TASK 3. MAINSTEM NURSERY HABITAT EVALUATION 2014 – 2018

SANTA MONICA BAY
ANADROMOUS ADULT AND JUVENILE
STEELHEAD MONITORING
2013 – 2018

Prepared for
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Prepared by:

RCD of the Santa Monica Mountains
540 S. Topanga Canyon Blvd.
Topanga, CA 90290

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EXECUTIVE SUMMARY

The focus of this task was to evaluate the current conditions in the mainstem of Topanga Creek with the goal of addressing the following questions posed by the Southern California Steelhead Recovery Plan (NMFS 2012):

- Do intermittent creeks serve as steelhead nursery habitat?
- Does mainstem habitat support high juvenile survival and growth?
- Does fast growth and good conditions in freshwater encourage a more resident population, or does this set the stage for successful marine survival when out-migration is possible?

While technically classified as interrupted rather than intermittent (due to perennial flows throughout most of the anadromous reach), Topanga Creek is representative of conditions commonly found in the small coastal creeks characteristic of southern California. Topanga Creek is entrenched in a steep-walled canyon, and with no tributaries. Mainstem habitat is the only available nursery to support the population of *O. mykiss*. Mainstem habitat conditions respond to both natural variability (drought, wildfire impacts, extreme range in flow patterns, higher summer water temperatures, etc.) and anthropogenic stressors (flow withdrawal, water pollution, low flow barriers, passage restrictions, etc.) (NMFS 2012).

In addition to the data collected during the study period (2013-2018), monitoring of habitat conditions, water temperatures, benthic macro-invertebrate and *O. mykiss* relative abundance and diversity, and the introduction of non-native species such as red swamp crayfish has been on-going since 2001. This long-term dataset provides a context within which to examine the impacts of the drought that directly impacted the study period 2012-2016. Rainfall during those five years ranged from 6 to 13 inches, well below the average of 24 inches/year typical of Topanga Creek (Dagit and Webb 2002). Although more average rains returned in 2017 (26 inches), the drought pattern remains firmly in place as of May 2018, with a total rainfall of only 9.96 inches.

Overall, the drought resulted in limited connectivity to the ocean restricting anadromous adults from accessing the creek, and restricted in-stream movement opportunities for resident fish. Loss of habitat type complexity, particularly shallow areas of riffles and runs, and encroachment of emergent vegetation into the active channel further restricted movement. The reduced complexity of habitat types and increased extent of dry sections in the lower reach is a concern. In general, water temperatures remained within the range considered suitable to support *O. mykiss* despite the drought, although refugia pools influenced by seeps and springs did show reduced depths.

The previous characterization of Topanga Creek carrying capacity found that summer and winter habitat availability were not limiting factors (Bell et al. 2011). The response of the *O. mykiss* population to drought conditions suggests that although habitat availability and complexity has decreased, the remaining habitat is still rated as moderate to good in the BMI sample reaches examined. Topanga Creek should be able to support more fish than are currently observed. The interplay of limited access for anadromous adults, fewer redds (9 in 2014, 1 in 2015, 0 in 2015, 4 in 2017, and 4 in 2018), limited dispersal, and low recruitment of young of the year make it difficult to validate our habitat suitability assumptions.

Young of the year *O. mykiss* in Topanga Creek typically emerge in April and May. One of the main limitations of assessing nursery habitat suitability for Topanga Creek as has been done in some more northern streams (Everest and Chapman 1972, Holmes et al. 2014), is the very low abundance of young of the year. Without a fully seeded population, it is not possible to ascertain why juvenile *O. mykiss* are found in some areas and not in others. Young of the year have been found clustered in close proximity to the location of redds, rather than spread out throughout the potentially suitable habitat (RCDSMM unpublished data). Also without connectivity to the entire stream due to many low flow barriers, young of the year are not able to freely distribute and chose their rearing locations. These low flow barriers likely lead to many fish being stuck in one pool, where resources can be quickly depleted. This can lead to intense intraspecific competition, and could be the cause of the large differences in total length (from 5 to 10 cm) of individuals from the same cohort (Table 3.20).

During this study we used two common methods to characterize the BMI community. Drift nets were deployed for 24 hour periods in March, July, and November 2014-2017 to measure invertebrate drift abundance at the upstream and downstream ends of a characteristic pool habitat (3.58-3.6 rkm). This data was supplemented with kick net data collected each April/May within the same reach. Using both sets of data helped discern the relative importance of aquatic-origin verses terrestrial origin prey availability in supporting growth of juvenile *O. mykiss*, and examined whether seasonal shifts in prey type may be important for growth.

Overall, the abundance of all BMI was low during the study period. Aquatic invertebrates were significantly more abundant than terrestrial, comprising 83.5% of the mean drift net sample and 97% of the kick net sample abundance. The most abundant aquatic taxa were *Argia sp*., followed by chironimids, simulidae, Ceratopogonidae (midges), copopods, and baetids (mayflies). The most abundant terrestrial invertebrate was Thysanoptera (thrips). Terrestrial insects can be an important food source for salmonids, particularly when benthic resources are low or compromised (Elliot 1973, Cada et al. 1987, Nakano et al. 1999, Kawaguchi 2001).

While the sampling site selected was characteristic of habitat throughout Topanga Creek, the overall patchiness of invertebrate distribution and abundance is definitely worth consideration. Low flow barriers present throughout the creek restricted invertebrates from moving throughout the creek freely. *O. mykiss* management and conservation actions must consider trout food resources and ensure their availability (Romaniszyn et al., 2007).

While this study measured abundance, future efforts comparing mass and caloric value of invertebrate groups may be useful to help understand food preference of trout. Maintaining and improving proper habitat for invertebrate life within the channel as well as the riparian corridor is a key conservation requirement in Topanga Creek, as it may be in other small mainstem dominated coastal creeks in southern California.

The Southern California Coastal Index of Biotic Integrity (SCC-IBI, Ode et al. 2005) provides a tool for quantitatively comparing ecological conditions across a regional area. Scores are based on identification of 500 individuals per sample and then grouped into seven metrics (EPT taxa, Coleoptera, predator taxa richness, percent non-insect, tolerant taxa, percent intolerant individuals, collector-gatherer and collector-feeder individuals (Tables 3.8 and 3.13). Very poor samples had a combined metric score of less than 13, with 14-26 being poor, and 27-40 being considered fair. Both the majority of drift net samples (84 of 84) as well as kick net samples (7 of 8) were considered to be poor or very poor. Mean IBI scores did not significantly change annually, so there was no obvious effect of the drought, however returning rains in 2017 were not sufficient to change the quality and diversity of the invertebrate assemblage.

These results are consistent with the patterns observed in Topanga Creek between 2002-2014 by Montgomery et al. (2015). Over that time, the extended drought resulted in increased abundance of chironomids, with decreased abundance of baetids. SCC-IBI scores for these reaches ranged between a low of 9 (upper reach 2013) to a high of 40 (lower reach 2007). Overall, the scores averaged 37 in the lower reach and 35 for the upper reach, putting them in the fair category. This suggests that the long-term drought affected overall species composition and abundance which resulted in continued decline during the study period.

We assessed relative levels of seasonal food availability (March, July, November), and in particular during low flow and thermal stress conditions. A primary objective was to better understand the relationship between seasonal growth patterns of juvenile *O. mykiss*, and mainstem habitat suitability characteristics associated with promoting the rapid growth needed for higher rates of marine survival.

Despite the impacts of the drought, Topanga Creek continues to provide important mainstem nursery habitat for *O. mykiss,* but the survival and growth patterns of young of the year was difficult to correlate directly to habitat suitability metrics, water temperature, availability and quality of BMI, and the impacts of invasive competitors/predators.

Survival and recruitment of young of the year into larger size classes occurs, but is hampered by the low numbers of redds, and the fact that few redds are produced by anadromous adults (Dagit et al. 2018). Resident *O. mykiss* appear to be the dominant reproducers, with fewer eggs typically produced (NMFS 2012).

Due to the low flow and limited connectivity between the creek and the ocean, it was not possible to realistically determine if the growth patterns and overall good habitat suitability observed in Topanga Creek encourage a more resident population or not. The fish simply had little choice but to remain residents, aside from brief windows during storm events when migration was possible. The arrival of two anadromous adults in 2017, one of which spawned, highlights the variability and capriciousness of passage conditions and how significantly even one anadromous adult can affect population abundance.

Projected climate changes suggest that this pattern of lower rainfall and higher overall temperatures can be anticipated to continue and perhaps intensify in the future (Cook et al. 2015, Diffenbaugh et al. 2015). Thus the patterns observed during this study begin addressing the questions above, and also provide a baseline that can be used to document changes over time in this system. *O. mykiss* remains critically endangered, and continued efforts to preserve mainstem nursery habitat as well as restore Topanga lagoon are essential to increase the ocean connectivity and the nursery potential of this stream.

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Collecting, sorting and identifying the many benthic macroinvertebrate samples was a daunting task, and we are grateful to Salvador Contreras, Russell Dauksis, Jenna Krug, and Elizabeth Montgomery for taking the lead on the BMI identification effort. They also trained many volunteers who contributed over 1,600 hours to help with picking, sorting and identification.

2013: Uriel Cobian, Carrie Fong, Ariane Jong, Matt Kirby, Diana LaRiva, Gabby Njm, Katherine Pease, Tessa Reeder, Vanessa Thulsiraj, Karen Vu, Amy Zimmer-Faust, Mark Ziman.

2014: Kayti Christianson, David Gottesman, Allie Irwin, Monica Jarquin, Robert Ruzicka and Sylvia Zamudo.

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INTRODUCTION

A greater understanding of potential factors influencing southern California steelhead growth, including habitat characteristics, flow, thermal stress limitations, and possible food availability restrictions would help better understand the nursery potential of small creeks such as Topanga Creek. Without any tributaries or a functional coastal lagoon, and only an average of fewer than 20 days of connectivity to the ocean each year, mainstream habitat is all that is available for *O. mykiss*. Food availability is a crucial element of overall habitat quality for fish and an important consideration in freshwater conservation and management. Benthic macroinvertebrate (BMI) communities respond quickly to abiotic changes such as increased or reduced flows, overall drought conditions, and water temperature changes (Ode et al. 2005). Between 2014 and 2016, Topanga Creek experienced primarily extreme drought conditions (US Drought Monitor 2017), followed by average rainfall in 2017 and dry conditions again in 2018. This provided an opportunity to compare aquatic and terrestrial insect abundance response to these conditions and can help managers understand what input sources affect the overall stream food web and food availability to trout. Water quality issues from human inputs can also be detected with intolerant species dropping in abundance when streams become impacted.

In this study, the abiotic factors such as habitat type, depth, flow, and water temperature were integrated with examination of the BMI community composition to characterize and evaluate the suitability of mainstem nursery habitat to support growth of endangered southern steelhead trout (*Oncorhynchus mykiss*). Previous studies of *O. mykiss* diet in Topanga Creek suggested that food was not a limiting factor (Bell et al. 2011, Krug et al. 2012). In Topanga Creek, the BMI community consists mainly of fly larvae, snails, dragonfly nymphs, worms, mayflies, amphipods and copepods but the community dominance shifted during the drought, moving from baetid dominated to chironomid dominated (Montgomery et al. 2015). As the primary consumers of leaf litter, aquatic plants, and algae, macroinvertebrates provide the most basic link to higher trophic levels (Voshell, 2002). There is also a substantial input of terrestrial insects falling into stream food webs, such as bees, ants, and beetles, which suggests an important linkage to the health of riparian trees. Invertebrate drift is one measurement of the quality and quantity of food available for maturing *O. mykiss*. Density of invertebrate drift has been correlated with benthic productivity (Pearson and Kramer 1972, Benke et al. 1991), as well as trout short-term growth rate (Wilzbach et al. 1986), and spatial distribution of fish (Ensign et al 1990, Shannon et al. 1996).

While invertebrate drift sampling is important, this method relies on capturing insects either moving purposefully downstream or deceased individuals floating on the surface of the water. Another approach that can capture what benthic and/or sessile organisms are available as potential trout food is kick net sampling. D-nets are the most commonly used sampling device, with 66% of stream research programs using some sort of kick net sampler (Stark et al. 2001). They are suitable for any hard-bottomed stream substrate from sand to bedrock, but are commonly used in riffles to maintain consistency with other sampling efforts. This method actively disturbs the substratum, and dislodges invertebrates that may not be represented in drift net samples. Combining this type of benthic sampling with drift net sampling provided a more complete snapshot of the invertebrate community throughout the entire water column.

In order to understand the BMI community relationship not only with trout, but also within a regional context, we applied the metrics used by the Southern California Coastal Index of Biotic Integrity (SCC-IBI, Ode et al. 2005). This tool allows for a regionally-focused quantification of the ecological condition of a sampling site characterized by its benthic macroinvertebrate community. SCC-IBI scores are calculated as a sum of the following seven metrics: EPT taxa (Ephemeroptera, Plecoptera, Trichoptera), Coleoptera taxa, predator taxa, percent non-insect taxa, tolerant taxa, intolerant individuals, and percent collector-gatherer individuals. SCC-IBI scores show significant negative correlations between percent non-insect taxa (plankton) as well as levels of dissolved oxygen. Drought-related drying events likely create ideal habitat conditions for mosquitoes (Culicidae) and midges (Chironomidae) to increase in abundance (Sanford et al. 2005).

Our local endangered *O. mykiss* population relies heavily on these primary consumers through multiple pathways, as illustrated in Figure 3.1. The diet of *O. mykiss* changes throughout its lifecycle, with juveniles (<100 mm) consuming smaller invertebrates such as damselfly nymphs, midge larvae, and gnat larvae while intermediate size fish (101-250 mm) target larger amphipods and ostracods. Adult *O. mykiss* then consume all of the above, plus non-insect prey such as juvenile crayfish and Arroyo chub (*Gila orcutti*), which are both likely competitors for the same food sources as juvenile and intermediate *O. mykiss* trout (Krug et al. 2012). Adult *O. mykiss* are occasionally found dead in this creek, providing additional opportunities to examine stomach contents. In several cases, empty stomachs suggest that starvation was a factor in causing death, and reinforces the importance of understanding the complexity of BMI abundance and distribution. This complex food web and differences in seasonal availability shows how important it is to assess both the quality and quantity of BMI.

Growth is a function not only of suitable and sufficient food availability, but also changes based on stressors such as increased water temperatures, decreased flows, limited suitable habitat, and competition. By examining the inter-relatedness of these factors, we hope to characterize the mainstem nursery habitat in Topanga Creek in response to drought.

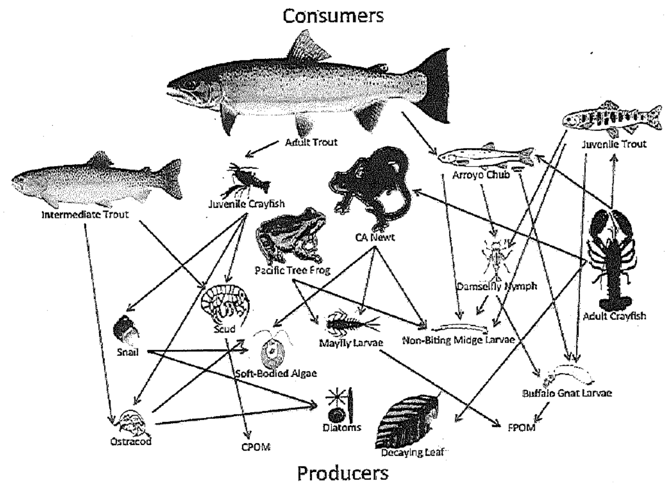


Figure 3.1. Theoretical food web of Topanga Creek showing the changes in diet of trout during different periods of its life cycle (excerpted from Dagit et al. 2014).

STUDY OBJECTIVES

The primary objective of this study was to better understand the relationship between seasonal growth patterns of juvenile steelhead trout (*Oncorhynchus mykiss*), and mainstem habitat suitability characteristics associated with promoting the rapid growth needed for increased rates of marine survival. Therefore, we assessed relative levels of food availability among seasons (March, April/May, July, November), and in particular during low flow and thermal stress conditions.

Measuring growth of marked juvenile steelhead during low flow periods in November and during storm event migration trapping has been occurring since 2008 in Topanga Creek. By examining food availability concurrently with environmental parameters, we hoped to better understand the relationship between growth rates and food availability provided by the existing mainstem habitat. We also hoped to better understand the role of terrestrial inputs resulting from the functional riparian vegetation, as compared to aquatic drift and benthic production. During the five-year long drought, riparian trees in Topanga Creek experienced diebacks, potentially altering terrestrial input levels. By conducting an integrated study of habitat conditions, BMI abundance and community composition, as well as trout growth, relative abundance and distribution, we assessed the suitability of small, interrupted coastal creek habitat. This information also provides important pre-fire condition documentation. Since most coastal creeks in southern California have little if any lagoon habitat remaining that can provide nursery habitat, data from a representative reach of the available mainstem habitat can assist in understanding the suitability requirements of young of the year trout. This habitat information can be integrated with the temperature and flow data to provide insight into the potential nursery role of mainstem habitat, and further examine which habitat characteristics promote rapid growth of juveniles.

METHODS

Study Area

The Topanga Creek Watershed is the third largest in the Santa Monica Bay at 50 km^2. Approximately 37 km^2 of the watershed is dedicated public open space, and the remaining area is privately held land. The study area extends from the ocean to the natural limit of anadromy located approximately 5.3 km upstream and is entirely within Topanga State Park. The mainstem of the creek represents all available habitat, as there are no tributaries in the watershed that can support *O. mykiss*. Topanga is one of two creeks that currently support a remnant reproducing population of federally endangered southern steelhead trout (*O. mykiss*). Topanga Creek was identified as a Core 1 focal creek by the Southern Steelhead Recovery Plan (NMFS 2012), and has been the site of a lifecycle monitoring station since 2008.

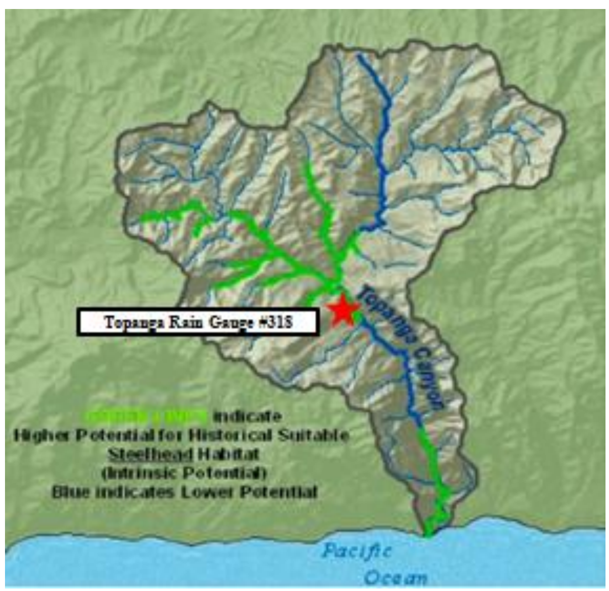


Figure 3.2. Topanga Creek Watershed Map and rain gauge location.

Rainfall and Drought Metrics

Rainfall data was measured by Los Angeles County Department of Public Works (LACDPW) gauge #318 located at the Topanga Fire Station in the center of the watershed (Figure 3.2). Rain data was summarized as each water year (October 1 through September 30). The US Drought Monitor (2017) documented sustained moderate to extreme drought conditions from 2012 through 2016, until an average rainfall year occurred in 2017. Data on pool volume and length of dry reach was collected during monthly snorkel surveys (Dagit et al. 2017).

Habitat Characteristics

Habitat type, percent dry, average and maximum depth, percent canopy cover, dominant substrate and percent algae were documented during monthly snorkel surveys. Data for percentage of each habitat type and the percent cover of vegetated banks for the 500-meter downstream kick net reach between 3.2-3.7 rkm was compiled for the corresponding sampling month for each year. Habitat suitability criteria for each life stage of *O. mykiss* (Table 3.1) were compiled for southern California by compiling all available literature and data (Dagit and Reagan 2006, Spina 2007, Sloat and Osterback 2012, Allen 2015). The criteria suitability was used to provide a qualitative metric to document trends in habitat over time and particularly in relation to benthic macroinvertebrate communities.

Table 3.1. Habitat suitability matrix for different size classes of trout.

Variable		5 = Excellent	4 = Good	3 = Moderate	2 = Fair	1 = Poor
Substrate		Gravel	Boulder	Cobble	Sand	Silt/Clay
Depth (cm)	Adults	>80	60-79	40-59	20-39	0-19
	Intermediates	>60	40-59	30-39	20-29	0-19
	Juveniles	>30	20-29	10-19	5-9	0-4
Shelter Value		>2.5	2	1.5	1	0.5
Canopy Cover (%)		80-100	60-79	40-59	20-39	<20
Habitat Type	Adults (>25 cm)	Main channel pools	Runs/glides/ step runs	Scour pools	Backwater pools	Low to high grade riffles
	Intermediates (11-25 cm)	Runs/glides/ step runs	Main channel pools	Low to high grade riffles	Scour pools	Backwater pools
	Juveniles (<10 cm)	Low to high grade riffles	Runs/glides/ step runs	Main channel pools	Scour pools	Backwater pools

Thermal Stress

A HOBO Tidbit continuously recording data logger was deployed each year at Engine Pool (3.5 rkm) from April through October, and recorded temperature every 30 minutes. Maximum, minimum, and average temperatures during the sampling months were compiled for all years.

Drift Net Sampling Reach

Drift nets were deployed for 24 hours on 3/24/14, 7/1/14, 11/24/14, 3/30/15, 7/13/15, 11/4/15, 3/22/16, 7/6/16, 11/17/16, 3/16/17, 7/10/17, and 11/1/17. Three drift nets (30 cm x 50 cm) with 363-micron nylon mesh were set at the upstream extent of the study pool (3.6 rkm (34.0638N, -118.5874W), and three were set downstream (3.58 rkm; 34.0637N, -118.5874W) to filter any flow entering or exiting the habitat unit (Figure 3.3). This pool was selected due to accessibility and displays habitat characteristics representative of the majority of pools in the system. The pool measured approximately 20 meters in length and four meters in width (Figure 3.4).

Figure 3.3. Topanga Creek drift net stations at 3.58 rkm and 3.6 rkm respectively.

The study site was flanked to the east by alder-dominated riparian forest which extends approximately 40 meters to Topanga Canyon Boulevard and runs 250 meters in length. Non-native smilo grass (*Piptatherum miliaceum)* dominates the groundcover and non-native *Cyperus* sedge was also present near the bank. Above the upstream nets (3.6 rkm), a non-native giant cane grass (*Arundo donax)* patch was growing to the west of and within the river channel. Willow roots were present at the downstream end of the pool habitat, just above the 3.58 rkm station, which is situated directly upstream of a riffle. A steep canyon wall abuts the pool to the west; total pool canopy/shade cover is 85-90%. The pool substrate was a mix of boulder and cobble, although gravel and fine sediments were deposited throughout the study period.

Figure 3.4. Topanga Creek drift net stations.

In-situ Water Chemistry

Physical and chemical habitat conditions including average depth, air and water temperature (^{o}C), salinity (ppm), dissolved oxygen (mg/l), pH, conductivity (mS/cm), dominate substrate, percent instream and canopy cover, dominate canopy type, and percent algae were measured at net deployment (12:00 hr) within the pool downstream of the 3.6 rkm nets.

Flow
Water depth at the nets was measured with a meter stick, and velocity was measured with a Marsh-McBirney 2000 flow meter set at the center of each net at drift collection times (18:00, 00:00, 06:00, 12:00 hrs). Total volume of flow per six-hour collection period was calculated by water depth (ft) * length of nets (ft) * flow (cfs) * 21600 seconds.

BMI Sample Collection from Drift Nets
Net contents were collected by removing the receptacle end of each net and emptying them directly into labeled composite sample jar for upper and lower sites. Contents were preserved in 70% ethanol solution until processed. Invertebrates were separated from other organic material, and up to 600 individuals identified by life stage, and to genus when possible, or lowest feasible taxonomic level per organism condition and size, according to the protocols of Ode 2007. Invertebrates were sorted by aquatic and terrestrial origin to assess food availability by source. Invertebrate density was calculated by total # organisms / total volume of flow (ft^3). Partial molts or body parts were excluded from the selection of the subsample of 600 individuals used to develop the SCS-IBI metrics.

Kick Net Sampling Reaches
Each spring during April or May, a 150-meter reach of creek in both the lower (3.2-3.7 rkm, 34.0631, -118.5872) and upper reaches (4.5-5.0 rkm; 34.0735N, -118.5873W) was sampled (Figure 3.5).

Figure 3.5. Locations of the lower (3.2-3.7 rkm) and upper (4.5-5.0 rkm) SWAMP survey kick net reaches in Topanga Creek.

Eleven samples were collected according to the SWAMP protocol (Fetscher et al. 2009) in rifles using a standard D net, which is a 30-cm diameter, D-shaped rim fitted with a heavy canvas bag with a 500-micron mesh bottom (Figure 3.6). In-situ water quality (dissolved oxygen, temperature, pH, conductivity, turbidity) data and flow were collected as noted above at the start of each survey reach.

Figure 3.6. Standard D-net used to collect kick net samples.

BMI Sample collection from Kick Nets

Starting at the first riffle complex, the net was placed with the mouth facing upstream perpendicular to the flow. One square foot of substrate in front of the net was disturbed by foot for 30 seconds and invertebrates were washed downstream with the flow and into the net. The composite BMI sample for each reach was collected into one labeled jar and fixed with 70% ethanol. Identification and analysis of samples was consistent with the protocol detailed under drift net methods. All samples were held at the RCDSMM office until arrangements can be made for transfer to LA County Natural History Museum. The results of this sampling will also be used to update the Index of Biological Integrity (IBI) for Southern California, as well as contribute to the metrics for the California Stream Condition Index being developed by SCCWRP.

O. mykiss Abundance, Distribution and Growth

Snorkel surveys were conducted monthly according to the protocol described in Dagit et al. (2015). Data recorded included abundance and size class of all trout, location, habitat type, maximum and average depth, percent canopy cover, dominant substrate, algae cover, shelter value, instream cover value and visibility. Surveys start at the ocean and extend to the limit of anadromy at 5.3 rkm (Figure 3.7).

Mark-recapture events occurred in November 2014-2017 and the protocols are detailed in Krug and Dagit (2016). The sampling occurred between 1.7-5.3 rkm as shown in Figure 3.7. In addition to measuring fork length, a small scale sample was taken from the left lateral side below the adipose fin. Scales were transferred from Rite in the Rain® paper in sample envelopes on to a flat glass microscope slide, then covered with another slide, secured and labeled. A minimum of ten scales per individual were taken to account for unclear growth patterns that may be present on some scales. Scales were analyzed under a dissecting microscope by two readers to determine fish age by counting annular rings.

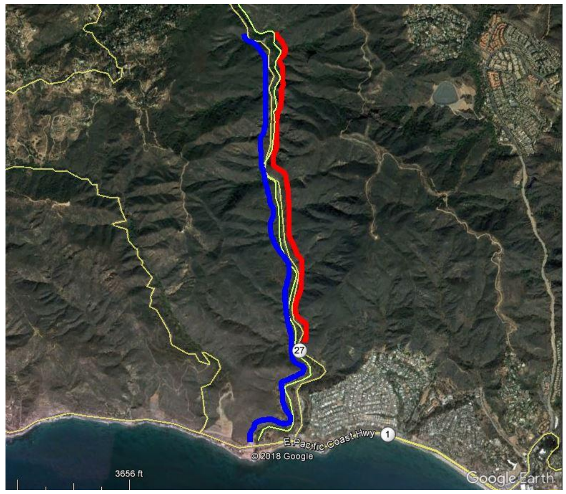


Figure 3.7. Topanga Creek snorkel survey reach (blue left line) from 0 – 5.3 rkm and mark-recapture reach (red right line) from 1.7 – 5.3 rkm from 2014-2017.

Mainstem Nursery Habitat Examination

Nursery habitat quality for juvenile trout was evaluated as a combination of habitat suitability as well as water quality and food availability. The metrics used to factor into our habitat suitability analyses were substrate, average depth, shelter value, canopy cover, and habitat type. This is not as comprehensive as other studies that used additional measurements such as in-water overhead cover, out-of-water overhead cover, distance to escape cover, substrate embeddedness, and surface/bottom water velocity (Everest and Chapman 1972, Holmes et al. 2014).

Data Analysis

Minimum, maximum, and average temperatures were compiled by month and year for Engine Pool (3.5 rkm). The proportion of time at each temperature was calculated to identify how long the critical thermal maximum for *O. mykiss* was sustained during the study period.

Habitat characteristic metrics of the 3.2-3.7 rkm sampling reach were compiled for each sampling period into a suitability score to provide context for the analysis of BMI community abundance and diversity. Habitat suitability was also expanded for the entire study reach and compared to the distribution and abundance of young of the year and juvenile *O. mykiss*.

For drift net flow data analysis, one-way ANOVAs were used to test for differences between sites, sampling times, and months from 2014 – 2017. In the abundance and species composition drift net section, mean and standard error was calculated for all major invertebrate groups and numbers of taxa to incorporate into graphs. Drift net invertebrate densities were analyzed with one-way ANOVAs for sampling site, sampling times, and month from 2014 – 2017. Mean and standard error were calculated for all major invertebrate groups and numbers of taxa for kick net sampling sites individually (n=5 each site) as well as combined together (n=10). A paired t-test compared lower and upper kick net site abundances. T-tests with unequal variances were used for comparison of composite kick net and drift net total abundances. T-tests with unequal variances were also used for testing for differences between the lower kick net and drift net sample abundances as well as upper kick net and drift net sample abundances.

Linear regression was used to test for correlations between mean monthly abundances of Arroyo chub and *O. mykiss* totals as well as Red Swamp Crayfish and *O. mykiss* totals from snorkel surveys from 2014 – 2018.

RESULTS

Rainfall and Drought Metrics

A summary of rainfall, and percent of all survey meters dry during the summer months are found in Table 3.2. These metrics were further analyzed in Dagit et al. (2017), but are provided here as context for understanding the implications of habitat loss due to drought over time and subsequent changes in BMI community characteristics as well as trout abundance and growth.

Table 3.2. Summary of rainfall and physical conditions in 3.2-3.7 rkm from 2014 – 2017.

	2014	2015	2016	2017
Drought metrics				
Rainfall (inches)	6.85	13.49	10.54	26.34
Jul-Sep dry (% of all 5.3 rkm)	45.57%	46.10%	61.19%	23.58%

Habitat Characteristics

Data collected during monthly snorkel surveys on depth, percent canopy cover, dominant substrate, and percent algae cover were augmented with specific habitat type information and percent vegetated bank conditions collected in May of each year using the SWAMP protocol (Fetscher et al. 2007). A summary of all metrics and the habitat suitability are detailed in Table 3.3.

Table 3.3. Habitat metrics of the 3.2-3.7 rkm stretch of Topanga Creek from 2014 – 2017.

	2014				**2015**				**2016**				**2017**			
Habitat Metrics (3.2-3.7 rkm)	March	May	July	November	March	May	July	November	March	May	July	November	February	May	July	November
Average maximum depth over 500 m	71	51	53	66	81	78	58	52	54	61	58	98	88	70	65	70
Mean Average depth over 500 m	44	26	25	36	43	41	36	33	31	33	26	49	50	37	34	38
Percent riffles over 500 m	0.0%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Percent runs over 500 m	0.0%	0.0%	38.5%	14.3%	0.0%	28.7%	22.2%	30.8%	0.0%	33.3%	15.4%	8.3%	25.0%	25.0%	25.0%	0.0%
Percent step-pools over 500 m	14.0%	14.3%	23.1%	28.7%	25.0%	14.3%	22.2%	15.4%	16.7%	13.3%	46.2%	41.7%	0.0%	0.0%	0.0%	16.7%
Percent pools over 500 m	86.0%	71.4%	38.5%	57.1%	75.0%	57.1%	55.6%	53.8%	83.3%	53.3%	38.5%	50.0%	75.0%	75.0%	75.0%	83.3%
Average Shelter Value	1.6	1.3	1.1	1.4	1.3	0.9	1.6	1.4	1.6	1.5	1.2	2	1.75	1.5	1.5	1.25
Percent vegetated right bank		10-40%				40-75%				10-40%				10-40%		
Percent vegetated left bank		10-40%				10-40%				10-40%				10-40%		
Percent overall canopy cover	71.25%	62.9%	67.08%	61%	51.3%	45.83%	51.67%	61.43%	43.00%	67%	45.83%	41.25%	5.25%	7.67%	52.50%	50%
Dominant substrate	Boulder	Boulder	Boulder	Boulder	S/G/B	Cobble	Boulder	Sand	Boulder	Gravel	Boulder	Sand	Sand	Sand	S/G/B/C	Gravel
Average Percent Algae cover	0%	3.57%	3.33%	0%	6.7%	5%	0%	0%	0%	0.75%	1.67%	0%	0%	103.33%	16.25%	4.17%
Suitability rating for juveniles (qualitative)	19	18	17.5	19	17.5	16	18	17	18	20	16	17	15	14	17.5	19
Suitability Score (qualitative)	**Good**	**Good**	**Good**	**Good**	**Good**	**Good**	**Good**	**Good**	**Good**	**Good**	**Good**	**Good**	**Moderate**	**Moderate**	**Good**	**Good**

* S/G/B = Equal combination of sand/gravel/boulder, S/G/B/C = Equal combination of sand/gravel/boulder/cobble.

All sampling periods scored Good qualitative habitat suitability ratings except February and May of 2017 which received Moderate ratings. Although there are no Excellent ratings, the canopy cover, decent depths, and dominance of harder substrates in this 3.2-3.7 rkm stretch suggests that it was consistently Good habitat for juvenile *O. mykiss* throughout the study period based on qualitative metrics. This stretch is less suitable for adult *O. mykiss* that require deeper depths. Habitat suitability was also evaluated for the entire stream based on November 2017 habitat mapping, where almost the whole stream was Moderate or Good except for a long dry stretch from 0.4-1.8 rkm (Figure 3.8). Juvenile *O. mykiss* were also found primarily in close proximity to where redds were seen. Low flow barriers likely constrict these juveniles from spreading out into other areas.

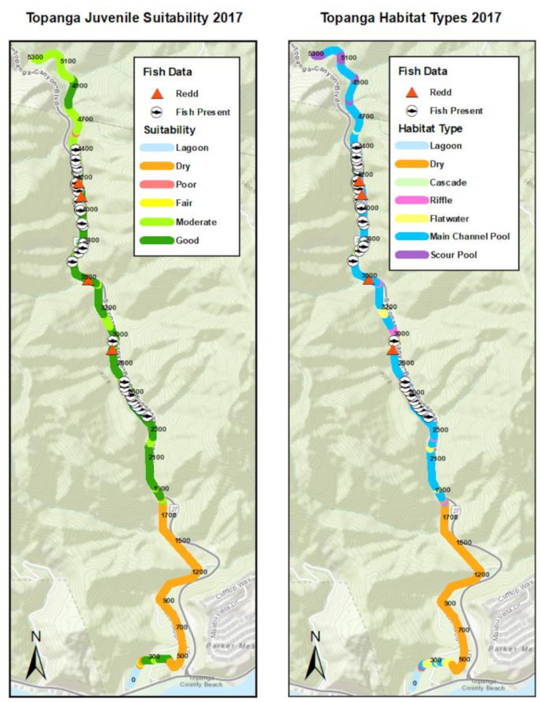


Figure 3.8. Habitat types from a November 2017 survey of Topanga Creek with locations of juveniles from November 2017 electrofishing data.

Thermal Stress

The HOBO tidbit located in the 3.5 rkm Engine Pool provides a representative profile of water temperature within the study reach (Figure 3.9). The most stressful months each year were from mid-June to mid-September, but did not reach the 25°C lethal limit of *O. mykiss* (Matthews and Berg 1997). The proportion of time above 23°C was less than 5% (Figure 3.10), so even when these higher temperatures were reached, they were not sustained for long periods of time and only occurred in 2017.

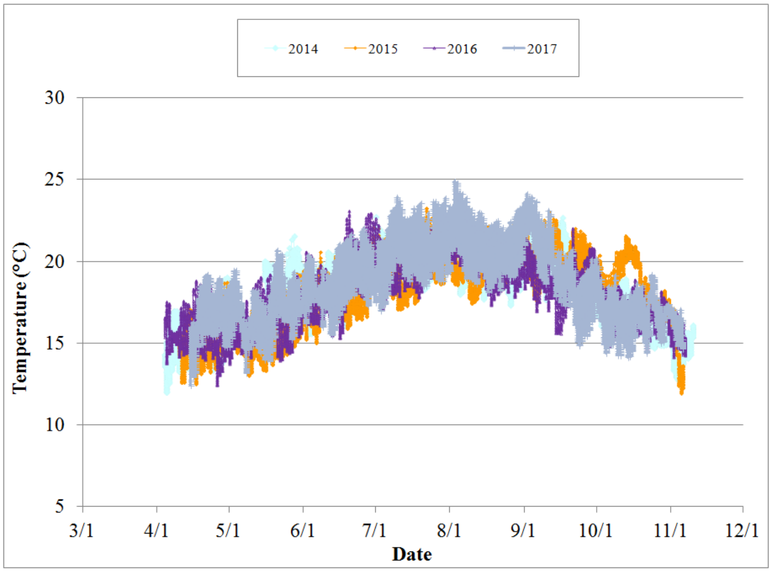


Figure 3.9. Water temperature between April and November in Engine Pool (3.5 rkm) of Topanga Creek from 2014 – 2017.

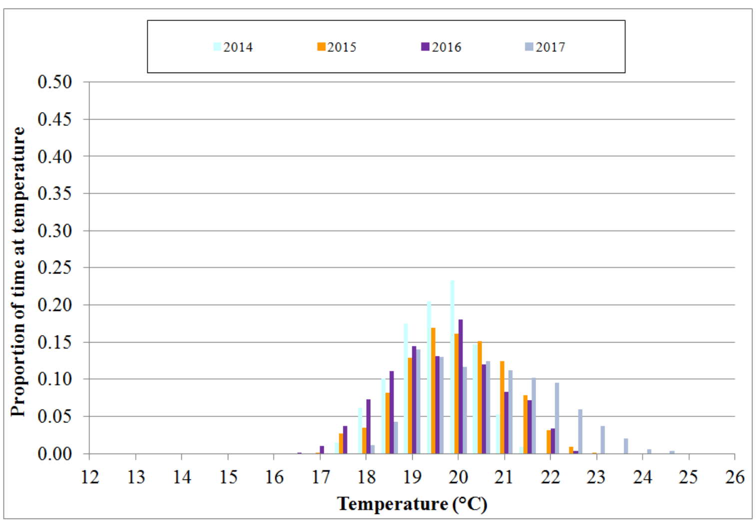


Figure 3.10. Proportion of time water is at different temperatures in Engine Pool (3.5 rkm) of Topanga Creek for April to November from 2014 – 2017.

Table 3.4. Significant differences in average, absolute maximum, and minimum temperatures (°C) from averages of the 4-year study period in Engine Pool (3.5 rkm) of Topanga Creek for April, July, and October of 2014 – 2017.

		2014	2015	2016	2017
Temperature Range	April	12.0 – 19.1	12.5 – 18.8	12.3 – 18.8	12.4 – 19.2
	July	18.1 – 22.8	17.1 – 23.3	17.1 – 22.6	17.0 – 23.9
	Oct	14.8 – 19.4	15.9 – 21.6	14.7 – 20.1	14.1 – 20.2
Average Daily Minimum	April	14.5	**13.8*** (-)	14.1	14.9
	July	19.1	18.4	18.8	18.9
	October	**17.5*** (-)	**18.2***** (+)	**17.3**** (-)	**17.2***** (-)
Average Daily Temperature	April	15.8	**15.2*** (-)	15.7	**16.5*** (+)
	July	20.2	**19.6**** (-)	20.2	20.4
	October	**17.1** * (-)	**18.8***** (+)	**17.0**** (-)	**16.6***** (-)
Average Daily Maximum	April	17.2	16.6	17.6	**18.0*** (+)
	July	21.5	21.4	**21.9**** (+)	**22.7***** (+)
	October	**18.0*** (-)	**19.5*****(+)	18.0	18.1

Significance was tested with t-tests, two-tailed. P-values *<.01 = 99%, **<.001 = 99.9%, ***<.0001 = 99.99% confidence

HOBOs were deployed April through October. Table 3.4 illustrates the patterns of average daily maximum, average, and minimum temperatures observed during that time. Individual time period data was compared to the four year study period average temperature conditions for the same time period in other years and significance reported. October was significantly different from the four-year study period average for all years of the study. Average daily temperature was significantly different from the four year average for all months in 2015. Average daily maximum was more variable.

Average minimum temperatures also show significant correlation over time. Most importantly, night temperatures did not significantly cool down as compared to both average and maximum temperatures. This resulted in a lower diurnal variation between maximum and minimum temperatures. While the overall water temperature remained within the range suitable for *O. mykiss*, it is not clear what implications increasing minimum temperatures and less diurnal variablity might have for foraging, spawning and rearing behaviors, and ultimately growth and survival.

DRIFT NET RESULTS

In-situ Water Chemistry

Physical and chemical habitat conditions were measured when setting drift nets at 12:00 (Table 3.5). Water chemistry was in the range of generally acceptable limits for *O. mykiss* (Matthews and Berg 1997). Water temperature, salinity, conductivity, dissolved oxygen, and pH measured in the pool downstream of the 3.6 rkm nets during sampling events did not correlate to invertebrate abundance differences.

Water temperatures were highest in July, but measurements did not exceed 21.6° C at the drift net site during the sampling events. The lowest dissolved oxygen reading of 4.38 mg/L was under the five mg/L threshold of concern (Matthews and Berg 1997) in July 2016 during the height of the drought but was otherwise suitable for *O. mykiss*.

Table 3.5. Physical and chemical pool conditions at the Upper Topanga drift net location (3.6 rkm).

Date	Location	Time	Air T (◦C)	Water T(◦C)	Salinity (ppm)	DO (mg/L)	pH	Cond (ms/cm)	Av. Depth (cm)	Substrate	Canopy (%)	Canopy type	Instream cover (%)	Algae (%)
03/24/14	Upper	12:00	ND	14.5	1	8.32	8.23	1670	20	gravel/boulder	85	arundo/alder	25	0
07/01/14	Upper	12:00	22	19.9	0	6.54	8.34	1480	2.5	boulder/gravel	90	willow	20	0
07/02/14	Upper	12:00	25	20.2	0	6.8	8.24	1500	2.5	boulder/gravel	90	arundo/alder	20	0
11/24/14	Upper	12:00	20	13.2	1	7.78	8.2	1200	7	cobble	90	arundo/alder	10	0
11/25/14	Upper	12:00	ND	11.1	1	8.21	8.27	1230	7	cobble	90	arundo/alder	10	0
07/13/15	Upper	12:00	24.5	19.2	1.5	9.22	8.19	1200	15	silt	85	arundo/alder	<5	0
07/14/15	Upper	12:00	24.5	18.9	2	9.38	8.27	1210	15	silt	85	arundo/alder	<5	0
11/04/15	Upper	11:30	18	13.5	0.5	11.68	8.5	1450	25	cobble/boulder	70	arundo/alder	5	0
03/22/16	Upper	12:00	17.2	14.9	2	8.87	8.3	1380	17	boulder	80	alder	5	0
07/06/16	Upper	12:00	26.5	18.8	2.5	4.38	8.08	1520	4.5	sand/silt	95	willow	5	0
11/17/16	Upper	12:00	20	13.2	0	7.41	ND	1220	5	sand/silt	95	willow	<1	0
03/16/17	Upper	12:00	18	14.4	2	7.25	7.4	1810	15	boulder	65	alder	5	70
07/10/17	Upper	12:00	26	21.6	0	5.58	7	1470	25	boulder	98	arundo	<5	0
11/01/17	Upper	11:30	19	16.7	0	8.08	8.5	1420	23	cobble	60	trees	1	0
11/02/17	Upper	11:50	18	16.3	0	7.41	8.4	1430	25	cobble	60	trees	1	0

Flow data

Flows remained low throughout the majority of the study period due to extreme drought conditions from 2014-16, which was downgraded to severe drought in 2017 (US Drought Monitor 2017). No significant difference in flow was observed between the four sampling years. Flows were not significantly different between stations at 3.58 rkm and 3.6 rkm ($F_{1,87}$ = 3.832, p = 0.0535) (Figure 3.11).

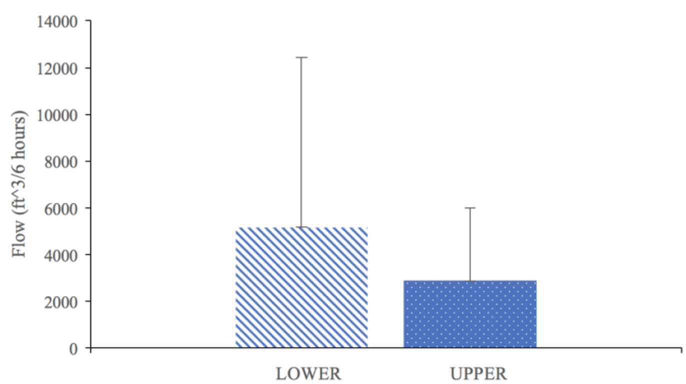


Figure 3.11. No significant difference in flow rate between the lower location at 3.58 rkm and the upper drift net location at 3.6 rkm from 2014 – 2017 ($F_{1,87}$ = 3.83 and p = 0.0535).

No significant trend was found between flow and time of day, although 00:00 had the greatest flow of sampling time periods when looking at all years of the study (Figure 3.12). Discharge (cubic feet per six hours) was significantly different between sampling months (one-way ANOVA, $F_{2,87}$ = 30.9, p < 0.01) with March having the greatest discharge of all years (Figure 3.13). The highest flow (0.45 cfs) was recorded in March 2017 at the 3.58 rkm lower station at 06:00. Discharge was lowest in July on average for all years, never measuring above 0.15 cfs.

There was no statistically significant relationship between invertebrate drift abundance and discharge.

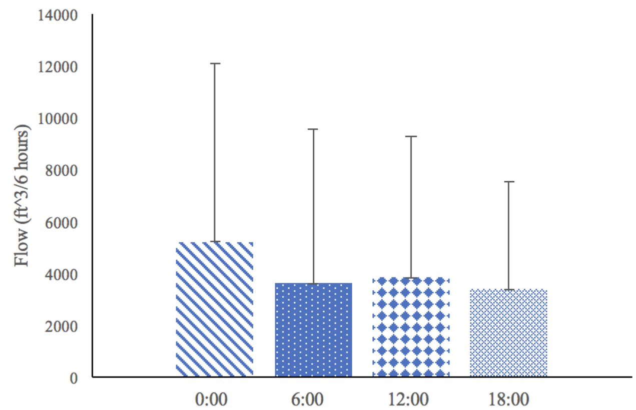


Figure 3.12. No significant difference in flow rate between the different sampling times of day from 2014 – 2017 ($F_{3,86}$ = 0.4678 and p = 0.7055).

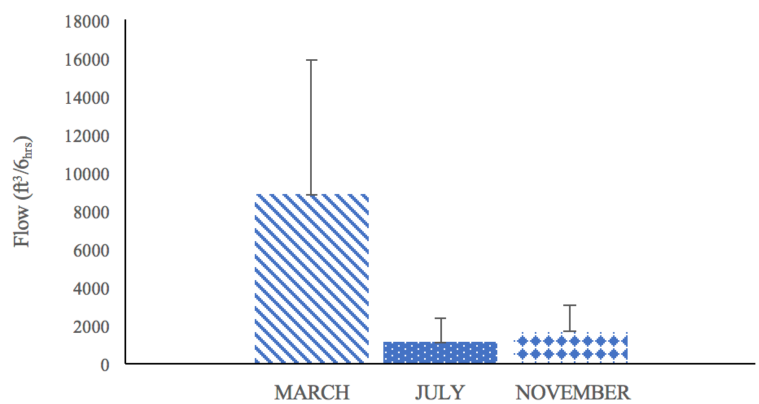


Figure 3.13. Significantly higher flow rate in March than the other seasons sampled from 2014 - 2017 ($F_{2,87}$ = 30.9 and p = 7.263e-11).

Drift Net Abundance and Species Composition

A total of 13,333 invertebrates representing 150 distinct taxa and life cycles were collected and identified throughout the study period from March 2014 - November 2017. Invertebrate abundance varied highly per six-hour sample, from 0 to 816 individuals. The most abundant aquatic taxa observed throughout the study period are summarized in Table 3.6. The relative abundance of over 50% of all aquatic individuals during the study were Coenagrionidae (*Argia sp*./*Enallagma sp*., 15.3%), Chironomidae larvae (14.2%), Copepoda (11.8%), Baetidae (*Baetis sp*. larvae (10.4%), and Amphipoda (*Hyalella sp*., 5.9%). The most abundant taxa of terrestrial origin were Thysanoptera (thrips, 5.7%), Diptera adults (3%), Aphidoidea (1.9%), Chironomidae adults (1.5%), and Formiscidae adults (1.5%). A complete taxa list is found in Appendix 3A.

Table 3.6. Percentage of each taxa representing over 1% of all drift net samples 2014-2017 (n=94).

Order	Family	Percentage of all individuals	Number of all individuals
Odonata	Coenagrionidae	15.3%	1,935
Diptera	Chironomidae	14.2%	1,895
Diptera	Ceratopogonidae (larvae)	3.3%	443
Diptera	Ceratopogonidae (pupae)	3.2%	422
Diptera	Diptera unidentified (adult)	3.0%	398
Diptera	Chironomidae (pupae)	2.1%	284
Diptera	Chironomidae (adult)	1.5%	195
Diptera	*Simulium sp*. (larvae)	1.1%	141
Copepoda	Copepoda	11.8%	1,583
Ephemeroptera	Baetidae (larvae)	10.4%	1,381
Amphipoda	Hyalellidae (*Hyalella sp*.)	5.9%	790
Thysanoptera	Thysanoptera	5.7%	756
Hemiptera	Aphidoidea(adult)	1.9%	251
Hemiptera	Hemiptera	1.2%	164
Hemiptera	Corixidae (adult)	1.2%	157
Hymenoptera	Formiscidae	1.5%	197
Ostracoda	Ostracoda	1.2%	154
	Other (133 taxa groups)	16.4%	2187
Total		**100.0%**	**13,333**

Although *Argia sp*. of Odonata has the highest relative abundance (Table 3.6) of families, Diptera represents a larger order with four times the number of taxa groups than Odonata. Diptera and Plankton were the most numerically dominant invertebrate groups of all samples from 2014-17, with mean abundances of 44.32 (+/- 8.38) and 27.80 (+/- 4.08 standard error) respectively from all samples (Table 3.7). Plankton includes copepods, *Hyalella sp*. amphipods, and ostracods. They were followed by Odonata (*Argia sp*./*Enallagma sp*.) and EPT groups. Hemipiterans and Thrips showed the lowest mean abundances of 9.91 +/- 1.5 and 8.04 +/- 3.87 respectively (+/- standard error) (Figure 3.14).

Table 3.7. Mean and standard error of metrics relating to all drift net samples 2014-2017 (n=94).

	Mean	Standard Deviation	Standard Error
total # organisms	141.87	177.12	18.27
# taxa	14.01	8.62	0.89
# aquatic taxa	9.60	5.24	0.54
percent aquatic taxa	72.3%	0.17	0.02
# aquatic org.	112.35	136.04	14.03
percent org. aquatic	83.5%	0.18	0.02
# terrestrial taxa	4.41	4.06	0.42
percent terrestrial taxa	27.7%	0.17	0.02
# terrestrial org.	29.52	66.53	6.86
percent org. terrestrial	16.5%	0.18	0.02
# Hemiptera	9.91	14.53	1.50
#Diptera*	44.32	81.25	8.38
#EPT	18.82	33.31	3.44
#Odonata	20.81	74.63	7.70
# Thrip	8.04	37.48	3.87
# Plankton	27.80	39.59	4.08

	Mean	Standard Deviation	Standard Error
#larval insect	69.65	106.33	10.97
# pupa insect	8.07	19.10	1.97
# adult insect	2.97	6.17	0.64
# non-insecta	33.97	43.03	4.44
%larva	40.8%	0.24	0.02
%pupa	3.7%	0.07	0.01
%adult	4.1%	0.10	0.01
%non-insect	37.6%	0.27	0.03

*includes Chironomids

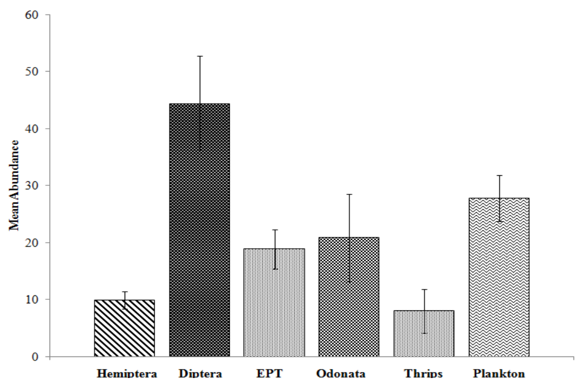


Figure 3.14. Means abundance of six different invertebrate groups across all drift net samples 2014-2017 (n=94).

Drift Net Invertebrate Density

Invertebrate density was calculated by total number of organisms / total volume of flow (m^3). Density of invertebrates was not significantly different between upper and lower drift net sites ($F_{1,86} = 0.4081$, $p = 0.5246$) or sampling time of day ($F_{3,84} = 1.327$, $p = 0.2712$). There was a significant difference between the three sampling months however, with higher density in July ($F_{2,85} = 4.328$, $p = 0.01622$), even though flows were higher in March (Figure 3.15). The numbers of individuals per sample were low overall, with samples with more than 500 individuals reached only in July 2014 and March 2015.

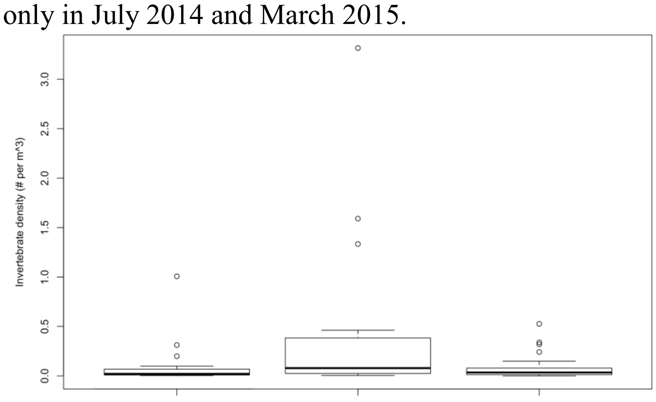


Figure 3.15. Density of individuals (# per m^3) during each sampling month in drift nets from 2014-2017 showed a significant difference ($F_{2,85} = 4.328$ and $p = 0.01622$).

Drift Net SCC-IBI Scores

Of the 94 drift net samples, ten received SCC-IBI ratings of Fair and all others were Poor (n=53) or Very Poor (n=27). Seven of the samples receiving a Fair rating were in March 2017 (Table 3.8), and 2017 had the highest average SCC-IBI score of 27.1. In 2014 there were two Fair scores (25.8 average), none in 2015 (20.9 average), and one in 2016 (24.7 average). Yearly mean SCC-IBI scores did not change in accordance with annual rainfall. Most to the Fair scores were in March 2017, with 10% tolerant taxa observed in five of the seven samples. This high percentage of tolerant taxa was also seen in two of the other three Fair ratings in previous years. Sampling location did not play a large role in these scores, with six of the Fair scores occurring at the lower 3.58 rkm site and four at the upper 3.6 rkm site. Sampling location did however have different average scores of 27.5 for the lower site and 21.9 for the upper site.

There was a slight decreasing trend in the average SCC-IBI scores by sampling month, with an average of 28.5 for March, 25.7 in July, and 19.6 in November. Number of predators was low for all samples, with many zeroes and only one sample with more than two. The most consistently good metric was percent collector/filterers and collector/gathers, with 10% abundance in 48 of the 94 samples.

Table 3.8. SCC-IBI scores for all drift net samples 2014 – 2017.

Year	Sample month	Sample Time	Site	#Total of Organisms	EPT Taxa	Taxa % Intolerant Individuals	# Predator	% Tolerant Taxa	% Non-Insect Taxa	% CF + CG	# Coleoptera Taxa	Total IBI Score (Adjusted on a scale of 0 to 100)	IBI Rating
2014	March	18:00	3.58 rkm	182	1	1	0	2	4	10	2	29	**Poor**
2014	March	0:00	3.58 rkm	88	1	0	0	5	9	5	0	29	**Poor**
2014	March	6:00	3.58 rkm	523	1	2	2	0	5	10	2	31	**Poor**
2014	March	12:00	3.58 rkm	182	1	2	0	0	3	5	0	16	**Very Poor**
2014	March	18:00	3.60 rkm	50	1	0	0	3	8	3	0	21	**Poor**
2014	March	0:00	3.60 rkm	48	1	0	0	2	1	6	0	14	**Very Poor**
2014	March	6:00	3.60 rkm	184	1	1	1	4	6	6	2	30	**Poor**
2014	March	12:00	3.60 rkm	54	1	0	0	5	4	3	0	19	**Very Poor**
2014	July	18:00	3.58 rkm	754	2	1	2	6	6	10	2	41	**Fair**
2014	July	0:00	3.58 rkm	32	1	2	0	9	8	10	2	46	**Fair**
2014	July	6:00	3.58 rkm	46	1	3	2	3	7	10	0	37	**Poor**
2014	July	12:00	3.58 rkm	112	2	2	0	0	4	10	0	26	**Poor**
2014	July	18:00	3.60 rkm	24	0	0	0	0	2	10	0	17	**Very Poor**
2014	July	0:00	3.60 rkm	22	0	0	0	0	4	9	0	19	**Very Poor**
2014	July	6:00	3.60 rkm	34	0	0	0	0	4	10	0	20	**Very Poor**
2014	July	12:00	3.60 rkm	19	0	0	0	0	0	10	0	14	**Very Poor**
2014	November	18:00	3.58 rkm	13	0	5	0	0	0	10	0	21	**Poor**
2014	November	0:00	3.58 rkm	44	1	0	1	0	4	10	2	26	**Poor**
2014	November	6:00	3.58 rkm	90	2	1	0	2	7	10	0	31	**Poor**
2014	November	12:00	3.58 rkm	97	1	0	0	2	6	10	2	30	**Poor**
2014	November	18:00	3.60 rkm	5	0	0	0	0	10	10	0	29	**Poor**
2014	November	0:00	3.60 rkm	24	0	0	0	0	7	10	0	24	**Poor**
2014	November	6:00	3.60 rkm	26	0	0	0	0	7	10	0	24	**Poor**
2014	November	12:00	3.60 rkm	58	0	0	0	0	8	10	0	26	**Poor**
2015	March	18:00	3.58 rkm	126	1	0	0	6	5	7	2	30	**Poor**
2015	March	0:00	3.58 rkm	410	1	0	0	3	3	4	2	19	**Very Poor**
2015	March	6:00	3.58 rkm	816	1	1	1	2	5	5	2	24	**Poor**
2015	March	12:00	3.58 rkm	593	3	1	1	3	5	7	2	31	**Poor**
2015	March	18:00	3.60 rkm	18	0	0	0	4	6	0	0	14	**Very Poor**
2015	March	0:00	3.60 rkm	69	0	0	0	2	4	0	0	9	**Very Poor**
2015	March	6:00	3.60 rkm	27	0	0	0	0	2	1	0	4	**Very Poor**
2015	March	12:00	3.60 rkm	68	0	1	0	3	5	1	0	14	**Very Poor**
2015	July	18:00	3.58 rkm	46	0	0	0	0	0	10	0	14	**Very Poor**
2015	July	0:00	3.58 rkm	34	0	0	0	3	0	10	0	19	**Very Poor**

TASK 3. Mainstem Nursery Habitat Evaluation - SMB Steelhead Monitoring 2014-2018

Year	Sample month	Sample Time	Site	#Total of Organisms	EPT Taxa	Taxa % Intolerant Individuals	# Predator	% Tolerant Taxa	% NonInsect Taxa	% CF + CG	# Coleoptera Taxa	Total IBI Score (Adjusted on a scale of 0 to 100)	IBI Rating
2015	July	6:00	3.58 rkm	10	0	5	0	5	2	10	2	34	**Poor**
2015	July	12:00	3.58 rkm	234	0	0	0	2	0	10	0	17	**Very Poor**
2015	July	18:00	3.60 rkm	26	0	5	0	0	4	10	0	27	**Poor**
2015	July	0:00	3.60 rkm	41	1	0	0	2	8	6	0	24	**Poor**
2015	July	6:00	3.60 rkm	31	0	0	0	4	6	7	0	24	**Poor**
2015	July	12:00	3.60 rkm	64	0	0	0	0	0	10	0	14	**Very Poor**
2015	November	18:00	3.58 rkm	61	0	0	0	0	7	10	2	27	**Poor**
2015	November	0:00	3.58 rkm	93	0	0	1	0	3	10	0	20	**Very Poor**
2015	November	6:00	3.58 rkm	25	1	0	0	0	2	10	2	21	**Poor**
2015	November	12:00	3.58 rkm	372	2	1	1	0	3	10	2	27	**Poor**
2015	November	18:00	3.60 rkm	46	0	1	0	0	5	10	0	23	**Poor**
2015	November	0:00	3.60 rkm	126	0	0	1	0	6	10	0	24	**Poor**
2015	November	6:00	3.60 rkm	95	0	0	0	0	5	10	0	21	**Poor**
2015	November	12:00	3.60 rkm	43	0	0	0	0	5	10	0	21	**Poor**
2016	March	18:00	3.58 rkm	60	1	0	0	7	5	6	0	27	**Poor**
2016	March	0:00	3.58 rkm	357	1	1	0	6	7	4	2	30	**Poor**
2016	March	6:00	3.58 rkm	330	1	0	1	7	8	7	4	40	**Poor**
2016	March	12:00	3.58 rkm	524	1	0	4	7	6	8	2	40	**Poor**
2016	March	18:00	3.60 rkm	74	1	0	0	7	5	10	0	33	**Poor**
2016	March	0:00	3.60 rkm	428	1	0	1	2	7	3	2	23	**Poor**
2016	March	6:00	3.60 rkm	391	1	1	1	5	7	2	0	24	**Poor**
2016	March	12:00	3.60 rkm	277	0	1	0	1	6	3	0	16	**Very Poor**
2016	July	18:00	3.58 rkm	71	0	1	0	5	4	10	2	31	**Poor**
2016	July	0:00	3.58 rkm	27	0	0	0	3	8	10	0	30	**Poor**
2016	July	6:00	3.58 rkm	54	0	0	0	0	3	10	0	19	**Very Poor**
2016	July	12:00	3.58 rkm	109	0	0	0	4	3	9	2	26	**Poor**
2016	July	18:00	3.60 rkm	47	0	4	0	0	7	10	0	30	**Poor**
2016	July	0:00	3.60 rkm	32	0	2	0	2	8	5	0	24	**Poor**
2016	July	6:00	3.60 rkm	84	0	0	0	0	0	5	0	7	**Very Poor**
2016	July	12:00	3.60 rkm	102	0	2	1	3	5	10	2	33	**Poor**
2016	November	18:00	3.58 rkm	1								0	**ND**
2016	November	0:00	3.58 rkm	1								0	**ND**
2016	November	6:00	3.58 rkm	68	0	0	0	0	10	10	0	29	**Poor**
2016	November	12:00	3.58 rkm	9	0	0	0	0	10	10	0	29	**Poor**
2016	November	18:00	3.60 rkm	14	0	0	0	0	4	10	0	20	**Very Poor**
2016	November	0:00	3.60 rkm	12	0	0	0	10	10	10	0	43	**Fair**
2016	November	6:00	3.60 rkm	26	0	8	0	5	7	7	0	39	**Poor**
2016	November	12:00	3.60 rkm	11	0	0	0	0	0	0	0	0	**Very Poor**
2017	March	18:00	3.58 rkm	81	1	1	0	10	10	10	0	46	**Fair**
2017	March	0:00	3.58 rkm	475	3	1	0	9	10	10	2	50	**Fair**
2017	March	6:00	3.58 rkm	499	1	0	0	10	8	10	0	41	**Fair**
2017	March	12:00	3.58 rkm	249	0	0	0	10	10	10	0	43	**Fair**
2017	March	18:00	3.60 rkm	60	0	0	0	5	10	10	4	41	**Fair**
2017	March	0:00	3.60 rkm	283	2	1	0	10	10	8	0	44	**Fair**
2017	March	6:00	3.60 rkm	173	0	1	1	10	10	5	0	39	**Poor**
2017	March	12:00	3.60 rkm	569	1	0	0	10	8	10	0	41	**Fair**
2017	July	0:00	3.58 rkm	255	3	1	2	5	7	7	0	36	**Poor**
2017	July	12:00	3.58 rkm	119	3	2	0	6	9	2	0	31	**Poor**
2017	July	18:00	3.60 rkm	8	0	0	0	2	10	0	0	17	**Very Poor**
2017	July	0:00	3.60 rkm	60	1	0	0	8	9	3	0	30	**Poor**
2017	July	6:00	3.60 rkm	88	1	1	0	7	8	7	0	34	**Poor**
2017	July	12:00	3.60 rkm	16	0	0	0	7	8	7	0	31	**Poor**
2017	November	18:00	3.58 rkm	144	1	1	1	2	4	5	2	23	**Poor**
2017	November	0:00	3.58 rkm	No sample								0	**ND**
2017	November	6:00	3.58 rkm	92	0	0	0	0	3	10	0	19	**Very Poor**
2017	November	12:00	3.58 rkm	141	1	1	0	5	7	5	0	27	**Poor**
2017	November	18:00	3.60 rkm	1	0	0	0	0	0	0	0	0	**Very Poor**
2017	November	0:00	3.60 rkm	No sample								0	**ND**
2017	November	6:00	3.60 rkm	16	1	0	0	0	2	0	0	4	**Very Poor**
2017	November	12:00	3.60 rkm	5	0	0	0	0	0	0	0	0	**Very Poor**

Drift Net Aquatic vs. Terrestrial Organisms

There were substantially more individuals of aquatic origin than terrestrial origin when looking at the means of all 94 drift net samples, as well as almost twice the number of aquatic taxa on average. Of all individuals collected between 2014-2017, 83.5% were aquatic. Also 72.3% of the taxa observed were aquatic compared to 30.8% terrestrial taxa (Figure 3.16).

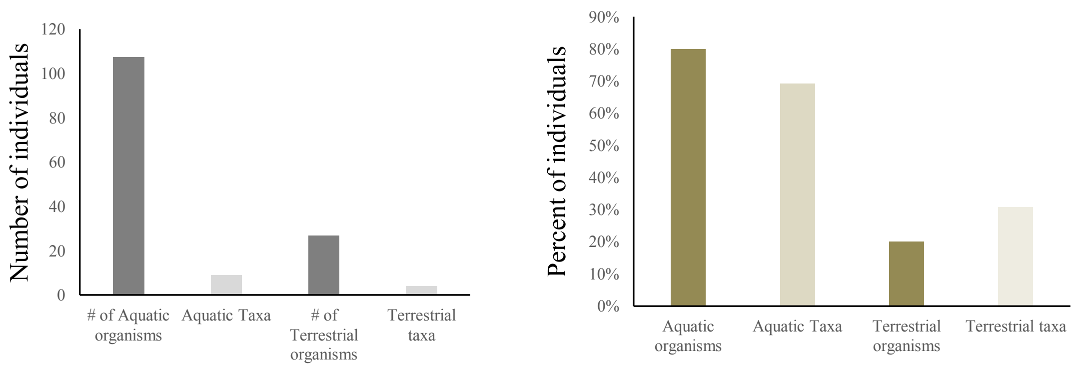


Figure 3.16. Number of individuals and number of taxa that are either aquatic or terrestrial followed by percentage of aquatic/terrestrial of individuals and number of taxa from 2014-2017.

Neither the total number of organisms and taxa, nor the ratio of aquatic to terrestrial taxa differed between the 2014-2016 drought years and 2017 rainy year (Figure 3.17).

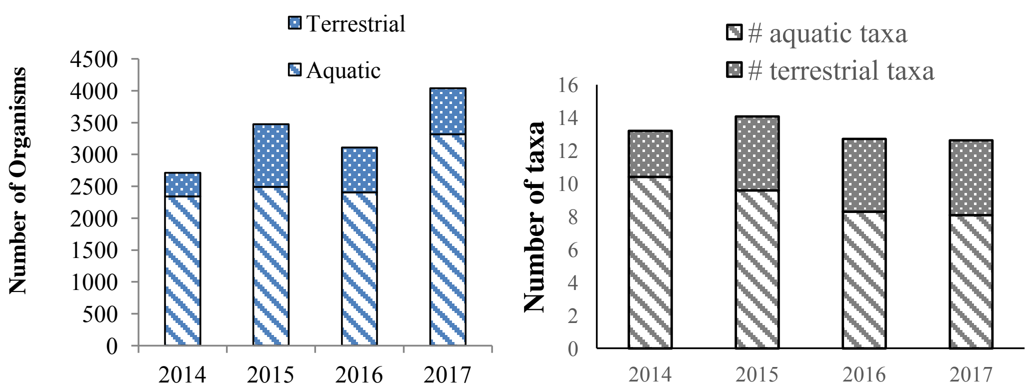


Figure 3.17. Total number of aquatic and terrestrial organisms sampled as well as the number of aquatic and terrestrial taxa from all drift net samples (n=94) in both upper vs. lower traps.

Spatial Distribution Patterns between Upper and Lower Drift Nets

More macroinvertebrates were collected in the lower nets for every group except plankton (Figure 3.18). The lower net was sampling only the 20 meters of the pool upstream to the nets at the top of the pool, as compared to the upstream nets, which would assumedly be sampling a much greater area of the upstream habitat. However, the flow was higher at the lower net, while the upstream net had slow and stagnant flow that was potentially augmented by the large Arundo patch.

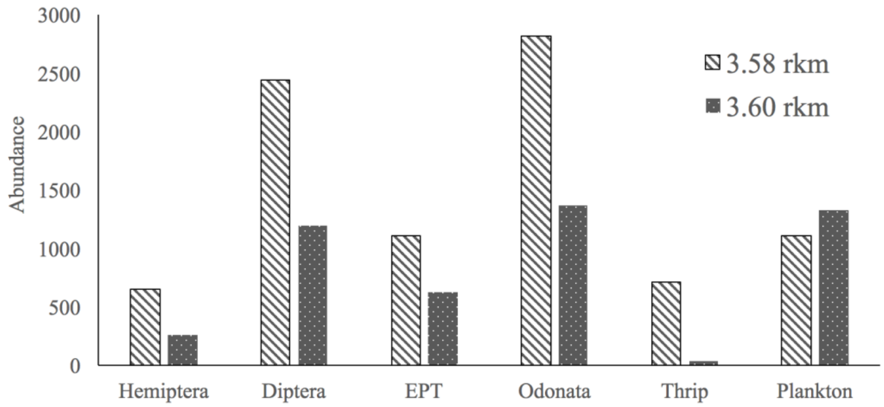


Figure 3.18. Total abundance of invertebrate groups from all drift net samples (n=94) in both upper vs. lower traps.

Drift Net Annual and Seasonal Variation

Diptera abundance increased greatly in 2017, quadrupling their total abundance as compared to previous drought years (Figure 3.19). Hemipterans had consistently low abundance in all four sampling years, while EPT only gradually increased slightly over the study period. Odonata and plankton showed similar trends of increasing steadily from 2014-16, then dropping in 2017. March samples consistently had the greatest abundance of invertebrates, with sharp declines in July. The sampling period of lowest abundance was November for all six invertebrate groups except Hemipterans (Figure 3.19).

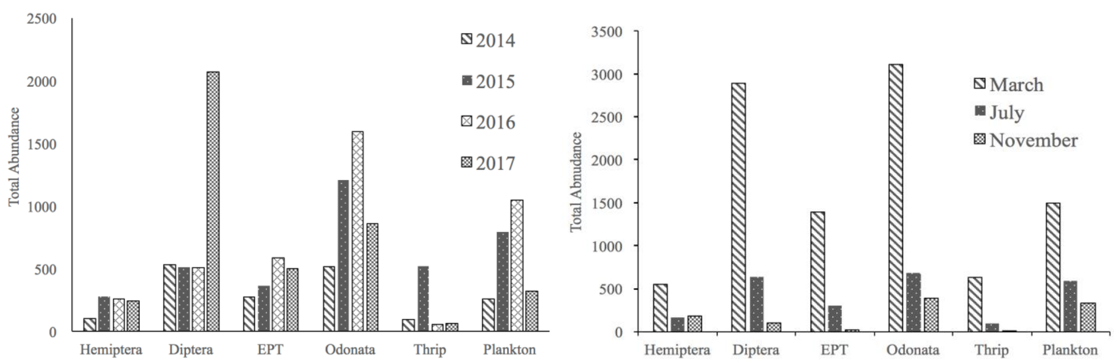


Figure 3.19. Total abundance of invertebrate groups from all samples 2014-2017 (n=94) by year and season.

Table 3.9 details the percentage of each group and life stage observed during the study period by year. Most of the species observed were collector/gathers, with fewer collector/filterers and predators, and other functional feeding groups (shredders) represented by only Lepidoptera larvae. The species were also skewed towards more tolerant species able to handle higher levels of sedimentation, higher water temperatures, and lower dissolved oxygen levels characteristic of drought conditions. Tolerance and functional feeding group information is not presented for terrestrial species.

The return of rain in 2017 drastically changed the species composition more than the total number of invertebrates. Some groups became absent in 2017 samples, such as *Hyalella sp.,* which had 5-14% abundance in 2014-2016 (Table 3.9). Chironomidae larvae more than doubled in relative abundance from 2016 to 2017, and Ceratopogonidae pupae and larvae represented over 10% of relative abundance in 2017, while they were not represented at all in 2014-2016 samples. The variation of Odonata abundance was not consistent with the drought, having the highest relative abundance of all groups in 2014 and 2015 and then becoming very rare (less than 3%) in 2016 and 2017 (Table 3.9).

Table 3.9. Summary of taxa found in all drift net samples 2014-2017 (n=94), with (n) under year showing total number of individuals per year.

	Water Year (inches)			6.85	13.49	10.54	26.34
Order	**Family**	**Tolerance Value**	**Functional Feeding Group**	**2014 (n=2,711)**	**2015 (n=3,474)**	**2016 (n=3,109)**	**2017 (n=4,042)**
Odonata	Coenagrionidae (Argia sp. larvae)	7	P	38.4%	20.6%	2.8%	1.2%
Diptera	Ceratopogonidae (larvae)	6	P				10.8%
Diptera	Ceratopogonidae (pupae)	6	P				10.0%
Diptera	Chironomidae (pupae)	6	CG	4.3%	1.8%	3.40%	
Diptera	Chironomidae (larvae)	6	CG	7.6%	4.5%	11.0%	29.5%
Diptera	Dixidae (Dixa sp.)	2	CG	1.0%			
Diptera	Simulidae (*Simulium sp.* larvae)	6	CF	1.5%	2.0%		
Diptera	Simulidae (pupae)	6	CF	1.3%			
Copepoda	Copepoda*	8	CG	4.4%	6.4%	28.2%	9.0%
Ephemeroptera	Baetidae (larvae)	4	CG		7.5%		10.2%
Ephemeroptera	Baetidae (*Baetis sp.*)	5	CG	3.8%	2.1%	17.2%	
Ephemeroptera	Baetidae (*Callibaetis sp.*)	9	CG	2.5%			
Amphipoda	Hyalellidae (*Hyalella sp.*)	8	CG	4.2%	14.7%	5.3%	
Amphipoda	Amphipoda	4	CG				2.1%
Lepidoptera	Crambidae (Crambus sp. larvae)	5	SH			1.6%	
Trichoptera	Polycentropodidae (larvae)	6	CF			1.3%	
Decapoda	Decapoda	8	CG	2.1%			
Ostracoda	Ostracoda	8	CG		1.8%		1.4%
Cladocera	Cladocera (Daphnia sp.)*	8	CF	1.1%			
	(*) Not included in IBI						

	Terrestrial Taxa	Tolerance Value	Functional Feeding Group	2014 (n=369)	2015 (n=981)	2016 (n=702)	2017 (n=723)
Diptera	Diptera unidentified (adult)	--	--	1.2%	4.3%	10.2%	1.4%
Gastropoda	Gastropoda	--	--		1.0%		
Hemiptera	Corixidae	10	P		3.1%	1.0%	
Hemiptera	Hemiptera	--	--	1.0%		1.6%	2.2%
Hemiptera	Gerridae (Metrobates hersperius)	--	--		1.1%		
Hemiptera	Aphidoidea (adult)	--	--		2.9%	2.2%	2.0%
	Terrestrial Taxa	**Tolerance Value**	**Functional Feeding Group**	**2014 (n=369)**	**2015 (n=981)**	**2016 (n=702)**	**2017 (n=723)**
Arachnida	Arachnidae	--	--	4.4%			
Thysanoptera	Thysanoptera	--	--	3.5%	15.1%	1.8%	2.0%
Homoptera	Homoptera (adult)	--	--				1.5%
Hymenoptera	Formiscidae (adult)	--	--		1.4%	1.5%	2.2%
Other taxa				17.7%	9.7%	10.9%	14.5%
Totals				**100%**	**100%**	**100%**	**100%**

Diurnal Variation of Drift Net Samples

Sample abundance patterns illustrated a trend with the 18:00 samples all having the lowest numbers for all groups, and then a steady increase in abundance overnight from 00:00 to 06:00 (Figure 3.20). The pattern between 06:00 and 12:00 was variable with all taxa except Diptera and plankton decreasing by the noon sampling. The increase in abundance overnight may be related to cooler night temperatures and the slight increase in flow (Figure 3.12).

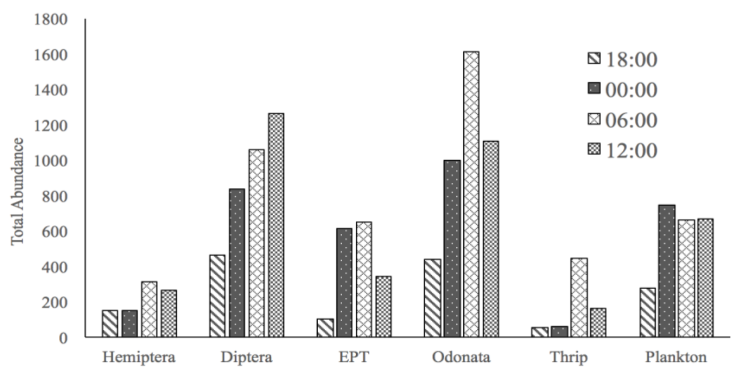


Figure 3.20. Total abundance of invertebrate groups from all drift net samples (n=94) by sampling time of day.

KICK NET RESULTS

Kick net results were analyzed to compare both the lower (3.2-3.7 rkm) and upper (4.5-5.0 rkm) reach sites, as well as to compare the lower reach site with the drift net data collected from a subsection of the reach.

In-situ Water Chemistry

All water quality metrics were well within the range of suitability for *O. mykiss* during the April and May samples, even during the drought years. The lowest dissolved oxygen reading occurred in the upper reach in 2016 (Table 3.10). There were no significant differences in water temperature, pH or salinity either between sites or between years.

Table 3.10. Water quality measurements at the lower and upper kick net samplings (n=10).

Date	Location (m)	Air T (∘C)	Water T(∘C)	Salinity (ppm)	DO (mg/L)	pH	Cond (ms/cm)
05/05/14	3200	18	14.9	1	7.65	8.27	1423
05/06/14	4500	14.2	14.7	0	7.34	8.29	ND
04/28/15	3200	17	14.4	1.5	8.19	8.44	1410
05/01/15	4500	18	15.5	1	9.15	8.70	1440
04/25/16	3200	ND	14.3	2	7.80	8.36	1630
04/28/16	4500	ND	13.4	1	5.19	8.45	1680
04/17/17	3200	ND	13.2	0	10.64	9.00	200
04/18/17	4500	ND	14.6	0	11.15	9.00	ND
05/08/18	3200	ND	14.8	0	4.46	8.49	1560
05/09/18	4500	ND	15.1	0	9.5	8.63	1610

Flow data

Water flow was recorded at the beginning of the lower reach sampling (3.2 rkm), and were generally low and did not vary much throughout the study period. No flow measurement was taken in 2014 due to lack of water, while 0.04 ft/sec was recorded in 2015, 0.036 ft/sec in 2016, 0.088 ft/sec in 2017 and 0.005 ft/sec in 2018. No measurements were made at the upper kick net sites or throughout the sampling reaches, so invertebrate density could not be calculated as it was for drift net samples.

Lower Kick Net vs. Upper Kick Net Abundance and Species Composition

The abundance and species composition for all samples is provided in Table 3.11. In the lower kick nets, a total of 4,761 invertebrates representing 79 distinct taxa and life cycles were collected and identified throughout the study period April/May 2014 - 2018. The most abundant aquatic taxa observed throughout the study were Chironimidae larvae (60.8%), Amphipoda (*Hyalella sp*., 7.1%), Baetidae larvae (5.5%), Simuliidae larvae (*Simulium sp*., 3.6%), Copepoda (1.5%) Coenagrionidae larvae (*Argia* sp., 3.0%), Cambaridae (2.3%), Ostracoda (1.1%) and Baetidae (*Baetis sp*. larvae (1.0%). Baetidae were separated by those identifiable to species, versus individuals that were only identifiable to family.

The upper kick nets had a total count of 2,823 individuals from 67 different taxa and life cycles. Chironimidae larvae (52.9%), Baetidae larvae (5.6%), Amphipoda (*Hyalella sp*., 6.1%), Turbellaria (4.1%), Baetidae (*Baetis sp*. larvae 2.8%), Polycentropodidae (2.4%), Coenagrionidae (Argia sp., 1.6%), Copepoda (1.4%), and Philopotamidae (0.8%).

Table 3.11. Comparison between upper and lower Percentage of each taxa representing over 0.5% in the kick net from 2014-2018 (n=10).

Order	Family	LIFE STAGE	Number of all individuals	Percentage of all individuals	LOWER # of organisms	Percent	UPPER # of organisms	Percent
Odonata	Coenagrionidae (Argia sp.)	Larvae	187	2.5%	142	3.0%	45	1.6%
Odonata	Coenagrionidae (Enallagma sp.)	Larvae	38	0.5%	38	0.8%	0	0%
Diptera	Chironomidae	Larvae	4,389	57.9%	2895	60.8%	1494	52.9%
Diptera	Simuliidae (Simulium sp.)	Larvae	186	2.5%	172	3.6%	14	0.5%
Diptera	Simuliidae	Larvae	234	3.1%	80	1.7%	154	5.5%
Diptera	Diptera unidentified	Adult	55	0.7%	0	0%	0	0%
Diptera	Chironomidae	Pupae	56	0.7%	23	0.5%	33	1.2%
Diptera	Chironomidae (Tanypodinae)	Larvae	40	0.5%	36	0.7%	4	0.1%
Diptera	Ceratopogonidae	Pupae	83	1.1%	37	0.8%	46	1.6%
Copepoda	Copepoda		109	1.4%	70	1.5%	39	1.4%
Ephemeroptera	Baetidae	Larvae	421	5.6%	263	5.5%	158	5.6%
Ephemeroptera	Baetidae (Baetis sp.)	Larvae	126	1.7%	46	1%	80	2.8%
Amphipoda	Hyalellidae (Hyalella sp.)		512	6.8%	339	7.1%	173	6.1%
Amphipoda			61	0.8%	26	0.6%	35	1.2%
Decapoda	Cambaridae		125	1.7%	111	2.3%	14	0.5%
Turbellaria	Turbellaria		117	1.5%	0	0%	117	4.1%
Trichoptera	Polycentropodidae	Larvae	98	1.3%	31	0.7%	67	2.4%
Trichoptera	Philopotamidae	Larvae	124	1.6%	101	2.1%	23	0.8%
Ostracoda	Ostracoda		55	0.7%	50	1.1%	5	0.2%
Gastropoda	Hydrobiidae		39	0.5%	38	0.8%	1	0.1%
Clitellata	Clitellata		58	0.8%	17	0.4%	41	1.5%
	Other groups		471	6.1%	246	5.0%	280	9.9%
Total			**7,584**	**100.0%**	**4,761**	**100.0%**	**2,823**	**100.0%**

Patterns of abundance show that aquatic larva of dipterans (Chironomidae and Simuliidae) remain the dominant group in the kick net assemblage (Table 3.11). Amphipods were the second most abundant group with similar relative abundances in both sampling reaches. Crayfish (Cambaridae), as well as Odonata (*Argia* sp. and *Enallagama* sp.) were much more abundant in the lower reach which has a lower gradient and higher canopy cover. Even though there were twice as many invertebrates sampled in the lower reach, numbers of taxa were not significantly higher (28) in the lower than upper (23) reach (Table 3.12).

Table 3.12. Mean and standard error of metrics comparing lower (n=5) and upper reach (n=5) kick net 2014-2018.

	LOWER Mean	Standard Deviation	Standard Error		UPPER Mean	Standard Deviation	Standard Error
total # organisms	952.20	449.84	201.17	total # organisms	565.60	247.83	110.83
# aquatic org.	942.60	446.64	199.75	# aquatic org.	539.60	239.19	106.97
# terrestrial org.	9.60	5.86	2.62	# terrestrial org.	26.00	29.57	13.22
Aquatic	0.99	0.01	0.00	Aquatic	0.96	0.05	0.02
Terrestrial	0.01	0.01	0.00	Terrestrial	0.04	0.05	0.02
# taxa (non-distinct)	28.00	6.44	2.88	# taxa (non-distinct)	23.40	4.16	1.86
# aquatic taxa	22.80	5.67	2.54	# aquatic taxa	18.60	3.85	1.72
# terrestrial taxa	5.20	2.17	0.97	# terrestrial taxa	4.80	2.59	1.16
percent aquatic taxa	0.81	0.07	0.03	percent aquatic taxa	0.79	0.10	0.04
percent terrestrial taxa	0.19	0.07	0.03	percent terrestrial taxa	0.21	0.10	0.04
Hemiptera	1.80	2.68	1.20	Hemiptera	5.00	6.08	2.72
Diptera	660.80	487.05	217.82	Diptera	351.80	187.90	84.03
EPT	104.00	86.46	38.67	EPT	88.60	95.29	42.61

Odonata	36.00	30.45	13.62	Odonata	9.00	11.45	5.12
Thrip	1.60	2.61	1.17	Thrip	1.20	1.30	0.58
Plankton	97.00	99.08	44.31	Plankton	52.40	34.05	15.23
#larval insect	737.40	498.54	222.96	#larval insect	354.00	243.23	108.78
# pupa insect	62.40	111.33	49.79	# pupa insect	86.00	170.74	76.36
# adult insect	0.40	0.55	0.24	# adult insect	1.80	2.95	1.32
# non-insecta	127.40	131.45	58.78	# non-insecta	86.60	69.50	31.08
%larva	0.73	0.20	0.09	%larva	0.61	0.26	0.12
%pupa	0.10	0.19	0.08	%pupa	0.14	0.29	0.13
%adult	0.00	0.00	0.00	%adult	0.00	0.00	0.00
%non-insect	0.14	0.15	0.07	%non-insect	0.18	0.13	0.06

Even though there were twice as many invertebrates on average in the lower reach than the upper reach, there was no significant difference in mean abundance between the lower (3.2-3.7 rkm) and upper (4.5-5.0 rkm) sampling sites (Figure 3.21).

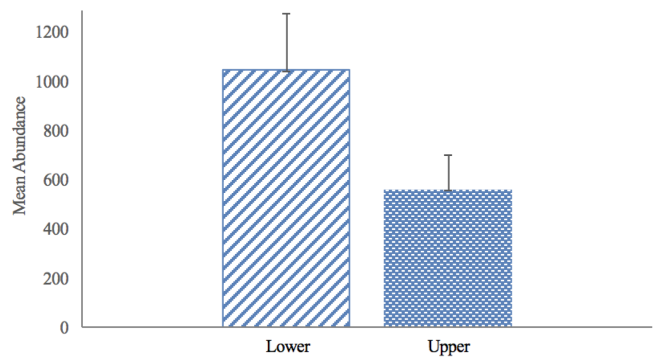


Figure 3.21. No significant difference between lower and upper kick net total invertebrate abundance ($p = 0.079$, paired t-test).

Invertebrate Density

Density of invertebrates per sample was not calculated as flow measurements were only recorded at the beginning of the lower reach (3.2 rkm) and not throughout the reach or at the upper reach. Even though twice the number of individuals was sampled in the lower reach, the relative abundances of invertebrate families were consistent between reaches.

Kick Net SCC-IBI Scores

Results of SCC-IBI scores for all kick net samples were overall poor, with nine scores of Poor and one Very Poor score (Table 3.13). There was no difference in the average SCC-IBI score of the lower reach (27.7) and the upper reach (27.9). SCC-IBI scores generally decreased each year except for an increase in 2017 at the lower sampling site. There were higher percentages of tolerant than intolerant taxa in six of the eight samples. There were also no intolerant individuals in the upper reach although they were present in the lower reach.

Table 3.13. SCC-IBI from the upper and lower kick net reaches of Topanga Creek from 2014-2018 (n=10).

Sample date	Site	#Total of Organisms	EPT Taxa	Taxa % Intolerant Individuals	# Predator	% Tolerant Taxa	% NonInsect Taxa	% CF + CG	# Coleoptera Taxa	Total IBI Score (Adjusted on a scale of 0 to 100)
Lower Topanga Creek (3.2-3.7 rkm)										
5/5/2014	3.2-3.7 rkm	1162	2	4	3	3	4	6	2	34
4/28/2015	3.2-3.7 rkm	761	3	3	2	2	2	3	2	24
4/25/2016	3.2-3.7 rkm	1643	2	0	1	3	0	1	2	13
4/17/2017	3.2-3.7 rkm	595	3	3	2	7	10	1	2	40
5/8/2018	3.2-3.7 rkm	600	4	0	3	0	8	2	5	31
Upper Topanga Creek (4.5-5.0 rkm)										
5/6/2014	4.5-5.0 rkm	639	2	0	0	7	5	6	5	36
4/28/2015	4.5-5.0 rkm	157	1	0	1	5	5	5	2	27
4/28/2016	4.5-5.0 rkm	832	1	0	2	3	4	3	4	24
4/18/2017	4.5-5.0 rkm	600	2	0	0	3	9	3	0	24
5/9/2018	4.5-5.0 rkm	600	2	0	1	0	8	5	2	26

Kick Net Aquatic vs. Terrestrial Organisms

Individual invertebrates in kick net samples were almost exclusively aquatic (99%), as well as 81% of the taxa observed, compared to 20% terrestrial taxa (Figure 3.22). There were fewer terrestrial organisms in the kick net samples (1%) compared to 15.8% in the drift net samples. The majority of the terrestrial invertebrates in kick net samples were adult Dipteran flies. This difference was because kick nets sample the substrate directly, while drift nets sample the whole water column including the surface, where most terrestrial invertebrates enter the system.

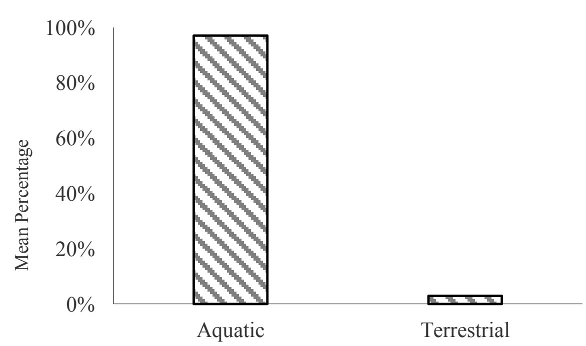


Figure 3.22. Percentage of all individuals sampled of either aquatic or terrestrial origin all kick nets (n=10).

Spatial Distribution Patterns between Upper and Lower Kick Nets

Diptera was the dominant taxonomic group for both kick net sampling sites, and there were more Dipterans in the upper reach than all groups combined in the lower reach (Figure 3.23). EPT taxa (Baetids) were the only group that had a higher abundance in the upper reach, and terrestrial taxa such as Hemipteran true bugs and Thrips were almost non-existent in both sampling stretches.

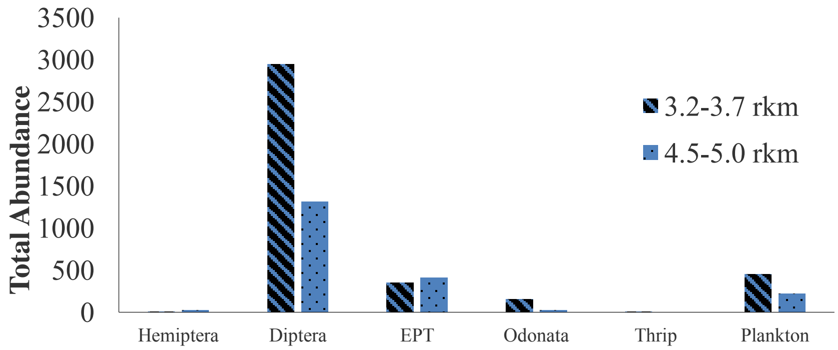


Figure 3.23. Total invertebrates by group in the lower kick net sampling section (3.2-3.7 rkm) versus the upper kick net sampling section (4.5-5.0 rkm).

Lower Reach vs. Upper Reach Kick Net Annual Variation

Lower and upper kick net samples varied in synchrony each year, with abundance consistently higher in the lower reach. Chironomids and *Hyalella sp*. the best examples of this as shown in Table 3.14. Some invertebrates had short pulses of abundance in only one site, such as Turbellaria in the 2014 upper reach, or Simuliidae larvae in the 2017 upper reach.

Table 3.14. Relative abundance of invertebrate groups over 1% in upper and lower kick net reaches by year of Topanga Creek from 2014-2018 (n=10).

Order	Taxa		2014 Lower (n=1,162)	2014 Upper (n=639)	2015 Lower (n=761)	2015 Upper (n=157)	2016 Lower (n=1,643)	2016 Upper (n=832)	2017 Lower (n=595)	2017 Upper (n=600)	2018 Lower (n=600)	2018 Upper (n=600)
Odonata	Argia/Enallagma sp.	Larvae	7.3%	-	4.9%	1.3%	2.0%	2.5%	-	-	3.0%	1.6%
Diptera	Chironomidae	Larvae	58.2%	53.7%	47.0%	31.9%	86.7%	62.9%	29.1%	24.8%	60.8%	52.9%
Diptera	Chironomidae	Pupae	-	1.1%	-	-	1.1%	3.0%	-	-	-	1.2%
Diptera	Chironomidae (Tanypodinae)	Larvae	3.1%	-	-	-	-	-	-	-	-	-
Diptera	Ceratopogonidae	Larvae	-	-	-	1.3%	-	-	-	-	-	-
Diptera	Ceratopogonidae	Pupae	-	-	-	-	-	-	3.5%	-	-	1.6%
Diptera	Simuliidae	Lavae	-	-	-	4.5%	-	-	-	15.7%	1.7%	5.5%
Diptera	Simuliidae	Pupae	-	-	-	-	-	-	-	1.0%	-	-
Diptera	Simuliidae (Simulium sp.)	Lavae	-	-	-	-	1.7%	1.4%	23.7%	-	3.6%	-
Diptera	Tipulidae (Tipula sp.)	Larvae	-	-	-	3.2%	-	-	-	-	-	-
Diptera	Diptera	Adult	-	-	-	-	-	-	-	9.7%	-	1.8%
Copepoda	Copepoda		-	2.4%	3.9%	1.9%	-	1.2%	3.7%	2.3%	1.5%	1.4%
Ephemeroptera	Ephemeroptera	Larvae	-	-	2.0%	-	-	-	-	-	-	-
Ephemeroptera	Baetidae	Larvae	-	-	-	-	-	-	28.6%	34.7%	5.5%	5.6%
Ephemeroptera	Baetis sp.	Larvae	-	6.6%	-	5.1%	2.1%	3.6%	-	-	1.0%	2.8%
Ephemeroptera	Baetidae (Fallceon quilleri)	Larvae	1.8%	1.6%	-	-	-	-	-	-	-	-
Amphipoda	Hyalellidae (Hyalella sp.)	Larvae	8.4%	6.1%	26.5%	23.6%	2.4%	11.7%	-	-	7.1%	6.1%
Hemiptera	Aphidoidea	Adult	-	-	-	-	-	-	-	2.0%	-	-
Hemiptera	Veliidae (Microvelia sp.)	Adult	-	-	-	-	-	1.1%	-	-	-	-
Trichoptera	Hydropsychidae	Larvae	1.3%	-	-	-	-	-	-	-	-	-
Trichoptera	Polycentropodidae	Larvae	-	-	-	10.2%	-	4.9%	1.8%	1.5%	-	-
Trichoptera	Philopotamidae	Larvae	-	-	-	-	-	-	6.6%	6.2%	2.1%	-
Trichoptera	Hydroptilidae	Larvae	-	-	-	3.2%	-	-	-	-	-	-
Decapoda	Cambaridae	Larvae	9.6%	2.2%	-	-	-	-	-	-	2.3%	-

Order	Taxa		2014 Lower (n=1,162)	2014 Upper (n=639)	2015 Lower (n=761)	2015 Upper (n=157)	2016 Lower (n=1,643)	2016 Upper (n=832)	2017 Lower (n=595)	2017 Upper (n=600)	2018 Lower (n=600)	2018 Upper (n=600)
Coleoptera	Elmidae (Microcylloepus sp.)	Larvae	-	-	-	1.3%	-	-	-	-	-	-
	Physidae	Larvae	2.0%	-	-	-	-	-	-	-	-	-
Arachnida	Acari		-	-	-	-	-	1.7%	-	-	-	1.0%
	Turbellaria		-	18.3%	-	-	-	-	-	-	-	4.1%
	Hydrobiidae		1.4%	-	2.5%	-	-	-	-	-	-	-
Ostracoda	Ostracoda		-	-	4.6%	-	-	-	-	-	1.1%	0
	Clitellata		-	1.4%	-	7.0%	-	-	-	-	-	1.5%
	Other taxa		6.9%	8.1%	13.2%	12.8%	4.1%	6.0%	3.0%	2.1%	10.3%	12.9%
Total			100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Both lower and upper sites showed similar trends across the four years, with cycles between high and then low abundance occurring each year. In 2014 there was moderate abundance of about 1,700 individuals in total, then dropping to about half of that total in 2015 (Figure 3.24). The highest abundance was recorded in 2016, followed by a large drop in abundance again in 2017.

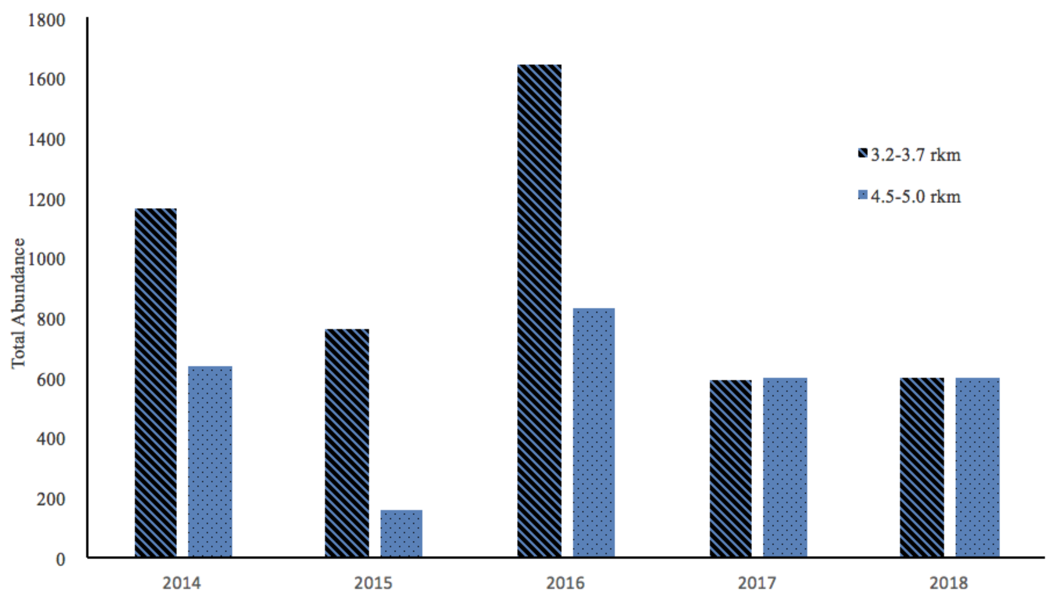


Figure 3.24. Total abundance of kick net data across all sampling years, by sampling site.

Diptera was the most abundant but variable group, with a trend of alternating high to low abundance (Figure 3.25). Annual patterns of abundance show that Thrips and Hemipterans had constant low abundance over the four years of sampling. Odonata was low in abundance at the upper sampling reach, and showed a decreasing trend each year at the lower reach. EPT taxa abundance increased from 2015-17. EPT taxa was dominated by baetid mayflies, who represented 8.5% of the total abundance of all eight kick net samples (Table 3.15). Intolerant taxa were present in low numbers in lower kick net samples, but were completely absent in the upper kick net reach. This may be related to the difference in gradient, with the upper kick net reach steeper (3-6%) while the lower is slightly lower gradient (1-3%).

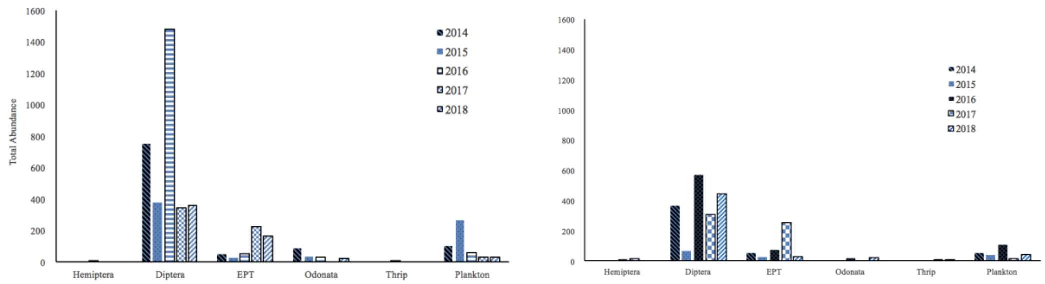


Figure 3.25. Total abundance of kick net invertebrates by group divided into each sampling year for the lower and upper kick net sites respectively.

Combined Kick Net Abundance and Species Composition

A total of 7,584 invertebrates representing 101 distinct taxa and life cycles were collected from all samples at both sampling sites (n=10) and identified throughout the study period March 2014 – May 2018 (Table 3.15). Invertebrate abundance varied highly per sample, from 157 to 1,643 individuals. The most abundant aquatic taxa observed throughout the study period were Chironomidae larvae (57.9% relative abundance), amphipods (*Hyalella* sp., 6.8%), Baetidae larvae (5.6%), Simuliidae larvae (3.1%), Coenagrionidae (*Argia* sp., 2.5%), Simuliidae larvae (*Simulium* sp., 2.5%), Baetidae larvae (*Baetis* sp., 1.7%), Cambaridae (1.7%), Philopotamidae (1.6%), Turbellaria (1.5%), Copepoda (1.4%), Polycentropodidae larvae (1.3%), and Ceratopogonidae pupae (1.1%). No terrestrial taxa accounted for over 1% of the all invertebrates sampled. A complete taxa list is found in Appendix 3B.

Table 3.15. Percentage of each taxa representing over 0.5% of all samples 2014-2018 (n=10).

Order	Family	LIFE STAGE	Percentage of all individuals	Number of all individuals
Odonata	Coenagrionidae (Argia sp.)	Larvae	2.5%	187
Odonata	Coenagrionidae (Enallagma sp.)	Larvae	0.5%	38
Diptera	Chironomidae	Larvae	57.9%	4,389
Diptera	Simuliidae (Simulium sp.)	Larvae	2.5%	186
Diptera	Simuliidae	Larvae	3.1%	234
Diptera	Diptera unidentified	Adult	0.7%	55
Diptera	Chironomidae	Pupae	0.7%	56
Diptera	Chironomidae (Tanypodinae)	Larvae	0.5%	40
Diptera	Ceratopogonidae	Pupae	1.1%	83
Copepoda	Copepoda		1.4%	109
Ephemeroptera	Baetidae	Larvae	5.6%	421
Ephemeroptera	Baetidae (Baetis sp.)	Larvae	1.7%	126
Amphipoda	Hyalellidae (Hyalella sp.)		6.8%	512
Amphipoda			0.8%	61
Decapoda	Cambaridae		1.7%	125
Turbellaria	Turbellaria		1.5%	117
Trichoptera	Polycentropodidae	Larvae	1.3%	98
Trichoptera	Philopotamidae	Larvae	1.6%	124
Ostracoda	Ostracoda		0.7%	55
Gastropoda	Hydrobiidae		0.5%	39
Clitellata	Clitellata		0.8%	58
	Other groups		6.1%	471
Total			**100.0%**	**7,584**

Diptera was the most numerically dominant invertebrate group found in all kick net samples, with mean abundances of 506.3 +/- 121.51 (Figure 3.26). EPT taxa and plankton were the next most abundant groups with mean abundances of 96 and 75 organisms/sample, which made them 1/5 as abundant as Diptera (Table 3.16). It was not possible to calculate density for kick net samples due to lack of flow measurements throughout sampling reaches.

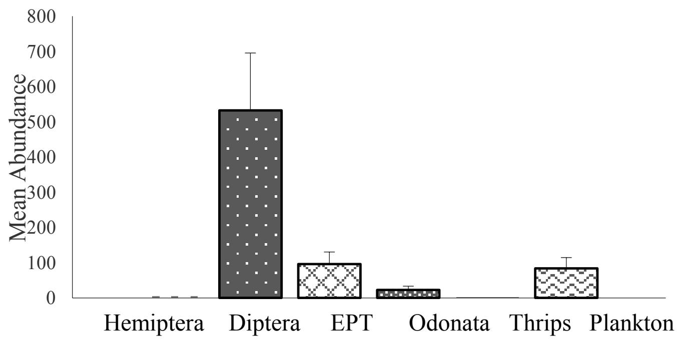


Figure 3.26. Mean abundance of all kick net samples (n=10) by invertebrate group.

Table 3.16. Mean and standard error of metrics relating to all kick net samples (n=10).

	Mean	Standard Deviation	Standard Error
total # organisms	758.90	398.43	126.00
# aquatic org.	741.10	399.00	126.18
# terrestrial org.	17.80	21.88	6.92
Aquatic	0.97	0.04	0.01
Terrestrial	0.03	0.04	0.01
# taxa (non-distinct)	25.70	5.66	1.79
# aquatic taxa	20.70	5.08	1.61
# terrestrial taxa	5.00	2.26	0.71
percent aquatic taxa	0.80	0.08	0.03
percent terrestrial taxa	0.20	0.08	0.03
Hemiptera	3.40	4.74	1.50
Diptera	506.30	384.25	121.51
EPT	96.30	86.16	27.25
Odonata	22.50	25.94	8.20
Thrip	1.40	1.96	0.62
Plankton	74.70	73.69	23.30
#larval insect	545.70	421.42	133.26
# pupa insect	74.20	136.45	43.15
	Mean	Standard Deviation	Standard Error
# non-insecta	107.00	101.43	32.08
%larva	0.67	0.23	0.07
%pupa	0.12	0.23	0.07
%adult	0.00	0.00	0.00
%non-insect	0.16	0.13	0.04

Annual Variation

Some invertebrate groups varied in abundance correlated to rainfall, such as Baetidae which was not present in the first three years of the study but then became 31.6% of the 2017 samples following return of the rains (Table 3.17). By contrast, Coenagrionidae and *Hyalella sp*. which have high tolerance values, were not present in 2017 following the rains, but were found during the drought in 2014-16. Simulidae also was not present or just 1.6% of the 2016 samples, but increased to 11.8% relative abundance in 2017. Chironomid larvae remained dominant in all years of the study period, highlighting their ability as clingers to both survive the drought stress and avoid being flushed out of the creek in heavy rains.

Table 3.17. Summary of taxa found in lower and upper kick nets (n=10).

	Water Year (inches)			6.85	13.49	10.54	26.34	9.96*
Order	**Family**	**Tolerance Value**	**Functional Feeding Group**	**2014 (n=1,801)**	**2015 (n=918)**	**2016 (n=2,475)**	**2017 (n=1,195)**	**2018 (n=1,200)**
Odonata	Coenagrionidae (Argia sp.)	7	P	2.6%	4.2%	2.2%		4.0%
Odonata	Coenagrionidae (Enallagma sp.)	9	P	2.1%				
Diptera	Ceratopogonidae (pupae)	6	P					3.5%
Diptera	Chironomidae (larvae)	6	P	56.8%	44.4%	78.7%	26.9%	53.7%
Diptera	Chironomidae (pupae)	6	P			1.7%		
Diptera	Chironomidae (Tanypodinae larvae)	6	--	2.2%				
Diptera	Simuliidae (larvae)	6	CF		1.5%		7.9%	7.8%
Diptera	Simuliidae (Simulium sp.)	6	CF			1.6%	11.8%	
Copepoda	Copepoda	8	CG		3.6%		3.0%	1.1%
Ephemeroptera	Ephemeroptera (larvae)	--	--		1.6%			
Ephemeroptera	Baetidae (larvae)	4	CG				31.6%	9.2%
Ephemeroptera	Baetidae (Baetis sp.)	5	CG	2.8%	1.2%	2.6%		
Ephemeroptera	Baetidae (Fallceon quilleri)	4	CG	1.7%				
Trichoptera	Philopotamidae (larvae)	3	CF				6.3%	5.3%
Trichoptera	Polycentropodidae (larvae)	6	CF		2.3%	2.2%	1.7%	0.1%
Amphipoda	Hyalellidae (Hyalella sp.)	8	CG	7.6%	26.0%	5.5%		5.0%
Decapoda	Cambaridae	8	CG	6.9%				0.3%
Clitellata	Clitellata	5	CG	1.0%	1.7%			0.6%
Gastropoda	Physidae	8	SC	1.3%				
Gastropoda	Hydrobiidae	8	SC		2.1%			
Turbellaria	Turbellaria	4	P	6.5%				
Ostracoda	Ostracoda	8	CG		3.9%		0.6%	
	Other groups			8.5%	7.5%	5.5%	10.2%	9.4%
Totals				**100%**	**100%**	**100%**	**100%**	**100%**

*Rainfall for 2018 up to May

The kick net samples combined showed a similar pattern to when they were separated by site, with an alternating pattern of high to low abundance (Figure 3.27). There were not any differences in water chemistry recordings across the four years of sampling, so it is difficult to infer why 2016 had the highest invertebrate abundance in kick net samples.

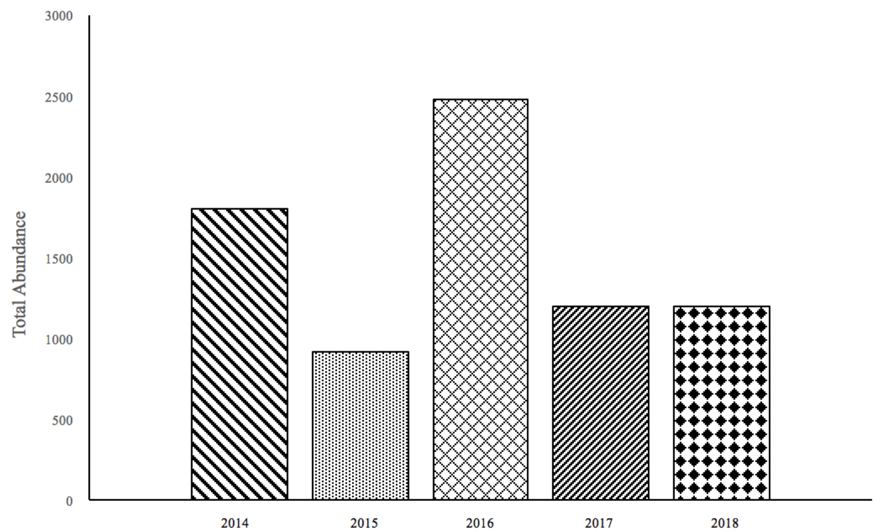


Figure 3.27. Total abundance of invertebrates collected during each sampling year for both kick net sampling sites.

Comparison Between Drift Net and Kick Net Abundance and Species Composition

There were some slight differences between the species composition of the upper and lower kick net samples, but with no significant difference in total invertebrate abundance and a small sample size (n=10), the lower and upper sites were combined when compared to all drift net samples (n=94). All eight kick net samples received Poor SCC-IBI scores, and there was also no significant difference in diversity between sites (Table 3.12).

One major difference that stood out when comparing the kick and drift net samples was that there were four more taxa representing over 1% abundance in drift net samples than in the kick net samples, showing a slightly more diverse species assemblage (Table 3.18). Odonata was rare in the kick net samples, while they were the most dominant invertebrate family in the drift net samples. Chironomids were dominant in both sampling methods, comprising 57.9% of the kick invertebrate abundance and 14.2% of the drift net relative abundance. Drift net samples had nine taxa groups over 3% relative abundance, compared to only three groups over 3% abundance in all kick net samples.

Table 3.18. Percentage of each taxa representing over 1% of all kick net samples (n=8) and drift net samples (n=94) from 2014-2018.

Order	Family	Percentage of all kick individuals	Number of all kick individuals	Percentage of all drift individuals	Number of all drift individuals
Odonata	Coenagrionidae	-	-	15.3%	1,935
Odonata	Coenagrionidae (Argia sp.)	2.5%	187	-	-
Diptera	Chironomidae (larvae)	57.9%	4,389	14.2%	1,895
Diptera	Chironomidae (pupae)	-	-	2.1%	284
Diptera	Chironomidae (adult)	-	-	1.5%	195
Diptera	Simuliidae (Simulium sp. Larvae)	2.5%	186	1.1%	141
Diptera	Simuliidae	3.1%	234	-	-
Diptera	Ceratopogonidae (larvae)	-	-	3.3%	443
Diptera	Ceratopogonidae (pupae)	-	-	3.2%	422
Diptera	Unidentified Adult	0.7%	55	3.0%	398
Copepoda	Copepoda	1.4%	109	11.8%	1,583
Ephemeroptera	Baetidae	5.5%	421	10.4%	1,381
Ephemeroptera	Baetidae (Baetis sp.)	1.7%	126	-	-
Amphipoda	Hyalellidae (Hyalella sp.)	6.8%	512	5.9%	790
Decapoda	Cambaridae	1.7%	125	-	-
Turbellaria	Turbellaria	1.5%	117	-	-
Trichoptera	Polycentropodidae	1.3%	98	-	-
Trichoptera	Philopotamidae	1.6%	124	-	-
Other (79 taxa groups)		1.6%	250	-	-
Thysanoptera	Thysanoptera			5.7%	756
	Hemiptera			1.2%	164
	Aphidoidea (adult)			1.9%	251
	Corixidae (adult)			1.2%	157
	Formiscidae			1.5%	197
	Ostracoda			1.2%	154
Other (133 taxa groups)				16.4%	2,187

Note: 2018 Kick net samples not included here

There were significantly more invertebrates sampled within the combined kick nets than drift nets, with four times as many individuals on average (Figure 3.28).

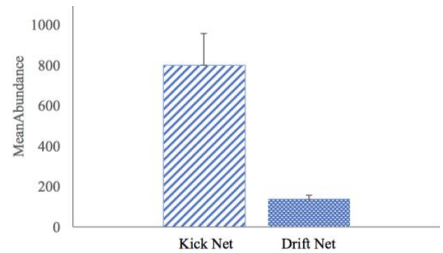


Figure 3.28. Significant difference between composite kick net and drift net total invertebrate abundance (p = 0.004, t-test with unequal variances).

When lower and upper kick nets were compared independently to drift net samples, there were different results. Lower kick net samples had significantly more invertebrates than drift net samples (Figure 3.29), while upper kick net samples showed no statistical difference between drift net samples (Figure 3.30).

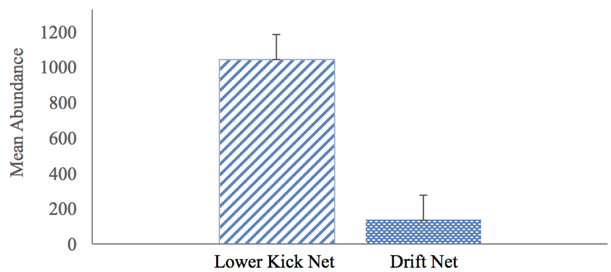


Figure 3.29. Significant difference between lower kick net and drift net total invertebrate abundance (p = 0.029, t-test with unequal variances).

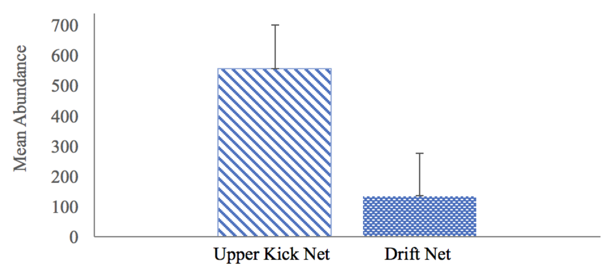


Figure 3.30. Significant difference between upper kick net and drift net total invertebrate abundance (p = 0.058, t-test with unequal variances).

SCC-IBI Scores

Overall there was much higher abundance of invertebrates sampled in kick nets than drift nets (Table 3.18). All SCC-IBI scores were Poor for kick net samples, while 10 drift net samples received Fair scores with the majority of them occurred in March 2017 (n=7). It should also be noted that almost all these scores were just over the cutoff of 40/100, so they were still consistently low with the highest score recorded of 50/100 for the study period.

Aquatic vs. Terrestrial Organisms

Because there was such a low number of terrestrial invertebrates in the kick net samples as compared to that in drift nets, aquatic invertebrates only were compared between the two methods (Figure 3.31). The trends were very similar to annual variation of all invertebrates including terrestrial ones (Figure 3.32), with drift nets showing only a slight decrease in abundance, and remaining stable over the four years.

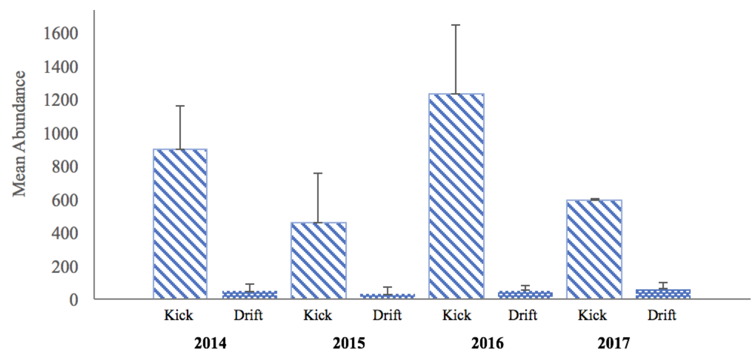


Figure 3.31. Comparison of aquatic invertebrate abundance only between kick net and drift nets from 2014 – 2017.

Annual Variation

While kick net samples varied each year alternating between high and low abundances, drift net samples remained much more stable over the four years of sampling (Figure 3.32). When looking at either the lower kick net (Figure 3.33) or upper kick net samples (Figure 3.34) alone against drift net samples, there was no difference as compared to the composite kick net sample comparison.

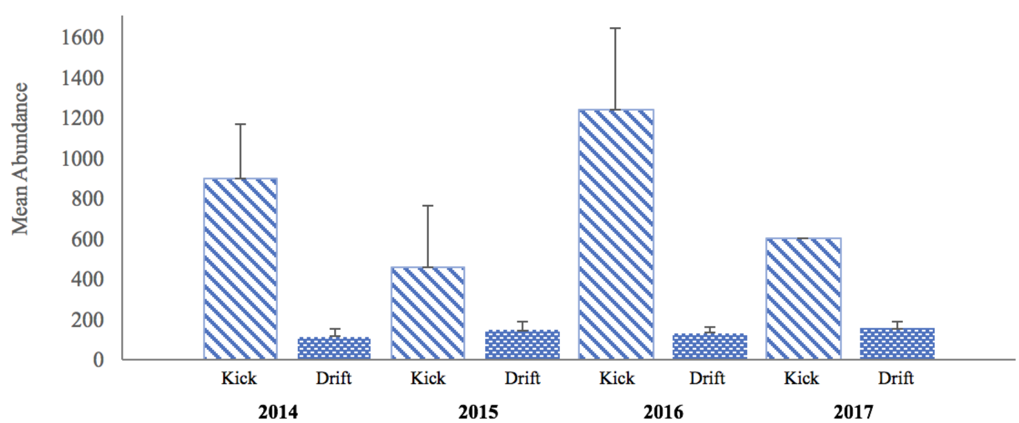


Figure 3.32. Comparison of composite kick net (n=8) and drift net (n=94) abundance from 2014 – 2017.

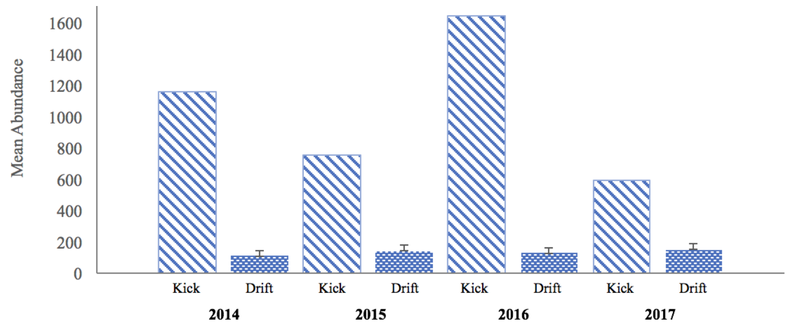


Figure 3.33. Comparison of lower kick net (n=4) and drift net (n=94) abundance from 2014 – 2017.

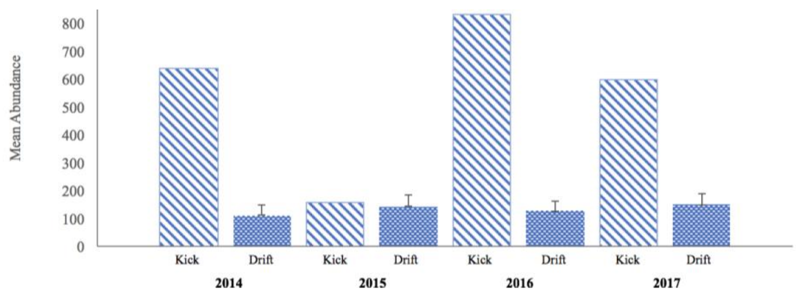


Figure 3.34. Comparison of upper kick net (n=4) and drift net (n=94) abundance from 2014 – 2017.

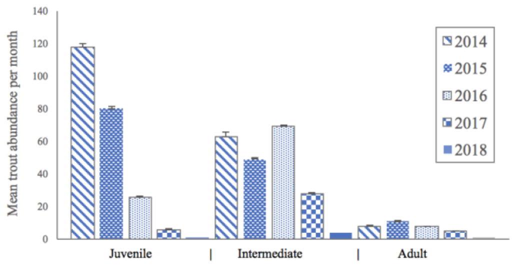
O. mykiss RESULTS

In order to investigate the relationship between BMI and *O. mykiss* abundance as well as growth of young of the year and 1+ year olds, we examined snorkel survey data within all BMI sampling reaches. Only one intermediate *O. mykiss* of 130 mm was observed throughout the study period in the drift net reach (3.58 rkm – 3.6 rkm) in April 2014. It should be noted that the drift net reach of 20 m is only 4% of the overall habitat within the 500 m kick net reaches. This sampling reach is unsuitable for adults over 250 mm, as it is relatively shallow with bigger pools above and below, and no adults were observed. No *O. mykiss* were observed in 2015-17. Electrofishing of the drift net pool habitat captured one young of the year *O. mykiss* (147 mm) in 2017. Since electrofishing started in 2008, two young of the year, and a 2+ year old adult (214 mm) were observed in November 2012. With an average depth of only 13.9 cm over all sampling years, this pool is most likely a migration corridor rather than an area for fish to reside long-term.

There were significantly more *O. mykiss* during the four year study period in the lower 3.2-3.7 rkm reach (471 total), than the upper 4.5-5.0 rkm reach (189 total) (paired t-test, p = 0.0001). Mean monthly abundance of *O. mykiss* young of the year within the lower kick net reach gradually dropped each year, from 9.8 per month in 2017 to 0.5 per month in 2014 (Table 3.19). The number of *O. mykiss* in the upper reach of 4.5-5.0 rkm was more variable; with relatively lower *O. mykiss* abundances than the lower kick net reach overall. Mean monthly abundance of *O. mykiss* young of the year in the upper reach started low in 2014 with 0.5 per month, peaked in 2015 with 7.7 fish per month, and then dropped to as low as 0.2 fish per month in 2017. Total abundance of *O. mykiss* of all sizes throughout the whole creek was more stable than the kick net reaches, with a slight drop in 2016 at the peak of the drought followed by a resurgence to their highest abundance in many years in 2017 with the heavy rains (Table 3.19). The majority of these fish were young of the year, and this increase was not seen until after the April 2017 kick net sampling period. When comparing abundance during the kick net sampling time frame, only 23 young of the year were observed by April 2017, which was similar to April and May observations in previous years. Mean monthly juvenile *O. mykiss* abundance in the lower kick net reach decreased each year of the study period, from 10/month in 2014, to less than one/month in 2017. Adult *O. mykiss* monthly abundance remained low, with less than one adult/month in all years in both the lower and upper kick net reaches.

Table 3.19. Summary of total *O. mykiss* abundance observed during monthly snorkel surveys per BMI kick net sampling month by size from 2014 – 2018 (monthly average of the year for that site in parentheses).

Water year (inches)	6.85	13.49	10.54	26.34	9.96
Lower Kick Net Reach (3.2–3.7 rkm) Abundance	**May 2014**	**April 2015**	**April 2016**	**April 2017**	**May 2018**
Young of the Year *O. mykiss* (length ≤ 100 nm)	18 (9.8)	0 (6.7)	4 (2)	0 (0.5)	1 (0.2)
Juvenile *O. mykiss* (100 mm < length ≤ 250 mm)	6 (5.3)	1 (4.1)	12 (5.3)	1 (2.5)	4 (0.8)
Adult *O. mykiss* (250 mm < length)	0 (0.7)	0 (0.9)	0 (0.6)	2 (0.5)	1 (0.2)
***O. mykiss* Total**	24 (15.8)	1 (11.7)	16 (7.9)	3 (3.5)	6 (0.8)
Upper Kick Net Reach (4.5–5.0 rkm) Abundance	**May 2014**	**April 2015**	**April 2016**	**April 2017**	**May 2018**
Young of the Year *O. mykiss* (length ≤ 100 nm)	0 (0.5)	2 (7.7)	3 (2.3)	1 (0.2)	0 (0)
Juvenile *O. mykiss* (100 mm < length ≤ 250 mm)	1 (1.3)	0 (0.4)	5 (0.8)	1 (0.5)	0 (0)
Adult *O. mykiss* (250 mm < length)	0 (1)	0 (0.4)	0 (0.1)	0 (0.4)	0 (0)
***O. mykiss* Total**	1 (2.8)	2 (8.5)	8 (3.2)	2 (1.1)	0 (0)
TOTAL CREEK (0-5.3 rkm) Abundance	**May 2014**	**April 2015**	**April 2016**	**April 2017**	**May 2018**
Young of the Year *O. mykiss* (length ≤ 100 nm)	25 (16.5)	32 (35.2)	9 (9.4)	23 (70.4)	39 (31.4)
Juvenile *O. mykiss* (100 mm < length ≤ 250 mm)	47 (31.1)	8 (14.4)	33 (17.7)	23 (19.9)	27 (23.8)
Adult *O. mykiss* (250 mm < length)	6 (9.2)	10 (8.6)	9 (7.3)	8 (6.5)	5 (5.4)
***O. mykiss* Total**	78 (56.8)	50 (58.6)	51 (34.5)	54 (96.2)	71 (60.6)



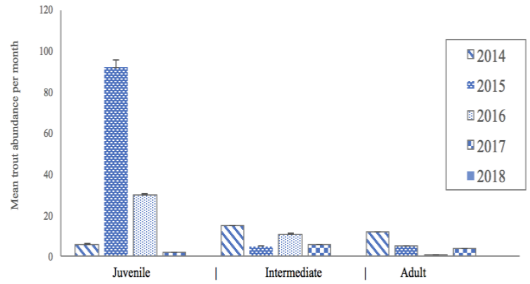


Figure 3.35. Mean *O. mykiss* abundance by size class found within the lower kick net reach of 3.2-3.7 rkm and upper kick reach of 4.5-5.0 rkm respectively from monthly snorkel surveys.

Observed *O. mykiss* size patterns 2014-2017

During November electrofishing events, 165 young of the year and 78 one-year-old *O. mykiss* were captured from 2014 – 2017. For all *O. mykiss* captured during that time (n= 327), fork length ranged from 45-386 mm, and age from 0-6 years based on scale analysis. Young of the year (0+) in this period ranged in fork length (FL) from 45-147 mm, and one year olds (1+) ranged from 119-266 mm. The minimum fork length of 0+ trout in 2014 was 68 mm, 45 mm in 2015, 65 mm in 2016, and 64 mm in 2017. Maximum fork length of 0+ trout in 2014 was 147 mm, 111 mm in 2015, 155 mm in 2016, and 144 mm in 2017. Average fork length of 0+ trout was highest in 2014 (109.9 mm) and lowest in 2015 (77.9) (Figure 3.36).

Adult *O. mykiss* abundance of 2+ years and older did not correlate with young of the year abundance per year, with 24 adult *O. mykiss* in 2014 (13 young), 35 adults in 2015 (52 young), 15 adults in 2016 (4 young), and eight adults in 2017 (96 young). Number of 1+ trout was more stable and ranged between 17 in 2016 and 23 in 2017 (Table 3.20).

Table 3.20. ***O. mykiss* fork length of young of the year and juveniles in the lower kick net reach vs. creek-wide from electrofishing events in November.**

Year	Lower Kick 3.2-3.7 rkm mean FL (0+)	Mean FL (mm) of all *O. mykiss* (0+)	Lower Kick 3.2-3.7 rkm Net *O. mykiss* Abundance (1+)	Mean FL (mm) of all *O. mykiss* (1+)
2014	112.6 (n=5)	109.9 (n=13)	172.8 (n=5)	169.2 (n=21)
2015	88.4 (n=12)	77.9 (n=52)	156.7 (n=5)	168.9 (n=17)
2016	65 (n=1)	95.0 (n=4)	145 (n=1)	143.9 (n=17)
2017	139.5 (n=2)	93.6 (n=96)	126 (n=1)	149.7 (n=23)

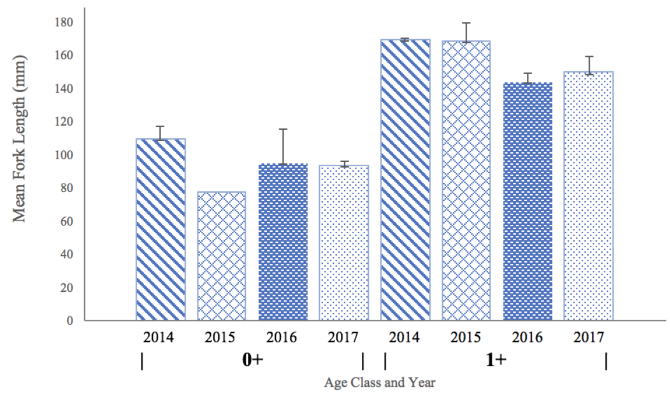


Figure 3.36. Mean length of *O. mykiss* of ages 0+ and 1+ from 2014-2017 in Topanga Creek.

Recaptured *O. mykiss* and Growth

The fastest growth rate occurred in 2017, when three recaptured 1+ aged *O. mykiss* showed increased mean growth of 0.20 mm/day (Table 3.21). This was however a much smaller sample size than previous years of this study. The slowest mean growth was in 2016, where 12 fish of all ages grew at a mean growth rate of 0.11 mm/day, and one 0+ *O. mykiss* grew only 0.09 mm/day. This may have been drought related, with the highest percentage of the creek dry during the summer of all study years at 61.2% dry. With so few fish caught in 2017, we could not statistically compare the growth of recaptured fish during and post-drought.

Table 3.21. *O. mykiss* mean simple growth (mm/day) and average fork length creek-wide.

Period	Mean Growth (mm/day) of all fish (n)	Mean Growth (mm/day) of 0+ fish (n)	Mean Growth (mm/day) of 1+ fish (n)
Nov 2013 to Nov 2014	0.11 (n=8)	0.10 (n=1)	0.10 (n=6)
Nov 2014 to Nov 2015	0.17 (n=12)	0.17 (n=3)	0.17 (n=4)
Nov 2015 to Nov 2016	0.11 (n=12)	0.09 (n=1)	0.17 (n=3)
Nov 2016 to Nov 2017	0.20 (n=3)	No individuals	0.20 (n=3)

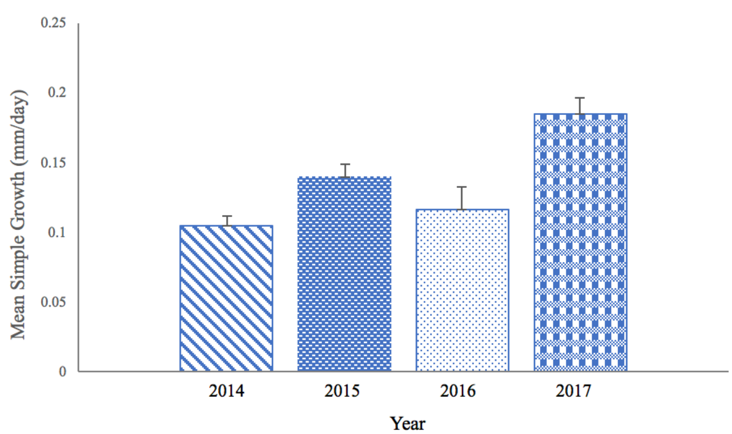


Figure 3.37. Mean simple growth (mm/day) of *O. mykiss* from 2014-2017.

One hypothesis was that Arroyo chub could be providing important food resources for *O. mykiss* in addition to benthic macroinvertebrates. Considering that juvenile trout and chub consume similar resources, it was thought that their abundance might fluctuate in synch, but that does not appear to be the case. While close, there was a non-significant ($p = 0.057$) positive correlation of Arroyo chub and *O. mykiss* abundance from 2014 – 2017 (Figure 3.38). Total creek-wide *O. mykiss* abundance from snorkel surveys was tallied, and there were wide ranges with *O. mykiss* abundance as low as eight in April 2017 quickly rebounding to a high of 169 in September 2017. Arroyo chub abundance declined throughout the drought from a high of 7,823 in August 2014 to a low of two in April 2017.

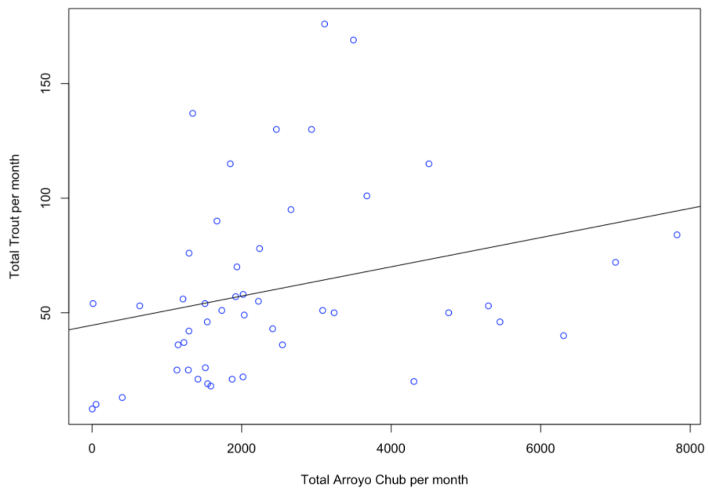


Figure 3.38. Arroyo chub and trout abundance did not correlate significantly ($p = 0.0571$, adjusted R-squared = 0.056).

DISCUSSION

The focus of this task was to evaluate the current conditions in the mainstem of Topanga Creek with the goal of addressing the following questions posed by the Southern California Steelhead Recovery Plan (NMFS 2012):

- Do intermittent creeks serve as steelhead nursery habitat?
- Does mainstem habitat support high juvenile survival and growth?
- Does fast growth and good conditions in freshwater encourage a more resident population, or does this set the stage for successful marine survival when out-migration is possible?

While technically classified as interrupted rather than intermittent (due to perennial flows throughout most of the anadromous reach), Topanga Creek is representative of conditions commonly found in the small coastal creeks characteristic of southern California. Topanga Creek is entrenched in a steep-walled canyon, and with no tributaries. Mainstem habitat is the only available nursery to support the population of *O. mykiss*. Mainstem habitat conditions respond to both natural variability (drought, wildfire impacts, extreme range in flow patterns, higher summer water temperatures, etc.) and anthropogenic stressors (flow withdrawal, water pollution, low flow barriers, passage restrictions, etc.) (NMFS 2012).

Although the primary data examined was collected during the study period (2013-2018), monitoring of habitat conditions, water temperatures, benthic macro-invertebrate and *O. mykiss* abundance and diversity, and the introduction of non-native species such as red swamp crayfish have been on-going since 2001. This long-term dataset provides a longer time frame within which to examine the impacts of the drought that directly impacted the study period 2012-2016. Rainfall during those five years ranged from 6 to 13 inches, well below the average of 24 inches/year typical of Topanga Creek (Dagit and Webb 2002). Although more average rains returned in 2017 (26 inches), the drought pattern remains firmly in place as of May 2018, with a total rainfall of only 9.96 inches.

<u>Habitat conditions</u>

Overall, the drought resulted in limited connectivity to the ocean restricting anadromous adults from accessing the creek, loss of habitat type complexity, particularly shallow areas of riffles and runs, restricted in-stream movement opportunities for resident fish, and enhanced encroachment of emergent vegetation into the active channel, further restricting movement. The reduced complexity of habitat types and increased extent of dry sections in the lower reach (gradient <1%) between the higher flow patterns observed in 2006 as compared to those mapped in 2017 (Figure 3.40) highlights the shift resulting from the drought. Topanga Creek has consistent groundwater inputs (Tobias 2006) that moderated the drought somewhat, resulting in less change in the larger refugia pools found in the higher gradient middle (1-3%) and upper (3-6%) reaches influenced by seeps and springs. The lowest gradient reach with less than 1% slope went dry for much of the study period.

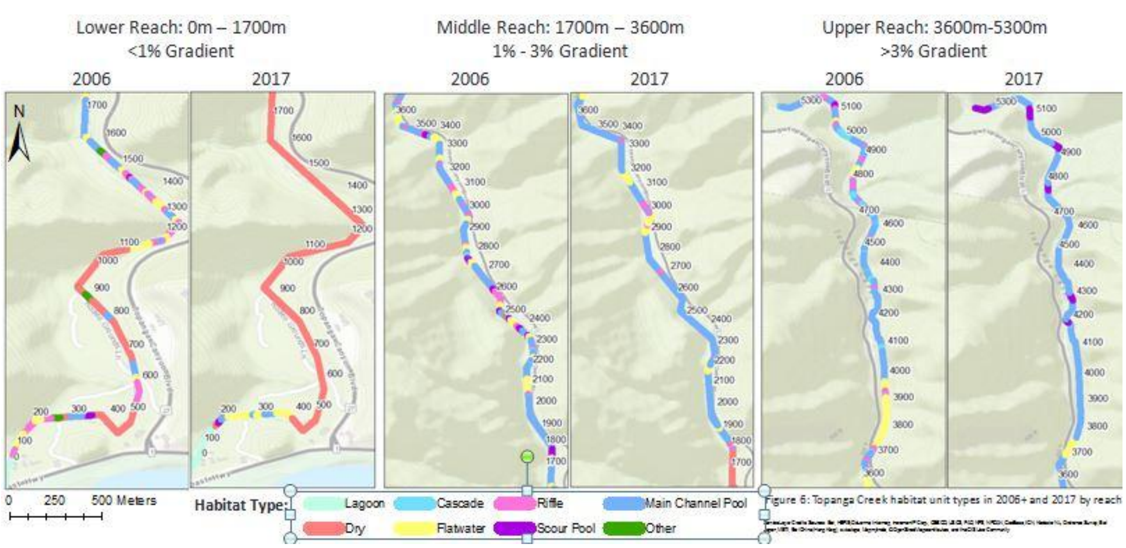


Figure 3.49. Comparison of habitat types between 2006 (pre-drought) and 2017 (drought). Excerpted from Demerci (2018).

This study used the qualitative habitat suitability criteria developed by Dagit and Reagan (2006), based on numerous references, which was further supported by the more recent work done in the Ventura River (Allen 2015). Additional work is needed to further investigate the inter-relationship of habitat suitability metrics (type, depth, substrate, canopy cover) applied, however, these metrics provide a qualitative way of comparing habitat changes over time. For our study, each metric was weighted equally, which did not allow for discriminating any differences in significance between each factor. Based on the data collected in this study, it appeared that depth and surface flow are potentially the most important metrics, shaping habitat type and connectivity. Further study is needed to determine if a weighted metric would characterize the habitat more accurately, however that was beyond the scope of this study. Another factor influencing the documented reduction of habitat suitability over the course of the study was the significant loss of canopy cover. Dieback of riparian trees was observed throughout the creek, but the lower kick net reach (3.5-3.7 rkm) lost of over 50% of riparian trees in 2017 (RCDSMM unpublished data). Despite this, canopy cover remained relatively high (40-60%), providing some shading and terrestrial invertebrate habitat as the leaves that fall into the stream are broken down and consumed by the BMI community.

Average depth of the kick and drift net sampling reach (3.2-3.7 rkm) was generally low, between 15-40 cm, and the highest average depth was 50 cm during the rains of February 2017. This reach was classified as having Good habitat suitability overall. It consists primarily of shallow step pools delineated by boulder cascades, with a few larger refugia pools interspersed with runs and riffles that virtually disappeared during the drought. The habitat suitability scores for 2017 reflected a remarkable reduction in percent canopy cover associated with dieback from the drought. By contrast, the percent of vegetated banks of the 3.2-3.7 rkm reach did not change much at all throughout the study period. The dominant substrate shifted slightly from boulder to more sand/gravel dominated following the pulses of storms in 2017, which also caused a slight change in overall pool depth. These shallower stretches, interspersed between deeper small pools provide mainstem nursery habitat, as they are generally unsuitable for larger *O. mykiss* and therefore have reduced competition for resources and predation.

The previous characterization of Topanga Creek carrying capacity based on 2008-2011 conditions found that summer and winter habitat availability were not limiting factors (Bell et al. 2011). The response of the *O. mykiss* population to drought conditions suggests that although habitat availability and complexity has decreased, the remaining habitat is still rated as Moderate to Good in the BMI sample reaches examined. Topanga Creek should still be able to support more fish than are currently observed. The interplay of limited access for anadromous adults, few redds (9 in 2014, 1 in 2015, 0 in 2015 and 4 in 2017, 4 in 2018), limited dispersal, and low recruitment of young of the year, make it difficult to validate our habitat suitability assumptions.

Young of the year *O. mykiss* in Topanga Creek typically emerge in April and May. One of the main limitations of assessing nursery habitat suitability for Topanga Creek as has been done in some more northern streams (Everest and Chapman 1972, Holmes et al. 2014), is the very low abundance of young of the year. Without a fully seeded population, it is not possible to ascertain why juvenile *O. mykiss* are found in some areas but not in others. Young of the year have been found clustered in close proximity to the location of redds, rather than spread out throughout the potentially suitable habitat (RCDSMM unpublished data). Also without connectivity to the entire stream due to many low flow barriers, young of the year are not able to freely distribute and chose their rearing locations. These low flow barriers likely lead to many fish being stuck in one pool, where resources can be quickly depleted. This can lead to intense intraspecific competition, and could be associated with differences in total length (from 50 to 100 mm) of individuals of the same cohort (Table 3.20).

Projected climate changes suggest that this pattern of lower rainfall and higher overall temperatures can be anticipated to continue and perhaps intensify in the future (Cook et al. 2015, Diffenbaugh et al. 2015). Thus the patterns observed during this study begin addressing the questions above, but also provide a baseline that can be used to document changes over time in this system.

<u>Water Temperature</u>

Water temperature was highest during 2017, but was over 23°C for less than 5% of the time and only in July to September. In prior years of the study, the temperature did not exceed 23°C at all. Optimal feeding temperature for *O. mykiss* is considered to be 15^{o}C (Hilton and Slinger 1981), but Spina (2007) found that *O. mykiss* in southern coastal California creeks are able to feed when temperatures rise to as high as 24^{o}C. Sloat and Osterback (2012) found that *O. mykiss* in Santa Paula Creek were able to survive in pools that reached up to 29.2^{o}C for short times, and that water temperatures did not significantly correlate with habitat metrics such as depth or cover. In Topanga Creek, water temperature did not vary significantly between sites, offering little summer cool water refugia. Dissolved oxygen measured at drift net deployment was adequate for *O. mykiss*, dropping below the 5 mg/L threshold of concern once in July 2016. In the summer months, observed conditions of higher water temperatures, low flows, and high drift invertebrate density may be favorable to growing young of the year *O. mykiss*. Invertebrate density was highest in July sampling months, which could be associated with intense algal blooms and mats that offer essentially unlimited food supply to primary consumers.

<u>BMI Abundance and community composition</u>

During this study we used two common methods to characterize the BMI community. Drift nets were deployed for 24 hour periods in March, July, and November 2014-2017 to measure invertebrate drift abundance at the upstream and downstream ends of a characteristic pool habitat (3.58-3.6 rkm). This data was supplemented with kick net data collected each April/May within the same reach. Using both sets of data helped discern the relative importance of aquatic versus terrestrial origin prey availability in supporting growth of juvenile *O. mykiss*, and examined whether seasonal shifts in prey type may be important for growth, as suggested by the CA Coastal Salmonid Population Monitoring Strategy, Design and Methods (Adams et al. 2011).

Taxonomic identification effort was the same for both sampling methods, making it possible for quantitative comparison. The main invertebrate groups (those with abundance up to 1.0%) were very similar between the two sampling methods, except that fewer terrestrial taxa were collected in kick nets. Drift nets samples had more groups of terrestrial origin (thrips, ants, hemipterans, etc.), which fall into the stream and were transported into the nets. Invertebrate groups present in the kick net samples were typically comprised of species living attached or below of the bottom rocks of the streams (turbellarians, trichopterans, etc.). There was also no significant difference between the lower and upper kick net sites, and significantly more invertebrates in kick nets than drift nets.

Overall, the abundance of all BMI was low during the study period. Aquatic invertebrates were significantly more abundant than terrestrial, comprising 83.5% of the mean drift net sample and 97% of the kick net sample abundance. The most abundant aquatic taxa were *Argia sp*., followed by chironimids, simulidae, Ceratopogonidae (midges), copopods, and baetids (mayflies). The most abundant terrestrial invertebrate was Thysanoptera (thrips). Terrestrial insects can be an important food source for salmonids, particularly when benthic resources are low or compromised (Elliot 1973, Cada et al. 1987, Nakano et al. 1999, Kawaguchi 2001). Richards and Soltz (1986) measured BMI drift in the San Gabriel River and found that 30% of stomach contents were made up of terrestrial and emerging insects. Stomach analysis of *O. mykiss* in Topanga Creek found similar results (Krug et al. 2012).

The main difference in species composition between drift nets and kick nets was that the dominant taxa of drift nets was Odonates, while Chironomids were the main group in kick nets. Chironomid larvae were still the second major group in drift net samples, but being sessile organisms it is thought that the physical disturbance of the substratum of kick net sampling as compared to passive drift net sampling caused this result. The trend of Odonate dominance in drift nets was also not stable over all sampling years. Relative abundance of Odonates was 38% in 2014-15, but dropped to 2% relative abundance in 2016-17. Chironomid larvae, baetid larvae, and copepods were the dominate taxa in 2016-2017.

Another important difference between the kick and drift net samples was that there were four more taxa representing over 1% abundance in drift net samples than kick net samples, suggesting a more diverse species assemblage due to the higher representation of terrestrial taxa. Drift net samples had nine taxa groups with more than 3% relative abundance, compared to only three groups over 3% abundance in all kick net samples. Kick net samples were more homogenous, but they are also quicker 30 second grab samples compared to the 6-hour drift net sets.

Drift Nets

Although not significant, invertebrate abundance measured with drift nets varied over diel and seasonal periods, with the highest diversity and abundance in March samples, and those collected between midnight and noon. Abundance per sample ranged from 0 – 816 individuals, with an average of 141 invertebrates per sample. There was a significant difference between BMI abundance captured in the downstream end of the pool, even though it was sampling only 20 m, the flow was slightly higher and drift abundance also higher. By contrast, supplemental drift captured at the upstream end flowing into the pool was relatively low, which could be a result of limited flow through a patch of non-native invasive *Arundo donax* immediately upstream of the sampling site that might be influencing flow patterns and substrate conditions. Additionally, Topanga Creek Bridge, located 40 meters upstream of the sampling site might also inhibit benthic productivity due to shading. While the sampling site selected was characteristic of habitat throughout Topanga Creek, the overall patchiness of invertebrate distribution and abundance is definitely worth consideration.

Drift net invertebrate abundance was lowest in 2017 in all major groups besides Diptera, whereas Chironomids dominated with the highest abundance of any group throughout the entire study period. Chironomids are sessile, and their attachment to the substrate may have helped them resist being flushed out of the stream during the rains of the 2017 winter. Species composition differed between seasons; while Diptera and EPT were most abundant in March, Odonates were generally more abundant in July and November. This may be due to several factors including flow, temperature, and timing of emergence. Abundance of the six main invertebrate groups seems to be affected positively by the increase of water volume in drift samples. All invertebrate groups showed the same decreasing trend by season from March to November as water levels drop. Significantly higher flow rates in March were observed in this study period.

Some differences in drift net samples were noted between years. Total invertebrate abundance was greater in 2015 (n=3,474) than 2014 (n=2,711). Throughout the study a pattern of sedimentation was observed as dominate substrate in pools shifted from gravel/boulder in March 2014 to silt/boulder in July 2015. There was a drop in invertebrate abundance in 2016 (n=3,109), potentially from the prolonged drought. The highest overall yearly abundance occurred in 2017 (n=4,042) with the return of rains and stream connectivity. The species composition changed a lot, with chironomids becoming the most abundant taxa. Debris was stuck in trees as high as five meters, and the flash flood surges may have flushed many invertebrates out of the stream completely. With steep canyon walls, the mainstem is entrenched and there are no eddying backwater pools offering refugia.

Plankton was more abundant in the upper drift nets. Willow roots located near the 3.58 rkm nets likely factor into increased benthic productivity at the downstream site. Additionally, more terrestrial insects were collected in downstream 3.58 rkm nets than upstream, suggesting that native riparian vegetation around the pool is an important source of food for *O. mykiss* inhabitants, compared to the invasive Arundo and a large concrete bridge upstream of the pool. The significant differences between invertebrate drift at 3.58 rkm and 3.6 rkm could also be indicative of the highly patchy distribution of benthic habitat and populations.

Kick Nets

Kick net sampling reaches were much larger than the more focused drift net sampling location. The lower reach of 3.2-3.7 rkm was more vegetated and has a lower gradient than the upper 4.5-5.0 rkm reach. More individual invertebrates were collected in the downstream kick net reach than the upstream reach, but chironomids were by far the most dominant taxa in both reaches. This could potentially be due to the much higher percent of vegetated banks in the lower sampling reach. Terrestrial invertebrate inputs have been shown to be higher in deciduous tree dominated locations than perennial dominated riparian zones (Allan et al. 2003).

Invertebrate abundance varied highly per kick net sample, from 157 to 1,643 individuals, with an average of 799 invertebrates. Throughout the four years of this study, kick net sample abundance alternated from high to low abundance. This could be due to a variety of reasons, but it must be noted that some of these invertebrates with multiyear life cycles such as Odonates could contribute to these pulses. During the higher rainfall in 2017, potentially Odonates were flushed out of the creek resulting in lower numbers. Chironomids were overwhelmingly dominant in all kick nets (58% abundance), but while previously scarce, baetid larvae made a strong re-appearance in 2017 reaching 31.6% relative abundance. With the highest level of disconnection in 2016 (61.2% dry), the rains of 2017 may have stimulated mixing and brought in invertebrates that had been isolated in areas upstream. Baetids are also very strong swimmers (Elliot 1968), so the heavy rains may not have affected them as much and they were able to take advantage of the disappearance of competitors.

SCC-IBI Evaluation

The Southern California Coastal Index of Biotic Integrity (SCC-IBI, Ode et al. 2005) provides a tool for quantitatively comparing ecological conditions across a regional area. Scores are based on identification of 500 individuals per sample and then grouped into seven metrics (EPT taxa, Coleoptera, predator taxa richness, percent non-insect, percent tolerant taxa, percent intolerant individuals, collector-gatherer and collector-feeder individuals) (Tables 3.8 and 3.13). Very Poor samples had a combined metric score total of less than 13, with 14-26 being Poor, and 27-40 being considered Fair.

During the course of this specific study, only six of the 94 drift net samples exceeded 500 individuals and most had under 100 individuals. Although all but one of the kick net samples had more than 500 individuals, overall abundance was still relatively low (<1600 individuals/ sample). Thus it was not surprising that the resulting combined metric scoring was generally low.

SCC-IBI scores were consistently Poor for most drift net samples (84 of 94 drift nets) with the only Fair IBI scores in March 2017. Mean IBI scores did not change annually, so there was no obvious effect of the drought, however returning rains in 2017 were not sufficient to change the quality and diversity of the invertebrate assemblage. A decreasing trend of average monthly IBI scores throughout the year occurred as water levels dropped. Most invertebrates were produced within the 3.58-3.6 rkm pool habitat, rather than drifting in from upstream, with lower invertebrate abundance at 3.6 rkm than 3.58 rkm. This suggests that the pool between 3.58 rkm and 3.6 rkm represents an example of a source pool of BMI. Possible explanations for the overall decreased abundance of invertebrates at 3.6 rkm may be that the massive non-native invasive Arundo patch upstream was hindering flow. The benthic habitat is also compromised 40 m upstream of the sample site due to Topanga Bridge shading the creek.

The pattern for the kick net samples was similar. Nine of ten kick net samples received Poor SCC-IBI scores, with one sample a Very Poor score. The likely cause of these low scores was the lack of percent intolerant individuals and number of predators. No intolerant taxa were observed at all in the upper kick reach. There was no difference in the average IBI scores between the lower reach and upper reach, further justifying combining the samples of these two different sites in the comparison to drift net samples.

These results are consistent with the patterns observed in Topanga Creek between 2002-2014 by Montgomery et al. (2015). Over that time, the extended drought resulted in increased abundance of chironomids, with decreased abundance of baetids. SCC-IBI scores for these reaches ranged between a low of 9 (upper reach 2013) to a high of 40 (lower reach 2007). Overall, the scores averaged 37 in the lower reach and 35 for the upper reach, putting them in the fair category. This suggests that the long term drought effected overall species composition and abundance that continued during the study period. By comparison, Arroyo Sequit Creek averaged 62 (very good) and Solstice Creek averaged 64 (very good) during the same time. Malibu Creek consistently scored lowest with an average score of 21 (Dagit et al. 2014).

O. mykiss growth

We assessed relative levels of food availability among seasons (March, July, November), and in particular during low flow and thermal stress conditions. A primary objective was to better understand the relationship between seasonal growth patterns of juvenile *O. mykiss*, and mainstem habitat suitability characteristics associated with promoting the rapid growth needed for increased rates of marine survival.

Food availability is a crucial element to overall habitat quality for fish and an important consideration in freshwater conservation and management. Invertebrate drift is one measurement of the quality and quantity of food available for maturing *O. mykiss*. Density of invertebrate drift has been correlated with benthic productivity (Pearson and Kramer 1972, Benke et al. 1991), as well as trout short-term growth rate (Wilzbach et al. 1986), and spatial distribution of fish (Ensign et al 1990, Shannon et al. 1996). Invertebrate drift is a key factor in fish production and the energy transfer efficiency between primary trophic levels and fish biomass. Food quality was not assessed in this study, but Odonates are the largest invertebrates available and while the dominant taxa in 2014-2015, they became increasingly rare in the second two years of the study.

There were over twice as many *O. mykiss* observed during snorkel surveys in the lower kick net sampling reach (which includes the drift net site) than the upper kick net reach. The lower reach also had slightly higher BMI abundance suggesting that with a lower gradient and more runs, which are preferred habitat for juvenile *O. mykiss*, this reach could potentially have greater nursery potential. However, due to limitations on number of redds and discontinuity throughout the reach, it was not possible to test this assumption. Abundance of *O. mykiss* did not change in synchrony with BMI abundance in the lower reach, again making it difficult to correlate these factors directly.

In November 2014, 13 young of the year *O. mykiss* collected by electrofishing measured between 68-147 mm fork length, with an average of 109.9 mm. This is highly consistent with young of the year growth in November observed by Bell et al. (2011) and Krug et al. (2012), which reported that young of the year ranged from 55-125 mm in 2008 (n=60) and 2009 (n=29) with a mean length of 106 mm and 98 mm. In 2015, young of the year were smaller, with an average fork length of 77.9 mm and a range of 45-111 mm (n=52). Lower abundance of invertebrate drift observed in July 2015 between 3.58 rkm and 3.6 rkm may be one possible reason for reduced size, although it is not possible to extrapolate conditions in this pool to creek-wide conditions. Young of the year minimum size increased slightly in 2016 and 017 to 65 mm, and the maximum size of young of the year was significantly larger (155 mm) in 2016 than in 2017 (144 mm), and higher than previously observed.

Timing of reproduction coinciding with winter rain events may also play a role, with earlier rain events potentially providing extra time to grow, along with wetter creek conditions supporting more BMI production, until being captured in November electrofishing events. Shifting seasonal patterns associated with climate or other factors is another potential driver, as are changes in suitable habitat area resulting from pools becoming shallower (Nislow et al. 1998). This could favor growth of smaller fish and exclude larger fish that require more resource, and thus offer a trade-off between cohort number and individual fish size.

Growth rates for recaptured fish in 2017 (n=4, 0.184 +/- 0.01 mm/day) were the highest since 2014-2015 (Bell et al. 2011, Krug et al. 2012). This could potentially be attributed to the higher number of young of the year represented in this sampling year as compared to previous years, resulting from spawning from at least one anadromous adult. Other factors beyond the scope of this study, such as the role of increased rainfall and more connectivity between pools providing an opportunity for young of the year to access more rearing habitat may also play roles.

Competition and Predation

One hypothesis is that although native Arroyo chub are smaller, they are competing with *O. mykiss* for similar food resources. Arroyo chub are known to favor algae and physid snails, but have also been found to consume a variety of benthic taxa (Richards and Soltz 1986). After testing for a correlation between monthly abundance of all *O. mykiss* and all chub in the entire stream, there was a non-significant positive correlation (p=0.0571). Since this is a positive relationship, they may both just increase abundance in response to more water or productivity in the stream.

Another possible competitor is the recently introduced fathead minnow (*Pimephales promelas*). The low flow conditions during the drought provided suitable habitat and like the chub, fathead minnows primarily eat algae, but also consume cladocerans, copepods and amphipods (Held and Peterka 2011). These taxa were also consumed by *O. mykiss* (Krug et al. 2012). Following the high flows of 2017, the abundance of these invasive fishes has declined significantly. Further study is needed to more clearly assess the impacts of potential competition from both chub and fatheads.

Red swamp crayfish (*Procambarus clarkia*) were introduced into Topanga Creek in 2001, but did not become abundant throughout the creek until 2012, at the start of the drought (Garcia et al. 2015). Crayfish are omnivores that primarily feed at night, with a diet that includes eggs of fish, frogs and newts, along with anything else they can find (Reynolds 2011). In addition to potentially competing directly with *O. mykiss* for food resources, they can also be predators of *O. mykiss* eggs or juveniles. In turn, *O. mykiss* will also prey upon juvenile crayfish (Krug et al. 2012, Richards and Soltz 1986). Reynolds (2011) examined the interactions of crayfish and fish, concluding that both can be primary controls in freshwater systems. The complexity of these interactions suggest that there are both direct and indirect effects when crayfish are introduced into a new system.

Crayfish were found to have a significant impact on the BMI community in Topanga Creek (Garcia et al. 2015). Targeted, sustained removal of crayfish from subsection of the lower kick net reach (3.5- 3.58 rkm) found that both species richness and abundance increased when crayfish were removed.

When crayfish monthly totals were compared to *O. mykiss* totals for the whole stream, there was little correlation (p=0.765) (Figure 3.14). There was also no negative correlation of young of the year and crayfish abundance per month (p=0.67). These results are slightly reassuring because with very few *O. mykiss* redds and low numbers of young of the year, high numbers of crayfish could potentially have a significant predatory impact on the *O. mykiss* population.

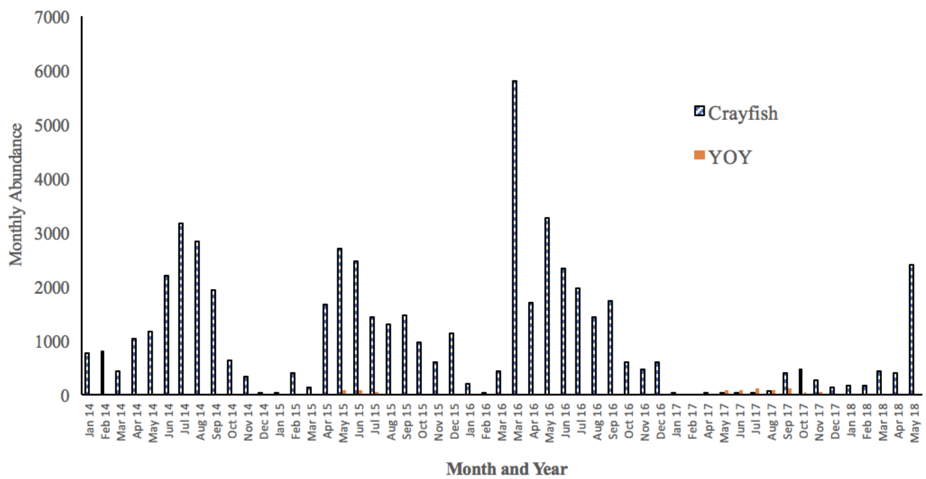


Figure 3.40. Total number of crayfish and young of the year *O. mykiss* per month from snorkel surveys from 2014 – 2018.

SUMMARY

Despite the impacts of the drought, Topanga Creek continues to provide important mainstem nursery habitat for *O. mykiss,* but the survival and growth patterns of young of the year were difficult to correlate directly to habitat metrics, water temperature, availability and quality of BMI, and the impacts of invasive competitors/predators.

Survival and recruitment of young of the year into larger size classes occurs, but is hampered by the low relative numbers of redds observed, and the fact that few redds are produced by anadromous adults (Dagit et al. 2018). Resident *O. mykiss* appear to be the dominant reproducers, with fewer eggs typically produced (NMFS 2012).

Growth rates during the drought period were variable, but the abundance of young of the year and juveniles declined overall. The 2017 rains combined with spawning by a single anadromous adult increased both the number of young of the year, and growth per day, although the sample size was quite small. Overall recruitment into larger size classes was observed but in low numbers (Figure 3.42).

Due to the low flow and limited connectivity between the creek and the ocean, it was not possible to determine if the growth patterns and overall habitat suitability observed in Topanga Creek encourage a more resident population or not. The fish simply had little choice but to remain residents other than brief windows during storm events when migration was possible. The arrival of two anadromous adults in 2017, at least one of which spawned (based on high numbers of young of the year nearby and subsequently confirmed in genetic analysis), highlights the variability of passage conditions and how significantly even one anadromous adult can affect relative abundance.

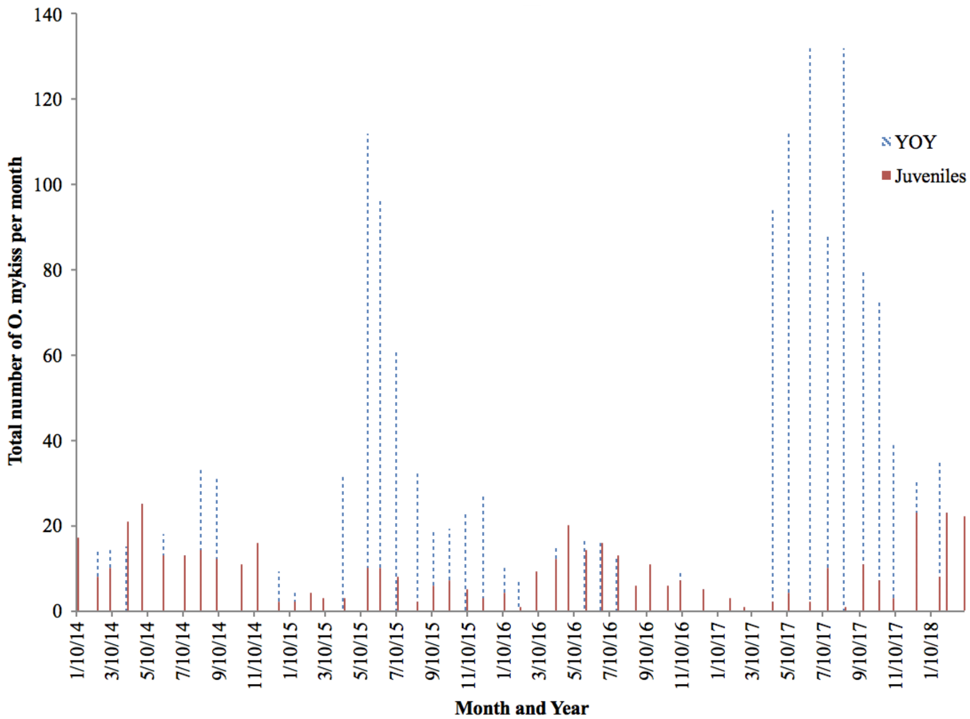


Figure 3.41. Total number of young of the year (< 100 mm FL) and juvenile (100-250 mm FL) *O. mykiss* per month from snorkel surveys from 2014 – March 2018.

Topanga Creek remains an important reference stream for the Santa Monica Mountains, and long-term monitoring is crucial to see how the BMI species assemblage responds to continued drought conditions. With only 9.96 inches (25 cm) of rain as of May 2018, the conditions appear bleak. If the drought lessens in future years, this baseline data will provide a comparison for assessing recovery. BMI species composition should continue to be monitored. Maintaining and improving proper habitat for BMI within the channel, as well as sustaining a functional riparian corridor are key conservation requirements in Topanga Creek, as they may be in other small mainstem dominated coastal creeks in southern California. Future management and conservation actions must consider *O. mykiss* food resources and ensure their availability (Romaniszyn et al. 2007).

O. mykiss remains critically endangered, and continued efforts to preserve mainstem nursery habitat as well as restore Topanga lagoon are essential to increase the ocean connectivity and the nursery potential of this stream.

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Appendix 3A

Drift Net Taxa List

TASK 3. MAINSTEM NURSERY HABITAT EVALUATION 2013 – 2018

SANTA MONICA BAY
ANADROMOUS ADULT AND JUVENILE
STEELHEAD MONITORING
2013-2018

Prepared for
CDFW contract No P1250013

Prepared by:

RCD of the Santa Monica Mountains
540 S. Topanga Canyon Blvd.
Topanga, CA 90290

May 2018

TASK 3. Appendix 3A - Drift Net Taxa List

Taxa, ocurrence and relative abundance calculations for invertebrate species from Topanga Creek drift nets Mar 2014 -Nov 2017								
Phylum	Subphylum	Class	Order	Family	Taxon	Life Stage	Total #	Percent
ACUATIC								
Arthropoda	Hexapoda	Insecta	Coleoptera	nd		Larvae	4	0.03%
				nd		Adult	9	0.07%
				Dytiscidae		Adult	2	0.02%
				Dytiscidae		Larvae	1	0.01%
				Dytiscidae	Agabus sp.	Larvae	1	0.01%
				Elmidae		Adult	26	0.21%
				Elmidae		Larvae	7	0.06%
				Elmidae	Ordobrevia nubifera	Larvae	2	0.02%
				Hydrophilidae		Adult	9	0.07%
				Hydrophilidae	Berosus sp.	Larvae	2	0.02%
			Diptera	nd		Larvae	6	0.05%
				Ceratopogonidae		Larvae	443	3.51%
				Ceratopogonidae		Pupae	406	3.22%
				Ceratopogonidae	Bezzia/ Palpomyia	Larvae	2	0.02%
				Ceratopogonidae	Atrichopogon sp.	Larvae	3	0.02%
				Chaoboridae	Chaoborus	Pupae	1	0.01%
				Chironomidae		Larvae	1645	13.03%
				Chironomidae		Pupae	284	2.25%
				Chironomidae	Tanytarsini	Larvae	12	0.10%
				Chironomidae	Tanypodinae	Larvae	19	0.15%
				Culicidae		Larvae	27	0.21%
				Culicidae	Culex sp.	Larvae	10	0.08%
				Dixidae		Pupae	14	0.11%
				Dixidae		Larvae	5	0.04%
				Dixidae	Dixa sp.	Larvae	37	0.29%
				Empididae		Larvae	4	0.03%
				Ephydridae		Larvae	2	0.02%
				Muscidae		Larvae	2	0.02%
				Psychodidae		Larvae	21	0.17%
				Simuliidae		Larvae	17	0.13%
				Simuliidae	Simulium sp.	Larvae	141	1.12%
				Simuliidae		Pupae	34	0.27%
				Stratiomyidae		Larvae	12	0.10%
				Stratiomyidae	Caloparyphus/Euparyphus	Larvae	5	0.04%
				Stratiomyidae	Euparyphus sp.	Larvae	7	0.06%
				Tabanidae	Tabanus sp.	Larvae	1	0.01%
				Tipulidae		Larvae	6	0.05%
				Tipulidae	Tipula sp.	Larvae	32	0.25%
			Ephemeroptera	nd		Larvae	25	0.20%
				Baetidae		Larvae	612	4.85%
				Baetidae	Baetis sp.	Larvae	711	5.63%
				Baetidae	Callibaetis sp.	Larvae	68	0.54%
				Baetidae	Diphetor hageni	Larvae	1	0.01%
				Baetidae	Fallceon quilleri	Larvae	3	0.02%
				Caenidae		Larvae	2	0.02%
				Caenidae	Caenis sp.	Larvae	44	0.35%
				Leptohyphidae		Larvae	5	0.04%
				Leptophlebiidae		Larvae	7	0.06%
			Hemiptera	nd		Adult	55	0.44%
				Belostomatidae		Adult	16	0.13%
				Belostomatidae	Abedus sp.	Adult	3	0.02%
				Belostomatidae	Belostoma	Adult	0	0.00%
				Corixidae		Adult	157	1.24%
			Lepidoptera	Pyralidae		Larvae	25	0.20%
				Pyralidae/Crambidae	Crambus sp.	Larvae	50	0.40%
			Odonata	nd		Larvae	3	0.02%
				Aeshnidae		Larvae	8	0.06%
				Coenagrionidae		Larvae	10	0.08%
				Coenagrionidae	Argia sp./Enallagma sp.	Larvae	1191	9.43%
				Coenagrionidae	Argia sp.	Larvae	698	5.53%
				Coenagrionidae	Enallagma sp.	Larvae	23	0.18%
			Plecoptera	nd		Larvae	2	0.02%
				Capniidae		Larvae	1	0.01%
				Chloroperlidae		Larvae	2	0.02%
				Nemouridae		Larvae	21	0.17%
				Perlodidae		Larvae	4	0.03%
				Taeniopterygidae		Larvae	1	0.01%
			Trichoptera	nd		Larvae	1	0.01%
				Brachycentridae		Larvae	1	0.01%
				Hydrobiosidae		Larvae	1	0.01%
				Hydropsychidae		Larvae	8	0.06%
				Hydropsychidae	Hydropsyche sp.	Larvae	2	0.02%
				Hydroptilidae		Larvae	20	0.16%
				Philopotamidae		Larvae	28	0.22%
				Philopotamidae	Dolophilodes sp.	Larvae	2	0.02%
				Polycentropodidae		Larvae	86	0.68%
				Polycentropodidae	Cyrnellus	Larvae	5	0.04%
				Polycentropodidae	Polycentropus sp.	Larvae	23	0.18%
				Psychomyiidae		Larvae	1	0.01%
	Crustacea	Malacostraca	Amphipoda	nd			47	0.37%
				Hyalellidae	Hyalella sp.		790	6.26%
			Decapoda	nd			56	0.44%
				Cambaridae	Procambarus clarkii sp.		41	0.32%
		Ostracoda		nd			139	1.10%
	Chelicerata	nd	nd	nd			15	0.12%
		Arachnida		nd			70	0.55%
			Trombidiformes	nd			12	0.10%
			Trombidiformes	Hydrodromidae			2	0.02%
Annelida	Clitellata	Oligochaeta	nd				3	0.02%
Mollusca		Gastropoda	nd				38	0.30%

TASK 3. Appendix 3A - Drift Net Taxa List

Mollusca		Gastropoda	nd				38	0.30%
			Basommatophora	nd			1	0.01%
				Lymnaeidae			1	0.01%
				Physidae			1	0.01%
				Physidae	Physa sp.		5	0.04%
				Planorbidae			4	0.03%
				Planorbidae	Gyraulus sp.		1	0.01%
				Valvatidae			1	0.01%
			Neotaenioglossa	Hydrobiidae			44	0.35%
Platyhelminthes		Turbellaria	Tricladida	planarian			6	0.05%
TERRESTRIAL and NON-BENTHIC (not included in IBI)								
Arthropoda	Hexapoda	Insecta	Adult flying insect	nd		Adult	26	0.21%
			Diptera	nd		Adult	375	2.97%
			Diptera	Chironomidae		Adult	181	1.43%
			Diptera	Raphidioptera			1	0.01%
			Coleoptera	nd			4	0.03%
			Coleoptera	Carabidae			4	0.03%
			Coleoptera	Coccinellidae			1	0.01%
			Coleoptera	Curculionidae		larvae	3	0.02%
			Coleoptera	Georyssidae			5	0.04%
			Coleoptera	Staphylinidae		Adults	3	0.02%
			Coleoptera	Elateridae		Adult	1	0.01%
			Coleoptera	Cantharidae		Adult	1	0.01%
			Epheperoptera	Baetidae		Adult	1	0.01%
			Hemiptera	nd			164	1.30%
			Hemiptera	Aphidoidea	aphid	Adult	250	1.98%
			Hemiptera	Pleidae			11	0.09%
			Hemiptera	Hebridae			14	0.11%
			Hemiptera	Veliidae			13	0.10%
			Hemiptera	Macroveliidae	Macrovelia sp.		18	0.14%
			Hemiptera	Mesovelidae			27	0.21%
			Hemiptera	Veliidae	Microvelia sp.		37	0.29%
			Hemiptera	Gerridae			47	0.37%
			Hemiptera	Gerridae	Metrobates hesperius sp.		44	0.35%
			Hemiptera	Gerridae	Trepobates		3	0.02%
			Hemiptera	Saldidae			7	0.06%
			Hemiptera	Miridae		adult	3	0.02%
			Hemiptera	Nepidae		nymph	1	0.01%
			Hemiptera	Lygaeidae		adult	2	0.02%
			Hemiptera	Largidae			3	0.02%
			Hemiptera	Reduviidae		nymph	1	0.01%
			Homoptera	nd		adult	68	0.54%
			Homoptera	nd		nymph	15	0.12%
			Homoptera	Cicadellidae		adult	4	0.03%
			Hymenoptera	nd		Adult	29	0.23%
			Hymenoptera	Apidae	Apis mellifera	Adult	2	0.02%
			Hymenoptera	Formiscidae		Adult	179	1.42%
			Lepidoptera	nd			48	0.38%
			Lepidoptera	Cosmopterigidae			11	0.09%
			Psocoptera	nd			5	0.04%
			Thysanoptera	nd		Adult	707	5.60%
		Entognatha	nd	nd			12	0.10%
			Collembola	nd			11	0.09%
			Collembola	Poduridae			1	0.01%
			Collembola	Smithuridae			11	0.09%
Annelida	Clitellata	Oligocheata					2	0.02%
Arthropoda	Chelicerata	Arachnida	nd	nd			122	0.97%
			Araneae	nd		Adult	46	0.36%
	Crustacea	Malacostraca	Isopoda				8	0.06%
OTHER (not included in IBI)								
Arthropoda	Crustacea	Copepoda	nd	nd			1581	12.52%
		Branchiopoda	Cladocera	Daphniidae	Daphnia sp.		51	0.40%
							12628	100.00%

Appendix 3B

Kick Net Taxa List

TASK 3. MAINSTEM NURSERY HABITAT EVALUATION 2013 – 2018

SANTA MONICA BAY
ANADROMOUS ADULT AND JUVENILE
STEELHEAD MONITORING
2013-2018

Prepared for
CDFW contract No P1250013

Prepared by:

RCD of the Santa Monica Mountains
540 S. Topanga Canyon Blvd.
Topanga, CA 90290

May 2018

TASK 3. Appendix 3B - Kick Net Taxa List

Taxalist and abundance calculations for benthic macroinvertebrates from Topanga kick nets.

Phylum	Subphylum	Class	Order	Family	Taxon	Life Stage	Total #	Percent
AQUATIC								
Arthropoda	Hexapoda	Insecta	Coleoptera	nd		Larvae	1	0.0%
			Coleoptera	nd		Adult	1	0.0%
			Coleoptera	Dytiscidae		Adult	1	0.0%
			Coleoptera	Dytiscidae		Larvae	1	0.0%
			Coleoptera	Dytiscidae	Agabus sp.	Larvae	3	0.0%
			Coleoptera	Elmidae		Adult	7	0.1%
			Coleoptera	Elmidae	Microcylloepus sp.	Larvae	8	0.1%
			Coleoptera	Eulichadidae		Larvae	1	0.0%
			Coleoptera	Eulichadidae		Adult	1	0.0%
			Coleoptera	Haliplidae	Peltodytes sp.	Larvae	3	0.0%
			Coleoptera	Lutrochidae	Lutrochus sp.	Larvae	1	0.0%
			Diptera	Ceratopogonidae		Larvae	2	0.0%
			Diptera	Ceratopogonidae		Larvae	3	0.0%
			Diptera	Ceratopogonidae		Pupae	22	0.3%
			Diptera	Chironomidae		Larvae	3700	57.9%
			Diptera	Chironomidae		Pupae	56	0.9%
			Diptera	Chironomidae	Chironiminae	Larvae	6	0.1%
			Diptera	Chironomidae	Chironomini	Larvae	2	0.0%
			Diptera	Chironomidae	Tanytarsini	Larvae	6	0.1%
			Diptera	Chironomidae	Reotanytarsus	Larvae	3	0.0%
			Diptera	Chironomidae	Orthocladiinae	Larvae	1	0.0%
			Diptera	Chironomidae	Orthocladiinae	Pupae	1	0.0%
			Diptera	Chironomidae	Orthocladius	Pupae	3	0.0%
			Diptera	Chironomidae	Tanypodinae	Larvae	40	0.6%
			Diptera	Culicidae	Culex sp.	Larvae	3	0.0%
			Diptera	Dixidae	Dixa sp.	Larvae	1	0.0%
			Diptera	Dolichopodidae		Larvae	1	0.0%
			Diptera	Empididae		Larvae	6	0.1%
			Diptera	Empididae	Chelifera	Larvae	4	0.1%
			Diptera	Ephydridae		Larvae	1	0.0%
			Diptera	Simuliidae	Simulium sp.	Larvae	186	2.9%
			Diptera	Simuliidae		Pupae	8	0.1%
			Diptera	Simuliidae		Larvae	108	1.7%
			Diptera	Stratiomyidae	Caloparyphus/Euparyphus	Larvae	1	0.0%
			Diptera	Stratiomyidae	Euparyphus sp.	Larvae	1	0.0%
			Diptera	Tipulidae		Larvae	1	0.0%
			Diptera	Tipulidae	Tipula sp.	Larvae	21	0.3%
			Ephemeroptera	nd		Larvae	18	0.3%
			Ephemeroptera	Ephemerellidae		Larvae	1	0.0%
			Ephemeroptera	Baetidae		Larvae	378	5.9%
			Ephemeroptera	Baetidae	Baetis sp.	Larvae	126	2.0%
			Ephemeroptera	Baetidae	Fallceon quilleri	Larvae	31	0.5%
			Ephemeroptera	Caenidae		Larvae	1	0.0%
			Ephemeroptera	Leptohyphidae		Larvae	2	0.0%
			Ephemeroptera	Leptophlebiidae		Larvae	6	0.1%
			Ephemeroptera	Leptophlebiidae	Paraleptophlebia sp.	Larvae	1	0.0%
			Ephemeroptera	Leptophlebiidae	Leptophlebia sp.	Larvae	3	0.0%
			Lepidoptera	Pyralidae		Larvae	1	0.0%
			Lepidoptera	Crambidae	Crambus sp.	Larvae	3	0.0%
			Odonata	Coenagrionidae	Argia sp.	Larvae	139	2.2%
			Odonata	Coenagrionidae	Enallagma sp.	Larvae	38	0.6%
			Plecoptera	Nemouridae		Larvae	4	0.1%
			Trichoptera	Hydrobiosidae		Larvae	1	0.0%
			Trichoptera	Hydropsychidae		Larvae	15	0.2%
			Trichoptera	Hydropsychidae	Hydropsyche sp.	Larvae	2	0.0%
			Trichoptera	Hydroptilidae		Larvae	6	0.1%
			Trichoptera	Philopotamidae		Larvae	76	1.2%
			Trichoptera	Polycentropodidae		Larvae	96	1.5%
	Crustacea	Malacostraca	Amphipoda	Hyalellidae	Hyalella sp.		512	8.0%
			Decapoda	Cambaridae			125	2.0%
			Decapoda	Cambaridae	Procambarus clarkii sp.		4	0.1%
		Ostracoda					52	0.8%
	Chelicerata	Arachnida			Acari		18	0.3%
Annelida	Clitellata	nd	nd	nd			34	0.5%
		Oligochaeta					5	0.1%
Mollusca		Gastropoda	nd	nd			6	0.1%
			Basommatophora	Physidae	Physa sp.		11	0.2%
				Physidae			23	0.4%
				Valvatidae			6	0.1%
			Mesogastropoda	Viviparidae			5	0.1%
			Neotaenioglossa	Hydrobiidae			39	0.6%
Platyhelminthes		Turbellaria					117	1.8%
TERRESTRIAL (not included in IBI)								
Arthropoda	Hexapoda	Insecta	Diptera	nd		Adult	68	1.1%
			Diptera	Ceratopogonidae		Adult	1	0.0%
			Diptera	Chironomidae		Adult	5	0.1%
			Diptera	Culicidae		Adult	1	0.0%
			Ephemeroptera	nd		Adult	1	0.0%
			Hemiptera	nd		Adult	2	0.0%
			Hemiptera	Aphidoidea	aphid	Adult	15	0.2%
			Hemiptera	Hebridae		Adult	1	0.0%
			Hemiptera	Macroveliidae	Macrovelia sp.	Adult	3	0.0%
			Hemiptera	Veliidae	Microvelia sp.	Adult	9	0.1%
			Hemiptera	Gerridae		Adult	1	0.0%