Supplement of Hydrol. Earth Syst. Sci., 21, 5763–5780, 2017
https://doi.org/10.5194/hess-21-5763-2017-supplement


Hydrology and Earth System Sciences
Open Access
EGU

*Supplement of*

# Importance of considering riparian vegetation requirements for the long-term efficiency of environmental flows in aquatic microhabitats

**Rui Rivaes et al.**

*Correspondence to:* Rui Rivaes (ruirivaes@isa.ulisboa.pt)

**Table S1. Flow curve considered in the downstream section of OCBA study site as the outflow condition in River2D model.**

| Discharge ($m^3$ $s^{-1}$) | Water surface elevation (m) |
|---|---|
| 0.05 | 139.65 |
| 0.1 | 139.67 |
| 0.3 | 139.80 |
| 0.5 | 139.92 |
| 0.7 | 140.00 |
| 1 | 140.08 |
| 2 | 140.25 |
| 3 | 140.39 |
| 4 | 140.50 |
| 5 | 140.60 |

**Table S2. Flow curve considered in the downstream section of OCPR study site as the outflow condition in River2D model.**

| Discharge ($m^3$ $s^{-1}$) | Water surface elevation (m) | Discharge ($m^3$ $s^{-1}$) | Water surface elevation (m) |
|---|---|---|---|
| 0.1 | 113.68 | 18 | 114.7 |
| 0.5 | 113.77 | 20 | 114.76 |
| 0.7 | 113.82 | 25 | 114.9 |
| 1 | 113.89 | 30 | 115.03 |
| 1.5 | 113.95 | 40 | 115.25 |
| 2 | 114 | 50 | 115.42 |
| 2.5 | 114.04 | 60 | 115.55 |
| 3 | 114.08 | 80 | 115.78 |
| 4 | 114.14 | 100 | 116 |
| 5 | 114.2 | 150 | 116.47 |
| 6 | 114.25 | 200 | 116.82 |
| 7 | 114.29 | 300 | 117.41 |
| 8 | 114.34 | 400 | 117.96 |
| 9 | 114.38 | 600 | 118.71 |
| 10 | 114.42 | 800 | 119.28 |
| 12 | 114.49 | 1000 | 119.77 |
| 14 | 114.58 | 1200 | 120.22 |
| 16 | 114.64 | | |

**Table S3. Channel roughness classification of the different substrates in the aquatic zone of the river without vegetation used in the River2D model for both case studies.**

| Substrate | Effective roughness height, $k_s$ (m) |
|---|---|
| Sand and gravel | 0.1 |
| Boulders and stones | 0.5 |

**Table S4. Channel roughness classification of the different considered riparian vegetation succession phases used in the River2D model for both case studies (IP – Initial phase, PP – Pioneer phase, ES – Early succession woodland phase, EF – Established forest phase and MF – Mature forest phase).**

| Succession phase | Effective roughness height, $k_s$ (m) |
|---|---|
| IP | 0.4 |
| PP | 0.5 |
| ES | 1.6 |
| EF | 1.1 |
| MF | 1.4 |

**Table S5. CASiMiR-vegetation model parameterization (IP – Initial phase, PP – Pioneer phase, ES – Early succession woodland phase, EF – Established forest phase and MF – Mature forest phase).**

| Parameter | Succession phase | Value |
|---|---|---|
| Height to water table elevation (m) | IP | < 0.2 |
| | PP | 0.2 – 0.6 |
| | ES | 0.6 – 1.05 |
| | EF | 1.05 – 3.4 |
| | MF | > 3.4 |
| Age (years) | IP | < 2 |
| | PP | 2 – 6 |
| | ES | 6 – 19 |
| | EF | 19 – 26 |
| | MF | > 26 |
| Resistance to shear stress (N $m^{-2}$) | IP | 30 |
| | PP | 30 |
| | ES | 50 |
| | EF | 300 |
| | MF | 300 |

**Table S6. Patch characterization of succession phases (IP – Initial phase, PP – Pioneer phase, ES – Early succession woodland phase, EF – Established forest phase and MF – Mature forest phase).**

| Succession phase | Patches surveyed | Mean height to mean water level (m) | Mean area ($m^2$) | Mean cover of herb layer (%) | Mean cover of shrub layer (%) | Mean cover of tree layer (%) | Mean number of woody species |
|---|---|---|---|---|---|---|---|
| IP | 11 | 1.12 | 357.51 | 0.48 | 0.05 | 0.00 | 0 |
| PP | 17 | 0.40 | 350.73 | 0.81 | 0.26 | 0.00 | 1 |
| ES | 20 | 0.68 | 256.82 | 0.29 | 0.71 | 0.04 | 2 |
| EF | 8 | 1.89 | 1132.20 | 0.61 | 0.46 | 0.19 | 5 |

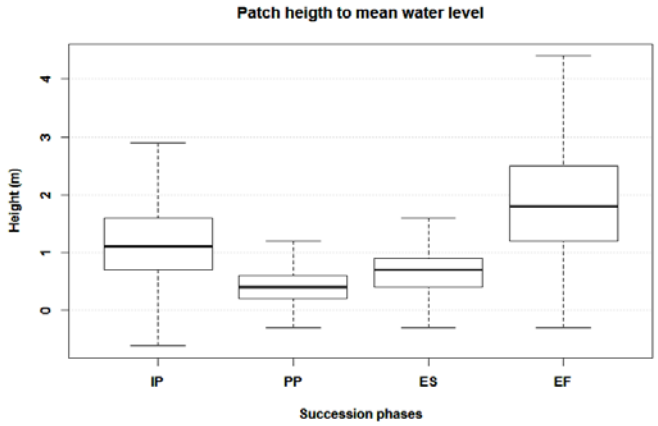


**Figure S1. Patch height to mean water level grouped by succession phase (IP – Initial phase, PP – Pioneer phase, ES – Early succession woodland phase and EF – Established forest phase).**

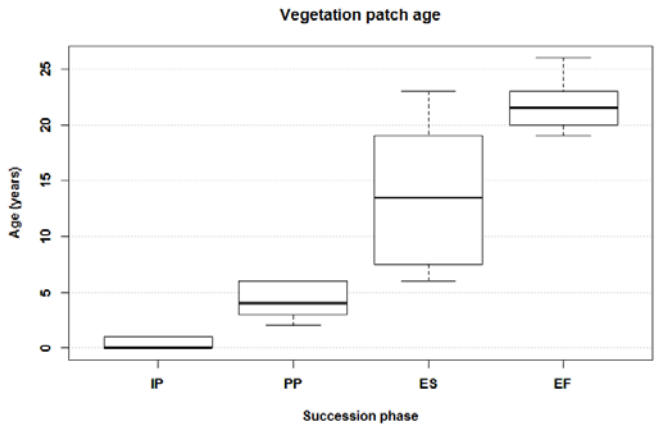


**Figure S2. Patch age grouped by succession phase (IP – Initial phase, PP – Pioneer phase, ES – Early succession woodland phase and EF – Established forest phase).**

**Table S7. Number of captured cyprinid individuals throughout different sampling seasons in Ocreza river basin.**

| Common name | Cyprinid Species | Spring | Summer | Autumn | Total |
|---|---|---|---|---|---|
| Iberian barbel | *Luciobarbus bocagei* | 666 | 300 | 102 | 1068 |
| Iberian straight mouth-nase | *Pseudochondrostoma polylepis* | 46 | 62 | 102 | 210 |
| Calandino | *Squalius alburnoides* | 277 | 364 | 134 | 775 |
| Southern Iberian chub | *Squalius pyrenaicus* | 9 | 0 | 29 | 38 |
| | Total | 998 | 726 | 367 | 2091 |

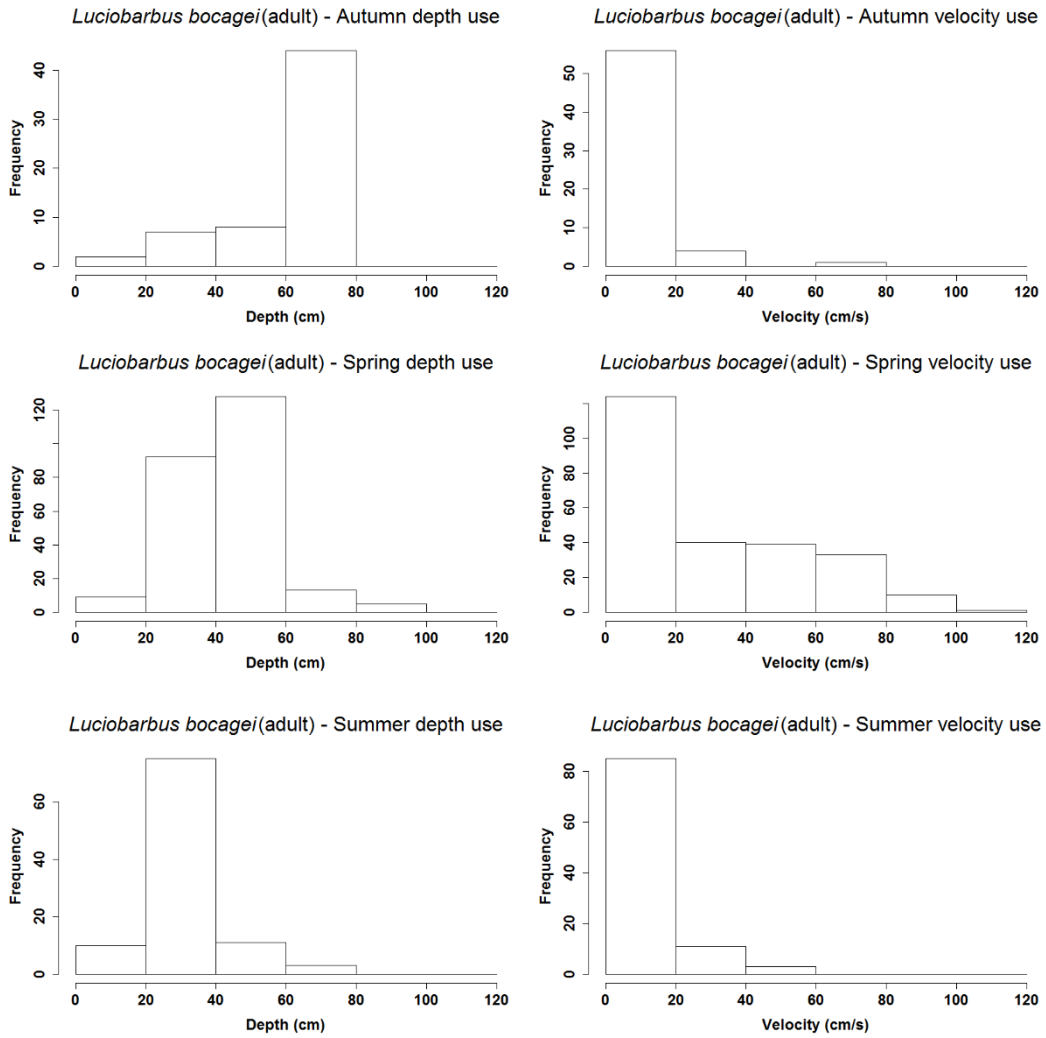


**Figure S3. Use frequency of Luciobarbus bocagei adults for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

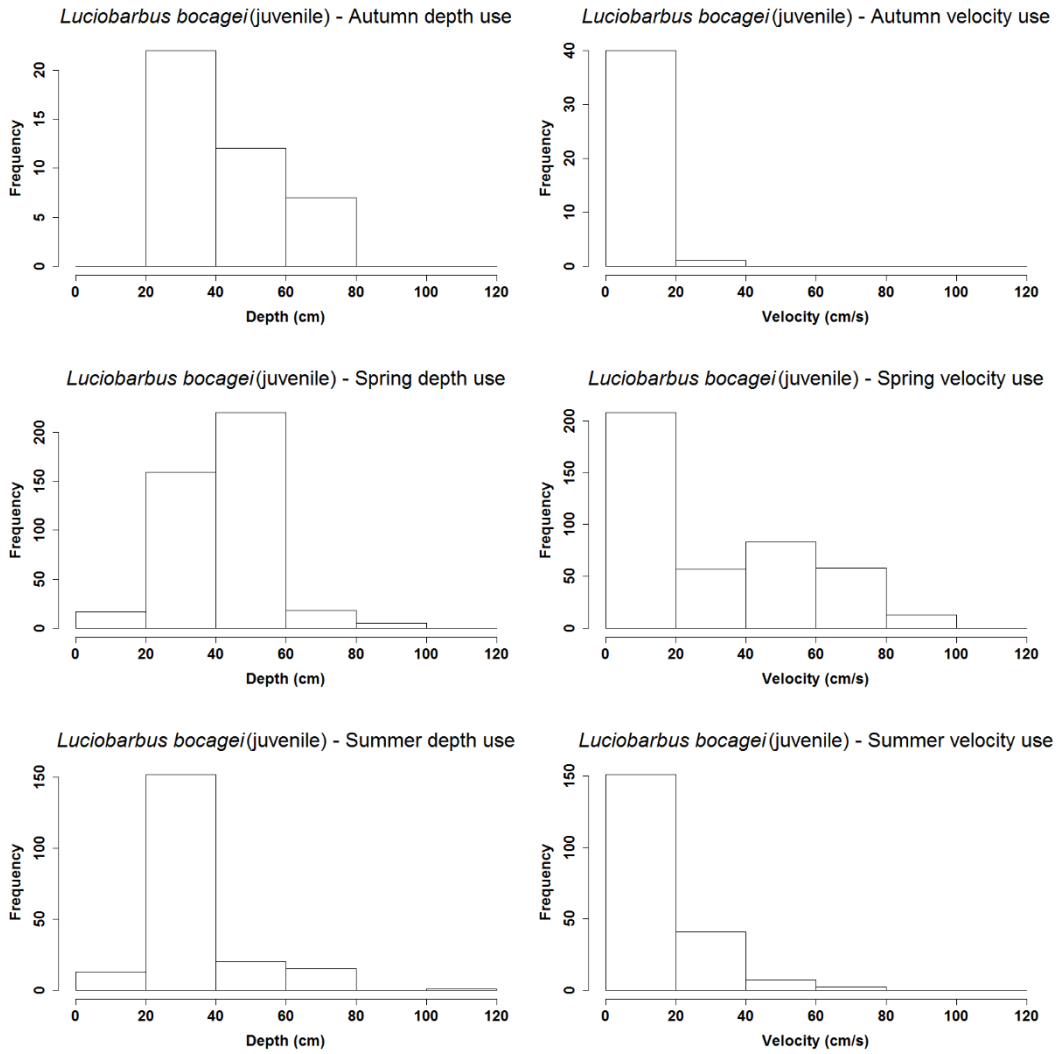


**Figure S4. Use frequency of *Luciobarbus bocagei* juveniles for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

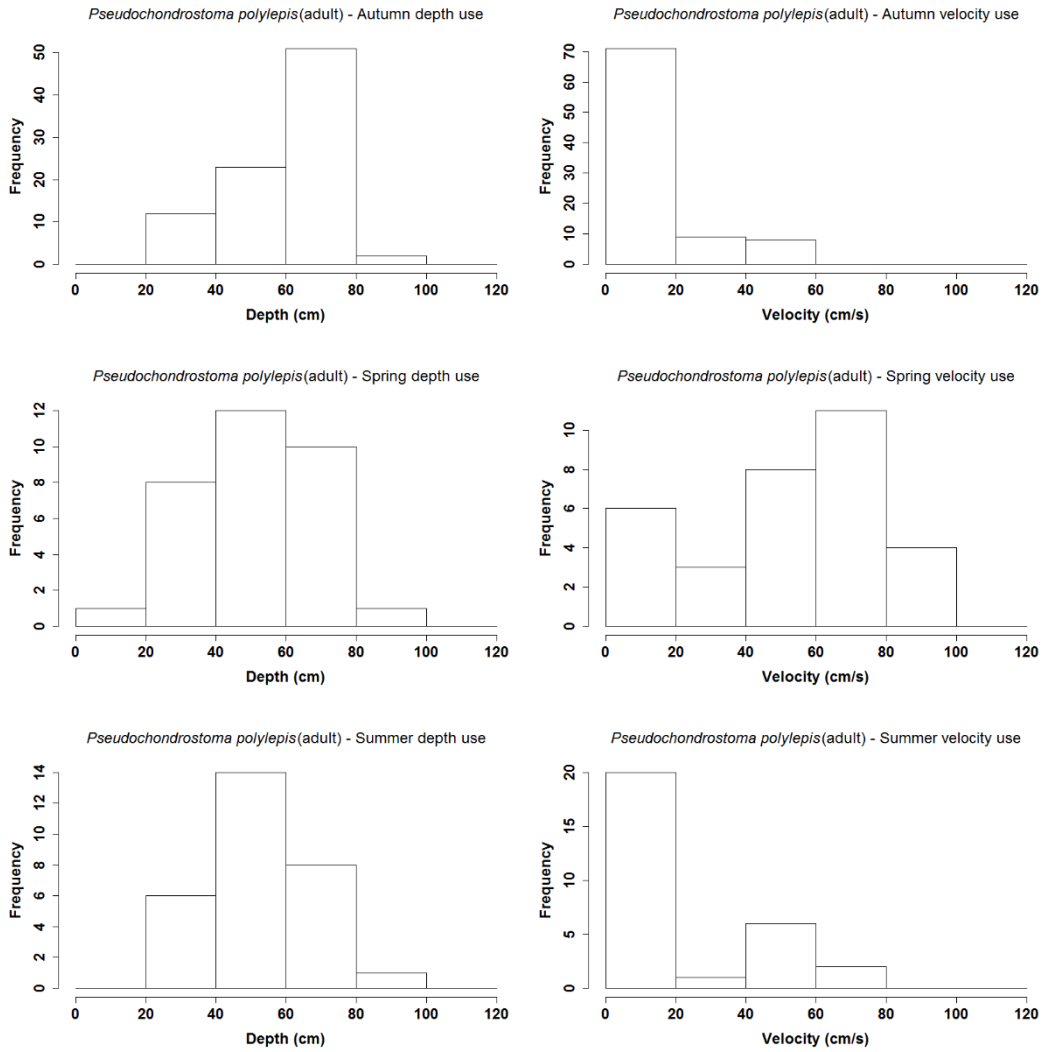


**Figure S5. Use frequency of *Pseudochondrostoma polylepis* adults for water depth (cm) and flow velocity (cm s$^{-1}$) during Autumn, Spring and Summer.**

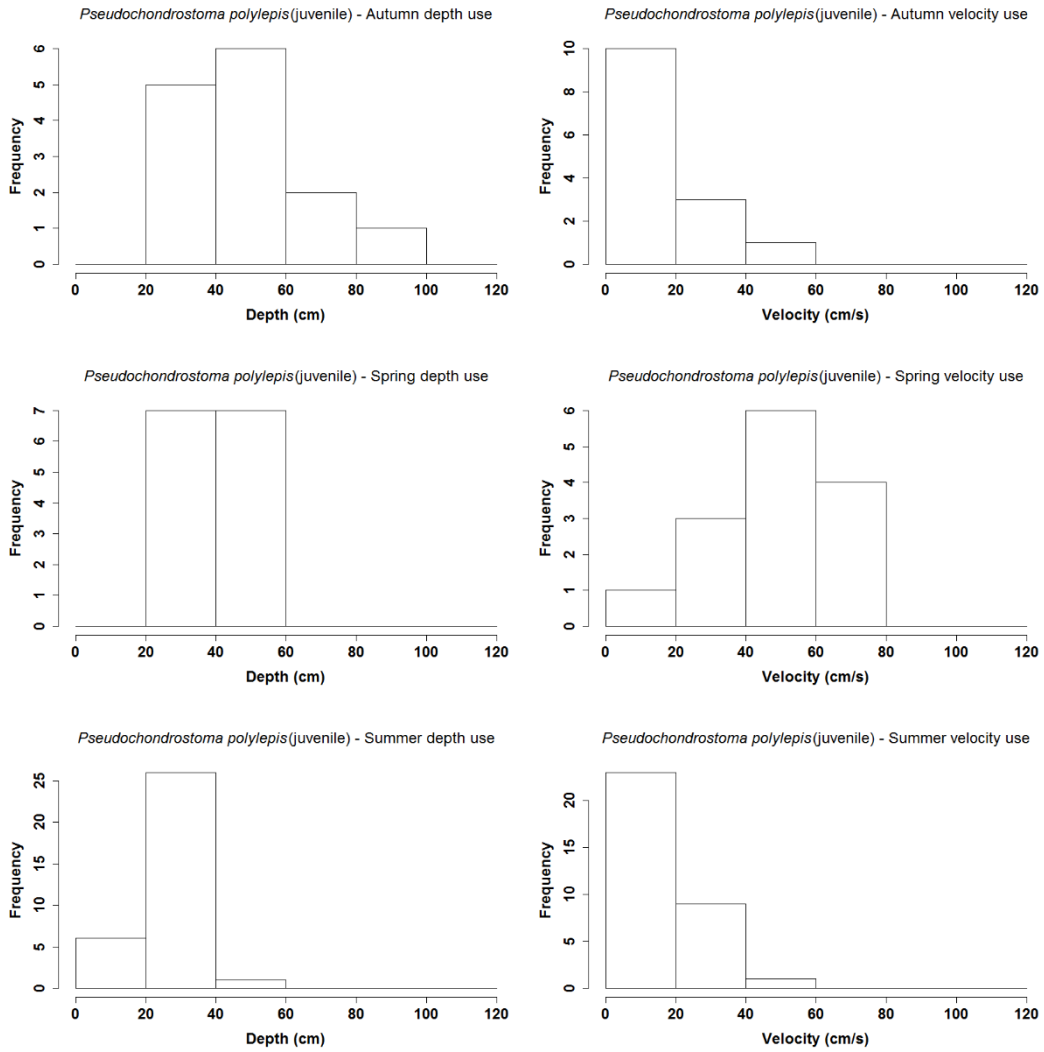


**Figure S6. Use frequency of *Pseudochondrostoma polylepis* juveniles for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

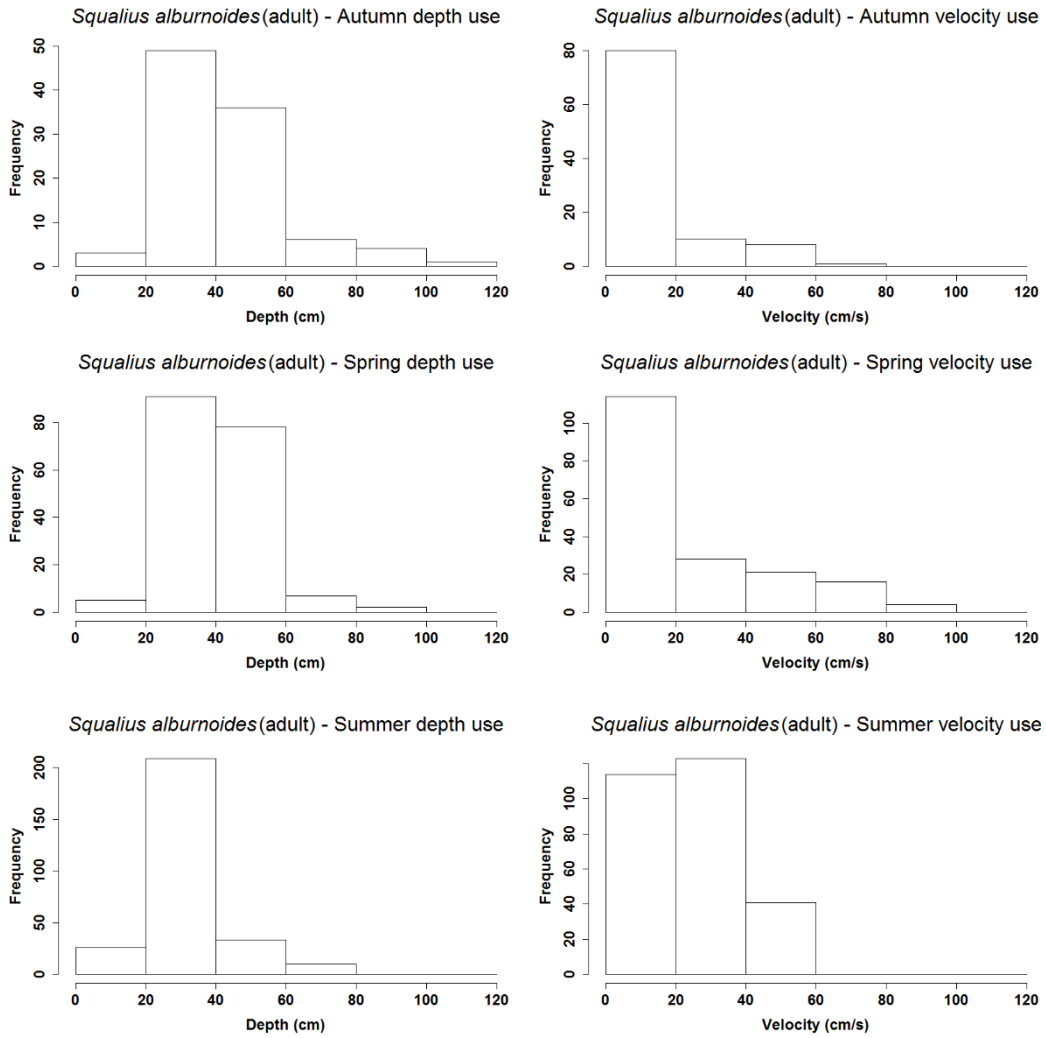


**Figure S7. Use frequency of *Squalius alburnoides* adults for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

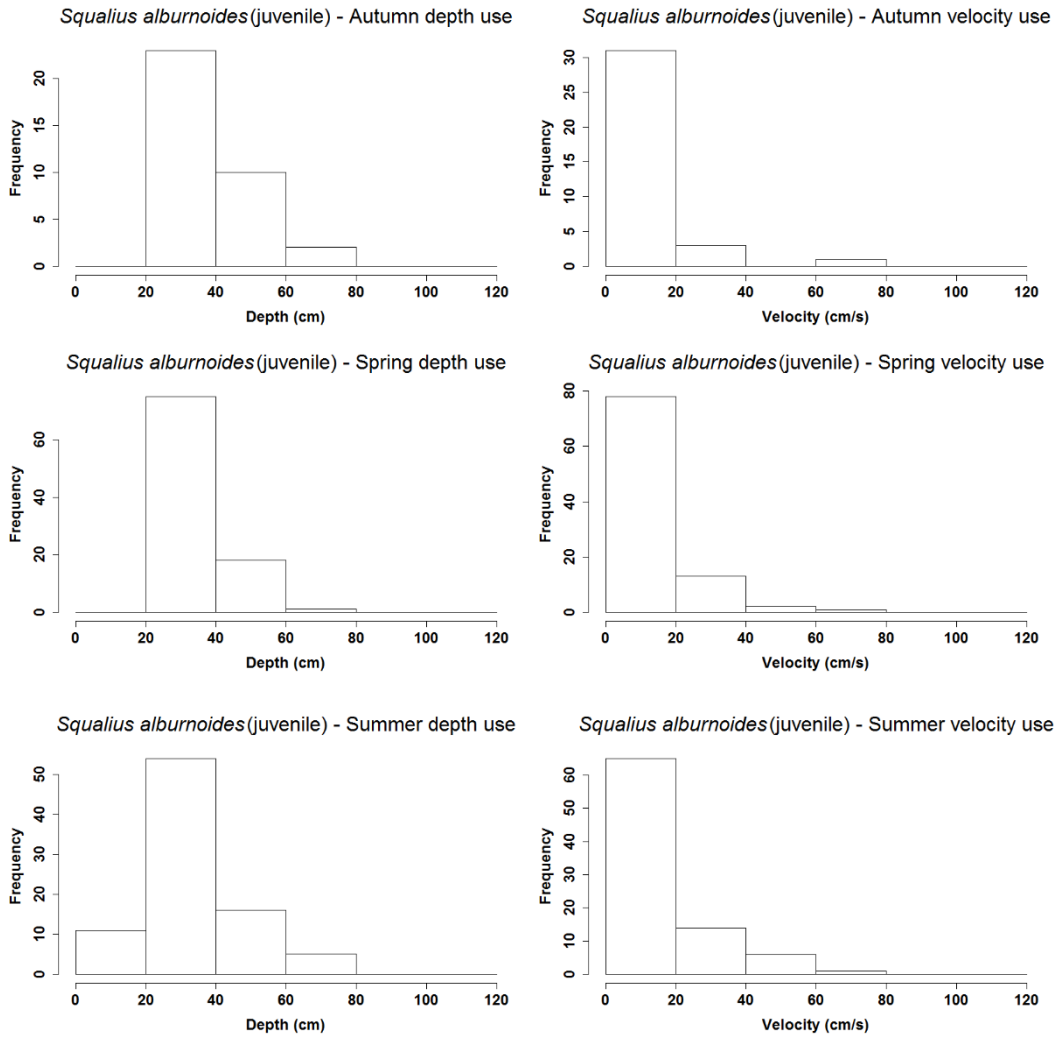


**Figure S8. Use frequency of *Squalius alburnoides* juveniles for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

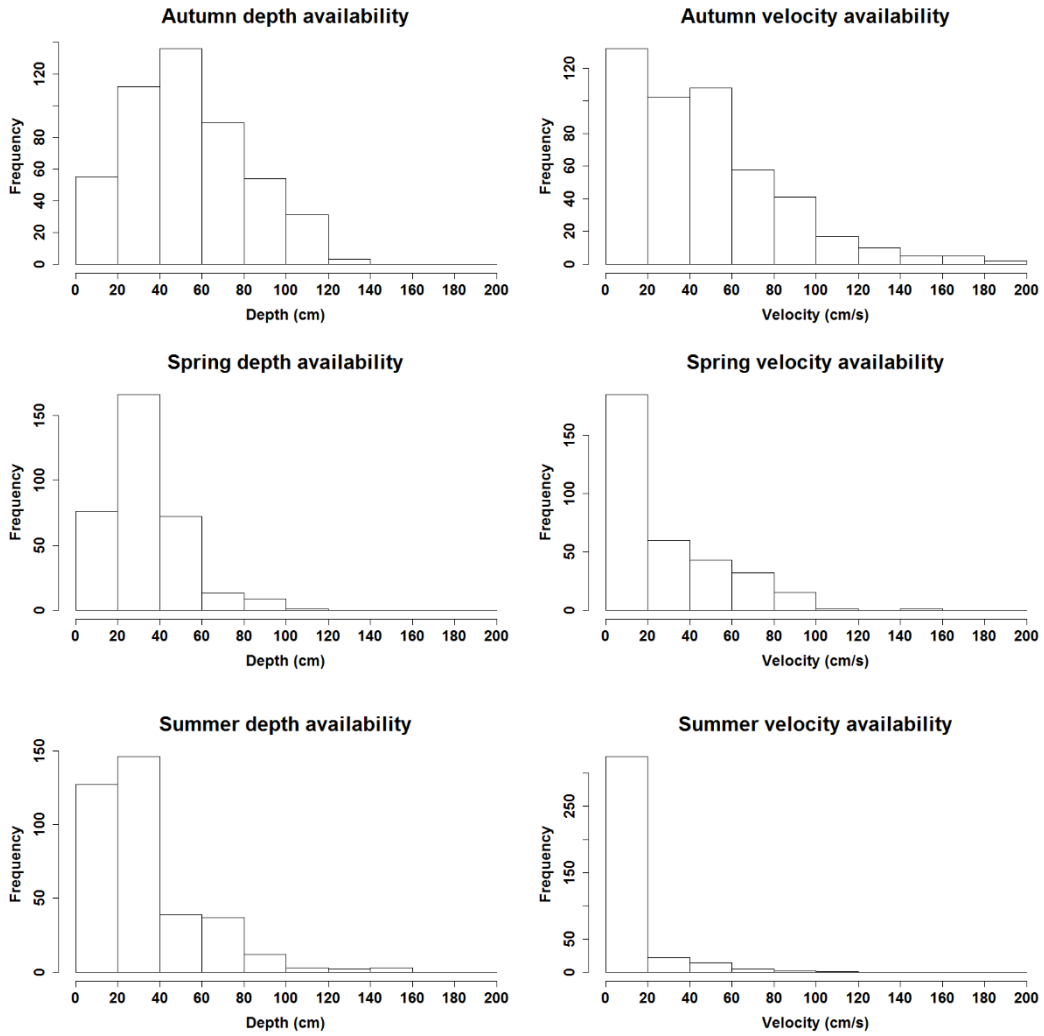


**Figure S9. Habitat availability for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

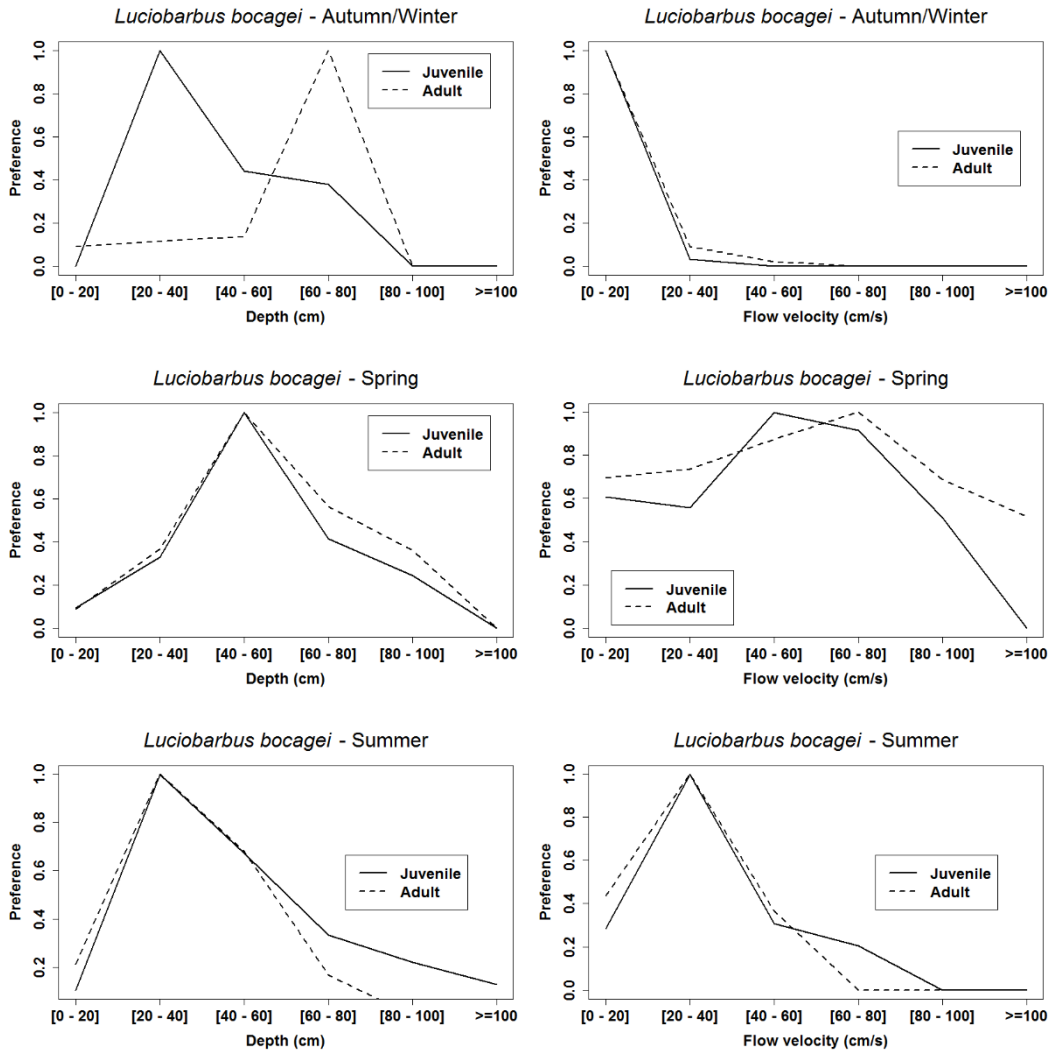


**Figure S10. Habitat preference of *Luciobarbus bocagei* for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

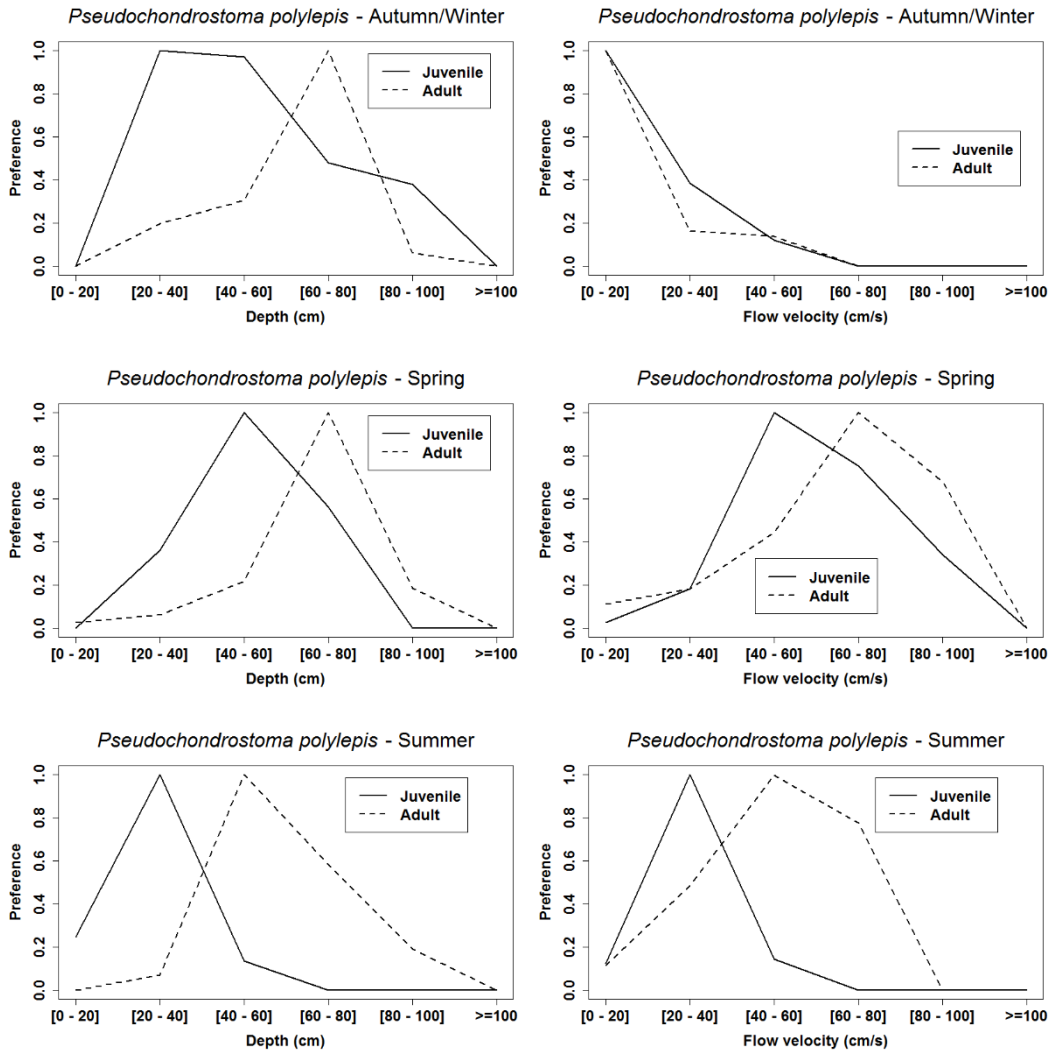


**Figure S11. Habitat preference of *Pseudochondrostoma polylepis* for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

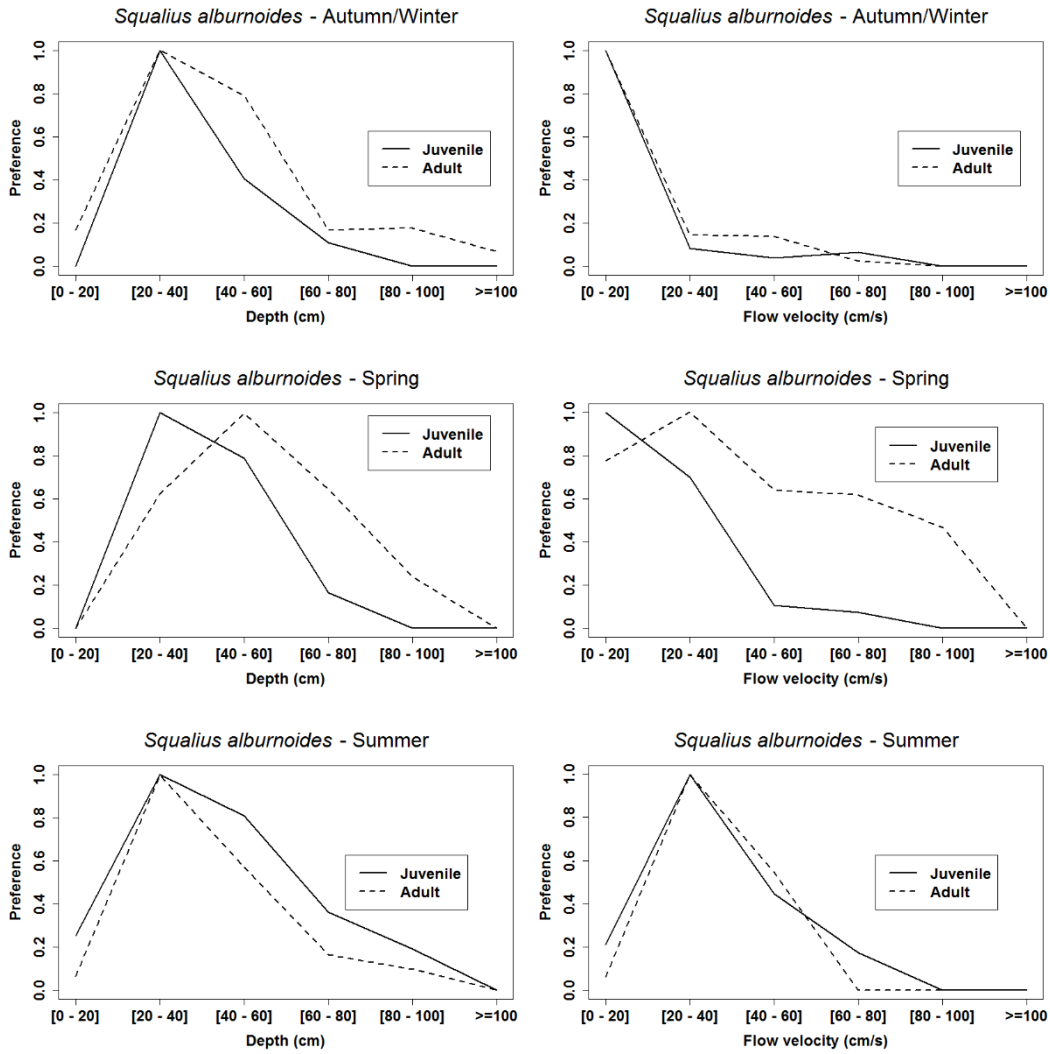


**Figure S12. Habitat preference of *Squalius alburnoides* for water depth (cm) and flow velocity (cm $s^{-1}$) during Autumn, Spring and Summer.**

**Table S8. Results of the t-tests (H0: true difference in means is equal to 0) for the differences between Natural, Eflow and Eflow&Flush habitats in channel roughness for OCBA and OCPR study sites.**

| | OCBA | | | OCPR | | |
|---|---|---|---|---|---|---|
| | t | df | p-value | t | df | p-value |
| Natural-Eflow&Flush | -94.978 | 124890 | < 2.2E-16 | -5.511 | 28189 | 3.6E-08 |
| Natural-Eflow | -194.420 | 118850 | < 2.2E-16 | -66.604 | 27816 | < 2.2E-16 |
| Eflow&Flush-Eflow | -92.292 | 137650 | < 2.2E-16 | -61.231 | 27855 | < 2.2E-16 |

**Table S9. Results of the t-tests (H0: true difference in means is equal to 0) for the differences between Natural, Eflow and Eflow&Flush habitats in water depth for OCBA and OCPR study sites.**

| | OCBA | | | OCPR | | |
|---|---|---|---|---|---|---|
| | t | df | p-value | t | df | p-value |
| Natural-Eflow&Flush | -2.047 | 445600 | 0.0407 | 0.107 | 121100 | 0.9145 |
| Natural-Eflow | -5.841 | 448080 | 5.2E-09 | -1.545 | 121360 | 0.1222 |
| Eflow&Flush-Eflow | -3.789 | 450190 | 1.5E-04 | -1.653 | 121500 | 0.0983 |

**Table S10. Results of the t-tests (H0: true difference in means is equal to 0) for the differences between Natural, Eflow and Eflow&Flush habitats in flow velocity for OCBA and OCPR study sites.**

| | OCBA | | | OCPR | | |
|---|---|---|---|---|---|---|
| | t | df | p-value | t | df | p-value |
| Natural-Eflow&Flush | 2.652 | 445460 | 0.0080 | 0.354 | 121090 | 0.7230 |
| Natural-Eflow | 16.122 | 443090 | < 2.2E-16 | 3.629 | 121060 | 2.8E-04 |
| Eflow&Flush-Eflow | 13.457 | 446670 | < 2.2E-16 | 3.279 | 121290 | 1.0E-03 |

**Table S11. Equality of proportions between Natural habitat and Eflow habitat in OCBA study site (H0: WUA's have the same true proportion). Species codes stand for Lb – *Luciobarbus bocagei*; Pp – *Pseudochondrostoma polylepis*; Sa – *Squalius alburnoides*.**

| Month | Lb_juv | Lb_adult | Pp_juv | Pp_adult | Sa_juv | Sa_adult |
|---|---|---|---|---|---|---|
| Oct | 0.000216 | 0.582952 | 6.21E-05 | 0.940216 | 0.323139 | 0.297538 |
| Nov | 0.000148 | 0.530769 | 1.74E-05 | 0.896214 | 0.370834 | 0.329465 |
| Dec | 0.000608 | 0.244612 | 1.17E-07 | 0.483554 | 0.668862 | 0.868717 |
| Jan | 0.000519 | 0.257775 | 1.41E-07 | 0.510652 | 0.789124 | 0.991580 |
| Feb | 0.000229 | 0.388867 | 1.60E-06 | 0.723955 | 0.587666 | 0.438736 |
| Mar | 0.005353 | 0.053108 | 0.462443 | 0.688765 | 0.035578 | 7.11E-05 |
| Apr | 0.005855 | 0.037780 | 0.398626 | 0.717639 | 0.041171 | 7.97E-05 |
| May | 0.001723 | 0.709184 | 0.524064 | 0.379709 | 0.005987 | 1.65E-05 |
| Jun | 0.795967 | 0.142917 | 0.610609 | 0.548629 | 0.248239 | 0.823737 |
| Jul | 0.878494 | 0.902296 | 0.931916 | 0.887568 | 0.978652 | 0.745271 |
| Aug | 0.878494 | 0.902296 | 0.931916 | 0.887568 | 0.978652 | 0.745271 |
| Sep | 0.308822 | 0.576689 | 0.272860 | 0.683524 | 0.562069 | 0.474081 |

**Table S12. Equality of proportions between Natural habitat and Eflow&flush habitat in OCBA study site (H0: WUA's have the same true proportion). Species codes stand for Lb – *Luciobarbus bocagei*; Pp – *Pseudochondrostoma polylepis*; Sa – *Squalius alburnoides*.**

| Month | Lb_juv | Lb_adult | Pp_juv | Pp_adult | Sa_juv | Sa_adult |
|---|---|---|---|---|---|---|
| Oct | 0.850180 | 0.975380 | 0.937319 | 0.982124 | 0.889660 | 0.929312 |
| Nov | 0.837909 | 0.975984 | 0.918213 | 0.986510 | 0.879203 | 0.920722 |
| Dec | 0.088235 | 0.361823 | 0.101082 | 0.422564 | 0.247659 | 0.189515 |
| Jan | 0.146970 | 0.462011 | 0.162449 | 0.516233 | 0.312924 | 0.256096 |
| Feb | 0.721348 | 0.970973 | 0.770267 | 0.981017 | 0.757865 | 0.774812 |
| Mar | 0.934309 | 0.853870 | 0.863878 | 0.997663 | 0.934126 | 0.976693 |
| Apr | 0.929003 | 0.844001 | 0.858171 | 0.998189 | 0.928228 | 0.970043 |
| May | 0.984099 | 0.955728 | 0.944510 | 0.987440 | 0.993220 | 0.956985 |
| Jun | 0.951283 | 0.919954 | 0.985273 | 0.981322 | 0.998841 | 0.911286 |
| Jul | 0.891434 | 0.870963 | 0.924438 | 0.982402 | 0.891084 | 0.850580 |
| Aug | 0.891434 | 0.870963 | 0.924438 | 0.982402 | 0.891084 | 0.850580 |
| Sep | 0.747660 | 0.865492 | 0.690731 | 0.875758 | 0.796120 | 0.742462 |

**Table S13. Equality of proportions between Natural habitat and Eflow habitat in OCPR study site (H0: WUA's have the same true proportion). Species codes stand for Lb – *Luciobarbus bocagei*; Pp – *Pseudochondrostoma polylepis*; Sa – *Squalius alburnoides*.**

| Month | Lb_juv | Lb_adult | Pp_juv | Pp_adult | Sa_juv | Sa_adult |
|---|---|---|---|---|---|---|
| Oct | 0.467174 | 0.787298 | 0.047326 | 0.505018 | 0.115923 | 0.066840 |
| Nov | 0.018055 | 0.443040 | 5.32E-07 | 0.294739 | 0.002503 | 0.001363 |
| Dec | 0.002366 | 0.274062 | 1.61E-12 | 0.154162 | 0.001140 | 0.000319 |
| Jan | 0.002625 | 0.290223 | 3.80E-12 | 0.156759 | 0.001164 | 0.000346 |
| Feb | 0.008752 | 0.386039 | 7.98E-09 | 0.233811 | 0.001850 | 0.000819 |
| Mar | 0.061766 | 0.554872 | 1.42E-05 | 0.295786 | 0.004822 | 0.002455 |
| Apr | 0.001355 | 0.114244 | 0.226976 | 0.716657 | 0.141175 | 3.90E-12 |
| May | 0.019642 | 0.262956 | 0.380338 | 0.839495 | 0.170810 | 1.42E-08 |
| Jun | 0.442916 | 0.665689 | 0.509405 | 0.856592 | 0.751174 | 0.715195 |
| Jul | 0.976778 | 0.991759 | 0.958640 | 0.981950 | 0.917565 | 0.869678 |
| Aug | 0.918253 | 0.850503 | 0.903803 | 0.915809 | 0.852783 | 0.913014 |
| Sep | 0.967843 | 0.907693 | 0.935341 | 0.945988 | 0.884826 | 0.902486 |

**Table S14. Equality of proportions between Natural habitat and Eflow&flush habitat in OCPR study site (H0: WUA's have the same true proportion). Species codes stand for Lb – *Luciobarbus bocagei*; Pp – *Pseudochondrostoma polylepis*; Sa – *Squalius alburnoides*.**

| Month | Lb_juv | Lb_adult | Pp_juv | Pp_adult | Sa_juv | Sa_adult |
|---|---|---|---|---|---|---|
| Oct | 0.948755 | 0.972671 | 0.966995 | 0.994709 | 0.997594 | 0.995991 |
| Nov | 0.918275 | 0.834241 | 0.982070 | 0.975136 | 0.978806 | 0.989342 |
| Dec | 0.948791 | 0.944823 | 0.979856 | 0.998893 | 0.981760 | 0.987061 |
| Jan | 0.951852 | 0.953759 | 0.980720 | 0.987732 | 0.994761 | 0.998211 |
| Feb | 0.935172 | 0.985107 | 0.982133 | 0.971475 | 0.981222 | 0.986931 |
| Mar | 0.953429 | 0.997549 | 0.984473 | 0.987587 | 0.999956 | 0.995221 |
| Apr | 0.986832 | 0.997796 | 0.999768 | 0.998475 | 0.988456 | 0.960142 |
| May | 0.992298 | 0.970561 | 0.999811 | 0.998420 | 0.993079 | 0.974589 |
| Jun | 0.994943 | 0.990000 | 0.996416 | 0.994406 | 0.994190 | 0.991033 |
| Jul | 0.835681 | 0.860729 | 0.846797 | 0.931103 | 0.841102 | 0.835942 |
| Aug | 0.808999 | 0.774405 | 0.806757 | 0.882440 | 0.777273 | 0.846911 |
| Sep | 0.978260 | 0.817781 | 0.841934 | 0.910452 | 0.819581 | 0.863367 |