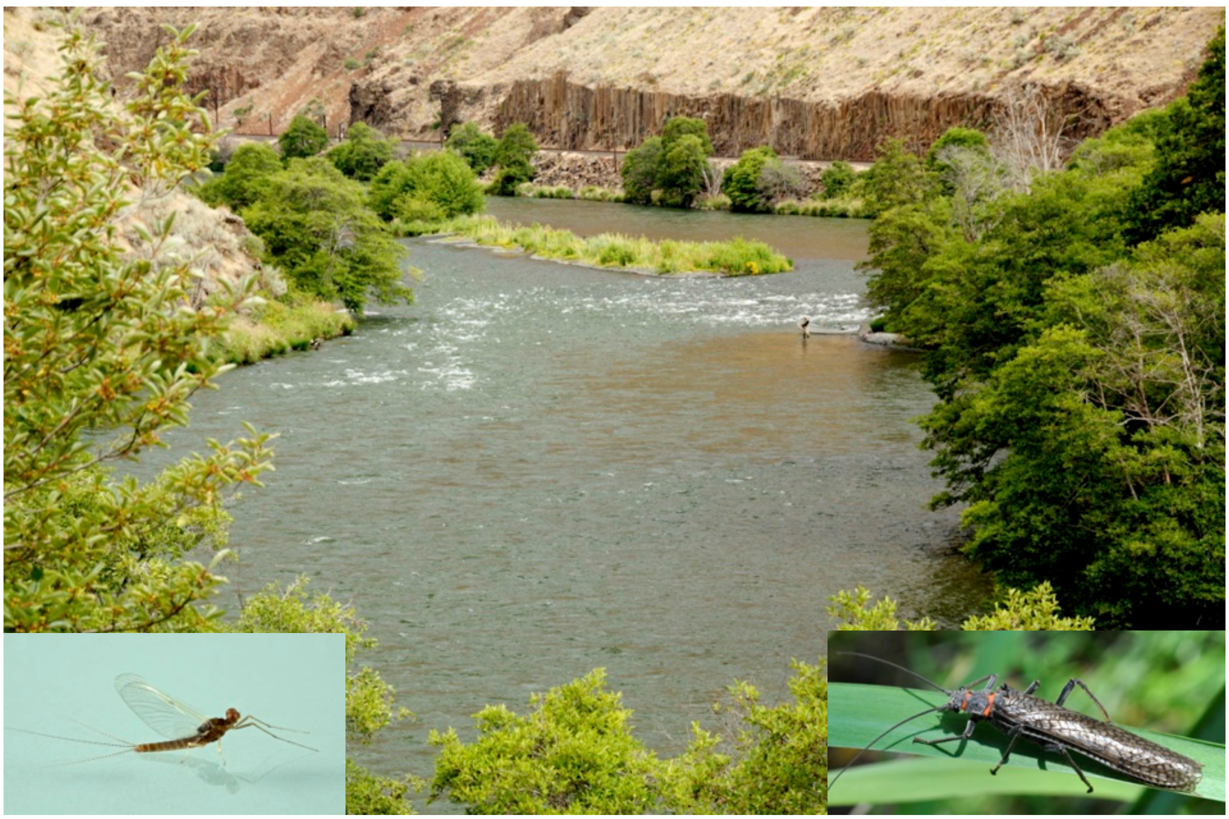
LOWER DESCHUTES RIVER MACROINVERTEBRATE HATCH ACTIVITY SURVEY RESULTS



A Deschutes River Alliance Report

Assessment & Report completed by
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EXECUTIVE SUMMARY

Deschutes River guides filled out stream survey forms following guide trips to document insect hatch activity. The data provide a subjective assessment of insect abundance by ranking the numbers of insects seen as 1 (low abundance), 2 (moderate abundance), or 3 (high abundance). A total of 33 trips were reported from May through October.

The majority of observations indicated low numbers of adult insects were present even for hatches with historically large numbers (e.g. net-spinning caddis) and some normally common insects were rarely seen (e.g. crane fly adults). Overall the results found that only 4 of 16 reported insect hatches were observed at high abundance and high numbers of adults were observed on just 9 of 33 days reported.

A total of 33 field survey forms were reported in 2013. This small sample size precludes drawing any conclusive findings, but the results raise real concerns about the effects the selective water withdrawal program may be having on aquatic insect populations due to changes in water temperature and water quality. In addition, anecdotal reports in recent years suggest greater amounts of algae in the lower river, especially the growth of diatoms that produce felt-like matts on rock surfaces, which overtakes other diatom species and reduces habitat and food quality for aquatic invertebrates. Continued growth of these diatoms could have important consequences for the river's food web. More monitoring is needed to assess the extent of changes and possible causes. The Deschutes River Alliance will be implementing a monitoring program in 2014 to further document water temperature, water quality, algal, and macroinvertebrate conditions in the lower 100 miles of the Deschutes River.

BACKGROUND & STUDY OBJECTIVES

Overview:

Fishing guides on the lower 100 miles of the Deschutes River have observed a number of changes since the Pelton Round Butte Dam started mixing surface and bottom water for release beginning in 2010, and raised concerns about what effect the new water management program may be having on the health of the river ecosystem. Observed changes include declines in major insect hatches, changes in insect hatch timing, the absence of insect feeding birds such as swallows, changes in fish movement and behavior, increased summer turbidity, and changes in the type and extent of benthic algal growth.

In order to address these concerns, and engage Portland General Electric (PGE) and the appropriate agencies in open discussion about them, local guides and other concerned anglers formed the Deschutes River Alliance (DRA) (go to http://www.deschutesriveralliance.org to read about DRA's history, mission, and work plan). The DRA, through meetings with PGE and agency personnel, has completed a monitoring plan for 2014 that includes an assessment of water quality (temperature, DO, pH, conductivity), algal biomass and species composition, and aquatic insect hatch activity.

One of the first steps taken by DRA in 2013 was to more systematically gather guide observations about insect hatch activity. To this end a field data form was created for guides to fill out while on the river. This report describes the results of the guides observations collected from May through October 2013.

Water Release Changes at Round Butte Dam:

In mid December 2009, the "selective water withdrawal tower (SWW)" and fish collection facility at Round Butte Dam was completed. Under mandate by the new operating license, the facility must mix surface water and bottom water from Lake Billy Chinook so the temperature of water released into the Deschutes River can be adjusted to "natural thermal potential (NTP)." NTP means the temperature that would occur below the dam complex if the reservoirs did not exist, and is calculated by modeling continuous temperature and flow data from the three tributaries entering the reservoir:

the Crooked River, Deschutes River, and Metolius River. A second objective of the SWW, and the new operating license agreement, is to produce surface currents in Lake Billy Chinook so steelhead and chinook smolts can find their way through the reservoir and be gathered in the fish collection facility for transport downstream below the dams.

Actual modification of in-stream temperature began July 1, 2010. As a result of the new facility, water released in May, June, and July will be up to 85% surface water, then decline to around 50% surface and 50% bottom water by October (http://www.deschutespassage.com/news/?p=65). This will increase spring and early summer temperatures up to 2 degrees centigrade, and lower late summer and fall temperatures up to 1.5 degrees centigrade. It's important to note that because of temperature stratification in Lake Billy Chinook, and the contrasting temperature of the major inflowing tributaries, surface water comes from the warmer Crooked and upper Deschutes Rivers, while bottom water in the lake is from the colder Metolius River. Though all three rivers have significant spring water inputs, the Metolius is nearly all spring water without agricultural or irrigation return flows. As a result, Metolius River water quality differs from the Crooked River or Deschutes above the reservoir. This means water now being released downstream into the Deschutes is not the same quality as prior to the SWW implementation.

Need for this Study:

Prior to SWW completion and implementation, PGE and the Confederated Tribes of the Warm Spring Reservation (CTWSR) funded a benthic macroinvertebrate study on the lower Deschutes River to establish a baseline pre-project database. Samples were collected at ten sites located from just below the Pelton Reregulating Dam (RM 100), downstream to just below White River (RM 44) (PGE and CTWSR 2002). Samples were collected in October 1999 and 2000, and May 2000 and 2001. The same study is now being repeated; sampling began in October 2013 and will continue through May 2015. This study will provide an assessment of the benthic macroinvertebrate community in the spring and fall to compare pre and post-project implementation, and assess if changes in the macroinvertebrate community have occurred. While this study provides valuable pre and post-project data, it does not address all of the concerns raised by guides and anglers as outlined below.

- PGE/CTWSR's study samples one site just below the White River at Sandy Beach (RM 45.4), with no sites further downstream. Some of the biggest concerns are coming from the section above and below Mack's Canyon (RM 24).

- PGE/CTWSR's study will only capture data from spring and fall. Those are two recommended periods to sample benthic macroinvertebrates, but some of the major concerns are during mid summer. DRA's survey will help understand what's happening in June, July and August.

- PGE/CTWSR's study will not provide information about the timing of adult insect activity. For example, what if the PGE/CTWSR study shows no noticeable change in the benthic community from before the project, but guides observe far fewer adult insects than pre-project levels. Information from guide surveys could help determine if in fact adult abundance is low or if the timing of adult activity has shifted compared to before SWW.

- Because guides are fishing most sections of the entire river every week, these data could show if there are differences between river sections - Warm Springs to Trout Creek vs. Mack's Canyon to the mouth for example. This could help determine where to look for other possible factors affecting the river.

- Guides will be floating and observing insect hatches long after the PGE/CTWSR study is completed in 2015. By starting to get a consistent set of observations from the guides now, it will provide a baseline to compare to five, ten, or twenty years from now.

METHODS

Guides were asked to fill out the form below following each day they spent on the river. Adult, larva, or pupa abundance was ranked on a simple scale from 1 to 3 with 1 representing low abundance, 2 moderate abundance, and 3 high abundance. Each reported insect was identified to whatever level was known. Most were reported by the common name of particular hatches such as Salmonfly, Pale Morning Dun, etc. Basic weather and fish feeding activity could also be recorded. Insect hatches not reported on a specific day were considered to be not present.

Completed forms were returned to the Deschutes River Alliance and all the data compiled for analysis. Though subjective, the data provide a consistent set of information about adult insect activity on the river.

Lower Deschutes Aquatic Macroinvertebrate Tracking Form (Page ___ of ___)

Name:__________________________ **Date:**____________________

River Section: 1 2 3 4 **GPS Location:**_________________________

Nearest Camp or Other Landmark:____

Weather: Clear Partly Cloudy Cloudy Rain Calm Light Wind Windy Air Temp_____ Water Temp_____ Time taken_________

Insect Abundance (1 = few; 2 = common; 3 = abundant): Use common or scientific name (if known)

Caddis

#1: 1 2 3 Adult Larva Pupa Size_________ Color__________ Name:____

#2: 1 2 3 Adult Larva Pupa Size_________ Color__________ Name:____

Mayflies

#1: 1 2 3 Adult Nymph Size_________ Color__________ Name:____

#2: 1 2 3 Adult Nymph Size_________ Color__________ Name:____

Stoneflies

#1: 1 2 3 Adult Nymph Size_________ Color__________ Name:____

#2: 1 2 3 Adult Nymph Size_________ Color__________ Name:____

Dipterids

#1: 1 2 3 Adult Larva Pupa Size_________ Color__________ Name:____

#2: 1 2 3 Adult Larva Pupa Size_________ Color__________ Name:____

Other

#1: 1 2 3 Adult Larva Pupa Size_________ Color__________ Name:____

#2: 1 2 3 Adult Larva Pupa Size_________ Color__________ Name:____

Fish Activity:

RESULTS & DISCUSSION

TABLE 1. Summary table of adult abundance for the four major insect orders.
1 = low abundance   *2 = moderate abundance*   *3 = high abundance*

# of Observations	Mayfly Adults	Stonefly Adults	Caddis Adults	Diptera Adults
Total # of Days with records	33	33	33	33
# with none recorded	2	20	1	11
# of 1's recorded	26	6	17	16
# of 2's recorded	5	5	12	1
# of 3's recorded	0	2	3	5
Data records range from May 8 to October 22 May - 1 record; June - 9 records; July - 8 records; August - 5 records Sept - 6 records; October - 4 records				

A total of 33 data forms were completed and reported back to DRA. Information was recorded from May 8th, to October 22nd, with the majority of data collected in June, July, and August (22 of 33 records collected in those three months). Ten data forms were completed in September and October (Table 1). The majority of data was recorded between Trout Creek and Maupin: there was not enough data to analyze for differences, if any, between river sections.

Overall results in Table 1 show that the majority of insects were observed in low numbers for all the major orders - mayflies, stoneflies, caddisflies and true flies (Diptera). The abundance of specific hatches within each order were also assessed and are described below. ***See Appendix for photos of all the major hatches discussed.***

MAYFLIES:

Table 2 provides a summary of abundance for major mayfly hatches typically found in the Deschutes River. There were no days observed with high abundance for any of the hatches. This is particularly noteworthy for Blue-winged Olive (*Baetis* spp.) and Pale Morning Duns (*Ephemerella excrucians*), two hatches that provide some of the more consistent and important mayfly hatches on the river. The sparse occurrence of Green Drakes (*Drunella grandis*) is not that unusual as this species occurs in relatively low numbers in the Deschutes, though occasionally large numbers of adults can be found. Mahogany Duns (*Paraleptophlebia* spp.) are a spring and fall hatch on the Deschutes and would normally be expected to occur in at least moderate abundance, but they were observed on only one occasion and then in low numbers.

TABLE 2. Summary table of mayfly hatch abundance.

1 = low abundance *2 = moderate abundance* *3 = high abundance*

# of Observations	Blue-winged Olives	Pale Morning Duns	Pale Evening Duns	Green Drakes	Mahogany Duns
Feeding Guild	Collector/ gatherer	Collector/ gatherer	Scrapers	Scrapers	Collector/ gatherer
Total # of Days with records	33	33	33	33	33
# with none recorded	19	21	25	32	32
# of 1’s recorded	11	9	6	0	1
# of 2’s recorded	3	3	2	1	0
# of 3’s recorded	0	0	0	0	0
Data records range from May 8 to October 22 May - 1 record; June - 9 records; July - 8 records; August - 5 records Sept - 6 records; October - 4 records					

STONEFLIES:

Stoneflies (Table 3) typically have a strong presence in the spring when Salmonflies (*Pteronarcys californica*) and Golden Stones (*Hesperoperla pacifica*) emerge. Guides observed abundant adult activity on three days (one for Salmonflies and two for Golden Stones). Abundant numbers of adults were seen as early as May 8th between Warm Springs and Trout Creek, which is several weeks earlier than observed before the implementation of SWW. Yellow Sallies (*Isoperla* spp.) are typically present in moderate to large numbers during the summer months, but were recorded on only two occasions as moderately abundant and no days as highly abundant. The short-winged stonefly, *Claassenia sabulosa,* was also recorded beginning on Aug 25, and last noted on October 10. *C. sabulosa* is a close relative of the Golden Stone that emerges in late summer and fall, and is not typically found in high abundance on the Deschutes. Adults of *C. sabulosa* are brachypterous, meaning their wings are reduced in size and not capable of flight. All of the above species are predators feeding primarily on smaller insects like midge larvae and mayfly nymphs.

TABLE 3. Summary table of stonefly hatch abundance.
1 = low abundance   2 = moderate abundance   3 = high abundance

# of Observations	Salmonfly	Golden Stone	Yellow Sallies	*Claassenia sabulosa*
Feeding Guild	Shredder	Predator	Predator	Predator
Total # of Days with records	33	33	33	33
# with none recorded	30	26	25	30
# of 1's recorded	1	2	6	2
# of 2's recorded	1	3	2	1
# of 3's recorded	1	2	0	0
Data records range from May 8 to October 22 May - 1 record; June - 9 records; July - 8 records; August - 5 records Sept - 6 records; October - 4 records				

CADDISFLIES:

Caddisflies (order Trichoptera) are one of the most abundant insect groups in the Deschutes River (PGE 2002), and typically provide some of the most abundant and consistent insect hatches and fishing opportunities throughout the spring, summer, and fall months. The net-spinning caddis (*Hydropsyche* and *Cheumatopsyche*) are especially known for their large summer hatches from Warm Springs to the mouth of the river, so much so that when camping along the river lantern light will attract massive numbers of adult caddis, and camp meals cooked at dusk become "caddis stir fries" whether intended or not.

The results in Table 4 show surprisingly low numbers of caddis adults with the majority of days recorded reporting none present, and only one day reported with high abundance (*Brachycentrus* sp., or American Grannom, on June 26). The low numbers of net-spinning caddis reported throughout the summer (no days with high abundance and only eight with moderate numbers observed) is of particular concern because in the past they have provided a rich food source for trout throughout the summer. Low numbers were also reported for the other dominant caddisfly hatches (Table 4).

TABLE 4. Summary table of caddisfly hatch abundance.
1 = low abundance *2 = moderate abundance* *3 = high abundance*

# of Observations	Brachycentrus	Green Rock Worms	Net-spinning Caddis	Saddle-case Caddis	October Caddis
Feeding Guild	Filterer	Predator	Filterer	Scraper	Scraper
Total # of Days with records	33	33	33	33	33
# with none recorded	24	24	18	25	27
# of 1's recorded	4	8	7	6	3
# of 2's recorded	4	1	8	2	3
# of 3's recorded	1	0	0	0	0
Data records range from May 8 to October 22 May - 1 record; June - 9 records; July - 8 records; August - 5 records Sept - 6 records; October - 4 records					

DIPTERA:

The order Diptera, or True Flies, on the Deschutes River primarily consists of midges (family Chironomidae), but also includes black flies (family Simuliidae), dance flies (family Empididae), and crane flies (family Tipulidae). Chironomids are often the most abundant insect group in the river (PGE 2002).

Results for Diptera (Table 5) show that chironomids were the group most often reported in high abundance (five days). But even chironomids were most often observed in low abundance (17 days). The crane fly (*Antocha* sp) is another Diptera that generally occurs in moderate to high numbers during the summer, mid-July through August, on the Deschutes. This survey found them generally not present or present only in low numbers.

TABLE 5. Summary table of Diptera hatch abundance.
1 = low abundance   2 = moderate abundance   3 = high abundance

# of Observations	Chironomids	Crane Flies (*Antocha* sp)
Feeding Guild	Varied	Collector/gatherer
Total # of Days with records	33	33
# with none recorded	11	26
# of 1's recorded	17	6
# of 2's recorded	0	1
# of 3's recorded	5	0
Data records range from May 8 to October 22 May - 1 record; June - 9 records; July - 8 records; August - 5 records Sept - 6 records; October - 4 records		

Based on the above results, all of the major insect orders were observed in low to moderate abundance, with high abundance seen for only a few insect hatches (4 of the 16 reported) and on just a few days (9 of 33 days reported) during the 2103 fishing season (May-October). While the number of observations reported in 2013 is not large enough to draw any conclusive findings, they do support the concerns raised by anglers and guides. The results need to be further verified with both the ongoing macroinvertebrate study funded by PGE and the CTWSR, and DRA's river guide surveys during 2014.

It is known that the SWW alters both water temperature and water quality in the Deschutes River. The extent and impact of these changes are still being documented through ongoing monitoring. How they might alter macroinvertebrate populations is discussed below.

Potential Effects of Temperature Changes on Macroinvertebrates:

One of the changes observed by guides has been shifts in the timing of certain insect hatches. Most obvious since the implementation of the new temperature regime has been the Salmonfly and Golden Stone stonefly hatches, which have emerged three to five weeks earlier than before the project (John Smeraglio - guide & owner Deschutes Canyon Fly Shop, personal communication).

Stream insects typically exhibit a general seasonal pattern of adult emergence. For example, March Browns hatch before the Salmonfly, which is followed by the Pale Morning Dun hatch, which is followed by the net-spinning caddis hatch, etc. This pattern on a particular river will be repeated year after year, but exactly when this cycle of hatches starts can vary from year to year and from stream to stream by several weeks. Water temperature is the primary factor controlling the timing of seasonal emergence cycles (Alexander etal. 2008). While that may sound simple, the way temperature interacts with growth and development, and ultimately the timing of adult emergence, is complex, and the way temperature affects development differs between different species.

It begins with the egg stage. For many species the number of days eggs incubate before hatching increases as temperature decreases (Ward 1992). The eggs of the mayfly *Baetis rhodani*, for example, developed and hatched within five days when held at 20 °C, but took over 100 days to hatch when held at 3 °C (Wichard 2002). For *Ecdyonurus picteti*, a species of heptageniid mayfly, eggs reared at 20 °C hatched in about 15 days, but when they were reared at 6 °C they took at least 80 days to hatch (see chart on following page) (Ward 1992). For other species, eggs may remain dormant until a minimum threshold temperature is reached, at which time the eggs hatch regardless of how long they spent at a lower temperature. The eggs of the burrowing mayfly *Ephoron album*, for example, will not hatch until water temperatures rises to 10 °C (Ward 1992).

Days to Egg Hatch for a Clinger Mayfly

Eggs reared at Temp. °C	**Days to Egg Hatch**
20	15
15	23
10	42
6	80

Laboratory studies typically monitor the response of egg development at different constant temperatures, but in nature temperature generally varies over a 24-hour period. When this is taken into account, eggs for some species hatch sooner than expected. For example, the greater the 24-hour range in water temperature the less time it took for the eggs of some water boatmen species to hatch (Sweeney and Schnack 1977).

Besides triggering when eggs hatch, temperature also affects the duration of hatching, a potentially important factor in synchronizing adult emergence. This is illustrated by studies of some *Baetis* (Blue-winged Olive) eggs. When held at 3 °C eggs began hatching after 119 days and extended over a 34-day period. When eggs were held at 22 °C hatching began after just seven days, and was completed for all eggs in just three days (Elliot 1972).

Temperature also affects egg diapause, a period of arrested development or dormancy. In a simple example, eggs of some species remain dormant until temperature drops to or near freezing, which breaks the diapause and the eggs then begin developing. Thus, eggs that may have been laid over a period of weeks all start development at nearly the same time.

After the eggs hatch, temperature also has an important, yet varied, affect on feeding and growth of the newly hatched nymphs and larvae. Since insects are cold-blooded, in general, growth rates are lower at cold temperatures and increase as temperature increases. There are many deviations however, from this simple response. Some species, for example, remain very active in cold water and complete most of their growth with temperatures at or near freezing, a phenomenon common to many stoneflies, some of which have been shown to complete two thirds of their growth under ice at temperatures less than 1 °C (Stewart and Stark 2002). While this doesn't help synchronize adult emergence, it does point out that many species can grow at temperatures typically thought to be too low for significant growth.

For species that over-winter as larvae, but do not grow significantly through the winter, a rapid increase in growth tends to occur as temperatures begin to warm in the spring. One way such temperature changes help synchronize adult emergence is through a process called *differential temperature-growth response* (Ward 1992). This means that as temperatures rise in the spring younger or smaller individuals have a lower temperature threshold for growth than larger or older individuals. As a result, growth is stimulated first in the youngest individuals allowing them to catch up in size and development to individuals that were larger and more mature. The net result is that the majority of individuals in a population all reach maturity at nearly the same time. Declining temperatures may also help synchronize emergence. For example, the closer individuals of *Chaoborus americanus* (phantom midges) are to emergence, the more a small drop in temperature slows their development. This results in highly synchronized emergence, and reduces the chance of adults emerging during periods of unsuitably cold air temperatures (Ward 1992).

There's at least one more way temperature may affect long-term seasonal emergence patterns. Changes in growth hormones tell larvae when to stop growing and to start developing adult tissue for emergence. These changes in growth hormones are often triggered by temperature. Some research has found that this shift from larval growth to adult tissue development occurs when temperature exceeds some critical threshold, regardless of how large or old the larvae are at the time (Vannote and Sweeney 1980). This synchronizes adult emergence and also explains why adults often decrease in size from spring through the summer emergence period.

There are other factors besides temperature that affect long-term emergence patterns. One of the most important is photoperiod. Photoperiod plays a role, though apparently a smaller one, in the timing and synchronization of emergence (Ward 1992). For example, photoperiod significantly affected larval development of some dragonflies when they were reared at constant temperature, but photoperiod had little or no effect on the same larvae when they were reared under natural fluctuating temperature regimes. This suggests that in more constant temperature environments (spring creeks for example) photoperiod becomes a significant factor in synchronizing emergence for some species. Other species that live in constant temperature environments, like spring creeks, however, show little or no response to photoperiod, and tend to have very poor emergence synchronization, instead showing nearly continuous development and emergence throughout the year (Ward 1992).

The changes in emergence timing of some insects in the Deschutes are likely due to the changes in water temperature from to the SWW project, especially from temperature increases in the early spring. However, the decline in insect abundance observed by guides is not explained by the change in temperature of a few degrees. Other potential changes in water quality need to be considered.

Potential Effects of Water Quality Changes on Macroinvertebrates:

Besides some alterations in the timing of insect hatches, a more troubling trend observed by guides is the drop in abundance of adult aquatic insects. Although it can be difficult to quantify the abundance of insects, routine observations made by experienced guides with a long history of fishing the river can provide important qualitative information on macroinvertebrates. The results from this study show that the number of days with "abundant" numbers of adult insects observed ranged from 0% for mayflies, 6% for stoneflies, 9% for caddisflies, and 15% for midges (Table 1). The majority of observations reported low numbers of adults. In addition crane fly adults (*Antocha* sp.) and aquatic moth adults (*Petrophila* sp.), two groups typically abundant throughout the summer, were rarely observed or not seen at all. While not conclusive these data indicate potential declines in abundance across all groups of aquatic insects. If continued monitoring further confirms this finding, it would have serious implications for trout populations that make the Deschutes River a famous fishing destination.

Though temperature exerts a significant effect on growth and development of aquatic insects, other factors influence productivity and abundance. Two important factors are substrate and food quality (Hynes 1972). The substrate in the Deschutes consists primarily of gravel, cobble, and small boulders in areas with slow to fast currents, with some attached aquatic plants (*Elodea* and *Potamogeton*) along near shore areas with gentle to quiet currents. These substrates provide excellent habitat for a diverse invertebrate community (PGE and CTWSR 2002). Food for invertebrates is primarily provided by a rich algal community dominated by diatoms that grows on the surface of most rocky substrates (PGE and CTWSR 2002).

Since the implementation of SWW, however, a change in the diatom/algal community has been documented. One change is the extensive blooms of two particular diatoms (*Cymbella mexicana janschii* and *Gomphoneis herculeana*) that produce felt-like gelatinous stalks. Both species are common in other Oregon rivers such as the Clackamas and North Umpqua (Kurt Carpenter, personal communication), but have not been previously observed in large matts in the Deschutes. Where present these species appear to overtake other beneficial diatom species and completely cover the surfaces of rocky substrates and even the leaves of aquatic plants (see photos in Appendix, page 25). In addition the gelatinous stalks of these diatoms are not palatable to aquatic insects. As a result the thick mat degrades the habitat quality for insects by reducing both food and substrate quality. An assessment of the invertebrate community in areas with these diatoms in August, 2013, found few insect larvae or nymphs present (Greg McMillan & Rick Hafele, personal communication).

The causes for the observed changes in the diatom community are not known, but one possibility is a change in water quality due to the surface water releases from Lake Billy Chinook. Monitoring studies by the Deschutes River Alliance during 2014 will work to identify both the extent of detrimental algal growth and possible factors contributing to it.

CONCLUSION

The results of fishing guide surveys during the 2013 fishing season documents a trend reported by numerous guides on the river: insect hatches have declined in recent years. Overall low abundance of adult insects was reported for all the major orders - mayflies, stoneflies, caddisflies, and Diptera. Some shift in hatch timing was also observed, particularly for the Salmonfly and Golden Stone hatches. Some of the most noticeable declines in abundance were observed for Pale Morning Dun (*Ephemerella excrucians*) and Mahogany Dun (*Paraleptophlebia* spp.) mayflies, net-spinning caddisflies (*Hydropsyche* spp. and *Cheumatopsyche* spp.), crane flies (*Antocha* sp.), and aquatic moth adults (*Petrophila* sp.).

Verification of these declines and determination of their causes need further investigation. Temperature changes due to the SWW probably account for the observed shifts in hatch timing, but do not explain the apparent decline in hatch abundance. One concern is the extensive growth of nuisance types of stalked diatom species that produce a thick mat of gelatinous stalk material on rock surfaces in rocky habitat important for insect populations. Where these diatom species occur few aquatic insect larvae have been collected. While these diatoms are known in other Oregon rivers, they were not noted in previous diatom studies in the Deschutes River prior to SWW (PGE 2002). A possible cause for this change in diatom growth is changes in water quality due to the increased surface water releases from Lake Billy Chinook. Other possible sources contributing to water quality changes include inputs from tributaries, agricultural runoff, and changes in nutrient inputs due to the recent fire history in the watershed.

Monitoring studies are needed to further define the scope of changes to insects, algae, and fish. A benthic macroinvertebrate study funded by PGE and CTWSR is underway. The Oregon Department of Fish & Wildlife (ODFW) has implemented trout population surveys in the spring of 2014. Finally, the DRA will be completing water quality, algal, and insect monitoring during critical periods in 2014 to help further define the extent and possible cause of these observed changes. DRA's detailed study plan and future reports of results can be found on their website: http://www.deschutesriveralliance.org .

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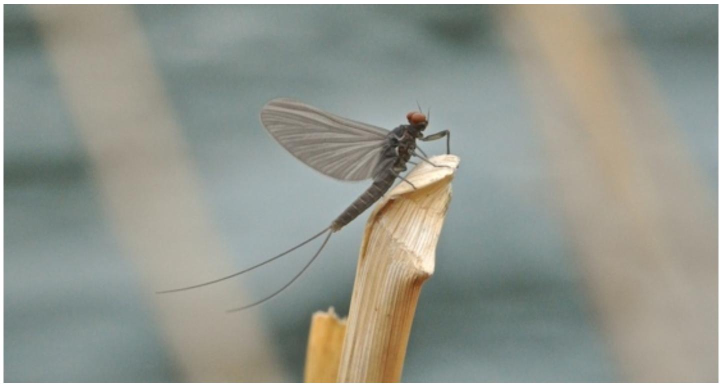
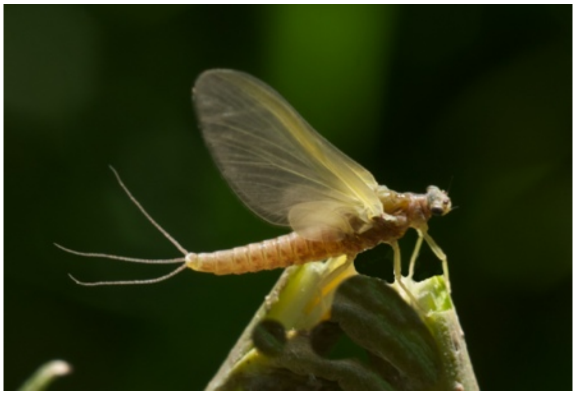
APPENDIX - PHOTOS

The following photos provide a visual summary of the insect hatches discussed in this report, and the diatom growth that is cause for concern. *Photos by Rick Hafele except where noted.*

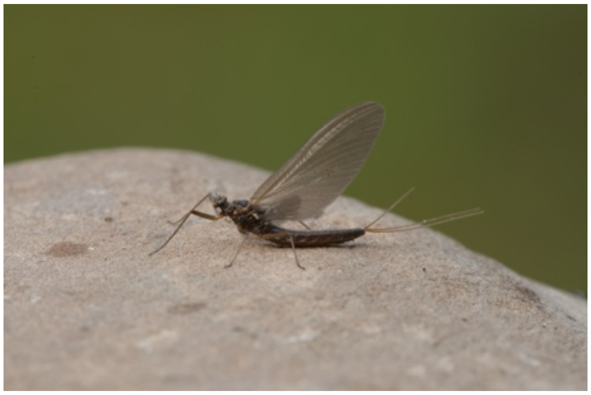
MAYFLIES:



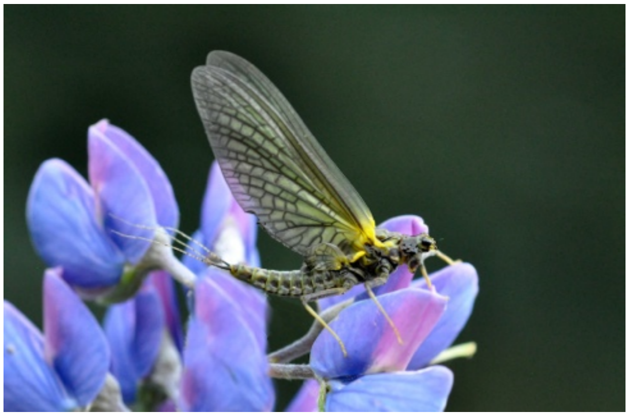
BLUE-WINGED OLIVE - *Baetis* sp.



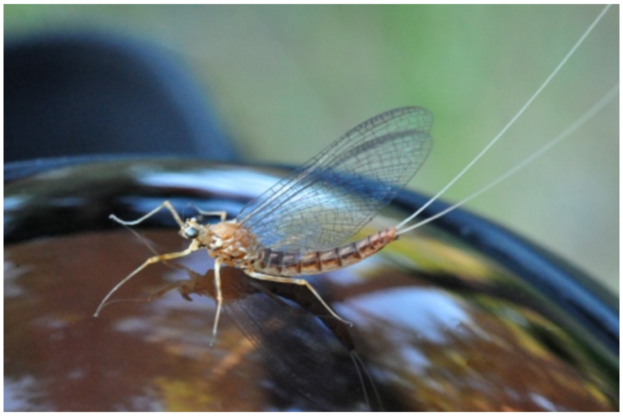
PALE MORNING DUN - E*phemerella excrucians*



MAHOGANY DUN - *Paraleptophlebia* spp.

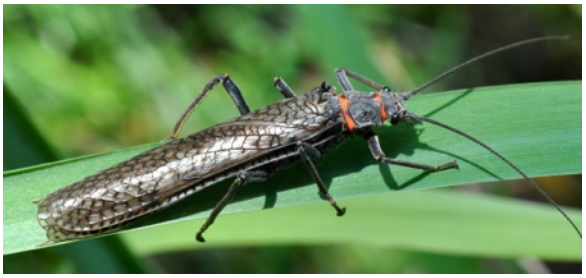


GREEN DRAKE - *Drunella grandis*

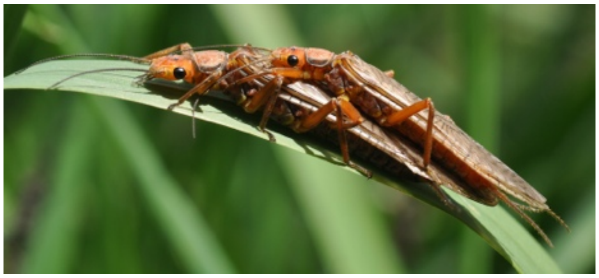


Pale Evening Dun - *Heptagenia* spp.

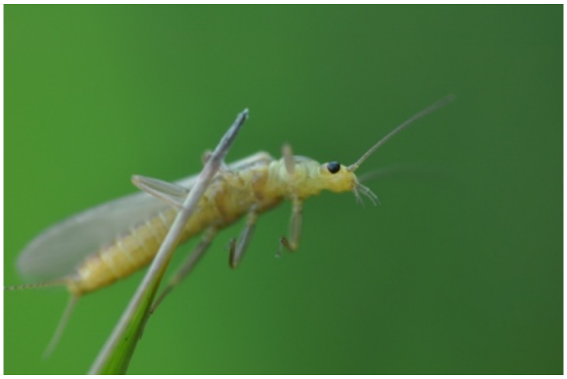
STONEFLIES:



Salmonfly - *Pteronarcys californica*

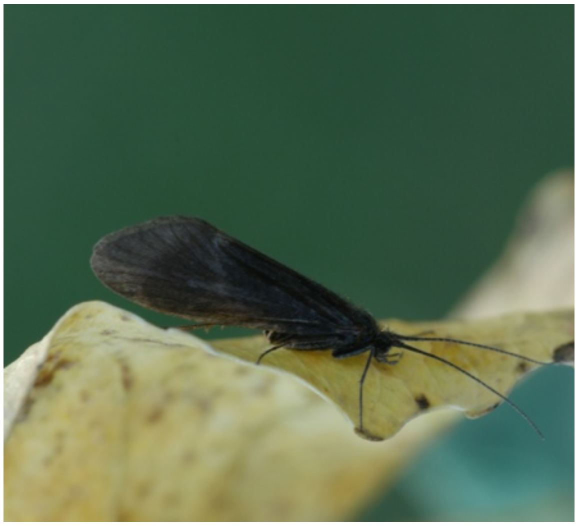


Golden Stone- *Hesperoperla pacifica*



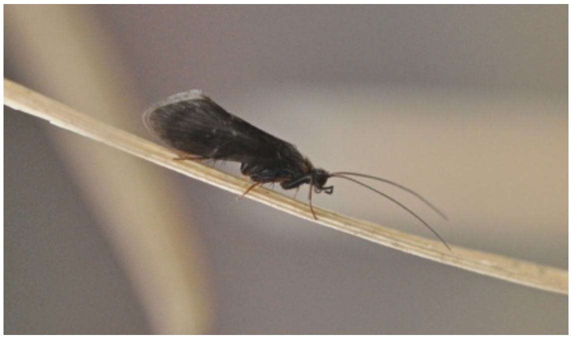
Yellow Sally - *Isoperla* spp.

CADDISFLIES:



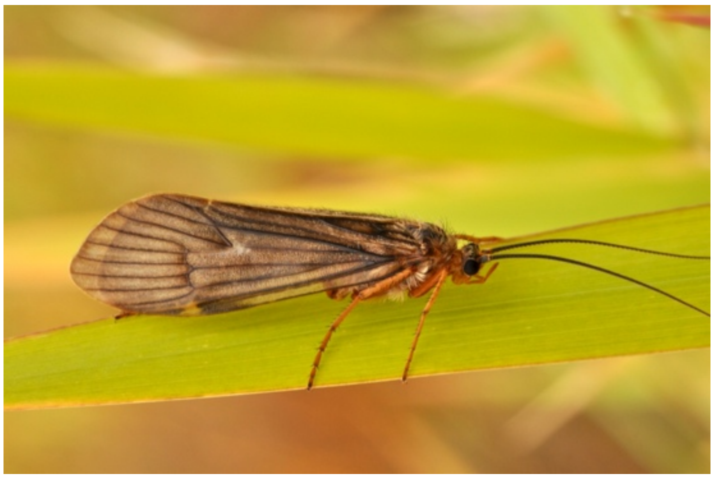
American Grannom - *Brachycentrus* spp.
(photo by Dave Hughes)

Green Rock Worm - *Rhyacophila* spp.



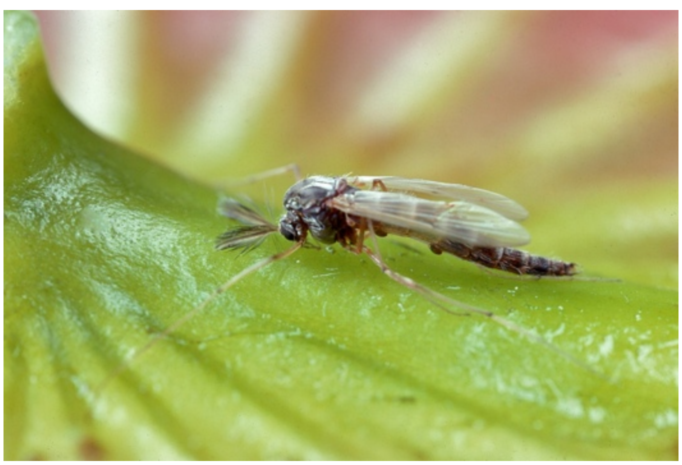
Saddle Case Caddis - *Glossosoma* spp.

Net-spinning Caddis - *Hydropsyche* spp.

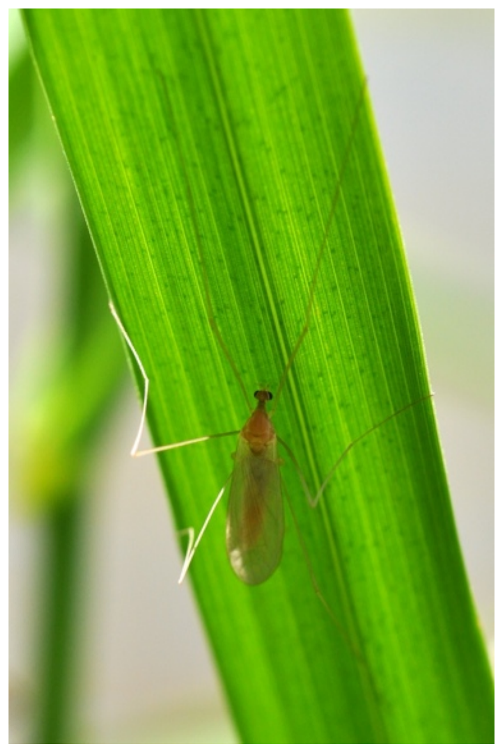


October Caddis - *Dicosmoecus* spp.

DIPTERA:



Midge - Chironomidae
(photo by Dave Hughes)



Crane Fly - *Antocha* spp.

NUISANCE DIATOM GROWTH:

Stalked diatom growth on rocks

Stalked diatom growth on aquatic plants