Hatchery Effectiveness Review

AN EXPLORATORY ANALYSIS INTO SPATIAL PATTERNS OF CORRELATION RELATIVE TO ENHANCEMENT

APPENDIX 1: AREA 25 CHUM SALMON

Photo credit: Eiko Jones

Prepared by Andrew Rosenberger

May 2023

PACIFIC SALMON FOUNDATION

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Appendix 1

Area 25 Chum Salmon

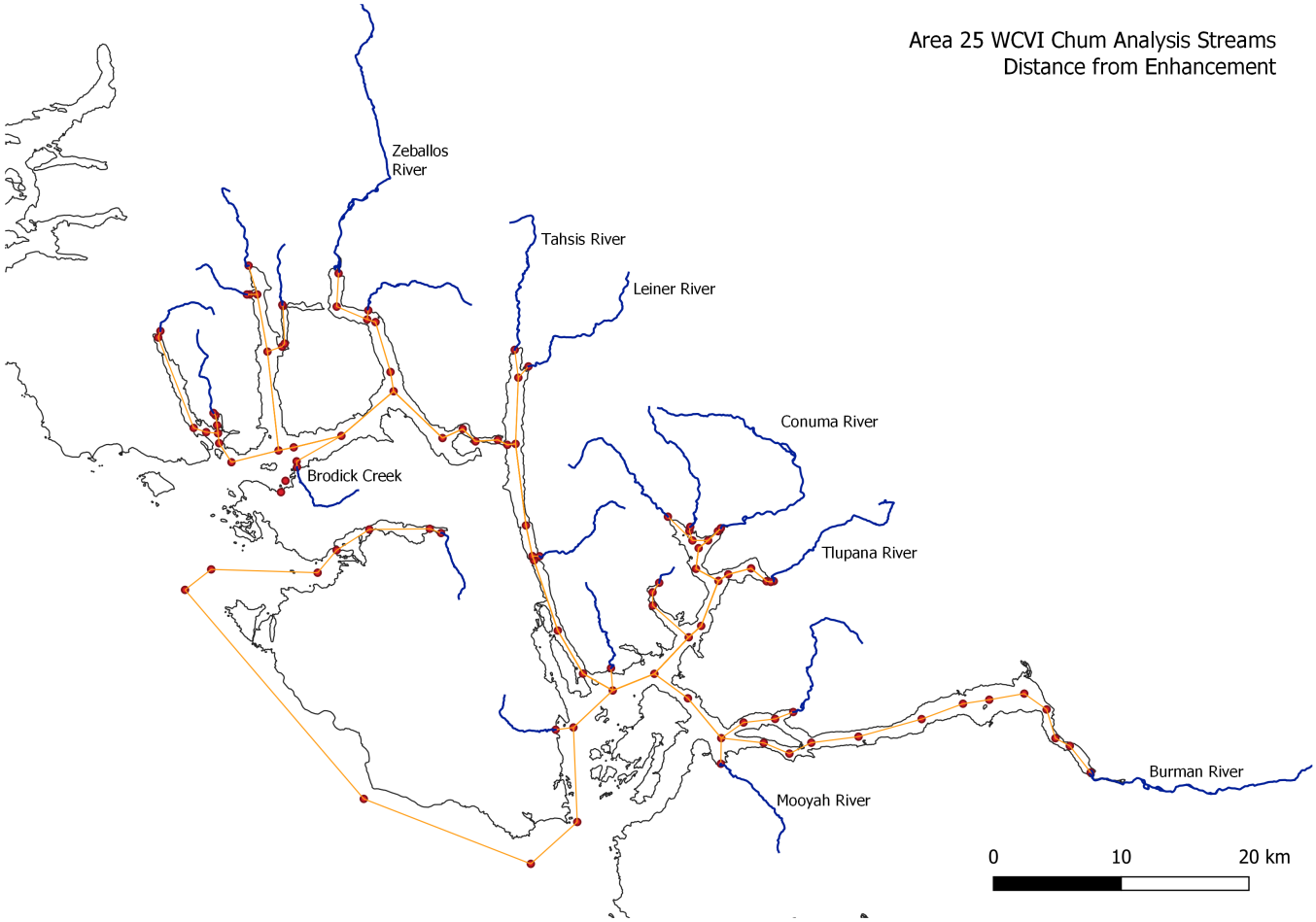
Coastland

2023-03-07

Contents

Study area

Area 25 Chum streams



Summary statistics

Bubbleplot of escapement by enhancement rank

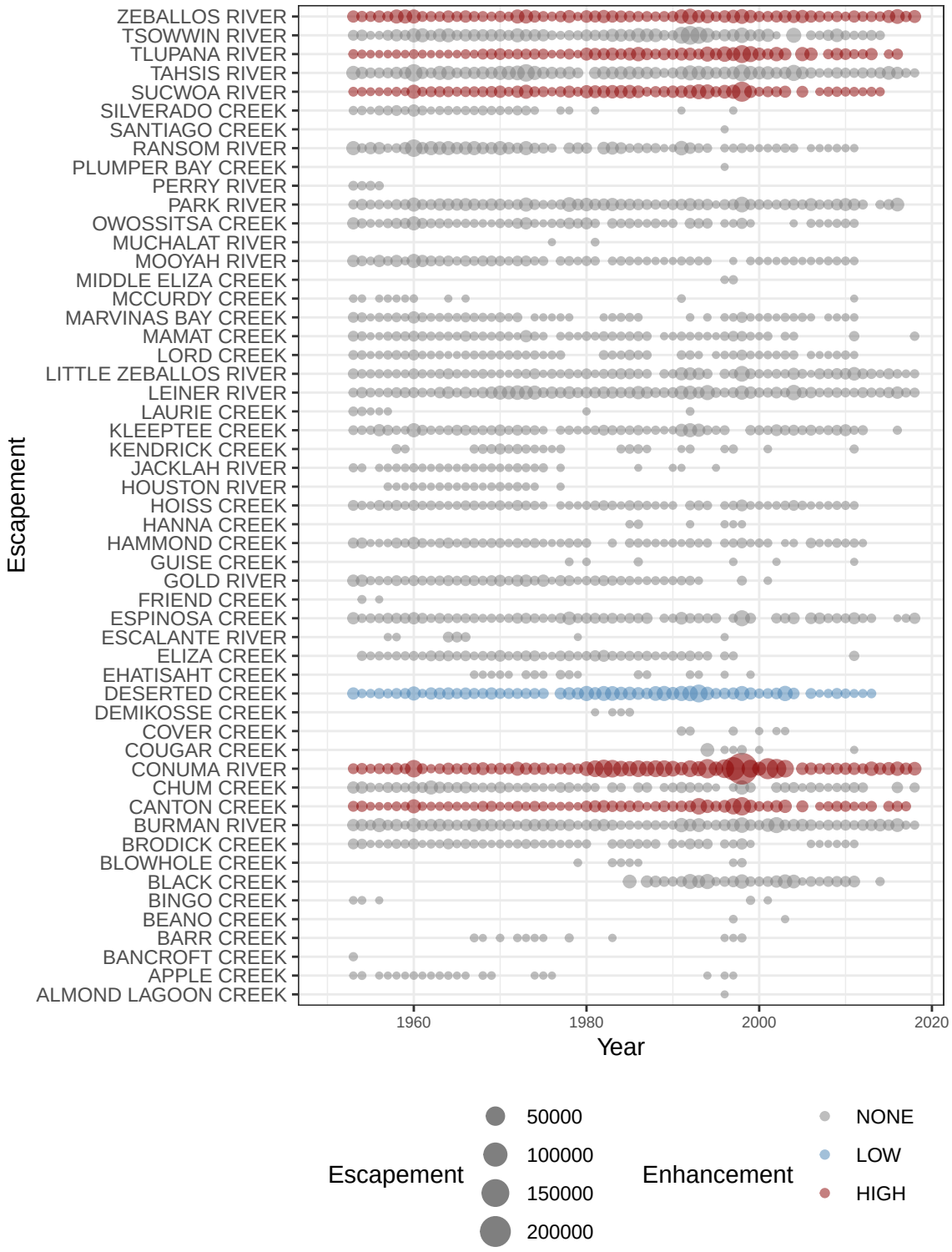


Figure 1: Escapement to all Area 8 chum streams in the PSE database.

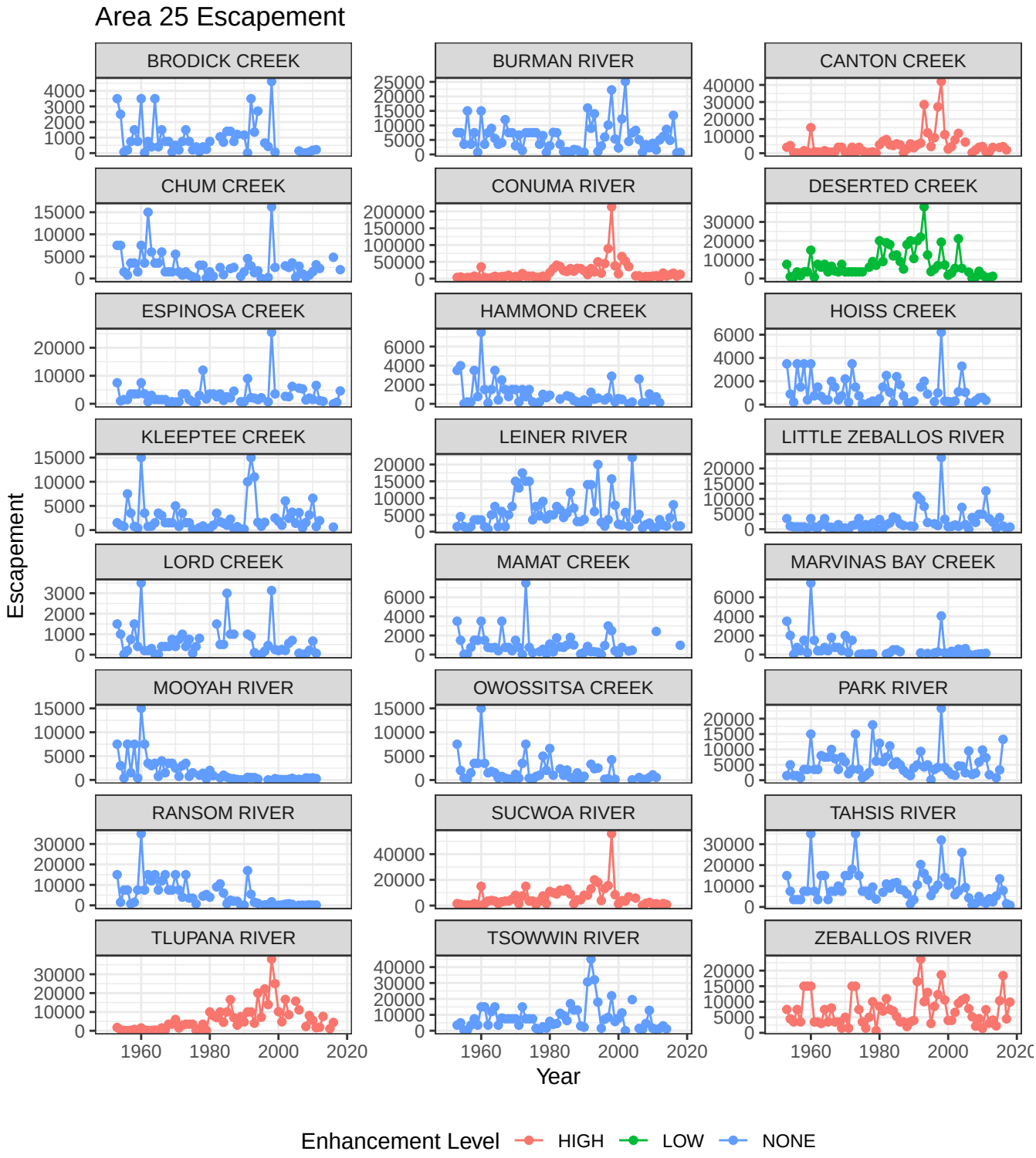


Figure 2: Escapement to all streams for Area 25 chum. Colour shows the stream enhancement level from the PSE database.

Table 1: Distance from Conuma River (major enhancement location for chum systems included in analysis)

Stream	Dist. from enhancement
BRODICK CREEK	61655
BURMAN RIVER	54299
CANTON CREEK	3718
CHUM CREEK	75361
CONUMA RIVER	0
DESERTED CREEK	16768
ESPINOSA CREEK	76904
HAMMOND CREEK	78677
HOISS CREEK	20255
KLEEPTEE CREEK	27400
LEINER RIVER	46500
LITTLE ZEBALLOS RIVER	58802
LORD CREEK	43611
MAMAT CREEK	73524
MARVINAS BAY CREEK	24133
MOOYAH RIVER	23265
OWOSSITSA CREEK	63067
PARK RIVER	70239
RANSOM RIVER	92551
SUCWOA RIVER	5286
TAHSIS RIVER	46465
TLUPANA RIVER	10890
TSOWWIN RIVER	30761
ZEBALLOS RIVER	63279

Hatchery releases to area

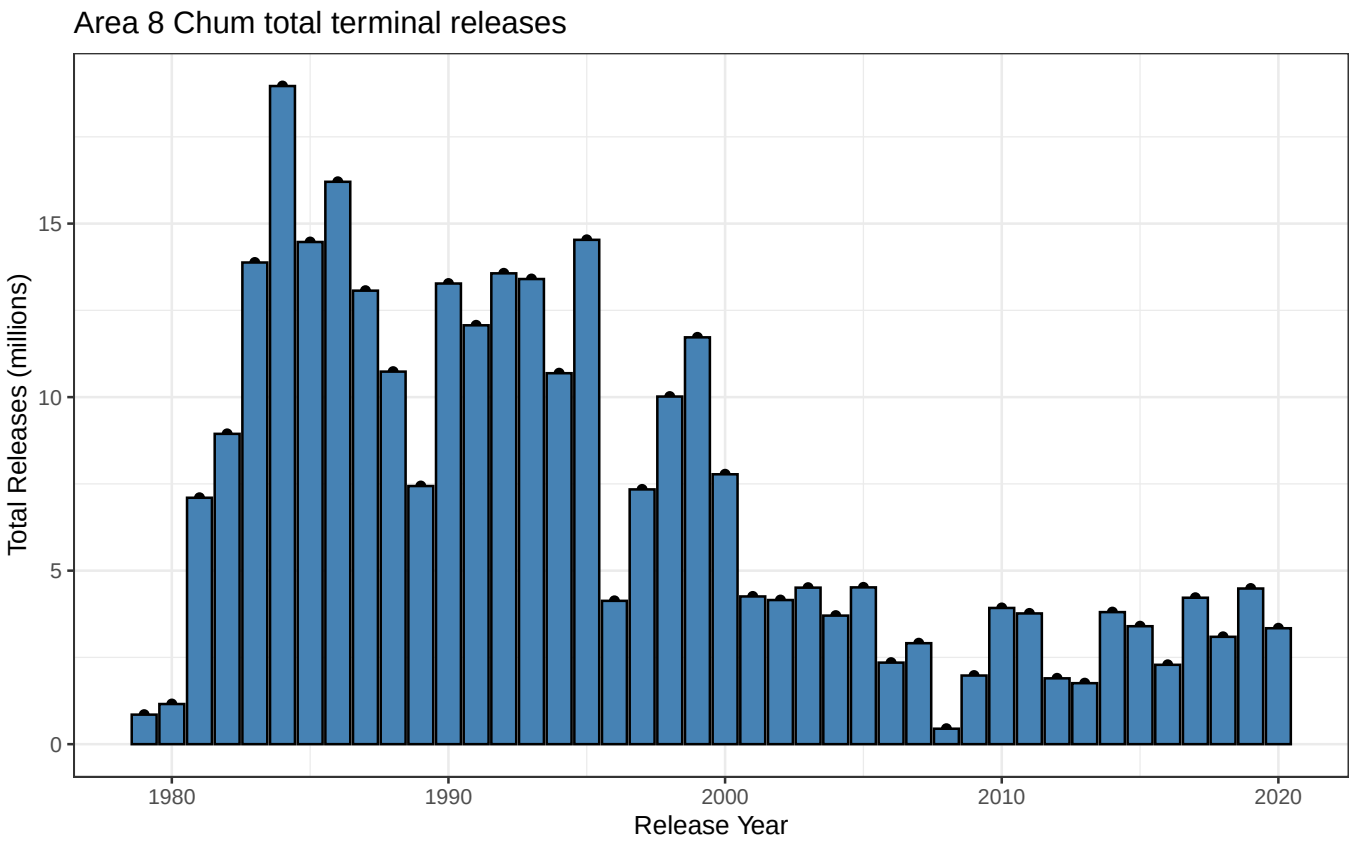


Figure 3: Total hatchery chum salmon releases in Area 25

Releases by system

Figure 4: Chum releases to Area 25 by release site and release stage.

Metrics

Escapement, logged escapement, Z-scores, Pavg, and moving average

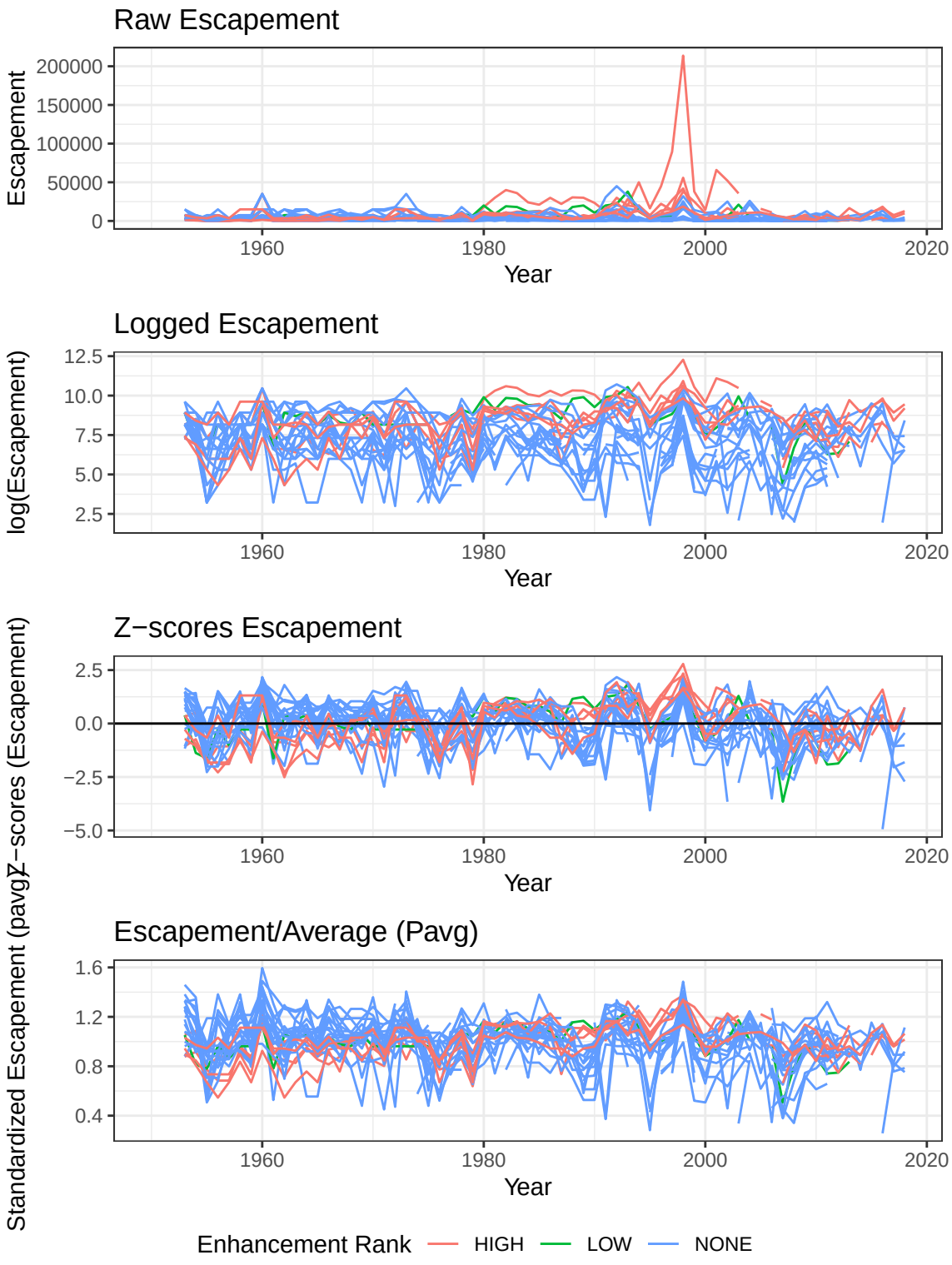


Figure 5: Various plots for escapement and transformations.

Moving average and LOESSS fits

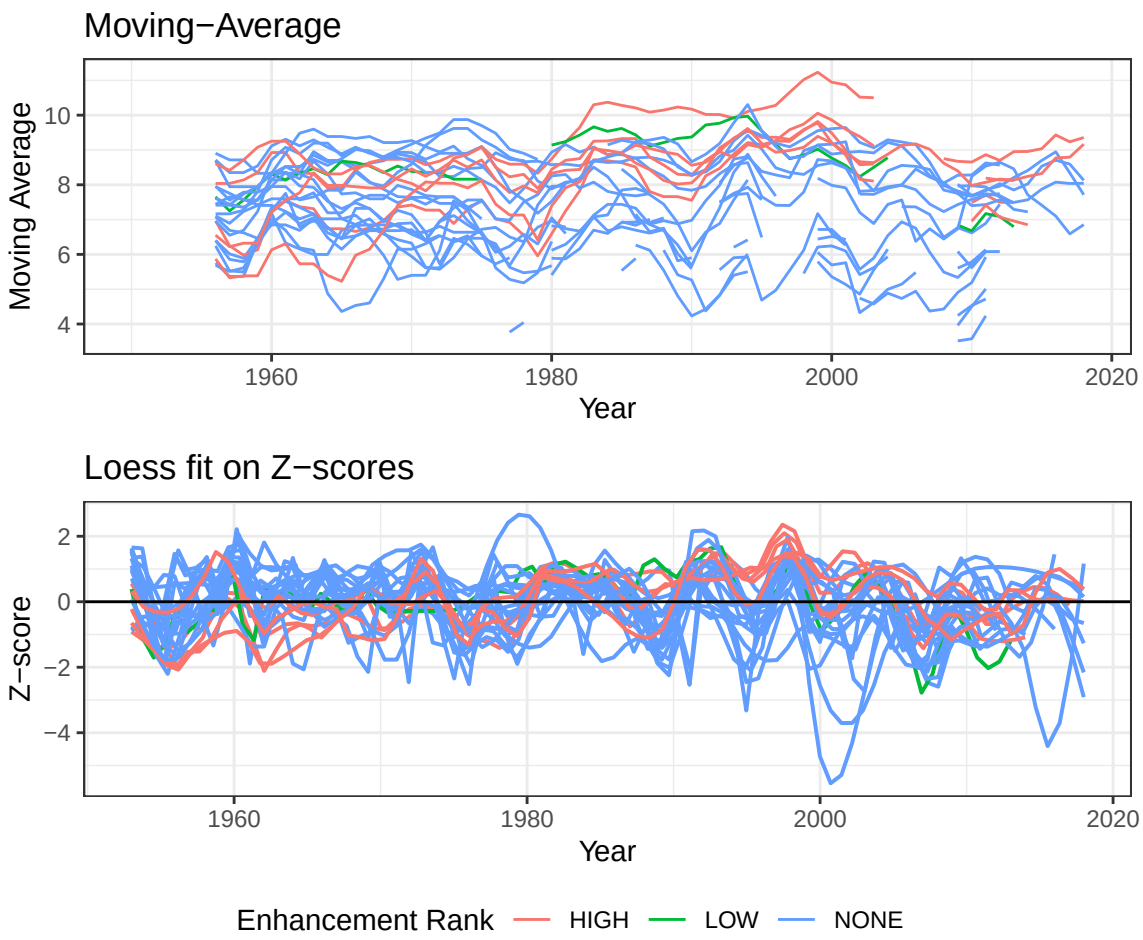


Figure 6: Moving average and LOESS fits on logged escapement by enhancement ranking.

Means trends by enhancement rank

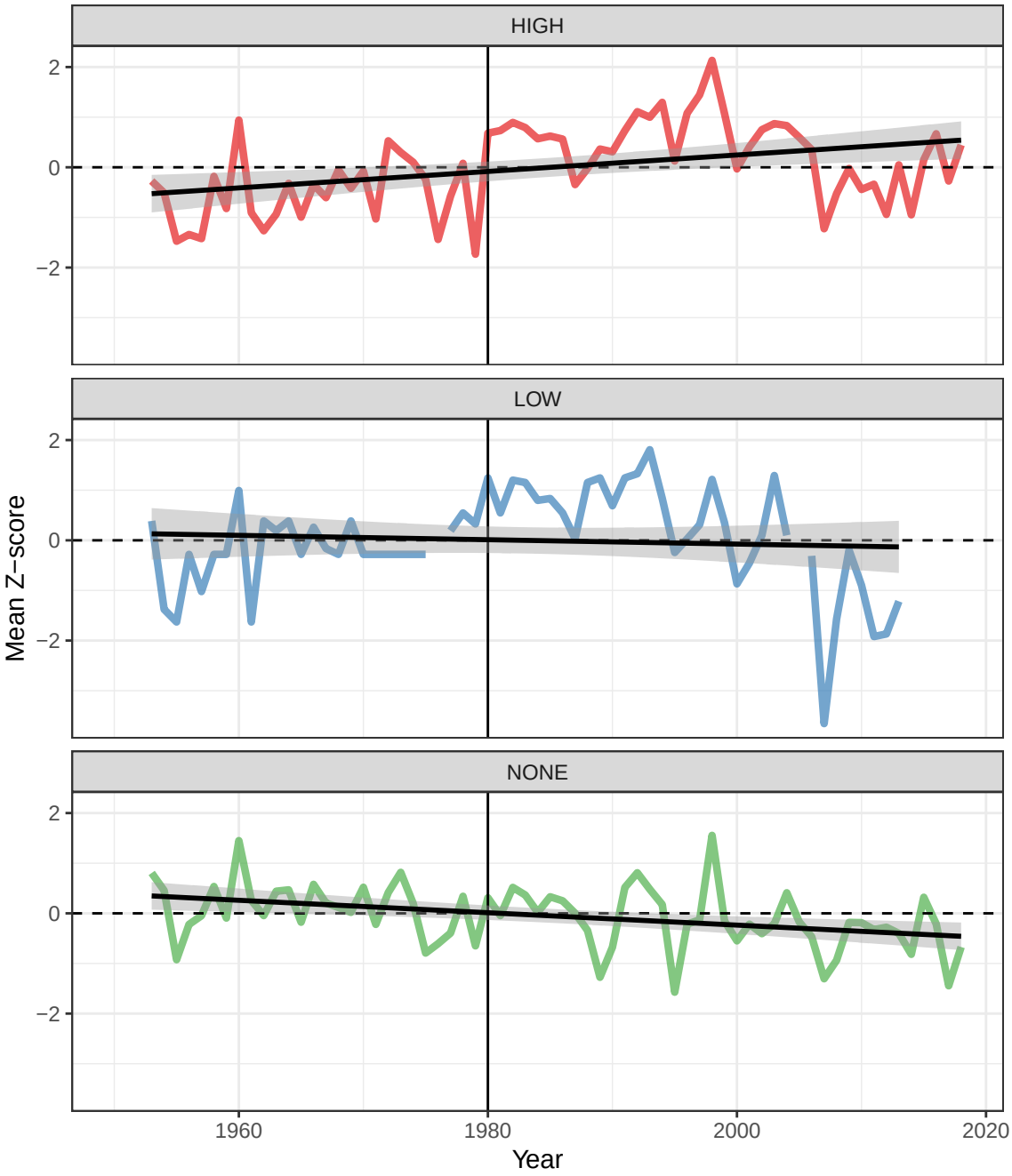


Figure 7: Area 25 chum: Mean Z-score for analysis streams by enhancement rank. Linear regression over all years with SE are shown.

Recruits per spawner by system

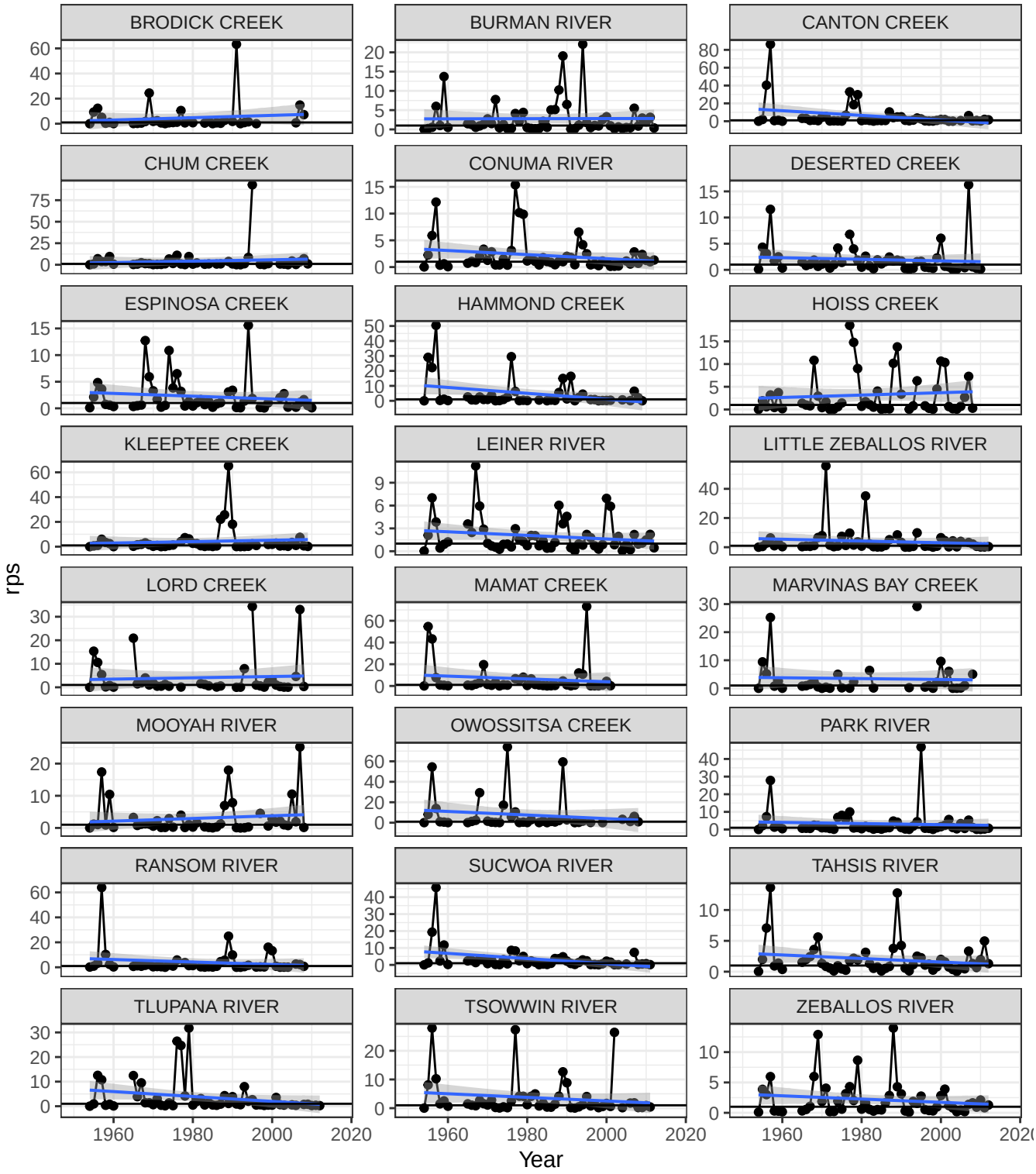


Figure 8: Area 25 chum: recruits per spawner by system.

Log recruits per spawner by system by period

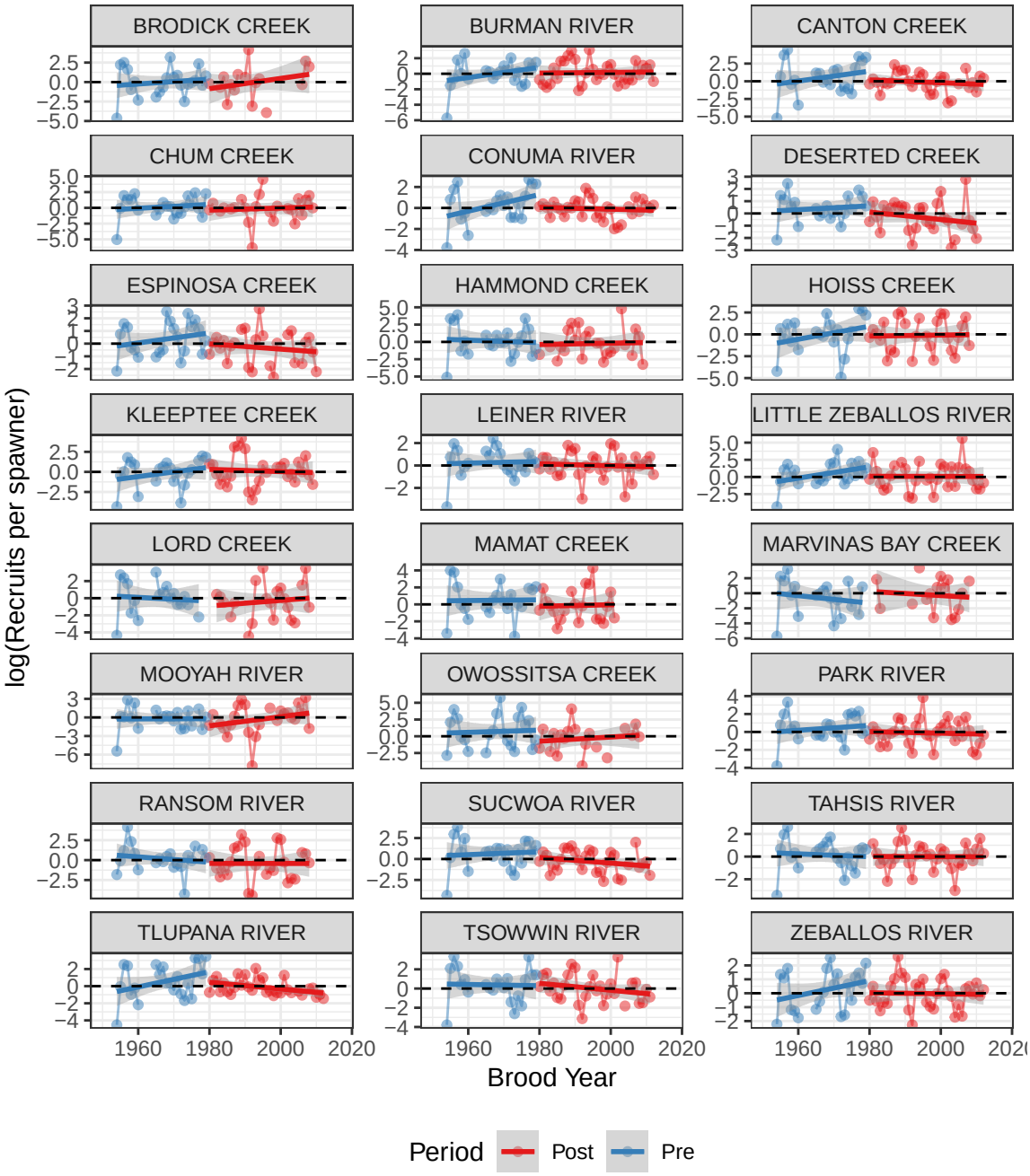


Figure 9: Area 25 chum: log recruits per spawner by system fitted with linear regression for the periods pre- and post-enhancement.

Log RPS comparison before and after enhancement

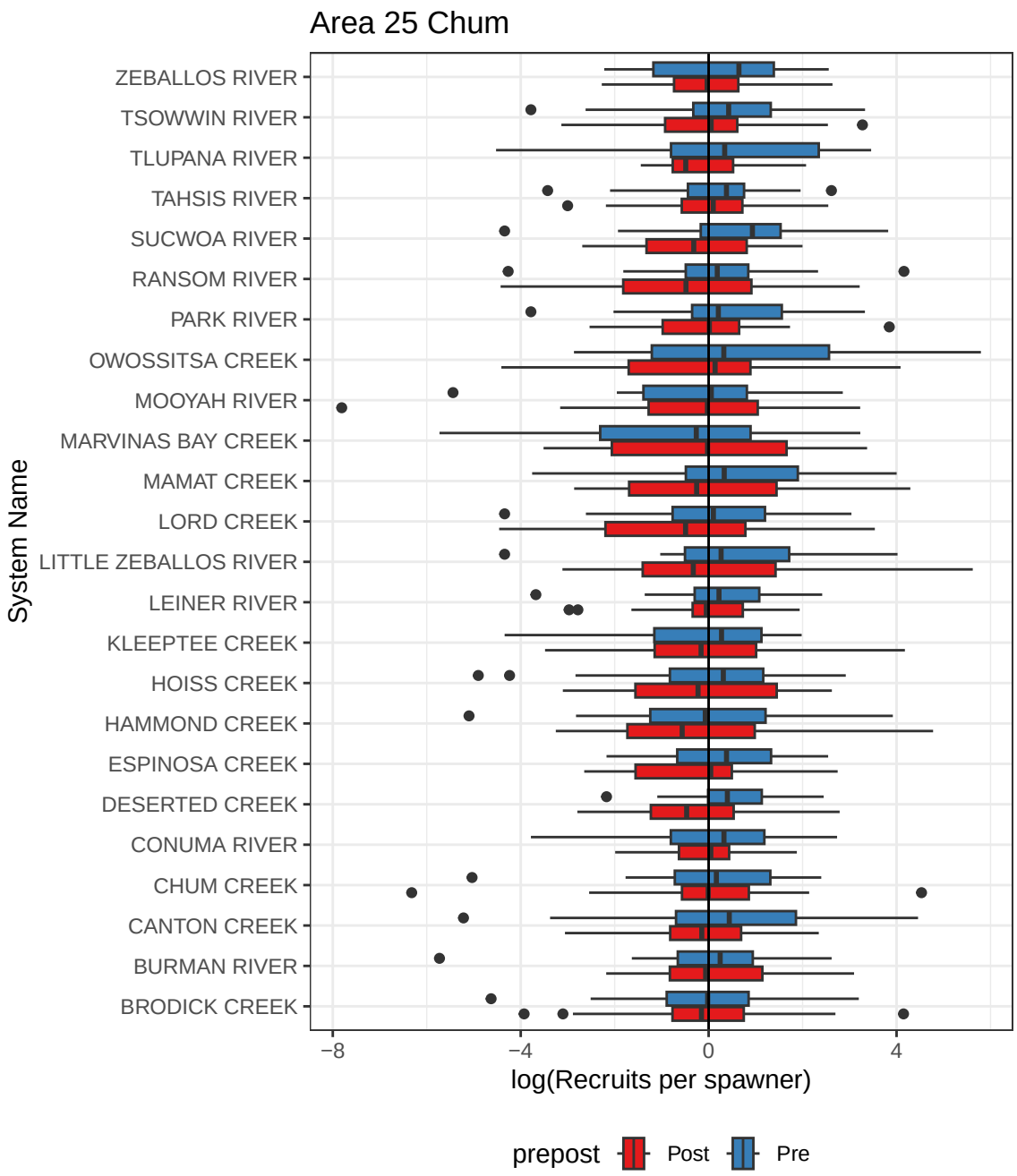


Figure 10: Area 25 chum: Boxplots of log recruits per spawner by system.

Bubbleplots of metric by inlet

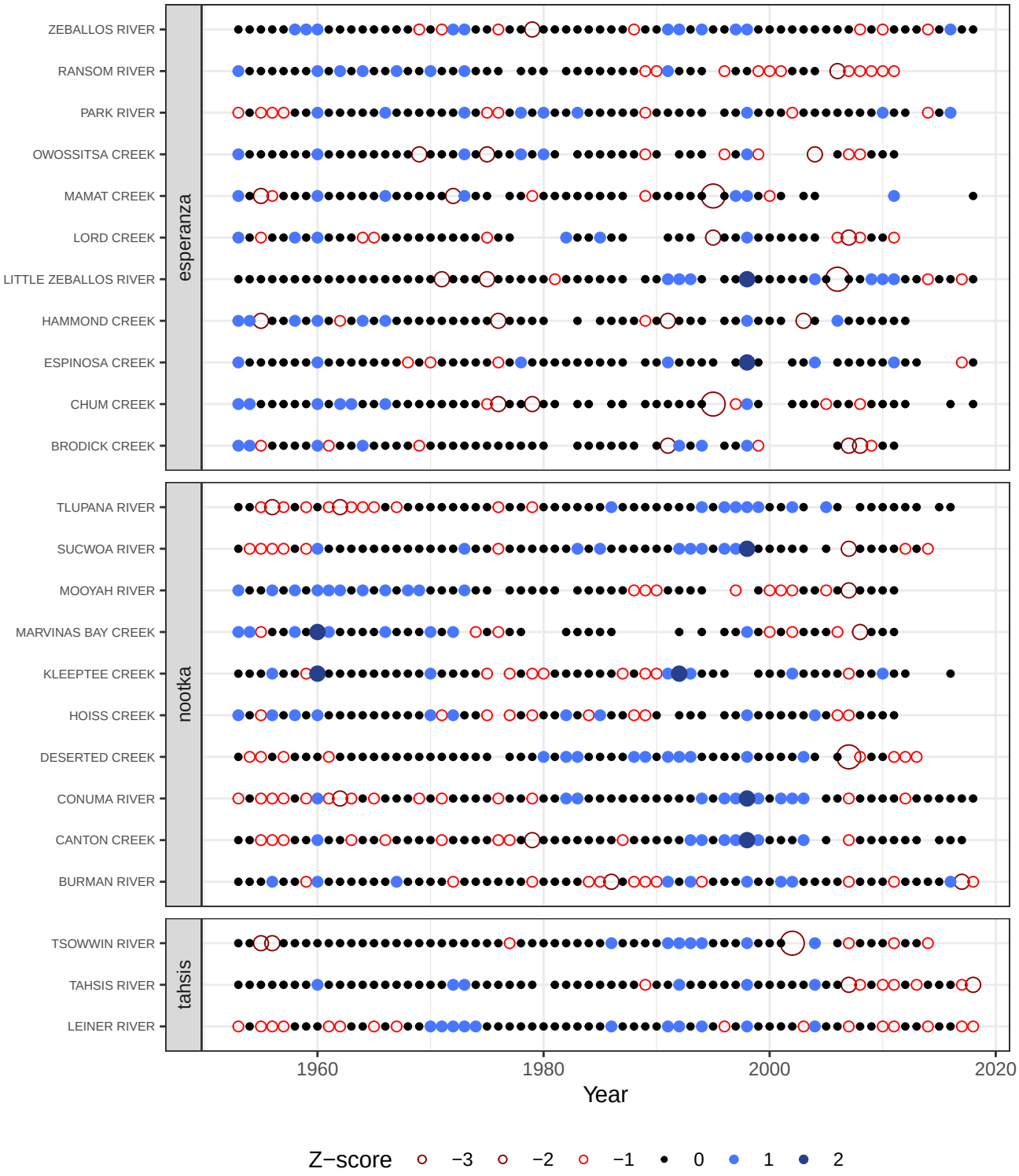


Figure 11: Z-scores of log escapement for each system grouped by inlet. Solid blue points indicate positive values and open red circles indicate negative values. The size of the point indicates the magnitude of the metric.

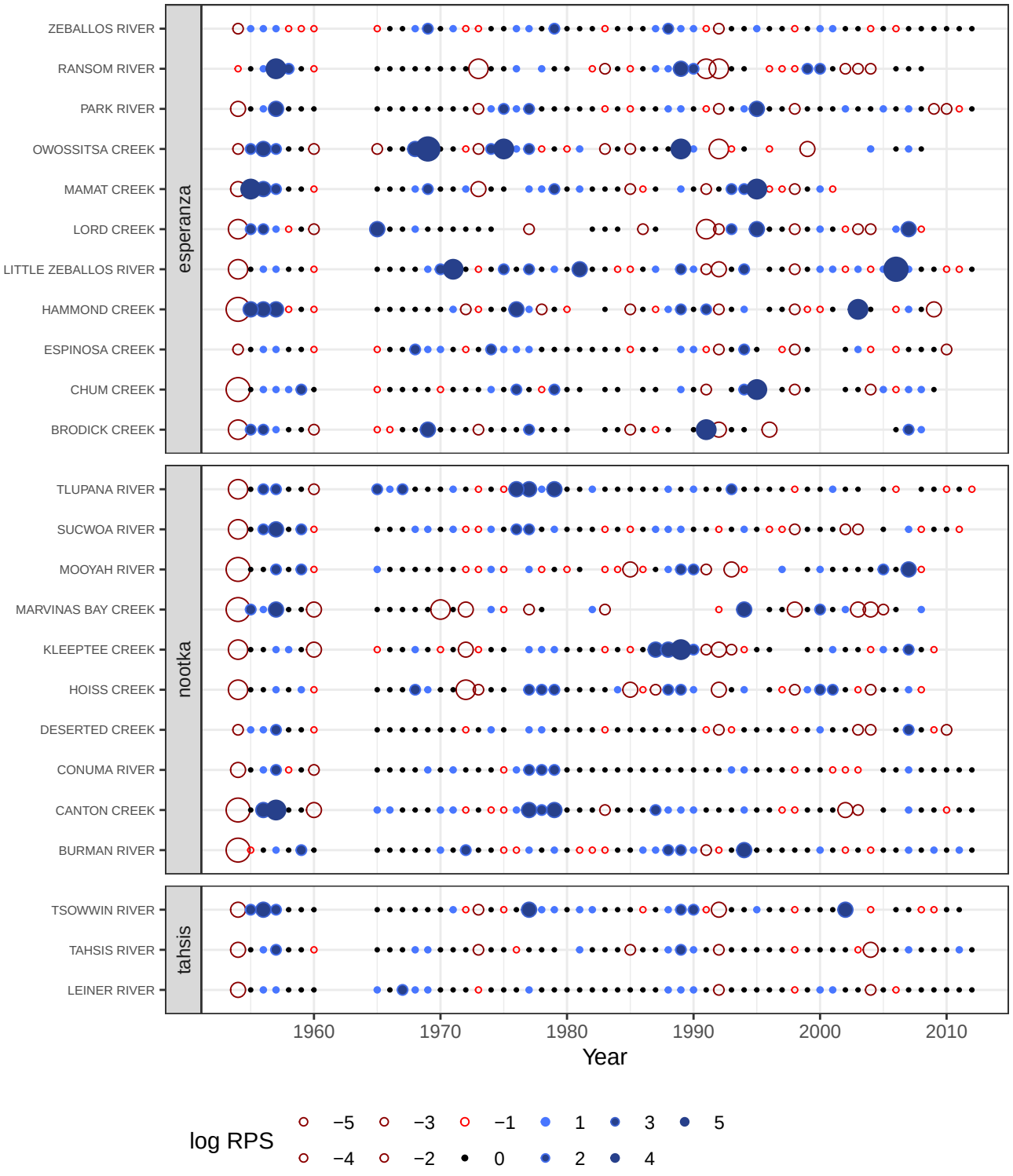


Figure 12: Log(recruits per spawner) for each system grouped by inlet. Solid blue points indicate positive values and open red circles indicate negative values. The size of the point indicates the magnitude of the metric.

Correlation analyses and Dendrograms

Cross correlation plots

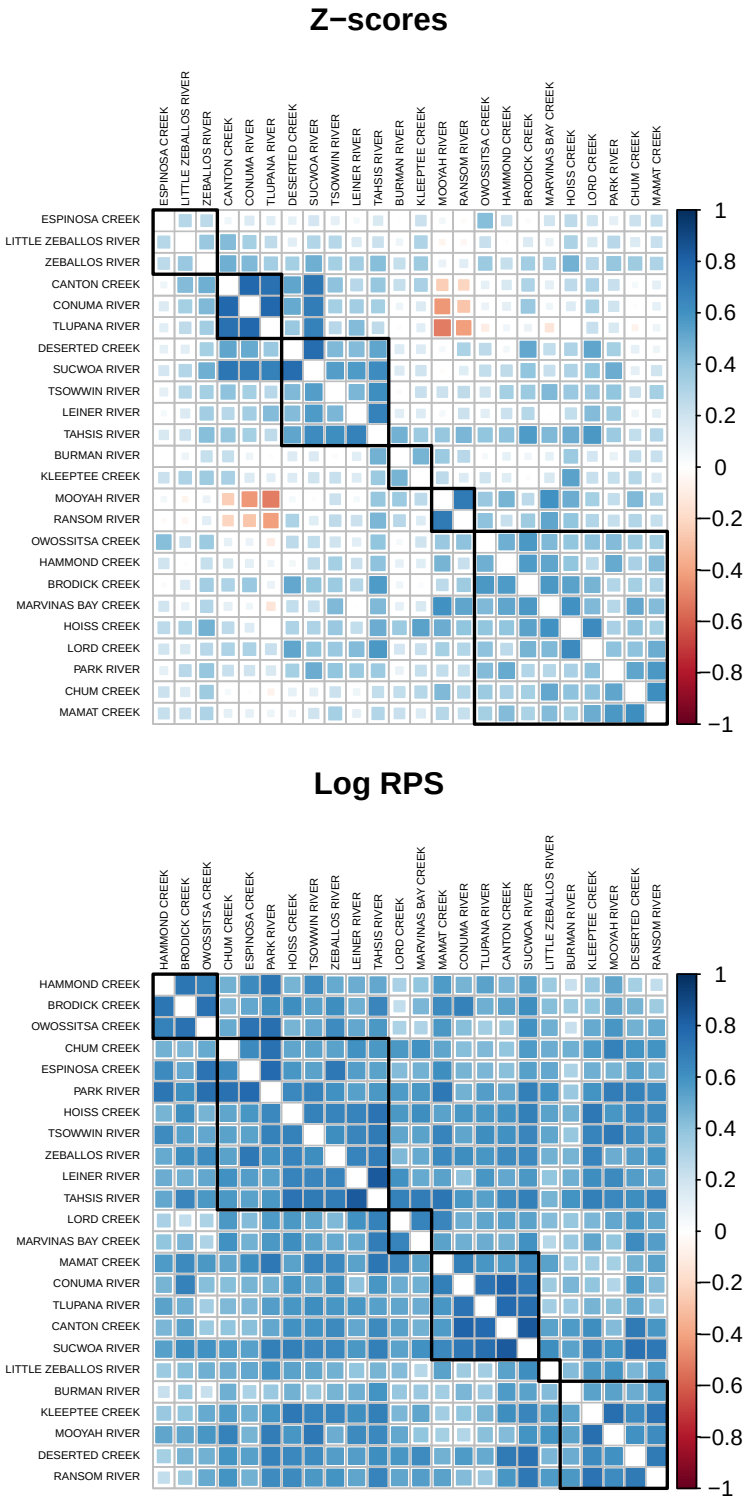


Figure 13: Cross correlation plots to compare metrics.

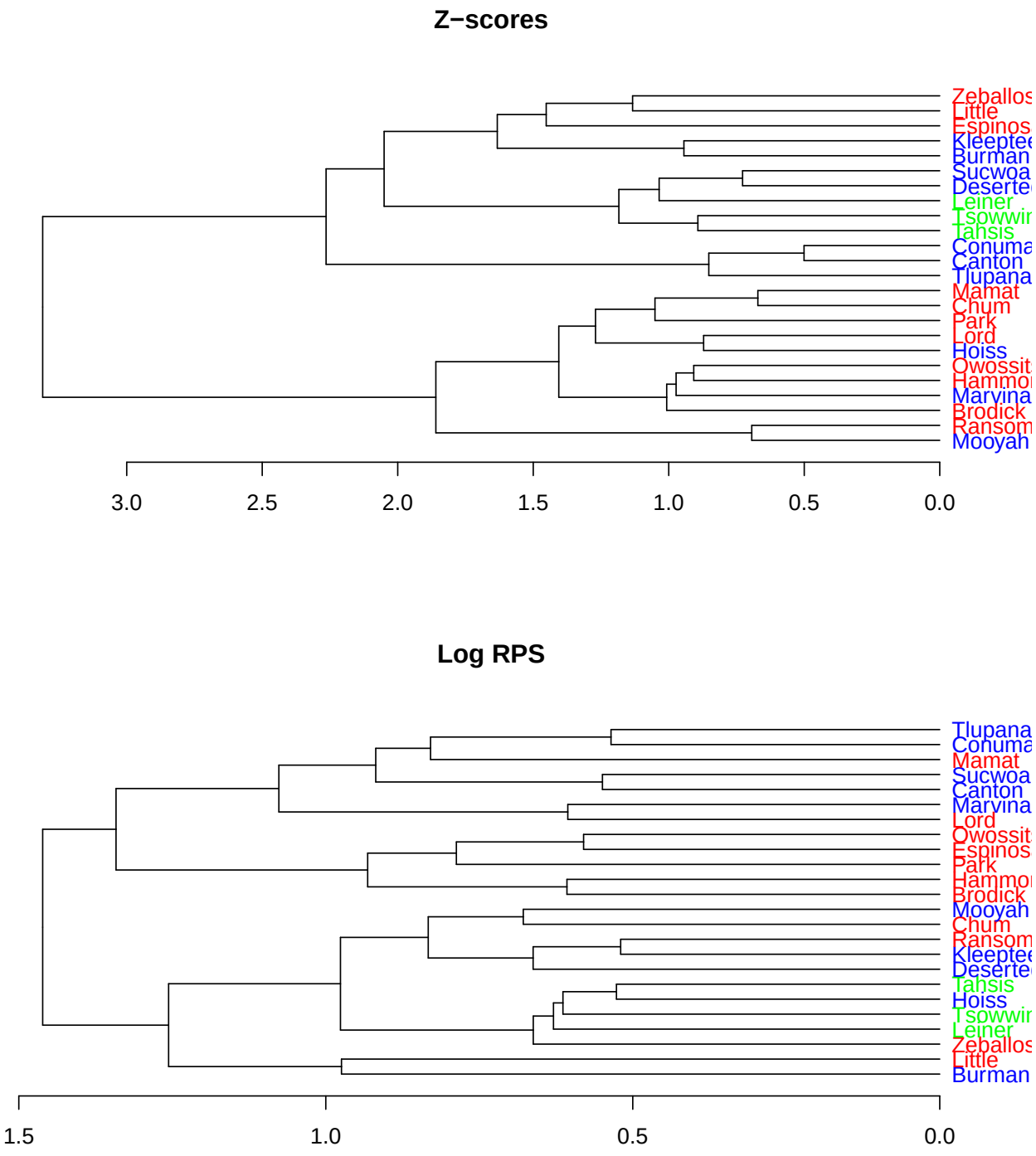


Figure 14: Dendrograms by metric. Red labels are from Esperanza inlet, blue are from Nootka inlet, and green are from Tahsis inlet.

Tanglegrams comparing effect of metric choice on cluster analysis

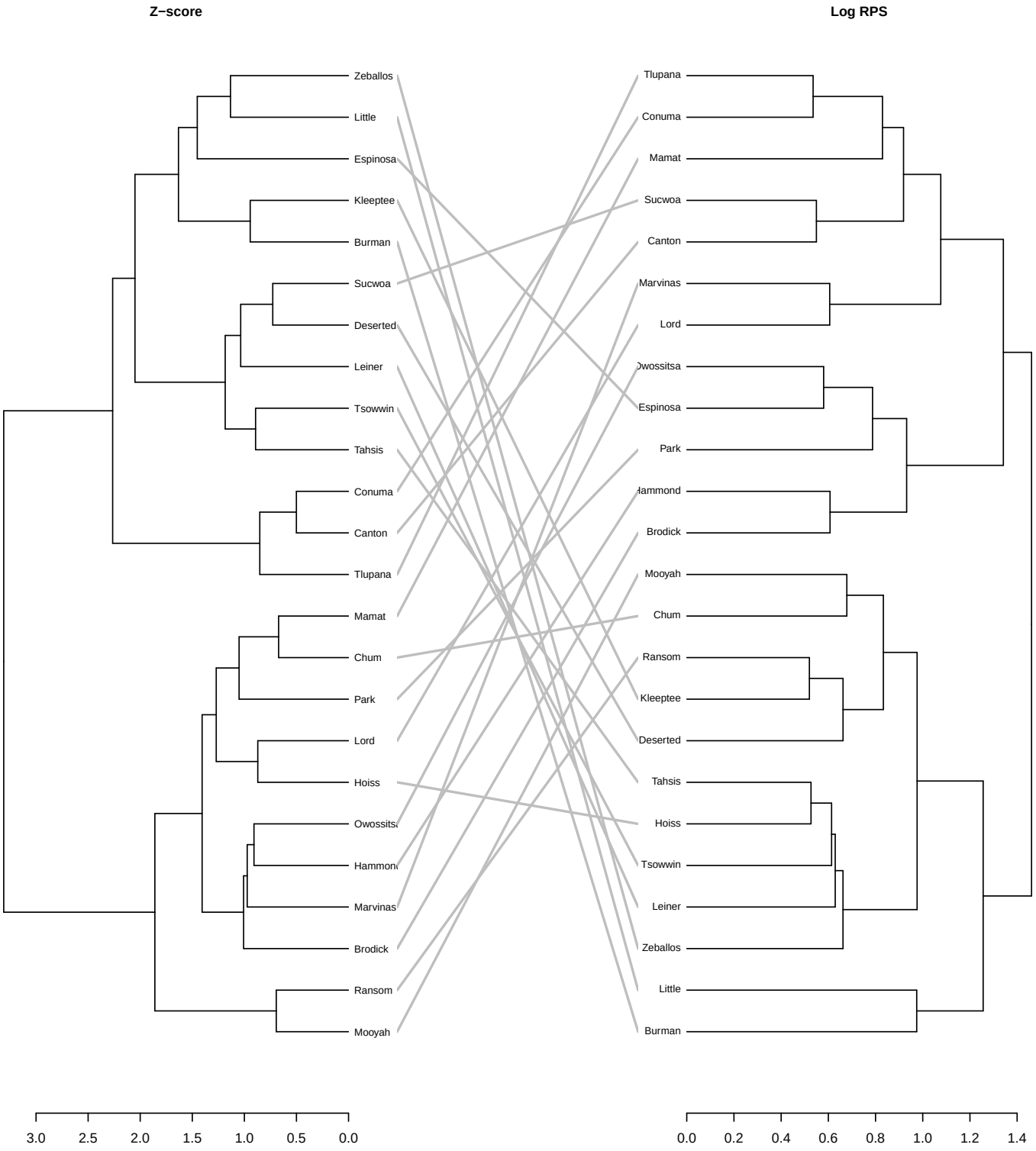


Figure 15: Tanglegram of z-score vs. Log RPS

Pre- and post-enhancement correlation analyses

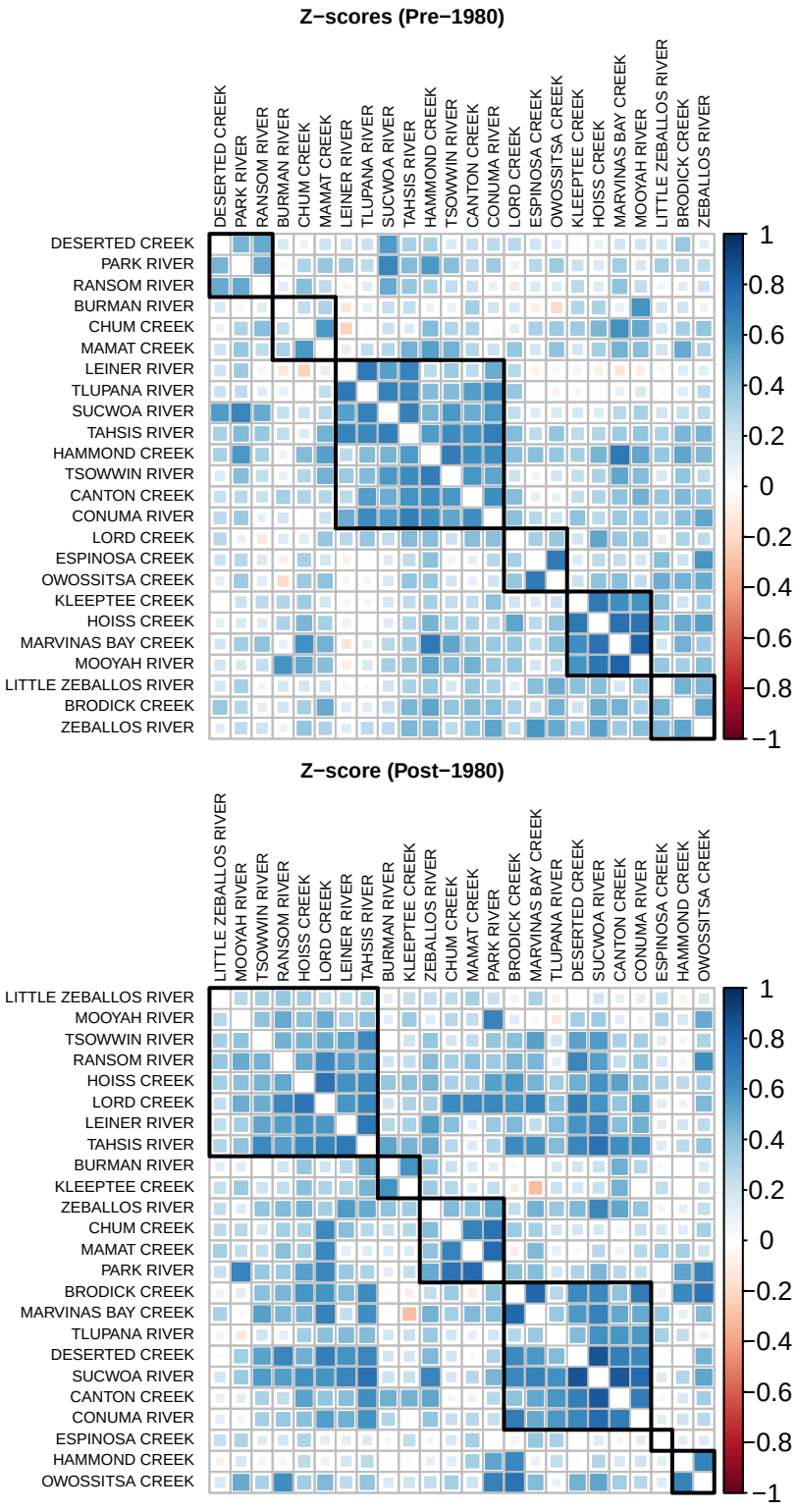


Figure 16: Cross correlation plots of z-scores to compare pre- and post-enhancement.

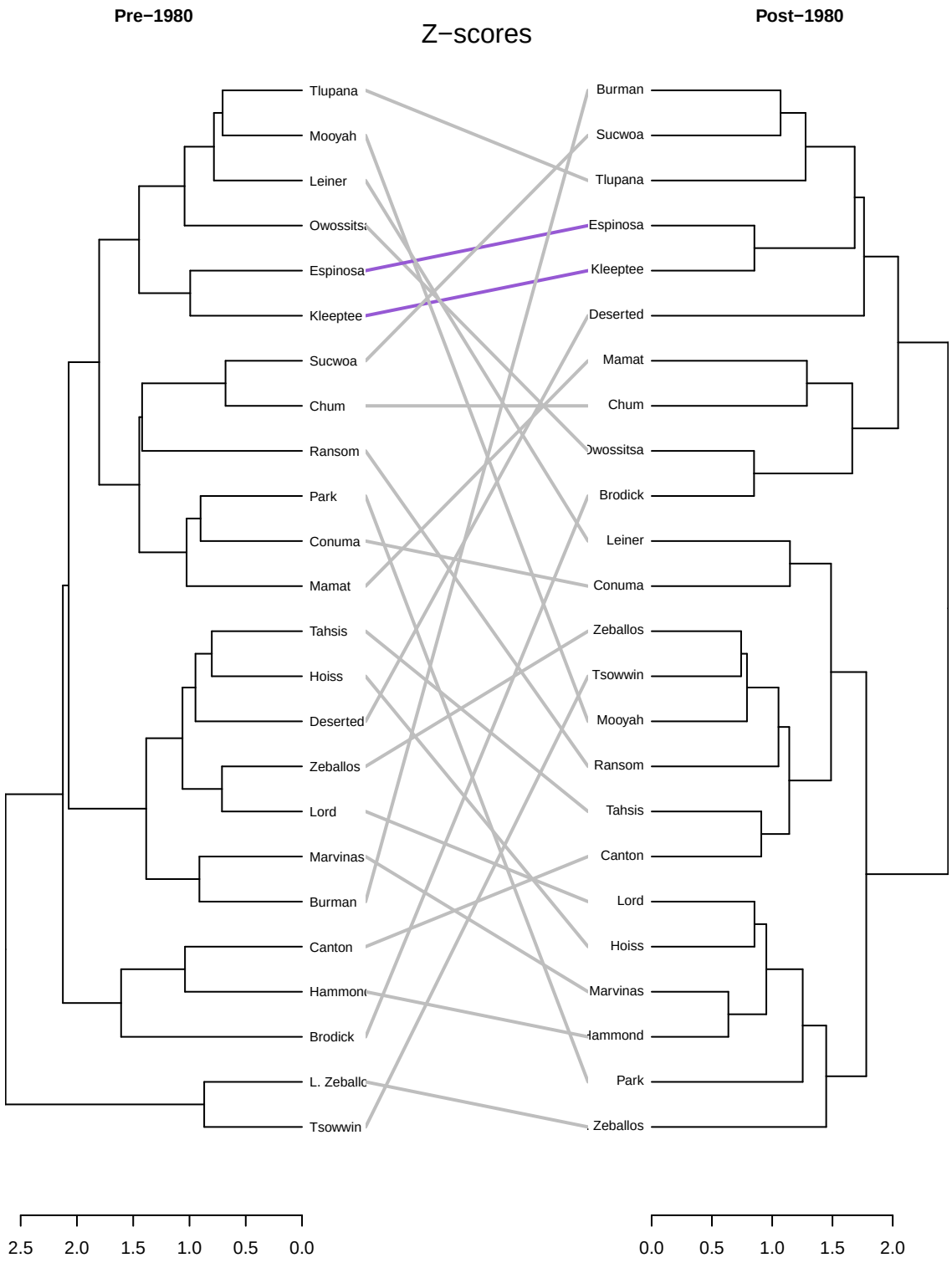


Figure 17: Tanglegram comparing z-scores pre- and post-enhancement (1980)

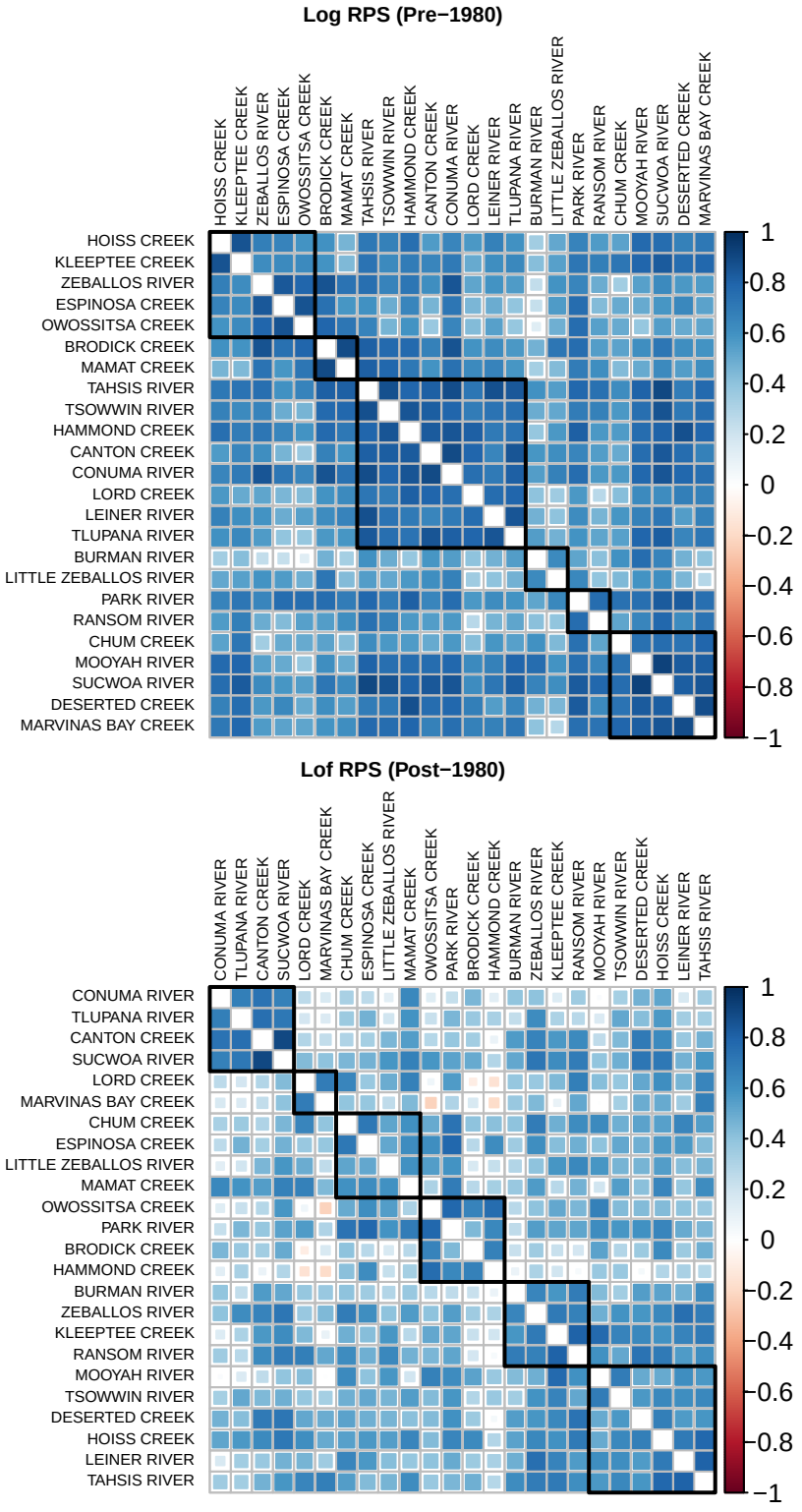


Figure 18: Cross correlation plots of Log RPS to compare pre- and post-enhancement.

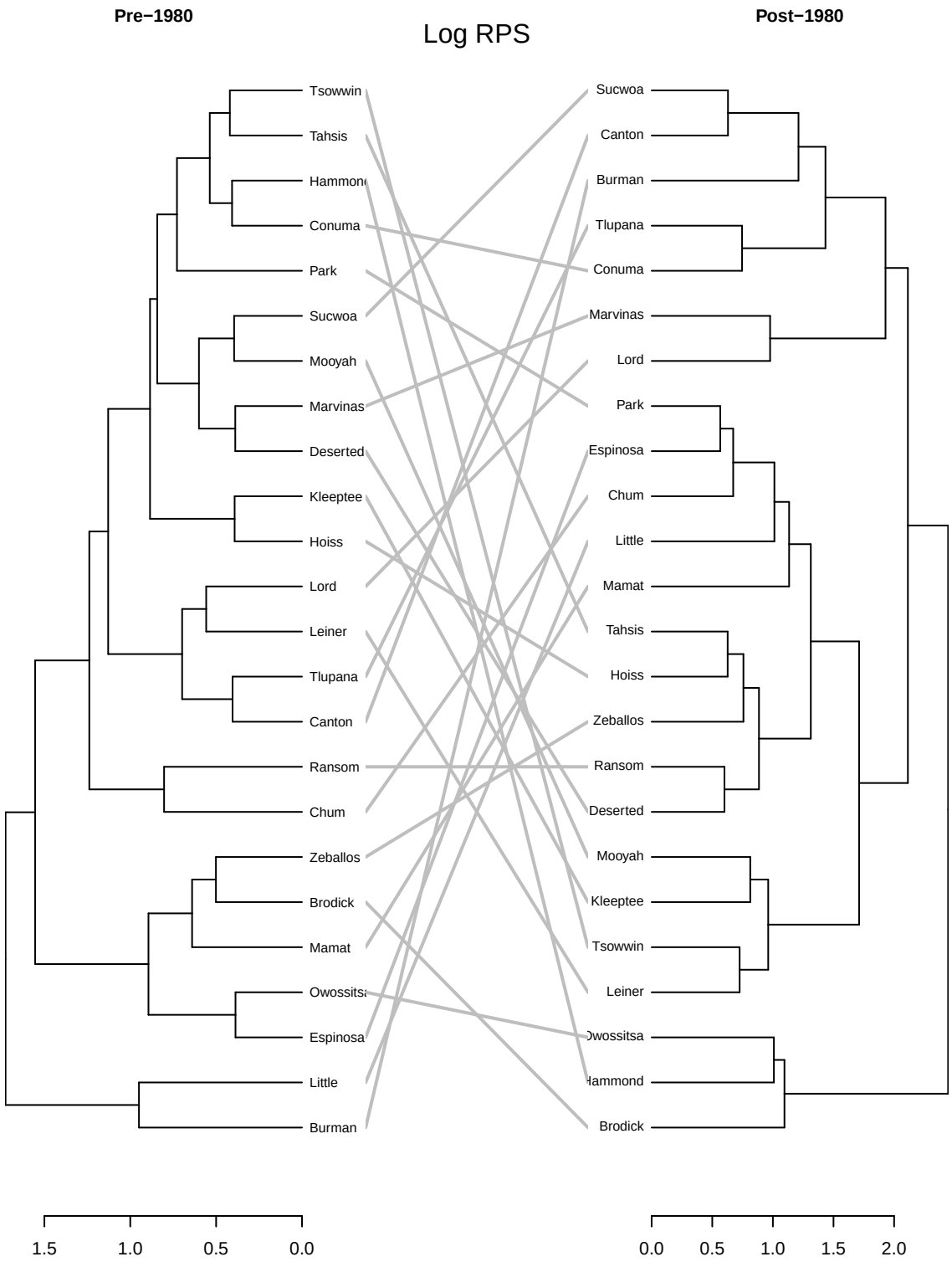


Figure 19: Tanglegram comparing Log RPS pre- and post-enhancement (1980)

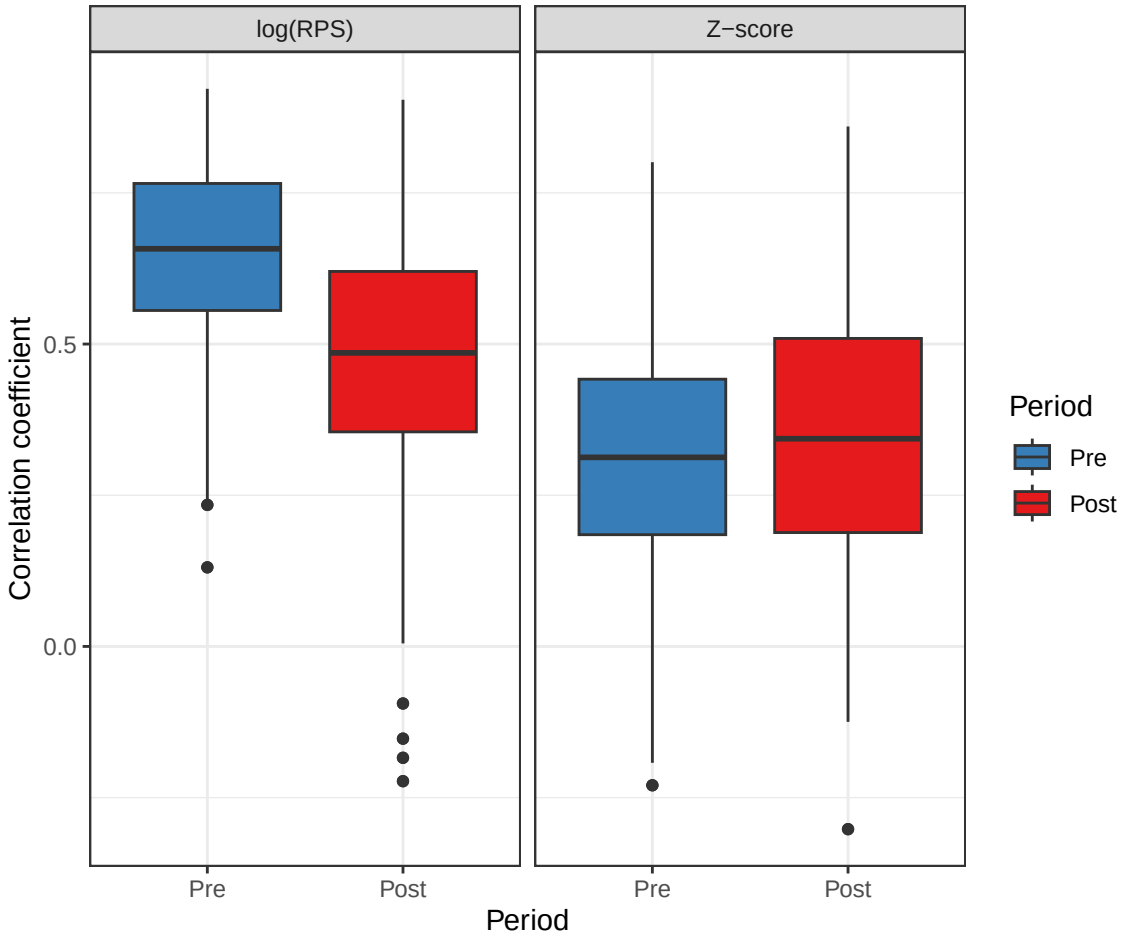


Figure 20: Comparison between correlation coefficients for all pairwise combinations of streams using Z-score and log(RPS) over the pre- and post-1980 periods.

Pairwise stream to stream correlation versus distance

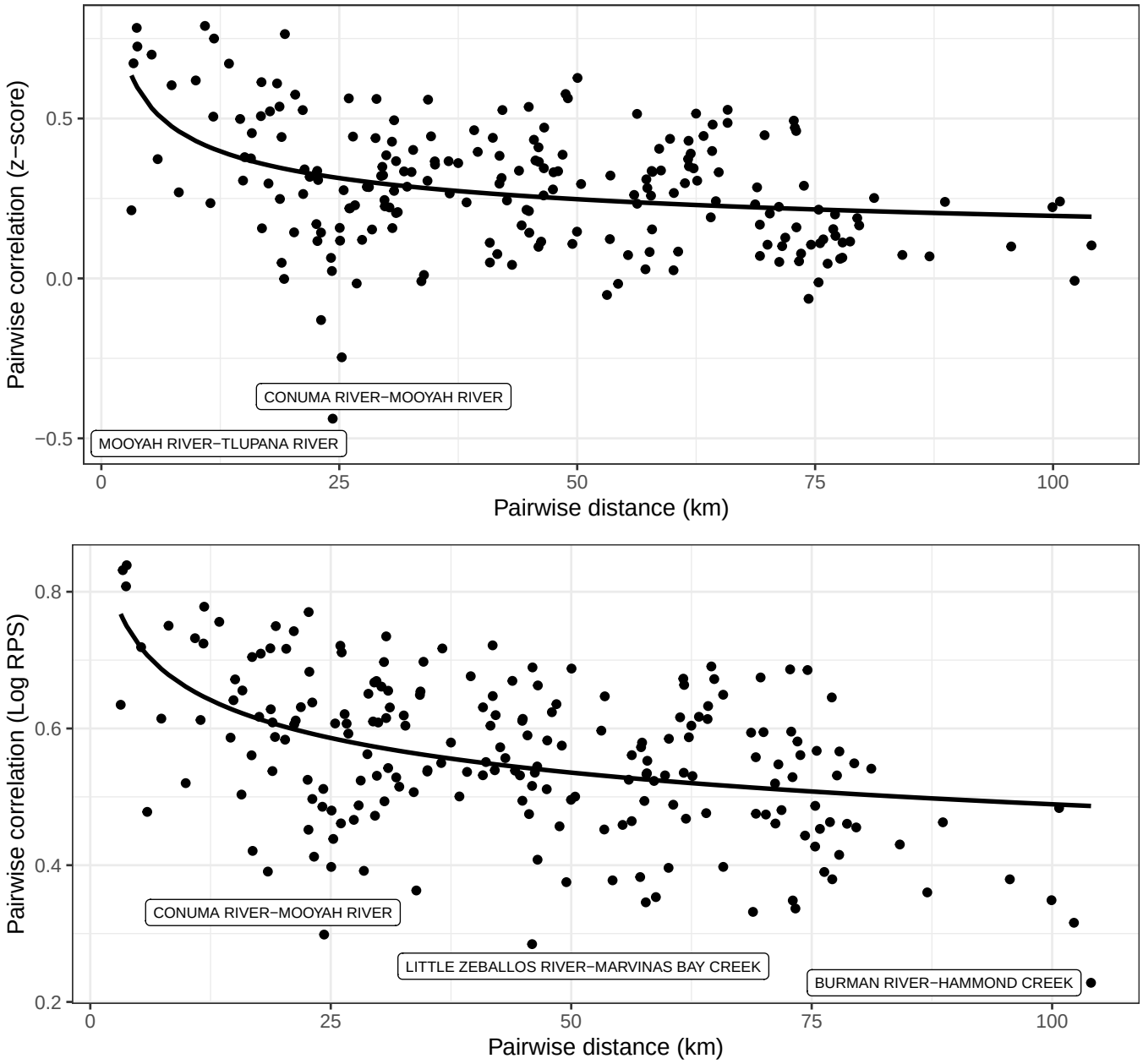


Figure 21: Pairwise stream-stream correlation of Z-score (top) and log(RPS) (bottom) against pairwise distance.

Dendrogram of pairwise distances

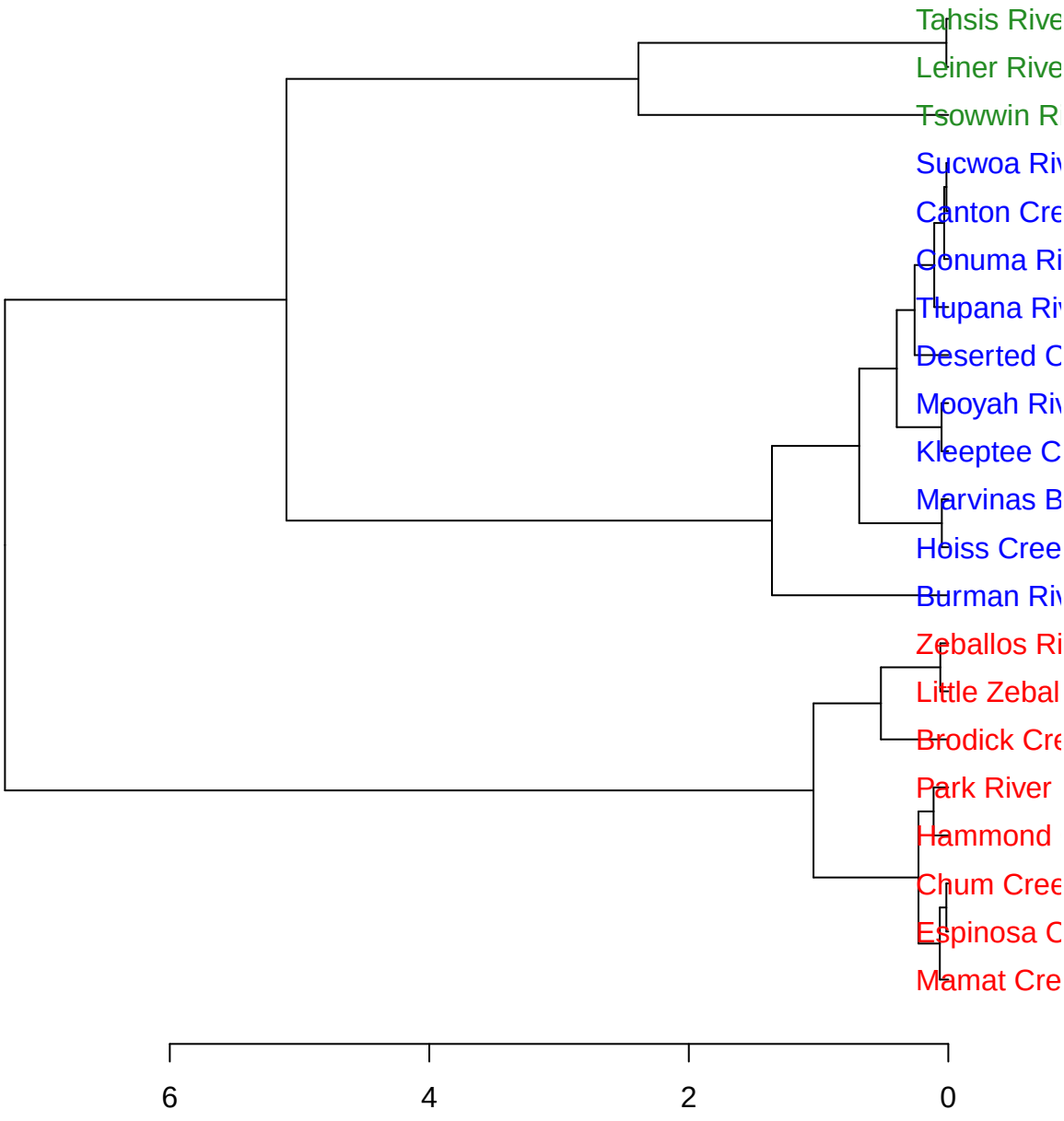


Figure 22: Dendrogram of pairwise distance between stream mouths. Red labels - Esperanza Inlet; Blue - Nootka Inlet; Green - Tahsis Inlet

Correlation metrics against distance, pre- and post-1980

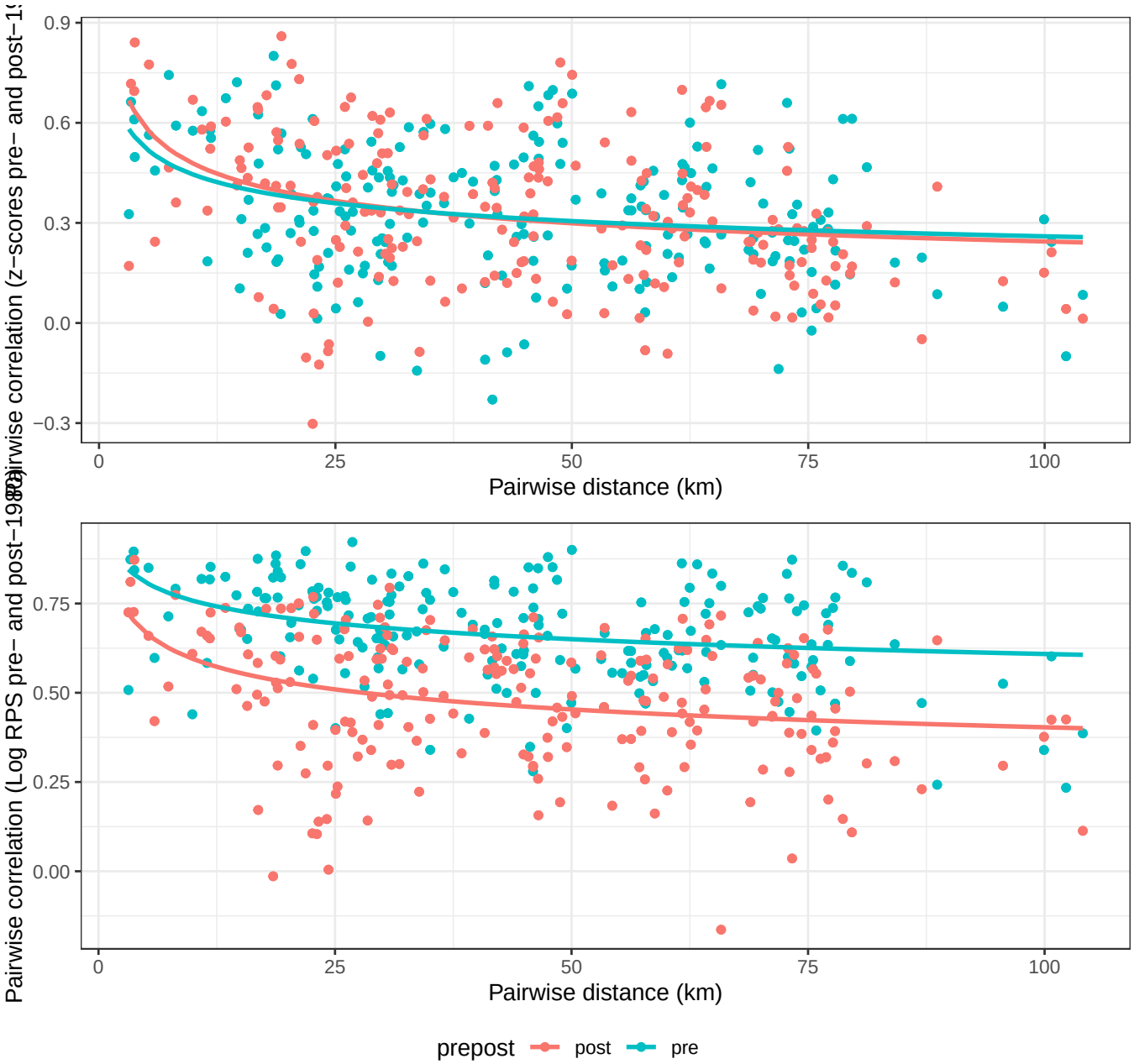


Figure 23: Pairwise stream-stream correlation of Z-score (top) and log(RPS) (bottom) against pairwise distance by period (pre-enhancement and post-enhancement.

Statistical models

Candidate Models with AIC scores for log RPS and log escapement

Table 2: Candidate models for log RPS and distance from enhancement (dist), total releases (totrel), and year, with AIC scores.

Candidate model	Degrees of freedom	AIC
logrps ~ total releases + factor(year)	33	1360.448
logrps ~ total releases + factor(year) + year	33	1360.448
log rps ~ total releases + year	4	1720.592
logrps ~ correlation coefficient + year + total releases	5	1720.627
log rps ~ distance from enhancement + total releases + year	5	1722.590
logrps ~ correlation coefficient + year	4	1722.756
log rps ~ distance from enhancement + year	4	1724.998
logrps ~ total releases + year + subinlet	12	1730.376
logrps ~ total releases + year + system name	27	1756.327
logrps ~ correlation coefficient + year + system name	26	1758.053

Table 3: Candidate models for log escapement and distance from enhancement (dist), total releases (totrel), and year, with AIC scores.

Candidate models	Degrees of freedom	AIC
log escapement ~ correlation coefficient + distance from enhancement + total releases + year	14	2645.411
log escapement ~ correlation coefficient + total releases + subinlet + year	13	2651.303
log escapement ~ correlation coefficient + total releases + inlet + year	7	2896.195
log escapement ~ correlation coefficient + total releases + year	5	2934.982
log escapement ~ distance from enhancement + total releases + year	5	2982.832
log escapement ~ distance from enhancement + year	4	2991.802

Effects plots for top model: log(RPS)

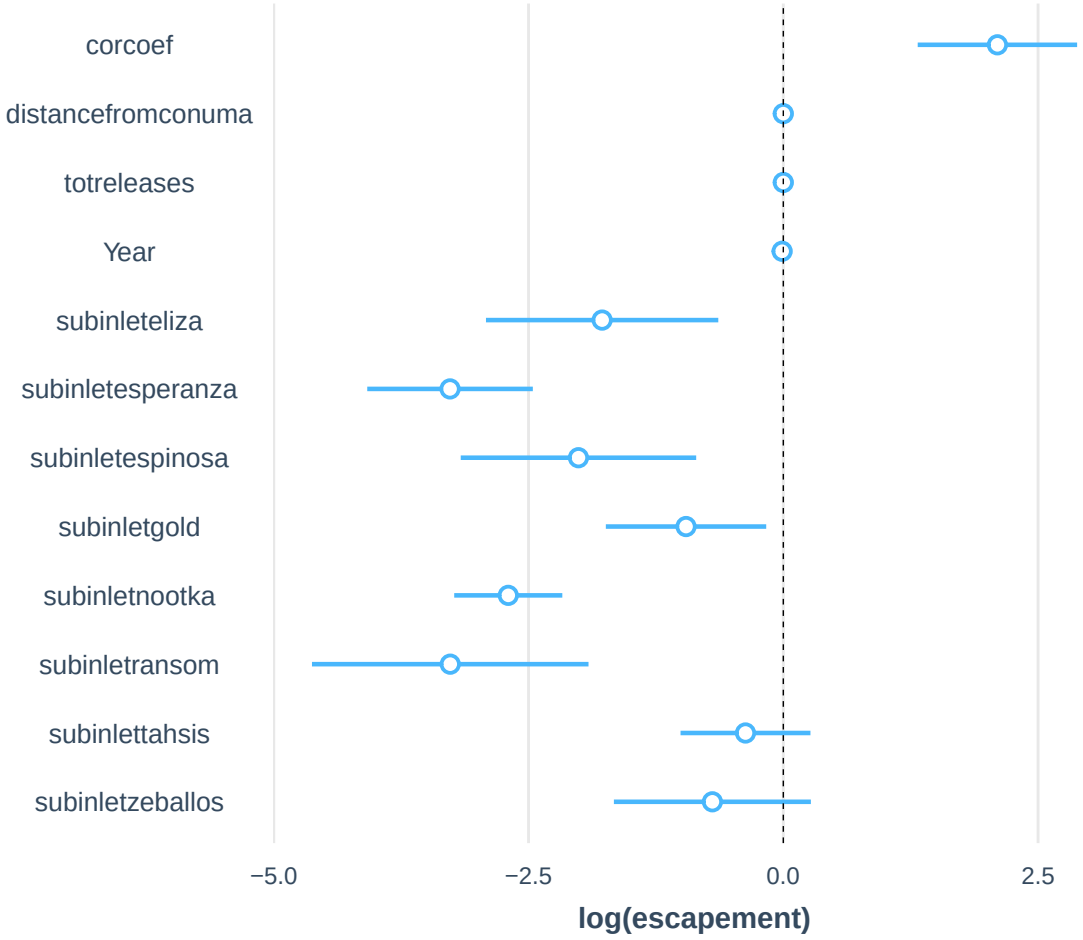


Figure 24: Plot of effects included in most parsimonious model.

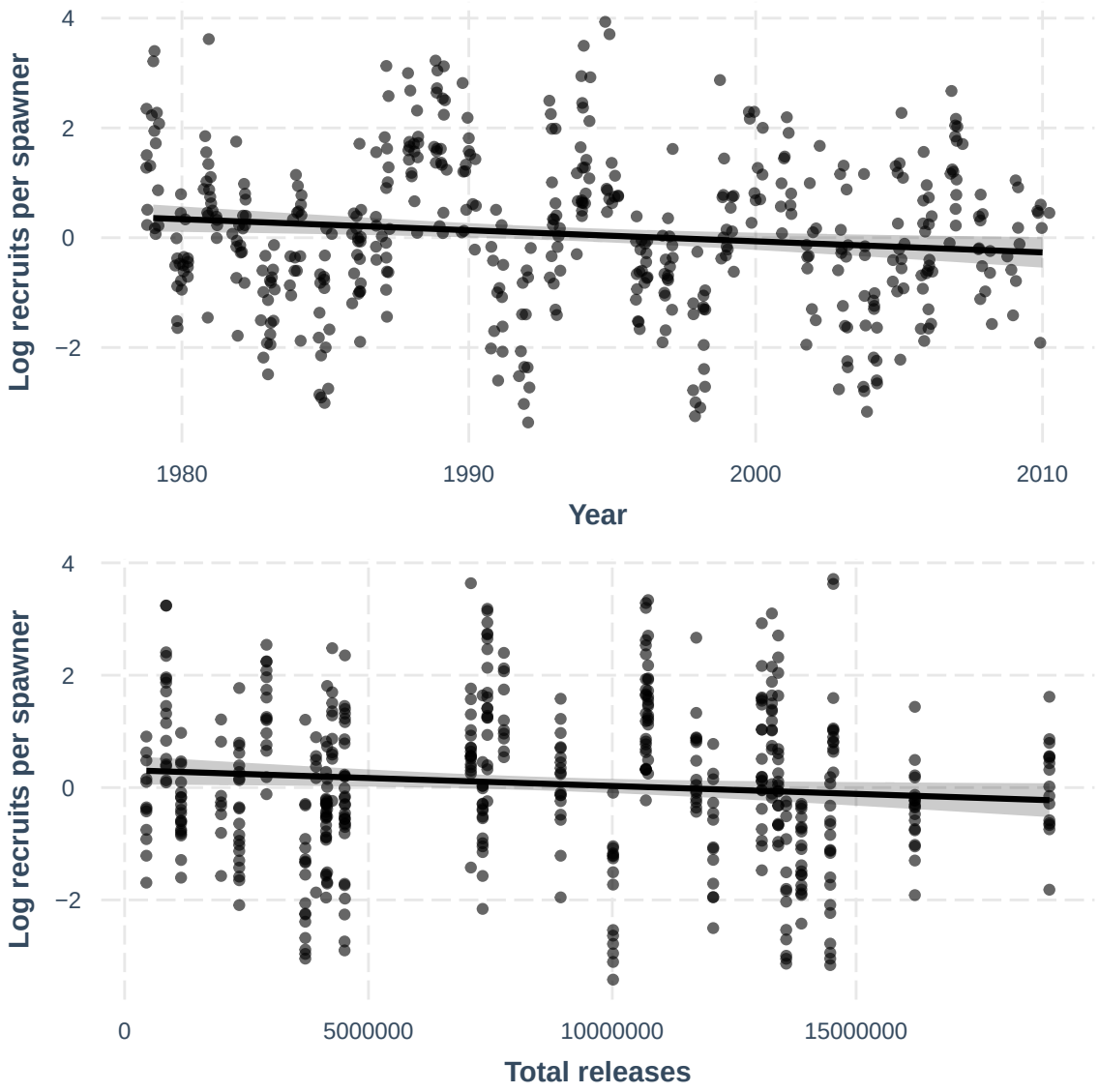


Figure 25: Effects plots of recruits per spawner by year (top) and total releases (bottom).

Effects plots for top model: log(escapement)

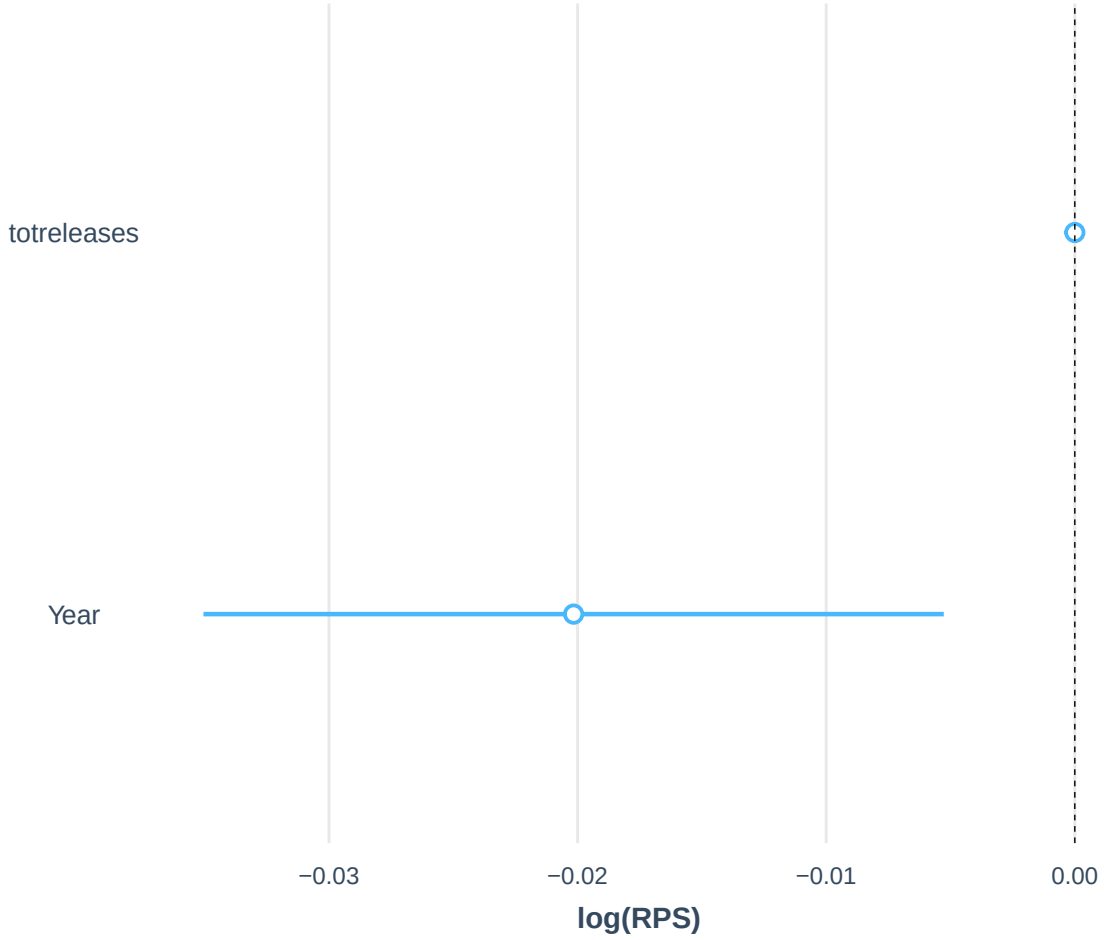


Figure 26: Effects plots of Escapement by correlation coefficient.

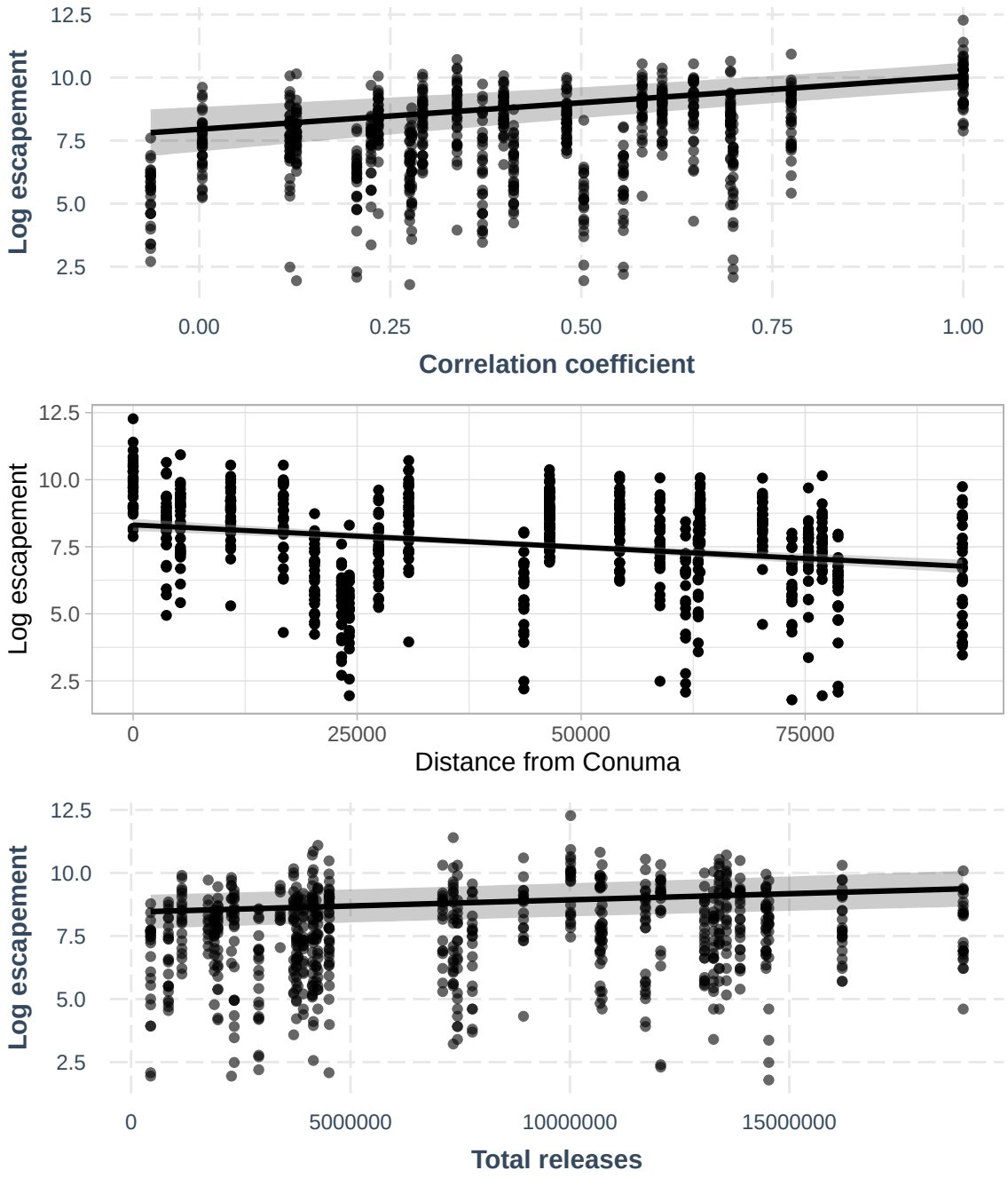


Figure 27: Effects plots of log(escapement) by correlation coefficient (top), distance from enhancement (middle) and total releases (bottom).