Appendix J, Winter and Spring Pulses and Delta Outflow

Attachment J.3 Zooplankton-Delta Outflow Analysis

J.3.1 Model Overview

Zooplankton are an important food source for many larval, juvenile, and small pelagic fishes in the Bay-Delta. Delta smelt and longfin smelt are two species that rely on zooplankton. This analysis followed the general framework of similar, prior analyses (Kimmerer 2002; Hennessy and Burris 2017; Greenwood 2018; California Department of Water Resources and U.S. Bureau of Reclamation 2023:2-10) to examine the relationship between Delta outflow and Delta smelt and longfin smelt zooplankton prey density (catch per cubic meter) in the low salinity zone (i.e., 0.5–6 parts per thousand salinity). The analyses related prey density to Delta outflow during winter (December - February), spring (March–May), summer (June–August), and fall (September–November) for the period from 2000 to 2021. This period generally represents the onset of the Pelagic Organism Decline ecological regime (Thomson et al. 2010). Zooplankton examined in the analyses were based on taxa (species or species groupings, split by life stage where appropriate) included in recent modeling and diet studies of both Delta smelt and longfin smelt (Slater and Baxter 2014, Smith 2021:45; Barros et al. 2022; Smith and Nobriga 2023). Results demonstrate the relationship between seasonal abundance of smelt prey in the Delta and outflow, controlled by CVP and SWP seasonal operations.

J.3.2 Model Development

J.3.2.1 Methods

Historical zooplankton data were synthesized using the R (R Core Team 2023) statistical software package zooper (Bashevkin et al. 2022; Bashevkin et al. 2023a, b). Data was subset as follows. For mysids, surveys included 'EMP' (Environmental Monitoring Program) data, whereas for other taxa surveys included 'EMP' as well as '20mm' (20-mm Survey, March - July), 'STN' (Summer Townet, June - August) and 'FMWT' (Fall Midwater Trawl, September - December). The data type chosen was 'Community', with size class of 'Macro' for mysids and 'Micro', 'Meso', and 'Macro' for other taxa. Only samples within the low salinity zone (salinity = 0.5–6 parts per thousand) were selected. The mean catch per unit effort (number per cubic meter) was calculated by year and for each season.

Historical Delta outflow data by year for each seasonal period were obtained from Dayflow via the Drought Data R package's dataset and are available upon request.

For each taxon, mean seasonal loge-transformed catch per unit effort + 1 for each taxon for each year was regressed against mean loge-transformed Delta outflow for each seasonal period for each year. Statistically significant regressions (Table J.3-1 through Table J.3-3) were then applied to seasonal 1922-2021 CalSim 3-modeled data for Baseline Conditions and Proposed Action scenarios for each season (e.g. only CalSim 3 modeled outflow from Dec. to Jan. was used for the winter analysis), with predictions back-transformed to the original measurement scale (catch per unit effort, number per cubic meter) for summary of results.

Table J.3-1. Winter (December – February) zooplankton regression summary. Bolded text indicates statistically significant (P<0.05) regressions subsequently applied to CalSim 3-modeled data. Note: regressions were loge(mean seasonal catch per meter+1) = loge(mean seasonal Delta outflow).

Taxon	Intercept	Slope	R2	P
Acartiella sinensis (copepod) adults	6.139	-0.120	0.011	0.635
Amphipods	-0.316	0.064	0.007	0.714
Barnacle larvae	1.078	0.122	0.008	0.687
Cladocerans except *Daphnia*	-2.674	0.601	0.151	0.073
Copepod nauplii	10.017	0.051	0.006	0.741
Cyclopoid copepods except *Limnoithona* adults	4.101	0.383	0.121	0.112
***Daphnia* adults**	**-4.518**	**0.682**	**0.206**	**0.034**
Decapod larvae	**-1.93**	**0.198**	**0.534**	**0.000**
***Eurytemora affinis* (copepod) adults**	**-2.219**	**0.641**	**0.227**	**0.025**
Harpacticoid copepods	2.783	0.313	0.046	0.336
Limnoithona (cyclopoid) adults	7.794	0.066	0.005	0.759
Mysids	0.749	0.052	0.008	0.699
Other calanoid copepod adults	**-15.955**	**1.858**	**0.598**	**0.000**
Other calanoid copepod copepodites	**-4.289**	**1.027**	**0.319**	**0.006**
Pseudodiaptomus (copepod) adults	6.136	-0.236	0.014	0.596
Pseudodiaptomus copepodites	4.355	-0.165	0.009	0.681

Table J.3-2. Spring (March–May) zooplankton regression summary. Bolded text indicates statistically significant (P<0.05) regressions subsequently applied to CalSim 3-modeled data. Note: regressions were loge(mean seasonal catch per meter+1) = loge(mean seasonal Delta outflow).

Taxon	Intercept	Slope	R2	P
Acartiella sinensis (copepod) adults	8.134	-0.506	0.125	0.107
Cladocerans except *Daphnia*	**-3.746**	**0.730**	**0.365**	**0.003**
Copepod nauplii	10.145	0.140	0.079	0.205
Cyclopoid copepods except *Limnoithona* adults	7.441	0.042	0.005	0.764
Daphnia adults	-0.639	0.318	0.169	0.057
***Eurytemora affinis* (copepod) adults**	**0.234**	**0.528**	**0.255**	**0.016**
Harpacticoid copepods	**1.072**	**0.501**	**0.309**	**0.007**
Limnoithona adults	7.973	0.135	0.030	0.439
Mysids	1.563	0.114	0.015	0.593
Other calanoid copepod adults	**-1.593**	**0.669**	**0.210**	**0.032**
Other calanoid copepod copepodites	**2.296**	**0.469**	**0.357**	**0.003**
Pseudodiaptomus (copepod) adults	4.496	0.053	0.001	0.874
Pseudodiaptomus (copepod) copepodites	0.882	0.476	0.149	0.076

Table J.3-3. Summer (June–August) zooplankton regression summary. Note: Regressions were loge(mean seasonal catch per meter+1) = loge(mean seasonal Delta outflow). None of the regressions were statistically significant (P<0.05).

Taxon	Intercept	Slope	R2	P
Acartiella sinensis (copepod) adults	3.779	0.196	0.006	0.732
Cladocerans except *Daphnia*	11.625	-0.836	0.034	0.410
Copepod nauplii	10.883	0.163	0.038	0.385
Cyclopoid copepods except *Limnoithona* adults	9.204	-0.021	0.000	0.922
Daphnia adults	13.713	-1.316	0.104	0.143
Eurytemora affinis (copepod) adults	-2.567	0.445	0.055	0.294
Harpacticoid copepods	-2.539	0.788	0.119	0.117
Limnoithona adults	9.811	0.077	0.012	0.621
Mysids	0.065	0.364	0.031	0.211
Other calanoid copepod adults	8.603	-0.444	0.076	0.215
Other calanoid copepod copepodites	4.051	0.188	0.024	0.487
Pseudodiaptomus (copepod) adults	4.822	0.211	0.058	0.282
Pseudodiaptomus (copepod) copepodites	2.674	0.435	0.072	0.228

Table J.3-4. Fall (September–November) zooplankton regression summary. Bolded text indicates statistically significant ($P<0.05$) regressions subsequently applied to CalSim 3-modeled data. Note: Regressions were loge(mean seasonal catch per meter+1) = loge(mean seasonal Delta outflow).

Taxon	Intercept	Slope	R2	P
Acartiella sinensis (copepod) adults	7.658	-0.119	0.005	0.752
Cladocerans except *Daphnia*	14.953	-1.375	0.053	0.300
Copepod nauplii	8.321	0.427	0.095	0.164
Cyclopoid copepods except *Limnoithona* adults	9.852	-0.069	0.002	0.862
Daphnia adults	6.854	-0.729	0.038	0.382
***Eurytemora affinis* (copepod) adults**	**-6.972**	**0.908**	**0.234**	**0.023**
Harpacticoid copepods	4.114	0.054	0.000	0.960
Limnoithona adults	5.613	0.542	0.173	0.054
Mysids	**-7.945**	**1.153**	**0.213**	**0.018**
Other calanoid copepod adults	6.321	-0.436	0.012	0.621
Other calanoid copepod copepodites	2.286	0.359	0.032	0.426
Pseudodiaptomus (copepod) adults	11.444	-0.581	0.146	0.080
Pseudodiaptomus (copepod) copepodites	10.184	-0.484	0.047	0.334

J.3.2.2 Assumptions / Uncertainty

This analysis is meant as a tool to compare mean abundance of zooplankton prey across different operation scenarios and is not a predictive tool.

While Delta outflow explains some of the variance in zooplankton CPUE, the relatively low R2 values suggest that other factors contribute as well. A historical regression of zooplankton CPUE with flow may be too simple and including other factors such as salinity, temperature, chlorophyll-*a*, residence time, etc., may have more explanatory power. For example, Hartman et al. (2024) found regional differences in the effects of drought on both chlorophyll and total zooplankton biomass due to differential impacts of residence time and top-down control by predation (especially the overbite clam, *Potamocorbula amurensis*).

Both Delta outflow and inflow are highly correlated (Kimmerer 2004); outflow is used as the variable of interest because it is more readily available and more easily linked to the position of X2, which is correlated with the geographical position and extent of the low salinity zone. There are various hypothesized mechanisms for how flow affects zooplankton abundance in the low salinity zone including subsidies of zooplankton, phytoplankton, or nutrients from more productive upstream regions into the low salinity zone (Hassrick et al. 2023, Kimmerer et al. 2019, Kimmerer 2002).

Historically, relationships between outflow and zooplankton abundance have changed over time (e.g., mysids in the summer) or relationships have become significant with increased outflow (e.g., *E. affinis* in the spring) or there is no relationship with outflow (e.g. rotifers and *E. affinis* in the summer) (Kimmerer 2009).

Zooplankton CPUE exhibits high variability, across regions, seasons, and years (Winder and Jassby 2011, Bollens et al. 2014, Lee et al. 2023), which may limit the statistical power to detect effects of flow alterations (Brandon et al. 2022).

J.3.2.3 Code and Data Repository

Biological data can be found online at www.wildlife.ca.gov/Conservation/Delta/Zooplankton-Study and are available upon request.

Hydrologic data can be found online at http://www.water.ca.gov/dayflow/output/

R code and results are available upon request.

J.3.3 Results

Results are presented by taxon for statistically significant zooplankton regressions by water year type for each alternative in Table J.3-6: Mean **Winter** (December – February) CalSim 3 outflow (cfs) by modeled scenario and different water year types. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	90861	88823 (-2%)	91382 (1%)	91313 (0%)	91068 (0%)	91128 (0%)	97388 (7%)	91469 (1%)
Above Normal	48883	46101 (-6%)	49101 (0%)	48992 (0%)	49058 (0%)	49246 (1%)	53786 (10%)	49046 (0%)
Below Normal	23935	21606 (-10%)	24309 (2%)	24152 (1%)	24060 (1%)	24231 (1%)	27913 (17%)	24319 (2%)
Dry	17030	14660 (-14%)	17481 (3%)	17473 (3%)	17441 (2%)	17509 (3%)	20454 (20%)	17133 (1%)
Critical	11882	10006 (-16%)	12184 (3%)	12079 (2%)	11931 (0%)	11875 (0%)	13723 (15%)	11898 (0%)

Table J.3-5 through Table J.3-.

Tables include results from Exploratory 1 (EXP 1), Exploratory 3 (EXP 3), No Action Alternative (NAA), Alternative 2 with TUCP Without VA (Alt2wTUCPwoVA), Alternative 2 Without TUCP Without VA (Alt2woTUCPwoVA), Alternative 2 Without TUCP Delta VA (Alt2woTUCPDeltaVA), and Alternative 2 Without TUCP Systemwide VA (Alt2woTUCPAllVA).

Another set of tables include results from No Action Alternative (NAA), Alternative 1 (Alt1), Alternative 2 with TUCP Without VA (Alt2wTUCPwoVA), Alternative 2 Without TUCP Without VA (Alt2woTUCPwoVA), Alternative 2 Without TUCP Delta VA (Alt2woTUCPDeltaVA), and Alternative 2 Without TUCP Systemwide VA (Alt2woTUCPAllVA), Alternative 3 (Alt3), Alternative 4 (Alt4).

J.3.3.1 Winter:

During winter months (December to February), CPUE for the following taxa was significantly related to Delta outflow: *Daphnia* adults, Decapod larvae, *Eurytemora affinis* (copepod) adults, Other calanoid copepod adults, Other calanoid copepod copepodites (Table J.3-1).

J.3.3.1.1 Daphnia *adults*

For *Daphnia* in the winter, during the **wet year type**, Alternative 3 had the highest CPUE (26) which was a 4% increase compared to the NAA. All other scenarios were no different from the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (17) which was a 6% increase compared to the NAA. Alternative 1 had the lowest CPUE (15) which was a 6% decrease compared to the NAA. All other scenarios were no different from the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (11) which was a 22% increase compared to the NAA. All other scenarios were no different from the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (8) which was a 14% increase compared to the NAA. Alternative 1 had the lowest CPUE (6) which was a 14% decrease compared to the NAA. All other scenarios were no different from the NAA.

For the **critical year type**, Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA and Alternative 3 had the highest CPUE (6) which was a 20% increase compared to the NAA. All other scenarios were no different from the NAA.

Historically, abundance of *Daphnia* in the low salinity zone (LSZ) is lower when compared to more freshwater regions, only sporadically appearing in the LSZ regions (Winder and Jassby 2011, Fig. 7). *Daphnia pulex* was found mainly during the winter-spring season (Ambler et al. 1985).

The mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow in the spring and summer, suggesting a bottom up, "agricultural model" explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater regions into the LSZ (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during the Wet WYT and lowest during Critical WYT. Similarly, outflow was highest during Wet years and lowest during Critical years. Compared to the NAA, outflow was consistently higher for

Alternative 3, similar for the phases of Alternative 2 and Alternative 4, and lower for Alternative 1 across all WYT. While CPUE was similarly highest for Alternative 3 across all WYTs, CPUE estimates for the other scenarios were similar regardless of differences in outflow. This is likely because CPUE for the taxa was relatively low overall, and any changes in CPUE were negligible when accounting for rounding to the nearest whole integer. Changes in CPUE across WYT and scenarios only differed by 1 – 2 CPUE when compared to the NAA (Table J.3-).

J.3.3.1.2 Decapod larvae

Results for decapod larvae were negligible when rounded to the nearest whole integer (values were 0) across all WYT and scenarios. Percent differences between the various scenarios were negligible as well. No table or figure is presented for decapod larvae.

J.3.3.1.3 Eurytemora affinis (copepod) adults

For *Eurytemora affinis* (copepod) adults in the winter, during the **wet year type**, Alternative 3 had the highest CPUE (169) which was a 5% increase compared to the NAA. Alternative 1 had the lowest CPUE (159) which was a 1% decrease compared to the NAA. All other scenarios had the same CPUE (162) which was a 1% increase compared to the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (115) which was a 7% increase compared to the NAA. Alternative 1 had the lowest CPUE (103) which was a 4% decrease compared to the NAA. Alternative 2 Alternative 2 Without TUCP Systemwide VA showed a 1% increase (108) compared to the NAA. All other scenarios were no different from the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (75) which was a 12% increase compared to the NAA. Alternative 1 had the lowest CPUE (62) which was a 7% decrease compared to the NAA. Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, Alternative 2 Without TUCP Systemwide VA, and Alternative 4 showed a 1% increase compared to the NAA. Alternative 2 Without TUCP Delta VA was no different from the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (61) which was a 13% increase compared to the NAA. Alternative 1 had the lowest CPUE (49) which was a 9% decrease compared to the NAA. All phases of Alternative 2 showed a 2% increase compared to the NAA. Alternative 4 was no different from the NAA.

For the **critical year type**, Alternative 3 had the highest CPUE (47) which was a 9% increase compared to the NAA. Alternative 1 had the lowest CPUE (38) which was a 12% decrease compared to the NAA. Alternative 2Without TUCP Without VA showed a 2% increase compared to the NAA. All other scenarios were no different from the NAA.

Kimmerer (2002) found a significant relationship between adult *E. affinis* and outflow in the spring. However, this relationship was only present after 1987, the post *Potamocorbula amurensis* invasion period which also coincided with a seven-fold decline in *E. affinis*. Ambler et al. (1985) also noted that winter floods can carry *E. affinis* downstream as far as northern Central Bay, suggesting an effect of flow on the range of *E. affinis.*

The mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow, suggesting a bottom up, "agricultural model" explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater regions into the LSZ (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during Wet years and lowest during Critical years. Similarly, outflow was highest during Wet years and lowest during Critical years. During the Wet WYT, flow and CPUE was highest for Alternative 3, relatively similar across the different Alternative 2 phases and Alternative 4 and decreased for Alternative 1 compared to the NAA. This pattern was repeated for the other WYT. Increase in CPUE for Alternative 3 ranged from 5 – 12%. Decreases in CPUE for Alternative 1 ranged from 1 – 12%. Changes in CPUE for the different Alternative 2 phases and Alternative 4 were relatively minor, ranging from 0 – 3%.

J.3.3.1.4 Other calanoid copepod adults

For Other calanoid copepod adults in the winter, during the **wet year type**, Alternative 3 had the highest CPUE (236) which was a 12% increase compared to the NAA. Alternative 1 had the lowest CPUE (204) which was a 3% decrease compared to the NAA. Alternative 2 Without TUCP Without VA, Alternative 2 Without TUCP Without VA, and Alternative 4 showed a 1% increase compared to the NAA. Alternative 2 Without TUCP Delta VA and Alternative 2 Without TUCP Systemwide VA were no different from the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (80) which was a 16% increase compared to the NAA. Alternative 1 had the lowest CPUE (63) which was a 9% decrease compared to the NAA. Alternative 2 Without TUCP Systemwide VA showed a 1% increase compared to the NAA. All other scenarios were no different from the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (24) which was a 33% increase compared to the NAA. Alternative 1 had the lowest CPUE (15) which was a 17% decrease compared to the NAA. Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, Alternative 2 Without TUCP Systemwide VA, and Alternative 4 showed a 6% increase compared to the NAA. Alternative 2 Without TUCP Delta VA was no different from the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (12) which was a 33% increase compared to the NAA. Alternative 1 had the lowest CPUE (6) which was a 33% decrease compared to the NAA. All other scenarios were no different from the NAA.

For the **critical year type**, Alternative 3 had the highest CPUE (6) which was a 50% increase compared to the NAA. Alternative 1 had the lowest CPUE (3) which was a 25% decrease compared to the NAA. Alternative 2 Without TUCP Without VA showed a 2% increase compared to the NAA. All other scenarios were no different from the NAA.

The other calanoid copepods species included as part of "other adult calanoid copepods" were: *Acartia* spp., unidentified calanoids, *Sinocalanus doerrii*, *Tortanus* spp., and Diaptomidae.

Acartia spp. are the dominant copepod at salinities higher than 10 ppt and are occasionally present in the LSZ regions (Ambler et al. 1985, Winder and Jassby 2011). Kimmerer (2002) found *Acartia* abundance may have a positive relationship with increased outflow for salinities from 6-20 (the analysis found it was not statistically significant but data from two outlier years increased error variance).

Historically, since its introduction in 1978, *S. doerrii* was most abundant in the Suisun Bay region, with peak abundance during the spring to summer season, although it was noted that flow during winter would advect individuals into San Pablo Bay (Ambler et al. 1985). Since then, the range of *S. doerrii* has shifted landwards, likely because of effects of *Potamcorbula amurensis* grazing (Kimmerer et al. 1998).

Tortanus spp. is an introduced predatory copepod associated with higher salinities (Bollens et al. 2014). *Tortanus* spp. is found less frequently in LSZ regions when there is increased outflow, likely due to lower salinities (Lee et al. 2023).

Diaptomidae are associated with other freshwater species/taxa such as Daphnidae and *Bosmina longirostris* (Bollens et al. 2014, Table 1). In the summer and fall seasons, Diaptomidae are a dominant taxon in the calanoid copepod community in the Sacramento River (Frantzich et al. 2018).

The mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow, suggesting a bottom up, "agricultural model" explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater seasons into the LSZ (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during Wet years and lowest during Critical years. Similarly, outflow was highest during Wet years and lowest during Critical years. During the Wet WYT, flow and CPUE was highest for Alternative 3, relatively similar across the different Alternative 2 phases and Alternative 4 and decreased for Alternative 1 compared to the NAA. This pattern was repeated for the other WYT. Increases for Alternative 3 ranged from 16 – 50%. Decreases for Alternative 1 ranged from 3 – 25%. Changes in CPUE for the different Alternative 2 phases and Alternative 4 were relatively minor, ranging from 0 – 6%.

J.3.3.1.5 Other calanoid copepod copepodites

For Other calanoid copepod copepodites in the winter, during the **wet year type**, Alternative 3 had the highest CPUE (1834) which was a 7% increase compared to the NAA. Alternative 1 had the lowest CPUE (1669) which was a 2% decrease compared to the NAA. Alternative 2Without TUCP Without VA, Alternative 2 Without TUCP Without VA , and A4 showed a 1% increase compared to the NAA. Alternative2Without TUCP Delta VA and Alternative 2 Without TUCP Systemwide VA were no different from the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (996) which was a 10% increase compared to the NAA. Alternative 1 had the lowest CPUE (851) which was a 6% decrease compared to the NAA. Alternative 2 Without TUCP Systemwide VA showed a 1% increase compared to the NAA. All other scenarios were no different from the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (508) which was a 17% increase compared to the NAA. Alternative 1 had the lowest CPUE (390) which was a 10% decrease compared to the NAA. Alternative 2 Without TUCP Without VA, and Alternative 4 showed a 2% increase compared to the NAA. Alternative 2 with TUCP Without VA and Alternative 2 Without TUCP Systemwide VA showed a 1% increase compared to the NAA. Alternative 2 Without TUCP Delta VA was no different from the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (368) which was a 21% increase compared to the NAA. Alternative 1 had the lowest CPUE (261), which was a 14% decrease compared to the NAA. All Alternative 2 phases showed a 3% increase compared to the NAA. Alternative 4 showed a 1% increase compared to the NAA.

For the **critical year type**, Alternative 3 had the highest CPUE (244) which was a 16% increase compared to the NAA. Alternative 1 had the lowest CPUE (176) which was a 16% decrease compared to the NAA. Alternative 2 Without TUCP Without VA showed a 3% increase compared to the NAA. Alternative 2 With TUCP Without VA showed a 2% increase compared to the NAA. All other scenarios were no different from the NAA.

The other calanoid copepods species included as part of “other copepodite calanoid copepods” were: *Acartia* spp., *Acartiella* spp., unidentified calanoids, *Eurytemora affinis*, *Sinocalanus doerrii*, *Tortanus* spp., and Diaptomidae.

Acartia spp. are the dominant copepod at salinities higher than 10 ppt but are occasionally present in the LSZ regions (Ambler et al. 1985, Winder and Jassby 2011). Kimmerer (2002) found *Acartia* abundance may have a positive relationship with increased outflow for salinities from 6-20 (his analysis found it was not statistically significant but data from two outlier years increased error variance).

Acartiella spp. is an introduced copepod predator present in the LSZ (Bollens et al. 2014). *Acartiella* spp. is found less frequently in LSZ regions when there is increased outflow, likely due to lower salinities (Lee et al. 2023).

Kimmerer (2002) found that adult *E. affinis* abundance had a positive relationship with outflow, analysis of the relationship between juvenile *E. affinis* and flow is limited. However, this relationship was only present after 1987, the post *Potamocorbula amurensis* invasion period which also coincided with a seven-fold decline in *E. affinis*. Ambler et al. (1985) also noted that winter floods can carry *E. affinis* downstream as far as northern Central Bay, suggesting an effect of flow on the range of *E. affinis*.

Historically, since its introduction in 1978, *S. doerrii* was most abundant in the Suisun Bay region, with peak abundance during the spring to summer season, though it was noted that flow during winter would advect individuals into San Pablo Bay (Ambler et al. 1985). Since then, the range of *S. doerrii* has shifted landwards, likely because of effects of *Potamcorbula amurensis* grazing (Kimmerer et al. 1998). Therefore, increased flow is possibly advecting more individuals from more freshwater regions into the LSZ.

Tortanus spp. is an introduced predatory copepod associated with higher salinities (Bollens et al. 2014). *Tortanus* spp. is found less frequently in LSZ regions when there is increased outflow, likely due to lower salinities (Lee et al. 2023).

Diaptomidae are associated with other freshwater species/taxa such as Daphnidae, *Bosmina longirostris* (Bollens et al. 2014, Table 1). In the summer and fall seasons, Diaptomidae are a dominant taxa in the calanoid copepod community in the Sacramento River (Frantzich et al. 2018).

The mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow, suggesting a bottom up, “agricultural model” explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater seasons into the LSZ (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during Wet years and lowest during Critical years. Similarly, outflow was highest during Wet years and lowest during Critical years. During the Wet WYT, flow and CPUE was highest for Alternative 3, relatively similar across the different Alternative 2 phases and Alternative 4 and decreased for Alternative 1 compared to the NAA. This pattern was repeated for the other WYT. Increases for Alternative 3 ranged from 7 – 21%. Decreases for Alternative 1 ranged from 2 – 16%. Changes in CPUE for the different Alternative 2 phases and Alternative 4 were relatively minor, ranging from 1 – 3%.

Table J.3-5: Mean **Winter** (December – February) CalSim 3 outflow (cfs) by modeled scenario and different water year types. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 woTUCP woVA	Alt2 wTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	110488	113243	90861	91313	91382	91068	91128
Above Normal	68627	67002	48883	48992	49101	49058	49246
Below Normal	38131	38061	23935	24152	24309	24060	24231
Dry	29612	27140	17030	17473	17481	17441	17509

WYT	EXP1	EXP3	NAA	Alt2 woTUCP woVA	Alt2 wTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Critical	19594	17416	11882	12079	12184	11931	11875

Table J.3-6: Mean **Winter** (December – February) CalSim 3 outflow (cfs) by modeled scenario and different water year types. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	90861	88823 (-2%)	91382 (1%)	91313 (0%)	91068 (0%)	91128 (0%)	97388 (7%)	91469 (1%)
Above Normal	48883	46101 (-6%)	49101 (0%)	48992 (0%)	49058 (0%)	49246 (1%)	53786 (10%)	49046 (0%)
Below Normal	23935	21606 (-10%)	24309 (2%)	24152 (1%)	24060 (1%)	24231 (1%)	27913 (17%)	24319 (2%)
Dry	17030	14660 (-14%)	17481 (3%)	17473 (3%)	17441 (2%)	17509 (3%)	20454 (20%)	17133 (1%)
Critical	11882	10006 (-16%)	12184 (3%)	12079 (2%)	11931 (0%)	11875 (0%)	13723 (15%)	11898 (0%)

Table J.3-5. Mean catch per unit effort (CPUE) for ***Daphnia*** **adults** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	29	29	25	25	25	25	25
Above Normal	21	20	16	16	16	16	16
Below Normal	13	13	9	9	9	9	9
Dry	11	10	7	7	7	7	7
Critical	8	7	5	6	6	5	5

Table J.3-7. Mean catch per unit effort (CPUE) for ***Daphnia* adults** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	25	25 (0%)	25 (0%)	25 (0%)	25 (0%)	25 (0%)	26 (4%)	25 (0%)
Above Normal	16	15 (-6%)	16 (0%)	16 (0%)	16 (0%)	16 (0%)	17 (6%)	16 (0%)
Below Normal	9	9 (0%)	9 (0%)	9 (0%)	9 (0%)	9 (0%)	11 (22%)	9 (0%)
Dry	7	6 (-14%)	7 (0%)	7 (0%)	7 (0%)	7 (0%)	8 (14%)	7 (0%)
Critical	5	5 (0%)	6 (20%)	6 (20%)	5 (0%)	5 (0%)	6 (20%)	5 (0%)

Table J.3-8. Mean catch per unit effort (CPUE) for ***Eurytemora affinis* (copepod) adults** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	184	187	161	162	162	162	162
Above Normal	135	133	107	107	107	107	108
Below Normal	91	92	67	68	68	67	68
Dry	78	74	54	55	55	55	55
Critical	59	55	43	43	44	43	43

Table J.3-9. Mean catch per unit effort (CPUE) for ***Eurytemora affinis* (copepod) adults** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	161	159 (-1%)	162 (1%)	162 (1%)	162 (1%)	162 (1%)	169 (5%)	162 (1%)
Above Normal	107	103 (-4%)	107 (0%)	107 (0%)	107 (0%)	108 (1%)	115 (7%)	107 (0%)
Below Normal	67	62 (-7%)	68 (1%)	68 (1%)	67 (0%)	68 (1%)	75 (12%)	68 (1%)
Dry	54	49 (-9%)	55 (2%)	55 (2%)	55 (2%)	55 (2%)	61 (13%)	54 (0%)

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Critical	43	38 (-12%)	43 (0%)	44 (2%)	43 (0%)	43 (0%)	47 (9%)	43 (0%)

Table J.3-10. Mean catch per unit effort (CPUE) for **Other calanoid copepod adults** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	295	308	210	212	212	211	211
Above Normal	123	119	69	69	69	69	70
Below Normal	43	41	18	19	19	18	19
Dry	26	21	9	9	9	9	9
Critical	13	9	4	4	4	4	4

Table J.3-11. Mean catch per unit effort (CPUE) for **Other calanoid copepod adults** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	210	204 (-3%)	212 (1%)	212 (1%)	211 (0%)	211 (0%)	236 (12%)	212 (1%)
Above Normal	69	63 (-9%)	69 (0%)	69 (0%)	69 (0%)	70 (1%)	80 (16%)	69 (0%)
Below Normal	18	15 (-17%)	19 (6%)	19 (6%)	18 (0%)	19 (6%)	24 (33%)	19 (6%)
Dry	9	6 (-33%)	9 (0%)	9 (0%)	9 (0%)	9 (0%)	12 (33%)	9 (0%)
Critical	4	3 (-25%)	4 (0%)	4 (0%)	4 (0%)	4 (0%)	6 (50%)	4 (0%)

Table J.3-6. Mean catch per unit effort (CPUE) for **Other calanoid copepod copepodites** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	2087	2141	1708	1717	1718	1712	1713
Above Normal	1280	1249	904	906	908	907	911
Below Normal	700	698	434	438	441	436	439
Dry	539	493	305	313	313	313	314
Critical	353	312	210	214	216	211	210

Table J.3-7. Mean catch per unit effort (CPUE) for **Other calanoid copepod copepodites** in **winter** by modeled scenario and water year type. Values are rounded to the nearest integer. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	1708	1669 (-2%)	1717 (1%)	1718 (1%)	1712 (0%)	1713 (0%)	1834 (7%)	1720 (1%)
Above Normal	904	851 (-6%)	906 (0%)	908 (0%)	907 (0%)	911 (1%)	996 (10%)	907 (0%)
Below Normal	434	390 (-10%)	438 (1%)	441 (2%)	436 (0%)	439 (1%)	508 (17%)	441 (2%)
Dry	305	261 (-14%)	313 (3%)	313 (3%)	313 (3%)	314 (3%)	368 (21%)	307 (1%)
Critical	210	176 (-16%)	214 (2%)	216 (3%)	211 (0%)	210 (0%)	244 (16%)	211 (0%)

J.3.3.2 Spring:

During spring months (March to May), the following taxa had a significant relationship with Delta outflow: Cladocerans (except *Daphnia*), *Eurytemora affinis* (copepod) adults, Harpacticoid copepods, Other calanoid copepod adults, and Other calanoid copepod copepodites (Table J.3-2).

J.3.3.2.1 Cladocerans (except Daphnia*)*

For Cladocerans (except *Daphnia*) in the spring, during the **wet year type**, Alternative 3 had the highest CPUE (76) which was a 10% increase compared to the NAA. Alternative 1, Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, Alternative 2 Without TUCP Delta VA, and Alternative 4 had the lowest CPUE (68) which was a 1% decrease compared to the NAA. Alternative 2 Without TUCP Systemwide VA was no different from the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (54) which was a 12% increase compared to the NAA. Alternative 1 had the lowest CPUE (44) which was an 8%

decrease compared to the NAA. Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, and Alternative 4 all showed a 4% decrease compared to the NAA. Alternative 2 Without TUCP Delta VA only showed a 2% decrease and Alternative 2 Without TUCP Systemwide VA was no different from the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (36) which was a 12% increase compared to the NAA. Alternative 1 had the lowest CPUE (30) which was a 6% decrease compared to the NAA. Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, and Alternative 4 all showed a 3% decrease compared to the NAA. Alternative 2 Without TUCP Delta VA was no different from the NAA and Alternative 2 Without TUCP Systemwide VA showed a 6% increase.

For the **dry year type**, Alternative 3 had the highest CPUE (29) which was a 16% increase compared to the NAA. Alternative 1 had the lowest CPUE (24) which was a 4% decrease compared to the NAA. Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, and Alternative 4 were no different than the NAA. Alternative 2 Without TUCP Delta VA showed a 4% increase and Alternative 2 Without TUCP Systemwide VA showed an 8% increase.

For the **critical year type**, Alternative 2 Without TUCP Systemwide VA and Alternative 3 had the highest CPUE (18), which was a 20% increase compared to the NAA. Alternative 2 Without TUCP Without VA and Alternative 4 had the lowest CPUE (15) which was the same as the NAA. Alternative 1, Alternative 2 With TUCP Without VA, and Alternative 2 Without TUCP Delta VA showed a 13% increase.

Historically, in the LSZ, CPUE of Cladocerans are lower when compared to more freshwater regions (Winder and Jassby 2011 Fig. 5, 7). While some marine and brackish water Cladocerans species are present in the San Francisco Estuary, freshwater Cladocerans tend to be more abundant in the Bay-Delta system. This could explain the lower CPUE observed during lower outflow scenarios and water year types.

Yet the mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow, suggesting a bottom up, “agricultural model” explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater regions into the LSZ (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during the Wet WYT and lowest during Critical WYT. Similarly, outflow was highest during Wet years and lowest during Critical years.

For all WYT, Alternative 3 had the highest outflow and the largest CPUE increase compared to the NAA, CPUE increases ranged from 10 – 20%. Alternative 1 generally had lower flows and lower CPUE compared to the NAA for all WYT, except for the critical year type, decreases in CPUE ranged from 1 – 8%. CPUE increased by 13% in the Critical WYT. Similarly, Alternative

2 with TUCP Without VA outflow and CPUE only increased for the critical year type compared to the NAA. Alternative 2 Without TUCP Without VA was similar to Alternative 2 with TUCP Without VA, except during the Critical WYT there was no change from the NAA. For Alternative 2 Without TUCP Systemwide VA, CPUE and outflow increased for Below Normal, Dry and Critical years. Alternative 4 outflow and CPUE generally was either slightly below or above the NAA.

J.3.3.2.2 Adult Eurytemora affinis

For adult *Eurytemora affinis* in the spring, during the **wet year type**, Alternative 3 had the highest CPUE (432) which was a 7% increase compared to the NAA. Alternative 1 had the lowest CPUE (396) which was a 2% decrease compared to the NAA.

For **above normal year type**, Alternative 3 had the highest CPUE (340) which was a 9% increase compared to the NAA. Alternative 1 had the lowest CPUE (297) which was a 5% decrease compared to the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (258) which was a 10% increase compared to the NAA. Alternative 1 had the lowest CPUE (223) which was a 5% decrease compared to the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (218) which was a 9% increase compared to the NAA. Alternative 1 had the lowest CPUE (192) which was a 4% decrease compared to the NAA.

For the **critical year type**, Alternative 3 had the highest CPUE (158), which was an 9% increase compared to the NAA. Alternative 2 Without TUCP Without VA had the lowest CPUE (141) which was the same compared to the NAA.

Kimmerer (2002) found a significant relationship between adult *E. affinis* and outflow. However, this relationship was only present after 1987, the post *Potamocorbula amurensis* invasion period, which also coincided with a seven-fold decline in *E. affinis*. This decline is likely due to predation by *P. amurensis* and replacement by another introduced calanoid copepod, *Psuedodiaptomus forbesi* which can overcome predation pressure on the population due to subsidies from more freshwater regions where *P. amurensis* isn't present (Durand 2010). Peak abundance of *E. affinis* has shifted several months to the spring season from the summer season (Merz et al. 2016).

The mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow, suggesting a bottom up, "agricultural model" explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater seasons into the LSZ as seen in *Pseudodiaptomus forbesi*, another calanoid copepod species (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during the Wet WYT and lowest during Critical WYT. Similarly, outflow was highest during Wet years and lowest during Critical years.

For all WYT, Alternative 3 had the highest outflow and the largest CPUE increase compared to the NAA, CPUE increases ranged from 7 – 12%. Alternative 1 generally had lower flows and lower CPUE compared to the NAA for all WYT, except for the critical year type, decreases in CPUE ranged from 2 – 5%. CPUE increased by 6% in the Critical WYT. Changes in outflow and CPUE for the different Alternative 2 phases and Alternative 4 were relatively minor, ranging from -2 – 4% for CPUE, except during the Critical WYT. During the Critical WYT, Alternative 2 Without TUCP Without VA and Alternative 4 outflow and CPUE were similar to the NAA, the other Alternative 2 phases showed increased outflow and CPUE increases ranging from 6 – 11% compared to the NAA.

J.3.3.2.3 Harpacticoids

For harpacticoids in the spring, during the **wet year type**, Alternative 3 had the highest CPUE (736) which was a 7% increase compared to the NAA. Alternative 1 had the lowest CPUE (678) which was a 2% decrease compared to the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (587) which was a 9% increase compared to the NAA. Alternative 1 had the lowest CPUE (517) which was a 4% decrease compared to the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (452) which was a 10% increase compared to the NAA. Alternative 1 had the lowest CPUE (393) which was a 5% decrease compared to the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (385) which was an 8% increase compared to the NAA. Alternative 1 had the lowest CPUE (342) which was a 4% decrease compared to the NAA.

For the **critical year type**, Alternative 3 had the highest CPUE (284), which was an 11% increase compared to the NAA. Alternative 2 Without TUCP Without VA and Alternative 4 had the lowest CPUE (256) which was a less than 0.5% decrease compared to the NAA.

Harpacticoids are not well studied in the Bay-Delta system but do sporadically show up in Delta smelt and longfin smelt diets (Burris et al. 2022, Slater et al. 2019, Slater and Baxter 2014, Nobriga 2002) and are a primary prey for common carp, Sacramento sucker, splittail (Feyrer et al. 2003), and smaller fish species such as mosquitofish, inland silversides, gobies (Gilbert et al. 2011). Harpacticoids are present throughout the Bay-Delta system year-round (Ambler et al. 1985). Harpacticoids tend to be associated with benthic environments and may not be as readily available for consumption by Delta smelt and longfin smelt. There has been no previous research that observed a relationship between harpacticoids and flow.

The mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow, suggesting a bottom up, "agricultural model" explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater seasons into the LSZ (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during the Wet WYT and lowest during Critical WYT. Similarly, outflow was highest during Wet years and lowest during Critical years.

For all WYT, Alternative 3 had the highest outflow and the largest CPUE increase compared to the NAA, CPUE increases ranged from 7 – 11%. Alternative 1 generally had lower flows and lower CPUE compared to the NAA for all WYT, except for the critical year type, decreases in CPUE ranged from 2 – 5%. CPUE increased by 6% in the Critical WYT. Changes in outflow and CPUE for the different Alternative 2 phases and Alternative 4 were relatively minor, ranging from -2 – 4% for CPUE, except during the Critical WYT. During the Critical WYT, Alternative 2 Without TUCP Without VA and Alternative 4 outflow and CPUE were similar to the NAA, the other Alternative 2 phases showed increased outflow and CPUE increases ranging from 8 – 11% compared to the NAA.

J.3.3.2.4 Other adult calanoid copepods

For other adult calanoid copepods in the spring, during the **wet year type**, Alternative 3 had the highest CPUE (333) which was a 9% increase compared to the NAA. Alternative 1 had the lowest CPUE (300) which was a 2% decrease compared to the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (244) which was an 11% increase compared to the NAA. Alternative 1 had the lowest CPUE (206) which was a 6% decrease compared to the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (172) which was a 13% increase compared to the NAA. Alternative 1 had the lowest CPUE (143) which was a 6% decrease compared to the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (138) which was an 11% increase compared to the NAA. Alternative 1 had the lowest CPUE (118) which was a 5% decrease compared to the NAA.

For the **critical year type**, Alternative 3 had the highest CPUE (92), which was a 15% increase compared to the NAA. Alternative 2 Without TUCP Without VA and Alternative 4 had the lowest CPUE (80) which was the same as the NAA.

The other calanoid copepods species included as part of "other adult calanoid copepods" were: *Acartia* spp., unidentified calanoids, *Sinocalanus doerrii*, *Tortanus* spp., and Diaptomidae. These species have been found in Delta smelt and longfin smelt diets (Burris et al. 2022, Slater et al. 2019, Slater and Baxter 2014, Nobriga 2002).

Acartia spp. are the dominant copepod at salinities higher than 10 ppt but are occasionally present in the LSZ regions (Ambler et al. 1985, Winder and Jassby 2011). Kimmerer (2002) found *Acartia* abundance may have a positive relationship with increased outflow for salinities from 6-20 (his analysis found it was not statistically significant but data from two outlier years increased error variance).

Historically, since its introduction in 1978, *S. doerrii* was most abundant in the Suisun Bay region, with peak abundance during the spring to summer season, though it was noted that flow during winter would advect individuals into San Pablo Bay (Ambler et al. 1985). Since then, the range of *S. doerrii* has shifted landwards, likely because of effects of *Potamcorbula amurensis* grazing (Kimmerer et al. 1998). Therefore, increased flow is possibly advecting more individuals from more freshwater regions into the LSZ.

Tortanus spp. is an introduced predatory copepod associated with higher salinities (Bollens et al. 2014). *Tortanus* spp. is found less frequently in LSZ regions when there is increased outflow, likely due to lower salinities (Lee et al. 2023).

Diaptomidae are associated with other freshwater species/taxa such as Daphnidae, *Bosmina longirostris* (Bollens et al. 2014, Table 1).

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CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during the Wet WYT and lowest during Critical WYT. Similarly, outflow was highest during Wet years and lowest during Critical years.

For all WYT, Alternative 3 had the highest outflow and the largest CPUE increase compared to the NAA, CPUE increases ranged from 9 – 15%. Alternative 1 generally had lower flows and lower CPUE compared to the NAA for all WYT, except for the critical year type. Decreases in CPUE ranged from 2 – 6%. CPUE increased by 8% in the Critical WYT. Changes in outflow and CPUE for the different Alternative 2 phases and Alternative 4 were relatively minor, ranging from -2 – 6% for CPUE, except during the Critical WYT. During the Critical WYT, Alternative 2 Without TUCP Without VA and Alternative 4 outflow and CPUE were similar to the NAA, the other Alternative 2 phases showed increased outflow and CPUE increases ranging from 11 – 14% compared to the NAA.

J.3.3.2.5 Other copepodite calanoid copepods

For other copepodite calanoid copepods in the spring, during the **wet year type**, Alternative 3 had the highest CPUE (1757) which was a 6% increase compared to the NAA. Alternative 1 had the lowest CPUE (1626) which was a 2% decrease compared to the NAA.

For the **above normal year type**, Alternative 3 had the highest CPUE (1423) which was an 8% increase compared to the NAA. Alternative 1 had the lowest CPUE (1264) which was a 4% decrease compared to the NAA.

For the **below normal year type**, Alternative 3 had the highest CPUE (1116) which was a 9% increase compared to the NAA. Alternative 1 had the lowest CPUE (978) which was a 4% decrease compared to the NAA.

For the **dry year type**, Alternative 3 had the highest CPUE (960) which was an 11% increase compared to the NAA. Alternative 1 had the lowest CPUE (860) which was a 3% decrease compared to the NAA.

For the **critical year type**, Alternative 3 had the highest CPUE (723), which was a 11% increase compared to the NAA. Alternative 2Without TUCP Without VA had the lowest CPUE (656) which was almost the same as the NAA.

The other calanoid copepods species included as part of "other copepodite calanoid copepods" were: *Acartia* spp., *Acartiella* spp., unidentified calanoids, *Eurytemora affinis*, *Sinocalanus doerrii*, *Tortanus* spp., and Diaptomidae. These species have been found in Delta smelt and longfin smelt diets (Burris et al. 2022, Slater et al. 2019, Slater and Baxter 2014, Nobriga 2002).

Acartia spp. are the dominant copepod at salinities higher than 10 ppt but are occasionally present in the LSZ regions (Ambler et al. 1985, Winder and Jassby 2011). Kimmerer (2002) found *Acartia* abundance may have a positive relationship with increased outflow for salinities from 6-20 (his analysis found it was not statistically significant but data from two outlier years increased error variance).

Acartiella spp. is an introduced copepod predator present in the LSZ (Bollens et al. 2014). *Acartiella* spp. is found less frequently in LSZ regions when there is increased outflow, likely due to lower salinities (Lee et al. 2023).

Kimmerer (2002) found that adult *E. affinis* abundance had a positive relationship with outflow, analysis of juvenile *E. affinis* is limited.

Historically, since its introduction in 1978, *S. doerrii* was most abundant in the Suisun Bay region, with peak abundance during the spring to summer season, though it was noted that flow during winter would advect individuals into San Pablo Bay (Ambler et al. 1985). Since then, the range of *S. doerrii* has shifted landwards, likely because of effects of *Potamcorbula amurensis* grazing (Kimmerer et al. 1998). Therefore, increased flow is possibly advecting more individuals from more freshwater regions into the LSZ.

Tortanus spp. is an introduced predatory copepod associated with higher salinities (Bollens et al. 2014). *Tortanus* spp. is found less frequently in LSZ regions when there is increased outflow, likely due to lower salinities (Lee et al. 2023).

Diaptomidae are associated with other freshwater species/taxa such as Daphnidae, *Bosmina longirostris* (Bollens et al. 2014, Table 1).

The mechanism for why CPUE increases in the LSZ during higher outflow has not been clearly and definitively established. Kimmerer (2002) found lower trophic level taxa (zooplankton) responded inconsistently with flow across seasons and historical periods. Kimmerer also found that chlorophyll showed little response to flow, suggesting a bottom up, "agricultural model" explanation for increased CPUE with higher flows is unlikely. Another possible mechanism is that increased flows increase subsidies of zooplankton from higher abundance freshwater seasons into the LSZ (Hassrick et al. 2023, Kimmerer et al. 2019).

CPUE appears to be most affected by WYT; CPUE was highest across all scenarios during the Wet WYT and lowest during Critical WYT. Similarly, outflow was highest during Wet years and lowest during Critical years.

For all WYT, Alternative 3 had the highest outflow and the largest CPUE increase compared to the NAA, CPUE increases ranged from 6 – 11%. Alternative 1 generally had lower flows and lower CPUE compared to the NAA for all WYT, except for the critical year type. Decreases in CPUE ranged from 2 – 4%. CPUE increased by 6% in the Critical WYT. Changes in outflow and CPUE for the different Alternative 2 phases and Alternative 4 were relatively minor, ranging from -2 – 4% for CPUE, except during the Critical WYT. During the Critical WYT, Alternative 2 Without TUCP Without VA and Alternative 4 outflow and CPUE were similar to the NAA, the other Alternative 2 phases showed increased outflow and CPUE increases ranging from 8 – 10% compared to the NAA.

Table J.3-14: Mean **Spring** (March – May) CalSim 3 outflow (cfs) by modeled scenario and different water year types. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	80267	68456	58938	57806	57779	58183	58293
Above Normal	52201	41586	34675	33460	33114	34416	35559
Below Normal	34410	25887	20361	19662	19631	20497	21808
Dry	25754	19100	14948	14711	14706	15311	16224
Critical	12741	10174	7766	7829	9029	9031	9421

Table J.3-15: Mean **Spring** (March – May) CalSim 3 outflow (cfs) by modeled scenario and different water year types. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	**NAA**	**Alt1**	**Alt2 wTUCP woVA**	**Alt2 woTUCP woVA**	**Alt2 woTUCP DeltaVA**	**Alt2 woTUCP AllVA**	**Alt3**	**Alt4**
Wet	58938	57389 (-3%)	57806 (-2%)	57779 (-2%)	58183 (-1%)	58293 (-1%)	66322 (13%)	57683 (-2%)
Above Normal	34675	31817 (-8%)	33460 (-4%)	33114 (-5%)	34416 (-1%)	35559 (3%)	40651 (17%)	33400 (-4%)
Below Normal	20361	18570 (-9%)	19662 (-3%)	19631 (-4%)	20497 (1%)	21808 (7%)	24358 (20%)	19599 (-4%)
Dry	14948	13890 (-7%)	14711 (-2%)	14706 (-2%)	15311 (2%)	16224 (9%)	17526 (17%)	14669 (-2%)
Critical	7766	8632 (11%)	7829 (1%)	9029 (16%)	9031 (16%)	9421 (21%)	9651 (24%)	7839 (1%)

Table J.3-8. Mean catch per unit effort (CPUE) for **Cladocerans (except *Daphnia*)** in **spring** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	**EXP1**	**EXP3**	**NAA**	**Alt2 wTUCP woVA**	**Alt2 woTUCP woVA**	**Alt2 woTUCP DeltaVA**	**Alt2 woTUCP AllVA**
Wet	88	78	69	68	68	68	69
Above Normal	65	54	48	46	46	47	48
Below Normal	47	38	32	31	31	32	34
Dry	38	30	25	25	25	26	27
Critical	22	19	15	17	15	17	18

Table J.3-9. Mean catch per unit effort (CPUE) for **Cladocerans (except *Daphnia*)** in **spring** by modeled scenario and water year type. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	**NAA**	**Alt1**	**Alt2 wTUCP woVA**	**Alt2 woTUCP woVA**	**Alt2 woTUCP DeltaVA**	**Alt2 woTUCP AllVA**	**Alt3**	**Alt4**
Wet	69	68 (-1%)	68 (-1%)	68 (-1%)	68 (-1%)	69 (0%)	76 (10%)	68 (-1%)

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Above Normal	48	44 (-8%)	46 (-4%)	46 (-4%)	47 (-2%)	48 (0%)	54 (12%)	46 (-4%)
Below Normal	32	30 (-6%)	31 (-3%)	31 (-3%)	32 (0%)	34 (6%)	36 (12%)	31 (-3%)
Dry	25	24 (-4%)	25 (0%)	25 (0%)	26 (4%)	27 (8%)	29 (16%)	25 (0%)
Critical	15	17 (13%)	17 (13%)	15 (0%)	17 (13%)	18 (20%)	18 (20%)	15 (0%)

Table J.3-10. Mean catch per unit effort (CPUE) for ***E. affinis*** **adults** in **spring** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	480	438	404	399	399	400	401
Above Normal	388	343	312	304	306	311	316
Below Normal	307	264	234	229	230	235	243
Dry	264	226	200	198	198	202	209
Critical	180	163	141	153	141	153	157

Table J.3-11. Mean CPUE for ***E. affinis*** **adults** in **spring** by modeled scenario and water year type. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	404	396 (-2%)	399 (-1%)	399 (-1%)	400 (-1%)	401 (-1%)	432 (7%)	398 (-1%)
Above Normal	312	297 (-5%)	304 (-3%)	306 (-2%)	311 (0%)	316 (1%)	340 (9%)	305 (-2%)
Below Normal	234	223 (-5%)	229 (-2%)	230 (-2%)	235 (0%)	243 (4%)	258 (10%)	229 (-2%)
Dry	200	192 (-4%)	198 (-1%)	198 (-1%)	202 (1%)	209 (4%)	218 (9%)	198 (-1%)
Critical	141	150 (6%)	153 (9%)	141 (0%)	153 (9%)	157 (11%)	158 (12%)	142 (1%)

Table J.3-12. Mean CPUE for **Harpacticoids** in **spring** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	813	746	690	682	682	684	685
Above Normal	666	592	541	528	531	539	548
Below Normal	533	462	412	404	405	414	428
Dry	463	399	355	352	352	359	370
Critical	321	292	255	276	256	276	282

Table J.3-13. Mean CPUE for **Harpacticoids** in **spring** by modeled scenario and water year type. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	690	678 (-2%)	682 (-1%)	682 (-1%)	684 (-1%)	685 (-1%)	736 (7%)	681 (-1%)
Above Normal	541	517 (-4%)	528 (-2%)	531 (-2%)	539 (0%)	548 (1%)	587 (9%)	531 (-2%)
Below Normal	412	393 (-5%)	404 (-2%)	405 (-2%)	414 (0%)	428 (4%)	452 (10%)	404 (-2%)
Dry	355	342 (-4%)	352 (-1%)	352 (-1%)	359 (1%)	370 (4%)	385 (8%)	352 (-1%)
Critical	255	270 (6%)	276 (8%)	256 (0%)	276 (8%)	282 (11%)	284 (11%)	256 (0%)

Table J.3-14. Mean CPUE for **other calanoid copepod adults** in **spring** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	380	340	306	302	302	303	304
Above Normal	289	247	219	212	214	218	223
Below Normal	216	178	152	148	149	153	160
Dry	178	146	124	123	123	126	131
Critical	109	96	80	89	80	89	91

Table J.3-15. Mean CPUE for **other calanoid copepod adults** in **spring** by modeled scenario and water year type. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	306	300 (-2%)	302 (-1%)	302 (-1%)	303 (-1%)	304 (-1%)	333 (9%)	301 (-2%)
Above Normal	219	206 (-6%)	212 (-3%)	214 (-2%)	218 (0%)	223 (2%)	244 (11%)	213 (-3%)
Below Normal	152	143 (-6%)	148 (-3%)	149 (-2%)	153 (1%)	160 (5%)	172 (13%)	148 (-3%)
Dry	124	118 (-5%)	123 (-1%)	123 (-1%)	126 (2%)	131 (6%)	138 (11%)	123 (-1%)
Critical	80	86 (8%)	89 (11%)	80 (0%)	89 (11%)	91 (14%)	92 (15%)	80 (0%)

Table J.3-16. Mean CPUE for **other calanoid copepod copepodites** in **spring** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	1930	1780	1653	1635	1635	1641	1643
Above Normal	1602	1434	1319	1291	1297	1315	1336
Below Normal	1301	1138	1023	1005	1005	1027	1059
Dry	1139	991	890	883	883	900	925
Critical	808	742	653	704	656	704	719

Table J.3-17. Mean CPUE for **other calanoid copepod copepodites** in **spring** by modeled scenario and water year type. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	1653	1626 (-2%)	1635 (-1%)	1635 (-1%)	1641 (-1%)	1643 (-1%)	1757 (6%)	1633 (-1%)
Above Normal	1319	1264 (-4%)	1291 (-2%)	1297 (-2%)	1315 (0%)	1336 (1%)	1423 (8%)	1295 (-2%)
Below Normal	1023	978 (-4%)	1005 (-2%)	1005 (-2%)	1027 (0%)	1059 (4%)	1116 (9%)	1004 (-2%)
Dry	890	860 (-3%)	883 (-1%)	883 (-1%)	900 (1%)	925 (4%)	960 (8%)	882 (-1%)
Critical	653	690 (6%)	704 (8%)	656 (0%)	704 (8%)	719 (10%)	723 (11%)	657 (1%)

J.3.3.3 Summer:

During the summer months (May to August), there were no significant relationships between outflow and zooplankton CPUE.

Kimmerer (2002) examined the relationship between several zooplankton taxa (*Synchaeta bicornis*, *Neomysis mercedis*, *E. affinis*, and *Acartia* spp and flow from June – October. Only *N. mercedis* showed a relationship with outflow; the relationship before 1987 changed from a positive relationship with flow to a negative relationship.

Kimmerer et al. (2017) found *Psuedodiaptomus forbesi* abundance in the low salinity zone had a positive relationship with flow in the summer, higher outflow during the dry season subsidized *P. forbesi* from higher abundance freshwater regions into the lower abundance low salinity zone region. However, this analysis did not find any relationship between *P. forbesi* and flow.

Other studies evaluating flow pulses during the summer season have found a mixed effect of increased flow with zooplankton prey; Frantzich et al. 2021 observed increased abundances with flow pulses (however this was observed in the freshwater region of the Delta) while Sommer et al. 2020 did not observe increased zooplankton abundances with a flow pulse action in the Suisun Marsh region. Evaluating any possible benefits of increased outflow and flow pulses during summer may be difficult given sampling frequency and the effect size of increases to zooplankton abundances (Brandon et al. 2021).

J.3.3.4 Fall:

J.3.3.4.1 Adult Eurytemora affinis

During fall months (September to November), the CPUE of following taxon was significantly related to Delta outflow: adult *Eurytemora affinis* and mysids (Table J.3-4).

For adult *Eurytemora affinis* in the fall, across all scenarios, CPUE was very low (≤ 5). When CPUE was rounded to the nearest integer there was often no change compared to the NAA. During the **wet year type**, scenario Alternative 3 had the highest CPUE (4) which was a 33% increase compared to the NAA. Alternative 1 had the lowest CPUE (2) which was a 33% decrease compared to the NAA.

For the **above normal year type**, scenario Alternative 2 With TUCP Without VA, Alternative 2 Without TUCP Without VA, Alternative 2 Without TUCP Delta VA, Alternative 2 Without TUCP Systemwide VA, Alternative 3 and Alternative 4 had the highest CPUE (3) which was no different compared to the NAA. Alternative 1 had the lowest CPUE (1) which was a 67% decrease compared to the NAA.

For the **below normal year type**, all scenarios were no different from the NAA, the CPUE was 1.

For the **dry year type**, scenarios Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, Alternative 2 Without TUCP Delta VA, Alternative 2 Without TUCP Systemwide VA, Alternative 3, and Alternative 4 had the highest CPUE (2) which was no different from the NAA. Alternative 1 had the lowest CPUE (1) which was a 50% decrease compared to the NAA.

For the **critical year type**, all scenarios were no different from the NAA, the CPUE was 1.

Kimmerer (2002) found a significant relationship between adult *E. affinis* and outflow. However, this relationship was only present after 1987, the post *Potamocorbula amurensis* invasion period, which also coincided with a seven-fold decline in *E. affinis*. This decline is likely due to predation by *P. amurensis* and replacement by another introduced calanoid copepod, *Psuedodiaptomus forbesi* which is able to overcome predation pressure due to subsidies from more freshwater regions where P. *amurensis* isn't present (Durand 2010). Peak abundance of *E. affinis* has shifted several months to the spring season from the summer season (Merz et al. 2016). While there is a significant relationship between outflow and CPUE of adult *E. affinis* in the fall, the effect is likely negligible for fish species that prey on calanoid copepods.

J.3.3.4.2 Mysids

For mysids in the fall, during the **wet year type**, scenario Alternative 3 had the highest CPUE (18) which was a 20% increase compared to the NAA. Alternative 1 had the lowest CPUE (11) which was a 27% decrease compared to the NAA.

For **above normal year type**, scenario Alternative 3 had the highest CPUE (15) which was a 25% increase compared to the NAA. Alternative 1 had the lowest CPUE (7) which was a 42% decrease compared to the NAA.

For the **below normal year type**, scenario Alternative 3 had the highest CPUE (7) which was a 17% increase compared to the NAA. Alternative 1 had the lowest CPUE (5) which was a 17% decrease compared to the NAA.

For the **dry year type**, scenarios Alternative 2 Without TUCP Systemwide VA and Alternative 3 had the highest CPUE (8) which was a 14% increase compared to the NAA. All other scenarios showed no difference from the NAA, the CPUE was 7.

For the **critical year type**, all scenarios were no different from the NAA, the CPUE was 4.

Mysids are a key prey for multiple fish species (Barros et al. 2022, Feyrer et al. 2003). The abundance and biomass of mysids in the San Francisco Estuary has severely declined since the introduction of *Potamocorbula amurensis* (Winder and Jassby 2011) resulting in a dietary shift in some fish species (Feyrer 2003). Kimmerer (2002) analyzed the relationship between *N. mercedis* and flow from June – October (summer) and found that the relationship before 1987 changed from a positive relationship with flow to a negative relationship. The native species, *Neomysis mercedis* has been replaced by the non-native and smaller *Hyperacanthomysis longirostris* (Avila and Hartman 2020, Winder and Jassby 2011). Analysis of FMWT data by Avila and Hartman 2020, found mysid abundance was highest during September.

During the Wet WYT, flow and CPUE was highest for Alternative 3, similar across Alternative 2 and Alternative 4 and decreased for Alternative 1. For the Above Normal WYT, there was a similar pattern to the Wet WYT, all scenarios except Alternative 1 had higher outflow and increased CPUE than the NAA. For the Below Normal WYT, the pattern was similar to the Wet WYT. For the Dry WYT, outflow and CPUE were similar for Alternative 2 Without TUCP Systemwide VA and Alternative 3 and there was no change in CPUE for Alternative 1, Alternative 2 with TUCP Without VA, Alternative 2 Without TUCP Without VA, Alternative 2 Without TUCP Delta VA and Alternative 4. For the critical WYT, there were no changes in CPUE across all scenarios, even though Alternative 1 had lower outflow. Flow across all other scenarios were relatively similar.

Table J.3-23: Mean **Fall** (September - November) CalSim 3 outflow (cfs) by modeled scenario and different water year types. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	12878	14599	10736	10739	10739	10728	10722
Above Normal	10313	11552	9137	9434	9433	9411	9426
Below Normal	8453	10364	5265	5375	5364	5383	5425
Dry	9287	10938	6036	6050	6043	6021	6144
Critical	2967	6352	4086	4113	4137	4109	4030

Table J.3-24: Mean **Fall** (September - November) CalSim 3 outflow (cfs) by modeled scenario and different water year types. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	10736	7973 (-26%)	10739 (0%)	10739 (0%)	10728 (0%)	10722 (0%)	12148 (13%)	10742 (0%)
Above Normal	9137	5891 (-36%)	9434 (3%)	9433 (3%)	9411 (3%)	9426 (3%)	10793 (18%)	9431 (3%)
Below Normal	5265	4897 (-7%)	5375 (2%)	5364 (2%)	5383 (2%)	5425 (3%)	5774 (10%)	5343 (1%)
Dry	6036	5839 (-3%)	6050 (0%)	6043 (0%)	6021 (0%)	6144 (2%)	6323 (5%)	6051 (0%)
Critical	4086	3622 (-11%)	4113 (1%)	4137 (1%)	4109 (1%)	4030 (-1%)	4000 (-2%)	4079 (0%)

Table J.3-18. Mean CPUE for ***E. affinis*** **adults** in **fall** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	4	5	3	3	3	3	3
Above Normal	3	4	3	3	3	3	3
Below Normal	2	3	1	1	1	1	1
Dry	3	3	2	2	2	2	2
Critical	0	2	1	1	1	1	1

Table J.3-26. Mean CPUE for ***E. affinis*** **adults** in **fall** by modeled scenario and water year type. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	3	2 (-33%)	3 (0%)	3 (0%)	3 (0%)	3 (0%)	4 (33%)	3 (0%)
Above Normal	3	1 (-67%)	3 (0%)	3 (0%)	3 (0%)	3 (0%)	3 (0%)	3 (0%)
Below Normal	1	1 (0%)	1 (0%)	1 (0%)	1 (0%)	1 (0%)	1 (0%)	1 (0%)
Dry	2	1 (-50%)	2 (0%)	2 (0%)	2 (0%)	2 (0%)	2 (0%)	2 (0%)
Critical	1	1 (0%)	1 (0%)	1 (0%)	1 (0%)	1 (0%)	1 (0%)	1 (0%)

Table J.3-27. Mean CPUE for **mysids** in **fall** by modeled scenario and water year type. Values are rounded to the nearest integer.

WYT	EXP1	EXP3	NAA	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA
Wet	19	22	15	15	15	15	15
Above Normal	15	16	12	13	13	13	13
Below Normal	11	14	6	6	6	6	6
Dry	13	15	7	7	7	7	8
Critical	3	8	4	4	4	4	4

Table J.3-28. Mean CPUE for **mysids** in **fall** by modeled scenario and water year type. Percentage values in parentheses indicate the difference between NAA and each alternative. Values and percent difference are rounded to the nearest integer.

WYT	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	15	11 (-27%)	15 (0%)	15 (0%)	15 (0%)	15 (0%)	18 (20%)	15 (0%)
Above Normal	12	7 (-42%)	13 (8%)	13 (8%)	13 (8%)	13 (8%)	15 (25%)	13 (8%)
Below Normal	6	5 (-17%)	6 (0%)	6 (0%)	6 (0%)	6 (0%)	7 (17%)	6 (0%)
Dry	7	7 (0%)	7 (0%)	7 (0%)	7 (0%)	8 (14%)	8 (14%)	7 (0%)
Critical	4	4 (0%)	4 (0%)	4 (0%)	4 (0%)	4 (0%)	4 (0%)	4 (0%)

J.3.3.5 Figures

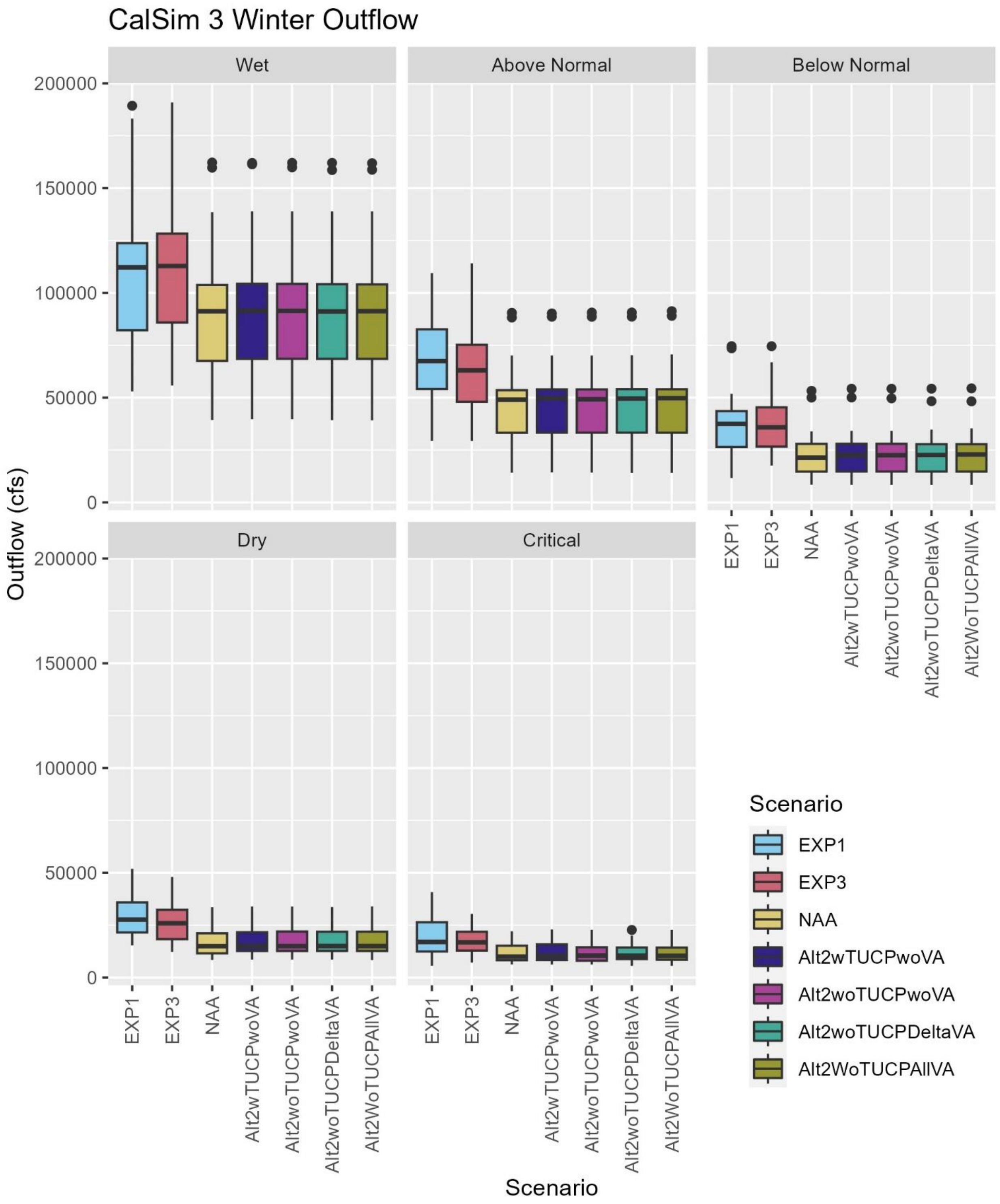
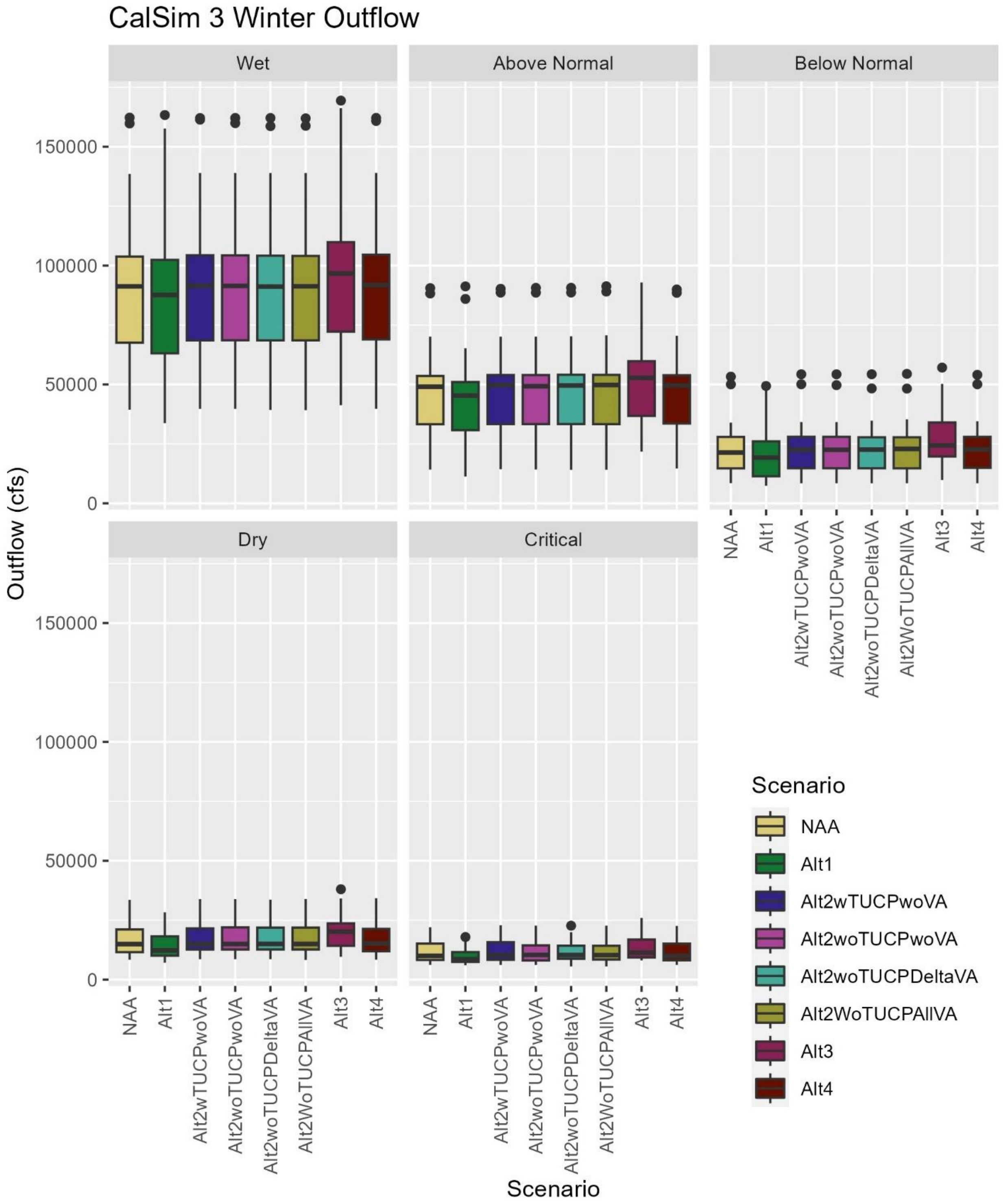


Figure J.3-1. Median, quartile and interquartile ranges for **Winter** (December – February) CalSim 3 outflow (cfs) by modeled scenario and different water year types.



FigureJ.3-2 This figure shows data also presented in data tables in this file.. Median, quartile and interquartile ranges for **Winter** (December – February) CalSim 3 outflow (cfs) by modeled scenario and different water year types.

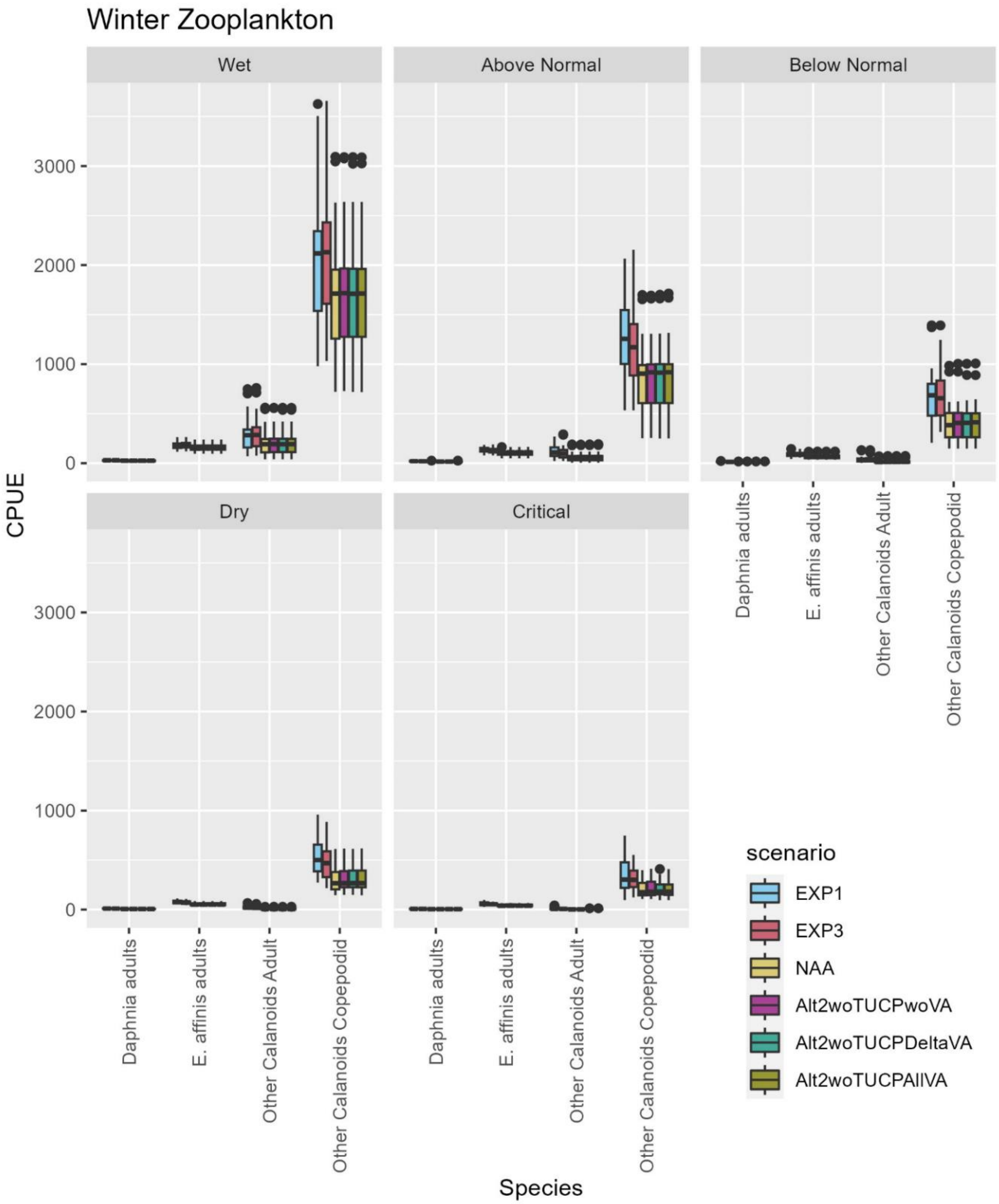


Figure J.3-3. Median, quartile and interquartile ranges of CPUE of significant zooplankton species by scenario across different water year types for winter.

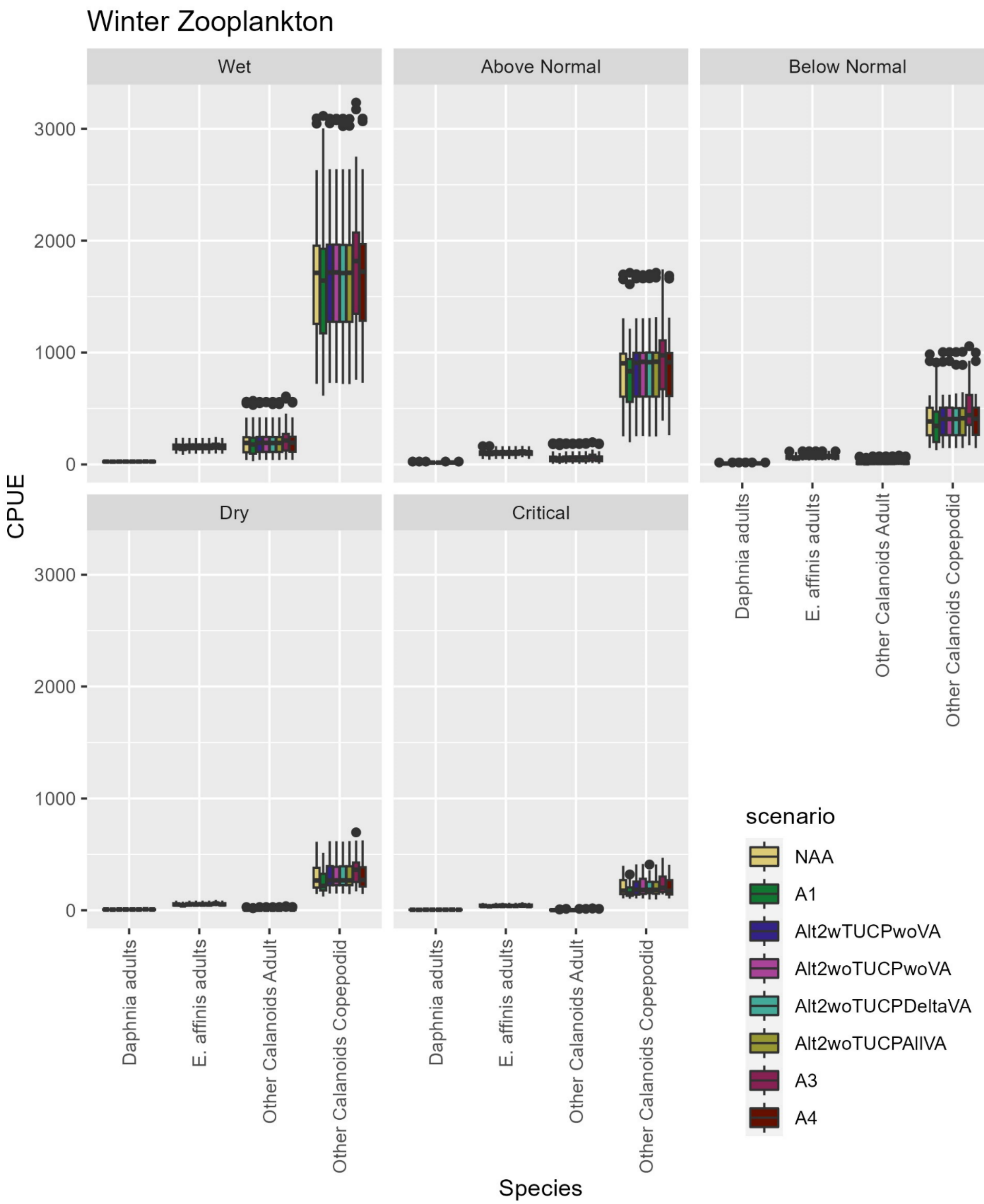


Figure J.3-4. median, quartile and interquartile ranges of CPUE of significant zooplankton species by scenario across different water year types for winter.

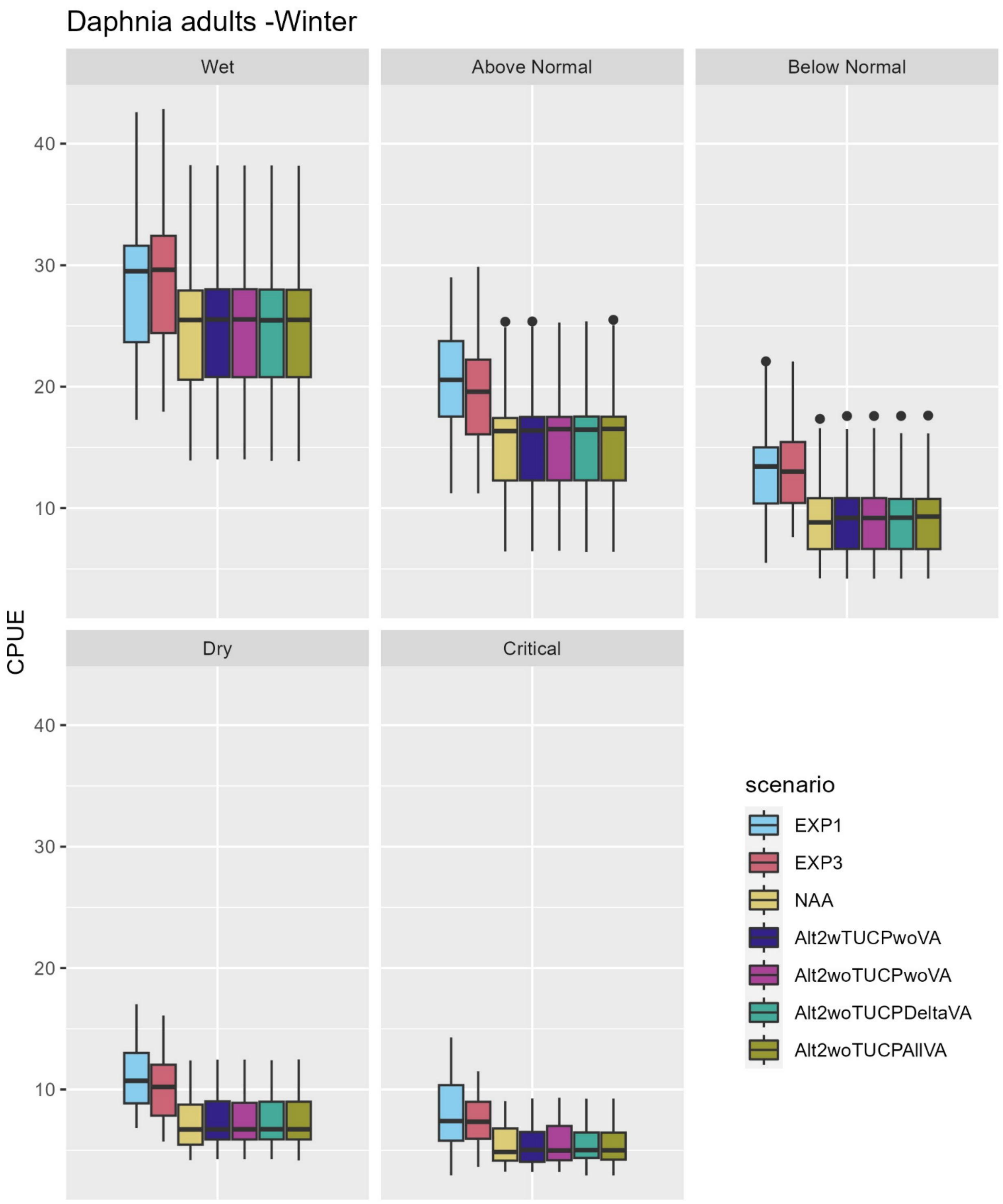


Figure J.3-5. Median, quartile and interquartile ranges of CPUE of *Daphnia* adults by scenario across different water year types for winter.

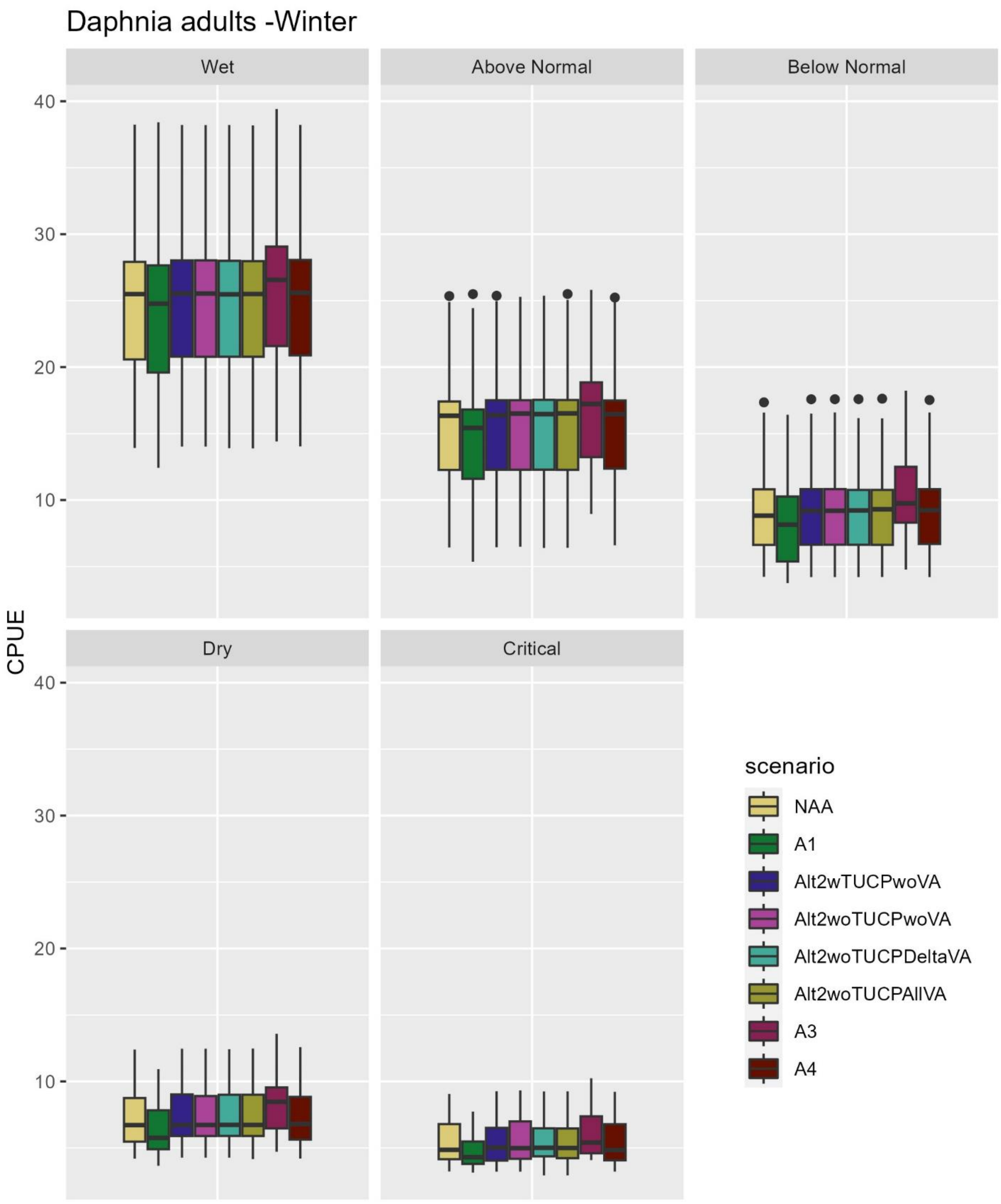


Figure J.3-6. Median, quartile and interquartile ranges of CPUE of *Daphnia* adults by scenario across different water year types for winter.

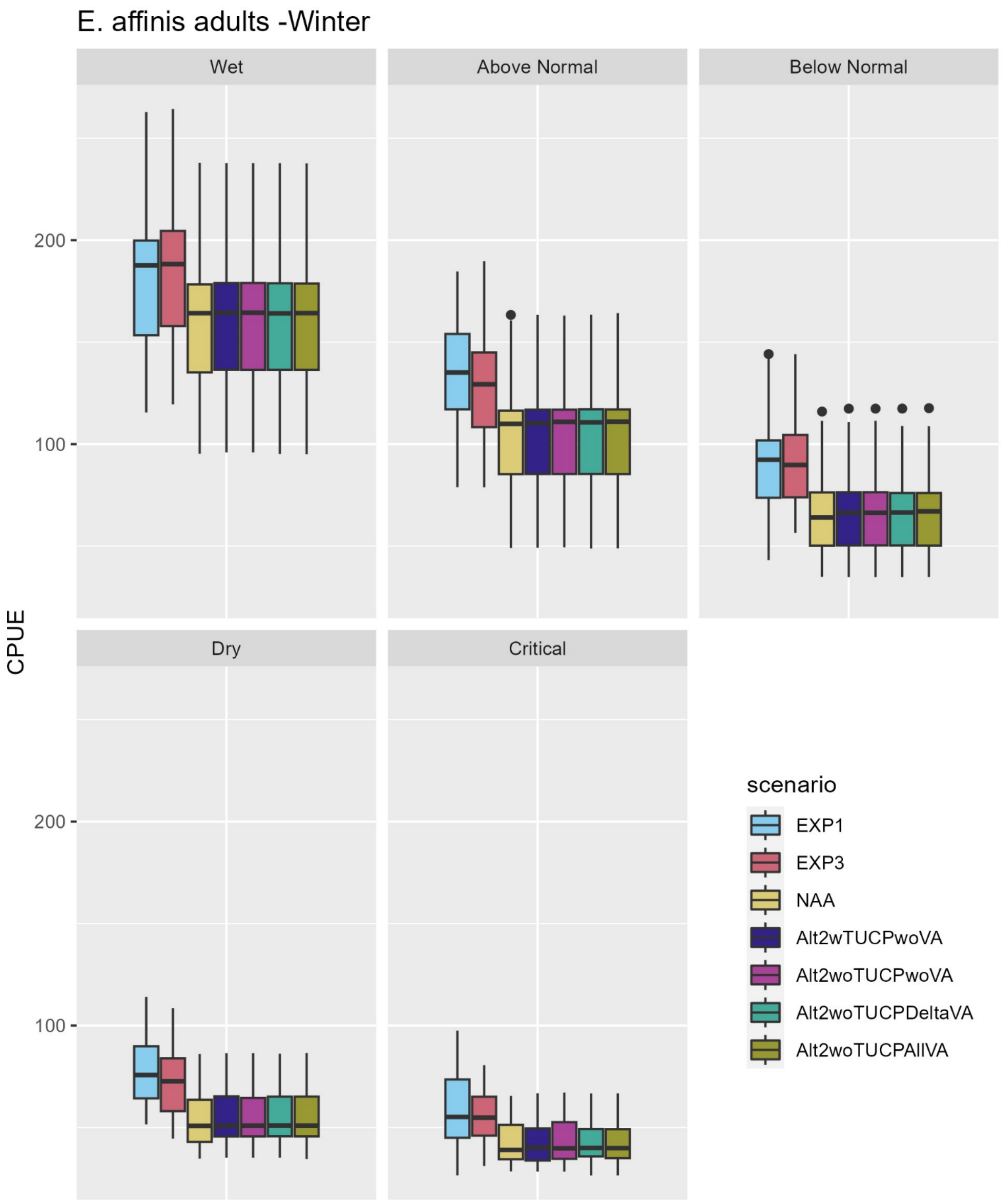


Figure J.3-7. Median, quartile and interquartile ranges of CPUE of *E. affinis* adults by scenario across different water year types for winter.

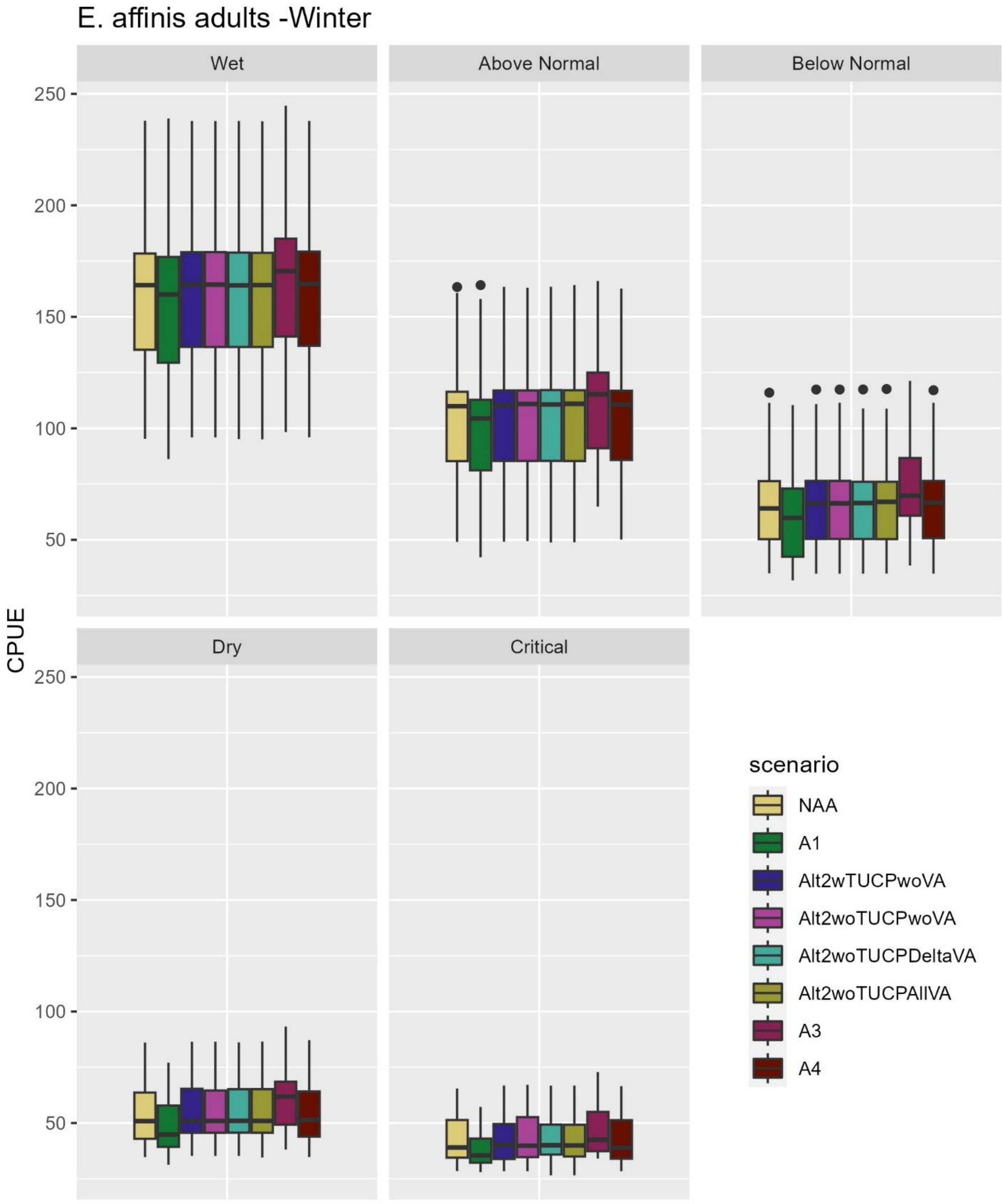


Figure J.3-8. Median, quartile and interquartile ranges of CPUE of *E. affinis* adults by scenario across different water year types for winter.

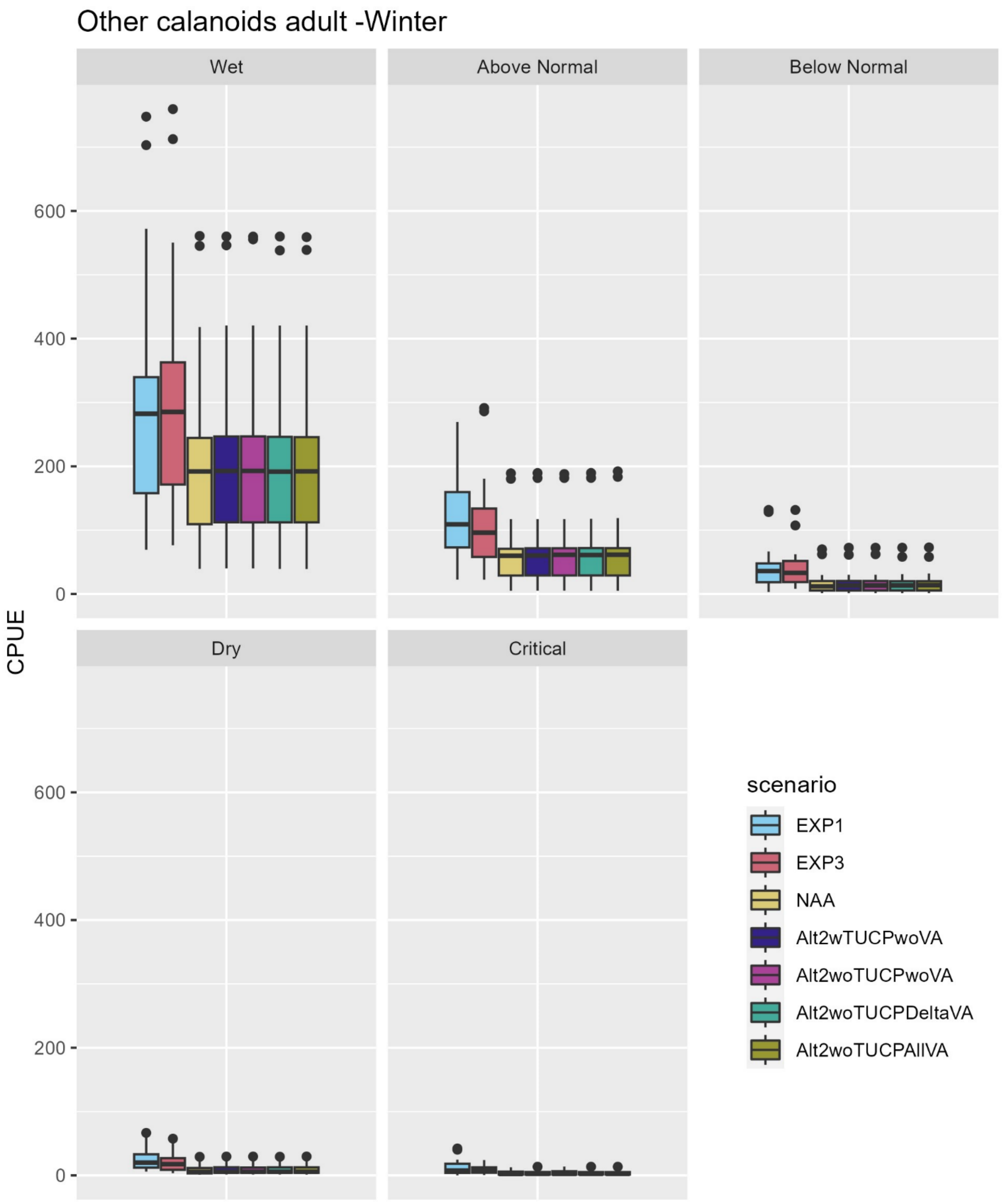


Figure J.3-9. Median, quartile and interquartile ranges of CPUE of Other calanoid copepod adults by scenario across different water year types for winter.

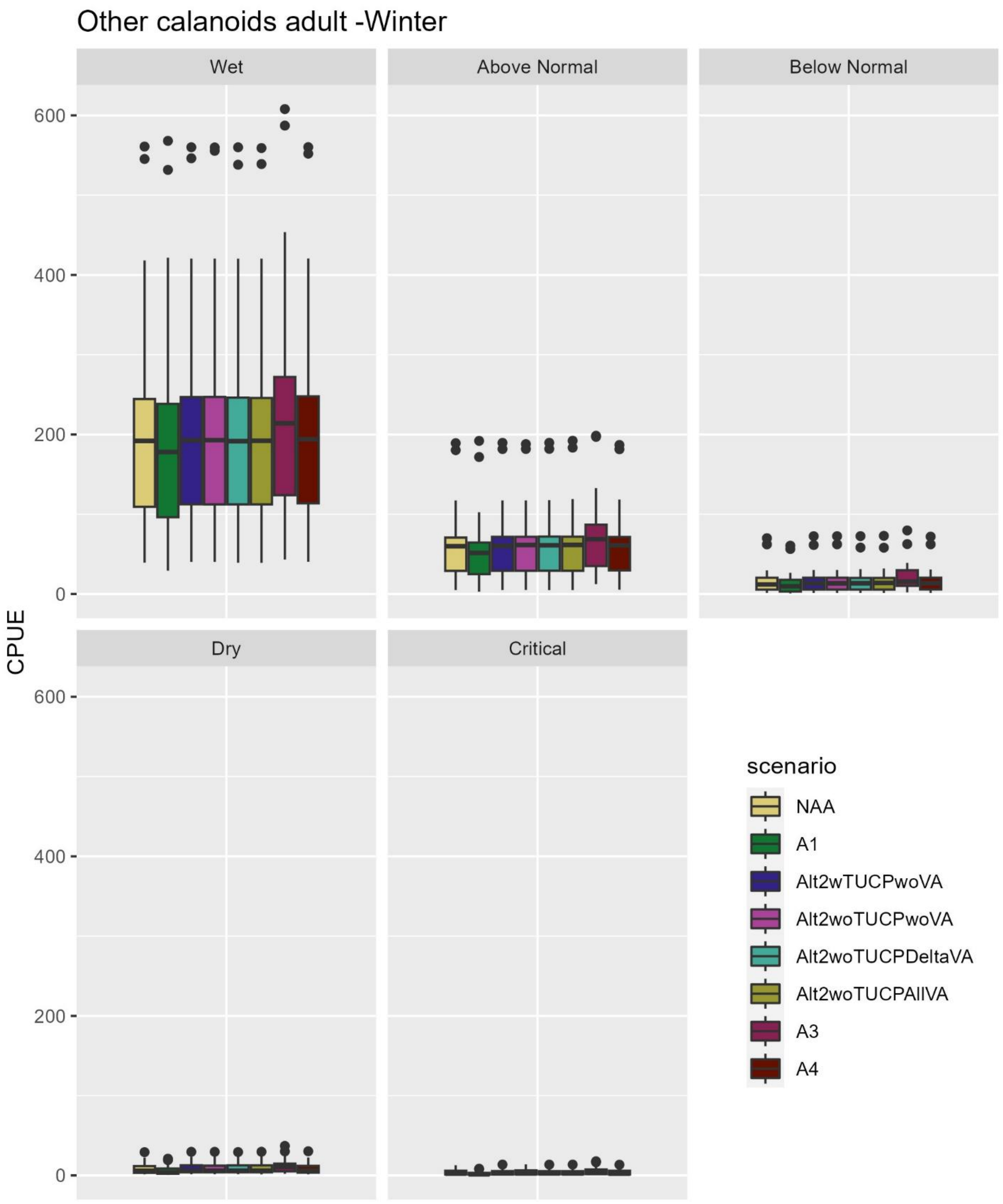


Figure J.3-10. Median, quartile and interquartile ranges of CPUE of Other calanoid copepod adults by scenario across different water year types for winter.

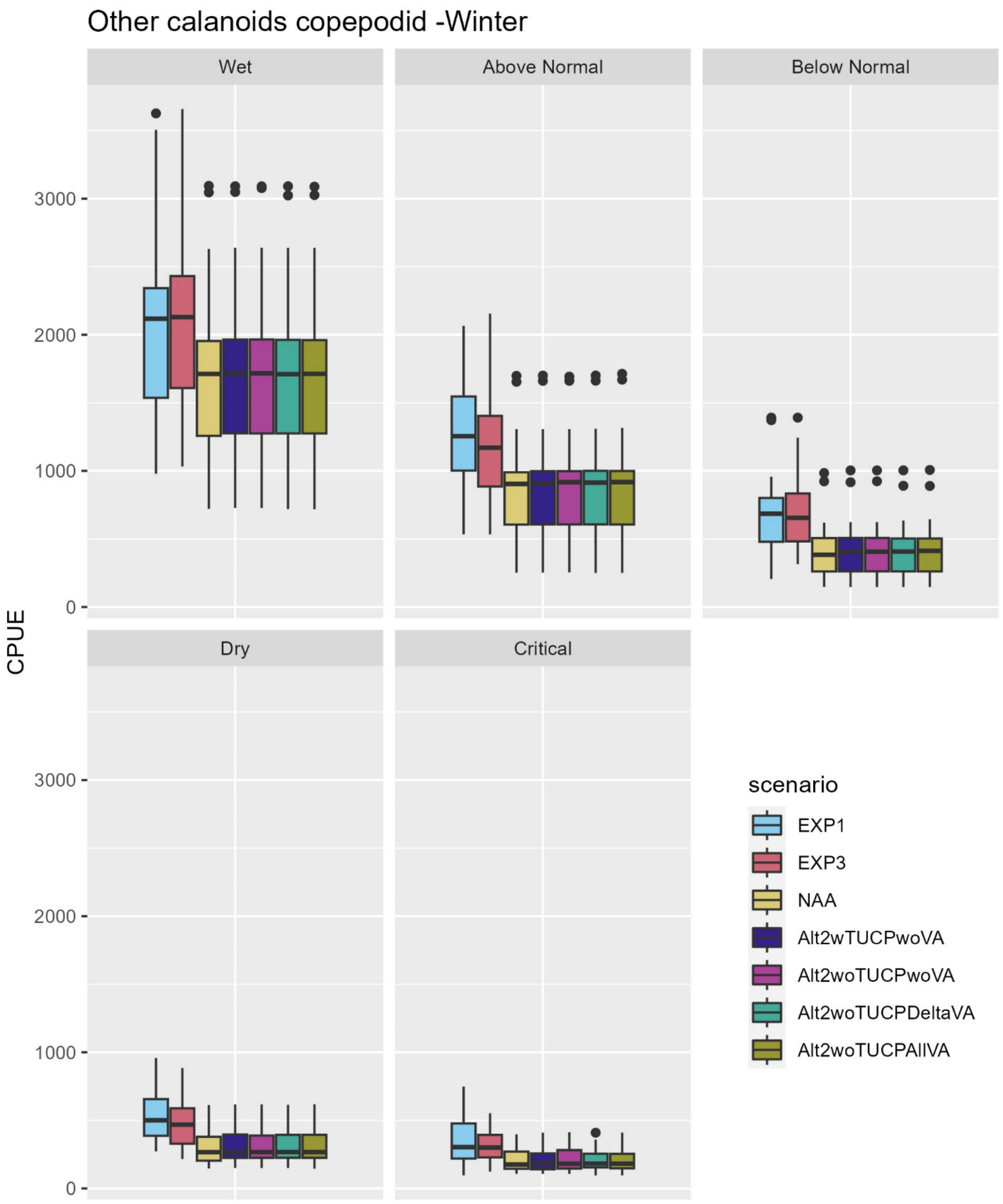


Figure J.3-11. Median, quartile and interquartile ranges of CPUE of Other calanoid copepod copepodites by scenario across different water year types for winter.

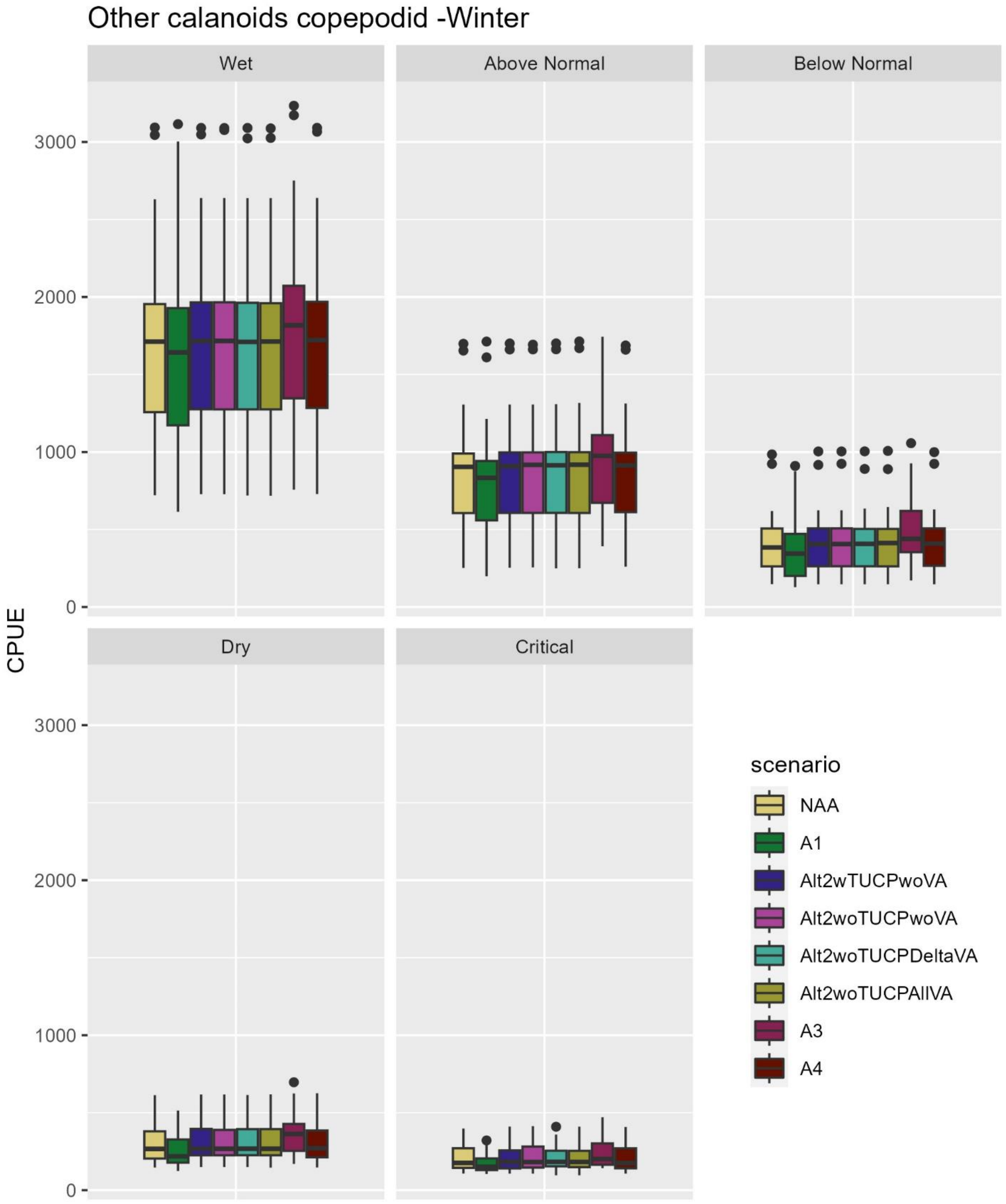


Figure J.3-1. Median, quartile and interquartile ranges of CPUE of Other calanoid copepod copepodites by scenario across different water year types for winter.

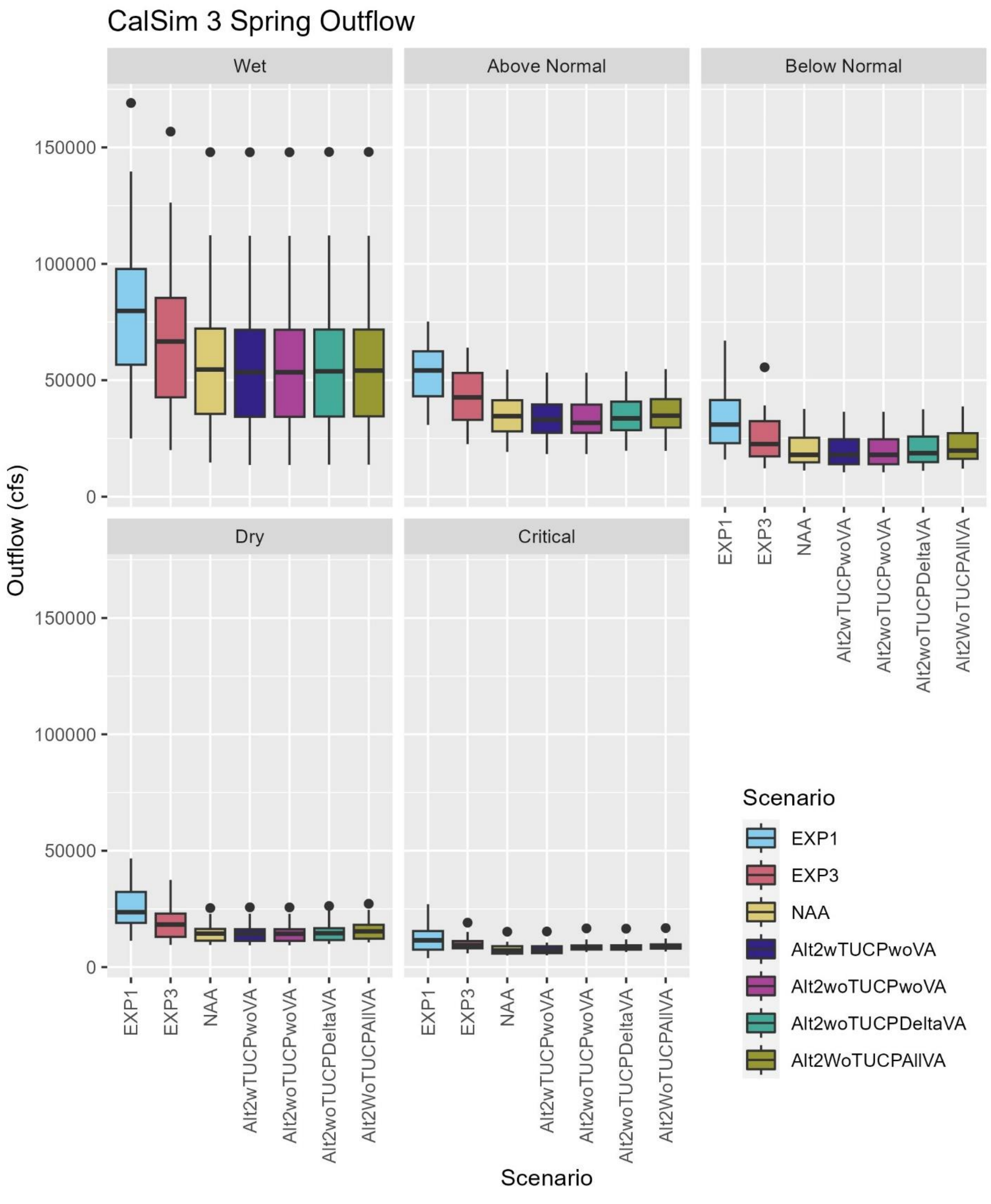


Figure J.3-13. This figure shows data also presented in data tables in this file. Median, quartile and interquartile ranges for **Spring** (March - May) CalSim 3 outflow (cfs) by modeled scenario and different water year types.

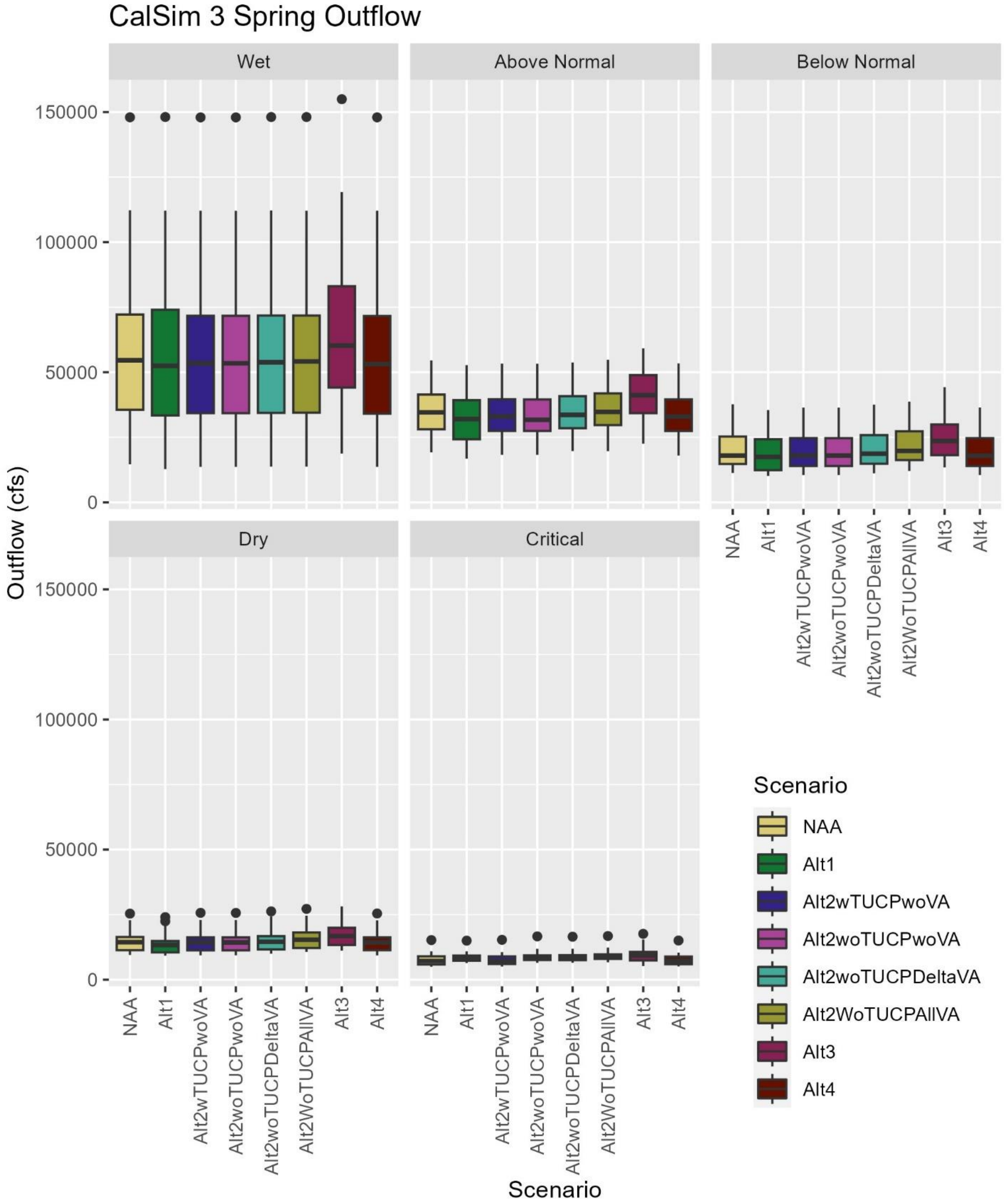


Figure J.3-14. Median, quartile and interquartile ranges for **Spring** (March - May) CalSim 3 outflow (cfs) by modeled scenario and different water year types.

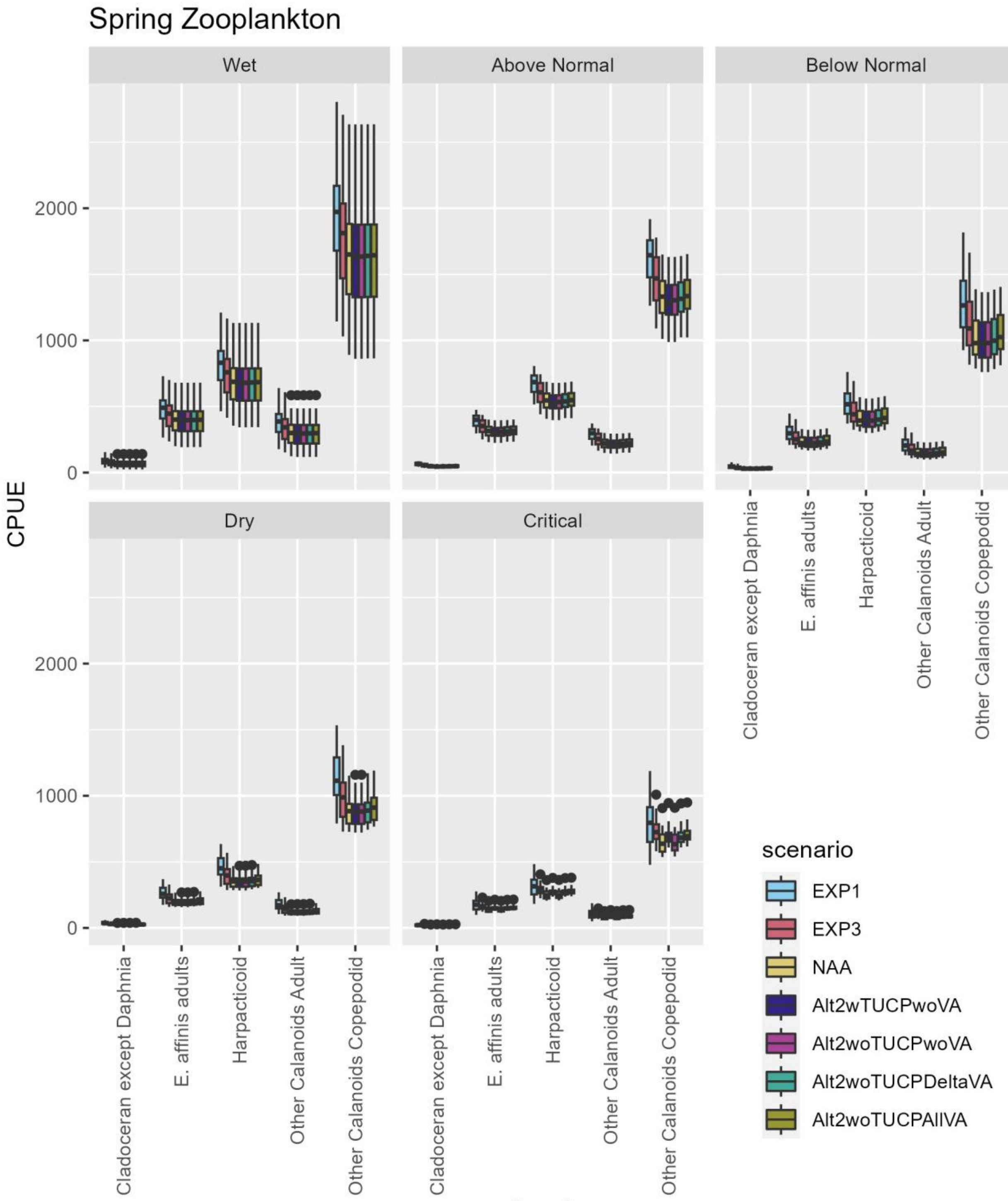


Figure J.3-15. Median, quartile and interquartile ranges of CPUE of significant zooplankton species by scenario across different water year types for spring.

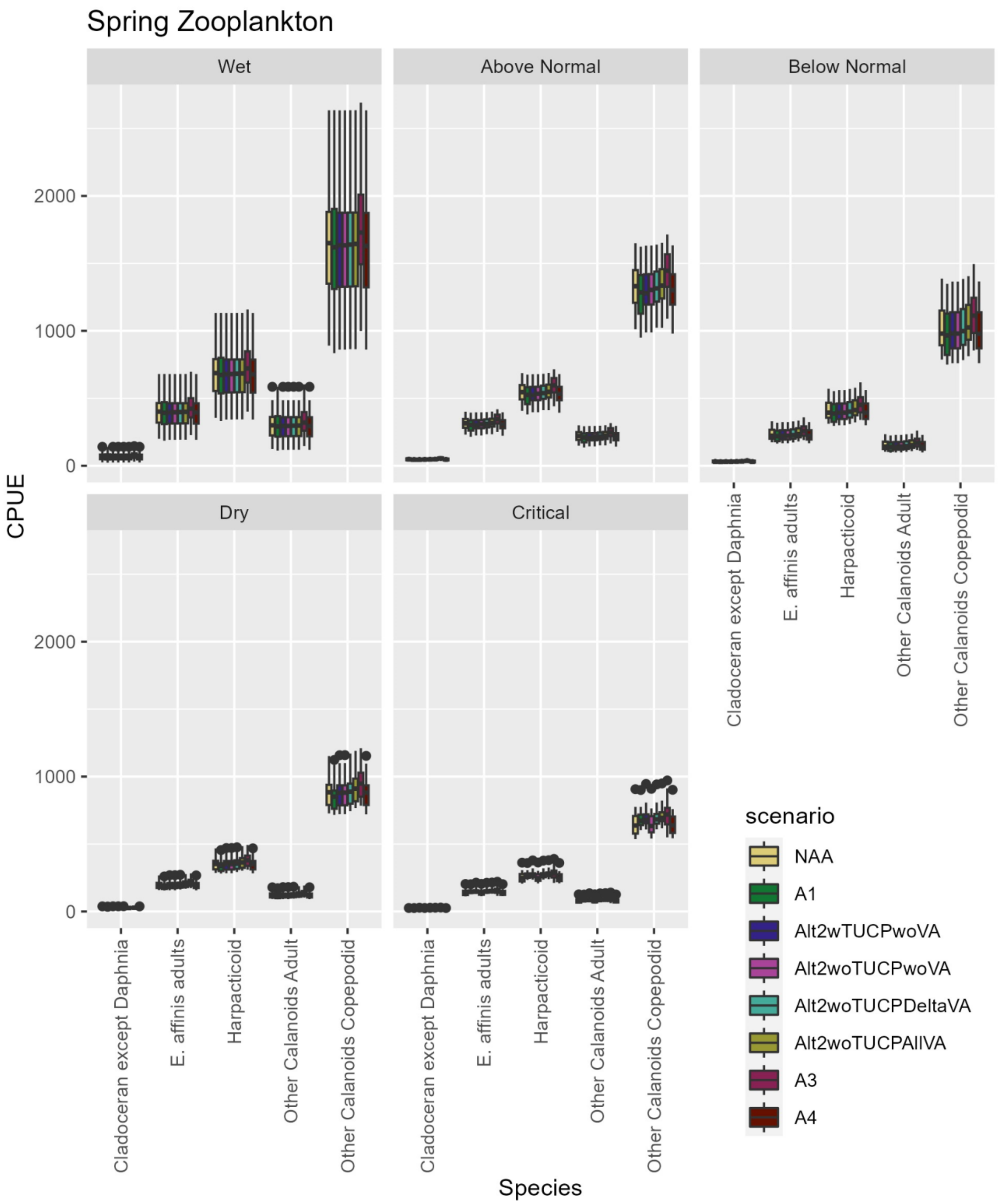


Figure J.3-16. Median, quartile and interquartile ranges of CPUE of significant zooplankton species by scenario across different water year types for spring.

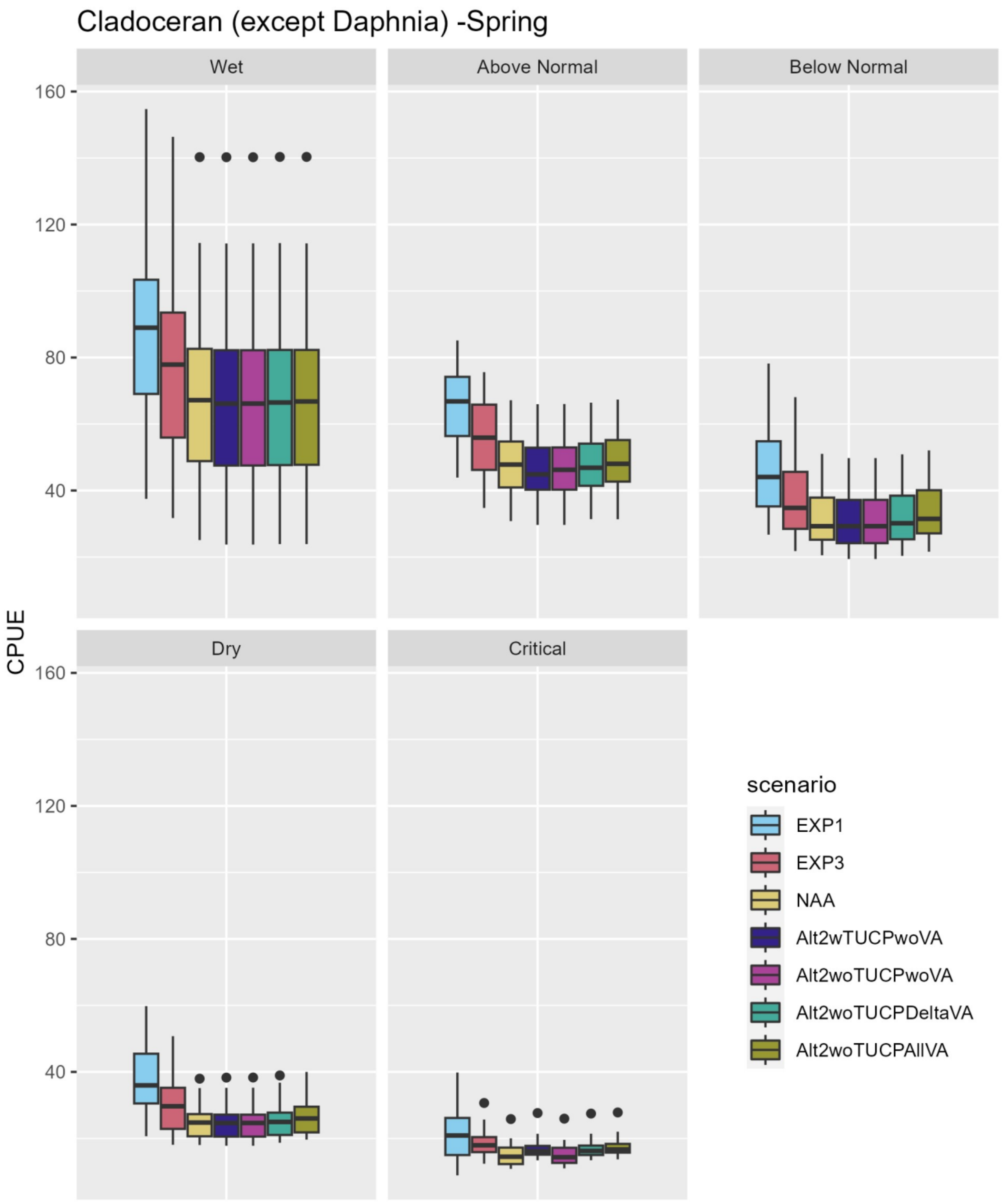


Figure J.3-17. Median, quartile and interquartile ranges of CPUE of Cladocerans (except *Daphnia*) by scenario across different water year types for spring.

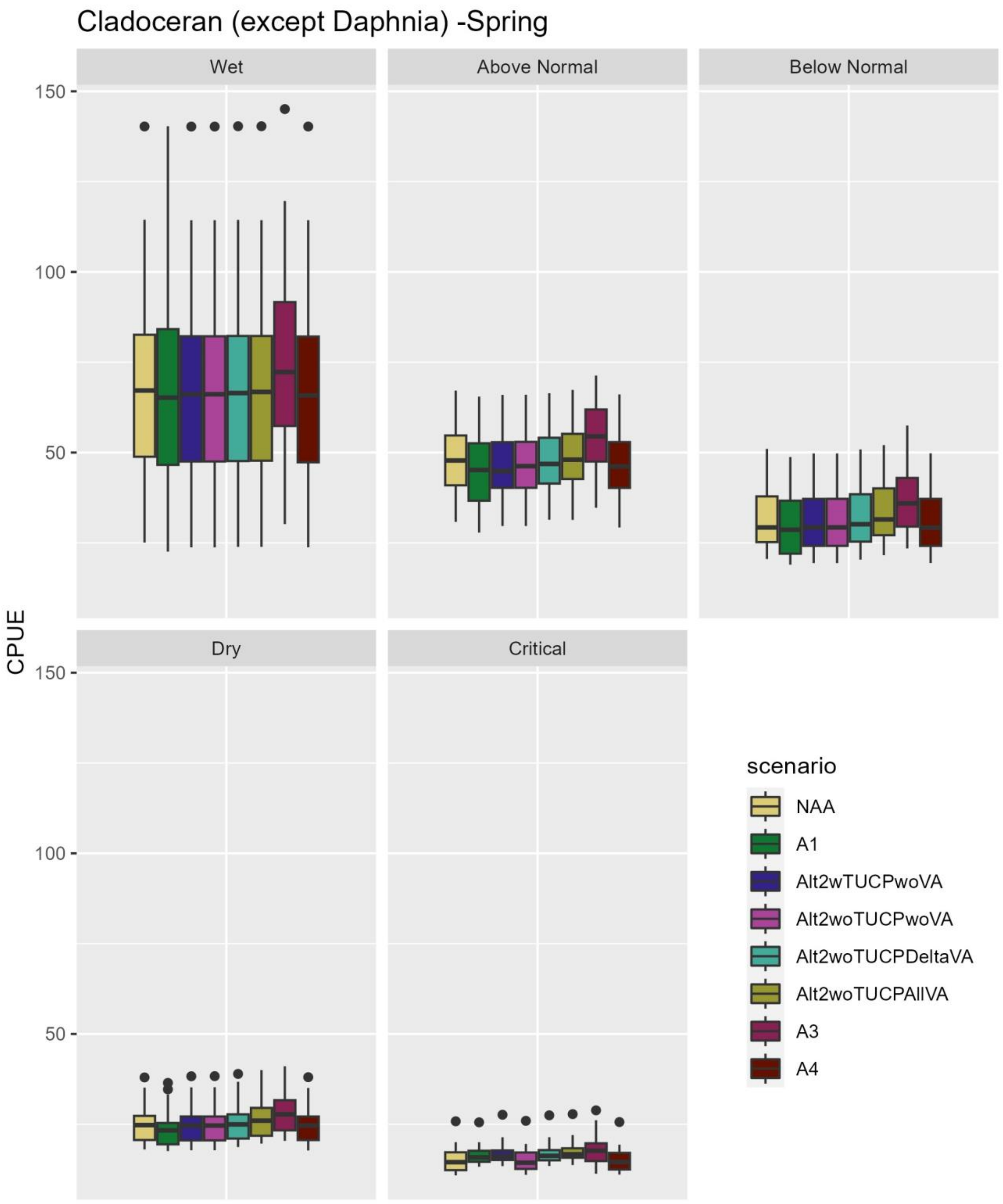


Figure J.3-18. Median, quartile and interquartile ranges of CPUE of Cladocerans (except *Daphnia*) by scenario across different water year types for spring.

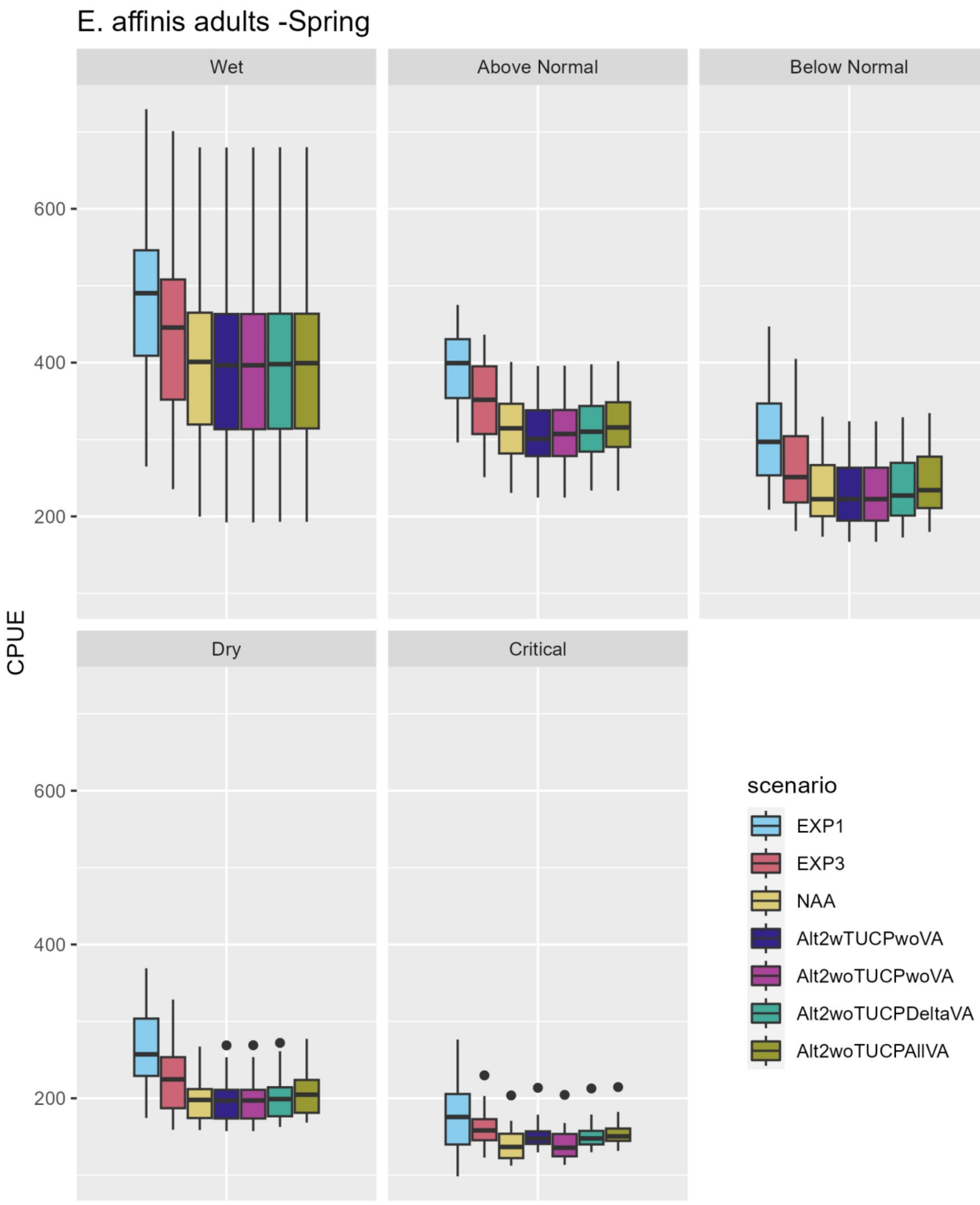


Figure J.3-19. Median, quartile and interquartile ranges of CPUE of *E. affinis* adults by scenario across different water year types for spring.

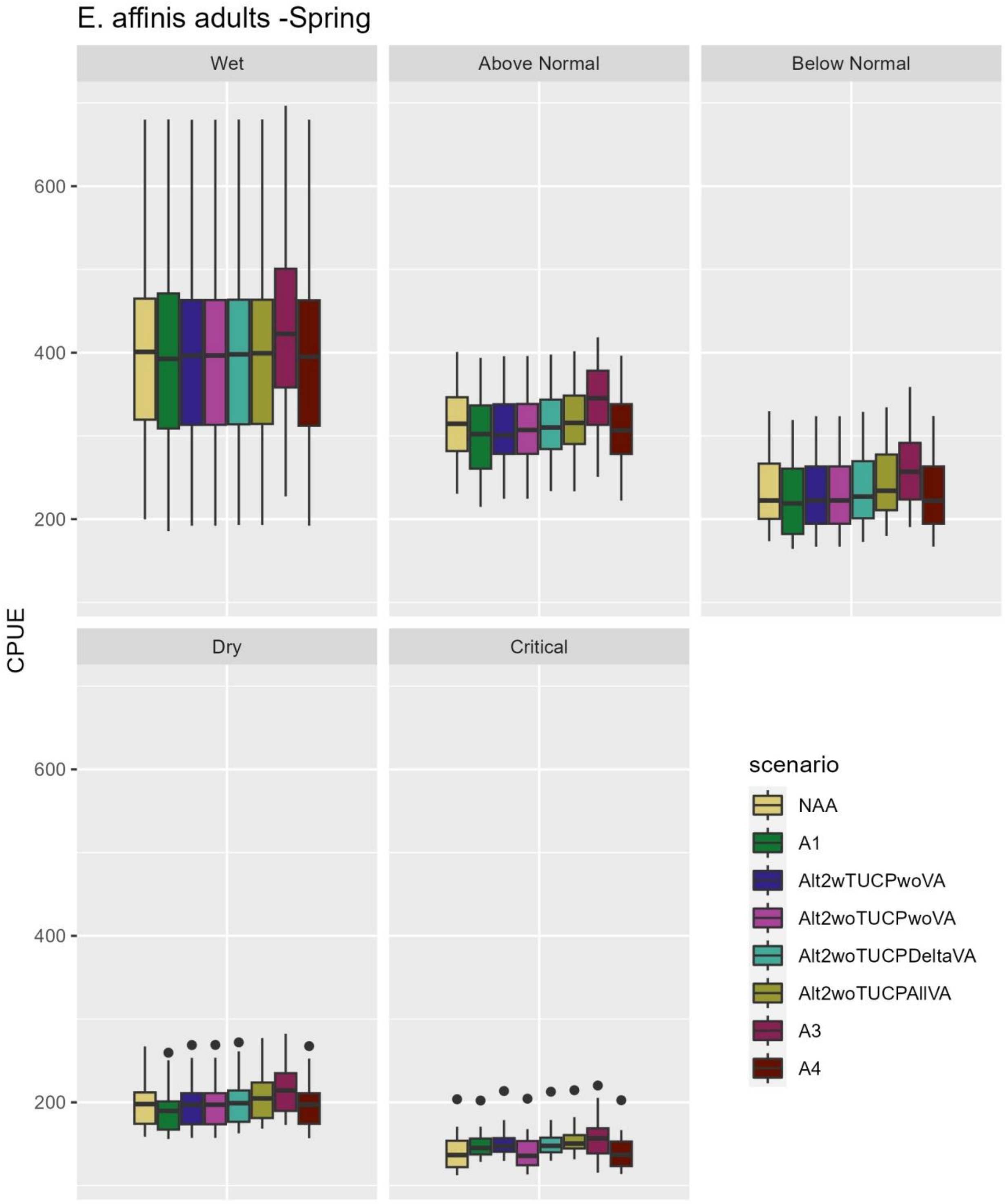


Figure J.3-2. Median, quartile and interquartile ranges of CPUE of *E. affinis* adults by scenario across different water year types for spring.

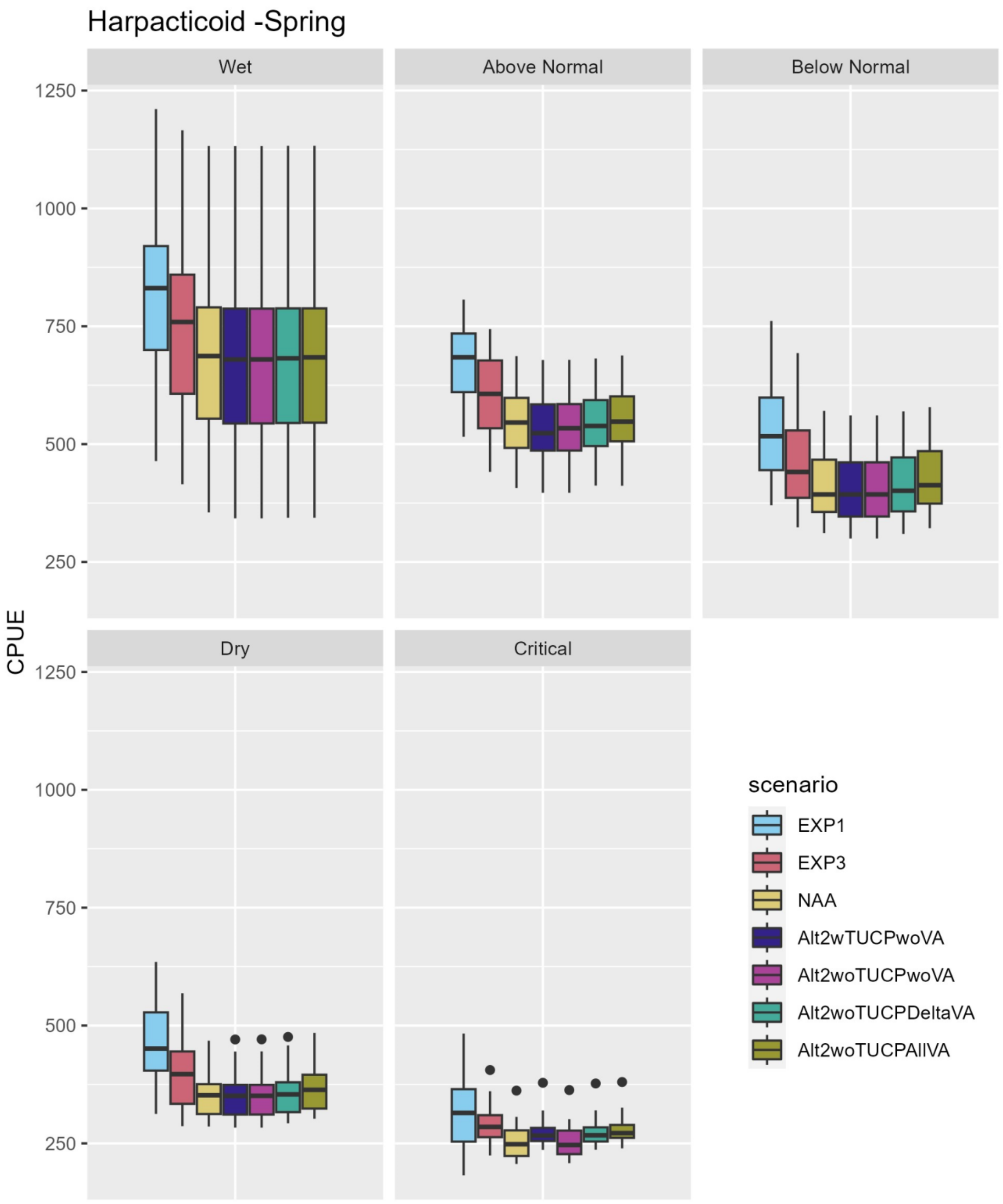


Figure J.3-21. Median, quartile and interquartile ranges of CPUE of harpacticoids by scenario across different water year types for spring.

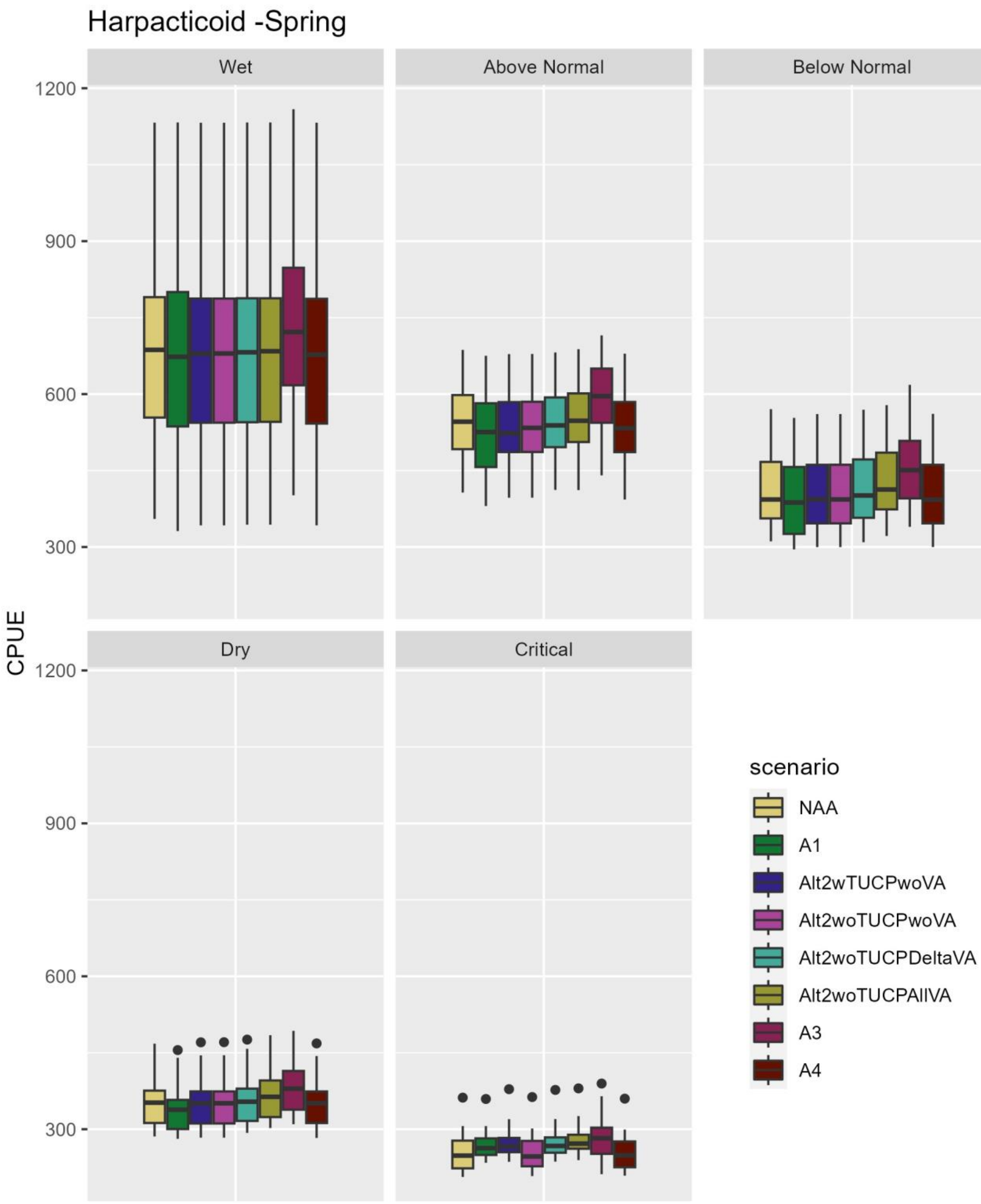


Figure J.3-22. Median, quartile and interquartile ranges of CPUE of harpacticoids by scenario across different water year types for spring.

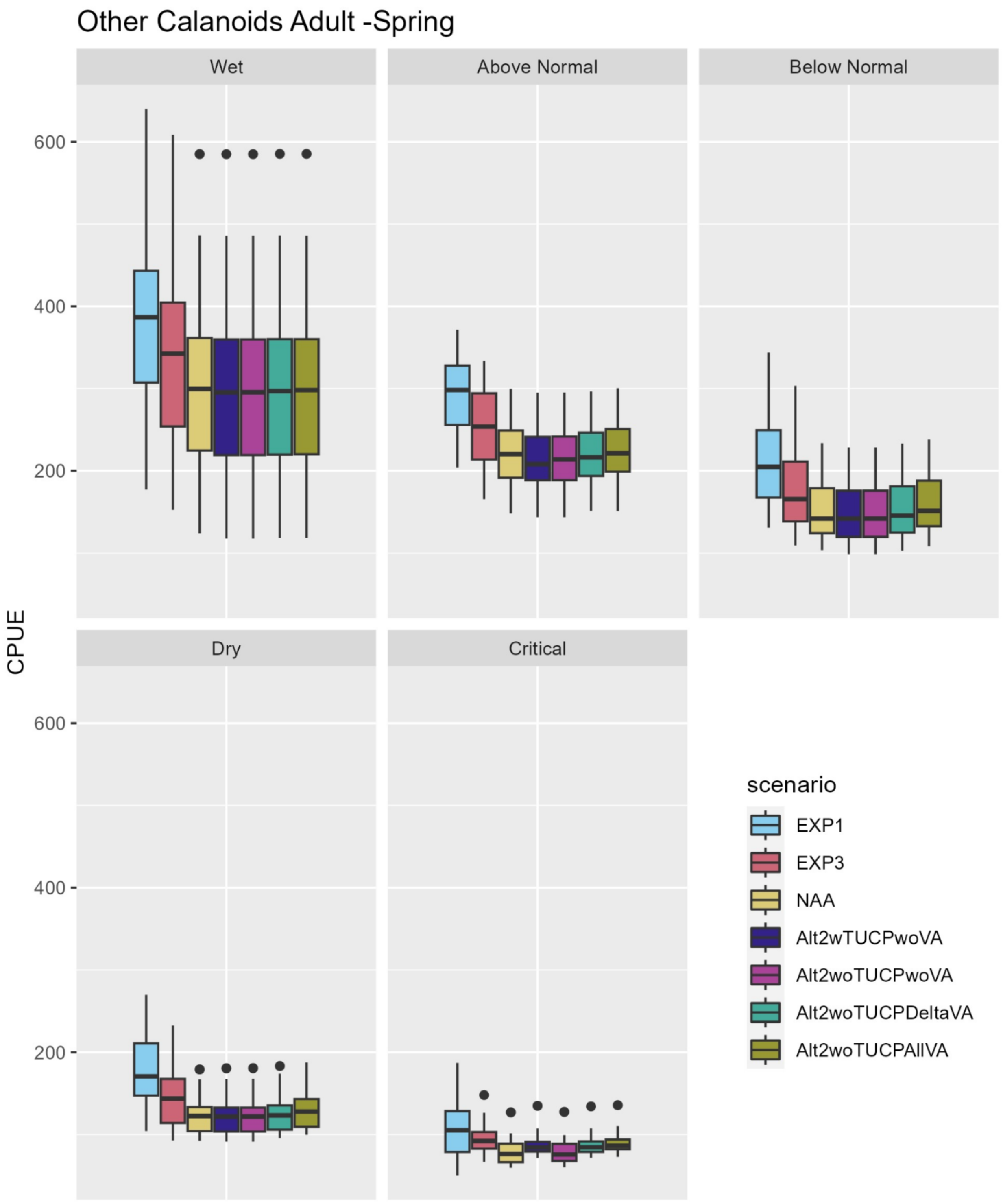


Figure J.3-23. Median, quartile and interquartile ranges of CPUE of other calanoids adults by scenario across different water year types for spring.

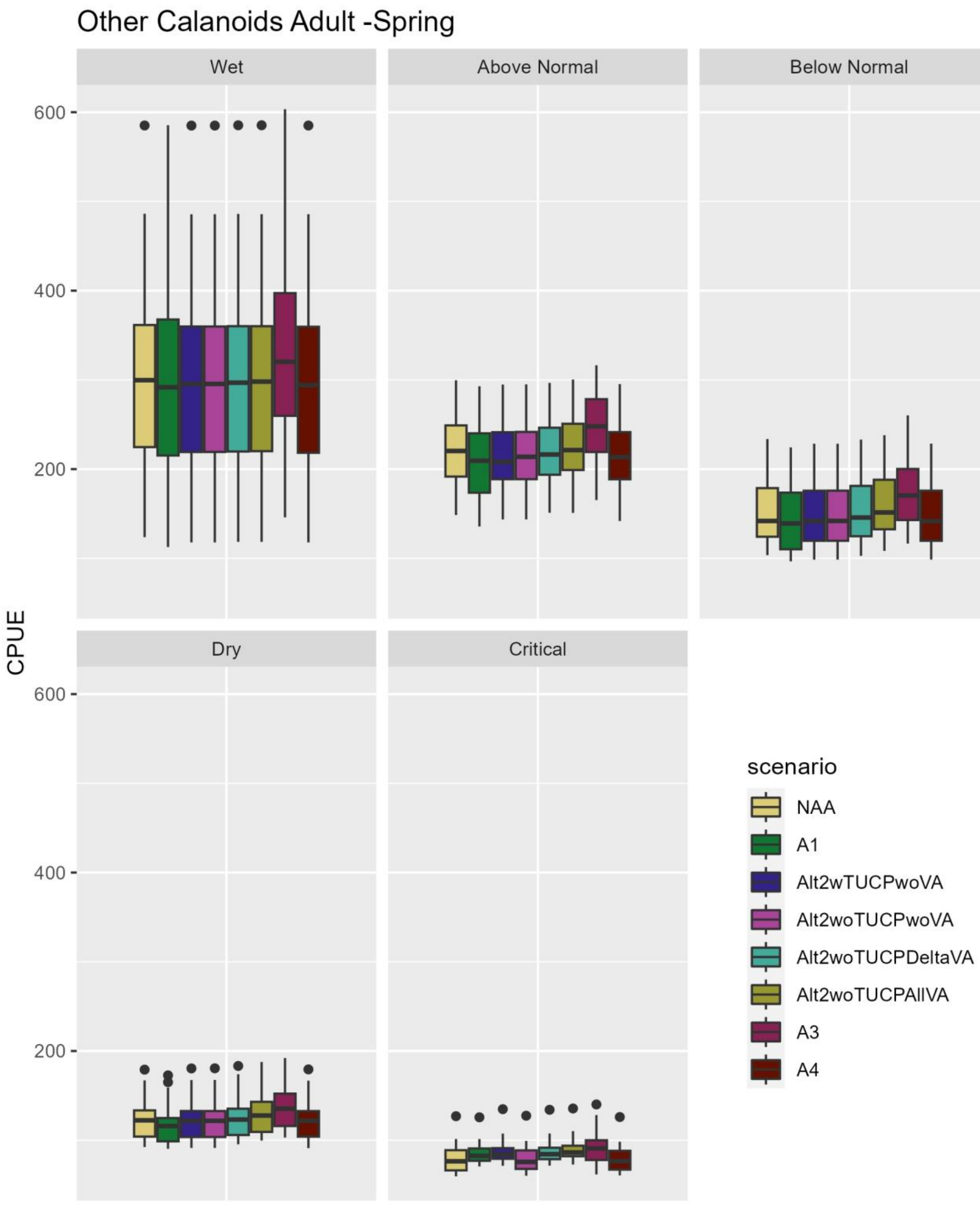


Figure J.3-24. Median, quartile and interquartile ranges of CPUE of other calanoids adults by scenario across different water year types for spring.

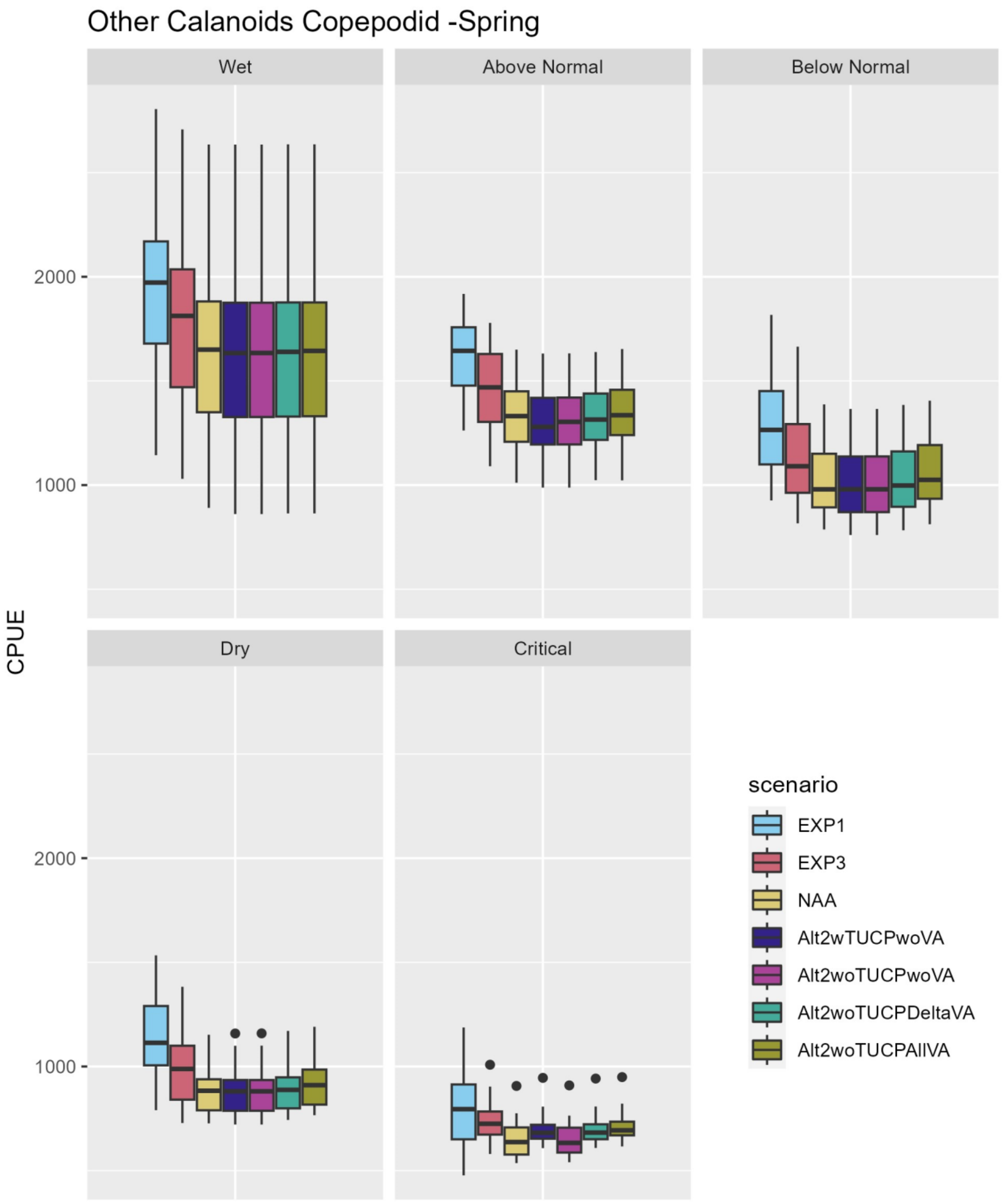


Figure J.3-3. Median, quartile and interquartile ranges of CPUE of other calanoids copepodids by scenario across different water year types for spring.

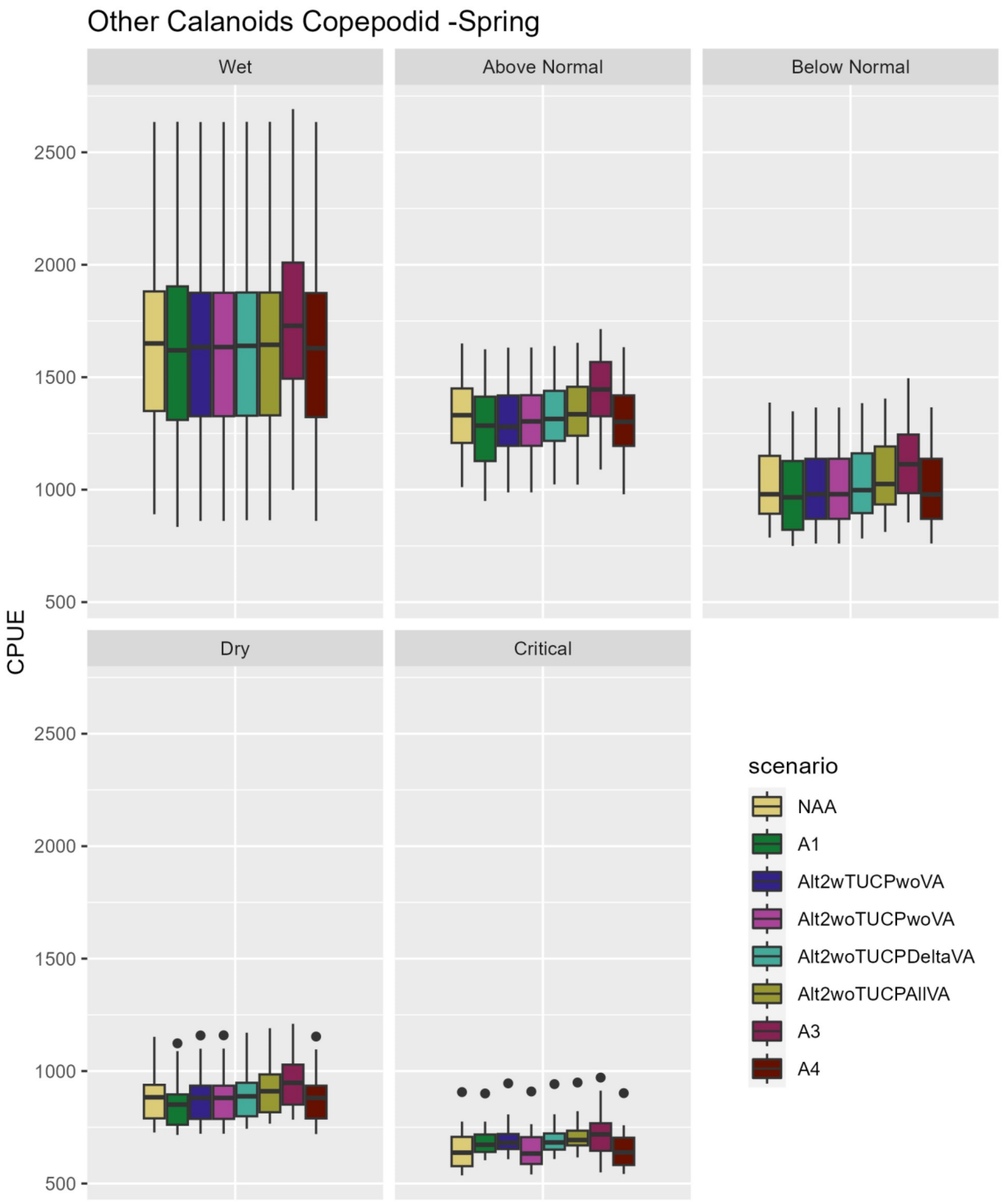


Figure J.3-26. Median, quartile and interquartile ranges of CPUE of other calanoids copepodids by scenario across different water year types for spring.

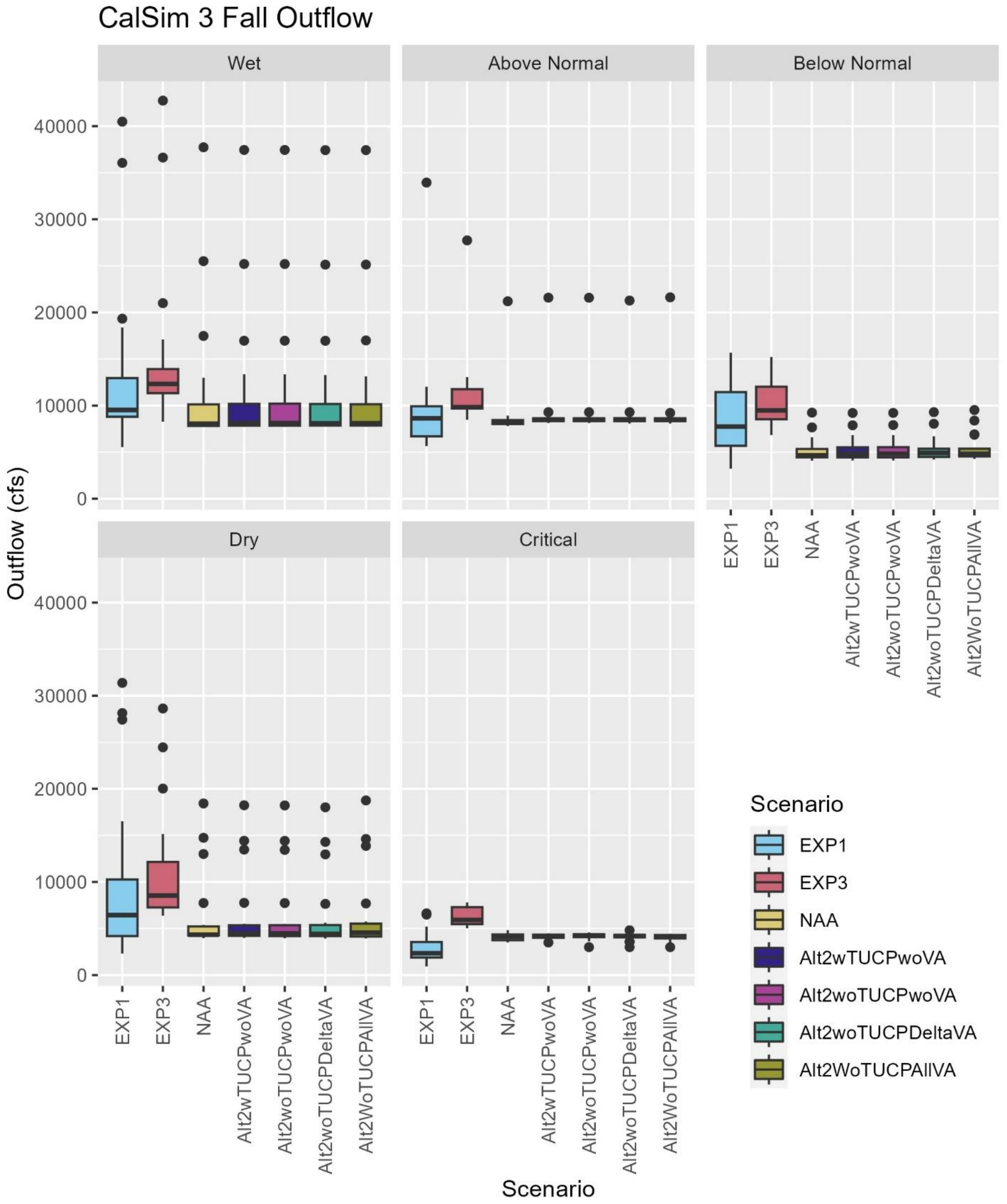


Figure J.3-27. Median, quartile and interquartile ranges for **Fall** (September - November) CalSim 3 outflow (cfs) by modeled scenario and different water year types.

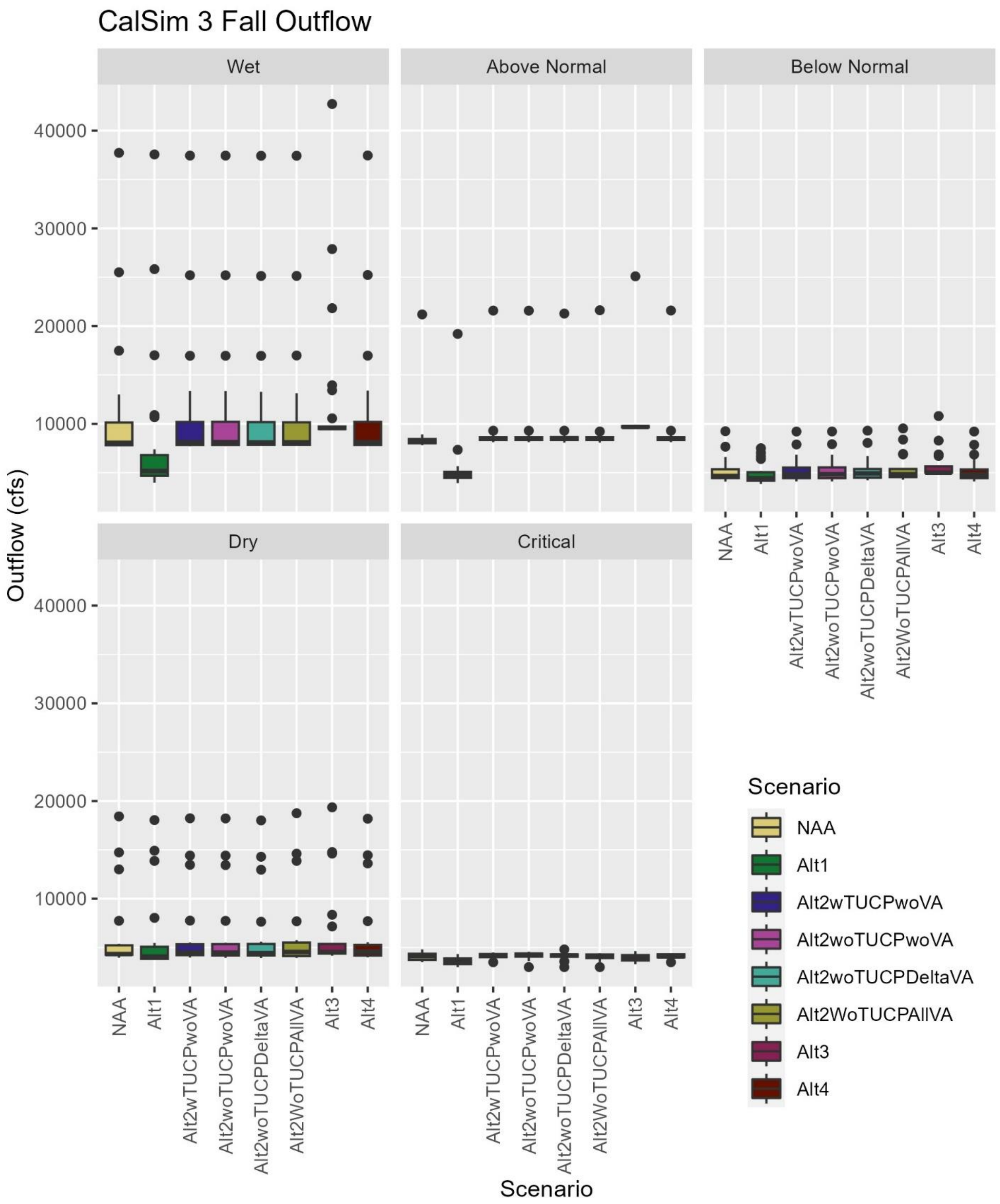


Figure J.3-28. Median, quartile and interquartile ranges for **Fall** (September - November) CalSim 3 outflow (cfs) by modeled scenario and different water year types.

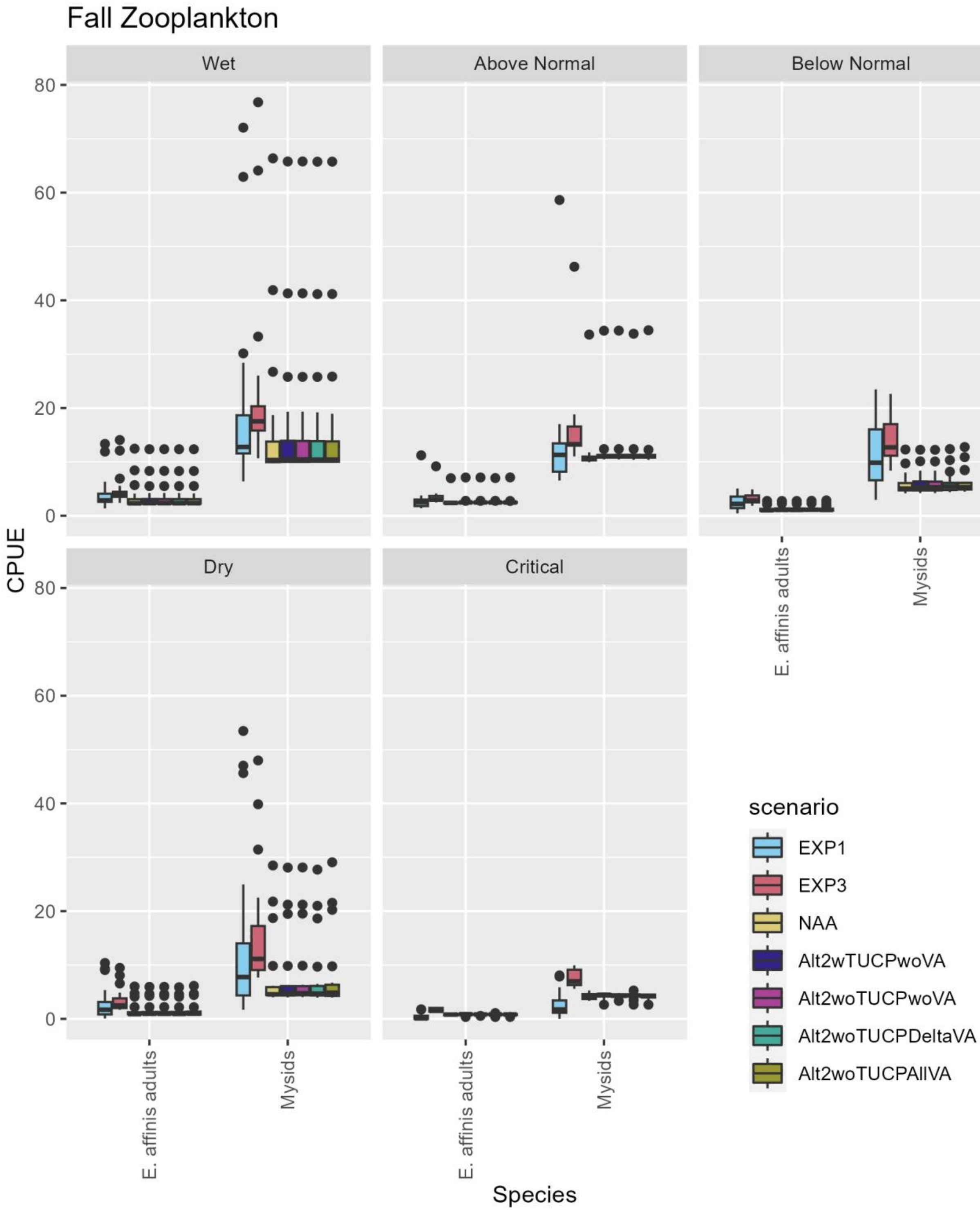


Figure J.3-29. Median, quartile and interquartile ranges of CPUE of significant zooplankton species by scenario across different water year types for fall.

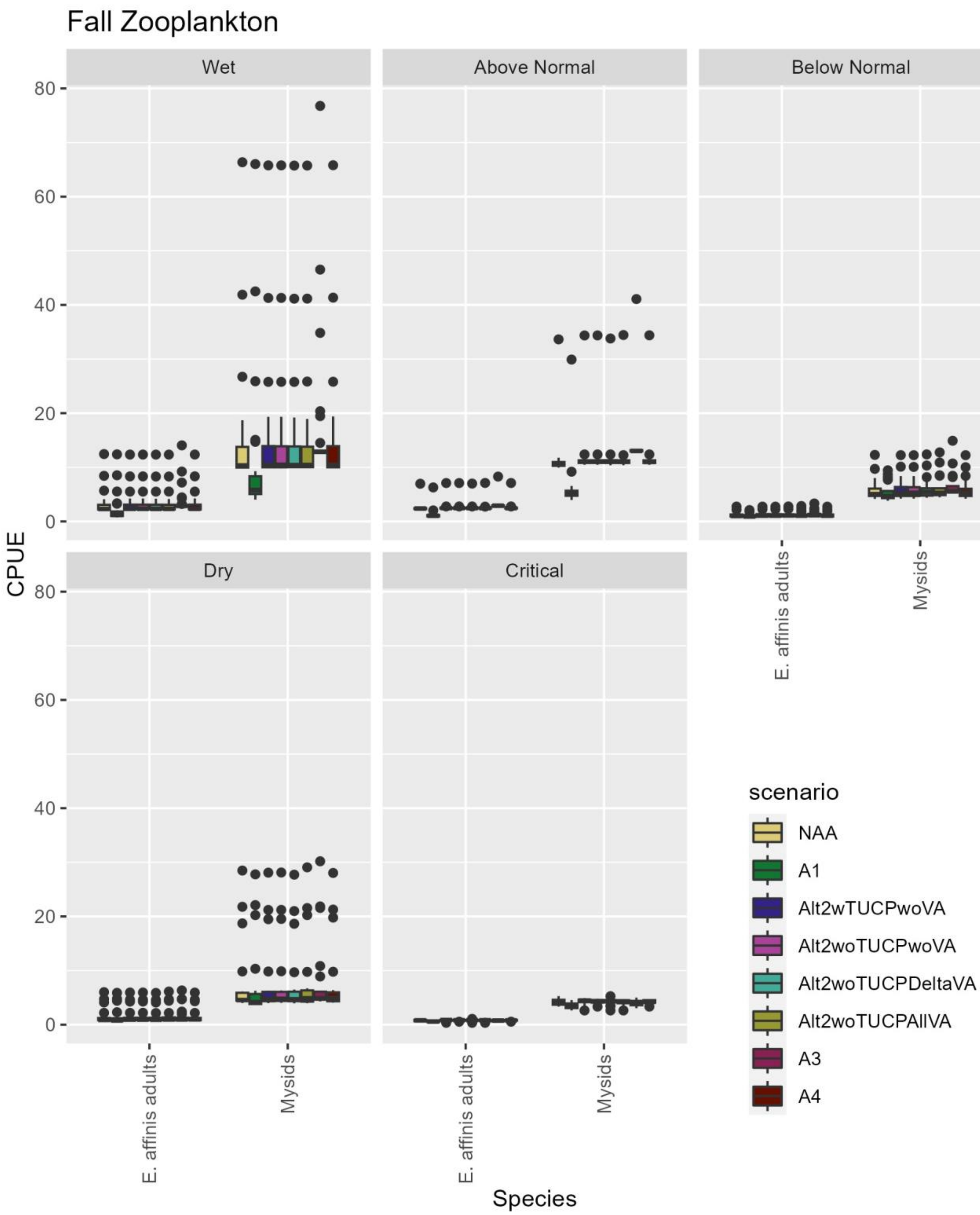


Figure J.3-30. Median, quartile and interquartile ranges of CPUE of significant zooplankton species by scenario across different water year types for fall.

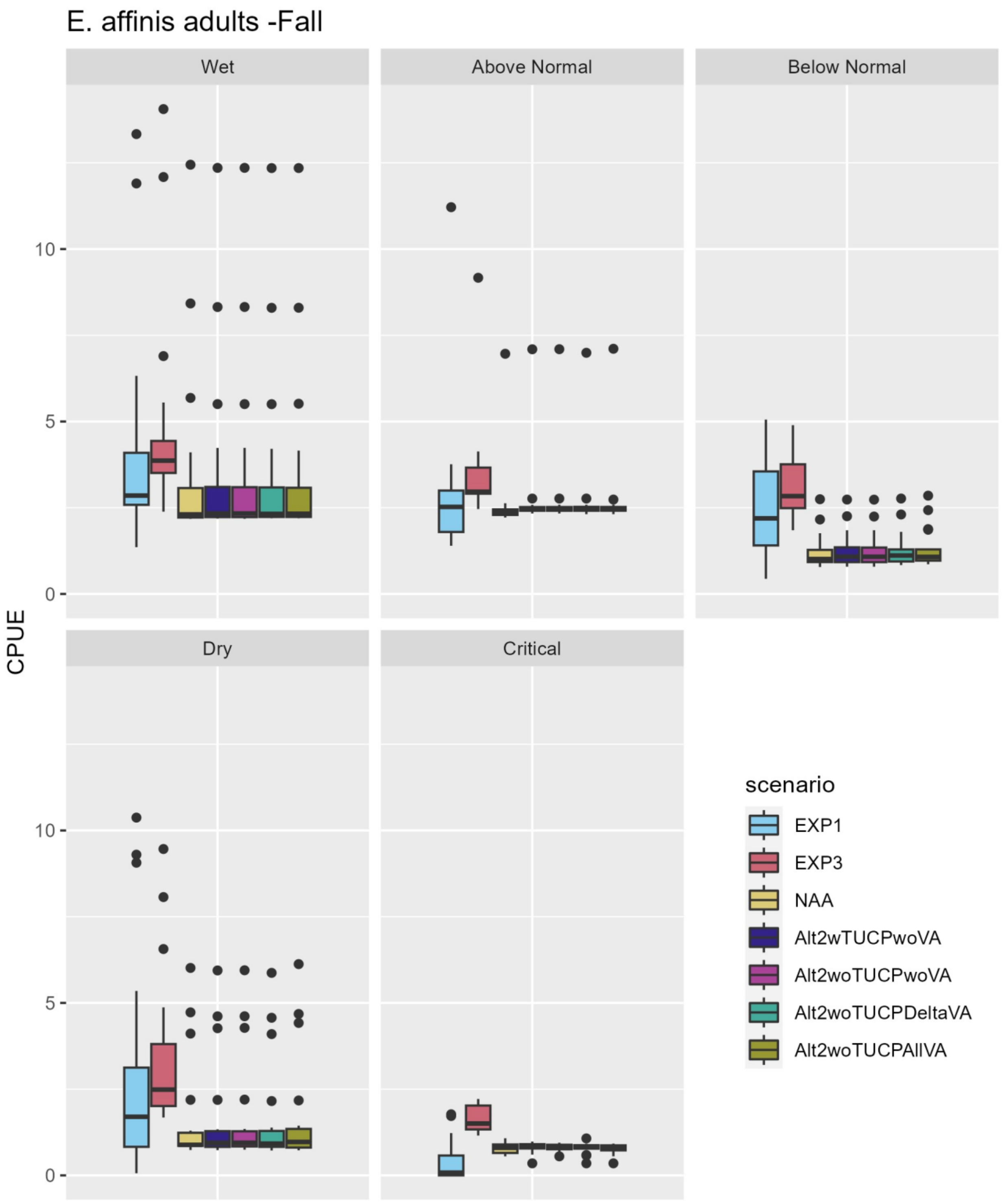


Figure J.3-31. Median, quartile and interquartile ranges of CPUE of *E. affinis* adults by scenario across different water year types for fall.

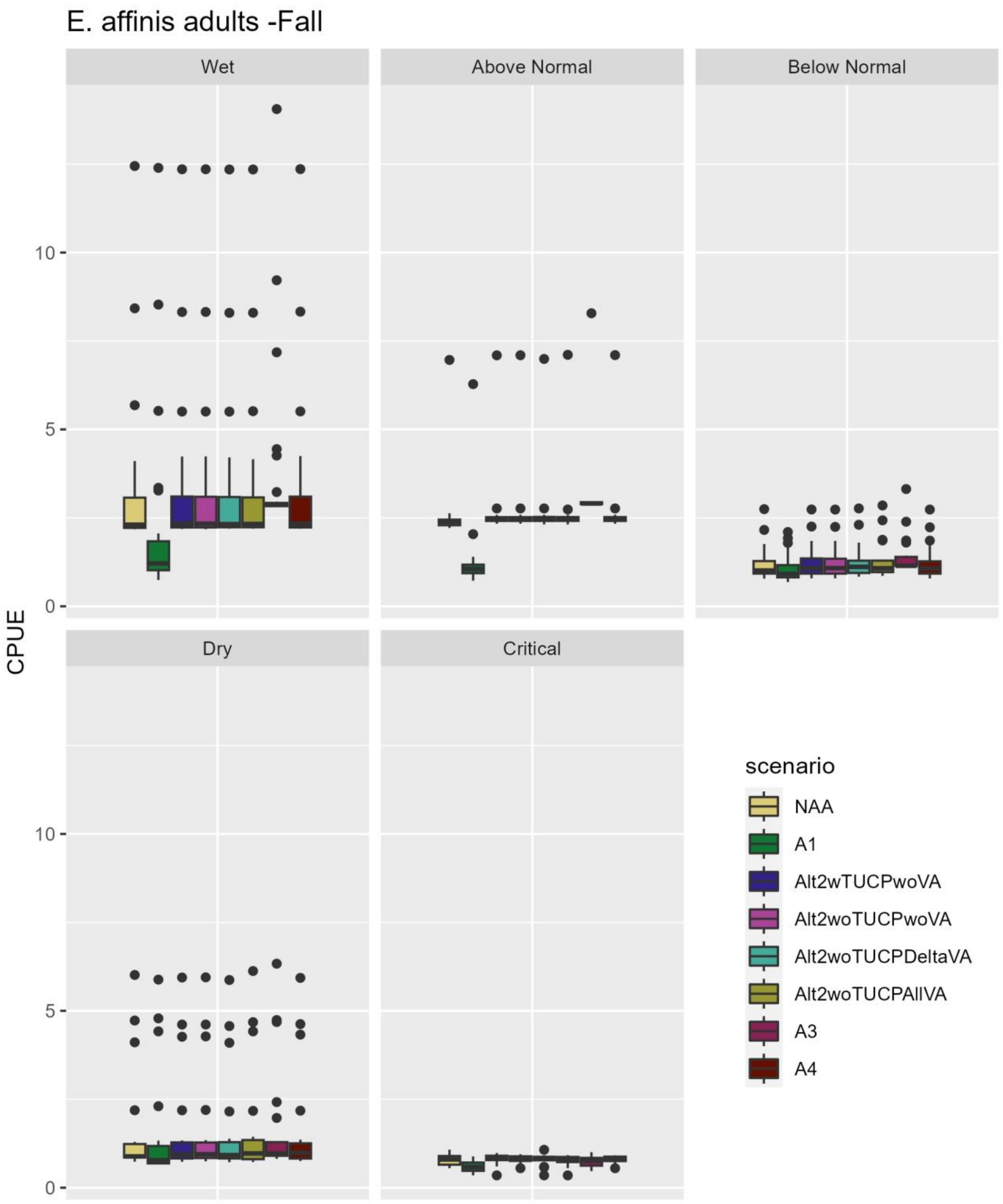


Figure J.3-32. Median, quartile and interquartile ranges of CPUE of *E. affinis* adults by scenario across different water year types for fall.

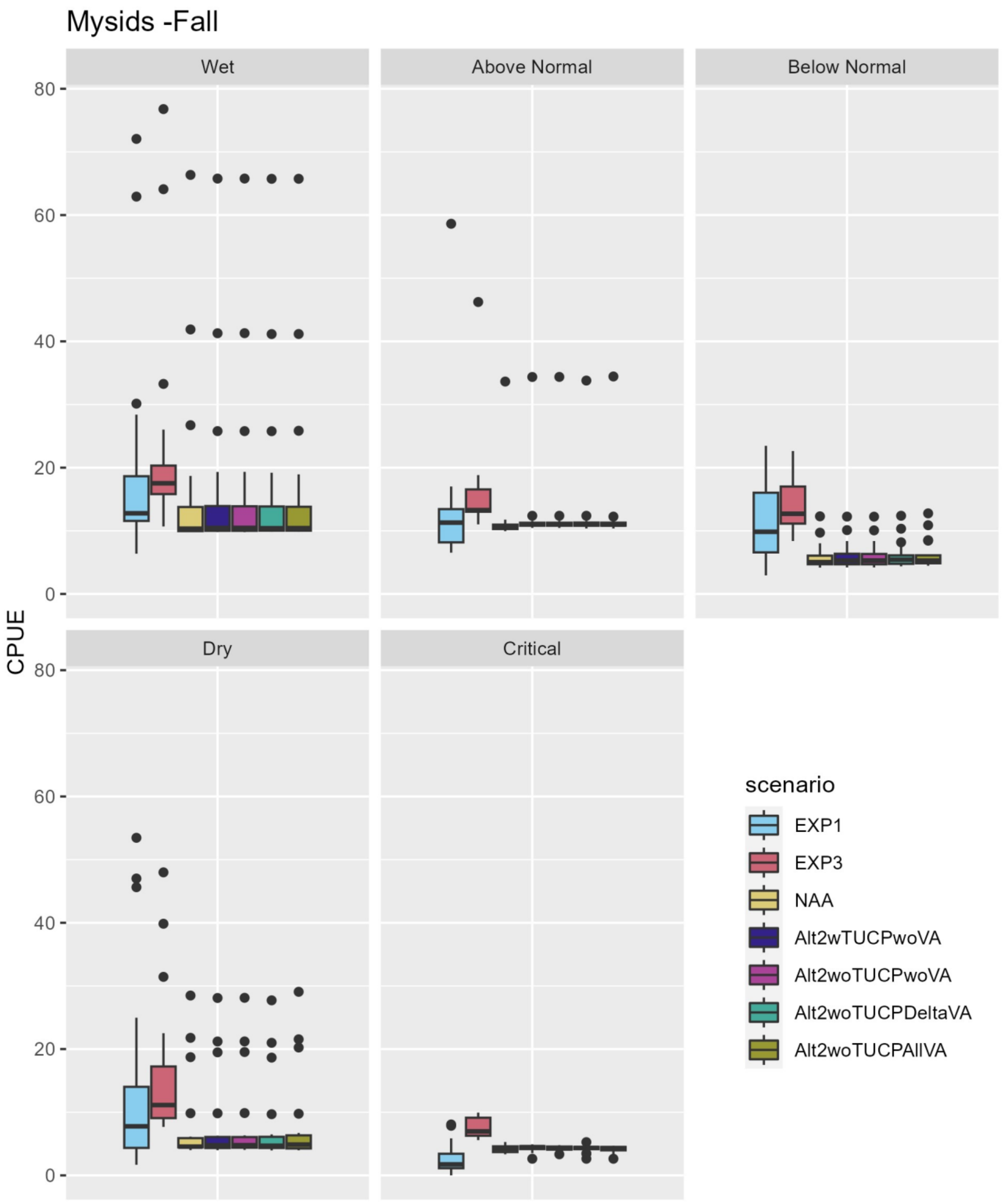


Figure J.3-33. Median, quartile and interquartile ranges of CPUE of mysids by scenario across different water year types for fall.

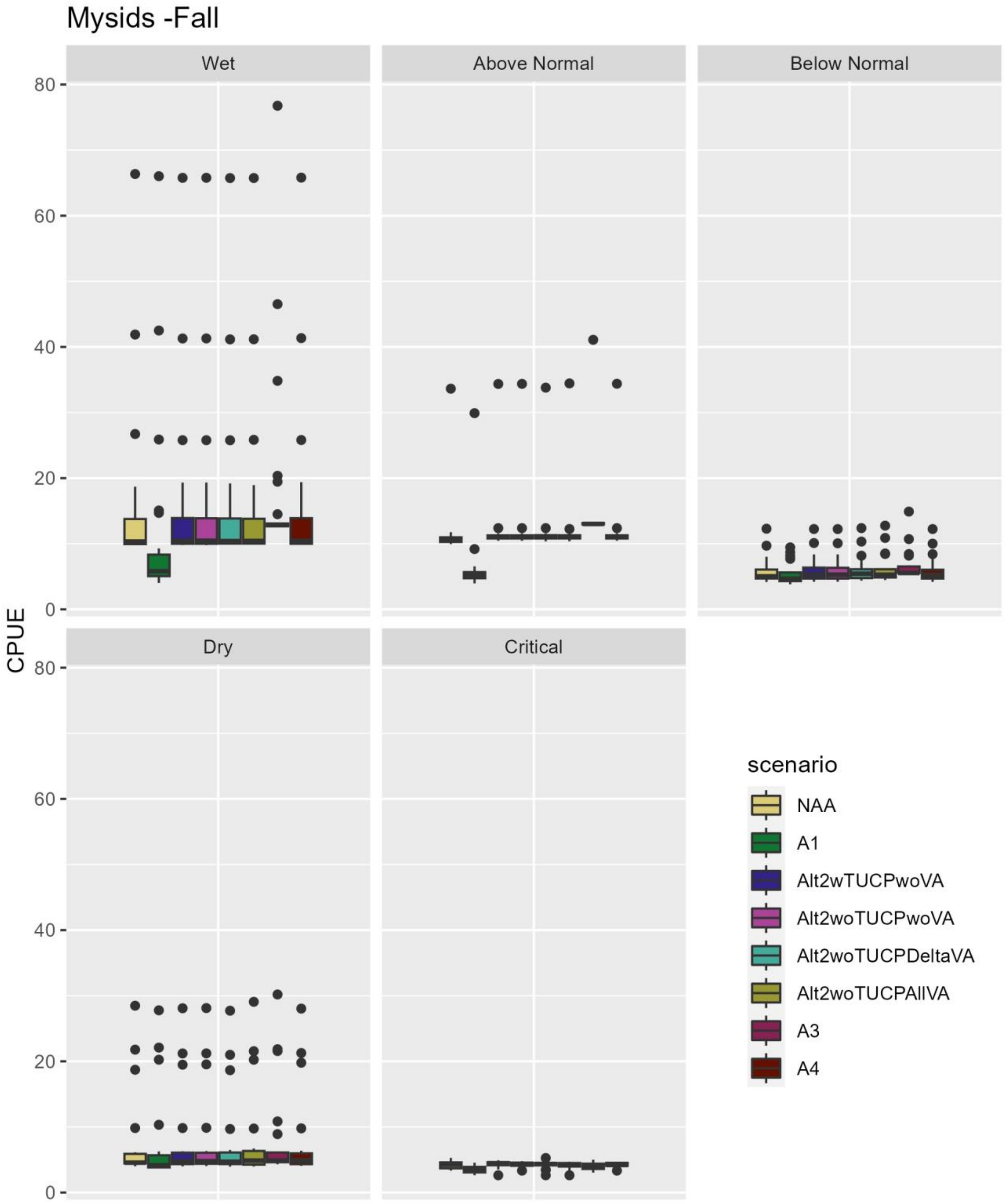


Figure J.3-34. Median, quartile and interquartile ranges of CPUE of mysids by scenario across different water year types for fall.

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