume different prey or occupy the same niche, but one will have the advantage and drive the other into extinction.

Pink salmon remain planktivorous throughout their short life cycle and in higher abundance years have been shown to outcompete other species for zooplankton resources (Ruggerone & Nielsen, 2004). Pink salmon have an obligate two-year life cycle, with genetically distinct odd-year and even- year broods, and in many areas one of the broods is more abundant than the other, creating biennial patterns of numerical dominance and absence, a natural treatment effect to study. Research has shown pink salmon have negatively impacted the growth and survival of chum, sockeye, chinook and coho salmon, as well as planktivorous trout and sea birds.

Chum salmon, the Pacific salmon species with the highest biomass, can be either planktivorous or piscivorous, but have also been shown to prey shift to gelatinous items. Consumption of gelatinous prey has been found in chum diet studies in different regions of the Pacific Ocean and in different life stages, reflecting a common strategy of the species. Juvenile chum are considerably flexible and adaptive salmon species, not only in prey choice but in life history as well, varying the amount of time they spend growing in the ocean. Since there are such large amounts of chum salmon released from hatcheries in the Pacific, their ecology, survival and interactions with other species requires further scientific inquiry.

Juvenile Pacific salmon foraging trends and interspecific competition during early marine migration can impact their survival to adulthood but is still not yet well understood. In order to survive the first ocean winter, juvenile salmon must achieve sufficient growth to reach a critical size to better catch food, avoid predators and survive periods of starvation. Prey quality and quantity mediates salmon growth and therefore growth and survival are closely coupled to the environmental conditions that salmon experience during the outmigration. Competition between salmon species for prey resources further compound effects of food limitation during the early phase and competitive interactions also likely shift with conditions.

The majority of juvenile salmon in southern British Columbia migrate northward through the Strait of Georgia pathway, where they encounter diverse coastal conditions. First, the Discovery Islands is an archipelago with complex oceanographic conditions and multiple routes for migrating salmon, which has been shown to affect early marine survival. The next leg of the migration is the Johnstone Strait, hypothesized to be a “trophic gauntlet” salmon have to endure before entering improved conditions in the Queen Charlotte Strait.

The conditions salmon encounter in this region of B.C. will likely be comparable to environments they will continue to migrate through, along the coast into the Gulf of Alaska. Coastal ocean conditions can vary from high freshwater inputs to purely oceanic, sheltered inlets to exposed areas, rocky shores to eelgrass habitats and high to low productivity levels. Therefore, not only does the Discovery Islands and Johnstone Strait region represent an important section of the salmon migration route, but is a microcosm of coastal conditions, transitioning from warm, fresh, stratified channels to a cold, saline, well-mixed, deep strait.

The purpose of this study is to classify the trophic niches that juvenile pink and chum salmon occupy, determine overlap and how niche and overlap change with feeding intensity. How does juvenile pink and chum salmon dietary overlap vary across coastal regions with unique zooplankton communities and what are main prey types for each salmon species? Does dietary overlap between species increase or decrease in relation to foraging intensity? Analyzing the Discovery Islands and Johnstone Strait regions as a case study, this research will dive into the relationships between pink and chum salmon, their prey and environment.

…

* Diet influenced by prey + overlap relationship to intensity
* Intuitive that prey=diet but counter intuitive that competition decr. W overlap
* When food scarce, fall back strategies, pink in nearshore and chum gelatinous
* Diversity of conditions shows species coexistence by diff trophic niche / partition
* Pink can outcompete for copes, chum had to adapt different strategy to survive
* Species occupy diff niche and relationship shifts across route b/c gfi, prey, envir.
* Therefore, pink-chum interacting important ecosystem dynamic 🡪 grow/survival
* Outmigrating salmon adapt to shifting prey and competitors, strategy pros/cons
* Study= competition research important, such as pink/chum in high/low (survival)
* Pink outcompete, more gauntlet research, chum can be ecosystem indicators…

Overall, juvenile pink and chum salmon diets are influenced by availability of prey and the overlap between species shows a clear relationship to feeding intensity. …

…

Interspecific competition between species shifts with the foraging environments encountered, and more research should be focused on the feeding grounds of Queen Charlotte Strait and whether that persists temporally as a recovery zone for these starving, migrating young salmon.

…

This study illustrates the importance of research on the interspecies competitive interactions, such as pink and chum salmon in high and low foraging opportunities to understand survival. Pink salmon have the potential to outcompete other species for calanoid copepods so further research is needed in this food limited area, and chum salmon could be used as ecosystem indicators, due to the consistent prey shifting between both high and low foraging conditions.

Pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) are the highest abundance and biomass, respectively, of all Pacific salmon, from natural and enhanced stocks.

Pink salmon (O gor) are the most abundant species of Pacific salmon, and chum salmon have the highest biomass

Pink and chum salmon are the most prelevant species of Pacific salmon, pink salmon have a two-year life cycle and are the most abundant and the large chum salmon have the highest biomass.

\*\*\*\*\* update intro to include this later (merge with what’s currently written + update sections)

Pacific salmon (Oncorhynchus. spp.) follow seasonal cycles, born in a freshwater system that is imprinted for them to return to after spending most of their life migrating through the ocean. Since time immemorial, humans noticed these cyclical patterns on different species of salmon returning to the rivers as adults, and co-evolved to rely on salmon as a critical food resource. Recently, Pacific salmon stocks have experienced regional declines in productivity, from habitat degradation, overfishing and climate change, yet declines are masked by hatchery production. Despite a wealth of knowledge and research on salmon, the mechanisms for ocean survival is still not yet fully understood, although the early marine phase has been proven to be crucial.

… \*\*\* chum then pink then the connection then the study area and research Q’s. \*\*\*

Chum salmon (O. keta) currently has the highest biomass of any salmon species, due to the hatchery production in Japan although British Columbia experienced a regional decline.

…

Pacific salmon (Oncorhynchus spp.) have complex, semelparous life cycles that begin and end in freshwater, but most of their time is spent growing to adult size in the Pacific Ocean.

Pacific salmon (Oncorhynchus spp.) have been embedded in the North American coastal landscape since populating new freshwater systems after major glacial retreat 17,000 years ago (pitman etal 2020). Since time immemorial humans have coexisted with salmon, archeological research has found evidence of human use of chum salmon (O. keta) in Alaska 11,500 years ago (halffman etal 2015). **\*\*\*\*\*** I love this paragraph, but I should put it in the introduction chapter.

Humans have coexisted with salmon since time immemorial, archeological studies recently found evidence of chum salmon (O. keta) consumption 11,500 years ago in Alaska.

after the last glacial period 21,000 years ago.

Pacific salmon (O. spp.)