

Hatchery Effectiveness Review

AN EXPLORATORY ANALYSIS INTO SPATIAL PATTERNS OF CORRELATION RELATIVE TO ENHANCEMENT

APPENDIX 3: AREA 06 - DOUGLAS GARDNER CU CHUM SALMON



Photo credit: Eiko Jones

Prepared by Andrew Rosenberger

May 2023



**PACIFIC SALMON
FOUNDATION**

PACIFIC SALMON FOUNDATION
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Appendix 3

Area 06 - Douglas Gardner CU Chum Salmon

Coastland

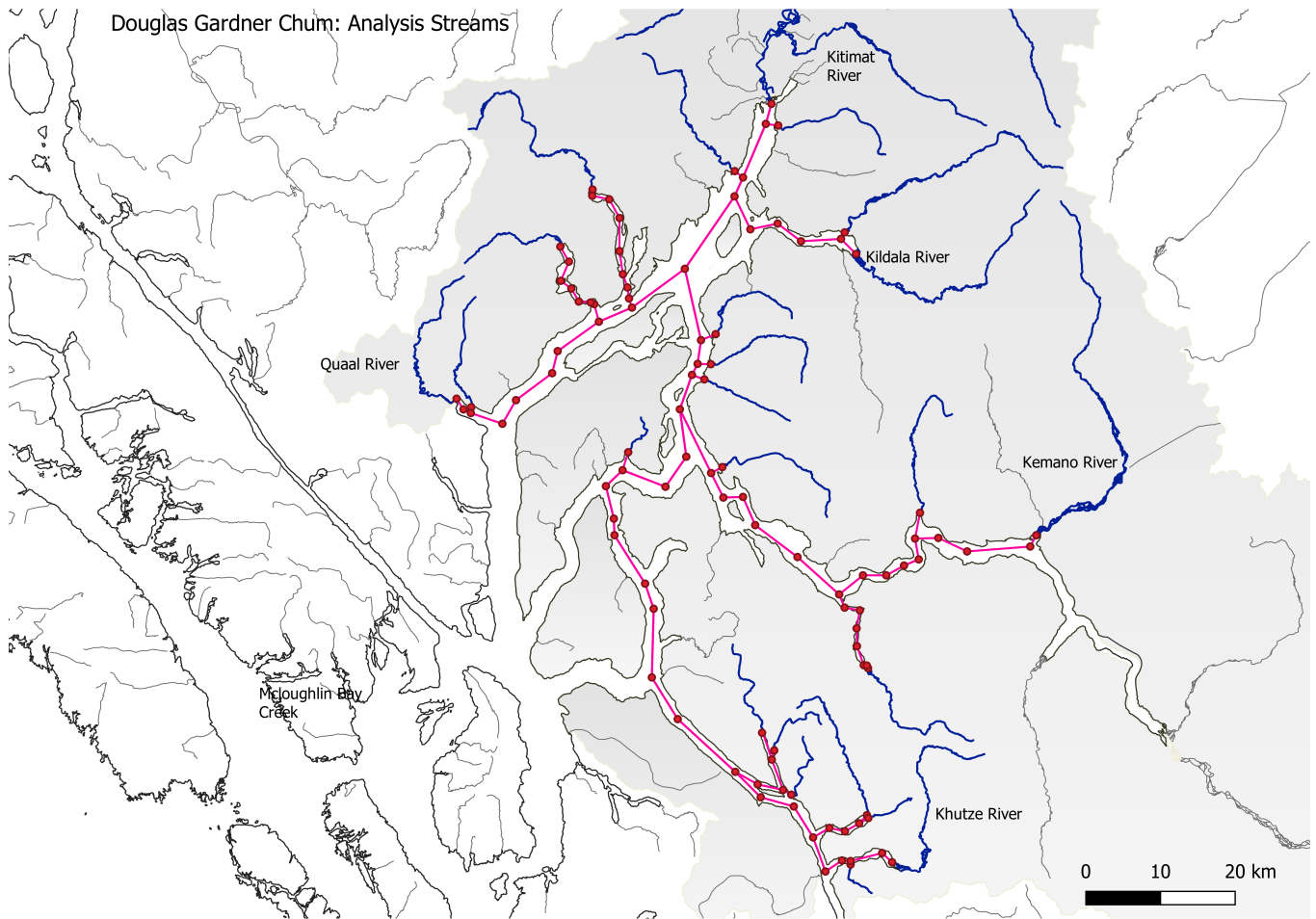
2023-03-08

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Study area

Douglas Gardner CU



Summary figures

Escapement: Raw and filtered stream list

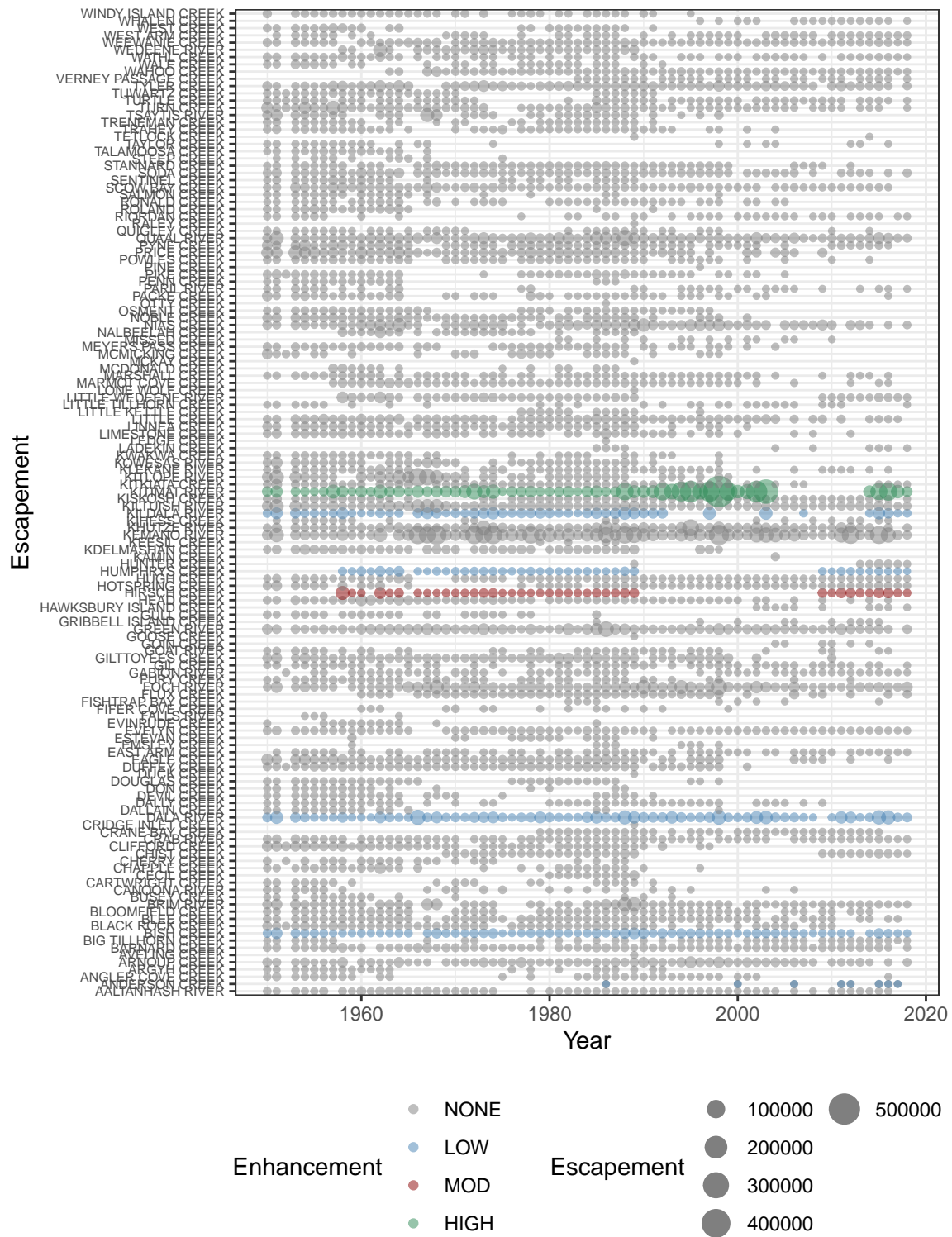
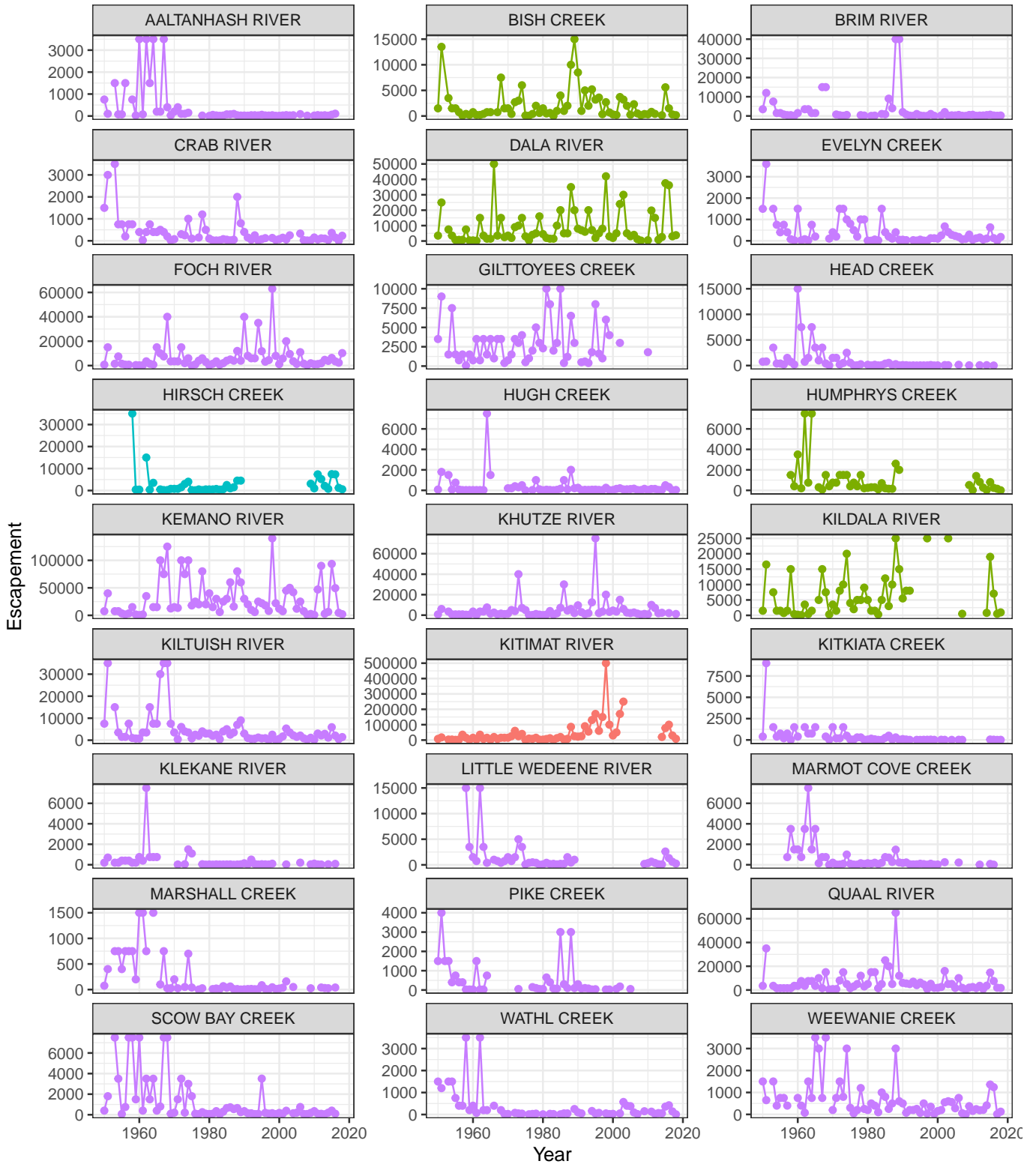


Figure 1: Escapement to all Douglas-Gardner chum streams in the PSE database, by enhancement rank.

Area 6 Escapement (filtered streams)



Enhancement Level — HIGH — LOW — MOD — NONE

Figure 2: Escapement to filtered streams for Douglas-Gardner chum. Colour shows the stream enhancement level from the PSE database.

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

Stream	Dist. from enhancement
WATHL CREEK	4.470
BISH CREEK	11.998
DALA RIVER	32.303
KILDALA RIVER	34.146
HUGH CREEK	37.112
WEEWANIE CREEK	39.982
PIKE CREEK	41.635
FOCH RIVER	52.191
GILTTOYEES CREEK	52.216
CRAB RIVER	55.985
KITKIATA CREEK	63.528
EVELYN CREEK	64.768
QUAAL RIVER	65.544
KILTUISH RIVER	91.658
BRIM RIVER	97.710
KEMANO RIVER	111.829
MARMOT COVE CREEK	117.746
SCOW BAY CREEK	122.091
KLEKANE RIVER	124.855
HEAD CREEK	132.104
AALTANHASH RIVER	132.200
MARSHALL CREEK	133.004
KHUTZE RIVER	138.697

Hatchery Releases: Total and by release site

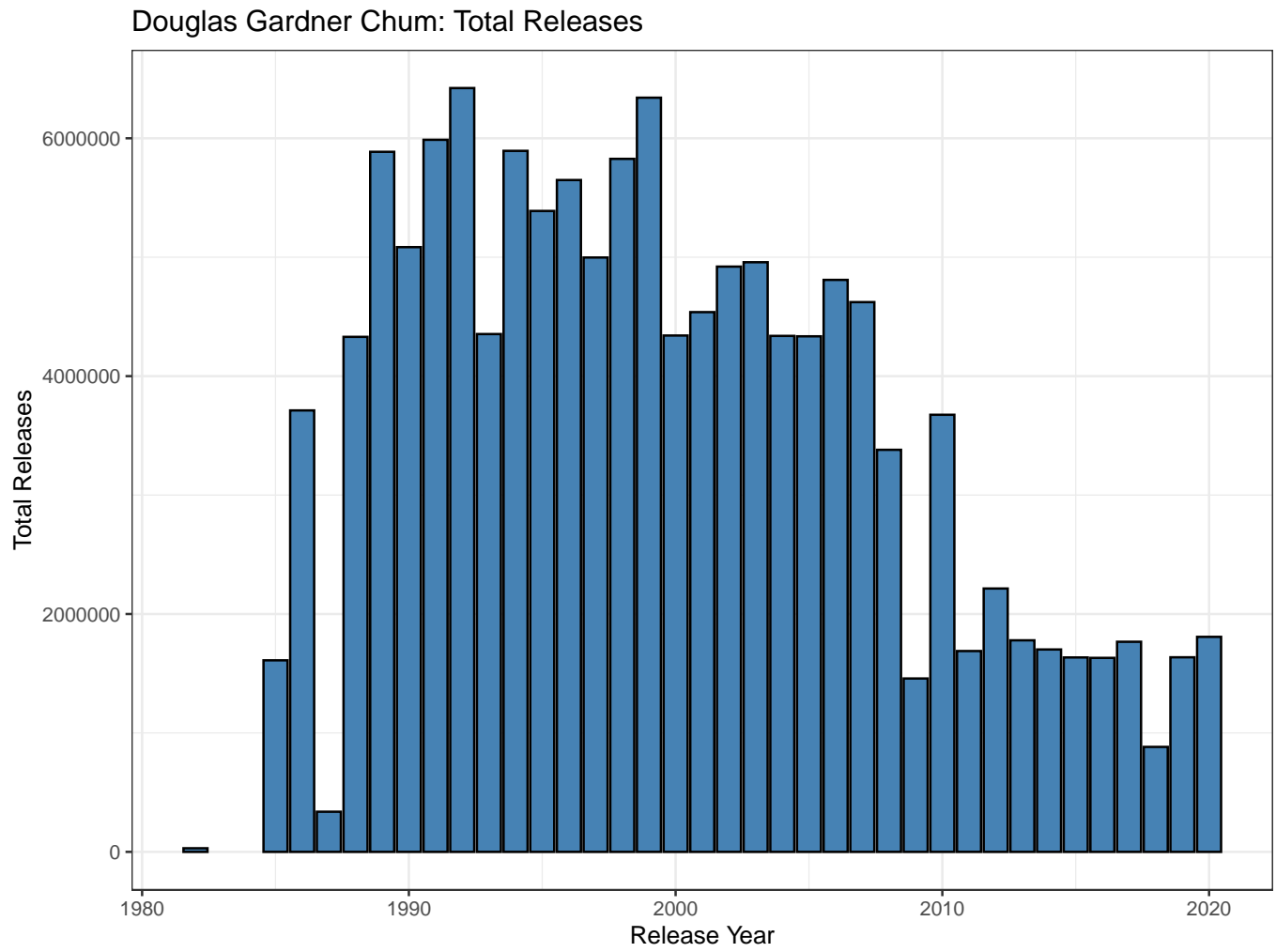


Figure 3: Total releases in the Douglas Gardner CU.

Chum: Douglas Gardner CU
 Release site:Origin stock

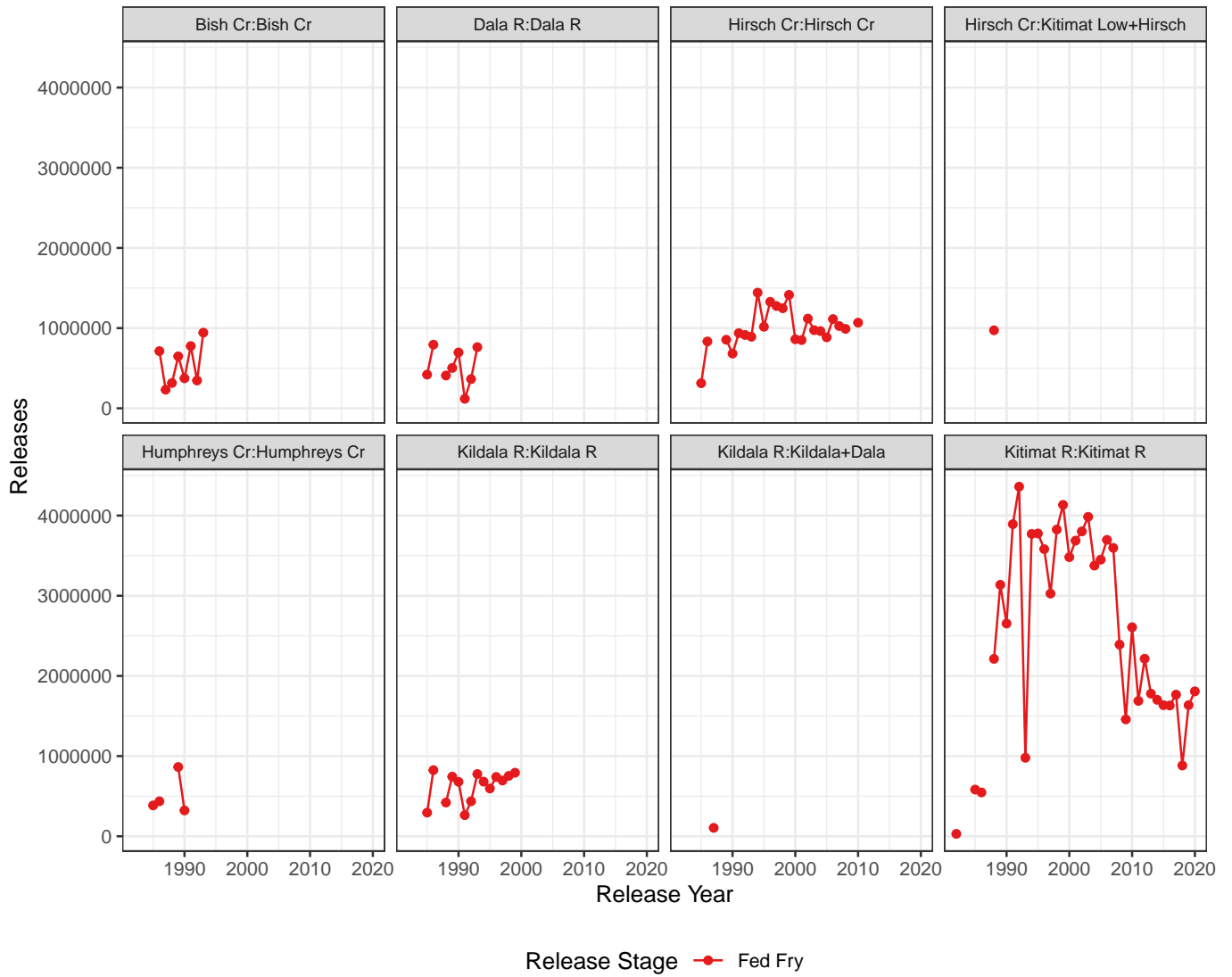


Figure 4: Releases by release site:origin stock for chum in the Douglas Gardner CU.

Metrics

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

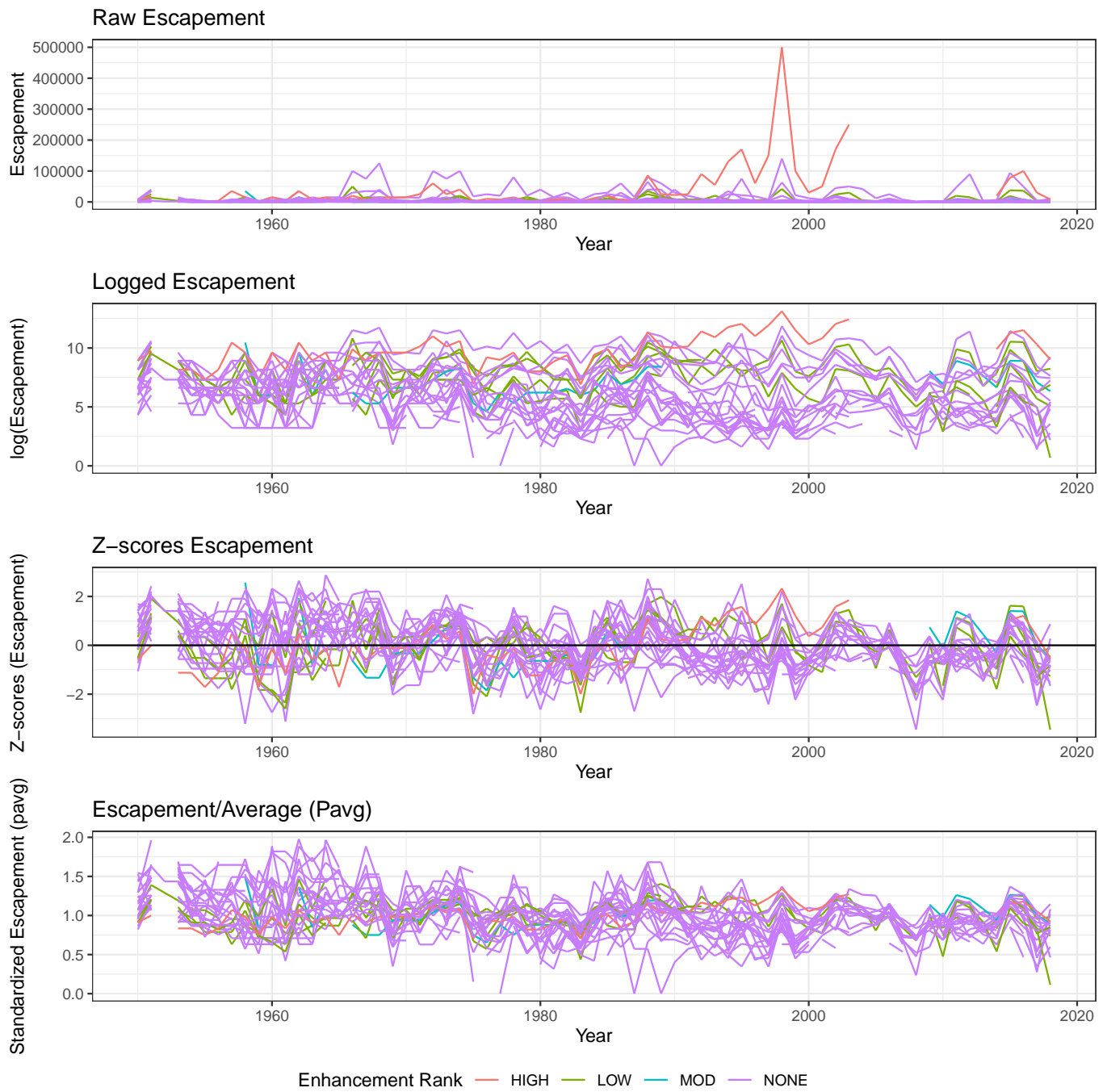


Figure 5: Various plots for escapement and transformations.

Moving average and LOESS fits

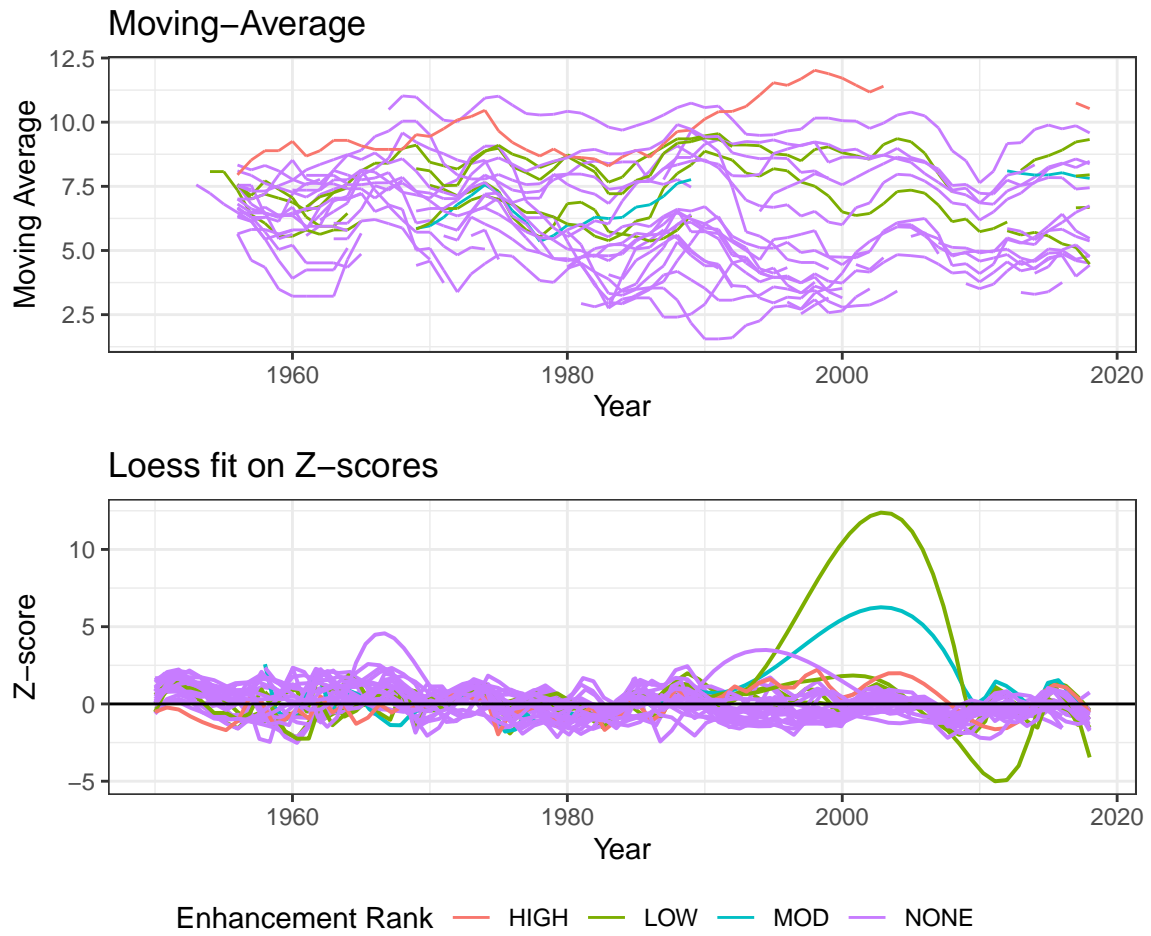


Figure 6: Moving average and LOESS fits on logged escapement by enhancement ranking.

Means trends by enhancement rank

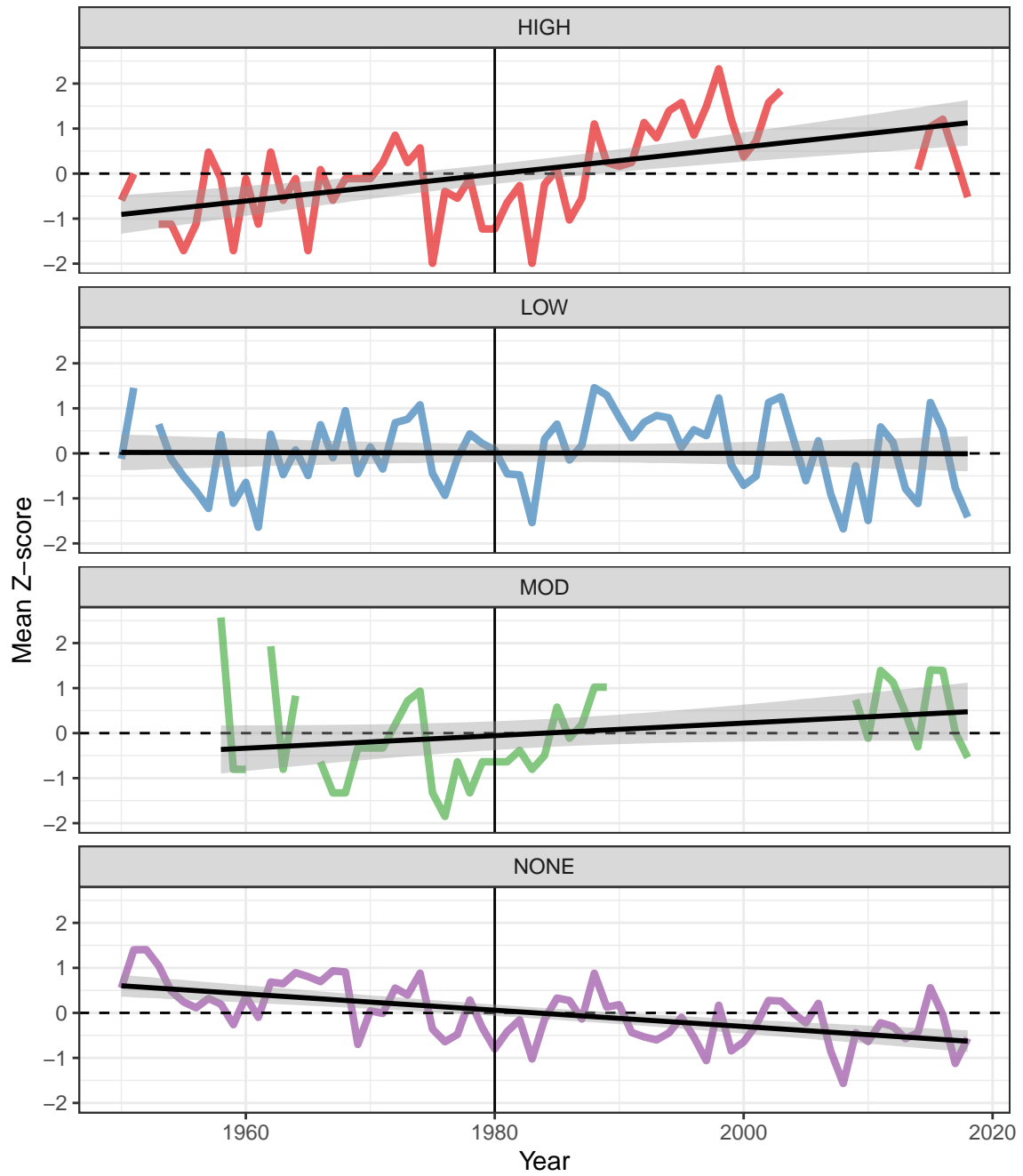


Figure 7: Douglas-Gardner chum: Mean Z-score for analysis streams by enhancement rank. Linear regression over all years with SE are shown.

Recruits per spawners

Recruits per spawner by system

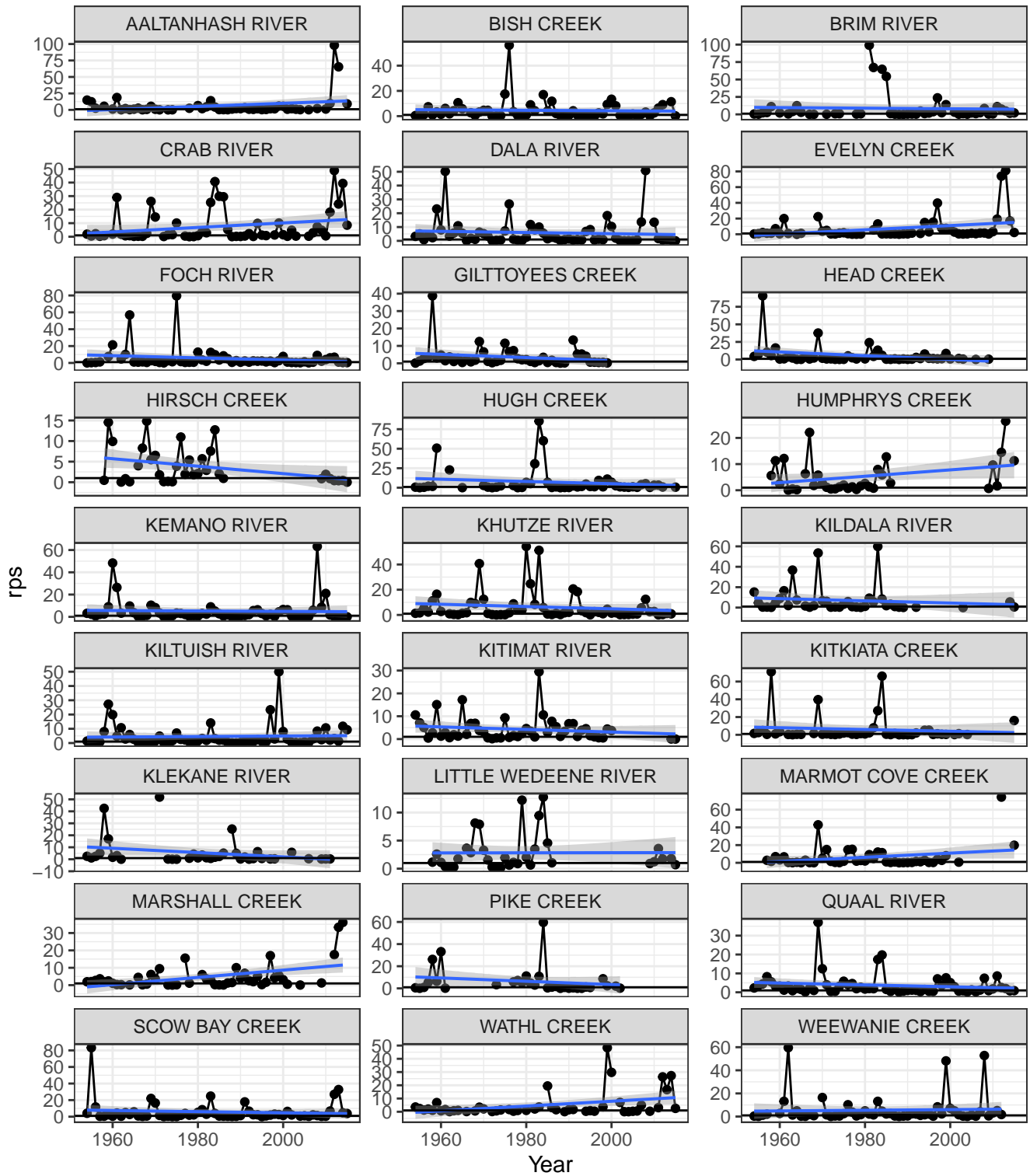


Figure 8: Douglas-Gardner chum: recruits per spawner by system.

Log recruits per spawner by system by period

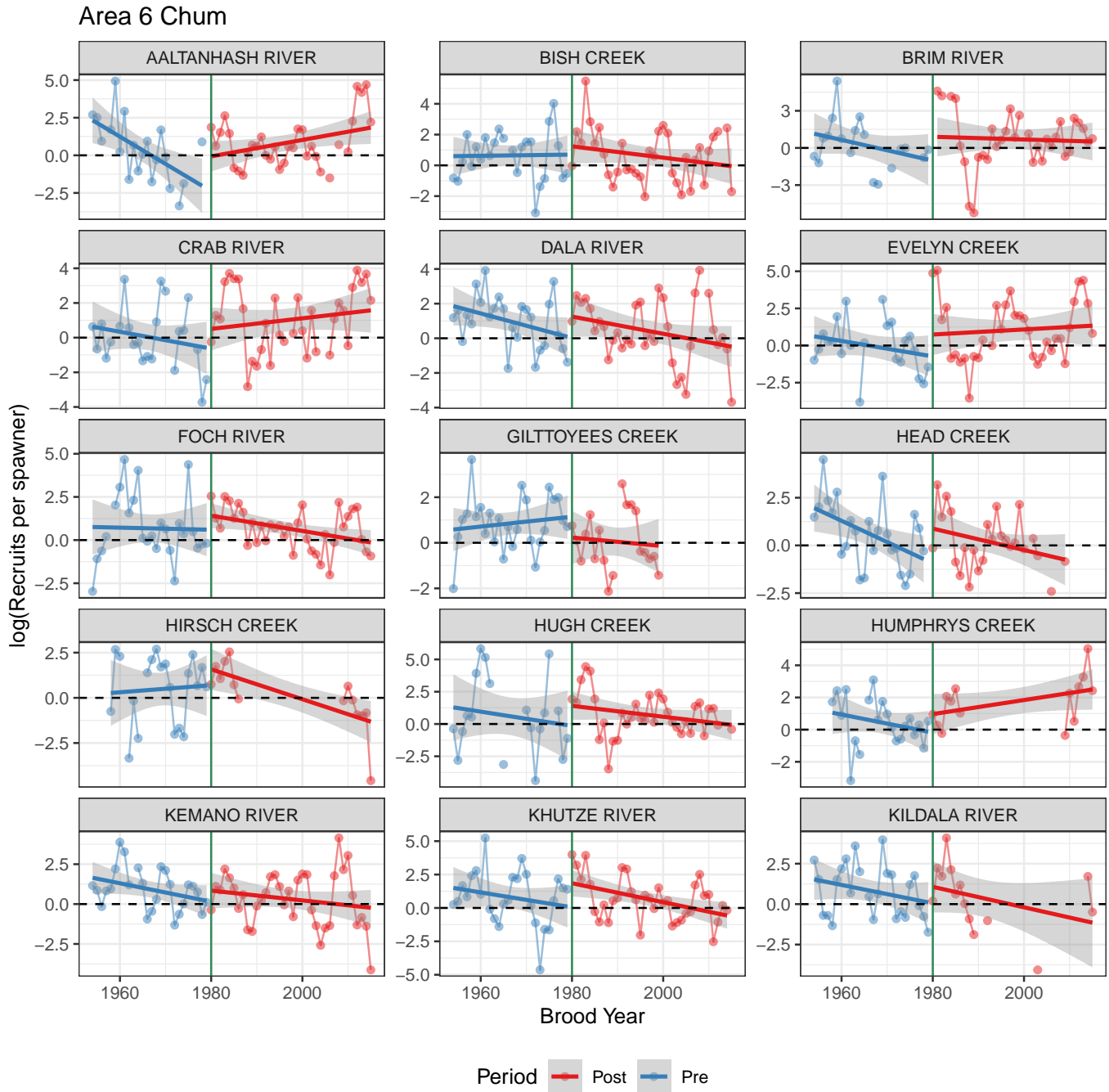


Figure 9: Douglas-Gardner chum: log recruits per spawner by system fitted with linear regression for the periods pre- and post-enhancement (Aaltanhash to Kildala).

Area 6 Chum

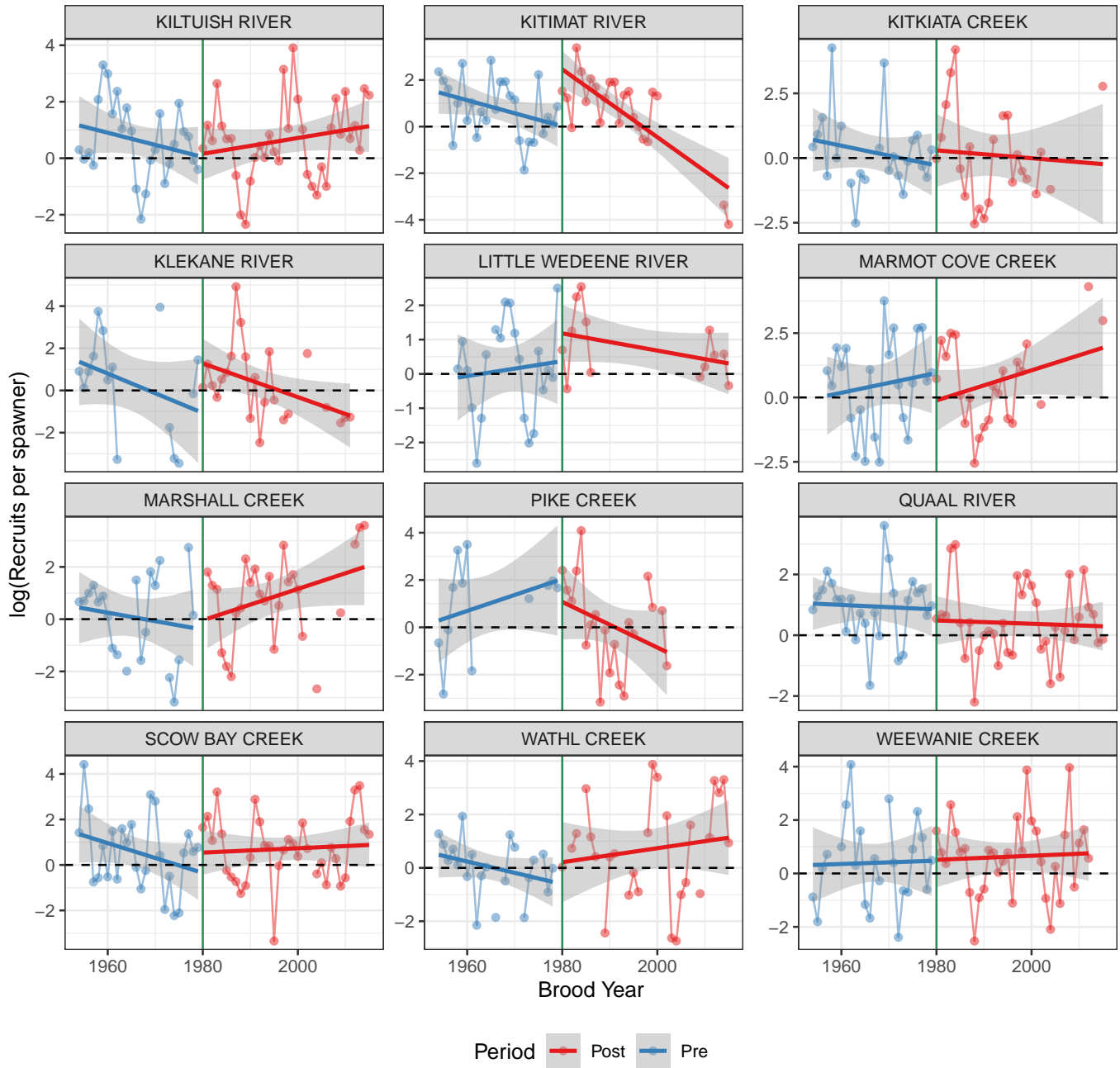


Figure 10: Douglas-Gardner chum: log recruits per spawner by system fitted with linear regression for the periods pre- and post-enhancement (Kiltuish to Weewanie).

Log RPS comparison before and after enhancement

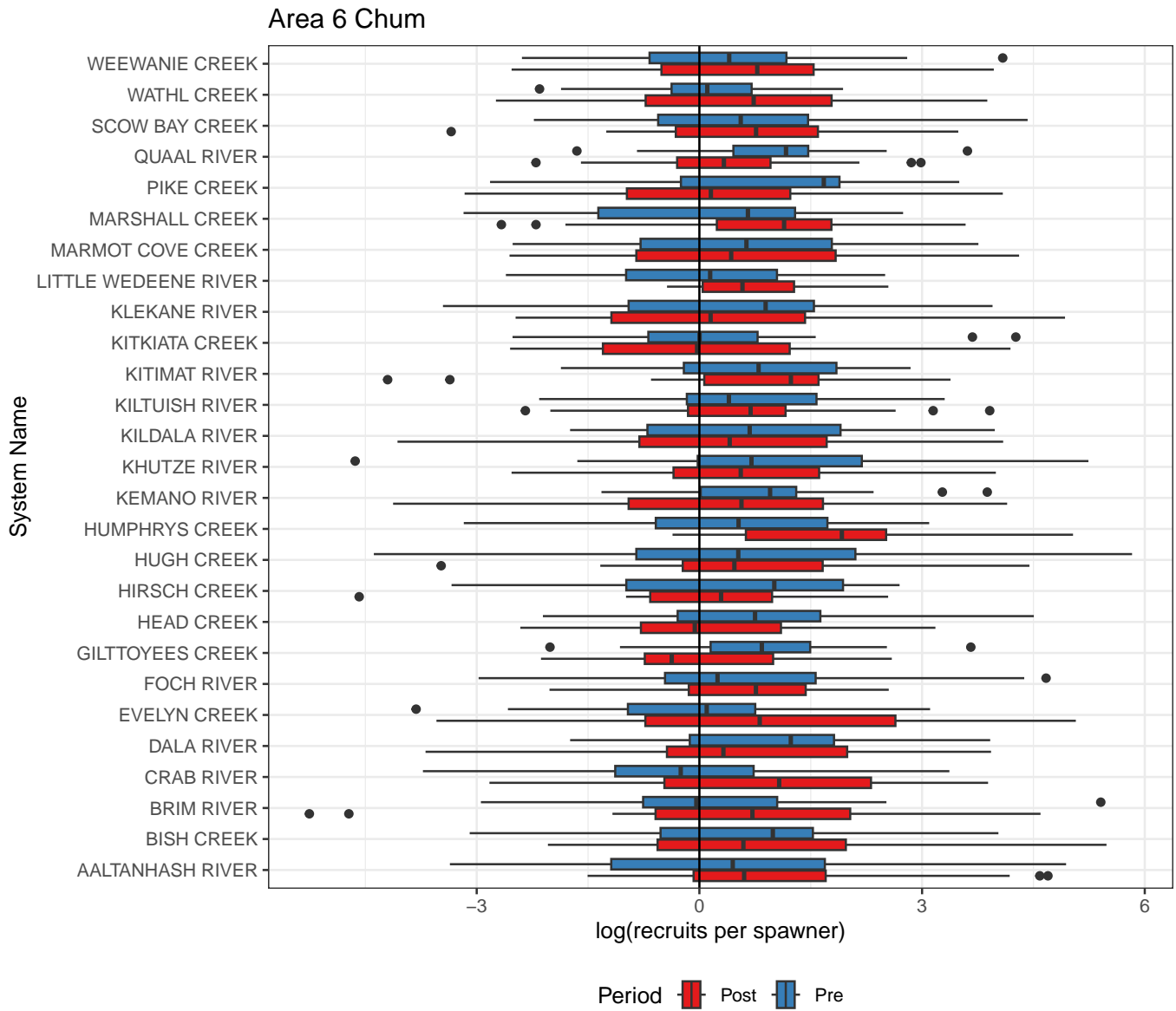


Figure 11: Douglas-Gardner chum: boxplot of log recruits per spawner by system.

Bubbleplots of metric by inlet

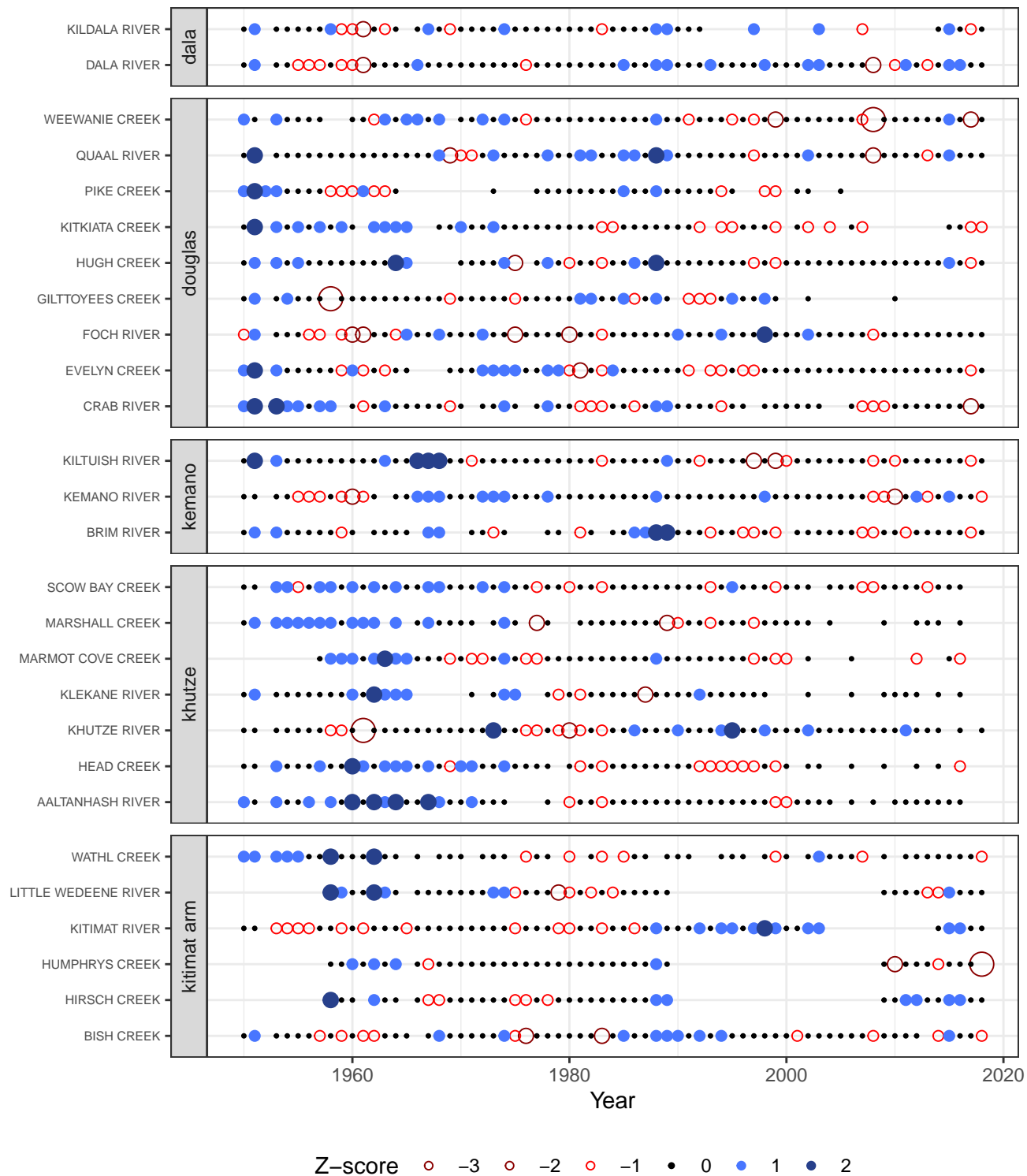


Figure 12: Z-scores of escapement for each system grouped by inlet. Solid blue points indicate positive values and open red circles indicate negative values. The size of the point indicates the magnitude of the metric.

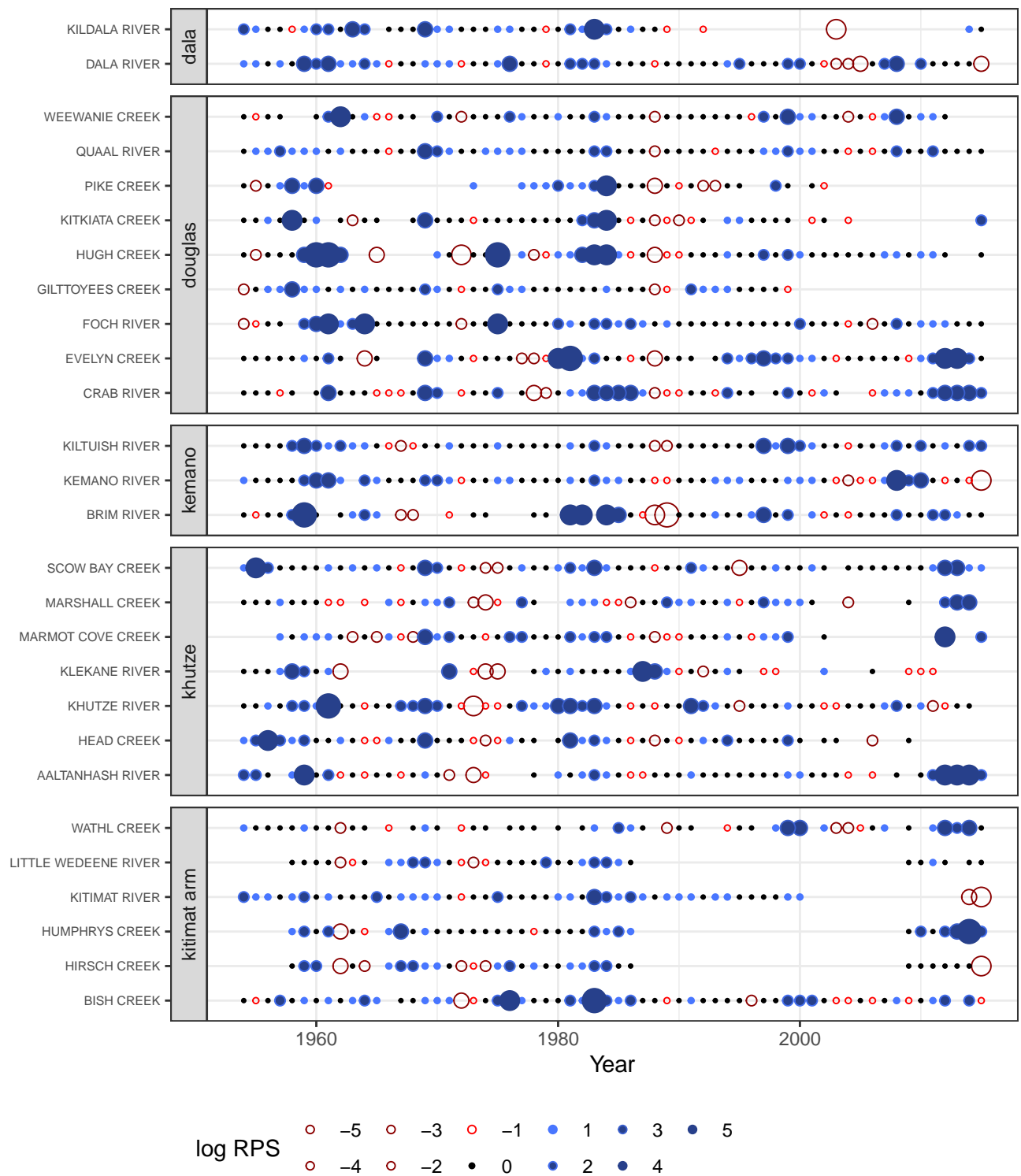


Figure 13: Log(recruits per spawner) for each system grouped by inlet. Solid blue points indicate positive values and open red circles indicate negative values. The size of the point indicates the magnitude of the metric.

Correlation analyses and Dendrograms

Cross correlation plots

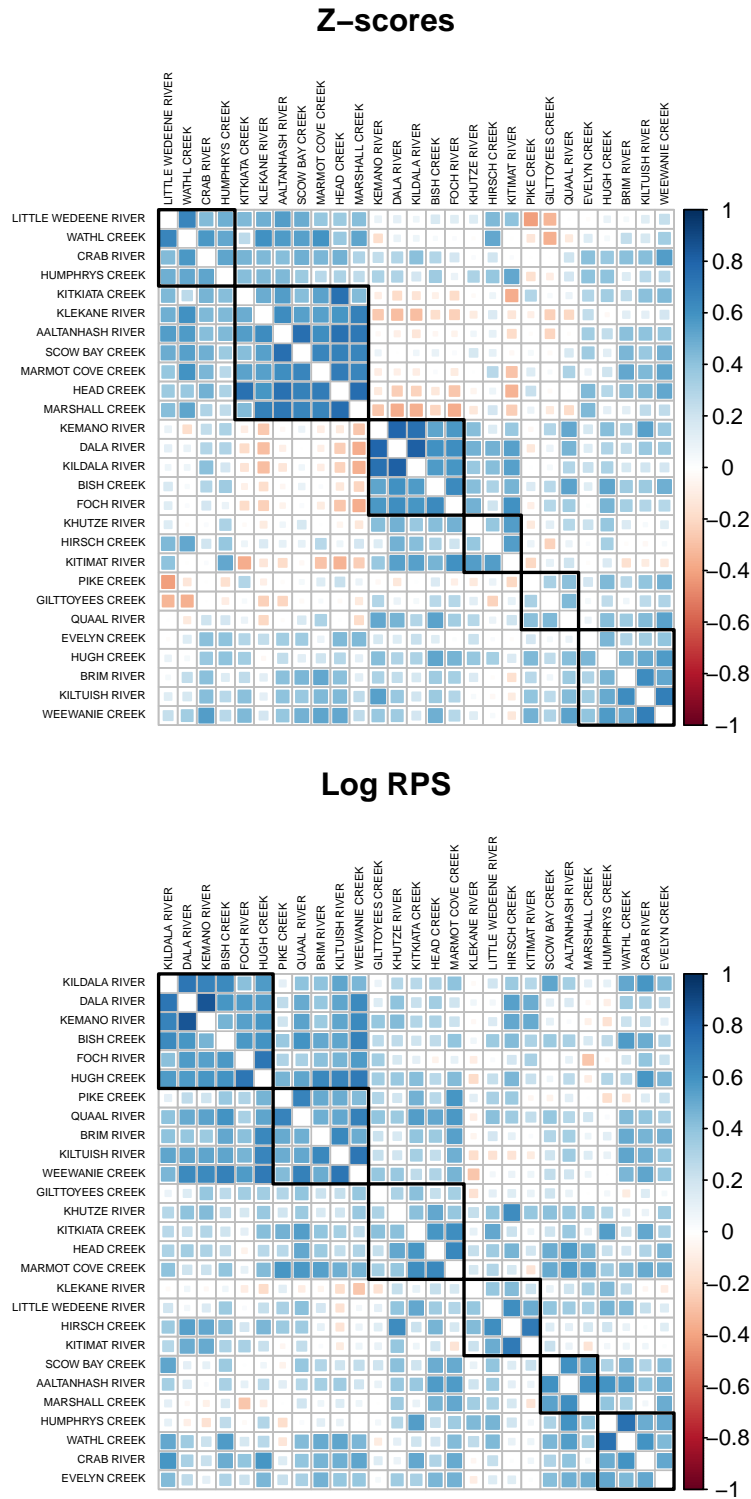


Figure 14: Cross correlation plots to compare metrics.

Dendrogram cluster analysis

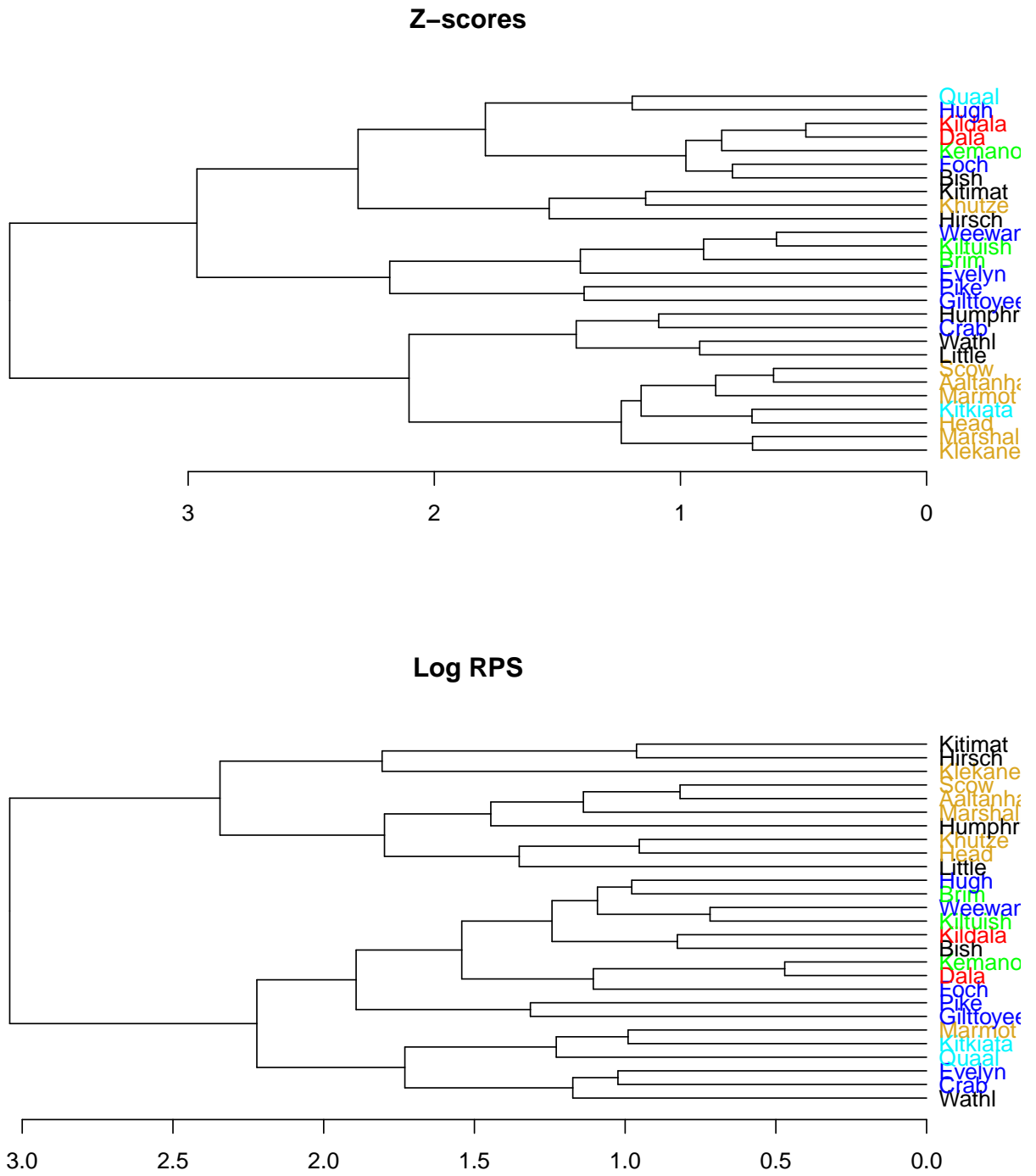


Figure 15: Dendrogram cluster analysis to compare uses of different metrics. Colours plotted by subinlet; Dala = red; Douglas = blue; Kemano = green; Khutze = yellow; Kitimat arm = black; Quaal = turquoise

Tanglegrams to compare dendrograms

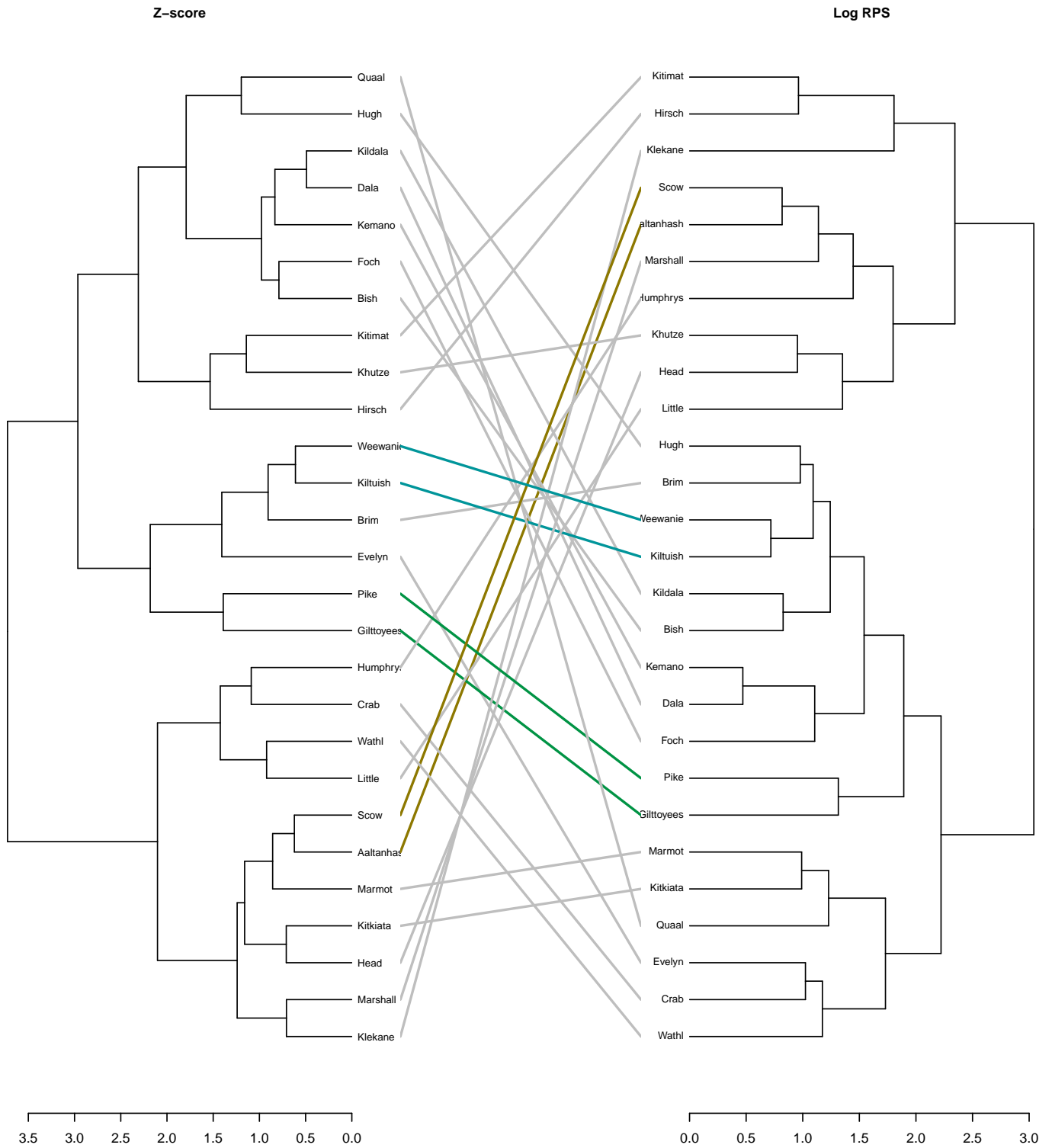


Figure 16: Tanglegram of z-score vs. Log RPS

Pre- and post-enhancement correlation analyses

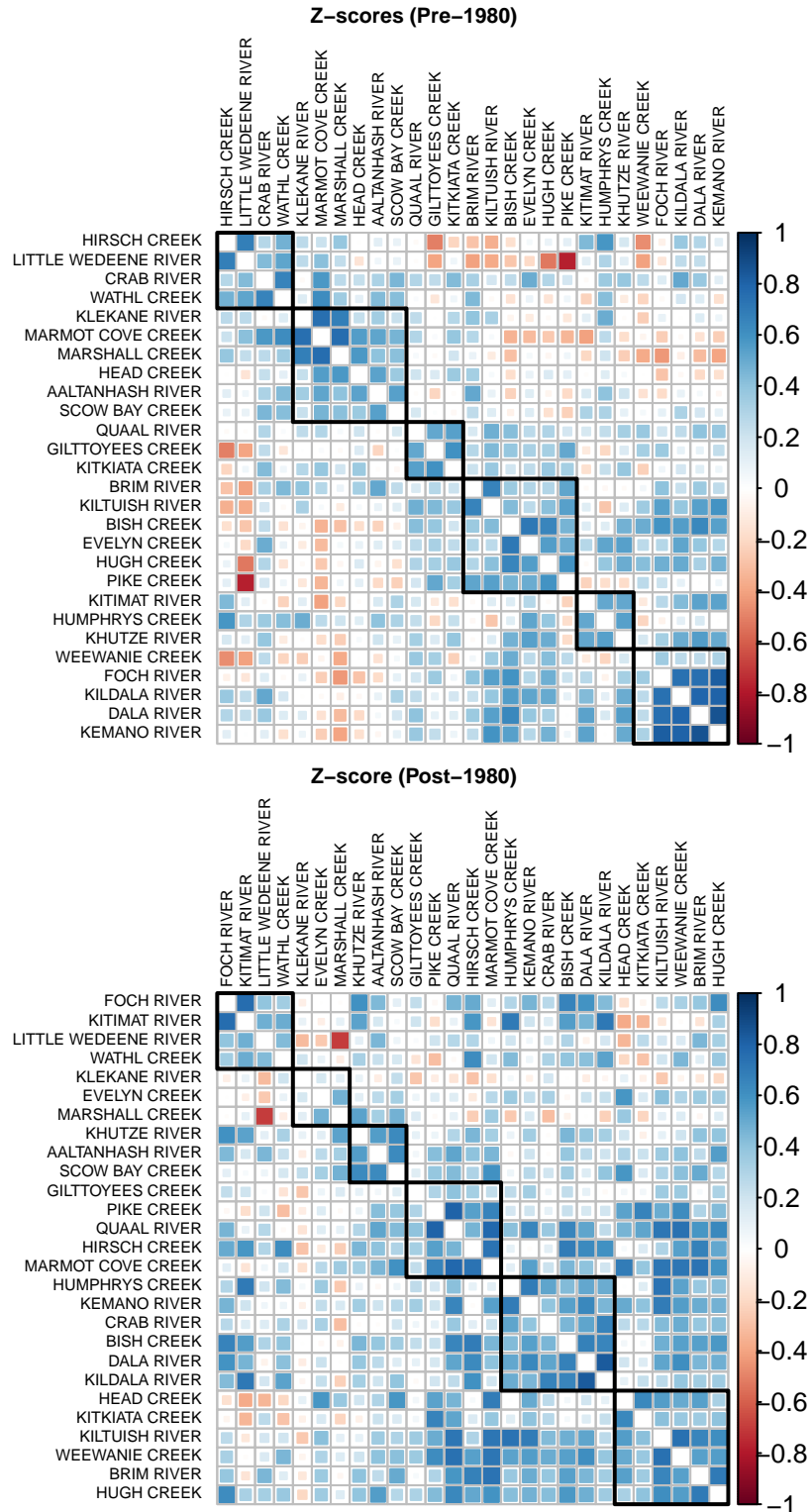


Figure 17: Cross correlation plots of z-scores to compare pre- and post-enhancement.

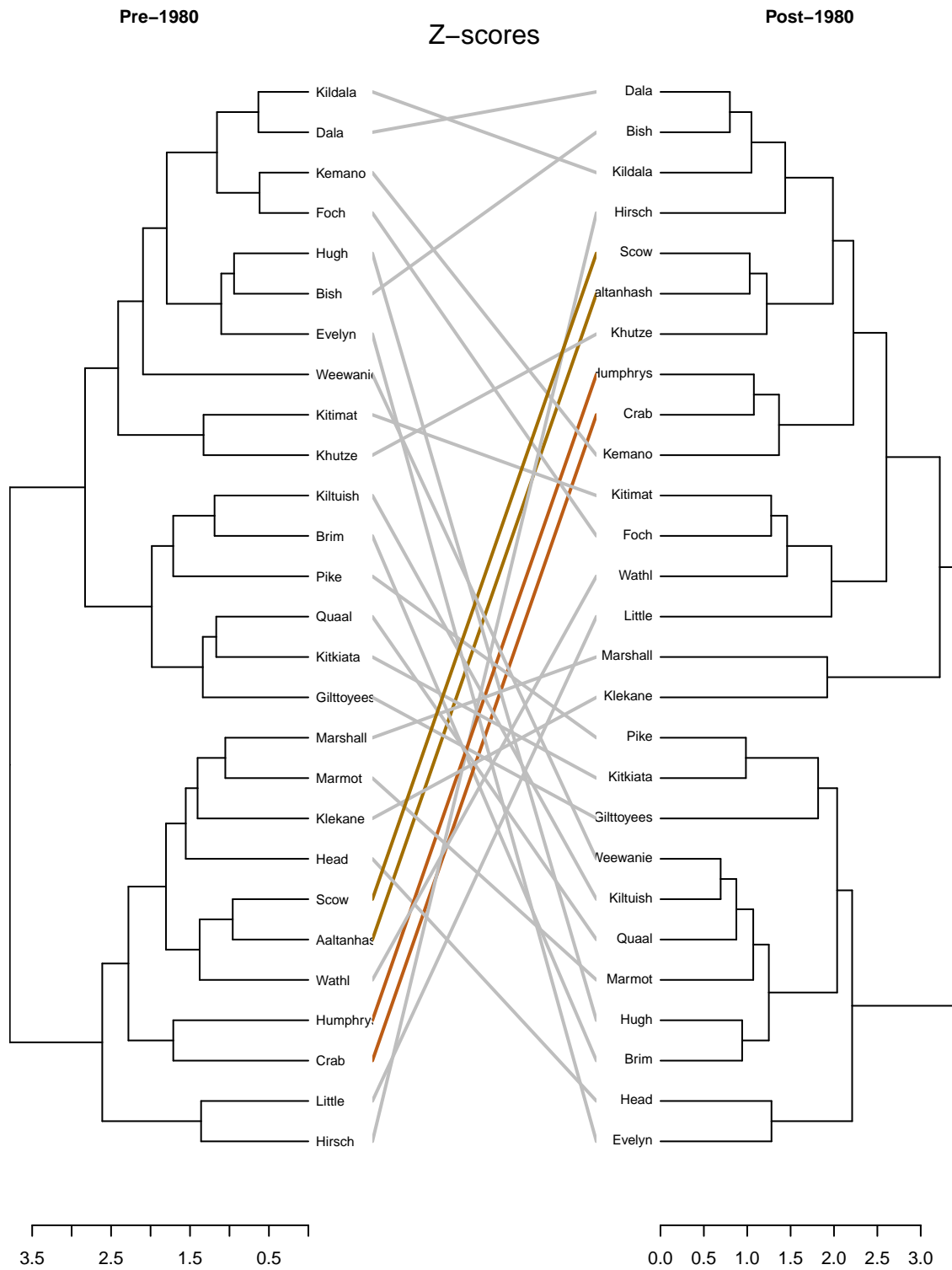


Figure 18: Tanglegram comparing z-scores pre- and post-enhancement (1980)

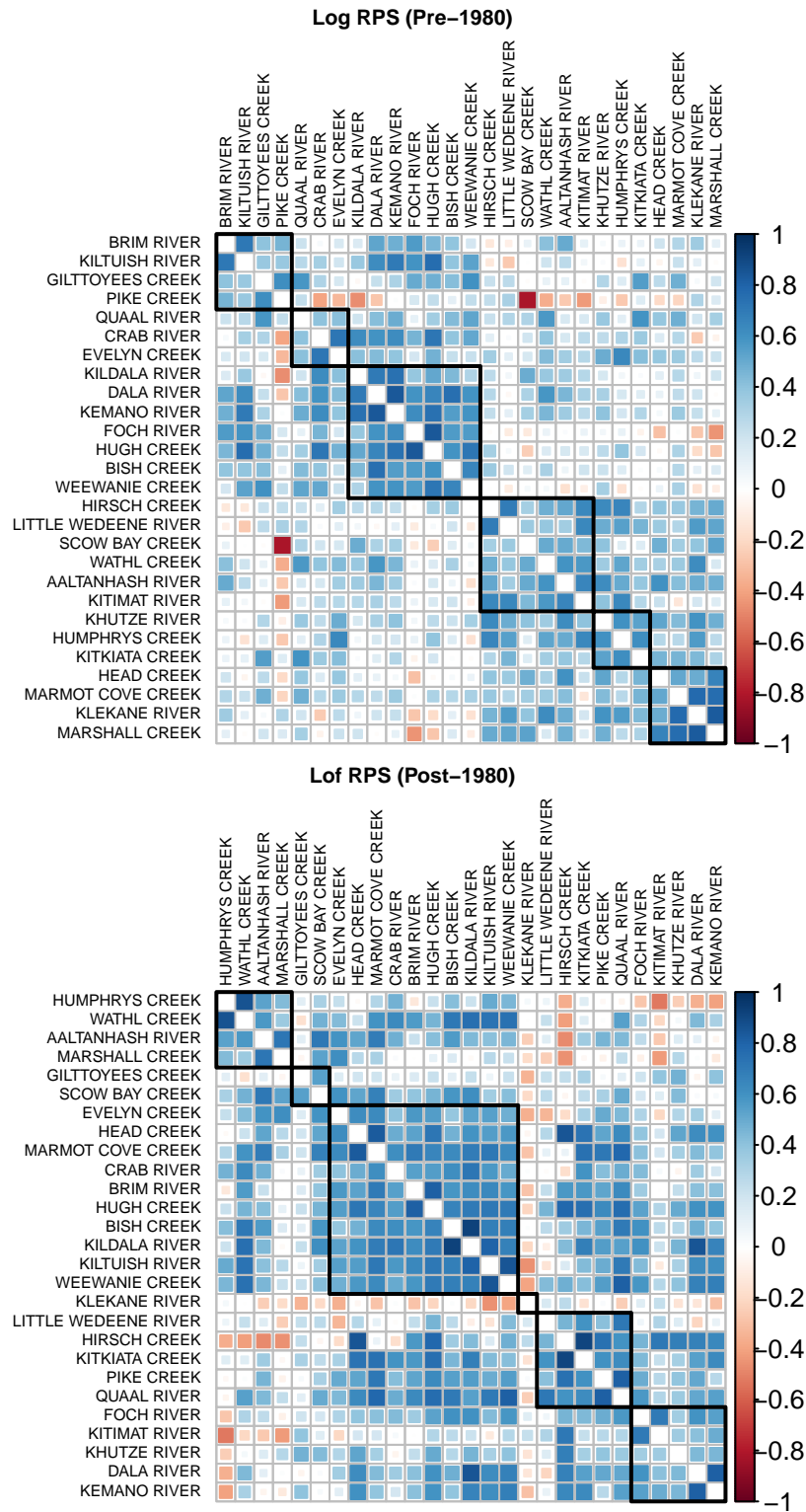


Figure 19: Cross correlation plots of Log RPS to compare pre- and post-enhancement.

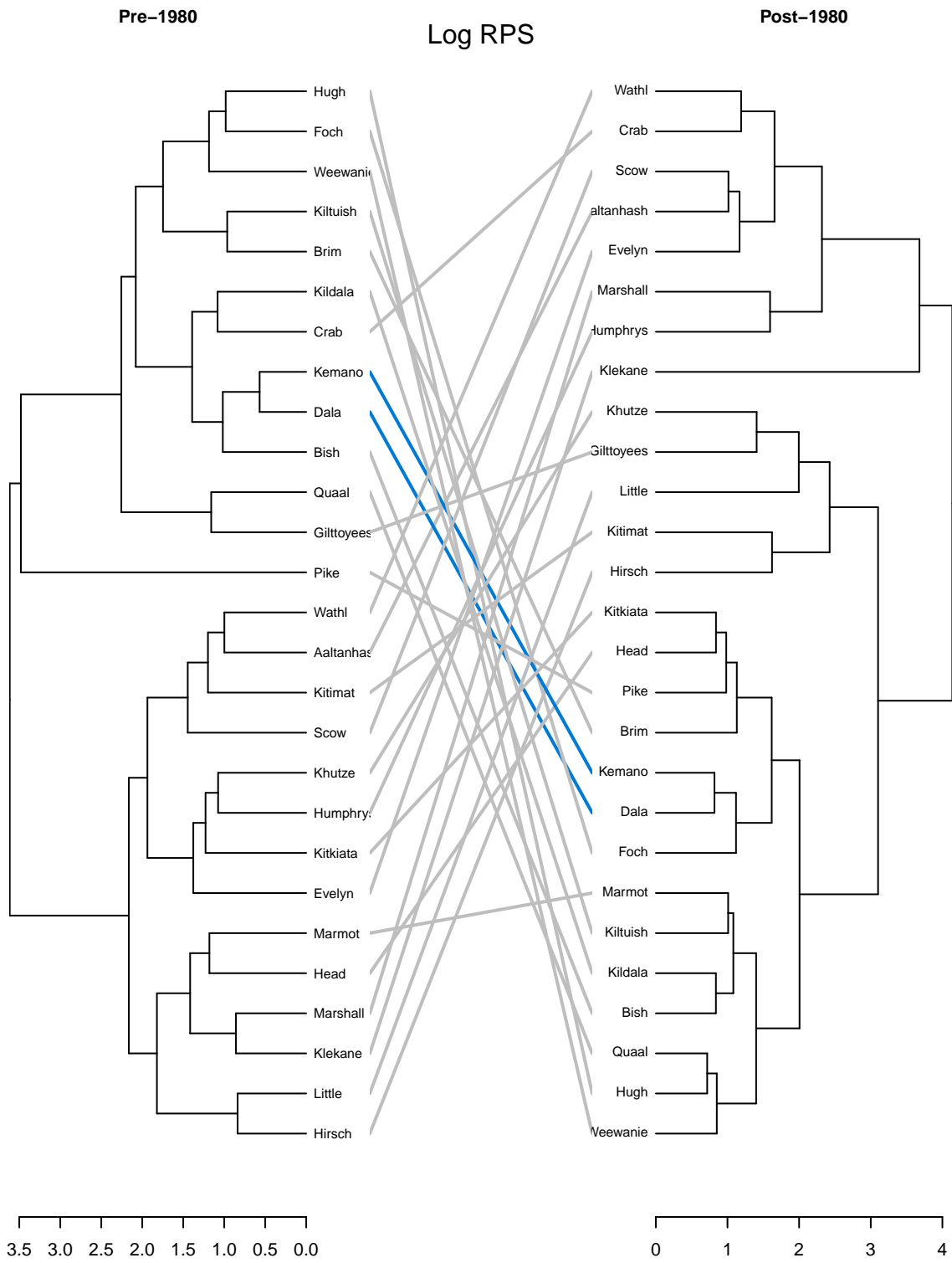


Figure 20: Tanglegram comparing Log RPS pre- and post-enhancement (1980)

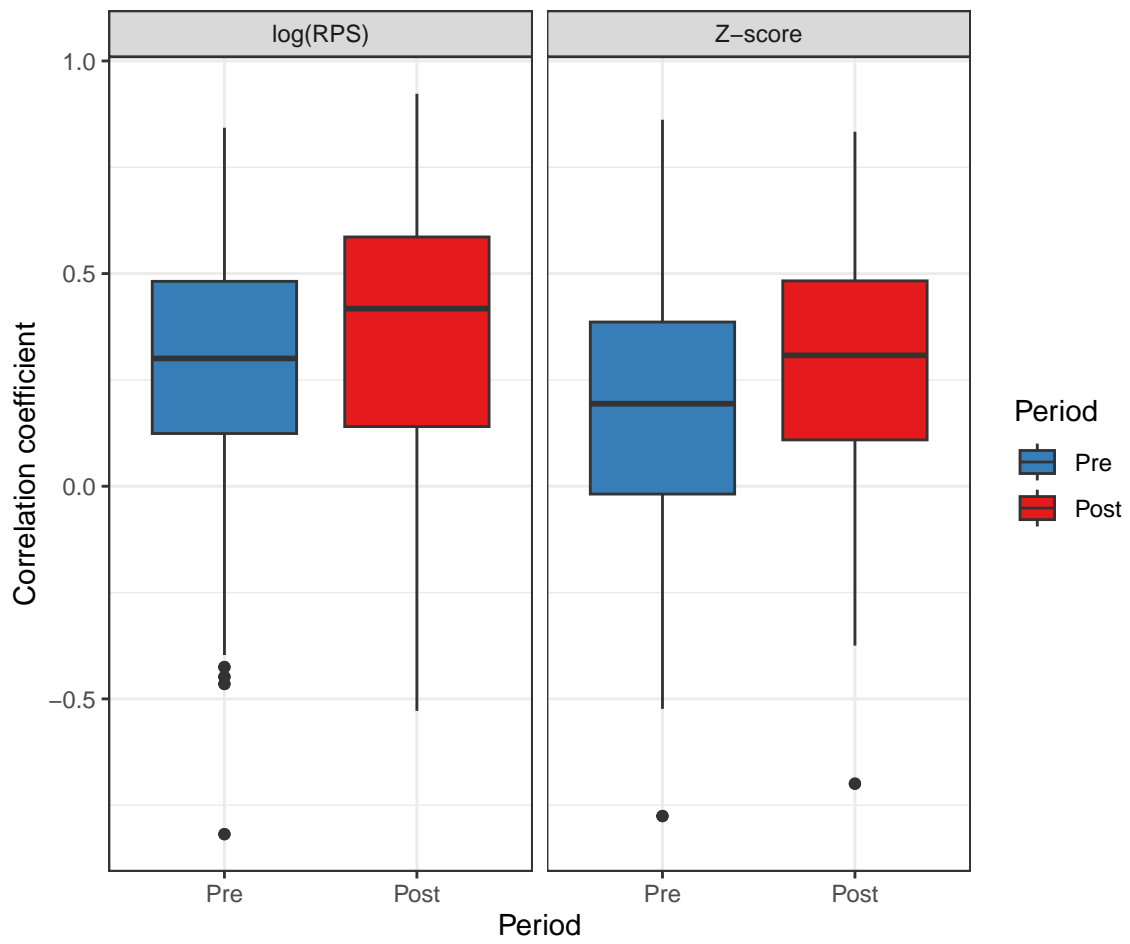


Figure 21: Comparison between correlation coefficients for all pairwise combinations of streams using Z-score and log(RPS) over the pre- and post-1980 periods.

Pairwise stream to stream correlation versus distance

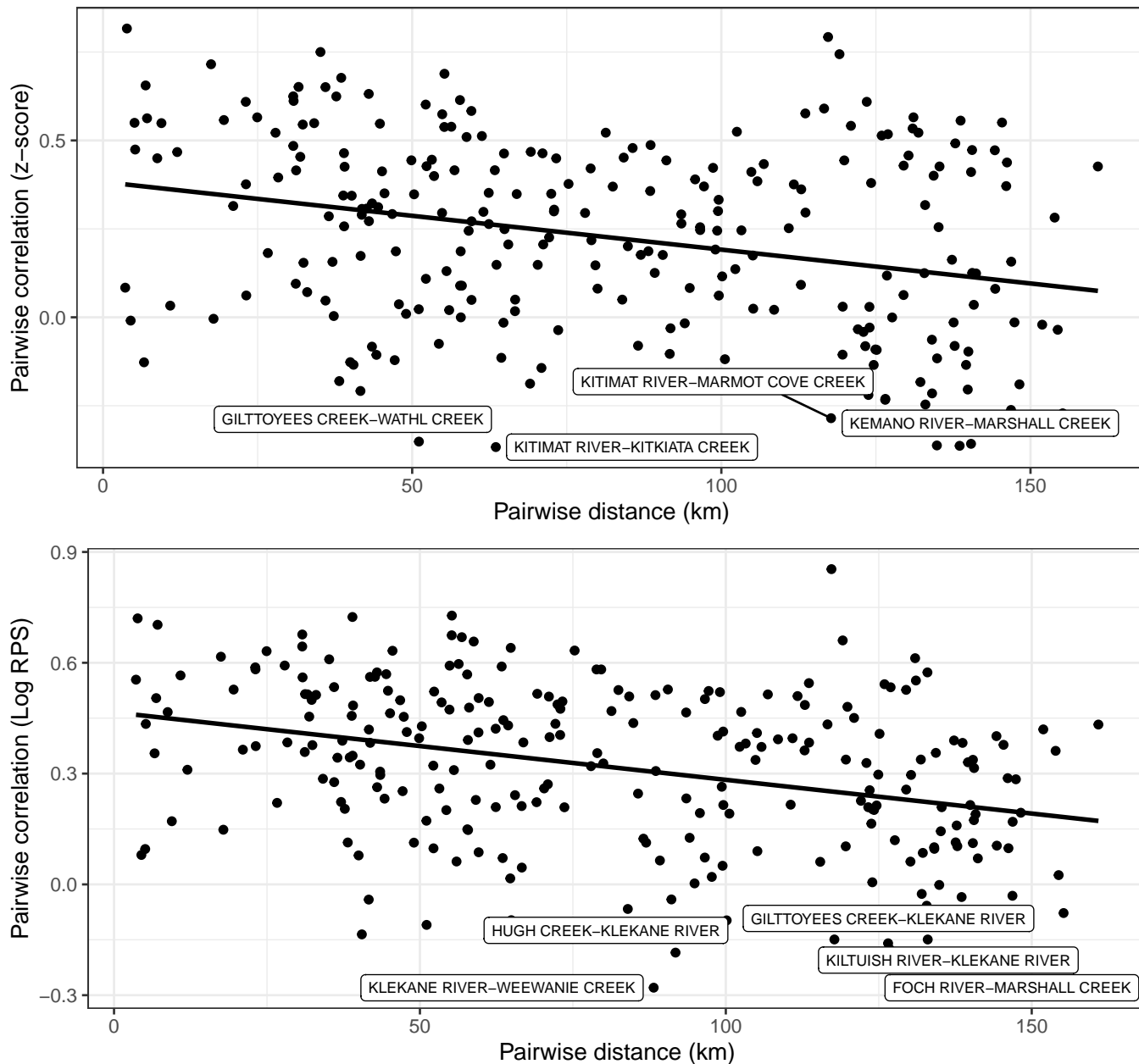


Figure 22: Pairwise stream-stream correlation of Z-score (top) and log(RPS) (bottom) against pairwise distance.

Dendrogram of pairwise distances

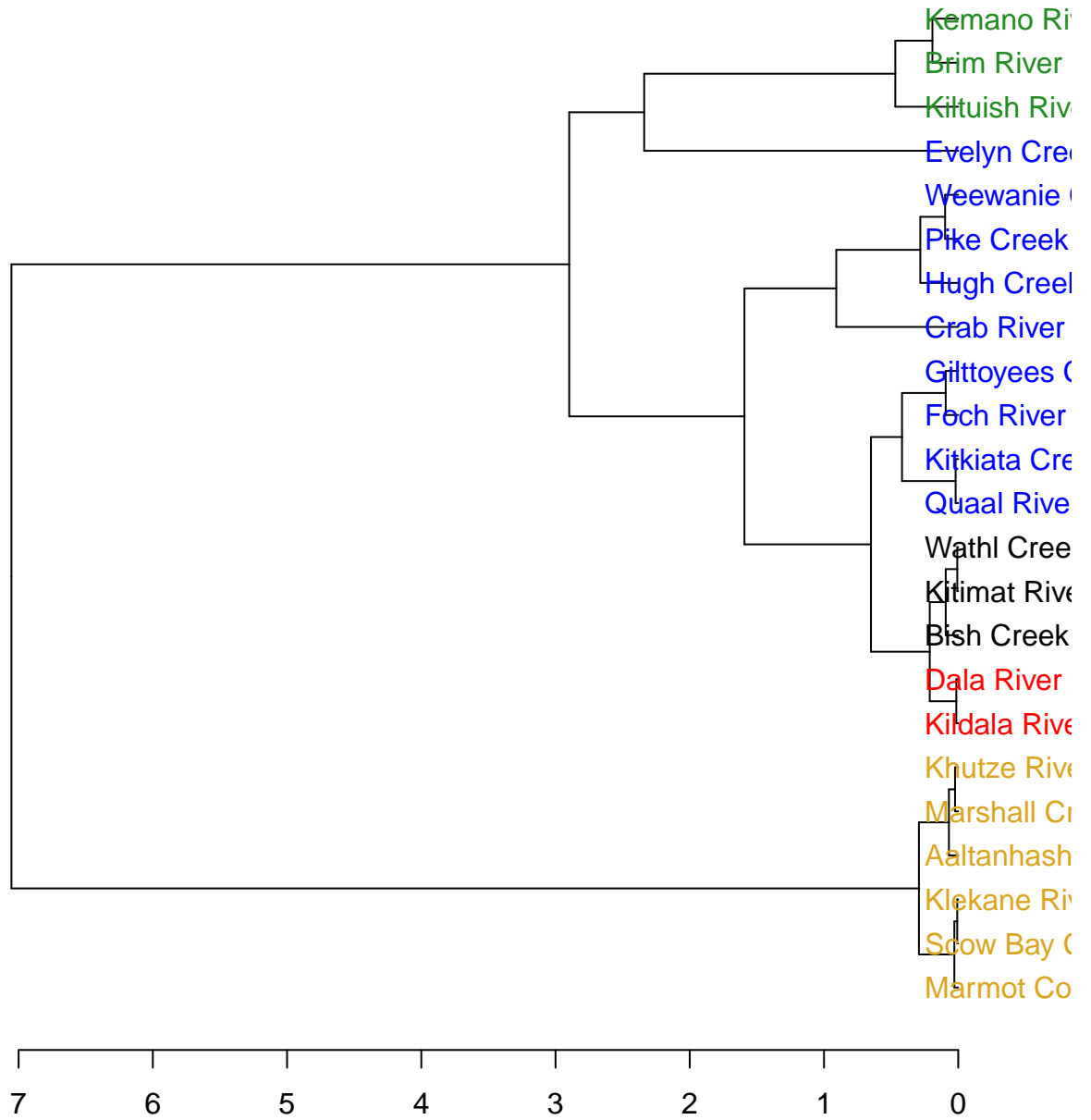


Figure 23: Dendrogram of pairwise distance between river mouths. Red labels - Dala Inlet; Blue - Douglas; Green - Kemano; Yellow - Khutze; Black - Kitimat Arm.

Correlation metrics against distance, pre- and post-1980

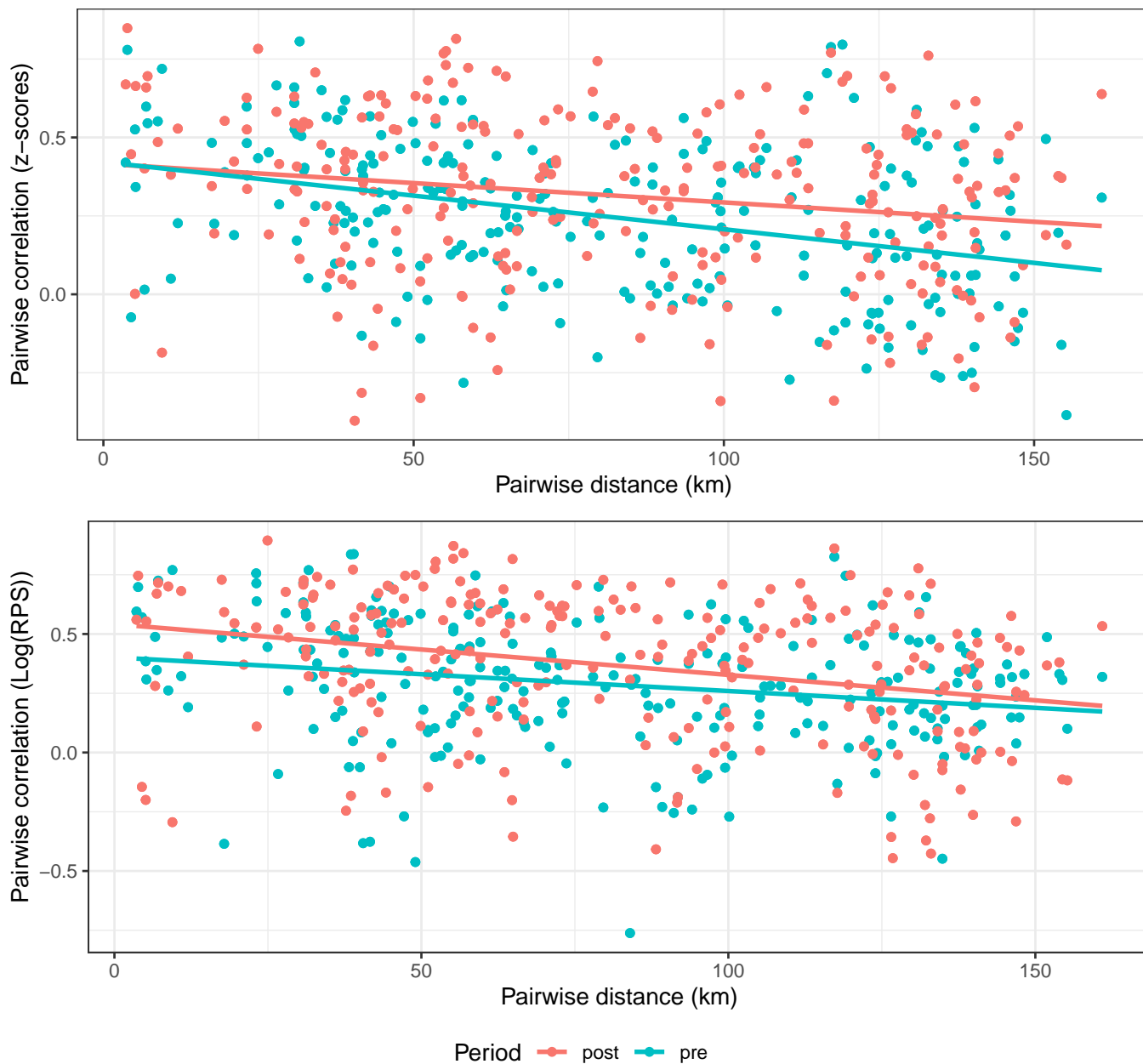


Figure 24: Pairwise stream-stream correlation of Z-score (top) and log(RPS) (bottom) against pairwise distance by period (pre-enhancement and post-enhancement).

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.

Response	Candidate model	df	AIC
log RPS	Log RPS ~ dist + totrel + year	5	4640.250
log RPS	Log RPS ~ dist + totrel	4	4649.087
log RPS	Log RPS ~ dist	3	4674.840
log RPS	Log RPS ~ dist + year	4	4675.224
log RPS	Log RPS ~ totrel + year	4	5207.678
log RPS	Log RPS ~ releases	3	5213.524
log RPS	Log RPS ~ year	3	5237.491

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

Response	Candidate model	df	AIC
log escapement	Log esc ~ dist + year	4	5455.093
log escapement	Log esc ~ dist + totrel + year	5	5457.085
log escapement	Log esc ~ dist + totrel	4	5468.276
log escapement	Log esc ~ dist	3	5478.798
log escapement	Log esc ~ year	3	6220.673
log escapement	Log esc ~ totrel + year	4	6222.325
log escapement	Log esc ~ releases	3	6236.895

Effects plots for top model: $\log(\text{RPS})$

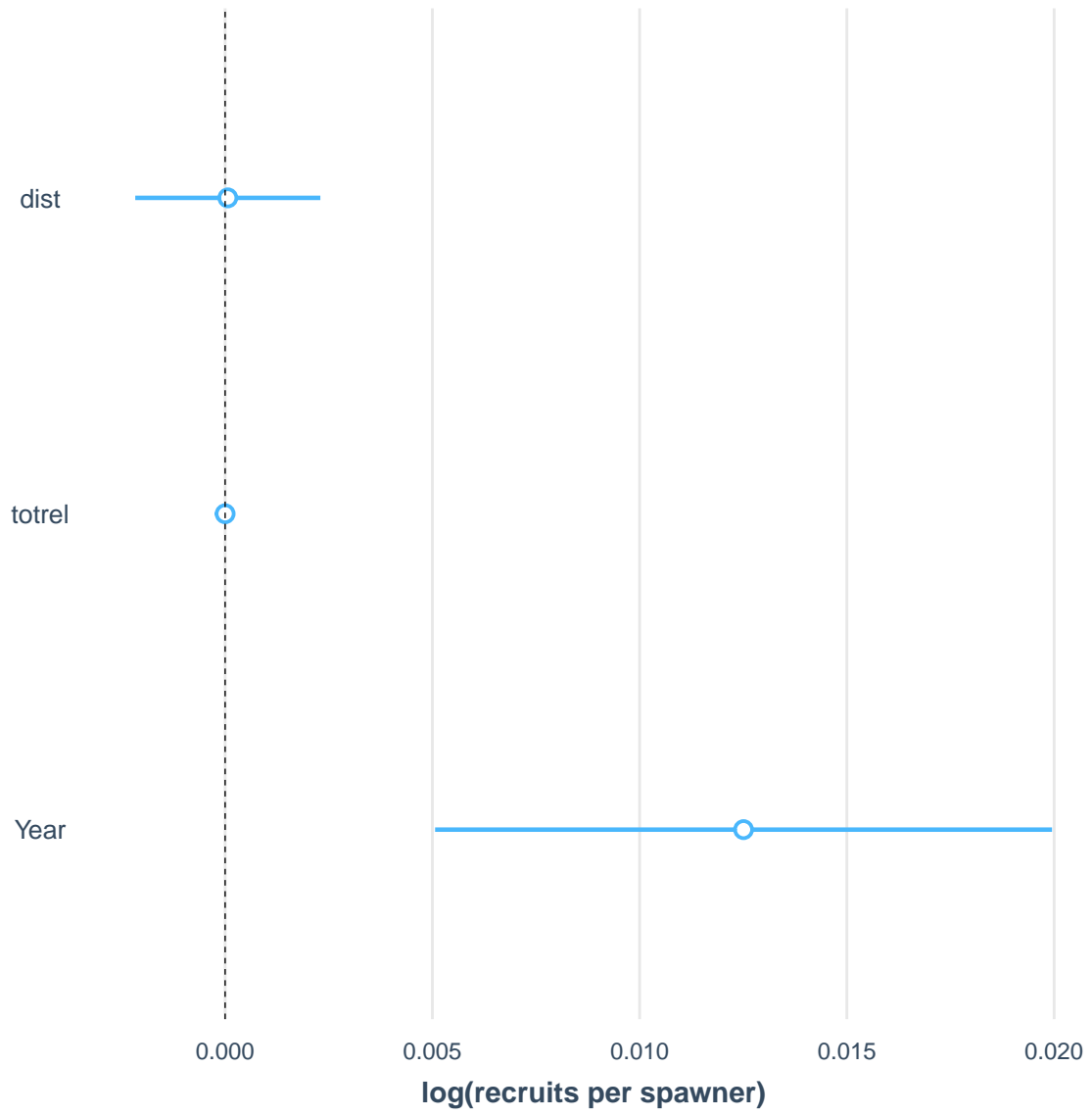


Figure 25: Plot of effects included in the most parsimonious model for $\log(\text{RPS})$.

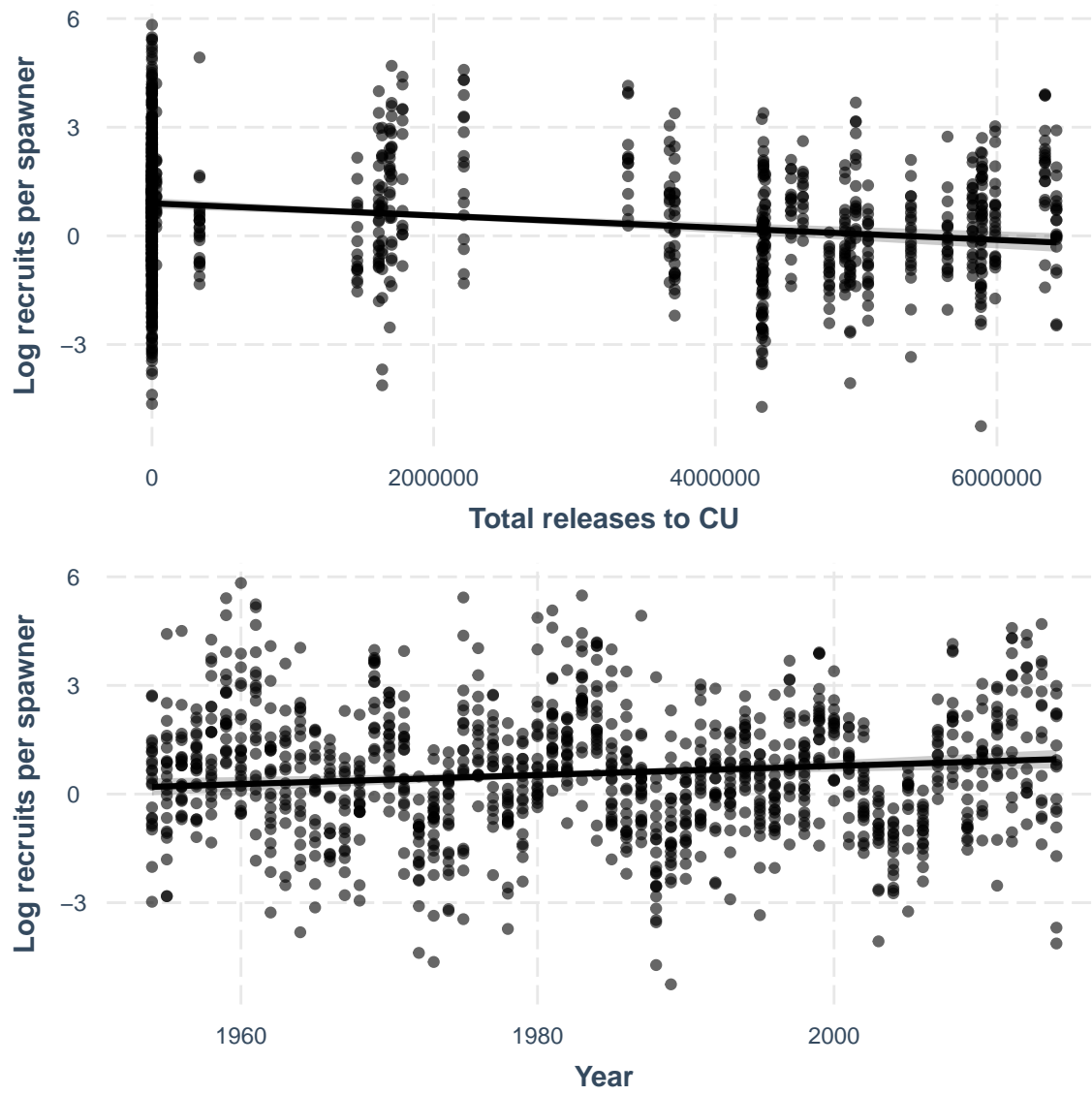


Figure 26: Effects plots of $\log(\text{RPS})$ by releases from Kitimat (top) and year (bottom).

Effects plots for top model: $\log(\text{escapement})$

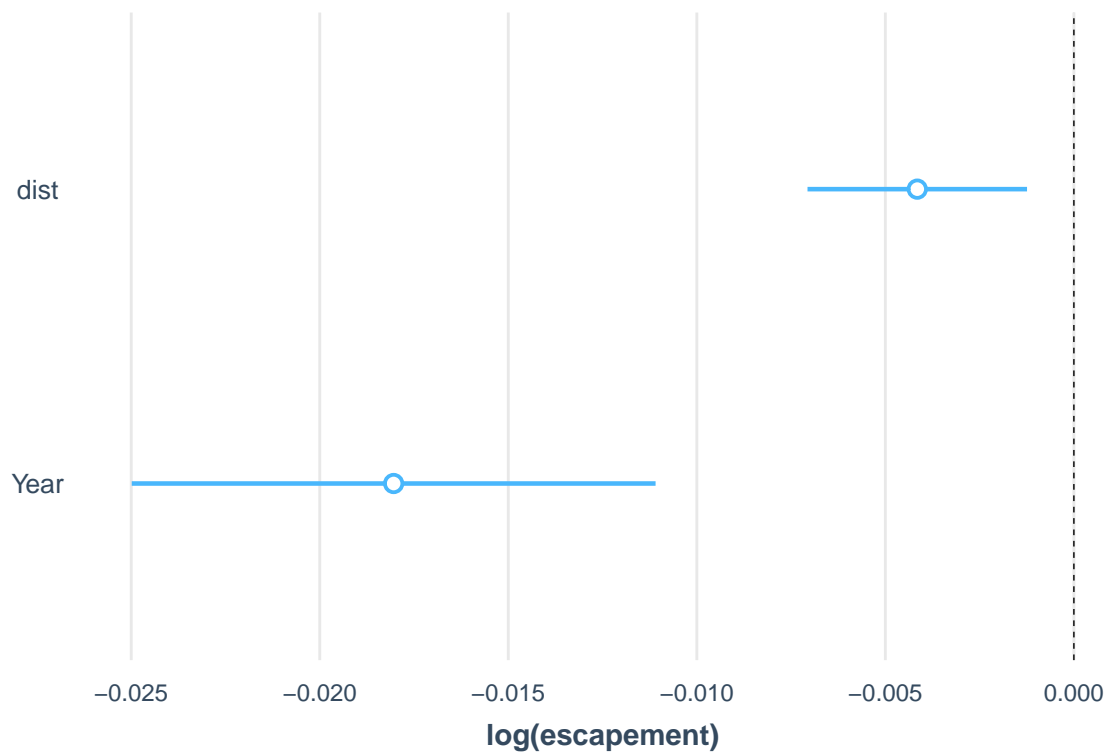


Figure 27: Plot of effects included in the most parsimonious model for $\log(\text{escapement})$.

