

Salmonid_Diet

Kaitlyn Kukula

2025-11-20

```
library(ggplot2)
library(tidyverse)

## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## vforcats   1.0.0     v stringr   1.5.1
## v lubridate 1.9.4     v tibble    3.3.0
## v purrr    1.1.0     v tidyverse 1.3.1
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()   masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(here)

## here() starts at /Users/kaitlynkukula/KukulaHipp

library(lubridate)
library(cowplot)

##
## Attaching package: 'cowplot'
##
## The following object is masked from 'package:lubridate':
##
##     stamp

here()

## [1] "/Users/kaitlynkukula/KukulaHipp"

kak_theme <- theme_classic() +
  theme(plot.title = element_text(size = 11, hjust = 0.5, face = "bold"), #Adjust title
        axis.text.x = element_text(size = 9), # Adjust x-axis values
        axis.text.y = element_text(size = 9), # Adjust y-axis values
        axis.title.x = element_text(size = 10.5, face = "bold"), # Adjust x-axis title
        axis.title.y = element_text(size = 10.5, face = "bold"), # Adjust y-axis title
        legend.position = "bottom", # Define legend position
        legend.text = element_text(size = 9), # Define legend entry sizes
        legend.title = element_text(size = 9)) # Define legend name sizes
set_theme(kak_theme)
```

Read in and clean data

```
salmonid_diet_raw <- read.csv("~/KukulaHipp/Data/Raw/Elwha_estuary_fish_diet/Elwha_estuary_fish_diet.csv")
  mutate(Date = mdy(Date),
        Year = as.numeric(Year)) %>%
  janitor::clean_names()
```

Explore data

```
colnames(salmonid_diet_raw)
```

```
## [1] "date"
## [2] "dam_condition"
## [3] "year"
## [4] "season"
## [5] "fish"
## [6] "sampling_event"
## [7] "replicate"
## [8] "acari_larva"
## [9] "acari_terrestrial_unknown"
## [10] "amphipoda_unknown"
## [11] "corophium_varies"
## [12] "gammarus_unknown"
## [13] "araneae_unknown"
## [14] "basommatophora_varies"
## [15] "lymnaeidae_immature"
## [16] "physidae_unknown"
## [17] "planorbidae_unknown"
## [18] "cladocera_unknown"
## [19] "agabini_larva"
## [20] "anobiidae_adult"
## [21] "cantharidae_adult"
## [22] "cerambycidae_adult"
## [23] "coccinellidae_adult"
## [24] "coleoptera_terrestrial_adult"
## [25] "coleoptera_terrestrial_larva"
## [26] "curculionidae_terrestrial_adult"
## [27] "dytiscidae_adult"
## [28] "dytiscidae_larva"
## [29] "haliplus_larva"
## [30] "hydroporinae_larva"
## [31] "malthodes_adult"
## [32] "oreodytes_larva"
## [33] "scolytinae_adult"
## [34] "staphylinidae_adult"
## [35] "stictotarsus_adult"
## [36] "throscidae_adult"
## [37] "collembola_nymph"
## [38] "entomobryomorpha_unknown"
## [39] "isotomidae_unknown"
```

```

## [40] "sminthuridae_unknown"
## [41] "cyclopoida_adult"
## [42] "dermaptera_ineterminate"
## [43] "forficula_auriculata_adult"
## [44] "diplopoda_unknown"
## [45] "anthomyiidae_adult"
## [46] "anthomyiidae_larva"
## [47] "asteiidae_adult"
## [48] "bezzia_larva"
## [49] "ceratopogonidae_adult"
## [50] "ceratopogonidae_larva"
## [51] "ceratopogonidae_pupa"
## [52] "ceratopogoninae_larva"
## [53] "chaoboridae_larva"
## [54] "chelifera_larva"
## [55] "chironomidae_adult"
## [56] "chironomidae_larva"
## [57] "chironomidae_pharate_adult"
## [58] "chironomidae_pupa"
## [59] "chironomini_adult"
## [60] "chironomini_larva"
## [61] "chrysops_larva"
## [62] "coelopidae_adult"
## [63] "diptera_adult"
## [64] "diptera_larva"
## [65] "diptera_pupa"
## [66] "dixa_larva"
## [67] "dixella_larva"
## [68] "dixidae_pupa"
## [69] "dolichopodidae_adult"
## [70] "dolichopodidae_larva"
## [71] "drosophilidae_adult"
## [72] "empididae_adult"
## [73] "empididae_larva"
## [74] "empididae_pupa"
## [75] "empidoidea_adult"
## [76] "ephydriidae_adult"
## [77] "ephydriidae_larva"
## [78] "ephydriidae_pupa"
## [79] "forcipomyiinae_larva"
## [80] "heleomyzidae_adult"
## [81] "hilara_adult"
## [82] "metachela_adult"
## [83] "muscidae_adult"
## [84] "muscidae_larva"
## [85] "muscomorpha_adult"
## [86] "muscomorpha_larva"
## [87] "muscomorpha_pupa"
## [88] "nematocera_adult"
## [89] "nematocera_pupa"
## [90] "opomyzidae_adult"
## [91] "ormosia_larva"
## [92] "orthocladiinae_sp_rai_taxon_0011_larva"
## [93] "orthocladiinae_sp_rai_taxon_0011_pupa"

```

```

## [94] "phoridae_adult"
## [95] "platypalpus_adult"
## [96] "prosimulium_larva"
## [97] "rhagionidae_adult"
## [98] "schizophora_adult"
## [99] "sciaridae_adult"
## [100] "simulium_larva"
## [101] "sphaeroceridae_adult"
## [102] "syrphidae_adult"
## [103] "tabanidae_larva"
## [104] "tanypodinae_larva"
## [105] "tanytarsini_larva"
## [106] "tephritidae_adult"
## [107] "tipulidae_adult"
## [108] "tipulidae_larva"
## [109] "tipulidae_pupa"
## [110] "acentrella_naiad"
## [111] "baetidae_naiad"
## [112] "baetis_naiad"
## [113] "cinygmula_naiad"
## [114] "ephemeroptera_naiad"
## [115] "heptageniidae_naiad"
## [116] "siphlonurus_naiad"
## [117] "gasterosteidae_juvenile"
## [118] "gastropoda_terrestrial_unknown"
## [119] "geophilomorpha_unknown"
## [120] "aphidoidea_adult"
## [121] "aphidoidea_nymph"
## [122] "auchenorrhyncha_adult"
## [123] "auchenorrhyncha_ineterminate"
## [124] "cercopidae_adult"
## [125] "cicadellidae_adult"
## [126] "cicadellidae_nymph"
## [127] "coccoidea_nymph"
## [128] "corixidae_adult"
## [129] "corixidae_nymph"
## [130] "delphacidae_adult"
## [131] "gerridae_adult"
## [132] "hemiptera_terrestrial_larva"
## [133] "lygaeidae_adult"
## [134] "miridae_adult"
## [135] "psylloidea_adult"
## [136] "psylloidea_nymph"
## [137] "reduviidae_adult"
## [138] "salda_adult"
## [139] "saldidae_adult"
## [140] "heteroptera_adult"
## [141] "heteroptera_nymph"
## [142] "hirudinea_unknown"
## [143] "braconidae_adult"
## [144] "chalcidoidea_adult"
## [145] "diapriidae_adult"
## [146] "dryinidae_adult"
## [147] "formicidae_adult"

```

```
## [148] "hymenoptera_adult"
## [149] "ichneumonidae_adult"
## [150] "megaspilidae_adult"
## [151] "mymaridae_adult"
## [152] "platygastridae_adult"
## [153] "proctotrupidae_adult"
## [154] "pteromalidae_adult"
## [155] "insecta_varies"
## [156] "isopoda_immature"
## [157] "geometridae_larva"
## [158] "lasiocampidae_larva"
## [159] "lepidoptera_adult"
## [160] "lepidoptera_larva"
## [161] "sialis_larva"
## [162] "microlepidoptera_larva"
## [163] "microlepidoptera_pupa"
## [164] "mysida_varies"
## [165] "nematoda_unknown"
## [166] "chrysopidae_larva"
## [167] "chrysopidae_hemerobiidae_larva"
## [168] "neuroptera_terrestrial_larva"
## [169] "coenagrionidae_adult"
## [170] "engallagma_naiad"
## [171] "ischnura_naiad"
## [172] "odonata_naiad"
## [173] "oligochaeta_unknown"
## [174] "osteichthyes_egg"
## [175] "osteichthyes_fry"
## [176] "osteichthyes_unknown"
## [177] "ostracoda_unknown"
## [178] "chloroperlidae_naiad"
## [179] "plumiperla_diversa_adult"
## [180] "sweltsa_naiad"
## [181] "psocoptera_adult"
## [182] "psocoptera_nymph"
## [183] "phlaeothripidae_adult"
## [184] "thripidae_adult"
## [185] "glossosomatidae_pupa"
## [186] "hydropsychidae_pupa"
## [187] "hydroptila_larva"
## [188] "hydroptilidae_adult"
## [189] "hydroptilidae_larva"
## [190] "hydroptilidae_pupa"
## [191] "integripalpia_larva"
## [192] "lepidostoma_larva"
## [193] "leptoceridae_larva"
## [194] "limnephilidae_adult"
## [195] "limnephilidae_larva"
## [196] "ochrotrichia_larva"
## [197] "rhyacophila_larva"
## [198] "trichoptera_adult"
## [199] "trichoptera_larva"
## [200] "trichoptera_pupa"
```

```

# What fish did they study
unique(salmonid_diet_raw$fish)

## [1] "Chinook" "Coho"

# What dates did they sample on
unique(salmonid_diet_raw$date)

## [1] "2006-05-11" "2006-05-26" "2006-06-09" "2006-07-20" "2006-08-17"
## [6] "2007-05-03" "2007-05-17" "2007-05-23" "2007-06-14" "2007-07-12"
## [11] "2007-07-26" "2007-08-28" "2013-05-15" "2013-05-17" "2013-05-29"
## [16] "2013-06-05" "2013-06-19" "2013-07-10" "2013-07-17" "2013-07-24"
## [21] "2013-08-07" "2013-08-21" "2014-05-07" "2014-05-08" "2014-05-09"
## [26] "2014-05-10" "2014-05-11" "2014-05-12" "2014-05-13" "2014-05-21"
## [31] "2014-06-04" "2014-06-18" "2014-07-02" "2014-07-15" "2014-08-13"
## [36] "2014-08-27"

```

Wrangle data

```

# Summed all taxa consumed by salmon type in a year
diet_totals <- salmonid_diet_raw %>%
  group_by(year, fish) %>%
  summarise(across(c(acari_larva:trichoptera_pupa), ~sum(., na.rm = TRUE))) %>%
  ungroup() %>%
  pivot_longer(c(acari_larva:trichoptera_pupa)) %>%
  pivot_wider(id_cols = c("fish", "name"),
              names_from = "year",
              values_from = "value",
              names_prefix = "value_") %>%
  mutate(taxa = str_extract(name, ".+\\_") %>% str_remove_all("\\_")) %>%
  group_by(fish, taxa) %>%
  summarise(across(c(value_2006:value_2014), ~sum(., na.rm = TRUE))) %>%
  ungroup()

## `summarise()` has grouped output by 'year'. You can override using the
## `.`.groups` argument.
## `summarise()` has grouped output by 'fish'. You can override using the
## `.`.groups` argument.

```

Creating individual dataframes

```

### Create a data frame for Chinook salmon diet
# Rows: taxa
# Columns: totals for each year
chinook_diet <- diet_totals %>%
  filter(fish == "Chinook") %>%
  mutate(value_2006 = as.numeric(value_2006))

```

```

### Create a data frame for Coho salmon diet
# Rows: taxa
# Columns: totals for each year
coho_diet <- diet_totals %>% filter(fish == "Coho")

### Create a data frame for the diet of all salmon species before dam removal
# Rows: taxa
# Columns: totals for each year
all_salmon_diet_before <- diet_totals %>%
  group_by(taxa) %>%
  summarise(across(c(value_2006:value_2007), ~sum(., na.rm = TRUE)))

### Create a data frame for the diet of all salmon species after dam removal
# Rows: taxa
# Columns: totals for each year
all_salmon_diet_after <- diet_totals %>%
  group_by(taxa) %>%
  summarise(across(c(value_2013:value_2014), ~sum(., na.rm = TRUE)))

```

Analyze data

Is the diet of Chinook and Coho different between species and before and after dam removal?

1. Compare which taxa were the most consumed with a histogram for before and a second histogram for after Datasets: chinook_diet, coho_diet
2. Compare the diversity of taxa (did one species consume more types of taxa than the other?) before and after between the salmon species Datasets: chinook_diet, coho_diet
3. Compare the diversity of taxa consumed for *all* fish before and after the dam removal (did dam removal change the abundance and diversity of diet?) Datasets: all_salmon_diet_before, all_salmon_diet_after
4. Compare the diversity of taxa consumed for individual salmon species before and after the dam removal (did dam removal change the abundance and diversity of diet?)

Create a table for the number of taxa consumed by each species per year

```

# Get taxa totals
chinook_total_2006 <- sum(chinook_diet$value_2006 > 0)
chinook_total_2007 <- sum(chinook_diet$value_2007 > 0)
chinook_total_2013 <- sum(chinook_diet$value_2013 > 0)
chinook_total_2014 <- sum(chinook_diet$value_2014 > 0)

coho_total_2006 <- sum(coho_diet$value_2006 > 0)
coho_total_2007 <- sum(coho_diet$value_2007 > 0)
coho_total_2013 <- sum(coho_diet$value_2013 > 0)

```

```

coho_total_2014 <- sum(coho_diet$value_2014 > 0)

df <- data.frame(Year = c("2006", "2007", "2013", "2014"),
                 Chinook = c(sum(chinook_diet$value_2006 > 0),
                             sum(chinook_diet$value_2007 > 0),
                             sum(chinook_diet$value_2013 > 0),
                             sum(chinook_diet$value_2014 > 0)))
knitr::kable(df)

```

Year	Chinook
2006	44
2007	50
2013	56
2014	85

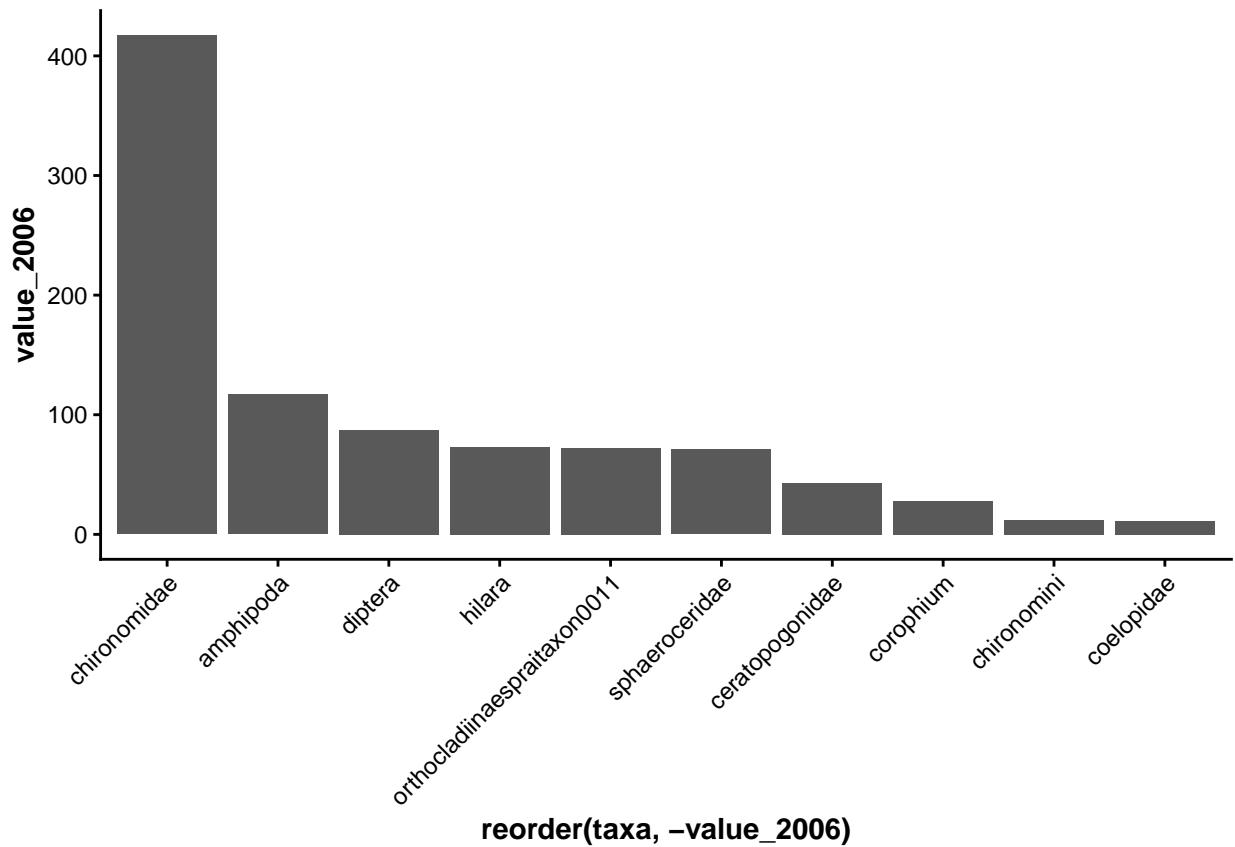
There was some increase in the diversity of taxa consumed by Chinook salmon during/after dam removal. In Coho salmon, the diversity of taxa consumed greatly increased after dam removal.

```

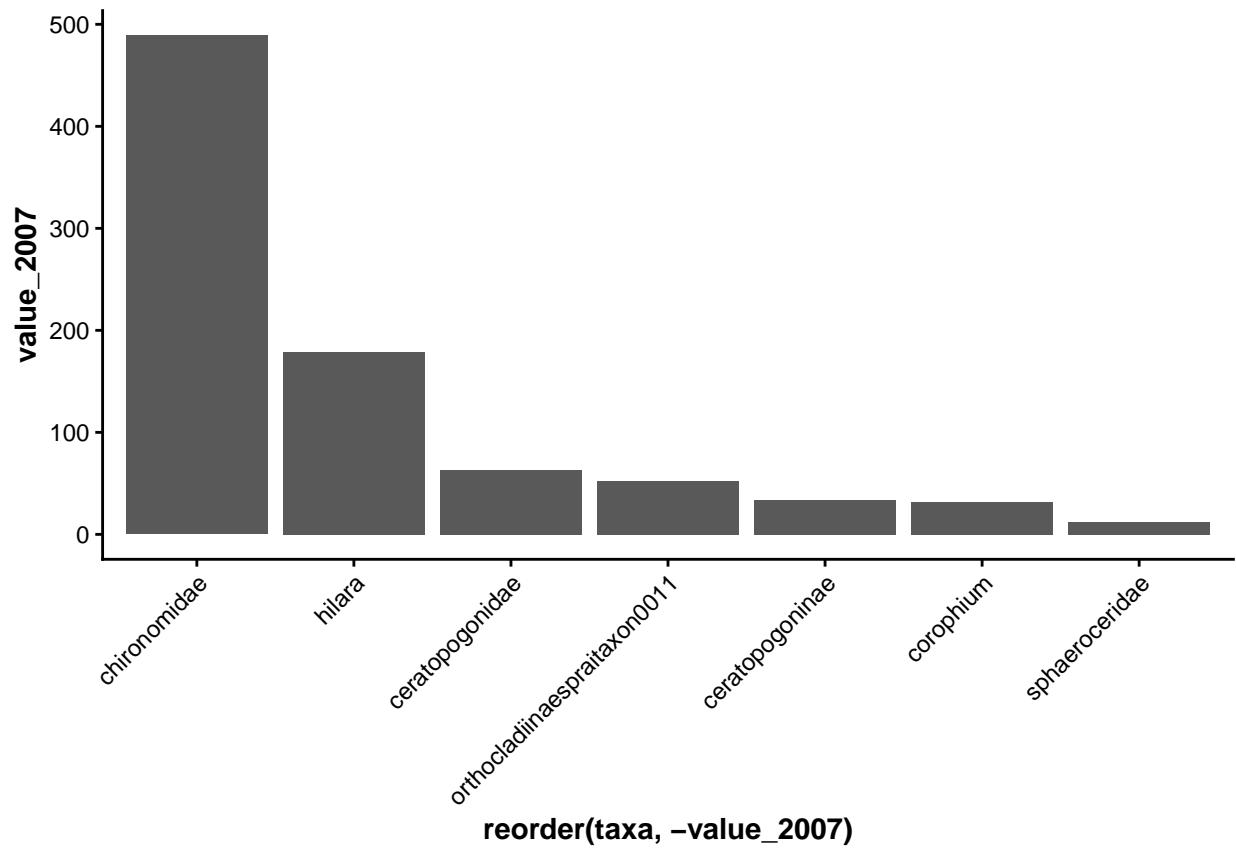
# Consumption by salmon species plotted

chinook_diet_plot_2006 <- ggplot(data = chinook_diet %>%
                                         filter(value_2006 > 10),
                                         aes(x = reorder(taxa, -value_2006), y = value_2006)) +
  geom_bar(stat = "identity") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
chinook_diet_plot_2006

```



```
chinook_diet_plot_2007 <- ggplot(data = chinook_diet %>%
  filter(value_2007 > 10),
  aes(x = reorder(taxa, -value_2007), y = value_2007)) +
  geom_bar(stat = "identity") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
chinook_diet_plot_2007
```



Is there a relationship between observed invertebrate counts and salmonid diet?

After wrangling the invert data, use inner_join to combine with diets so you only grab similar taxa