

AN ABSTRACT OF THE THESIS OF

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Title: Seasonal Dynamics of a Riparian Food Web in the Oregon Coast Range Mountains

Abstract approved: _____
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Riparian areas are eco-tones where aquatically- and terrestrially-derived insect biomass is exchanged between habitats, presenting consumers with new sources of energy, and resulting in a reciprocal subsidy. The relative contribution of energy exchange and the resulting impacts on vertebrate riparian consumers, such as fish or birds, remains poorly understood. We explored this reciprocal exchange within Honeygrove watershed--an alder dominated riparian system within the Oregon Coast Range. Diet samples were collected from birds and fish along with a suite of insect samples during the summer and fall of 2003 and spring 2004. We detected seasonal differences in the abundance and biomass of terrestrial and aquatic insects available to riparian consumers. Spring provided the most adult aquatic insect biomass, and biomass was similar in summer; the fall emergence was an order of magnitude less than the other seasons. Prey sources differed between salmonids. Salmonid diet varied in biomass consumption by season and prey type. Coho salmon (*Oncorhynchus kitsutch*) on average, consumed more benthic aquatic biomass than adult aquatic insect biomass regardless of season. Despite the availability of externally derived prey, this species depended more on stream-derived resources in summer and fall but not during spring. In all sampling seasons, co-occurring cutthroat

trout (*Oncorhynchus clarkii*), consumed more terrestrial invertebrate biomass than aquatic biomass, on average. Only in summer, cutthroat trout ate more adult aquatic than benthic aquatic biomass. In fall, their consumption of adult and benthic insect biomass was equal. During spring, cutthroat trout consumption, on average, consisted of more benthic aquatic biomass than adult aquatic biomass. Bird diet samples obtained from commonly encountered species such as Swainson's thrush, Song Sparrow, and Pacific-slope Flycatcher, showed more terrestrial derived than aquatic prey during the summer sampling season. These data provided evidence of a reciprocal subsidy occurring in the Honeygrove watershed. There is potentially a seasonal synchrony between the two habitats such that when prey availability is low in one habitat, it is subsidized by the other's high productivity.

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Seasonal Dynamics of a Riparian Food Web in the Oregon Coast Range Mountains

by

Amanda Lynn Robillard

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented May 3, 2006

Commencement June 2007

Master of Science thesis of Amanda Lynn Robillard presented on May 3, 2006.

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Amanda Lynn Robillard, Author

ACKNOWLEDGEMENTS

- I would like to thank my advisor Judy Li for all of her support and patience during our time together. She encouraged me to speak up, think in new ways and explore ideas I would have never come to on my own. She taught me to believe in myself because she believed in me. Throughout the graduate process, I have seen other advisors, but I have never seen anyone as encouraging and involved as Judy; she really is the best. And not only does she rock as an advisor, she is an excellent person and I am lucky to have her as a friend as well.

- I would also like to thank my husband, Jonathan, who rivals Judy in patience. I would not have been able to complete this project without him. From his help in the field, moral and statistical support as his well as writing tips, he supported and comforted me throughout this long process and kept me laughing when I thought there was no hope. He rocks too and I really owe him one.

- Thanks are also in order to the many field helpers (paid and kind friends) I had. These folks made it all happen: Evelyn Riffe, Brian Neilson, Anthony Olegario, Jeremiah Osborne-Gowey, Randy Colvin, Katie Whitehead, Dave Leer and all his dudes, and especially Jeremy Romer as there aren't too many people who could show up for work at four a.m. chipper and laughing

- Thanks also to Justin Miles who helped identified bugs in the lab

- Thanks to my lab mates, Bill Gerth, Charles Frady, Janel Banks, and Scott Miller, who helped me id and shared their learning with me. I'd still be in the lab without you.

- I would also like to thank AREMP's Kirsten Gallo and Chris Moyer who helped me get my foot in the door.
- Thanks to my committee members, Doug Robinson, Sandy DeBano, and Frank Moore, for their participation (Thanks for the mist nets Doug!)
- Thanks to my parents who always are there for me.

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Introduction

The transfer of energy or resources from one ecosystem to another is an ecological subsidy (Polis et al. 1997). Subsidies come in many forms and their importance varies widely from ecosystem to ecosystem. Well documented subsidies exist between upland terrestrial ecosystems and lowland aquatic ecosystems. In this example, terrestrial ecosystems are donors of structural elements, such as large wood (Reeves et al. 1997), and nutritional elements such as leaves, which are fed on by macroinvertebrates (Hart 2006). In the Pacific Northwest, migratory salmon filled with marine-derived nutrients eventually decompose and, elevate stream productivity, which has cascading influences on stream and terrestrial organisms, from invertebrates to grizzly bears (*Ursus arctos*) (Hilderbrand et al. 1999; Chaloner & Wipfli 2002; Naiman et al. 2002). This food web contains a spatial subsidy where nutrients and energy cross landscape-scale spatial boundaries (Polis et al. 1997). In one-sided subsidies there are donor and recipient habitats; reciprocal subsidies are situations where energy and resources flow across boundaries in both directions, and each ecosystem is both a donor and a recipient. Stream systems and adjacent riparian areas are coupled in such a way that both habitats contribute and receive energy. Insects are an important commodity in this exchange. Aquatic insects emerge from the stream and are prey to riparian consumers, such as birds and bats. Terrestrial insects fall into streams and are available to aquatic consumers, such as fish. This thesis explores flows of insect prey into and out of a stream in western Oregon. Our objective was to quantify the magnitude of this reciprocal subsidy and determine the relative importance of energy transfer between the two ecosystems by using insect prey consumption by fish and birds as the currency. By measuring aquatic

and terrestrial insect availability and comparing that to actual fish and bird diets we have completed one of the first empirical examinations of a reciprocal subsidy.

Insect Availability

The emergence of aquatic insects and their recruitment into the riparian area is difficult to delineate. In previous studies, abundance and biomass of these insects tended to decrease with increased lateral distance from the stream (Lynch et al. 2002; Premdas 2004). There is also evidence of a reduction in abundance and biomass with vertical movement up in to the tree canopy (Jackson & Resh 1989). Both the height and distance adult aquatic insects move determine their availability as prey for birds. In addition to spatial variation of emerging aquatic insects there is also a temporal variability. Peaks in adult aquatic insect emergence typically occur in late spring to early summer (Progar & Moldenke 2002; Jackson & Fisher 2003) that potentially affect both terrestrial and aquatic predators. Timing of emergence can also be affected by temperature as an early spring or a late summer may alter the normal timing of emergence (Wallace & Anderson 1996).

Abundance of terrestrial invertebrates is also variable with season. Terrestrial invertebrates are typically most abundant in late summer (Mason & MacDonald 1982; Cloe & Garman 1996; Wipfli 1997; Kawaguchi & Nakano 2001; Nakano & Murakami 2001). Riparian vegetation may also influence the amount and composition of terrestrial insects depending on location. In a study that was a precursor to ours, allochthonous input of prey was greater in deciduous and mixed-conifer-hardwood than in pure conifer sites in coastal Oregon (Romero et al. 2005). In Alaska, terrestrial invertebrate biomass was greater in streams surrounded by young alder forests than in streams surrounded by

young conifer forests (Piccolo & Wipfli 2002). Likewise, terrestrial invertebrate biomass was higher in alder sites and mixed-conifer (*Tsuga heterophylla*) sites compared with Sitka spruce (*Picea sitchensis*) sites (Allan et al. 2003). Edwards and Huryn (1995) found higher abundances and biomass of terrestrial invertebrates with higher mean daily temperatures. Wingless invertebrates, those with passive dispersal, and those getting ready to pupate, are at greater risk of falling into the stream in the face of strong winds or heavy rainfall (Mason & MacDonald 1982).

Consumer use of externally derived prey

Are consumers utilizing this externally derived prey source? Consumption of terrestrial invertebrates by stream dwelling predators, particularly salmonid fishes, is well documented and has been shown to vary with season. Terrestrial invertebrates represented 11-percent of fish diet in spring, 68-percent in summer and 48-percent in fall in northern Japan (Kawaguchi & Nakano 2001). A similar pattern was found in warm-water streams in Virginia (Cloe & Garman 1996). In a manipulative study in a Horonai Japan stream where terrestrial invertebrate input was reduced, there was a corresponding decrease in fish biomass (Kawaguchi et al. 2003). Terrestrial invertebrates made up 50-percent of biomass in the diet of three salmonid species in southeastern Alaska streams. The energetic importance of these prey increased as aquatic prey abundance declined through the season (Wipfli 1997). Similar patterns have been noted elsewhere in the Pacific Northwest. Whereas coho consumed equal amounts of terrestrial and aquatic prey during the summer in coastal Alaska (Allen et al. 2003), allochthonous prey of non-dominant coho in Washington comprised 69-percent of total energy intake during summer (Nielsen 1992). A slightly different seasonal pattern was noted in three streams

spanning much of the Oregon coast range where coastal cutthroat trout consumed equal amounts of terrestrial and aquatic prey during the summer and spring but ingested more prey of terrestrial origin in the fall (Romero et al. 2005).

The transfer and consumption of insects out of streams and into riparian ecosystems is comparatively less well understood. Gray (1993) found that insectivorous bird densities in a tall-grass prairie riparian area were highly correlated with the timing of aquatic insect emergence. In a spring-fed system in Japan, aquatic prey subsidies were observationally estimated at 25.6-percent of the total energy budget of the birds (Nakano & Murakami 2001). In the same study area, the number of hourly foraging visits was greater in a riparian site versus upland forest, and there were more birds in the riparian area than upland (Murakami & Nakano 2002). A common riparian bird, Wilson's Warbler (*Wilsonia pusilla*), showed a preference for aquatic Ephemeroptera and Plecoptera over terrestrial prey during breeding season in Wyoming (Raley & Anderson 1990). Although the aquatic portion of diet was not as substantial as in other studies, aquatic insects comprised nine percent of bird diets sampled in the Grand Canyon during summer and spring (Yard et al. 2004).

This study is part of a larger, multi-disciplinary research program, the Cooperative Forest Ecosystem Research (CFER) program. There are a number of focal program areas within CFER, including bat ecology, herpetology, and silviculture, with overriding interest in the influence of riparian vegetation on animal communities. Many individual graduate student projects compare processes in deciduous and conifer-dominated riparian areas; CFER intended to use these projects to gain a holistic view of Oregon Coast Range riparian areas. As a result, overlap in the location of study sites was

an intentional design of CFER projects. The Honeygrove watershed, located in the central Oregon Coast Range Mountains, was chosen because a number of other projects were in progress there.

Given the findings discussed above, there seems to be sufficient evidence to support the notion of a reciprocal subsidy of insect biomass between stream and riparian ecosystems. However, there are still several uncertainties. Most of the research has focused on one-sided subsidies, looking at either the aquatic or the terrestrial contributions, not the reciprocal nature of that occurring in the riparian area. To assess this potential exchange, we collected both aquatic and terrestrial insects to simultaneously measure availability to consumers. We believe this dual manner of sampling both habitats combined with empirical evidence of consumer diet, particularly related to aquatic donation to bird diets, is a unique approach.

Previously, researchers have relied on observational techniques, such as counting the number of times birds flew through aquatic insect swarms to quantify the aquatic portion of the diet. To test the hypothesis that the reciprocal subsidies at Honeygrove were equal in three seasons of the year, we developed direct measures of prey availability and consumption. We will directly determine consumption of terrestrial and aquatic prey in birds by examining fecal samples and in fish by using stomach lavage. The predator diet samples, collected in three seasons, in conjunction with the insect samples, were used to develop a complete picture of the extent of the across-habitat prey flux and year-round dynamics of the riparian food web.

The specific objectives for this study were:

1. Determine the extent to which the aquatic and terrestrial habitats in the Honeygrove riparian area exchange resources with insect prey as currency and how these exchanges vary with season.
2. Determine the amount of terrestrial invertebrate prey utilized by two primary aquatic consumers, coho salmon and cutthroat trout, and the seasonal variation associated with the transfer.
3. Determine the amount of adult aquatic insect prey transferred from the stream to riparian obligate bird species and the seasonal variation associated with the transfer.
4. Establish if adjacent habitats subsidize each other in times of naturally low production.

Study Area

Honeygrove Watershed

The study area was located in the Coast Range of Oregon on three reaches of Honeygrove Creek, located approximately one mile east of Alsea (Lat: 44.4 N, Long.: -123.5W). Honeygrove Creek is a fifth-order stream and flows into the North Fork of the Alsea River (Figure 1); the watershed drains 1625 hectares. Elevation is approximately 240 meters at the headwaters and 90 meters at the confluence with the North Fork Alsea.

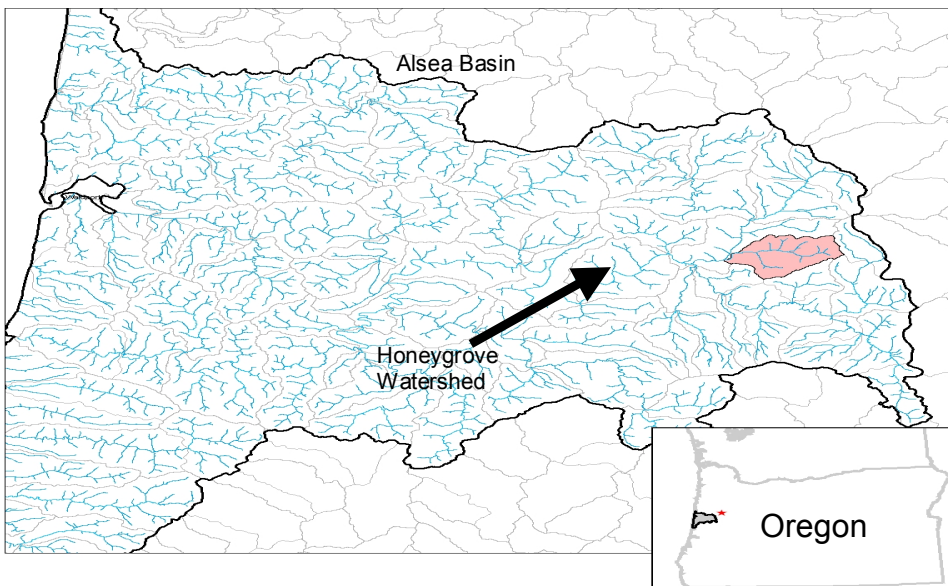


Figure 1. Honeygrove watershed.

The area has a checkered public-private ownership pattern that alternates between one-mile blocks of Bureau of Land Management (BLM), private forest industry, and private residential ownership. Vegetation is characteristic of the Western Hemlock Vegetation Zone (Franklin and Dyrness 1988). Timber harvest in the mid-1950s has influenced the modern overstory in the riparian area, which is now dominated by red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*). Average rainfall in June 2003 was 0.43 cm, 3.84 cm in September, and 5.27 cm in

May, and 4.12 cm in June of 2004. We sampled three study reaches: two unnamed tributaries that we called the Amphib reach and the Bird reach, and one on the mainstem of Honeygrove Creek (Figures 2). Reaches were approximately three hundred meters in length to accommodate the bird sampling transects that had already been established for another project. Substrate on all three reaches was primarily cobble but towards the end of the Bird reach there were some meadow-like conditions with silt / mud conditions with incised channels. The average channel width of the Amphib reach was 1.5 meters, the Bird reach spanned 2.3 meters and the mainstem (MS) was 3.8 meters in width. The average channel width was calculated as an average of the stream width at each of the six pan trap locations. Overstory and understory vegetation composition was assessed both directly next to the stream and five meters into the riparian area (upslope) on all three reaches at the same locations of the channel measurements. Percent cover and overstory species were determined using a moose horn in both locations. Understory percent cover and species composition were determined within a square-meter quadrat, both streamside and upslope.

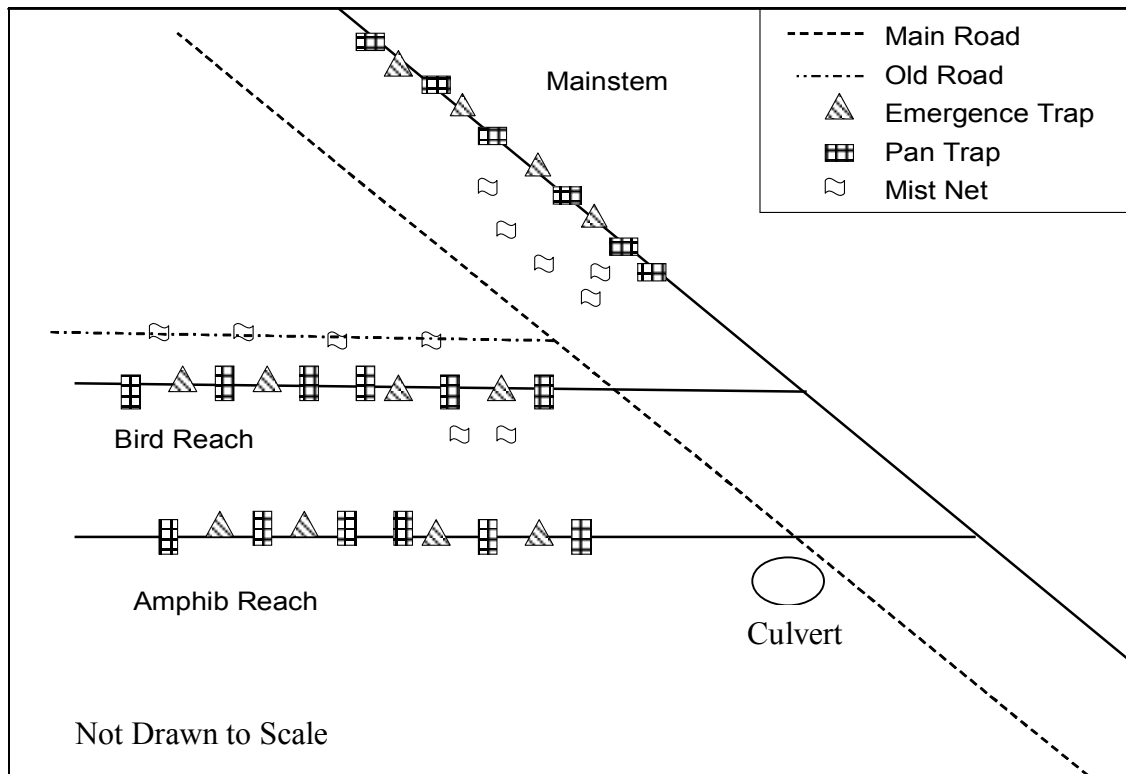


Figure 2. Schematic drawing of trap placement and reach locations

The Amphib reach was fairly uniform along the 300-m study reach. The primary streamside overstory vegetation was a mix of red alder and bigleaf maple and allowed for little light to penetrate to forest floor (~1-5%); the understory along the stream was comprised of wood sorrel (*Oxalis* sp.), salmonberry (*Rubrus spectabilis*), bracken fern (*Pteridium aquilinum*), and foam flower (*Tiarella cordifolia*). The upslope vegetation was similar to that located along the stream, though it was more open. Overstory was comprised of red alder and bigleaf maple and the overhead canopy was about 60%. The understory was sword fern (*Polystichum munitum*), salmonberry, and foam flower with approximately 20% open. The Bird reach differed from the other two as the beginning of the 300-m reach consisted of meadow-like conditions (~100 m). The streamside vegetation in the overstory was red alder with 85% cover. The understory vegetation was

comprised of foam flower, grasses, and horsetail (*Equisetum telmateia*). The upslope vegetation in this area in the overstory was 60% red alder while stinging nettle (*Urtica dioica*) and grasses were found in the understory. The remainder of the study reach was more uniform and similar to the Amphib reach. Both the streamside and upslope overstory was a mix of red alder, bigleaf maple and dotted with coniferous species, such as western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and Douglas-fir (*Pseudotsuga menziesii*). Both under-and-overstory vegetation was comprised of foam flower, oxalis, bracken and sword ferns, salmonberry, salal (*Gaultheria shallon*), and vine maple (*Acer circinatum*). The vegetative cover along the mainstem study reach was similar to those found on the other two reaches although the canopy was more open along the stream, with a seemingly denser upslope. The streamside and upslope tree species were similar to each other: Douglas-fir, bigleaf maple, and red alder. Understory was comprised of salmonberry, oxalis, foam flower, bracken fern and some mosses (See appendix for complete list of channel widths, vegetative cover, and substrates). These three reaches currently support coho salmon, resident cutthroat trout and sculpin populations. However, a culvert was installed on the Amphib reach after sampling was finished in summer of 2003; prior to that time, no coho or cutthroat trout were present.

This study was conducted in three seasons: summer (June 2003), fall (September 2003) and spring (May / June 2004). The extended spring season was unintentional, but could not be avoided due to the amount of rain encountered in May.

Predators

The study area within the Oregon Coast Range Mountains was home to five primary riparian obligate species (Ammon & Gilbert 1999; Lowther 2000; Mack & Yong 2000; Arcese et al. 2002; Hejl et al. 2002). Two were year-round residents: the Winter Wren (*Troglodytes troglodytes*) and Song Sparrow (*Melospiza melodia*). The remaining three species, Swainson's Thrush (*Catharus ustulatus*), Wilson's Warbler, and Pacific-slope Flycatcher (*Empidonax difficilis*) are migratory and are known to breed in the study area. The migrants spend winter in Mexico and Central America and arrive in the Pacific Northwest between late April and mid-May. All species begin breeding by mid-May. Once the eggs hatch, the chicks rely on food provided to them by their parents. Feeding the offspring requires numerous flights to and from the nest with food. This provided an excellent opportunity in spring to capture the adults and examine their diet.

While there are many modes of foraging and thus many ways to encounter prey, there is some overlap among these species in foraging methods and diet. Winter Wren and Song Sparrow feed on the ground, often hopping along side streams (Arcese et al. 2002; Hejl et al. 2002). Swainson's Thrush is a near-ground forager and gleans from the litter as well as from the shrub layer (Mack & Yong 2000). Wilson's Warbler forages in the shrub layer taking prey from leaves and twigs (Ammon & Gilbert 1999). Pacific-slope Flycatcher uses the lower and middle canopy, capturing prey in mid-air or gleaned from trees and shrubs (Lowther 2000). The diet of these birds primarily consist of terrestrial invertebrates such as beetles (Coleoptera), caterpillars and moths (Lepidoptera), true bugs (Hemiptera), and hoppers (Homoptera). Aquatic insects also comprise a portion of their diet, especially for Wilson's Warbler, Song Sparrow, and Swainson's Thrush, according to other studies; these prey include midges and craneflies (Diptera), mayflies

(Ephemeroptera), dragonflies (Odonata), and stoneflies (Plecoptera) (Raley & Anderson 1990; Ammon & Gilbert 1999; Lowther 2000; Mack & Yong 2000; Arcese et al. 2002; Hejl et al. 2002).

Fish and Amphibians

Although there are several Pacific salmonids present in the Alsea Basin, only two reside in Honeygrove creek, coho salmon and cutthroat trout. Coho salmon (*Oncorhynchus kisutch*) are anadromous; juveniles migrate to the ocean in their second year, spending up to two years there. The cutthroat trout (*Oncorhynchus clarkii*) present in the Honeygrove watershed are year-round residents. There are also a number of resident sculpin species. Amphibians are also present in the stream and surrounding riparian area. Four species commonly encountered are: Pacific-giant salamanders (*Dicamptodon tenebrosus*), rough-skinned newt (*Taricha granulosa*), Pacific-tree frog (*Hyla regilla*), and Western redback salamander (*Plethodon vehiculum*) (P. Graff, pers. comm., March, 2006).

Birds forage in multiple habitats. Fish, on the other hand, are limited by boundaries of the stream in which they live. However, there are a number of factors that influence how fish forage. Flow alters stream dimensions and available habitat increases or decreases (Bjornn 1971; Gowan & Fausch 1996). In addition, flow rate affects energy spent to maintain a position during feeding as well as the abundance of drifting prey (Godin & Ranglely 1989). Species-specific body shape also influences location within the channel. Coho have a deep laterally compressed body form with large median fins best suited to pool habitats; cutthroat trout are more cylindrical and have shorter median fins allowing for use of faster-moving water (Bisson et al. 1988).

Nonetheless, in streams that have undergone removal of riparian vegetation, habitat complexity can be reduced (loss of pools) and coho and cutthroat may be forced to share space. As a result, the bigger fish obtain the best resources, usually in the form of the largest prey items (Fausch 1984; Nakano et al. 1999). Thus, it is necessary to defend and maintain a territory for survival (Chapman 1966). In a one-on-one trial, coho and cutthroat trout were equal competitors if size was equal (Sabo & Pauley 1997). Larger-bodied coho were able to defend a good feeding area where they fed on drift which is most energetically efficient and enabled faster growth (Nielsen 1992).

Methods

Insect sampling

Three techniques for collecting insect samples were used to assess prey availability to birds and fish. Benthic juvenile insects were collected using a 500 μ m-mesh Surber sampler 0.093 m² in area, to determine potential benthic aquatic prey for fish. Collected in all three seasons, these samples were taken directly before fish sampling occurred. Six random locations were chosen by dividing the 300-meter reach into six sections and a random number was selected within each section, and samples were collected on each reach in summer 2003 and spring 2004; these were composited by date and reach (Table 1). No benthic samples were taken in fall 2003 on the Amphib reach because there were no anadromous fish species present during the summer effort. Samples were collected by kicking the substrate within the sampling area and then gently scrubbing each rock to remove all invertebrates. Benthic samples were collected within the same week for all sites within each sampling season, the weeks of June 19 & September 23, 2003, and May 19, 2004.

Table 1. Number of composited samples; total number of samples before compositing in parenthesis (number of traps*number of days sampled*number of reaches).

| | Emergence | Pan | Surber |
|-------------|-----------|----------|--------|
| Summer 2003 | 18 (72) | 15 (90) | 3 (18) |
| Fall 2003 | 18 (72) | 18 (108) | 2 (12) |
| Spring 2004 | 18 (72) | 15 (90) | 3 (18) |

Emergence and pan samples were collected over longer time intervals: from June 13-28 (summer) and September 8-22, 2003 (fall) and intermittently in spring 2004 (May 5, 10, 15, 20 and June 18) (Table 1). Six randomly placed pan traps were set on all three reaches to assess invertebrates entering the stream, either as terrestrial allochthonous input or aquatic adults returning (Table 1). Pan traps were plastic, opaque, and rectangular in shape, filled with water, approximately 15 cm deep and a few drops of soap. Each trap sampled 0.1 m² in area, comprising 1.8 m² (18 traps * 0.1 m²) for the entire watershed per sample date. Traps were placed in random locations in the same manner described for benthic samples (Figure 2). These were placed on the left bank, on the stream bed, as near to the water as possible.

In 2003, pan and emergence traps were emptied every other day and then reset, but in spring 2004, pan and emergence were emptied after three days to coincide with bird sampling. There were fewer pan trap days in the summer because sampling started one day later (Table 1). In the spring, samples were collected on only five dates because there was literally nothing in the traps on the first day of sampling. Invertebrates caught in pan traps were considered potential prey for both birds and fish.

To assess adult aquatic insects leaving the stream, also potential prey for fish and birds, four randomly placed emergence traps were set on all three reaches in all seasons (Figure 2). These pyramid shaped traps were covered in “no-seeum mesh” and set in the center of the stream directly on the substrate. Emerging insects were collected in

receptacles hanging from the center of the trap filled with soap and water. Each trap sampled 0.25 m². Trap locations were determined by dividing each 300-m reach by four, and the trap was placed at a randomly chosen number within each 75-meter segment. Pan and emergence trap samples were each composited by date and reach prior to lab identification; a sample for a given day and reach was comprised of four emergence trap samples or six pan trap samples.

Samples were preserved in 90-percent ethyl alcohol in sealable plastic bags (Whirlpaks©) and returned to the lab. Benthos were identified to the family level, and adult aquatic insects (excluding Diptera) were identified to genus when possible (Blickle 1979; Nimmo 1987; Merritt & Cummins 1996). Aquatic Diptera were identified to family and when origin was unknown, down to species (McAlpine et al. 1981). Length and head capsule width were recorded to the nearest millimeter using a dissecting microscope equipped with a micrometer. For benthos, prior to identification, a two minute timed search was conducted to remove all large organisms. The remaining sample was sub-sampled to a count of five hundred individuals (Vinson & Hawkins 1996). Biomass was estimated using Benke et al. (1999). Terrestrial insects were identified using Borror, Triplehorn, and Johnson (1989) and were counted rather than measured. These were dried (method described below) to determine total terrestrial biomass.

For a given day in the full study there were three pan and three emergence composited samples used to obtain average seasonal biomass / day / square meter; the sum of date totals were divided by the number of sampling days and total area sampled for pan and emergence traps. Because benthic samples were taken at one point in time,

the totals were corrected for subsampling and area to obtain total biomass for the study area. In the summer, six subsamples were taken from the whole sample, four in spring and none during fall because they were already small. Pan and emergence trap samples were each composited by date and reach prior to lab identification; a sample for a given day and reach was comprised of four emergence trap samples or six pan trap samples.

Biomass estimation of adult aquatic insects

To estimate biomass of adult aquatic insects, 658 insects from the Oregon Cascades and Coast Range were identified and measured by our laboratory group using the procedure described above. Insects were dried (ash free dry mass) at 50-60°C for a period of 24 hours, then weighed using an analytical balance (mg). From these, a weight-length regression was created at the order level describing weight (mg) as a power function of length and head capsule width (mm). The equation used was:

$$W=aL^b \quad [1]$$

where W equals weight (mg), L equals any linear dimension (mm), and *a* and *b* were constants derived from the regression (Benke et al. 1999). Equation 1 was converted to obtain linearity using logarithm transformation. The intercept (*a*) and slope (*b*) were then used in the equation:

$$\ln W = \ln a + b \ln L \quad [2]$$

The best fitting model was determined using the regression coefficients (R^2). The weights of the remaining insects were calculated using length measurements and by solving for W in Equation 2. Provided below are the regression equations and regression

coefficients for each adult order and associated head capsule widths as the linear dimension.

Table 2. Intercept (*a*) and slope (*b*) from regression equations used to estimate adult aquatic insect biomass. Regression coefficients (R^2) indicate goodness of fit. Equations for length use log-transformed weight and length data. Equations for head capsule width use log-width only.

| | Equation for Length | | R^2 | Equation for Head Capsule | | R^2 |
|---------------|---------------------|----------|--------|---------------------------|----------|--------|
| | <i>a</i> | <i>b</i> | | <i>a</i> | <i>b</i> | |
| Diptera | 3.3294 | -6.3458 | 72.18% | 4.5169 | -5.2412 | 70.27% |
| Ephemeroptera | 3.1318 | -6.358 | 85.32% | 2.0681 | -2.9958 | 70.93% |
| Plecoptera | 2.4589 | -4.9803 | 73.05% | 1.3579 | -0.5684 | 74.9% |
| Trichoptera | 2.8361 | -5.1735 | 83.08% | 3.1105 | -3.5688 | 84.9% |

Fish sampling

To collect fish, electro-fishing was conducted on all three reaches in summer 2003 and spring 2004 and on two reaches in fall 2003 (Table 3).

Table 3. Number and length of juvenile salmonids captured in Honeygrove tributaries.

| Cutthroat Trout | | | | |
|------------------------|--------|------------------|------------------|------|
| | Number | Fork Length (mm) | Mean length (mm) | SD |
| Summer (6/18/03) | 20 | 78 – 183 | 93 | 38.6 |
| Fall (9/27/03) | 24 | 52 – 143 | 76 | 24.5 |
| Spring (5/19/04) | 33 | 75 – 179 | 116 | 27.6 |
| Coho Salmon | | | | |
| | Number | Fork Length (mm) | Mean length (mm) | SD |
| Summer (6/18/03) | 20 | 51 – 80 | 63 | 7.9 |
| Fall (9/27/03) | 23 | 52 – 72 | 59 | 5.6 |
| Spring (5/19/04) | 25 | 50 – 78 | 56 | 8.2 |

In the morning, electro-fishing was conducted until approximately twenty juvenile cutthroat trout and coho salmon were captured. The number of fish was restricted by our permit to collect salmonids in these streams. After we anesthetized fish using MS-222, fork length (mm) and weight (g) were measured*; gastric lavage, a gentle flushing of the

stomach with a fine tipped squirt bottle, was employed to collect stomach contents. Samples were collected onto coffee filters and preserved in ninety-percent ethyl alcohol. Fish were revived and released in the reaches where they were collected.

* Weight was not collected in the fall due to a faulty scale.

Diet samples were identified to lowest possible taxonomic resolution. Length or head capsule width was recorded to the nearest millimeter. Biomass was estimated for juvenile benthic invertebrates and adult aquatic insects using the regression relationships described above. Biomass estimates for terrestrial invertebrates were constructed using the published information found in Hódar (1996). Insect biomass was averaged in two ways: biomass was summed for each prey type (aquatic VS terrestrial, adult aquatic VS benthic, adult aquatic by order, benthic by order) and divided by number of individual fish for each species captured in fall. Insect prey biomass was also examined as a proportion of fish biomass calculated as a per milligram of fish basis, within each fish species for the summer and spring seasons. Unfortunately, our scale was broken in the field and we were only able to obtain weights for summer and spring. Prey items found in the diet that were unrecognizable were not included in the analysis. Those prey of uncertain origin were noted; table 4 shows percent uncertainty for each species and season.

Table 4. Percent uncertainties for prey found in fish diet samples by species and season

| | Summer | Fall | Spring |
|-----------|--------|------|--------|
| Cutthroat | 5% | 0% | 7% |
| Coho | 2% | 1% | 6% |

Bird sampling

Bird fecal samples were collected directly from birds captured in mist nets. Sampling efforts included two early morning days in summer (June 17 & 23) and fall (September

12 & 19) of 2003 on the Bird reach only and six early mornings (May 5 & 24, June 16, 17, 18). On May 5 and June 18, 2004, no birds were captured on the mainstem reach. Mist nets were set for a period no greater than five hours for each effort. The number of nets employed varied with each effort, ranging from five to ten, and were placed along an abandoned road adjacent to the Bird Reach and within the immediate riparian area on the Mainstem (Figure 2). Mist nets were 12 meters long and extended vertically approximately three meters. Once the nets were set, each was checked on a 15 to 20 minute interval.

If a bird was captured, it was removed from the net and placed in a small paper sack and attached to a nearby tree branch while the other nets were checked. Upon return, each bird was removed from the bag, if present, a fecal sample was collected from the bag and species and sex information were gathered. Fecal samples were preserved in 90-percent ethyl alcohol.

It was very difficult to identify prey items in fecal samples. Digestion frequently caused the insects to break apart. There were, on occasion, whole items found. These were identified to the lowest possible resolution, primarily order level and designated as aquatic or terrestrial. In the absence of whole prey items, parts were identified by matching characteristics specific to an invertebrate order. Table 5 lists some of the characteristics used to identify primary prey items found in bird fecal samples. Items that were unidentifiable were not included in the total and those that were questionable were noted. In the summer, there were 2% of prey there were questionable, 9% in the fall, and 8% in the spring.

Table 5. Characteristics of primary prey found in bird fecal samples

| Prey Item | Characteristic |
|---|---|
| Coleoptera (terrestrial) | Arrangement of tarsi; color of elytra |
| Coleoptera (aquatic) | Arrangement of tarsi; color & pattern of elytra |
| Homoptera | Arrangement of tarsi |
| Lepidoptera larvae | number of legs; crochets; mouthparts |
| Lepidoptera adult | Proboscis; scaled wings |
| Hymenoptera adult (not Formicidae) | Constricted waist; wing structure; arrangement of tarsi |
| Formicidae | Mouthparts |
| Hymenoptera larvae | Mouthparts; number of legs; lack of crochets |
| Araneae | Eyes; chelicerae & form of appendages |
| Trichoptera | Hairy wings; hook plates on abdomen |
| Diptera (Usually classified as terrestrial) | Halteres |
| Ephemeroptera | Number & arrangement of tarsi; wing structure |
| Plecoptera | Wing structure; patterned thorax; tarsal arrangement |

Statistical Analyses

Parametric statistical tests, Welch's Modified Two-Sample t-test and Multiple Comparisons Analysis (MCA) with Bonferroni correction, were used to assess differences in biomass data. Before any tests were conducted, biomass data were either natural log-transformed or natural log-transformed plus 0.001 to handle zeros in the data; this transformation was done to equalized the spread of the data (Ramsey and Shafer 2002). We compared seasonal biomass estimates of aquatic versus terrestrial invertebrates collected by pan traps, seasonal differences in aquatic versus terrestrial biomass consumption by fish, seasonal differences between adult aquatic and benthic biomass consumption by fish species by season, and number of aquatic and terrestrial prey in bird diets using Welch's Modified Two-Sample t-Test; this test was performed instead of the standard two-sample t-test because the Welch's test does not assume equal variances

(Ramsey & Shafer 2002). Welch's t-test uses an approximation of the t-distribution with $d.f._w$ degrees of freedom, Satterthwaite's approximation; this tool produces a smaller t-distribution and smaller degrees of freedom using a complex equation (Ramsey & Shafer 2002); alpha (α) levels for this test were set at 0.05. Low sample sizes of adult aquatic insect prey in fish diet and both prey types in bird diet precluded comparisons for fish species within a season.

MCA with the Bonferroni adjustment was used to make pair-wise comparisons of mean biomass. The Bonferroni adjustment lowered the chances of incorrect agreements between comparisons by dividing the alpha value by the number of things being compared (Miller 1991). MCA was conducted on: allochthonous input by season and order, aquatic emergence by season and order, and benthic invertebrate biomass across seasons. Sample sizes for benthic biomass and fish prey biomass data by order were insufficient for MCA because sample sizes were not sufficient. Data for "Seasons" were \ln transformed; data for "Order" were \ln transformed + 0.001. When Coleoptera were included in the MCA to test for within-seasonal differences in aquatic insect order biomass, statistical significances were skewed so analyses with and without Coleoptera have been included.

Results

Allochthonous Invertebrates

Biomass of adult aquatic insects returning to the streams was similar to terrestrial invertebrate inputs as measured in pan traps (Figure 3).

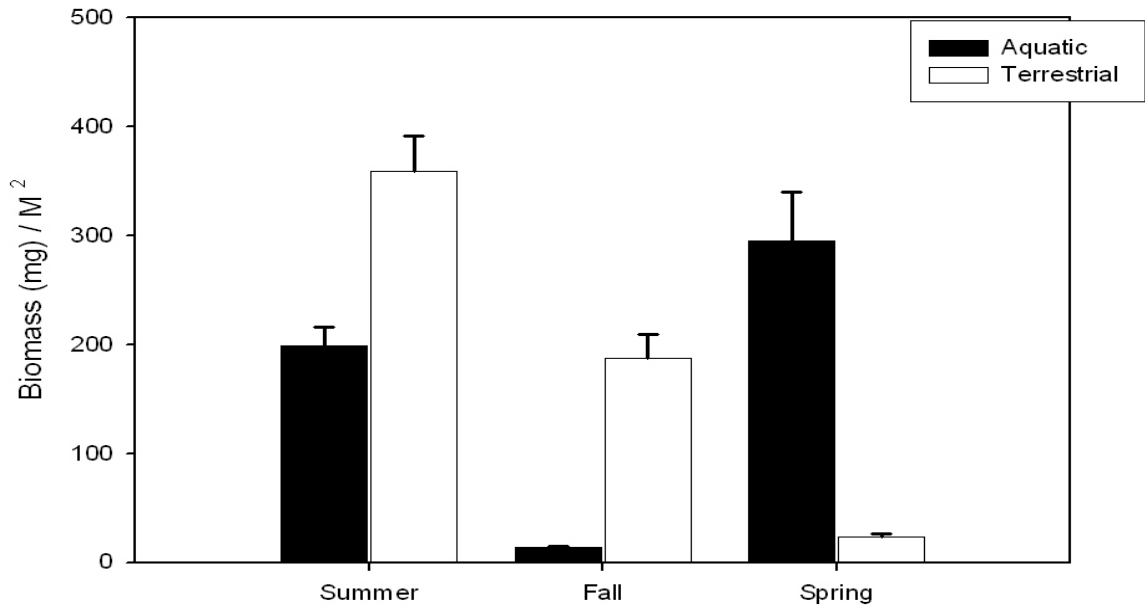


Figure 3. Pan Traps: Mean seasonal contribution of aquatic and terrestrial biomass in pan traps (averaged across all three reaches for each season). Error bars represent standard deviation. Diptera of uncertain origin were placed in terrestrial category.

Absolute differences appeared in each season, particularly contrasts in spring when there was 12 times more aquatic biomass (Table 6) than terrestrial; degrees of freedom were low and only spring samples were significantly different when data were transformed. The opposite pattern was observed in summer and fall when terrestrial biomass in pan traps was somewhat greater than aquatic.

Table 6. Seasonal comparison of aquatic and terrestrial biomass (mg) per square meter collected in pan traps tested with Welch's Modified two-sample t-test. Standard deviations are in parenthesis.

| Season | Biomass (mg) / m ² | | Significance ($\alpha = 0.05$) | d.f. |
|--------|-------------------------------|--------------|-------------------------------------|------|
| | Aquatic | Terrestrial | | |
| Summer | 199.1 (37.0) | 382.1 (73.4) | p = 0.85 | 26 |
| Fall | 14.2 (1.85) | 186.8 (56.0) | p = 0.11 | 34 |
| Spring | 294.6 (99.9) | 23.4 (7.2) | p < 0.01 | 22 |

When adult aquatic insects from pan traps were compared separately across seasons, they were significantly higher in the spring and summer than in fall (Table 7); biomass averaged only 2.37 mg/m² in the fall.

Table 7. Comparison of average biomass (mg) of aquatic adults collected in pan traps tested with Multiple Comparisons Analysis with Bonferroni adjustment 95% confidence interval. ^x indicates a significant difference using Welch's t-test. Capital letters represent between season comparisons; lower case within a season.

| Average Allochthonous Biomass (mg) / m ² | | | | | | |
|---|--------------------|------------|---------------------|-------------------|--------------------|---------------------|
| Season | Total | Order | | | | |
| | | Coleoptera | Diptera | Ephemeroptera | Plecoptera | Trichoptera |
| Summer | 202.7 ^A | 3.6 | 57.5 ^{a x} | 8.0 ^b | 111.3 ^a | 22.2 ^{a x} |
| Fall | 14.0 ^B | 0.0 | 9.3 ^a | 1.2 ^a | 3.2 ^a | 0.3 ^a |
| Spring | 287.8 ^A | 0.4 | 6.6 ^a | 12.9 ^b | 250.9 ^c | 17.5 ^b |

MCA of all orders within a season including Coleoptera were skewed due to the small amount of biomass this order contributed and therefore are not included in the MCA analysis. Diptera and Plecoptera represented the greatest average biomass meter-2 in the summer (Figure 4), and Diptera was significantly greater than Ephemeroptera. Surprisingly, Trichoptera biomass did not differ from the other orders according to MCA analysis (Table 7). However, there was a significant difference between Diptera and Trichoptera when using Welch's t-test (p-value = 0.04) but no significant difference between Trichoptera and Plecoptera (p-value = 0.19). Diptera biomass appeared higher

in the fall, but was not significantly different from other orders. In the spring, Plecoptera contributed the greatest amount of biomass and was significantly higher than other orders. In each season, there was a percentage of Diptera that were of unknown origin: Summer = 13%, Fall = 11%, and Spring = 2%.

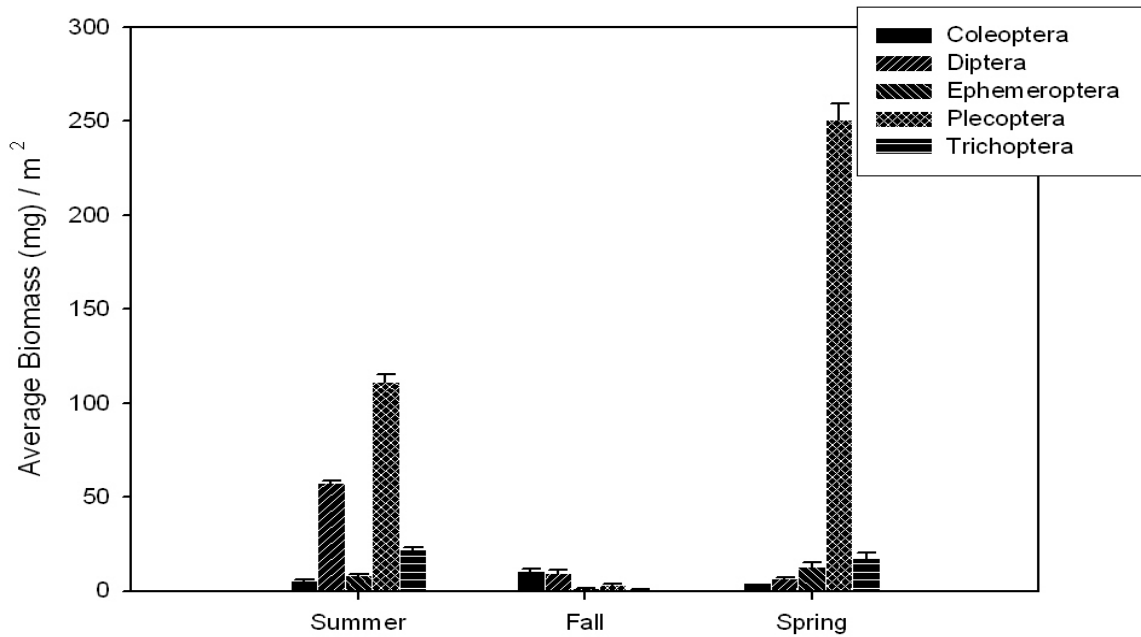


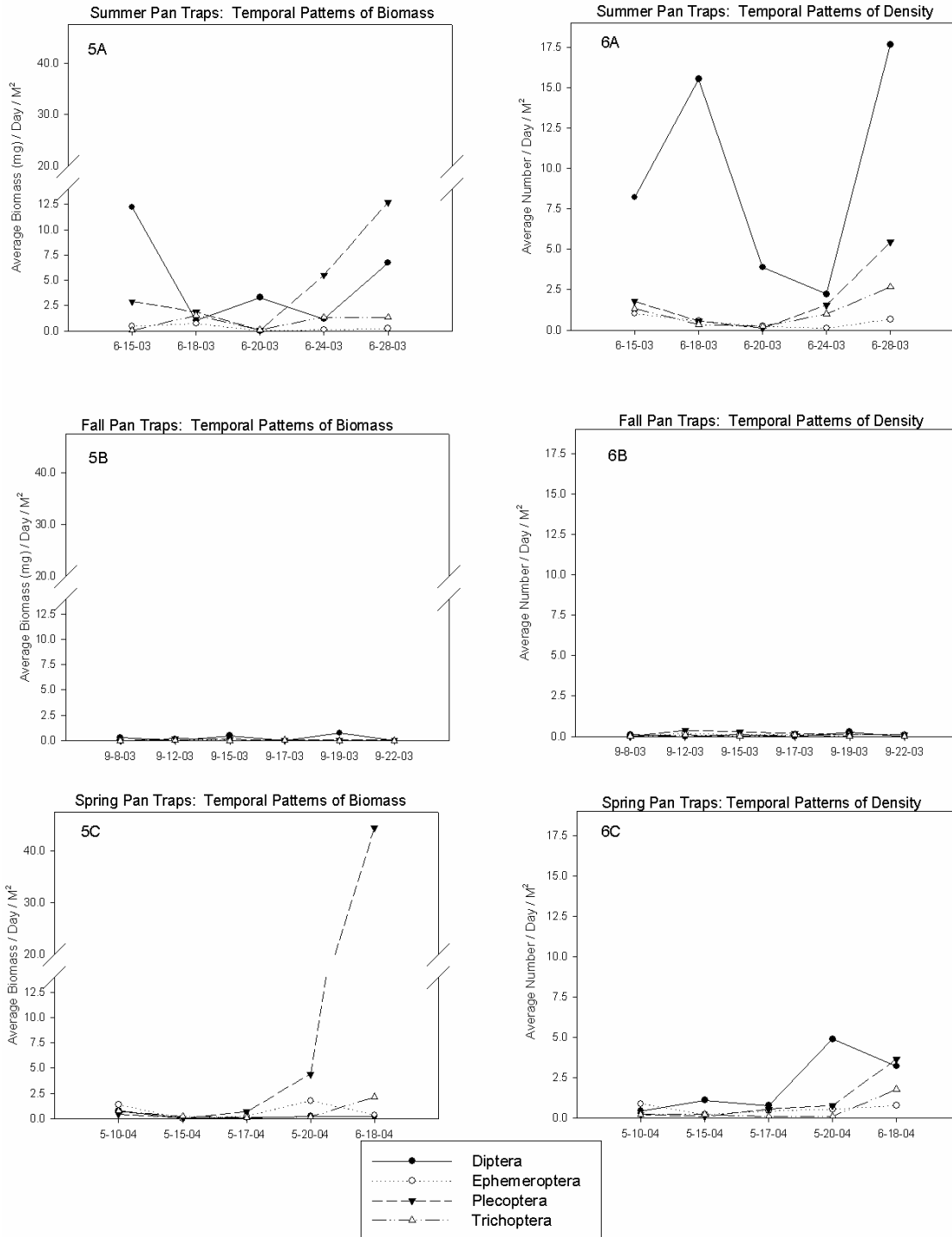
Figure 4. Mean seasonal differences in adult aquatic insect biomass collected by pan traps. Error bars represent standard deviation.

Densities of terrestrial invertebrates in pan traps, used as a surrogate measure of prey availability to both birds and fish, varied by season and order (Table 8). In summer, Diptera and Homoptera were most abundant. In the fall, the season of lowest terrestrial invertebrate densities, Diptera and Araneae were the most abundant. In the spring, Collembola and Thysanoptera represented the highest number per square meter as collected by the pan traps.

Table 8. Mean density of terrestrial invertebrates captured in pan traps average number across all sites.

| | Summer | Fall | Spring |
|-------------------------------------|--------|-------|--------|
| Araneae | 14.44 | 8.33 | 17.78 |
| Coleoptera | 11.67 | 2.22 | 6.11 |
| Collembola | 9.44 | 7.22 | 44.44 |
| Diptera | 95.1 | 12.78 | 20.56 |
| Haplotaxida (<i>Earthworm</i>) | 1.11 | 0.00 | 0.56 |
| Hemiptera | 0 | 1.67 | 0 |
| Homoptera | 33.89 | 4.44 | 10 |
| Hymenoptera | | | |
| Adult | 8.33 | 2.78 | 4.44 |
| Juvenile | 3.33 | 1.67 | 2.78 |
| Lepidoptera | | | |
| Adult | 6.11 | 1.11 | 0 |
| Juvenile | 2.78 | 2.78 | 1.67 |
| Mollusca | 0.56 | 1.11 | 0.56 |
| Orthoptera | 3.33 | 2.22 | 0.56 |
| Polydesmidae (<i>Millipede</i>) | 0.56 | 1.67 | 0 |
| Scutigermorpha (<i>Symphians</i>) | 0 | 1.67 | 0 |
| Thysanoptera | 1.67 | 0.00 | 37.22 |

There were variable patterns of daily within-season biomass (Figures 5A-C) and density of adult aquatic insect orders (Figure 6A-C) in pan traps, especially Plecoptera and Diptera. Patterns of allochthonous biomass were much different than abundance. In June 2003, sampling captured one major Plecoptera event, beginning on the 20th. The majority of the biomass were Perlodidae: *Isoperla* and Perlidae: *Calineura*; this pulse was reflected in both biomass and density (Figures 5A, 6A). In the same season dramatic fluctuations of Diptera density but not biomass were driven by aquatic taxa from the families Empididae, Ephydriidae, and Chironomidae. In spring, there was another large pulse of Plecoptera biomass, also comprised of Perlidae: *Calineura*. In the fall, densities were very low and there were no apparent fluctuations.



Figures 5 A-C. Pan Traps: Temporal comparison of mean adult aquatic insect biomass.
 Figure 6 A-C. Pan Traps: Temporal comparison of mean adult aquatic insect density.

Benthos

There was significantly greater total benthic biomass in summer and spring than there was in the fall, when biomass was a magnitude lower than other seasons (Table 9).

Table 9. Seasonal comparison of average benthic biomass (mg) by season for the Bird and MS reaches tested with Multiple Comparisons Analysis with Bonferroni adjustment 95% confidence interval. Lower case represent between season comparisons; Capital letters within a season.

| Average Benthic Biomass (mg) / m ² | | | | | | |
|---|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|
| Season | Total | Order | | | | |
| | | Coleoptera | Diptera | Ephemeroptera | Plecoptera | Trichoptera |
| Summer | 502.1 ^a | 13.2 ^A | 42.2 ^A | 25.5 ^A | 184.7 ^A | 236.5 ^A |
| Fall | 30.2 ^b | 4.4 ^A | 7.7 ^A | 0.8 ^A | 3.9 ^A | 17.8 ^A |
| Spring | 511.6 ^a | 17.8 ^A | 48.8 ^A | 149.9 ^A | 161.0 ^A | 134.1 ^A |

There were no significant differences between any of the orders within a season. However, Trichoptera apparently had greater biomass than other orders in summer and fall (Table 9, Figure 7). Plecoptera biomass was the second greatest in summer and highest in spring compared to low levels in fall. Ephemeroptera biomass was comparable to Trichoptera and Plecoptera biomass only in spring when mayfly biomass was almost three times as high as in summer.

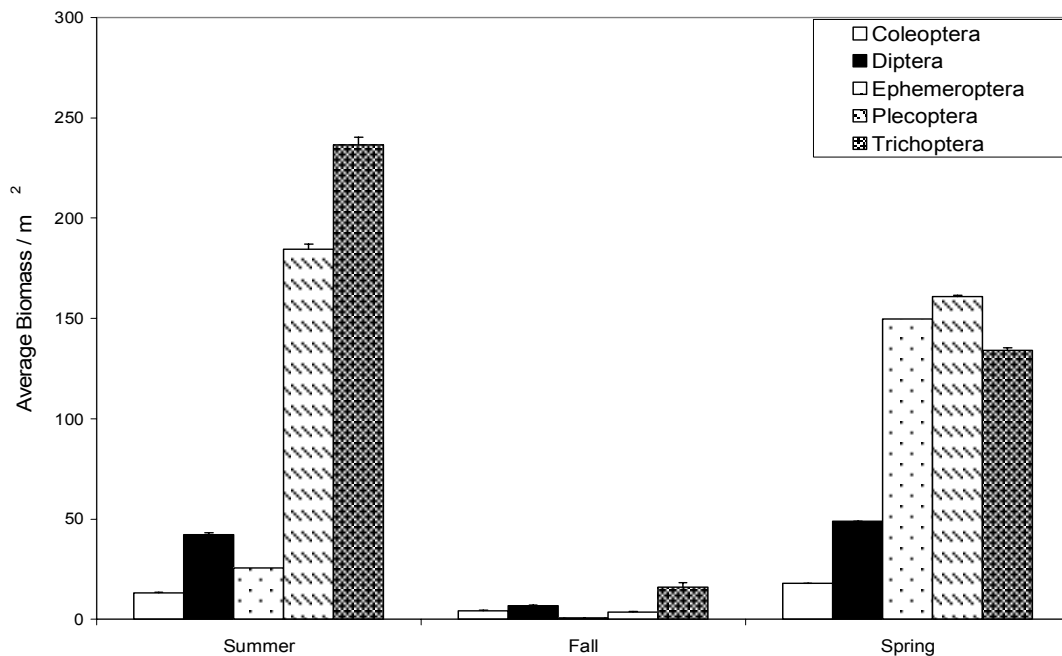


Figure 7. Seasonal comparison of average benthic biomass. Error bars represent standard deviation among two composited sampler per season.

Emergence

Total emergent aquatic insect biomass meter⁻² was two-to-three times greater in summer and spring than in the fall (Figure 8, Table 10). Spring emergence differed significantly from the other two seasons.

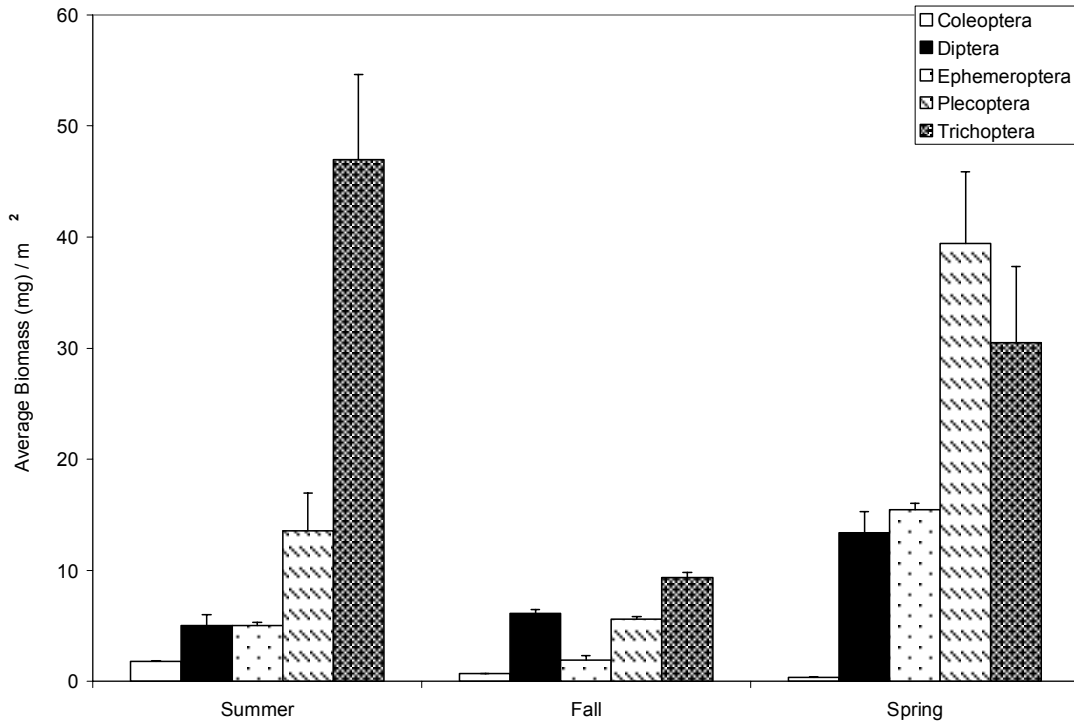


Figure 8. Mean seasonal biomass of emergent aquatic adult insects based on mean number per site per season. Error bars represent standard deviation among eighteen composited samples per season.

Table 10. Seasonal comparison of average emergent biomass (mg) m⁻² by season and order tested with Multiple Comparisons Analysis with Bonferroni adjustment 95% confidence interval. Lower case represent between season comparisons; Capital letters within a season.

| Average Emergence Biomass (mg) / m ² | | | | | | |
|---|-------------------|------------|-------------------|-------------------|-------------------|-------------------|
| Season | Total | Order | | | | |
| | | Coleoptera | Diptera | Ephemeroptera | Plecoptera | Trichoptera |
| Summer | 75.8 ^a | 1.8 | 10.3 ^A | 5.0 ^A | 13.5 ^A | 7.8 ^A |
| Fall | 23.0 ^a | 0.7 | 6.2 ^A | 1.9 ^A | 5.6 ^A | 9.3 ^B |
| Spring | 98.8 ^b | 0.6 | 13.4 ^A | 15.5 ^A | 39.4 ^A | 30.5 ^A |

Coleoptera were omitted from the MCA between orders because low sample size skewed results. Plecoptera and Trichoptera contributed the most biomass particularly during spring (Table 10), but did not differ significantly from other orders in either spring or summer. Only in the fall, was Trichoptera biomass significantly greater than other orders.

The daily patterns of emergent aquatic insect biomass and density within summer and spring sampling intervals were variable among insect orders; Trichoptera and Diptera had the highest variability (Figure 9A-C, 10 A-C). In the summer, we captured an emergence event of Trichoptera with a peak occurring on June 21st. Hydropsychidae: *Hydropsyche* was the primary contributor. Summer sampling revealed a pulse of Diptera emergence on June 21st comprised mostly of Chironomidae, Ephydriidae, and Empididae. During the spring season, the peak emergence of biomass occurred on the last day of sampling (June 18th) and was primarily made up of Rhyacophilidae: *Rhyacophila* and Philopotamidae: *Dolophilodes*. For density, peak emergence in the spring occurred on May 20th - Chironomidae was the primary taxon.

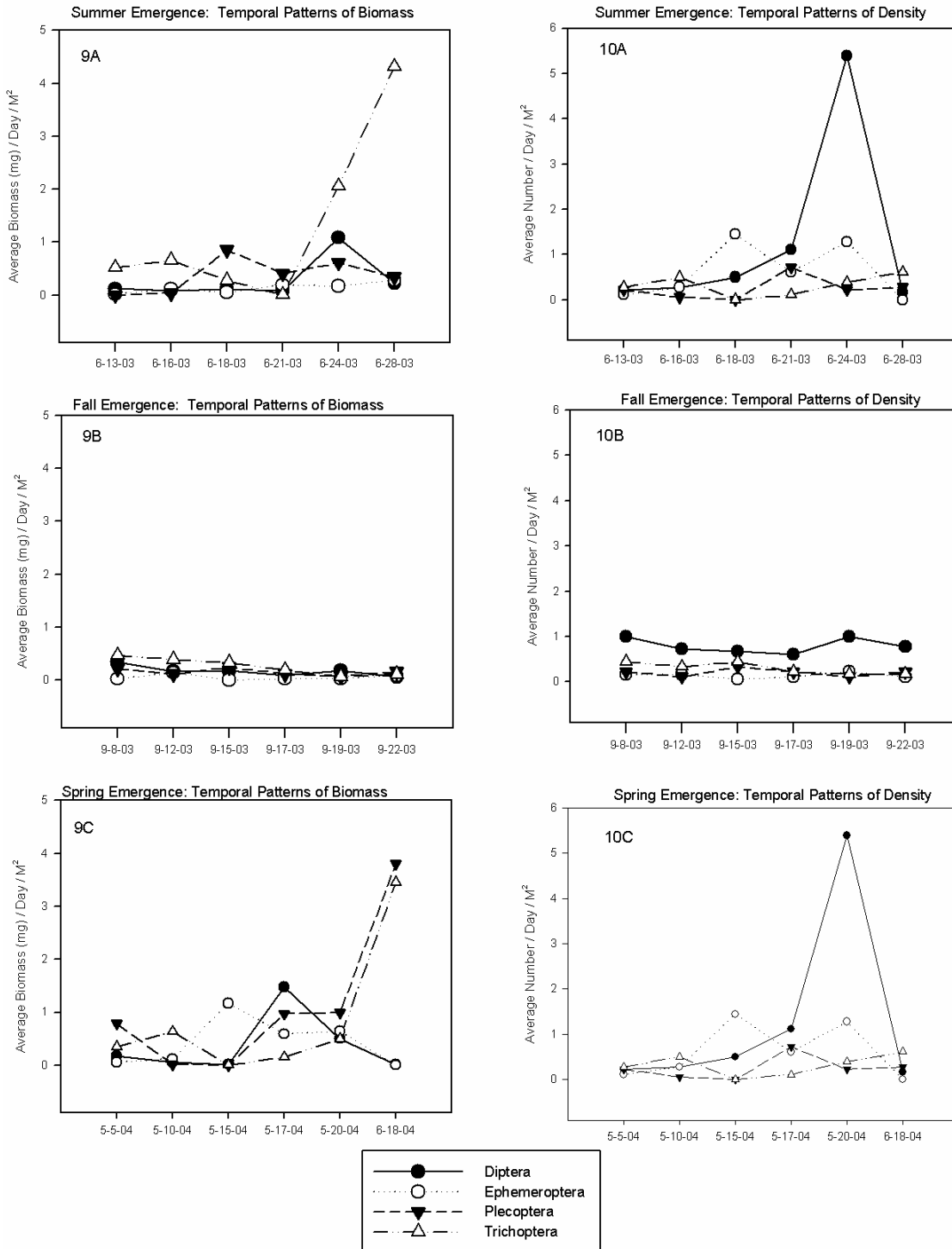


Figure 9A-C. Temporal comparison of mean emergent adult aquatic insect biomass.
Figure 10A-C. Temporal comparison of mean emergent adult aquatic insect density.

Fish Diet

Juvenile coho salmon were smaller than cutthroat trout (Table 3) collected in the Honeygrove watershed. To compare diet, prey consumption was relativized for fish weight; this altered neither the pattern of consumption nor insignificant differences in origin of prey consumed by either fish species. Note the difference in scales of consumption in Figure 11.

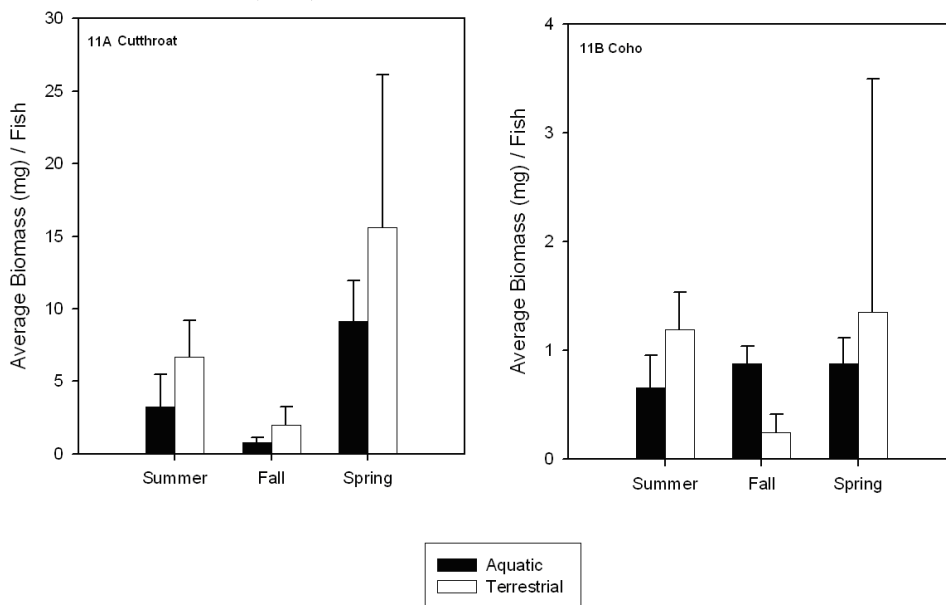


Figure 11. Un-relativized fish data showing differences in consumption between cutthroat (A) and coho (B).

Fish weights were not obtained in fall because of a broken scale so they are not included in the following analysis; nonetheless, because so little was available during the fall, they provide a context for patterns in summer and spring. Fall fish diet is included below as a separate section.

Juvenile cutthroat trout consumed differing volumes of aquatic and terrestrial biomass by in summer and spring (Figure 12A) however, the differences were not statistically significant (Table 11).

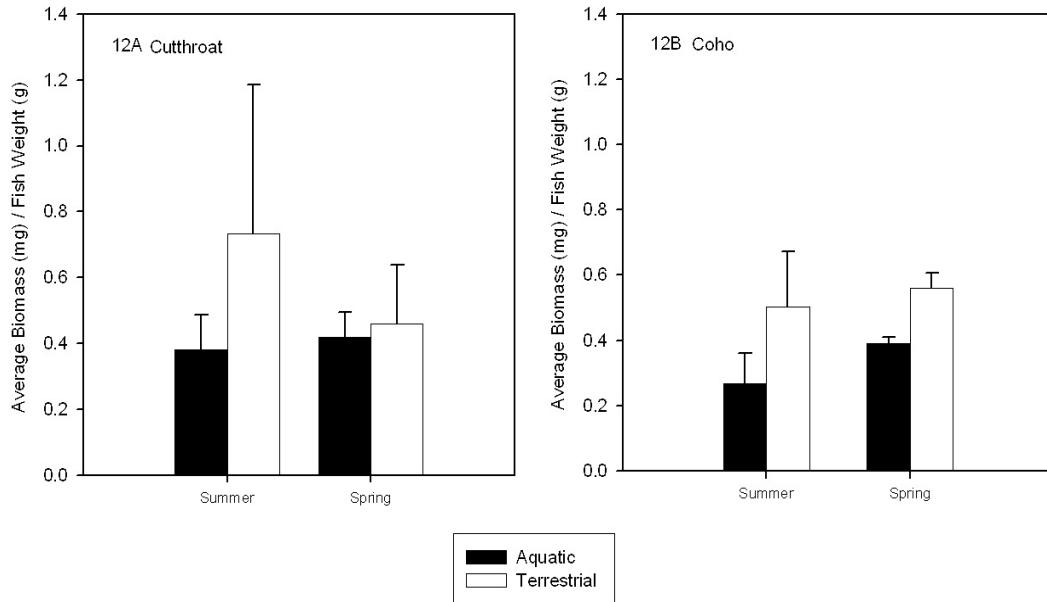


Figure 12. Relativized average aquatic and terrestrial biomass (mg) consumption by cutthroat trout (A) and coho salmon (B) in summer and spring. Error bars represent standard error.

Coho consumed more prey of terrestrial origin in both summer and spring (Figure 12B) though these differences were not statistically significant (Table 11). Only when aquatic prey were ungrouped (i.e. benthic separate from adult aquatic) did significant differences begin to appear.

Table 11. Standardized average biomass (mg) of aquatic and terrestrial prey / gram fish tested with Welch's modified two sample t-test. Number of fish in this analysis consumed both aquatic and terrestrial prey.

| Average Biomass (mg) / Gram of Fish | | | | | | |
|--|-----------------|----------------|---------|-------------|--------------------------------|------|
| | Species | Number of fish | Aquatic | Terrestrial | Significance ($\alpha=0.05$) | d.f. |
| Summer | | | | | | |
| | Cutthroat trout | 19 | 0.38 | 0.73 | p = 0.20 | 34 |
| | Coho | 16 | 0.27 | 0.50 | p = 0.28 | 19 |
| Spring | | | | | | |
| | Cutthroat trout | 24 | 0.42 | 0.46 | p = 0.19 | 41 |
| | Coho | 15 | 0.39 | 0.56 | p = 0.27 | 24 |

In a comparison of stream derived-prey (Table 12), we observed cutthroat trout ate more adult aquatic insect biomass than benthic biomass in the summer (Figure 13A), and more benthics in the spring. Coho consumed more benthic in both seasons (Figure 13B).

Table 12. Relativized average biomass (mg) of adult aquatic and benthic prey tested with Welch's modified two sample t-test. Number of fish in this analysis consumed both benthic and adult aquatic prey.

| Average Aquatic Prey Biomass (mg) / Gram of Fish | | | | | | |
|---|-----------------|----------------|---------------|---------|--------------------------------|------|
| | Species | Number of fish | Adult Aquatic | Benthic | Significance ($\alpha=0.05$) | d.f. |
| Summer | | | | | | |
| | Cutthroat trout | 17 | 0.19 | 0.16 | p = 0.03 | 26 |
| | Coho | 16 | 0.03 | 0.24 | p < 0.01 | 28 |
| Spring | | | | | | |
| | Cutthroat trout | 21 | 0.06 | 0.29 | p < 0.01 | 27 |
| | Coho | 15 | 0.03 | 0.32 | p < 0.01 | 28 |

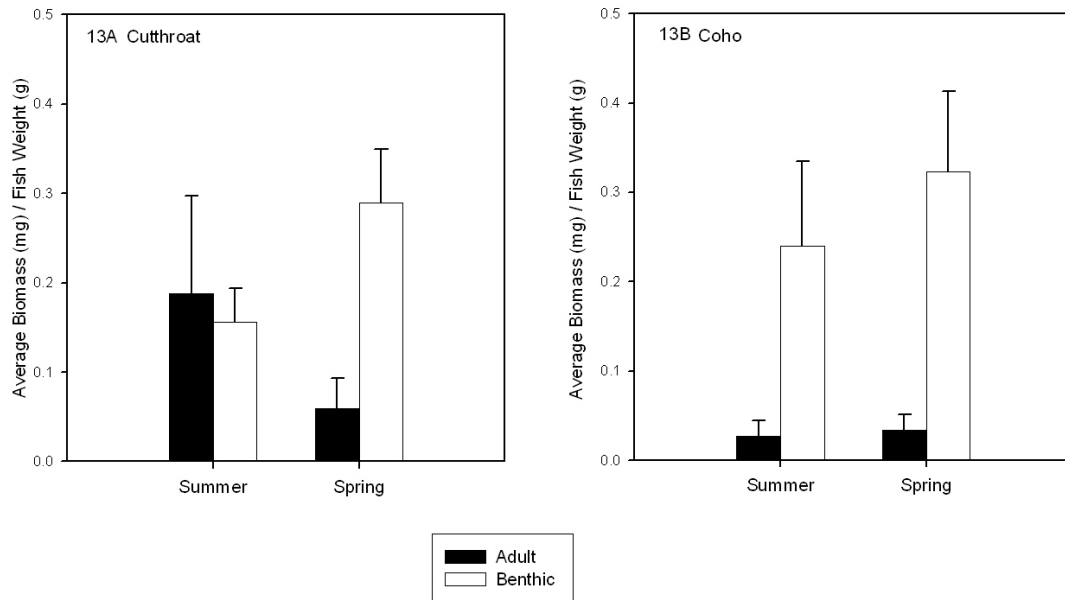


Figure 13. Relativized average adult aquatic and benthic biomass consumption for summer and spring by cutthroat (A) and coho (B). Error bars represent standard error.

In summer cutthroat trout diet of adult aquatic insects was more diverse (Table 13); Diptera and Trichoptera were dominant when coho diet was dominated by Trichoptera only. Plecoptera biomass in the diet of both fish species was high in spring but Ephemeroptera was equally important in coho diet.

Table 13. Relativized average biomass (mg) for adult aquatic insect orders. Neither fish species consumed adult aquatic Coleoptera.

| Average Adult Insect Biomass Consumed (mg) / Gram of Fish | | | | | |
|---|-----------------|---------|---------------|------------|-------------|
| | Species | Diptera | Ephemeroptera | Plecoptera | Trichoptera |
| Summer | Cutthroat trout | 0.06 | 0.001 | 0.02 | 0.05 |
| | Coho | 0.007 | 0.00 | 0.01 | 0.04 |
| Spring | Cutthroat trout | 0.001 | 0.009 | 0.04 | 0.003 |
| | Coho | 0.002 | 0.02 | 0.02 | 0 |

As with adult aquatic prey consumption, cutthroat trout ate benthic Diptera and Trichoptera biomass in summer. Trichoptera dominated the benthic portion of diet (Table 14, Figure 14A) in the spring comprising nearly three times as much biomass than

the other orders. Coho ate more Coleoptera in the summer as well as similar amounts of Diptera and Plecoptera (Figure 14B, Table 14). During spring, no Coleoptera were consumed and Diptera were the most abundant prey found.

Table 14. Relativized average benthic biomass (mg) for benthic aquatic insects in summer and spring.

| Average Benthic Insect Biomass Consumed (mg) / Gram of Fish | | | | | |
|---|------------|---------|---------------|------------|-------------|
| Species | Coleoptera | Diptera | Ephemeroptera | Plecoptera | Trichoptera |
| Summer | | | | | |
| Cutthroat | 0.02 | 0.06 | 0.01 | 0.02 | 0.06 |
| Coho | 0.21 | 0.14 | 0.01 | 0.11 | 0.05 |
| Spring | | | | | |
| Cutthroat | 0.01 | 0.05 | 0.04 | 0.02 | 0.23 |
| Coho | 0 | 0.18 | 0.10 | 0.02 | 0.03 |

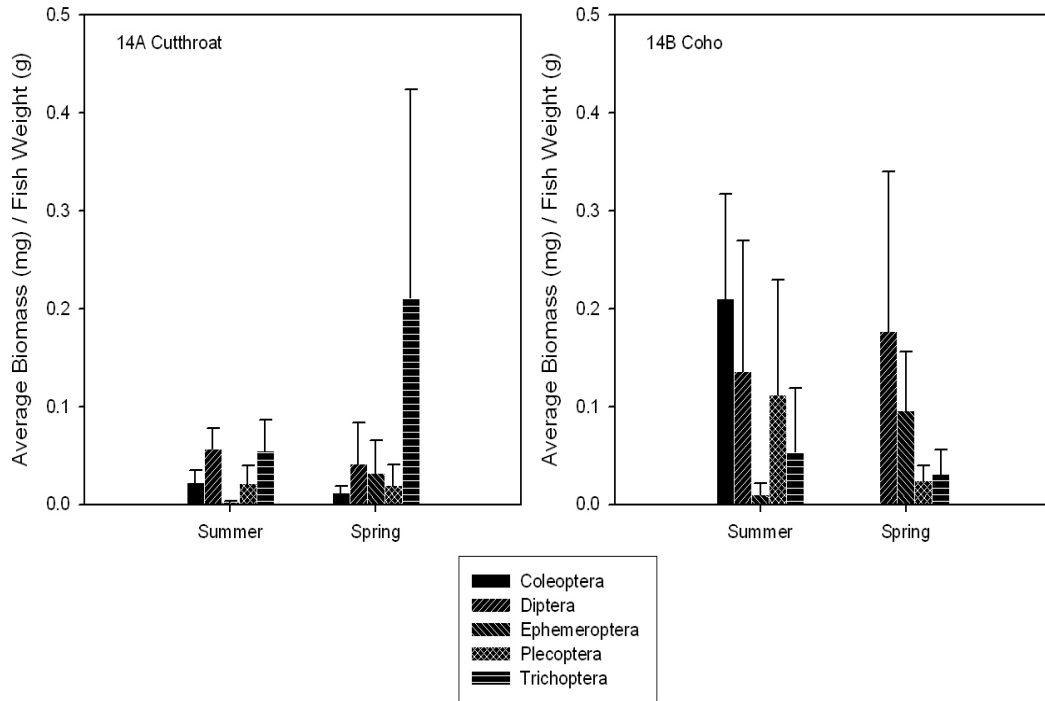


Figure 14. Mean benthic biomass (mg) consumption by order for cutthroat trout (A) and coho salmon (B) in summer and spring. Error bars represent mean plus standard error.

Both fish species consumed more terrestrial invertebrate biomass than adult aquatic biomass in summer and spring (Table 15, Figure 15). The differences were significant in both seasons for coho and for cutthroat in the spring; the data suggest there may be a significant difference in the summer (Table 15).

Table 15. Relativized mean adult aquatic and terrestrial invertebrate prey tested with Welch's modified two-sample t-test. Number of fish in this analysis consumed both adult aquatic insect and terrestrial invertebrate prey.

| | | Average Prey Biomass (mg) / Gram of Fish | | | | |
|---------------|-----------|--|---------------|-------------|--------------------------------|------|
| | Species | Number of fish | Adult Aquatic | Terrestrial | Significance ($\alpha=0.05$) | d.f. |
| Summer | Cutthroat | 19 | 0.19 | 0.73 | p = 0.06 | 36 |
| | Coho | 16 | 0.03 | 0.53 | p < 0.01 | 25 |
| Spring | Cutthroat | 24 | 0.06 | 0.46 | p < 0.01 | 45 |
| | Coho | 15 | 0.03 | 0.56 | p < 0.01 | 26 |

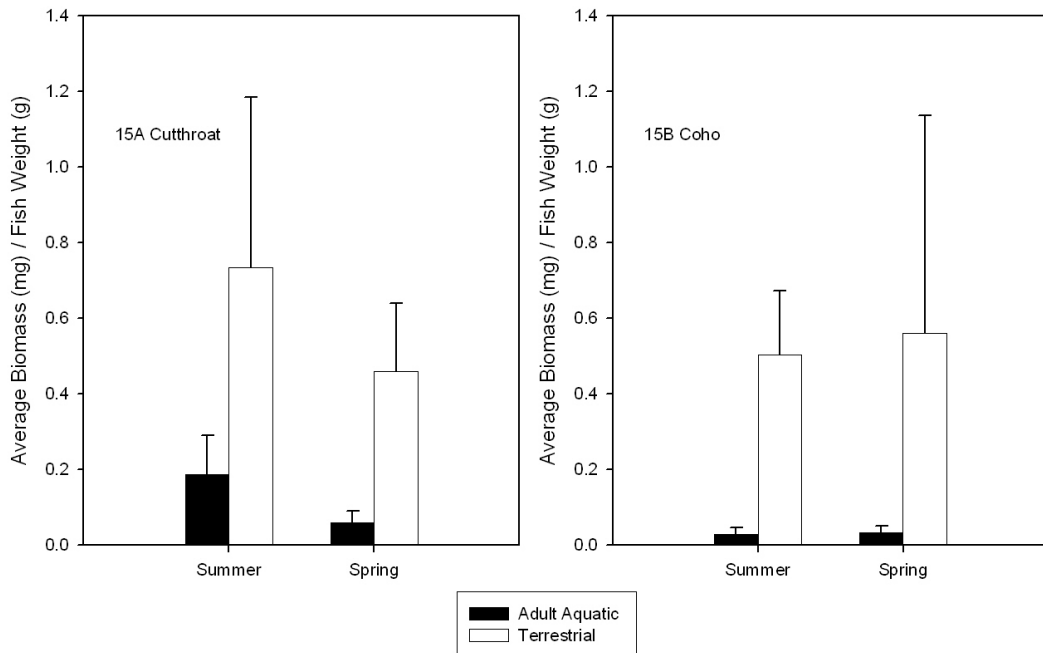


Figure 15. Mean adult aquatic insect prey and terrestrial invertebrate insect prey in fish diet.

Fall Fish Diet

During fall, cutthroat trout appeared to consume more terrestrial prey biomass while coho salmon seemed to consume more aquatic (Figure 11) but neither of these differences were statistically significant (Table 16).

Table 16. Mean aquatic and terrestrial biomass consumed by cutthroat trout and coho in the fall tested with Welch's t-test.

| Fall Season - Average Biomass (mg) / Fish | | | | | |
|---|--------|---------|-------------|-----------------------------------|------|
| Species | Number | Aquatic | Terrestrial | Significance ($\alpha=0.05$) | d.f. |
| Cutthroat trout | 15 | 0.81 | 1.99 | p = 0.26 | 13 |
| Coho | 14 | 0.88 | 0.25 | p = 0.14 | 15 |

When stream-derived prey were analyzed separately, both cutthroat trout and coho salmon consumed statistically more benthic than adult aquatic insect biomass in the fall (Table 17, Figure 16).

Table 17. Mean adult and benthic aquatic insect biomass consumed by cutthroat trout and coho in the fall.

| Average Adult and Benthic Biomass (mg) / Fish | | | | | |
|---|----|------------------|---------|-----------|----|
| | | Adult Aquatic | Benthic | | |
| Cutthroat trout | 15 | 0.32 | 0.56 | p = 0.001 | 20 |
| Coho | 14 | 0.02 | 0.69 | p < 0.001 | 23 |

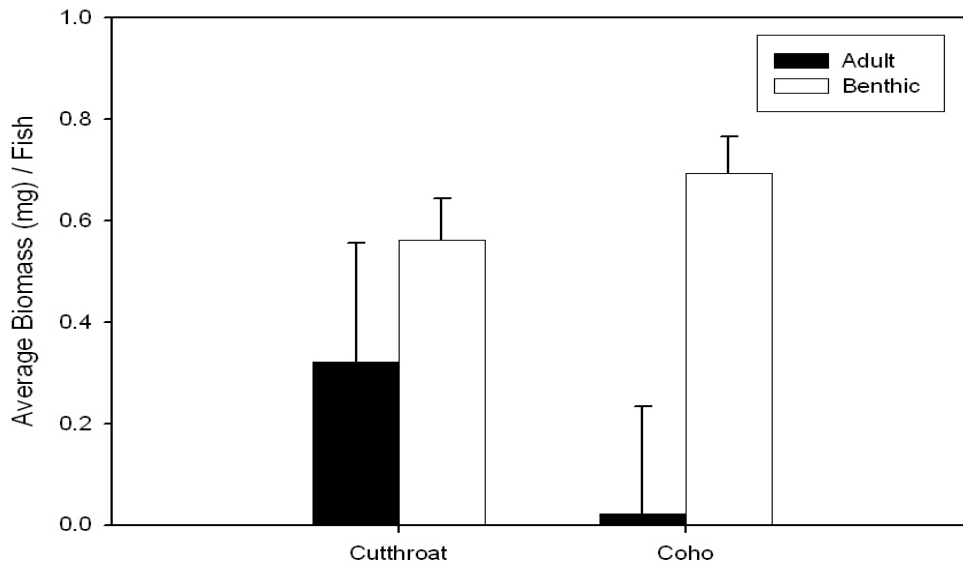


Figure 16. Mean adult aquatic and benthic biomass consumption for fall. Error bars represent standard error.

Trichoptera comprised almost the entirety of aquatic adult prey consumed by both fish species in the fall (Table 18).

Table 18. Mean adult aquatic insect biomass by order in fall.

| Average Adult Aquatic Insect Biomass (mg) / Fish | | | | |
|---|---------|---------------|------------|-------------|
| | Diptera | Ephemeroptera | Plecoptera | Trichoptera |
| Cutthroat trout | 0.002 | 0 | 0 | 0.23 |
| Coho | 0 | 0 | 0 | 0.29 |

In contrast to adult aquatics in the fall diet, benthic insects in the diet varied by fish species. Of the benthic biomass consumed in the fall, cutthroat trout consumed primarily Diptera and Plecoptera (Figure 17), 0.15 mg and 0.22 mg, respectively (Table 19).

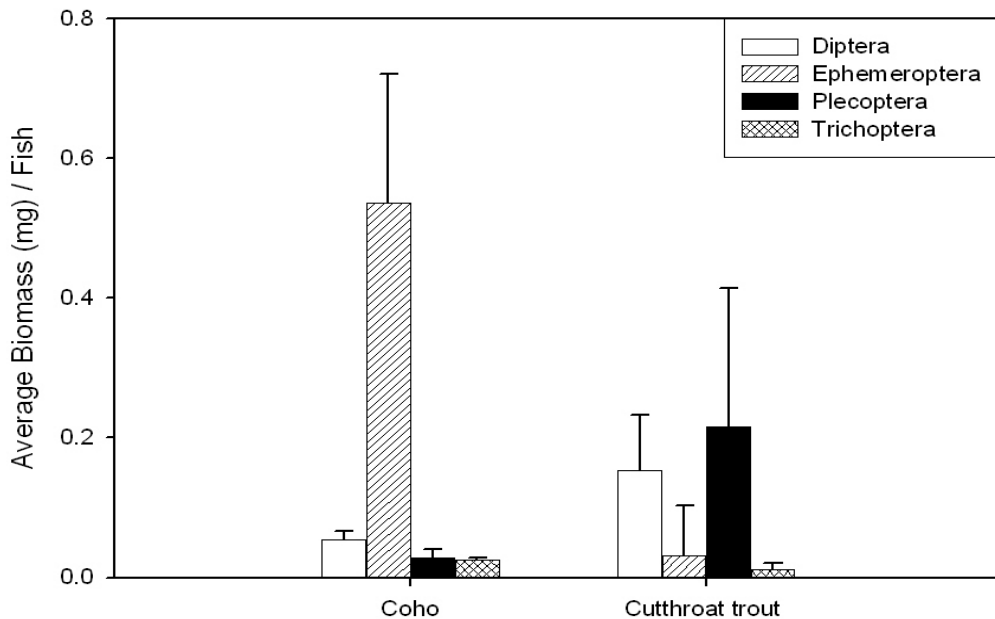


Figure 17. Mean benthic biomass consumption by order for fall. Error bars represent standard error. Fish did not consume juvenile Coleoptera during this season.

Coho salmon consumed Ephemeroptera; though actual biomass was low, Ephemeroptera made up 83% of total benthic biomass consumed (0.54 mg) (Table 19).

Table 19. Mean benthic biomass consumed by each fish species in the fall. Fish did not consume any juvenile aquatic Coleoptera during this season.

| Average Seasonal Benthic Insect Biomass Consumed (mg) / Fish | | | | |
|---|---------|---------------|------------|-------------|
| Species | Diptera | Ephemeroptera | Plecoptera | Trichoptera |
| Cutthroat trout | 0.15 | 0.03 | 0.22 | 0.01 |
| Coho | 0.05 | 0.54 | 0.03 | 0.03 |

The two fish species consumed significantly greater terrestrial invertebrate than adult aquatic biomass in this season (Table 20, Figure 18).

Table 20. Mean adult aquatic insect and terrestrial invertebrate prey consumed by fish in the fall.

| Fall Season - Average Biomass (mg) / Fish | | | | | |
|--|----------------|---------------|-------------|--------------------------------|------|
| Species | Number of fish | Adult Aquatic | Terrestrial | Significance ($\alpha=0.05$) | d.f. |
| Cutthroat trout | 14 | 0.25 | 1.99 | $p < 0.01$ | 23 |
| Coho | 14 | 0.02 | 0.25 | $p < 0.01$ | 23 |

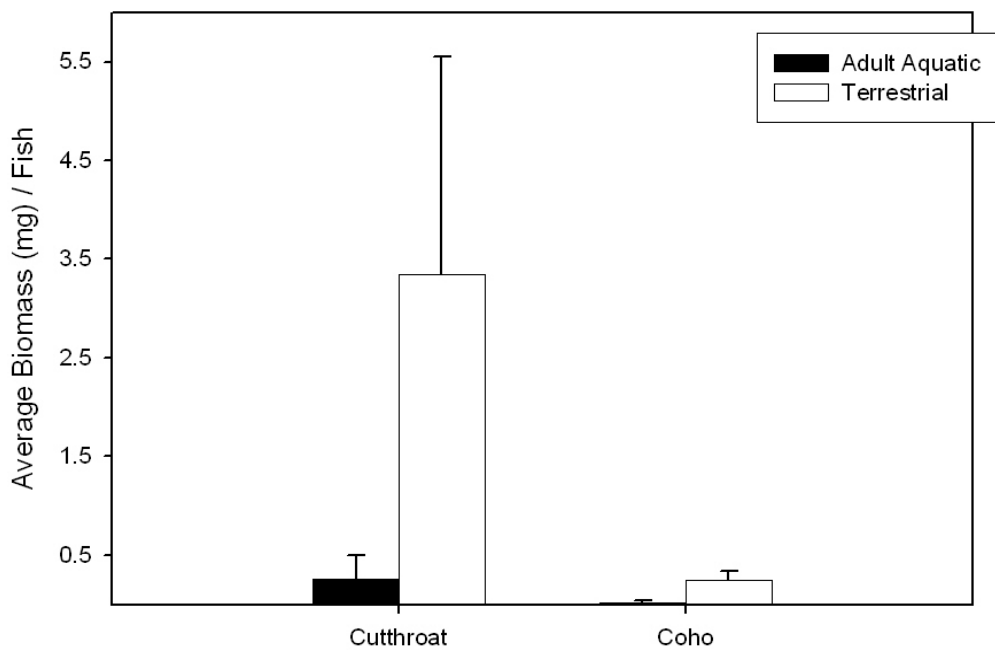


Figure 18. Mean adult aquatic and terrestrial biomass consumed in fall. Error bars represent standard error.

Fish Diet – Overlap between Consumption and Availability

In the summer season, fish diet corresponded to general availability for aquatic and terrestrial prey. Though summer terrestrial biomass was only apparently greater than aquatic biomass (Figure 3) both coho and cutthroat trout consumed significantly more terrestrial biomass than adult aquatic (Figure 15, Table 15).

Table 21. Characterization of terrestrial prey components as proportion of total biomass and proportion of total number in fish diet.

| Cutthroat | | Summer | | Fall | | Spring | | Coho | | Summer | | Fall | | Spring | |
|-----------------------------|-----------------------------|--------|--------|--------|------|-----------------------------|------|-----------------------------|------|--------|------|------|--|--------|--|
| Araneae | Proportion of Total Biomass | 0.05 | 0.03 | 0.1 | 0.18 | Araneae | | Proportion of Total Biomass | 0.17 | 0.15 | 0.01 | | | | |
| | Proportion of Total Diet | 0.08 | 0.13 | 0.18 | | Proportion of Total Diet | 0.18 | 0.16 | 0.03 | | | | | | |
| Coleoptera | Proportion of Total Biomass | 0.07 | 0.05 | 0.1 | 0.11 | Coleoptera | | Proportion of Total Biomass | 0 | 0.27 | 0.01 | | | | |
| | Proportion of Total Diet | 0.1 | 0.03 | 0.11 | | Proportion of Total Diet | 0 | 0.05 | 0.03 | | | | | | |
| Collembola | Proportion of Total Biomass | 0.04 | 0.01 | < 0.01 | 0.11 | Collembola | | Proportion of Total Biomass | 0.02 | < 0.01 | 0.01 | | | | |
| | Proportion of Total Diet | 0.18 | 0.87 | 0.11 | | Proportion of Total Diet | 0.09 | 0.42 | 0.44 | | | | | | |
| Diptera | Proportion of Total Biomass | 0.1 | 0.06 | 0.1 | 0.1 | Diptera | | Proportion of Total Biomass | 0.22 | 0.35 | 0.02 | | | | |
| | Proportion of Total Diet | 0.22 | 0.17 | 0.1 | | Proportion of Total Diet | 0.06 | 0.21 | 0.06 | | | | | | |
| Homoptera | Proportion of Total Biomass | 0.08 | 0.04 | 0.03 | 0.07 | Homoptera | | Proportion of Total Biomass | 0.15 | 0 | 0.02 | | | | |
| | Proportion of Total Diet | 0.17 | 0.07 | 0.07 | | Proportion of Total Diet | 0.18 | 0 | 0.06 | | | | | | |
| Hymenoptera | Proportion of Total Biomass | 0.03 | 0.49 | 0.02 | 0.07 | Hymenoptera | | Proportion of Total Biomass | 0.06 | 0.23 | 0.02 | | | | |
| | Proportion of Total Diet | 0.1 | 0.2 | 0.07 | | Proportion of Total Diet | 0.27 | 0.11 | 0.03 | | | | | | |
| Lepidoptera | Proportion of Total Biomass | 0.13 | 0 | 0.34 | 0.11 | Lepidoptera | | Proportion of Total Biomass | 0.26 | 0 | 0.89 | | | | |
| | Proportion of Total Diet | 0.06 | 0 | 0.11 | | Proportion of Total Diet | 0.06 | 0 | 0.11 | | | | | | |
| Polydesmidae (Millipede) | Proportion of Total Biomass | 0.5 | 0.32 | 0.28 | 0.07 | Polydesmidae (Millipede) | | Proportion of Total Biomass | 0.12 | 0.01 | 0 | | | | |
| | Proportion of Total Diet | 0.09 | 0.03 | 0.07 | | Proportion of Total Diet | 0.15 | 0.05 | 0 | | | | | | |
| Orthoptera | Proportion of Total Biomass | 0 | 0 | 0.03 | 0.15 | Orthoptera | | Proportion of Total Biomass | 0 | 0 | 0.04 | | | | |
| | Proportion of Total Diet | 0 | 0 | 0.03 | | Proportion of Total Diet | 0 | 0 | 0.25 | | | | | | |
| Thysanoptera | Proportion of Total Biomass | 0 | < 0.01 | 0.03 | 0.03 | Thysanoptera | | Proportion of Total Biomass | 0 | 0 | 0 | | | | |
| | Proportion of Total Diet | 0 | 0.03 | 0.03 | | Proportion of Total Diet | 0 | 0 | 0 | | | | | | |

Adult aquatic Diptera contributed ~30% to allochthonous biomass in summer (Table 7, Figure 4) and these comprised almost half (46%) of the adult aquatic prey in cutthroat trout diet (Table 13). Both adult aquatic and terrestrial adult Diptera density was high, and cutthroat trout likely encountered them while feeding on the waters surface (Table 21). Terrestrial Diptera were the most abundant taxa in the pan traps (Table 8) in summer and comprised 22% of terrestrial cutthroat diet in the summer but only 10% of total terrestrial prey biomass (Table 21). Likewise, terrestrial insects in coho diet were comprised primarily of terrestrial Diptera. Though relatively few in number Araneae, Lepidoptera, and Polydesmidae were important in coho summer diet; Polydesmidae biomass was more important and Lepidoptera and Araneae less so in cutthroat trout diet. Of the latter prey, only Araneae were numerous in pan traps (Table 8).

The amount of benthic prey available (Figure 7) to fish was high in the summer, similar to spring, although consumption of these prey was lowest of all three seasons (Figure 14, Figure 17). Larval Coleoptera and Diptera contributed most total benthic biomass consumed in coho diet although availability was relatively low for Diptera (Table 9). Cutthroat trout also consumed more Diptera biomass as well as Trichoptera.

The fall sampling season was compared using the un-relativized data which we analyzed separately from the other two seasons. Both species consumed significantly more terrestrial prey than adult aquatic insect prey in agreement with tendencies in availability (Figure 3, Figure 18). Cutthroat trout consumption did not correspond with seasonal lows in aquatic biomass, benthic and emergent, available. Nonetheless, of all the terrestrial biomass consumed by cutthroat trout, hymenoptera and millipedes contributed most (Table 21). Although coho and cutthroat trout both consumed adult

aquatic prey, they ate only Trichoptera (Table 18) that was one of the orders providing the greatest emergent biomass in the fall. Very low availability of other emergent or terrestrial prey was apparent in reduced fish consumption (Figure 3). Both fish species consumed significantly more benthic biomass than adult aquatic biomass during this season (Table 17).

In spring, pan traps collected more aquatic than terrestrial biomass (Figure 3) so it is surprising to see fish ate more terrestrial prey. The two dominant terrestrial prey items in cutthroat trout diet samples were millipedes and Lepidoptera larvae (Table 21). For coho diet we observed Lepidoptera larvae likely having the most biomass and Collembola being the most dense. Comparing this to dominant terrestrial taxa in pan traps, we see some overlap for coho as Collembola were most abundant taxon in the traps during this sampling period.

In the benthic portion of the fish diet, there was some overlap between availability and consumption. More Trichoptera biomass was consumed by cutthroat trout in spring. Although benthic biomass availability was well spread out among orders, Trichoptera only comprised 26.7% of total biomass. Coho consumed nearly equal amounts of Diptera and Trichoptera biomass. Ephemeroptera were most available but neither fish species ate them in proportion to availability (Table 9).

Bird Diet

Of all the birds captured in our study area, Swainson's Thrush were the most numerous (Table 22). Summer sampling, when more species were captured, was the most productive; only Black-headed Grosbeak were not captured in the summer sample.

Table 22. Number of birds captured and used for diet analysis in each season.

| Species | Number per Season | | |
|--|-------------------|-----------|-----------|
| | Summer | Fall | Spring |
| Black-headed Grosbeak (<i>Pheucticus melanocephalus</i>) | 0 | 0 | 1 |
| Pacific-slope Flycatcher (<i>Empidonax difficilis</i>) | 2 | 0 | 0 |
| Song Sparrow (<i>Melospiza melodia</i>) | 3 | 3 | 0 |
| Swainson's Thrush (<i>Catharus ustulatus</i>) | 6 | 5 | 7 |
| Wilson's Warbler (<i>Wilsonia pusilla</i>) | 2 | 0 | 0 |
| Winter Wren (<i>Troglodytes troglodytes</i>) | 3 | 3 | 2 |
| Total | 16 | 11 | 10 |

Birds captured in the Honeygrove watershed consumed greater numbers of terrestrial invertebrates than aquatic insects (Figure 19).

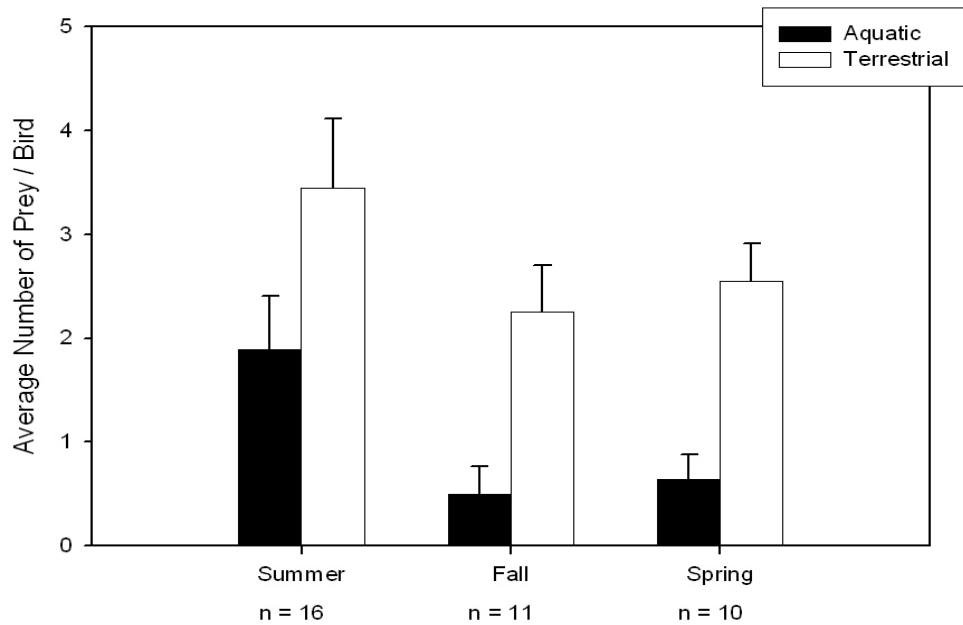


Figure 19. Mean seasonal bird consumption of aquatic and terrestrial invertebrates. Error bars represent standard error.

In summer, average consumption per bird consisted of 1.9 aquatic insects and 3.4 terrestrial invertebrates; however, the number of terrestrial food items was not

significantly different from the number of aquatic prey (Table 23). The relative number of aquatic prey decreased in fall and spring.

Table 23. Mean number of aquatic and terrestrial prey items in bird diet by season tested with Welch's t-test. Standard deviations in parenthesis.

| | Aquatic | Terrestrial | Significance ($\alpha = 0.05$) | d.f. |
|--------|-----------|-------------|-------------------------------------|------|
| Summer | 1.9 (1.5) | 3.4 (2.0) | 0.08 | 14 |
| Fall | 0.5 (0.8) | 2.3 (1.3) | < 0.01 | 9 |
| Spring | 0.6 (0.8) | 2.6 (1.2) | < 0.01 | 8 |

During the fall, average consumption was significantly different - 0.5 aquatic insects and 2.3 terrestrial invertebrates per bird. In spring, there were also significantly greater amounts of terrestrial prey (2.6) than adult aquatic (.06) per bird, found in the diet samples.

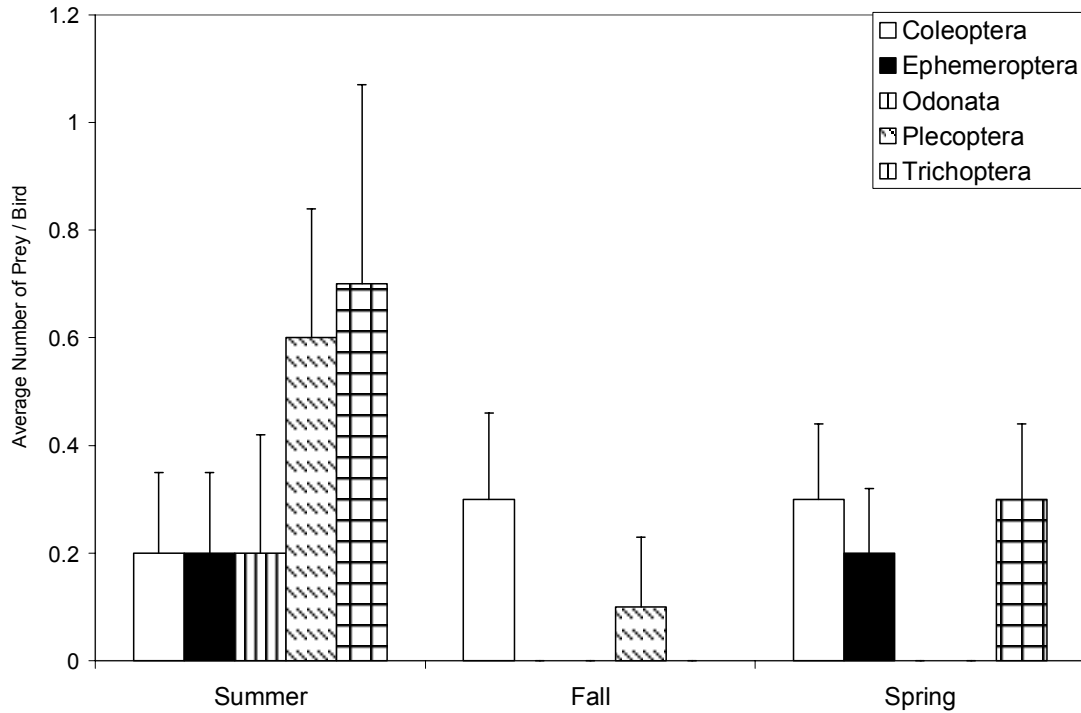


Figure 20. Aquatic distribution of bird diet expressed as mean number of prey per bird.

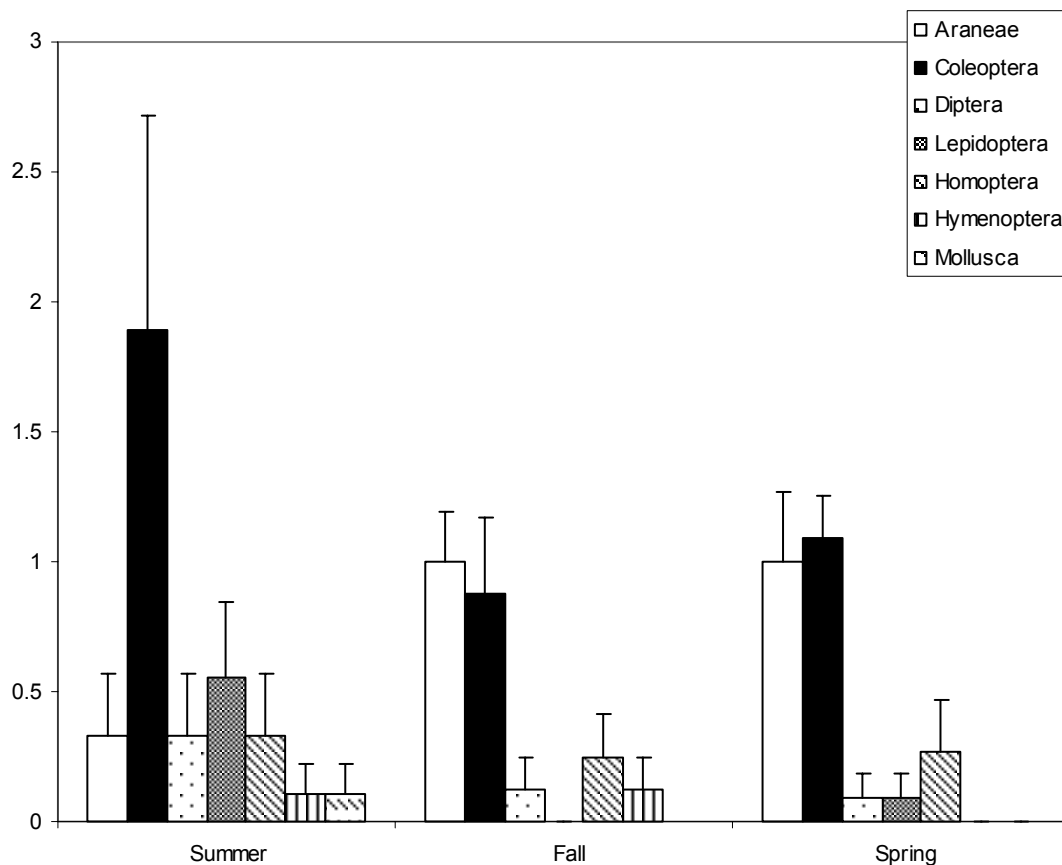
A greater diversity of aquatic orders were eaten in summer than fall and spring, with summer diets including Trichoptera and Plecoptera that were eaten most frequently (Figure 20, Table 24). In the fall, only two orders were represented, Trichoptera and Coleoptera, which were most abundant. In spring, Coleoptera, Ephemeroptera, and Trichoptera were found in the fecal samples. Among the birds caught, Pacific-slope flycatcher consumed the most aquatic prey though it was collected only in summer (Table 24); these birds consumed Plecoptera, Trichoptera, and Odonata. In the same season, 37% of Song Sparrow diet was comprised of aquatic insects (Ephemeroptera, Plecoptera, and Coleoptera). Aquatic prey comprised 33% of Wilson's Warbler diet during the summer; Ephemeroptera, Trichoptera, and Plecoptera were the dominant prey. Swainson's Thrush and Winter Wren consumed the least aquatic prey, 21% and 20% of total prey in the summer, respectively. In the fall, one representative from each of the three bird species captured consumed one aquatic prey item. Song Sparrow and Winter Wren ate aquatic Coleoptera; Swainson's Thrush consumed Plecoptera. In the spring, several Swainson's Thrush consumed six aquatic prey from the orders Coleoptera and Ephemeroptera. A Winter Wren fecal sample contained pieces of a Trichopteran.

Table 24. Number of aquatic and terrestrial prey consumed by each bird species and season. Numbers in parenthesis indicate number of prey from each order. All Lepidoptera consumed were larval. All Diptera were adult. * Indicates larval hymenopteran.

| Summer | | | | |
|--|------------------------------|--|----------------------------------|---|
| | Total Number of Aquatic Prey | Aquatic Prey Orders & Number | Total Number of Terrestrial Prey | Terrestrial Prey Orders & Number |
| <u>Pacific-slope Flycatcher</u> n = 2 | 8 | Trichoptera (3) Plecoptera (3) Odonata (2) | 12 | Coleoptera (9) Diptera (2) Araneae (1) |
| <u>Song Sparrow</u> n = 3 | 3 | Ephemeroptera (1) Plecoptera (1) Coleoptera (1) | 5 | Coleoptera (3) Lepidoptera (2) |
| <u>Swainson's Thrush</u> n = 6 | 3 | Trichoptera (2) Coleoptera (1) | 11 | Coleoptera (4) Lepidoptera (3) Homoptera (1) Hymenoptera (1) Mollusca (1) |
| <u>Wilson's Warbler</u> n = 2 | 3 | Ephemeroptera (1) Plecoptera (1) Trichoptera (1) | 6 | Araneae (2) Homoptera (2) Coleoptera (1) Diptera (1) |
| <u>Winter Wren</u> n = 3 | 1 | Plecoptera (1) | 5 | Coleoptera (3) Homoptera (2) |
| Fall | | | | |
| | Total Number of Aquatic Prey | Aquatic Prey Orders & Number | Total Number of Terrestrial Prey | Terrestrial Prey Orders & Number |
| <u>Song Sparrow</u> n = 3 | 1 | Coleoptera (1) | 6 | Coleoptera (3) Araneae (2) Homoptera (1) |
| <u>Swainson's Thrush</u> n = 5 | 1 | Plecoptera (1) | 7 | Araneae (4) Coleoptera (1) Diptera (1) Hymenoptera (1)* |
| <u>Winter Wren</u> n = 3 | 1 | Coleoptera (1) | 6 | Coleoptera (3) Araneae (2) Homoptera (1) |
| Spring | | | | |
| | Total Number of Aquatic Prey | Aquatic Prey Orders & Number | Total Number of Terrestrial Prey | Terrestrial Prey Orders & Number |
| <u>Black-headed Grosbeak</u> n = 1 | 0 | ----- | 3 | Araneae (1) Coleoptera (1) Diptera (1) |
| <u>Swainson's Thrush</u> n = 7 | 6 | Coleoptera (4) Ephemeroptera (2) | 23 | Coleoptera (11) Araneae (10) Homoptera (1) Lepidoptera (1) |
| Winter Wren | 1 | Trichoptera (1) | 2 | Homoptera (2) |

Terrestrial prey in bird summer diet (Figure 21) was also most diverse (Table 24).

Coleoptera were more than double the other prey consumed (mean = 1.9).



Fig

ure 21. Terrestrial prey by season found in bird fecal samples.

In both fall and spring, spiders and Coleoptera were consumed in similar numbers and were more numerous than other prey.

Bird Diet – Overlap between Consumption and Availability

Within the aquatic portion of bird diet in summer, Trichoptera and Plecoptera made up 35% and 29% of aquatic prey eaten, respectively (Figure 20). Interestingly, Trichoptera were abundant in summer emergence (Figure 8), increasing late in the week when birds were sampled (June 17th and 23rd). Biomass of Plecoptera, the second most abundant aquatic prey in bird diet, increased on the June 20th, continuing

until the 28th, during which time bird sampling occurred. Two Odonata were present in the fecal samples taken from one Pacific-slope flycatcher; this bird species forages in the air. The greatest biomass and density of Odonata was collected June 15th in pan traps, two days before sampling occurred (because of low numbers odonates were not included in the availability analysis). The dominant terrestrial prey in summer bird diet was Coleoptera (51.5%); however, only 6% of total terrestrial prey collected was Coleoptera (Table 8).

Relative availability of aquatic and terrestrial prey (Figure 3) during fall was similar to prey sources found in the fecal samples, i.e. birds consumed more terrestrial than aquatic prey according to availability. The primary prey found in diet were spiders and Coleoptera. Spiders were more abundant but it is likely that Coleoptera contributed more biomass. Of the twenty-three prey items found in the fall fecal samples, only four were aquatic.

With increased emergent biomass in spring (Table 10) we expected a greater number of aquatic prey in the diet. However, greater numbers of terrestrial prey were eaten by birds in the spring. Spiders comprised 36.6% of the terrestrial portion of the bird spring diet. They made up only 14% of total terrestrial invertebrates captured in spring pan traps though these traps were not set to collect spiders efficiently. To examine the aquatic to terrestrial subsidy, we used bird fecal samples to estimate the contribution of aquatic prey to diet. While this type of sampling was informative, we should note that the sample size was low, and the technique could underestimate soft-bodied prey.

Overlap between bird and fish diet

A comparison of bird and fish diet revealed seasonal overlap in consumption of terrestrial and adult aquatic prey. Because fish diet was measured as biomass while bird diet was measured as average number of prey we compared diets by a common currency of average number of prey. Estimates for birds were based on average number of prey for all species (Table 25). In the summer, cutthroat trout and birds ate similar numbers of aquatic prey. From these data, it appeared that cutthroat consumed a greater amount of terrestrial prey than birds did, while birds appeared to consume a greater amount of aquatic prey than did the cutthroat. Coho consumed the least amount of either prey and was not similar to the other predators. In the fall, both birds and fish consumed less adult aquatic insect prey, and consumption by cutthroat trout and birds was similar. Again, cutthroat trout appeared to consume more terrestrial prey than birds in the fall. In the spring, consumption of aquatic prey was at its highest for the fish species but remained similar to fall for the birds. Terrestrial consumption was higher for cutthroat compared to other consumers; birds and coho appeared to consume approximately equal amounts of terrestrial prey during this season.

Table 25. Diet Score Card – compares average number of prey items per consumer by season.

| | Summer | | Fall | | Spring | |
|-----------------|---------|-------------|---------|-------------|---------|-------------|
| | Aquatic | Terrestrial | Aquatic | Terrestrial | Aquatic | Terrestrial |
| Cutthroat trout | 1.7 | 4.1 | 0.7 | 3.1 | 2.3 | 3.5 |
| Coho | 0.8 | 1.9 | 0.1 | 1.4 | 1.2 | 2.6 |
| Birds | 1.9 | 3.4 | 0.5 | 2.3 | 0.6 | 2.6 |

Discussion / Conclusions

Reciprocal subsidy

There is evidence that a reciprocal subsidy is occurring in the Honeygrove watershed with notable similarities between our findings and the seminal “Reciprocal

Subsidies” paper by Nakano and Murakami (2001). Both aquatic and terrestrial habitats are receiving and contributing energy in the form of prey to consumers but the reciprocity is not symmetrical. In this food web, like the one in Japan, there is a seasonal synchrony where one habitat contributes more when prey from the other habitat is scarce. For example, in the fall when there was little aquatic production, the terrestrial habitat contributed ten times more biomass to the stream. Our measures of terrestrial prey availability were limited to stream allochthonous input, and total terrestrial availability to birds are likely underestimated in our study. Like Nakano and Murakami, we noted that birds did not utilize aquatic prey to the same degree that fish consumed terrestrial invertebrates. For birds in the Honeygrove watershed, aquatic prey made up 25.5% of total prey in all three seasons, a remarkably similar proportion to the 25.6% of total annual energy demand, reported by Nakano and Murakami, despite differences in how diet was assessed.

The major difference between our studies occurred in estimates of the terrestrial subsidy to fish. In Horonai stream, terrestrial prey comprised 44% of annual energy for fish. Though we did not measure annual energy, terrestrial prey biomass comprised more of fish diet at Honeygrove; they made up 64.5% of cutthroat trout diet for three seasons and 54.6% for coho diet. For fish and bird consumers, we noted important differences among species in prey consumption that we believe to be related to foraging behavior and predator size.

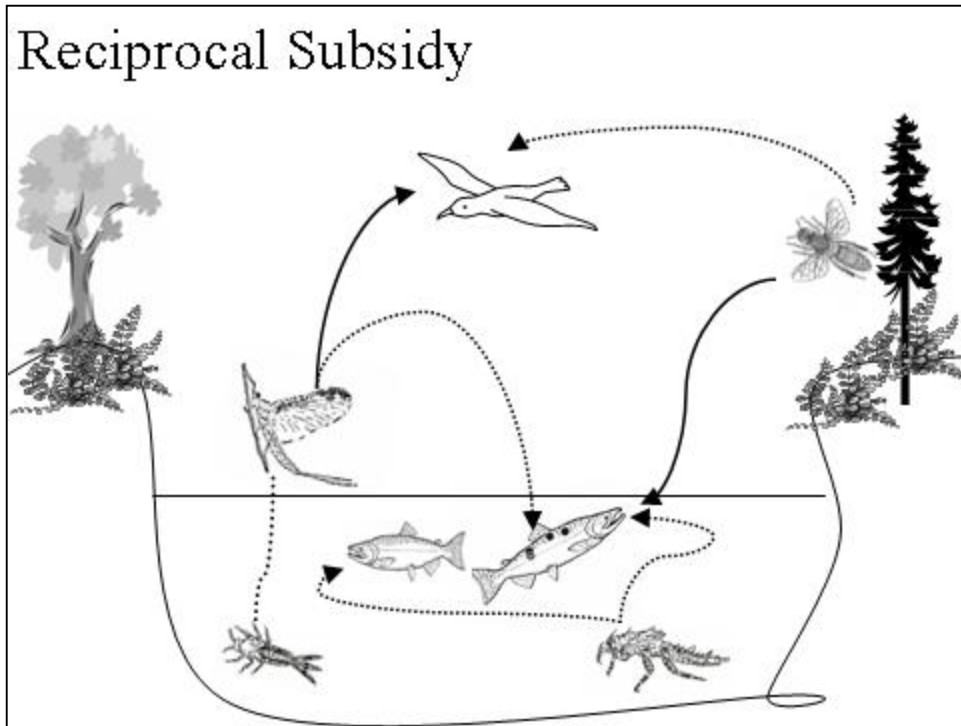


Figure 22. Representation of a reciprocal subsidy. Solid lines represent prey inputs from the external habitats. Dashed lines represent prey available from the same habitat.

Multiple measures of prey availability and consumption were important for estimating patterns between consumers and seasonal variations. Our seasonal comparisons of available prey biomass supported other studies done in the region. Emergence traps that effectively caught aquatic invertebrates in a fixed stream location captured similar adult aquatic biomass in the spring and the summer, a result similar to Progar & Moldenke (2002). Pan traps have a more general target and capture both terrestrial and aquatic invertebrates at the interface between stream and terrestrial environments. Our summer pan trap samples contained the most allochthonous aquatic insect biomass in agreement with Romero et al. (2005); terrestrial biomass input was also highest in summer, which was consistent with other studies in Oregon and elsewhere (e.g.

Mason & MacDonald 1982; Cloe & Garman 1996; Wipfli 1997; Kawaguchi & Nakano 2001; Nakano & Murakami 2001).

However, daily measurements of emergent biomass and density often did not track each other during the summer and spring (Figures 10 & 11). This differs from studies in other western Oregon streams where increases in density corresponded to increases in biomass (Progar & Moldenke 2002). It is likely that taxa-specific patterns in our collections account for discrepancy between densities and biomass. For example, the Trichopteran family Hydropsychidae emerged from our streams in low numbers, however, individuals from this family are large-bodied resulted in high biomass. While Plecoptera was more frequently captured in pan traps (only 17 were found in emergence), individuals of the single Perlid genus collected in emergence traps contributed 15.3 mg of biomass.

In our samples, Diptera density was much higher than other orders; because many Diptera are small bodied but ubiquitous, density measures increased dramatically with little change in total biomass. Similarly, Lynch et al. (2002) found Diptera to be the most abundant taxon, but as the majority of the insects were less than 3.5 mm in length, they contributed little to overall biomass. High densities of Diptera or other small bodied taxa underscore the differences between density and biomass as measures of energy exchange and illustrate why density alone is an inadequate measure for food web investigations. Though we measured densities, biomass was a more critical currency for our study because biomass is a direct estimate of the potential energy available as prey (Hódar 1996; Sabo et al. 2002).

The subsidy from terrestrial to aquatic habitats was important to fish at Honeygrove in all seasons. Where higher terrestrial invertebrate biomass was available in the summer elsewhere, (Mason & MacDonald 1982; Wipfli 1997; Nakano & Murakami 2001) and in our study, those prey were similarly elevated in the fish diet. Like other studies of cutthroat trout diet (Wipfli 1997; Romero et al. 2005) terrestrial prey biomass consumed was greatest during summer and fall. Whereas cutthroat trout consumed more aquatic biomass in spring, cutthroat trout diet at Honeygrove tended toward greater terrestrial or equally apportioned prey biomass. These differences in spring diet may be related to differences in canopy type. As changes in streamside vegetation can directly influence terrestrial invertebrates (Southwood 1961; Wipfli 1997). For example, Romero et al. (2005) study reaches were placed in areas with varying deciduous vegetation, common in the Oregon Coast Range, which may have contributed to high variation in prey availability in that study. In contrast, our study sites were close together and similar in their mixed-deciduous riparian vegetation.

The amount and kinds of prey biomass consumed were affected by differences between fish species and size. In our study, juvenile coho were noticeably smaller, 50-80 mm, than cutthroat trout, ranging from 52-183 mm. Standardizing prey biomass by fish weight (prey biomass mg / grams of fish) was an important step in making diet comparisons between these two species of difference sizes (Elliot & Persson 1978). Whereas we did not detect a strong preference for aquatic or terrestrial prey, Allen et al. (2003) found coho consumed more aquatic biomass in summer and in the fall coho ate more terrestrials (they did not sample in the spring). In the spring at Honeygrove, neither fish species ate aquatic and terrestrial invertebrates in accordance with what was

available. In this Oregon Coastal watershed, there is a terrestrial subsidy to cutthroat trout in all seasons and to coho salmon in summer and spring.

Where prey availability and diet overlapped, consumption was sometimes driven by particular taxa. For example, in summer, proportions of adult terrestrial dipteran biomass were similar in pan traps and fish diet. In fall, cutthroat trout diet was largely Lepidoptera larvae that also comprised a large portion of pan biomass. As in coho diet of Alaskan streams studied by Allen et al. (2003) adult Plecoptera contributed most biomass in fish diet; stonefly biomass was also greatest in pan traps. However, the importance of Plecoptera can be variable and in other Alaskan streams flowing through second-growth forests, Plecoptera contributed the least aquatic insect biomass to cutthroat trout diets (Wipfli 1997).

Discrepancies between insect availability and fish diet argue for the importance of examining both elements in order to understand the nature of riparian subsidies. Collections of invertebrates such as pan and emergence traps are not substitutes for measuring fish diet. In this study, Polydesmidae comprised 50% of total terrestrial biomass in fish diet while only four were collected in pan traps. Wipfli (1997) found Coleoptera and Lepidoptera comprised the greatest amount of biomass in cutthroat trout diet; however, those orders did not make up a large portion of overall pan biomass in their study. Similarly, Allen et al. (2003) found low biomass of these same taxa in pans while Lepidoptera were the second greatest contributor in coho diet. In our study, other large invertebrates, e.g. katydids, found in fish diet were not represented in pan traps. Potential bias in sampling availability must also be taken into account. Pan trap data as an estimate

of terrestrial availability may be limited due to the patchiness of insects and may underestimate terrestrial abundance.

The ways in which fish utilize prey can be examined not only by availability but also the by the way each species and size class forages. The frequency of terrestrial prey in fish diet is likely a result of the characteristics of terrestrial invertebrates found in the drift. Drifting terrestrials are more numerous during the day and are more visible due to backlighting. This actual and apparent increased availability is heightened because terrestrials can have greater buoyancy than aquatic prey (Baxter et al. 2005). In addition, the larger size of these prey made them more energetically important (Nakano et al. 1999; Sabo & Power 2002). While coho tended to consume more terrestrial than aquatic prey in summer and spring than aquatic, terrestrial prey played a constant role in cutthroat trout diet. The likely reason for more terrestrial prey in the cutthroat trout diet may be due to the larger size of these fish that probably conferred a dominant position over the smaller coho. Thus, coho might be left to consume benthos when unable to compete with larger cutthroat trout.

We used fecal samples to directly measure of aquatic and terrestrial insects in the diets of riparian obligate bird species. Although these data may be more reliable than those derived from previous studies, which simply witnessed birds consuming aquatic insects in flight (Murakami & Nakano 2001; Iwata et al. 2003), there are still several sources of uncertainties in our estimates of bird diet. The most obvious limitation was that many invertebrates consumed by birds could be predominantly soft-bodied. Digestion tends to dissolve non-chitinous tissue first, leaving little evidence in the fecal sample. To identify insects in fecal matter, we relied on hard sclerotized prey parts that

were less affected by digestion. To a lesser extent, more intact insects were identified when defecation released undigested food; this often occurs when birds feel stressed as they might have felt during mist netting and waiting time in the brown paper sacks. There may be some bias associated with the hard parts remaining as they could reside longer in the digestive tract.

However, in a comparison of diet assessed differences in diet using two different techniques - fecal samples and neck-collars; there were no significant differences between the two methods though fecal analysis risks underestimating soft-bodied prey groups (Moreby & Stoate 2000). These authors also note that fecal samples identified significantly more invertebrate prey groups than the other technique. In a similar study, fecal sample analysis was also deemed adequate to determine presence of prey items (Kleintjes & Dahlsten 1992). Another limitation we faced when estimating aquatic versus terrestrial invertebrates in fecal samples was our inability to distinguish between Diptera of aquatic and terrestrial origin. Aquatic Diptera were therefore excluded from our estimates of consumed prey; Diptera comprised 5% of total prey in these samples. The final potential bias to our estimates may be that birds have been observed to removing only soft fleshy parts from prey items, and leaving hard parts.

Despite our limitations, we observed an aquatic to terrestrial subsidy, where birds were consuming aquatic insects. Though this subsidy was relatively small, aquatic insects made up 32% of total prey in the summer, 17% in the fall, and 21% in the spring. These findings differed somewhat from Nakano & Murakami (2001) who found that aquatic insects comprised 25.6% total annual energy when they examined the subsidy through observations of feeding behavior. Differences in methodology may account for the fairly

small differences in overall estimates. In the Japanese study, there was great fluctuation in consumption of aquatic prey by all migrants and significant variation among other species. We also saw differences in the amount of prey consumed by different species, and resident species tended to eat the least aquatic prey. In Winter Wren, a resident species that occurred in both studies, aquatic prey contributed 98.2% of energy for a six-month period in Horonai stream (Nakano & Murakami 2001); but during all three of our sampling seasons, wrens consumed only 20% aquatic prey. Lower proportions of aquatic prey were also observed in a study of Wilson's Warblers (a riparian-obligate species), where terrestrial prey were the top five most preferred food groups and aquatic insects were in the latter half of the list (Raley & Anderson 1990). Two other riparian bird species, Yellow Warbler (*Dendroica petechia*) and Lucy's Warbler (*Vermivora luciae*), showed a similar feeding pattern, consuming 91% terrestrial prey and 9% aquatic prey (Yard et al. 2004).

We noted a general correspondence between bird foraging behavior, the types of prey they were likely to encounter, and prey in the fecal samples. Ephemeroptera, which generally emerge before dawn and form mating swarms above the stream (Sweeney & Vannote 1982), were found in the diet of three species, Swainson's Thrush, Song Sparrow, and Wilson's Warbler, all of which can take prey from the air. Plecoptera are poor fliers, and can be found on boulders, in vegetation, as well as flying above streams (Collier & Smith 2000). Four of our bird species, particularly Pacific-slope Flycatcher consumed Plecoptera that were most likely taken from the air. Trichoptera often rest on the undersides of leaves in the shrub layer and can be well dispersed horizontally throughout the canopy (Jackson & Resh 1989; Collier & Smith 1998). These prey were

consumed by four species, Winter Wren and Swainson's Thrush that forage on the ground, and Wilson's Warbler, and Pacific-slope Flycatcher, who either glean from shrubs or search foliage within the canopy. Though bird species tended to select among aquatic prey, spiders were the second most frequently consumed prey of the birds we sampled. They are less mobile than other potential prey, and are more abundant along the stream edge than adult aquatics in summer (Premdas 2004).

The patchy overlap of bird diet with prey availability may indicate the temporal variation of emergence and invertebrate sampling as well as bird energy profits and expenditures. Indeed, we were able to document pulses in emergence with our sampling (Figures 8, 10A-C). Seasonal and daily fluxes in emergence are driven by environmental factors such as temperature (Sweeney & Vannote 1996) and stream flow (Lytle & Poff 2004). The energy spent by a bird while foraging must be compensated for by energy provided in prey consumed; thus birds are inclined to consume foods of high energy return (Gill 1994). Prey size may influence prey selection in surprising ways as the time it takes to consume larger prey may outweigh the benefits of size (Davies 1977). Based on the number of smaller prey versus larger ones, i.e., large-bodied aquatic insects, consumed by the birds in Honeygrove, it is likely smaller prey requiring less foraging energy are being consumed by birds.

The empirical method of our sampling simultaneously addressed the fluxes of prey between the stream and riparian forest, following the reciprocal subsidy. It is one of a few studies that assess the synchronous exchanges between these habitats. Our examination of bird fecal samples to compare with fish diet samples and prey availability, produced results comparable to other studies of riparian consumers. As

difference in prey choices were more apparent among insect orders, resolving diet to order level was important in comparing diet overlap. Determining and understanding movement of resources between aquatic and terrestrial habitats is necessary to understand food web dynamics (Jackson & Fisher 1986). Food web theory predicts that predator densities will increase when subsidized by allochthonous prey and may alter community dynamics by suppressing *in situ* prey (Polis et al. 1997; Baxter et al. 2005). Nakano et al. 1999 found the opposite outcome, as the subsidy of terrestrial invertebrates alleviated predation pressure on benthos. If this pattern occurs at Honeygrove, the terrestrial subsidy to fish could indirectly increase benthic production and subsequently increase emergence of aquatic insects. In this scenario, the eventual benefit may accrue to the terrestrial predators, birds, who currently utilize only a small fraction of the aquatic subsidy. Conversely, there is the potential for birds to indirectly affect benthic prey resources by their consumption of adult aquatic insects. As birds consume these prey before they are able to mate and lay their eggs, there could be a potential influence in benthic production. The asymmetrical subsidy observed at Honeygrove, in which birds and fish tend to consume more terrestrial prey than aquatic three seasons of the year, likely reduces predation effects on either larval or adult aquatic insects .

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APPENDIX

A 1. Average biomass consumed by cutthroat trout and coho salmon in summer and spring using un-relativized data.

| | Average Biomass (mg) / Fish | | | | Significance ($\alpha = 0.05$) | d.f. |
|---------------|-----------------------------|--------|---------|-------------|-------------------------------------|------|
| | Species | Number | Aquatic | Terrestrial | | |
| Summer | Cutthroat trout | 19 | 3.24 | 6.7 | p = 0.09 | 16 |
| | Coho | 17 | 0.66 | 1.2 | p = 0.06 | 12 |
| Spring | Cutthroat trout | 24 | 9.14 | 15.61 | p = 0.50 | 20 |
| | Coho | 15 | 0.88 | 1.35 | p = 0.26 | 14 |

A 2. Number of terrestrial insects collected in pan traps.

| | Summer | Fall | Spring |
|--------------|--------|------|--------|
| Araneae | 26 | 15 | 32 |
| Coleoptera | 20 | 4 | 11 |
| Collembola | 17 | 13 | 80 |
| Diptera | 171 | 23 | 37 |
| Gastropoda | 1 | 2 | 1 |
| Haplotaxida | 2 | 1 | 1 |
| Hemiptera | 0 | 3 | 0 |
| Homoptera | 61 | 8 | 18 |
| Hymenoptera | 17 | 7 | 13 |
| Lepidoptera | 20 | 8 | 3 |
| Orthoptera | 12 | 4 | 1 |
| Polydesmida | 1 | 3 | 0 |
| Thysanoptera | 3 | 0 | 1 |
| Thysanura | 1 | 3 | 0 |

A 3. Streamside overstory and understory vegetation by reach.

| | | Streamside Vegetation | | | |
|-----------------|-------------------|-----------------------|-------------|---------|--|
| | | Percent | | Percent | |
| | Overstory | Cover | Understory | Cover | |
| <u>Amphib</u> | | | | | |
| | Red Alder | 60 - 80% | Oxalis | 40% | |
| | Bigleaf Maple | 40 - 60% | Salmonberry | 35% | |
| | | | Bracken | | |
| | | | Fern | 10% | |
| | | | Foam | | |
| | | | Flower | 10% | |
| | | | Sword Fern | 5% | |
| <u>Bird</u> | | | | | |
| 1-100 m | | | | | |
| | Red Alder | 85 - 100% | Foam | | |
| | | | Flower | 40% | |
| | | | Horsetail | 20% | |
| 100-300 m | | | | | |
| | Red Alder | 50 - 100% | Grasses | 20% | |
| | Bigleaf Maple | 10 - 20 % | Bracken | | |
| | | | Fern | 30% | |
| | | | Salmonberry | 30% | |
| | | | Foam | | |
| | Douglas-fir | 0 - 20% | Flower | 20% | |
| | Western Red Cedar | 0 - 30 % | Oxalis | 20% | |
| <u>Mainstem</u> | | | | | |
| | Bigleaf Maple | 0 - 60% | Salmonberry | 30% | |
| | | | Bracken | | |
| | Red Alder | 0 - 60% | Fern | 10% | |
| | | | Foam | | |
| | Douglas-fir | 0-10% | Flower | 15% | |
| | | | Oxalis | 40% | |
| | | | Mosses | 5% | |

A 4. Upslope overstory and understory vegetation by reach.

| Upslope Vegetation | | | | |
|--------------------|--------------------|---------------|---------------------------------|------------------|
| | Overstory | Percent Cover | Understory | Percent Cover |
| <u>Amphib</u> | | | | |
| | Red Alder | 40% | Sword Fern | 40% |
| | Bigleaf Maple | 20% | Salmonberry Foam Flower | 40% 20% |
| <u>Bird</u> | | | | |
| 1-100 m | | | | |
| | Red Alder | 60 - 100% | Grasses Stinging Nettle | 60% 40% |
| 100-300 m | | | | |
| | Red Alder | 0 - 90% | Salal | 20% |
| | Bigleaf Maple | 0 - 40% | Sword Fern Foam | 20% |
| | Douglas-Fir | 0 - 30% | Flower | 20% |
| | Western Hemlock | 0 - 50% | Salmonberry Mosses Oxalis | 20% 5% 15% |
| <u>Mainstem</u> | | | | |
| | Bigleaf Maple | 0 - 30% | Salal | 10% |
| | Red Alder | 0 - 75% | Salmonberry | 40% |
| | Douglas-Fir | 0 - 60% | Oxalis Sword Fern | 20% 30% |

A 5. Itemized summer cutthroat diet.

| SUMMER | CUTTHROAT | REACH | BOTH | |
|--------|--------------|--------------|------------|-------------|
| FISH | | | | |
| NUMBER | ORDER | FAMILY | LIFE STAGE | BIOMASS |
| 1 | AQUATIC | | | |
| | DIPTERA | DIXIDAE | JUVENILE | 0.470916527 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.0056 |
| | | | | 0.0056 |
| | HEMIPTERA | GERRIDAE | ADULT | 0.090691196 |
| | TERRESTRIAL | | | |
| | COLEOPTERA | UNKNOWN | ADULT | 0.014531496 |
| | | | | 0.161495386 |
| | | | | 0.539249385 |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.0664 |
| | DIPTERA | UNKNOWN | ADULT | 0.0312 |
| | | | | 0.082293377 |
| | | | | 0.279271807 |
| | HYMENOPTERA | UNKNOWN | ADULT | 0.1636 |
| | | | | 0.1636 |
| | | | | 0.1636 |
| | | | | 0.353473363 |
| 2 | AQUATIC | | | |
| | DIPTERA | UNKNOWN | JUVENILE | 0.00506612 |
| | HEMIPTERA | GERRIDAE | ADULT | 0.084922175 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.010472194 |
| | TRICHOPTERA | UNKNOWN | ADULT | 1.257530654 |
| | TERRESTRIAL | | | |
| | Araneae | UNKNOWN | ADULT | 0.023261846 |
| | COLEOPTERA | UNKNOWN | ADULT | 0.958414744 |
| | | | | 1.311540476 |
| | | | | 3.347318784 |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.016516681 |
| | | | | 0.026604131 |
| | | | | 0.114238576 |
| | | | | 0.452895833 |
| | | | | 1.028583452 |
| | DIPTERA | UNKNOWN | ADULT | 0.62454733 |
| | | | | 0.76032095 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.10162562 |
| | | | | 0.254490544 |
| | HYMENOPTERA | FORMICIDAE | ADULT | 0.534057738 |
| | | | ADULT | 0.58145062 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 10.27452226 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 0.02707907 |
| | | | | 0.075515885 |
| 3 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | PUPAE | 0.027289281 |

A5. continued

| | | | | |
|---|--------------------|---------------|----------|-------------|
| | | | | 0.119967244 |
| | | | ADULT | 0.019506296 |
| | | | | 0.03331641 |
| | | | | 0.205458544 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.087759738 |
| | TRICHOPTERA | GLOSSOMATIDAE | JUVENILE | 0.181042997 |
| | | UNKNOWN | | 0.181042997 |
| | | | | 0.360001094 |
| | <u>TERRESTRIAL</u> | | | |
| | Araneae | UNKNOWN | ADULT | 0.801774986 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.213509539 |
| 4 | <u>AQUATIC</u> | | | |
| | COLEOPTERA | ELMIDAE | JUVENILE | 1.217988085 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.011071437 |
| | | | | 0.019063219 |
| | | | | 0.090387795 |
| | | | | 0.090387795 |
| | | | | 0.238263559 |
| | TRICHOPTERA | UNKNOWN | ADULT | 0.127160654 |
| | | UNKNOWN | JUVENILE | 2.289945981 |
| | <u>TERRESTRIAL</u> | | | |
| | NONE | | | |
| 5 | <u>AQUATIC</u> | | | |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.112643556 |
| | | | | 0.385595729 |
| | | | | 0.69625772 |
| | | | | 0.759876404 |
| | | | | 0.960976468 |
| | | | | 1.219786841 |
| | <u>TERRESTRIAL</u> | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.673682173 |
| | DIPTERA | UNKNOWN | ADULT | 0.231160939 |
| | | | | 0.269748574 |
| | | | | 0.357532883 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 1.033075555 |
| 6 | <u>AQUATIC</u> | | | |
| | COLEOPTERA | ELMIDAE | JUVENILE | 0.541259951 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.107623667 |
| | | DIXIDAE | JUVENILE | 0.094189023 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.010125858 |
| | | | | 0.101222718 |
| | <u>TERRESTRIAL</u> | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.056226049 |
| | | | | 0.94535441 |
| | DIPTERA | UNKNOWN | ADULT | 2.85 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 7.370550468 |
| 7 | <u>AQUATIC</u> | | | |
| | DIPTERA | DIXIDAE | JUVENILE | 0.153870798 |

| | | | | |
|------------------|---------------|----------------|----------|-------------|
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.148507104 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| A5. | | | | |
| continued | | | | |
| 8 | AQUATIC | | | |
| | NONE | | | |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.012206799 |
| | DIPTERA | UNKNOWN | ADULT | 0.577802226 |
| 9 | AQUATIC | | | |
| | DIPTERA | TIPULIDAE | JUVENILE | 0.584837763 |
| | DIPTERA | UNKNOWN | JUVENILE | 0.140449824 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.843080284 |
| | | | | 5.6517902 |
| | TERRESTRIAL | | | |
| | ARANAE | UNKNOWN | ADULT | 0.427610356 |
| | DIPTERA | UNKNOWN | ADULT | 0.231160939 |
| | LEPIDOPTERA | UNKNOWN | ADULT | 0.836194681 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 5.471318462 |
| 10 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.223701855 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.670632978 |
| | | UNKNOWN | ADULT | 3.649996468 |
| | TERRESTRIAL | | | |
| | POLYDESMIDAE | UNKNOWN | ADULT | 17.00883017 |
| 11 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.126755033 |
| | | | | 0.137054897 |
| | | | | 0.1710008 |
| | | | | 0.209703283 |
| | | | | 0.253396831 |
| | | | | 0.319811684 |
| | | | | 0.482551189 |
| | | | | 0.482551189 |
| | DIPTERA | DIXIDAE | JUVENILE | 0.044993573 |
| | DIPTERA | | | 0.3118112 |
| | TRICHOPTERA | PHILOPOTAMIDAE | PUPAE | 0.368731393 |
| | | | | 0.368731393 |
| | | | ADULT | 0.971375666 |
| | | UNKNOWN | ADULT | 0.185300953 |
| | TERRESTRIAL | | | |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 0.253441174 |
| 12 | AQUATIC | | | |
| | NONE | | | |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.048702931 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.213509539 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 0.256142471 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 4.630437802 |

| | | | | |
|------------------|---------------|----------------|----------|-------------|
| 13 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.090387795 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| A5. | | | | |
| continued | | | | |
| 14 | AQUATIC | | | 0.036253607 |
| | DIPTERA | SIMULIDAE | JUVENILE | 0.09897513 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.023096373 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.008002662 |
| | | | | 0.008002662 |
| | | | | 0.162648229 |
| | | UNKNOWN | ADULT | 0.648290747 |
| | TERRESTRIAL | | | |
| | HOMOPTERA | UNKNOWN | ADULT | 0.118165638 |
| 15 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.137054897 |
| | | UNKNOWN | JUVENILE | 0.907598873 |
| | | | | 0.950340865 |
| | | | | 3.523870569 |
| | EPHEMEROPTERA | UNKNOWN | ADULT | 0.245769051 |
| | PLECOPTERA | CHLOROPERLIDAE | ADULT | 0.693517365 |
| | | UNKNOWN | ADULT | 1.206338091 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.152162914 |
| | TERRESTRIAL | | | |
| | ARANAE | UNKNOWN | ADULT | 0.609197403 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.232593187 |
| | | | | 0.280819322 |
| | | | | 0.393299287 |
| | | | | 0.457828448 |
| | | | | 0.868377486 |
| | | | | 1.075750759 |
| | | | | 3.294209337 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 14.23950595 |
| 16 | AQUATIC | | | |
| | DIPTERA | EPHYDRIDAE | ADULT | 9.198856658 |
| | | UNKNOWN | JUVENILE | 0.31013692 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.001288618 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.020070026 |
| 17 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 1.787856623 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.036965511 |
| | TERRESTRIAL | | | |
| | COLEOPTERA | STAPHYLINIDAE | ADULT | 0.115574975 |
| | DIPTERA | UNKNOWN | ADULT | 0.098926925 |
| 18 | AQUATIC | | | 0.725383199 |
| | COLEOPTERA | HYDROPHILIDAE | JUVENILE | 4.473370237 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.069981348 |
| | | | ADULT | 0.248010995 |

A5. continued

| | | | |
|--------------------|---------------|----------|-------------|
| | | | 0.019506296 |
| | DIXIDAE | JUVENILE | 0.051565487 |
| | | | 0.051565487 |
| | | | 0.107946591 |
| | EPHYDRIDAE | ADULT | 0.04354115 |
| | PHORIDAE | ADULT | 0.04354115 |
| | SIMULIDAE | ADULT | 0.0380872 |
| | | | 0.0380872 |
| | | | 0.04354115 |
| | | | 0.049776087 |
| | | | 0.049776087 |
| | | | 0.065052269 |
| | | | 0.097190763 |
| | | | 1.980273934 |
| | TIPULIDAE | ADULT | 0.065052269 |
| | UNKNOWN | JUVENILE | 0.022874686 |
| ODONATA | | ADULT | 71.4 |
| TRICHOPTERA | UNKNOWN | JUVENILE | 0.181042997 |
| | | | 0.482354961 |
| | | | 0.886357074 |
| TRICHOPTERA | | ADULT | 0.106739286 |
| | | | 0.211570712 |
| | | | 0.276166868 |
| <u>TERRESTRIAL</u> | | | |
| ARANAE | UNKNOWN | ADULT | 2.358913322 |
| | | | 0.801774986 |
| COLEOPTERA | STAPHYLINIDAE | ADULT | 0.158775773 |
| COLLEMBOLA | UNKNOWN | ADULT | 0.037088921 |
| | | | 0.149653429 |
| DIPTERA | UNKNOWN | ADULT | 0.042149169 |
| | | | 0.352004592 |
| | | | 0.58352983 |
| HOMOPTERA | UNKNOWN | ADULT | 0.213509539 |
| HYMENOPTERA | UNKNOWN | ADULT | 0.207753382 |
| | | | 0.883965304 |

A 6. Itemized summer coho diet.

| SUMMER | COHO | REACH | MS | |
|--------|---------------|--------------|----------|-----------|
| FISH | | | LIFE | |
| NUMBER | ORDER | FAMILY | STAGE | BIOMASS |
| 1 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.0136669 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.431625 |
| | TERRESTRIAL | | | |
| | POLDESMIDAE | UNKNOWN | ADULT | 1.5379025 |
| 2 | AQUATIC | | | |
| | DIPTERA | DIXIDAE | JUVENILE | 0.2330113 |
| | DIPTERA | UNKNOWN | JUVENILE | 0.2907523 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.0527055 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 3 | AQUATIC | | | |
| | DIPTERA | DIXIDAE | JUVENILE | 0.0142518 |
| | PLECOPTERA | UNKNOWN | ADULT | 0.2155799 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 4 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.1169477 |
| | | | | 0.1833614 |
| | | SIMULIDAE | ADULT | 0.0855384 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.1083798 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.1331117 |
| | | | | 0.2082555 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 5 | AQUATIC | | | |
| | DIPTERA | SIMULIDAE | ADULT | 0.0403546 |
| | TERRESTRIAL | | | 0.0848763 |
| | NONE | | | |
| 6 | AQUATIC | | | |
| | DIPTERA | UNKNOWN | PUPAE | 0.000632 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.0035199 |
| | | | | 0.0548993 |
| | TERRESTRIAL | | | |
| | ARANAE | | ADULT | 0.573477 |
| 7 | AQUATIC | | | |
| | COLEOPTERA | ELMIDAE | JUVENILE | 0.6533051 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.0035765 |
| | | | | 0.0198007 |
| | | | | 0.0219411 |
| | | SIMULIDAE | JUVENILE | 0.0603282 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.0118987 |
| | | | | 0.0223846 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.1449118 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.0041522 |
| | | | | 0.0056 |

A6.
Continued

| | | | | |
|---|--------------------|--------------|----------|-----------|
| | | | | 0.0056 |
| | | | | 0.0056 |
| | | | | 0.0093969 |
| | | | | 0.0117943 |
| | <u>TERRESTRIAL</u> | | | |
| | NONE | | | |
| 8 | <u>AQUATIC</u> | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.090508 |
| | | DIXIDAE | JUVENILE | 0.0481227 |
| | | UNKNOWN | JUVENILE | 0.0525637 |
| | TRICHOPTERA | UNKNOWN | ADULT | 0.6824268 |
| | <u>TERRESTRIAL</u> | | | |
| | COLEOPTERA | UNKNOWN | ADULT | 1.9287181 |
| | DIPTERA | UNKNOWN | ADULT | 0.8052993 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 0.4677783 |
| 9 | <u>AQUATIC</u> | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.0141707 |
| | | DIXIDAE | JUVENILE | 0.339671 |
| | | UNKNOWN | ADULT | 0.9118714 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.49556 |
| | | | | 0.6285834 |
| | <u>TERRESTRIAL</u> | | | |
| | NONE | | | |

A 7. Itemized fall cutthroat diet.

| FALL | CUTTHROAT | REACH | BOTH | |
|--------|--------------------|--------------|----------|------------|
| FISH | | | LIFE | |
| NUMBER | ORDER | FAMILY | STAGE | BIOMASS |
| 1 | <u>AQUATIC</u> | | | 0.011 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | |
| | <u>TERRESTRIAL</u> | | | |
| | COLEOPTERA | UNKNOWN | ADULT | 1.38 |
| 2 | <u>AQUATIC</u> | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.07 |
| | <u>TERRESTRIAL</u> | | | |
| | NONE | | | |
| 3 | <u>AQUATIC</u> | | | |
| | DIPTERA | DIXIDAE | JUVENILE | |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.0013 |
| | | | | 0.024 |
| | <u>TERRESTRIAL</u> | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 6.5881E-06 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.943 |
| 4 | <u>AQUATIC</u> | | | |
| | NONE | | | |
| | <u>TERRESTRIAL</u> | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.0503 |
| | HYMENOPTERA | UNKNOWN | ADULT | 0.102 |

A7.
Continued

| | | | | |
|----|--------------|--------------|----------|-------------|
| 5 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.07 |
| | | | | 0.07 |
| | TERRESTRIAL | | | |
| | ARANEAE | UNKNOWN | ADULT | 0.114 |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.028 |
| | DIPTERA | CECIOMYIIDAE | ADULT | 0.5426 |
| | HYMENOPTERA | UNKNOWN | ADULT | 12.38 |
| 6 | AQUATIC | | | |
| | NONE | | | |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.008937715 |
| | DIPTERA | UNKNOWN | ADULT | 0.008 |
| | HYMENOPTERA | UNKNOWN | ADULT | 0.657 |
| 7 | AQUATIC | | | |
| | DIPTERA | DIXIDAE | JUVENILE | 0.024 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 1.72 |
| | TERRESTRIAL | | | |
| | ARANEAE | UNKNOWN | ADULT | 0.735 |
| | DIPTERA | UNKNOWN | ADULT | 0.944 |
| 8 | AQUATIC | | | |
| | DIPTERA | DIXIDAE | JUVENILE | 0.0005 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.013 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.002 |
| | | | | 0.102 |
| | TERRESTRIAL | | | |
| | HYMENOPTERA | UNKNOWN | ADULT | 0.038 |
| 9 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.002 |
| | | DIXIDAE | JUVENILE | 0.001 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 8.52519E-06 |
| 10 | AQUATIC | | | |
| | NONE | | | |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 1.16106E-05 |
| | THYSANOPTERA | UNKNOWN | ADULT | 2.33354E-05 |
| | ARANEAE | UNKNOWN | ADULT | 0.000537831 |
| | COLLEMBOLA | UNKNOWN | ADULT | 1.48405E-06 |
| 11 | AQUATIC | | | |
| | NONE | | | |
| | TERRESTRIAL | | | |
| | HYMENOPTERA | UNKNOWN | ADULT | 0.020134723 |
| | ARANEAE | UNKNOWN | ADULT | 0.19068408 |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.012306577 |
| | | | | 0.012306577 |
| | | | | 0.027949785 |
| 12 | AQUATIC | | | |

| A7. | | | | |
|-----------|--------------|--------------|----------|-------------|
| Continued | | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.147674901 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 1.13965981 |
| | TERRESTRIAL | | | |
| | ARANEAE | UNKNOWN | ADULT | 0.19068408 |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.012306577 |
| | | | | 0.012306577 |
| | | | | 0.027949785 |
| | | | | 0.027949785 |
| | | | | 0.035433338 |
| | | | | 0.035433338 |
| | | | | 0.054632206 |
| | DIPTERA | SCIARIDAE | ADULT | 0.15414072 |
| | HYMENOPTERA | UNKNOWN | ADULT | 1.535895561 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 9.683703164 |
| 13 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.028156743 |
| | | | | 0.035356973 |
| | | DIXIDAE | JUVENILE | 0.290484926 |
| | | UNKNOWN | JUVENILE | 0.005903381 |
| | | | | 1.36707946 |
| | EPEMEROPTERA | UNKNOWN | JUVENILE | 0.035200613 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.367354557 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.00297208 |
| | | | | 0.004987192 |
| | | | | 0.008745159 |
| | | | | 0.013183504 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.000962833 |
| | | | | 0.001911742 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.1656834 |
| 14 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.010334586 |
| | DIPTERA | | | 0.019184939 |
| | DIPTERA | | | 0.021941068 |
| | DIPTERA | CHIRONOMIDAE | ADULT | 0.023010653 |
| | DIPTERA | CHIRONOMIDAE | PUPA | 0.008627388 |
| | DIPTERA | DIXIDAE | JUVENILE | 0.043114622 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.006674642 |
| | EPEMEROPTERA | UNKNOWN | JUVENILE | 0.427420943 |
| | TRICHOPTERA | UNKNOWN | ADULT | 3.498992255 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.002532593 |
| | | | | 0.002532593 |
| | | | | 0.005944165 |
| | | | | 0.005944165 |
| | | | | 0.005944165 |
| | | | | 0.007466243 |
| | | | | 0.024249494 |

A 8. Itemized fall coho diet.

| FALL | COHO | REACH | BOTH | |
|--------|---------------|---------------|----------|-------------|
| FISH | | | LIFE | |
| NUMBER | ORDER | FAMILY | STAGE | BIOMASS |
| 1 | AQUATIC | | | |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.004209716 |
| | TERRESTRIAL | | | |
| 2 | ARANEAE | UNKNOWN | ADULT | 0.084711311 |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.002364899 |
| | AQUATIC | | | |
| 3 | DIPTERA | UNKNOWN | ADULT | 0.146501602 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.052 |
| | TERRESTRIAL | | | 0.056 |
| 4 | NONE | | | |
| | AQUATIC | | | |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.034246213 |
| 5 | PLECOPTERA | UNKNOWN | JUVENILE | 0.315513311 |
| | TERRESTRIAL | | | 0.002107021 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 0.008 |
| 4 | AQUATIC | | | |
| | DIPTERA | UNKNOWN | JUVENILE | 0.019824694 |
| | | UNKNOWN | PUPAE | 0.003067847 |
| 5 | | | | 0.007367019 |
| | | | | 0.008521243 |
| | TERRESTRIAL | | | |
| 5 | COLEOPTERA | UNKNOWN | ADULT | 0.9215 |
| | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.004431846 |
| 5 | | | | 0.005929227 |
| | | | | 0.007704559 |
| | | | | 0.016357331 |
| | | | | 0.025144954 |
| | | UNKNOWN | JUVENILE | 0.002 |
| | EPHEMEROPTERA | HEPTAGENIIDAE | JUVENILE | 0.004 |
| | | UNKNOWN | JUVENILE | 0.034246213 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.002107021 |
| | | | | 0.003043538 |
| | | | | 0.003043538 |
| 5 | | | | 0.004209716 |
| | | | | 0.004209716 |
| | | | | 0.007315843 |
| 5 | | | | 0.007315843 |
| | | | | 0.011589612 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.001198627 |
| 5 | | | | 0.0024465 |
| | | | | 0.004324785 |
| | TERRESTRIAL | | | |
| 5 | COLLEMBOLA | UNKNOWN | ADULT | 0.014883162 |
| | | | | |

A8.
Continued

| | | | | |
|---|-------------|---------------|----------|-------------|
| | | | | 0.000326079 |
| | | | | 0.000326079 |
| | | | | 0.000532723 |
| 6 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.001371066 |
| | | | | 0.001418484 |
| | | | | 0.002594889 |
| | | | | 0.004431846 |
| | | | | 0.004431846 |
| | | | | 0.00721701 |
| | | | | 0.007704559 |
| | | | | 0.008702019 |
| | | | | 0.008702019 |
| | | | | 0.009775559 |
| | | | | 0.021707918 |
| | | UNKNOWN | PUPAE | 0.013473646 |
| | | | | 0.000799853 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.025144954 |
| | TRICHOPTERA | GLOSSOMATIDAE | JUVENILE | 0.001198627 |
| | | UNKNOWN | JUVENILE | 0.005626896 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 7 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.003745199 |
| | | | | 0.006781025 |
| | DIPTERA | UNKNOWN | JUVENILE | 0.009314635 |
| | TRICHOPTERA | | JUVENILE | 0.012159308 |
| | | | | 0.00553664 |
| | | | | 0.768964206 |
| | | | | 0.008576463 |
| | | | | 0.012529893 |
| | | | | 0.017505293 |
| | | | | 0.017505293 |
| | | | | 0.017505293 |
| | | | | 0.017505293 |
| | | | | 0.020409492 |
| | | | | 0.020409492 |
| | | | | 0.020409492 |
| | | | | 0.023608853 |
| | | | | 0.023608853 |
| | | | | 0.027116355 |
| | TERRESTRIAL | | | |
| | DIPTERA | UNKNOWN | ADULT | 0.00553664 |
| | HYMENOPTERA | UNKNOWN | ADULT | 0.017505293 |
| 8 | AQUATIC | | | |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.768964206 |
| | | | | 0.008576463 |

A8.
Continued

| | | | | |
|----|--------------------|-----------------|----------|-------------|
| | | | | 0.012529893 |
| | | | | 0.017505293 |
| | | | | 0.017505293 |
| | | | | 0.017505293 |
| | | | | 0.017505293 |
| | | | | 0.020409492 |
| | | | | 0.020409492 |
| | | | | 0.020409492 |
| | | | | 0.023608853 |
| | | | | 0.023608853 |
| | | | | 0.027116355 |
| | | | | 0.030944874 |
| | <u>TERRESTRIAL</u> | | | |
| | NONE | | | |
| 9 | <u>AQUATIC</u> | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.035107189 |
| | | | | 0.003956637 |
| | | | | 0.013802888 |
| | | | | 0.120139951 |
| | | DIXIDAE | JUVENILE | 0.15741123 |
| | EPHEMEROPTERA | BAETIDAE | JUVENILE | 0.012209563 |
| | | | | 0.031649895 |
| | | HEPTAGENIIDAE | JUVENILE | 0.066258459 |
| | | UNKNOWN | JUVENILE | 0.201449541 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.901577012 |
| | <u>TERRESTRIAL</u> | | | |
| | NONE | | | |
| 10 | <u>AQUATIC</u> | | | |
| | EPHEMEROPTERA | HEPTAGENIIDAE | JUVENILE | 0.066258459 |
| | | | | 0.066258459 |
| | | | | 0.201869757 |
| | | | | 0.235485771 |
| | | LEPTOPHLEBIIDAE | JUVENILE | 0.02372763 |
| | | UNKNOWN | JUVENILE | 0.15472186 |
| | | | | 0.061639691 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.019867895 |
| | | | | 2.165794423 |
| | <u>TERRESTRIAL</u> | | | |
| | ARANAE | UNKNOWN | ADULT | 0.132523411 |
| 11 | <u>AQUATIC</u> | | | |
| | EPHEMEROPTERA | EPHEMERELIDAE | JUVENILE | 0.018802623 |
| | <u>TERRESTRIAL</u> | | | |
| | HYMENOPTERA | | ADULT | 0.036173719 |
| 12 | <u>AQUATIC</u> | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.231160939 |
| | | | | 0.008943912 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.006900765 |

A8.
Continued

| TERRESTRIAL | | | | | |
|-------------|---------------|---------------|----------|-------------|-------------|
| | COLLEMBOLA | UNKNOWN | ADULT | 0.010507993 | |
| | | | | 0.000229411 | |
| | | | | 0.000431486 | |
| | DIPTERA | UNKNOWN | ADULT | 0.000870924 | |
| AQUATIC | | | | | |
| 13 | EPHEMEROPTERA | HEPTAGENIIDAE | JUVENILE | 0.359569249 | |
| | | UNKNOWN | JUVENILE | 0.016837105 | |
| | | | JUVENILE | 0.144929351 | |
| | | | JUVENILE | 0.201869757 | |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.27220775 | |
| | | | JUVENILE | 0.001811702 | |
| | | | JUVENILE | 0.004256441 | |
| | TRICHOPTERA | HYDROPTILIDAE | ADULT | 2.517617842 | |
| | | UNKNOWN | JUVENILE | 0.01075185 | |
| | TERRESTRIAL | | | | |
| | | ARANAE | | ADULT | 0.087188006 |

A 9. Itemized cutthroat spring diet.

| SPRING | CUTTHROAT | REACH | BOTH | |
|-------------|---------------|----------------|------------|----------|
| FISH NUMBER | ORDER | FAMILY | LIFE STAGE | BIOMASS |
| 1 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.009776 |
| | | | | 0.056262 |
| | | | | 0.112772 |
| | | DIXIDAE | JUVENILE | 0.258462 |
| | | TIPULIDAE | ADULT | 0.248011 |
| | | UNKNOWN | ADULT | 0.065052 |
| | | | | 0.145207 |
| | EPHEMEROPTERA | EPHEMERELLIDAE | JUVENILE | 0.483023 |
| | | HEPTAGENIIDAE | JUVENILE | 0.06921 |
| | | | | 0.271986 |
| | | | | 0.529557 |
| | | UNKNOWN | ADULT | 0.28897 |
| | | | | 0.391185 |
| | | | | 1.019681 |
| | | UNKNOWN | JUVENILE | 0.157593 |
| | PLECOPTERA | LEUCTRIDAE | ADULT | 0.473783 |
| | | UNKNOWN | ADULT | 2.641795 |
| | | | JUVENILE | 0.253869 |
| | | | | 0.351828 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.136264 |
| | | | | 0.157625 |
| | | | | 0.157625 |
| TERRESTRIAL | | | | |
| | ARANAE | UNKNOWN | ADULT | 2.358913 |
| | | | | 3.091421 |
| | LEPIDOPTERA | LEPIDOPTERA | JUVENILE | 6.084959 |

| | | | | |
|----------------------|--------------------|----------------|----------|----------|
| A9. Continued | ORTHOPTERA | UNKNOWN | ADULT | 0.368744 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 2.5527 |
| | THYSANOPTERA | UNKNOWN | ADULT | 0.136614 |
| 2 | AQUATIC | | | |
| | COLEOPTERA | DYTISCIDAE | JUVENILE | 2.040962 |
| | DIPTERA | UNKNOWN | JUVENILE | 0.59053 |
| | PLECOPTERA | UNKNOWN | ADULT | 6.368588 |
| | TRICHOPTERA | PHILOPOTAMIDAE | JUVENILE | 0.903338 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.046397 |
| | | | | 0.206604 |
| | | | | 0.331979 |
| | | | | 0.452636 |
| | | | | 0.546987 |
| | | | | 0.764253 |
| | | | | 1.074866 |
| | | | | 1.46333 |
| | | | | 1.575693 |
| | | | | 1.792149 |
| | | | | 6.658579 |
| | TERRESTRIAL | | | |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 1.430616 |
| | | | | 4.142808 |
| | | | | 5.870039 |
| | | | | 9.323776 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 26.51332 |
| | PSOCOPTERA | UNKNOWN | ADULT | 0.159244 |
| 3 | AQUATIC | | | |
| | PLECOPTERA | UNKNOWN | JUVENILE | 3.101184 |
| | TERRESTRIAL | | | |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.643759 |
| | | | | 0.643759 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 0.712673 |
| 4 | AQUATIC | | | |
| | DIPTERA | UNKNOWN | JUVENILE | 0.047606 |
| | EPHEMEROPTERA | BAETIDAE | JUVENILE | 0.237023 |
| | | UNKNOWN | JUVENILE | 0.036945 |
| | | | | 0.670871 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.376274 |
| | TRICHOPTERA | UNKNOWN | ADULT | 0.267396 |
| | | | | 0.435187 |
| | TERRESTRIAL | | | |
| | ARANAE | UNKNOWN | ADULT | 0.038555 |
| | | | | 0.914261 |
| | | | | 1.208048 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.630074 |
| | HYMENOPTERA | UNKNOWN | ADULT | 2.333178 |
| 5 | AQUATIC | | | |
| | NONE | | | |

| | | | | |
|----------------------|---------------|-----------------|----------|----------|
| A9. Continued | TERRESTRIAL | | | |
| | THYSANOPTERA | UNKNOWN | ADULT | 0.106093 |
| 6 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.056262 |
| | | | | 0.085596 |
| | | | | 0.094143 |
| | | UNKNOWN | JUVENILE | 0.246999 |
| | | | | 0.557312 |
| | | | | 1.792842 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.416686 |
| | | | | 0.624903 |
| | | | | 1.513592 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.083656 |
| | | | | 0.482355 |
| | TERRESTRIAL | | | |
| | ARANAE | UNKNOWN | ADULT | 0.393355 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 0.10591 |
| | THYSANOPTERA | UNKNOWN | ADULT | 0.188375 |
| 7 | AQUATIC | | | |
| | TRICHOPTERA | PHILOPOTAMIDAE | JUVENILE | 0.07346 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.993263 |
| | | | | 1.792149 |
| | | | | 2.951759 |
| | TERRESTRIAL | | | |
| | ARANAE | UNKNOWN | ADULT | 0.577246 |
| | COLEOPTERA | UNKNOWN | ADULT | 0.087474 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.090998 |
| 8 | AQUATIC | | | |
| | COLEOPTERA | DYTISCIDAE | JUVENILE | 1.959132 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.239422 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.259625 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.903911 |
| | | | | 1.209747 |
| | | | | 2.375388 |
| | | | | 3.565928 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.062762 |
| | | | | 0.079567 |
| 9 | AQUATIC | | | |
| | DIPTERA | CERATOPOGONIDAE | ADULT | 0.023125 |
| | | CHIRONOMIDAE | ADULT | 0.032582 |
| | | UNKNOWN | JUVENILE | 1.299509 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.416686 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.005166 |
| | | | | 0.022029 |
| | | | | 0.028875 |
| | | | | 0.028875 |
| | | | | 0.036966 |

| | | | | |
|----------------------|---------------|-----------------|----------|----------|
| A9. Continued | | | | 0.083656 |
| | | | | 0.181043 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.027635 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.49443 |
| | POLYDESMIDAE | UNKNOWN | ADULT | 7.76255 |
| 10 | AQUATIC | | | |
| | DIPTERA | UNKNOWN | JUVENILE | 0.086243 |
| | EPHEMEROPTERA | UNKNOWN | ADULT | 0.190964 |
| | | | JUVENILE | 0.372882 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.089654 |
| | | UNKNOWN | ADULT | 7.935589 |
| | TRICHOPTERA | GLOSSOSOMATIDAE | JUVENILE | 1.275481 |
| | | PHILOPOTAMIDAE | ADULT | 0.255134 |
| | | UNKNOWN | ADULT | 0.444217 |
| | TERRESTRIAL | | | |
| | DIPTERA | UNKNOWN | ADULT | 5.342966 |
| 11 | AQUATIC | | | |
| | COLEOPTERA | DYTISCIDAE | JUVENILE | 3.590944 |
| | DIPTERA | PHORIDAE | ADULT | 0.074368 |
| | DIPTERA | TIPULIDAE | ADULT | 0.016302 |
| | EPHEMEROPTERA | HEPTAGENIIDDAE | JUVENILE | 1.305175 |
| | | | | 2.672505 |
| | | UNKNOWN | ADULT | 0.166255 |
| | | | | 0.166255 |
| | PLECOPTERA | UNKNOWN | ADULT | 1.619871 |
| | PLECOPTERA | | | 1.701481 |
| | TRICHOPTERA | BRACHYCENTRIDAE | JUVENILE | 1.103253 |
| | TRICHOPTERA | GLOSSOSOMATIDAE | JUVENILE | 2.300094 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 1.46333 |
| | | | | 7.20562 |
| | | | | 10.13417 |
| | TERRESTRIAL | | | |
| | ARANAE | UNKNOWN | ADULT | 0.373869 |
| | | | | 1.208048 |
| | COLEOPTERA | UNKNOWN | ADULT | 1.826398 |
| | HOMOPTERA | UNKNOWN | ADULT | 1.091546 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 6.304619 |
| 12 | AQUATIC | | | |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.463689 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 1.782736 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.021953 |
| | DIPTERA | MYCETOPHILIDAE | ADULT | 0.196429 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.314265 |
| 13 | AQUATIC | | | |
| | DIPTERA | UNKNOWN | JUVENILE | 1.792842 |
| | TRICHOPTERA | BRACHYCENTRIDAE | JUVENILE | 0.588278 |

| | | | | |
|----------------------|---------------|--------------|----------|----------|
| A9. Continued | TRICHOPTERA | UNKNOWN | JUVENILE | 0.004325 |
| | | | | 0.01253 |
| | | | | 0.028875 |
| | | | | 0.044484 |
| | | | | 0.046397 |
| | | | | 0.055347 |
| | | | | 0.057261 |
| | | | | 0.06965 |
| | | | | 0.06965 |
| | | | | 0.06965 |
| | | | | 0.06965 |
| | | | | 0.181043 |
| | | | | 0.452636 |
| | | | | 0.99 |
| | | | | 0.993263 |
| | TERRESTRIAL | | | |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.063218 |
| | | | | 0.314265 |
| 14 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.003782 |
| | | DIXIDAE | JUVENILE | 0.059053 |
| | | UNKNOWN | JUVENILE | 1.725672 |
| | EPHEMEROPTERA | UNKNOWN | ADULT | 0.140032 |
| | | | ADULT | 0.373213 |
| | PLECOPTERA | LEUCTRIDAE | ADULT | 0.594196 |
| | | NEMOURIDAE | ADULT | 1.098702 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.264497 |
| | | | | 0.993263 |
| | | | | 1.384899 |
| | | | | 1.792149 |
| | | | | 1.792149 |
| | | | | 1.792149 |
| | | | | 2.951759 |
| | | | | 2.951759 |
| | | | | 4.547795 |
| | | | | 4.547795 |
| | | | | 4.547795 |
| | | | | 12.74931 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 15 | AQUATIC | | | |
| | DIPTERA | PHORIDAE | ADULT | 0.021593 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 16 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.003548 |
| | | | | 0.025507 |
| | | | | 0.036374 |

| | | | | |
|----------------------|---------------|-----------------|----------|-------------|
| A9. Continued | | | | 0.044377 |
| | | | | 0.050083 |
| | | | | 0.050083 |
| | | | | 0.112772 |
| | | DIXIDAE | JUVENILE | 0.027289 |
| | | EMPIDIDAE | JUVENILE | 0.061025 |
| | EPHEMEROPTERA | EPHEMERELLIDAE | JUVENILE | 2.223511 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.493138 |
| | | | | 0.731348 |
| | TRICHOPTERA | GLOSSOSOMATIDAE | JUVENILE | 0.17813 |
| | TERRESTRIAL | | | |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 8.237032 |
| 17 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | ADULT | 0.016302 |
| | | | JUVENILE | 0.050083 |
| | | | | 0.112772 |
| | | | | 0.125519 |
| | | SIMULIDAE | ADULT | 0.119882 |
| | | | JUVENILE | 0.085897 |
| | | | | 0.119315 |
| | EPHEMEROPTERA | HEPTAGENIIDAE | ADULT | 0.729393 |
| | | UNKNOWN | ADULT | 0.415612 |
| | EPHEMEROPTERA | | JUVENILE | 0.022132 |
| | TRICHOPTERA | BRACHYCENTRIDAE | JUVENILE | 0.427451 |
| | TRICHOPTERA | GLOSSOSOMATIDAE | JUVENILE | 0.015679 |
| | | UNKNOWN | JUVENILE | 0.452636 |
| | | | | 1.792149 |
| | | | | 1.792149 |
| | | | | 2.951759 |
| | | | | 4.547795 |
| | TERRESTRIAL | | | |
| | ARANAE | UNKNOWN | ADULT | 0.103444 |
| | | | | 0.508006 |
| | COLEOPTERA | UNKNOWN | ADULT | 1.972429 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.872175 |
| | | | | 0.978325 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 4.142808 |
| 18 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.062891 |
| | | DIXIDAE | JUVENILE | 0.06751 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 1.478302 |
| | | | | 1.792149 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 19 | | AQUATIC | | |
| | DIPTERA | CHIRONOMIDAE | ADULT | 0.015325469 |
| | | | JUVENILE | 0.016301602 |
| | | | JUVENILE | 0.017128008 |
| | | | JUVENILE | 0.017128008 |

| A9. Continued | | | | 0.017128008 |
|---------------|---------------|-----------------|----------|-------------|
| | | PSYCHODIDAE | ADULT | 0.01247613 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.112581218 |
| | | TERRESTRIAL | | 0.112581218 |
| | ARANAE | UNKNOWN | ADULT | 1.931743445 |
| 20 | THYSANOPTERA | UNKNOWN | ADULT | 0.074222197 |
| | | AQUATIC | | |
| | COLEOPTERA | DYTISCIDAE | JUVENILE | 0.505535735 |
| | DIPTERA | CHIRONOMIDAE | ADULT | 0.016301602 |
| | | PHORIDAE | ADULT | 0.029143208 |
| | | PSYCHODIDAE | ADULT | 0.016301602 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 1.07486579 |
| | | | | 1.463330291 |
| | | | | 1.792149169 |
| | | | | 1.939384562 |
| | | TERRESTRIAL | | |
| | ARANAE | UNKNOWN | ADULT | 1.379638292 |
| | COLEOPTERA | STAPHYLINIDAE | ADULT | 0.535619023 |
| | | | | 1.076503652 |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.018502075 |
| | | | | 0.0258496 |
| | | | | 0.027634951 |
| | | | | 0.030227264 |
| | DIPTERA | UNKNOWN | ADULT | 0.061495649 |
| | | | | 2.118312801 |
| | HYMENOPTERA | UNKNOWN | ADULT | 0.306348132 |
| 21 | PSOCOPTERA | UNKNOWN | ADULT | 0.097432954 |
| | | AQUATIC | | |
| | DIPTERA | DOLICHOPODIDAE | ADULT | 0.030422397 |
| | | UNKNOWN | ADULT | 0.885496827 |
| | | | | 1.161225381 |
| | | | | 3.240194306 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.136264468 |
| | | | | 0.157625077 |
| | | | | 0.181042997 |
| | | | | 0.181042997 |
| | | TERRESTRIAL | | |
| | COLEOPTERA | UNKNOWN | ADULT | 6.13701805 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.156951747 |
| | ORTHOPTERA | | | 0.147174382 |
| 22 | ORTHOPTERA | | | 0.220989126 |
| | | AQUATIC | | |
| | DIPTERA | DIXIDAE | JUVENILE | 0.032467244 |
| | TRICHOPTERA | UNKNOWN | | 0.338794691 |
| | | | | 0.521983204 |
| | | TERRESTRIAL | | |
| | HOMOPTERA | UNKNOWN | ADULT | 0.106853518 |
| 23 | COLEOPTERA | STAPHYLINIDAE | ADULT | 0.32890597 |
| | | AQUATIC | | |
| | DIPTERA | CERATOPOGONIDAE | JUVENILE | 0.111024815 |

A9. Continued

| | | | | |
|----|----------------|----------------|----------|---|
| | | CHIRONOMIDAE | JUVENILE | 0.358235462 0.038932828 0.059970424 |
| | | EMPIDIDAE | JUVENILE | 0.064934938 |
| | | SIMULIDAE | JUVENILE | 0.054000895 0.193466685 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.135089677 0.222327377 0.354173598 |
| | TRICHOPTERA | PHILOPOTAMIDAE | JUVENILE | 0.482993764 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.205697891 0.338794691 1.07486579 |
| | | TERRESTRIAL | | |
| | COLEOPTERA | STAPHYLINIDAE | ADULT | 1.926705837 |
| | THYSANOPTERA | THYSANOPTERA | ADULT | 0.154899189 0.154899189 |
| 24 | | AQUATIC | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.021349781 |
| | EPEHEMEROPTERA | HEPTAGENIIDDAE | JUVENILE | 0.974762596 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.604791142 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.993263466 1.792149169 |
| | TERRESTRIAL | | | |
| | NONE | | | |

A 10. Itemized coho spring diet.

| SPRING FISH NUMBER | COHO ORDER | REACH FAMILY | BOTH LIFE STAGE | BIOMASS |
|--------------------|-------------|--------------|-----------------|-------------|
| 1 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | ADULT | 0.021592533 |
| | TERRESTRIAL | | | |
| | HYMENOPTERA | UNKNOWN | ADULT | 1.309201295 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.823513094 |
| 2 | AQUATIC | | | |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.044483855 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 3 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.029330938 |
| | | UNKNOWN | JUVENILE | 0.037664982 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.000185023 |
| 4 | AQUATIC | | | 0.00171752 |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.003781655 |
| | | | | 0.007704559 |
| | | | | 0.007704559 |
| | | | | 0.008702019 |
| | | | | 0.012159308 |

| | | | | |
|------------------|----------------|-----------------|----------|-------------|
| A10. | | | | 0.050267446 |
| Continued | | | | 0.053384543 |
| | | | | 0.056618326 |
| | | | | 0.063442453 |
| | | | | 0.070752699 |
| | | SIMULIDAE | JUVENILE | 0.063548096 |
| | | UNKNOWN | JUVENILE | 0.089259864 |
| | EPHEMEROPTERA | UNKNOWN | ADULT | 0.234352403 |
| | | | JUVENILE | 0.036945259 |
| | | | | 0.768811626 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.222327377 |
| | | | | 0.238814586 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.000821368 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.546277656 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 7.959133752 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.01560088 |
| | | | | 0.258519097 |
| 5 | AQUATIC | | | |
| | DIPTERA | CERATOPOGONIDAE | JUVENILE | 1.919136111 |
| | | CHIRONOMIDAE | JUVENILE | 0.012159308 |
| | | | | 0.013473646 |
| | | | | 0.044376723 |
| | | DIXIDAE | JUVENILE | 0.02659951 |
| | | | | 0.044129541 |
| | EPHEMEROPTERA | HEPTAGENIIDAE | JUVENILE | 0.29271248 |
| | | UNKNOWN | JUVENILE | 0.018824301 |
| | TRICHOPTERA | GLOSSOSOMATIDAE | JUVENILE | 0.05858378 |
| | | TERRESTRIAL | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.000821368 |
| | | | | 0.021952707 |
| | | | | 0.021952707 |
| | TERRESTRIAL | | | |
| | LEPIDOPTERA | LEPIDOPTERA | JUVENILE | 0.47226641 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.09099788 |
| | | | | 0.265084249 |
| 6 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.021764831 |
| | | | | 0.021764831 |
| | | | | 0.025506926 |
| | | | | 0.027188184 |
| | | | | 0.039027326 |
| | | DIXIDAE | JUVENILE | 0.246999272 |
| | | EMPIDIDAE | JUVENILE | 0.011118752 |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.11289436 |
| | | | | 0.372881618 |
| | TERRESTRIAL | | | |
| | COLEOPTERA | PTILIDAE | ADULT | 0.46496154 |

| | | | | |
|---------------------------------|---------------|-----------------|----------|-------------|
| A10. Continued | COLLEMBOLA | UNKNOWN | ADULT | 0.00120988 |
| | | | | 0.54460501 |
| | HOMOPTERA | UNKNOWN | ADULT | 0.680597547 |
| 7 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.959951127 |
| | TERRESTRIAL | | | |
| | DIPTERA | UNKNOWN | ADULT | 0.972592144 |
| | LEPIDOPTERA | LEPIDOPTERA | JUVENILE | 4.142808143 |
| 8 | AQUATIC | | | |
| | EPHEMEROPTERA | UNKNOWN | JUVENILE | 0.00418878 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.00171752 |
| | | | | 0.030227264 |
| 9 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.008702019 |
| | | | | 0.009775559 |
| | | | | 0.025144954 |
| | | | | 0.031575011 |
| | | | | 0.036374208 |
| | | | | 0.130975156 |
| | | UNKNOWN | JUVENILE | 0.014251795 |
| | PLECOPTERA | LEUCTRIDAE | ADULT | 0.563793122 |
| | TERRESTRIAL | | | |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.110367547 |
| 10 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.008702019 |
| | | | | 0.009775559 |
| | TERRESTRIAL | | | |
| | NONE | | | |
| 11 | AQUATIC | | | |
| | DIPTERA | CHIRONOMIDAE | JUVENILE | 0.013473646 |
| | | | | 0.014872324 |
| | | | | 0.230073598 |
| | DIPTERA | UNKNOWN | JUVENILE | 0.037664982 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.020531248 |
| | TRICHOPTERA | UNKNOWN | JUVENILE | 0.021817036 |
| | | | | 0.061366645 |
| | | | | 0.074644528 |
| | | | | 0.114004014 |
| | | | | 0.114004014 |
| | TERRESTRIAL | | | |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.174790133 |
| 12 | AQUATIC | | | |
| | DIPTERA | CERATOPOGONIDAE | JUVENILE | 0.027884259 |
| | | | | 0.057833228 |
| | DIPTERA | CHIRONOMIDAE | ADULT | 0.01882555 |
| | | | JUVENILE | 0.044376723 |
| | DIPTERA | EMPIDIDAE | JUVENILE | 0.025013515 |

| | | | | |
|----|--------------|-----------------|----------|-------------|
| | DIPTERA | UNKNOWN | JUVENILE | 0.04000158 |
| | | | | 0.07680603 |
| | EPEMEROPTERA | UNKNOWN | ADULT | 0.227216743 |
| | TRICHOPTERA | GLOSSOSOMATIDAE | JUVENILE | 0.089211505 |
| | | UNKNOWN | JUVENILE | 0.030944874 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 4.16788E-05 |
| | | | | 0.000326079 |
| | ORTHOPTERA | UNKNOWN | ADULT | 0.124772167 |
| | | | | 0.564659291 |
| 13 | AQUATIC | | | |
| | DIPTERA | PSYCHODIDAE | ADULT | 0.01757801 |
| | | UNKNOWN | JUVENILE | 0.008521243 |
| | | | | 0.008521243 |
| | | | | 0.009782976 |
| | | | | 0.038222838 |
| | EPEMEROPTERA | BAETIDAE | JUVENILE | 0.548651292 |
| | | | | 1.061554466 |
| | | UNKNOWN | JUVENILE | 0.039068662 |
| | PLECOPTERA | UNKNOWN | JUVENILE | 0.253868836 |
| | TERRESTRIAL | | | |
| | COLLEMBOLA | UNKNOWN | ADULT | 0.062762452 |
| | LEPIDOPTERA | UNKNOWN | JUVENILE | 47.7847329 |

A 11. Aquatic taxa collected in summer pan traps.

| ORDER | FAMILY | GENUS / TAXA | Number |
|--------------|-----------------|-------------------|--------|
| Amphib Reach | | | |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 3 |
| | CHIRONOMIDAE | | 13 |
| | EMPIDIDAE | CLINOCERA | 4 |
| | | MICROPHORELLA | 10 |
| | EPHYDRIDAE | | 8 |
| | PHORIDAE | | 2 |
| | PTYCHOPTERIDAE | | 6 |
| | SIMULIDAE | | 1 |
| | TIPULIDAE | | 17 |
| EPEMEROPTERA | | | |
| | EPEMERELLIDAE | | 1 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 3 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | SWELTSIA | 1 |
| | NEMOURIDAE | | 2 |
| | PERLODIDAE | ISOPERLA | 1 |
| TRICHOPTERA | | | |
| | HYDROPTILIDAE | OCHROTRICHIA | 2 |
| | HYDROPTILIDAE | HYDROPTILIDAE sp. | 3 |
| | PHILOPOTAMIDAE | WORMALDIA | 2 |
| Bird Reach | | | |

| A11. Continued | | | |
|-----------------------|------------------|------------------|----|
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 2 |
| | CHIRONOMIDAE | | 57 |
| | EMPIDIDAE | MICROPHORELLA | 97 |
| | EMPIDIDAE | CLINOCERA | 1 |
| | EPHYDRIDAE | | 79 |
| | PHORIDAE | DOHRNIPHORA | 5 |
| | PSYCHODIDAE | | 3 |
| | SIMULIDAE | | 3 |
| | TIPULIDAE | | 1 |
| | UNKNOWN | | 1 |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 1 |
| | EPHEMERELLIDAE | | 2 |
| | HEPTAGENIIDAE | | 1 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 1 |
| | UNKNOWN | | 10 |
| HEMPITERA | | | |
| | GERRIDAE | | 1 |
| ODONATA | | | |
| | GOMPHIDAE | | 2 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | ALLOPERLA | 2 |
| | CHLOROPERLIDAE | SWELTSIA | 5 |
| | PERLIDAE | SUWALLIA | 1 |
| | PERLODIDAE | ISOPERLA | 1 |
| | UNKNOWN | | 2 |
| TRICHOPTERA | | | |
| | HYDROPTILIDAE | | 2 |
| | PHILOPOTAMIDAE | WORMALDIA | 4 |
| | PHRYGANEIDAE | | 2 |
| Mainstem Reach | | | |
| COLEOPTERA | | | |
| | ELMIDAE | | 3 |
| | PSEPHENIDAE | | 3 |
| DIPTERA | | | |
| | ATHERICIDAE | | 1 |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 3 |
| | CHIRONOMIDAE | | 53 |
| | EMPIDIDAE | MICROPHORELLA | 27 |
| | EPHYDRIDAE | | 28 |
| | PELECOHYNICHIDAE | | 1 |
| | PHORIDAE | DOHRNIPHORA | 9 |
| | PSYCHODIDAE | | 1 |
| | PTYCHOPTERIDAE | | 1 |
| | SIMULIDAE | | 6 |
| | TIPULIDAE | | 4 |

| A11. Continued | | | |
|-----------------------|-----------------|--------------------|----|
| EPHEMEROPTERA | | | |
| | HEPTAGENIIDAE | | 1 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 3 |
| | UNKNOWN | | 1 |
| ODONATA | | | |
| | CALOPTERYGIDAE | | 1 |
| | GOMPHIDAE | | 13 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | ALLOPERLA | 11 |
| | CHLOROPERLIDAE | CHLOROPERLIDAE sp. | 5 |
| | CHLOROPERLIDAE | SWELTSIA | 8 |
| | LEUCTRIDAE | | 1 |
| | NEMOURIDAE | | 4 |
| | PERLIDAE | CALINEURA | 9 |
| | PERLODIDAE | ISOPERLA | 25 |
| | PERLODIDAE | PERLODIDAE sp. | 6 |
| TRICHOPTERA | | | |
| | BRACHYCENTRIDAE | | 2 |
| | GLOSSOSOMATIDAE | | 1 |
| | HYDROPSYCHIDAE | HYDROPSYCHE | 7 |
| | HYDROPSYCHIDAE | HYDROPSYCHIDAE sp. | 1 |
| | HYDROPTILIDAE | OCHROTRICHIA | 11 |
| | HYDROPTILIDAE | HYDROPTILIDAE sp. | 4 |
| | LIMNEPHILIDAE | | 1 |
| | PHILOPOTAMIDAE | DOLOPHILODES | 3 |
| | PHILOPOTAMIDAE | WORMALDIA | 2 |
| | RHYACOPHILIDAE | | 2 |
| | UNKNOWN | | 2 |

A 12. Aquatic taxa collected in fall pan traps.

| Amphib Reach | | | |
|----------------------|------------------|------------------|---|
| DIPTERA | | | |
| | TIPULIDAE | TIPULA | 2 |
| EPHEMEROPTERA | | | |
| | EPHEMERELLIDAE | | 1 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 1 |
| | UNKNOWN | | 1 |
| PLECOPTERA | | | |
| | CAPNIIDAE | | 1 |
| | NEMOURIDAE | NEMOURA | 1 |
| | NEMOURIDAE | NEMOURIDAE sp. | 1 |
| | NEMOURIDAE | ZAPADA | 2 |
| TRICHOPTERA | | | |
| | LEPIDOSTOMATIDAE | | 1 |
| | PHILOPOTAMIDAE | | 1 |
| Bird Reach | | | |
| DIPTERA | | | |
| | TIPULIDAE | TIPULA | 1 |

| A12. Continued | | | |
|-----------------------|------------|--------|---|
| EPHEMEROPTERA | | | |
| | UNKNOWN | | 2 |
| PLECOPTERA | | | |
| | CAPNIIDAE | | 2 |
| | LEUCTRIDAE | | 1 |
| | NEMOURIDAE | | 2 |
| Mainstem Reach | | | |
| DIPTERA | | | |
| | PHORIDAE | | 1 |
| | TIPULIDAE | TIPULA | 1 |
| PLECOPTERA | | | |
| | NEMOURIDAE | ZAPADA | 1 |

A 13. Aquatic taxa collected in spring pan traps.

| ORDER | FAMILY | GENUS / TAXA | Number |
|----------------------|-----------------|--------------------|--------|
| Amphib Reach | | | |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 2 |
| | CHIRONOMIDAE | | 10 |
| | EMPIDIDAE | CHELIFERA | 2 |
| | EPHYDRIDAE | | 1 |
| | PHORIDAE | | 2 |
| | PSYCHODIDAE | | 2 |
| | TIPULIDAE | | 1 |
| | UNKNOWN | | 2 |
| EPHEMEROPTERA | | | |
| | UNKNOWN | | 6 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | CHLOROPERLIDAE sp. | 1 |
| | CHLOROPERLIDAE | SWELTSIA | 4 |
| | NEMOURIDAE | | 2 |
| | PERLODIDAE | PERLINODES | 1 |
| | UNKNOWN | | 1 |
| Bird Reach | | | |
| COLEOPTERA | | | |
| | ELMIDAE | | 1 |
| DIPTERA | | | |
| | PHORIDAE | | 1 |
| EPHEMEROPTERA | | | |
| | UNKNOWN | | 1 |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 1 |
| | CHIRONOMIDAE | | 9 |
| | DOLICHOPODIDAE | | 1 |
| | EMPIDIDAE | CHELIFERA | 2 |
| | PHORIDAE | | 2 |
| | PSYCHODIDAE | | 2 |

| | | | |
|-----------------------|-----------------|--------------------------------|----|
| A13. Continued | TIPULIDAE | | 1 |
| EPHEMEROPTERA | | | |
| | UNKNOWN | | 7 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | SWELTSA | 1 |
| | NEMOURIDAE | | 1 |
| | PERLODIDAE | PERLINODES | 1 |
| TRICHOPTERA | | | |
| | CALAMOCERATIDAE | HECTEROPLECTRON CALIFONICUM | 1 |
| | PHILOPOTAMIDAE | WORMALDIA | 1 |
| Mainstem Reach | | | |
| COLEOPTERA | | | |
| | ELMIDAE | | 1 |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 4 |
| | CHIRONOMIDAE | | 27 |
| | DOLICHOPODIDAE | | 8 |
| | EPHYDRIDAE | | 4 |
| | PHORIDAE | | 2 |
| | PSYCHODIDAE | | 1 |
| | SIMULIDAE | | 5 |
| | TIPULIDAE | | 2 |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 2 |
| | HEPTAGENIIDAE | | 1 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 1 |
| | UNKNOWN | | 8 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | ALLOPERLA | 2 |
| | CHLOROPERLIDAE | SWELTSA | 1 |
| | LEUCTRIDAE | PERLOMYIA | 1 |
| | LEUCTRIDAE | LEUCTRIDAE sp. | 1 |
| | NEMOURIDAE | SOYEDINA | 1 |
| | NEMOURIDAE | NEMOURIDAE sp. | 1 |
| | PERLIDAE | CALINEURA | 22 |
| | PERLIDAE | PERLIDAE sp. | 6 |
| | PERLODIDAE | | 1 |
| TRICHOPTERA | | | |
| | BRACHYCENTRIDAE | | 1 |
| | CALAMOCERATIDAE | HECTEROPLECTRON | 1 |
| | HYDROPTILIDAE | OCHROTRICHIA | 12 |
| | LIMNEPHILIDAE | | 2 |
| | PHILOPOTAMIDAE | | 3 |
| | PSYCHOMYIIDAE | | 1 |

A 14. Taxa collected in summer emergence traps.

| ORDER | FAMILY | GENUS / TAXA | Number |
|---------------|-----------------|-----------------------|--------|
| AMPHIB REACH | | | |
| DIPTERA | | | |
| | CHIRONOMIDAE | | 14 |
| | CULICIDAE | | 1 |
| | EMPIDIDAE | MICROPHORELLA | 4 |
| | PHORIDAE | | 1 |
| | PSYCHODIDAE | | 1 |
| | PTYCHOPTERIDAE | | 1 |
| | SIMULIDAE | | 2 |
| | TIPULIDAE | | 3 |
| | UNKNOWN | | 2 |
| EPHEMEROPTERA | | | |
| | HEPTAGENIIDAE | | 1 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 15 |
| HEMIPTERA | | | |
| | GERRIDAE | | 1 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | | 1 |
| | PERLODIDAE | | 2 |
| TRICHOPTERA | | | |
| | CALMOCERATIDAE | | 2 |
| | HYDROPTILIDAE | OCHROTRICHIA | 3 |
| | PHILOPOTAMIDAE | WORMALDIA | 2 |
| | RHYACOPHILIDAE | | 1 |
| BIRD REACH | | | |
| COLEOPTERA | | | |
| | AMPHIZOIDAE | | 1 |
| | LAMPYRIDAE | | 1 |
| DIPTERA | | | |
| | CHIRONOMIDAE | | 12 |
| | EMPIDIDAE | MICROPHORELLA | 6 |
| | EPHYDRIDAE | | 15 |
| | PHORIDAE | DORHNIPHORA | 8 |
| | TIPULIDAE | | 1 |
| EPHEMEROPTERA | | | |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 2 |
| | UNKNOWN | | 11 |
| HEMIPTERA | | | |
| | GERRIDAE | | 1 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | ALLOPERLA | 1 |
| | CHLOROPERLIDAE | CHLOROPERLIDAE sp. | 1 |
| TRICHOPTERA | | | |
| | GLOSSOSOMATIDAE | | 1 |
| | HYDROPSYCHIDAE | | 1 |

| | | | |
|-----------------------|-----------------|-----------------------|----|
| A14. Continued | LIMNEPHILIDAE | | 1 |
| | PHILOPOTAMIDAE | PHILOPOTAMIDAE sp. | 1 |
| | PHILOPOTAMIDAE | WORMALDIA | 4 |
| MS REACH | | | |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 1 |
| | CHIRONOMIDAE | | 40 |
| | EMPIDIDAE | MICROPHORELLA | 4 |
| | EPHYDRIDAE | | 7 |
| | PHORIDAE | | 1 |
| | SCATHOPHAGIDAE | | 1 |
| | SIMULIDAE | | 11 |
| | SYRPHIDAE | | 1 |
| | TIPULIDAE | | 1 |
| | UNKNOWN | | 2 |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 2 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 1 |
| | UNKNOWN | | 4 |
| HEMIPTERA | | | |
| | GERRIDAE | | 2 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | ALLOPERLA | 8 |
| | CHLOROPERLIDAE | CHLOROPERLIDAE sp. | 1 |
| | CHLOROPERLIDAE | SWELTSIA | 1 |
| | NEMOURIDAE | | 1 |
| | PERLIDAE | | 1 |
| TRICHOPTERA | | | |
| | BRACHYCENTRIDAE | | 1 |
| | CALMOCERATIDAE | | 1 |
| | GLOSSOSOMATIDAE | | 1 |
| | HYDROPSYCHIDAE | HYDROPSYCHE | 18 |
| | | | |
| | HYDROPTILIDAE | OCHROTRICHIA | 2 |
| | HYDROPTILIDAE | HYDROPTILIDAE sp. | 1 |
| | LIMNEPHILIDAE | | 1 |
| | PHILOPOTAMIDAE | DOLOPHIODES | 3 |
| | | PHILOPOTAMIDAE | |
| | PHILOPOTAMIDAE | sp. | 1 |
| | PHILOPOTAMIDAE | WORMALDIA | 2 |

A 15. Taxa collected in fall emergence traps.

| ORDER | FAMILY | GENUS / TAXA | Number |
|----------------------|------------------|------------------|--------|
| AMPHIB REACH | | | |
| COLEOPTERA | | | |
| | DYTISCIDAE | | 1 |
| | ELMIDAE | | 1 |
| | HYDROPHILIDAE | | 1 |
| DIPTERA | | | |
| | CHIRONOMIDAE | | 14 |
| | EPHYDRIDAE | | 1 |
| | PHORIDAE | | 2 |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 3 |
| | UNKNOWN | | 2 |
| PLECOPTERA | | | |
| | LEUCTRIDAE | DESPAXIA | 4 |
| | LEUCTRIDAE | LEUCTRIDAE sp. | 1 |
| | NEMOURIDAE | | 2 |
| TRICHOPTERA | | | |
| | LEPIDOSTOMATIDAE | | 1 |
| | PHILOPOTAMIDAE | WORMALDIA | 2 |
| | PHRYGAENIIDAE | | 1 |
| | RHYACOPHILIDAE | | 1 |
| BIRD REACH | | | |
| COLEOPTERA | | | |
| | AMPHIZOIDAE | | 1 |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 2 |
| | CHIRONOMIDAE | | 33 |
| | PHORIDAE | | 1 |
| | PSYCHODIDAE | | 1 |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 2 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 1 |
| | UNKNOWN | | 2 |
| PLECOPTERA | | | |
| | LEUCTRIDAE | | 3 |
| | NEMOURIDAE | | 3 |
| | PERLODIDAE | | 1 |
| TRICHOPTERA | | | |
| | HYDROPTILIDAE | | 1 |
| | LEPIDOSTOMATIDAE | | 1 |
| | PHILOPOTAMIDAE | | 8 |
| MS REACH | | | |
| COLEOPTERA | | | |
| | DYTISCIDAE | | 2 |
| | ELMIDAE | | 1 |
| DIPTERA | | | |

| | | | |
|-----------------------|-----------------|--------------|----|
| A15. Continued | CHIRONOMIDAE | | 22 |
| | EMPIDIDAE | HEMERODROMIA | 1 |
| | EMPIDIDAE | CLINOCERA | 2 |
| | EPHYDRIDAE | | 5 |
| | PSYCHODIDAE | | 1 |
| | SIMULIDAE | | 1 |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 3 |
| | UNKNOWN | | 2 |
| PLECOPTERA | | | |
| | LEUCTRIDAE | DESPAXIA | 7 |
| | NEMOURIDAE | ZAPADA | 1 |
| TRICHOPTERA | | | |
| | GLOSSOSOMATIDAE | | 5 |
| | HYDROPTILIDAE | HYDROPTILA | 2 |
| | HYDROPTILIDAE | PALACAGATUS | 2 |
| | PHILOPOTAMIDAE | WORMALDIA | 6 |
| | PHRYGAENIIDAE | | 2 |
| | UNKNOWN | | 1 |

A 16. Taxa collected in spring emergence traps.

| ORDER | FAMILY | GENUS / TAXA | Number |
|----------------------|-----------------|--------------|--------|
| AMPHIB REACH | | | |
| COLEOPTERA | | | |
| | AMPHIZOIDAE | | 1 |
| DIPTERA | | | |
| | CHIRONOMIDAE | | 2 |
| | EPHYDRIDAE | | 3 |
| | TIPULIDAE | | 2 |
| EPHEMEROPTERA | | | |
| | HEPTAGENIIDAE | | 2 |
| | UNKNOWN | | 1 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | SWELTSIA | 1 |
| | LEUCTRIDAE | PARALEUCTRA | 1 |
| | NEMOURIDAE | MALENKA | 1 |
| | NEMOURIDAE | ZAPADA | 4 |
| BIRD REACH | | | |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 1 |
| | CHIRONOMIDAE | | 2 |
| | DOLICHOPODIDAE | | 2 |
| | EMPIDIDAE | CHELIFERA | 2 |
| | EPHYDRIDAE | | 3 |
| | PHORIDAE | | 1 |
| | PSYCHODIDAE | | 1 |
| | PTYCHOPTERIDAE | | 1 |
| | TIPULIDAE | DICRANOTA | 3 |

| | | | |
|-----------------------|-----------------|-----------------------|----|
| A16. Continued | | | |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 2 |
| | HEPTAGENIIDAE | | 3 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 3 |
| | UNKNOWN | | 5 |
| HEMIPTERA | | | |
| | GERRIDAE | | 1 |
| PLECOPTERA | | | |
| | CHLOROPERLIDAE | ALLOPERLA | 1 |
| | LEUCTRIDAE | PARALEUCTRA | 1 |
| | NEMOURIDAE | MALENKA | 1 |
| | NEMOURIDAE | SOYEDINA | 2 |
| | NEMOURIDAE | SP. | 1 |
| | PERLODIDAE | ISOPERLA | 3 |
| TRICHOPTERA | | | |
| | PHILOPOTAMIDAE | WORMALDIA | 8 |
| MS REACH | | | |
| DIPTERA | | | |
| | CERATOPOGONIDAE | | 5 |
| | CHIRONOMIDAE | | 83 |
| | EPHYDRIDAE | | 1 |
| | PHORIDAE | | 3 |
| | PSYCHODIDAE | | 3 |
| | SIMULIDAE | | 1 |
| | TIPULIDAE | | 3 |
| EPHEMEROPTERA | | | |
| | BAETIDAE | | 6 |
| | HEPTAGENIIDAE | | 16 |
| | LEPTOPHLEBIIDAE | PARALEPTOPHLEBIA | 4 |
| | UNKNOWN | | 10 |
| HEMIPTERA | | | |
| | GERRIDAE | | 6 |
| PLECOPTERA | | | |
| | NEMOURIDAE | ZAPADA | 2 |
| | PERLIDAE | CALINEURIA | 4 |
| | PERLODIDAE | ISOPERLA | 1 |
| TRICHOPTERA | | | |
| | HYDROPTILIDAE | | 3 |
| | PHILOPOTAMIDAE | DOLOPHIODES | 6 |
| | PHILOPOTAMIDAE | WORMALDIA | 1 |
| | PHILOPOTAMIDAE | PHILOPOTAMIDAE sp. | 1 |
| | PSYCHOMYIIDAE | | 2 |
| | RHYACOPHILIDAE | RHYACOPHILA | 1 |
| | UNKNOWN | | 2 |
| | UENOIDAE | | 1 |