NEW JERSEY DIVISION OF
Fish and Wildlife

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Thermal Mitigation: Model Prediction Application

DELAWARE RIVER BASIN COMMISSION, SEF

Multiple Linear Regression

- Approach:
  - Understand relationship between Cannonsville releases and Lordville Maximum Water Temperature (75°F / 77°F) for SEF's given charge.
  - NJDFW
    - Dataset – May 15 – Sept 15, 2008-2018
    - CFS – 0 – 2,000
    - Multiple Linear Regression: R Studio
- Application of MLR:
  - Apply appropriate cfs based on Peter's model (~195 cfs/°C), to days exceeding thresholds under phased and non phased approach

Multiple Linear Regression

	LordTmax
LordTmax	1
LordTavg	0.99
HarvDisch	-0.01
HarvTmax	0.84
HarvTmin	0.79
HarvTavg	0.86
BingTavg	0.71
BingTavglag	0.73
HaleEddyTmax	0.55
HaleEddyTmin	0.07
HaleEdduTavg	0.38
HaleEddyDisch	-0.28
BeaverKTMax	0.85
BeaverKTavg	0.85
BeaverkDisch	-0.08
StilesDisc	-0.23
StilesMaxT	-0.09
StilesAvgT	-0.2
FEddyDisc	-0.09
FEddyMaxT	0.85
FEddyMinT	0.82
FEddyAvgT	0.85
PercSTil	-0.01
StilesDiscL	-0.28

- Rudimentary step-wise regression
  - Adding and subtracting variables based on Pearson correlations and scatterplots to find best model

Model:

```
Call:
lm(formula = Lowest$LordTmax ~ Lowest$HaleEddyDisch + Lowest$FEddyMaxT + Lowest$BingTavglag, data = Lowest)

Residuals:
    Min      1Q  Median      3Q     Max 
-3.9798 -0.6028  0.0847  0.6870  9.2523 

Coefficients:
                      Estimate Std. Error t value Pr(>|t|)    
(Intercept)          7.3554961  0.2986481   24.63   <2e-16 ***
Lowest$HaleEddyDisch -0.0044207  0.0001701  -25.99   <2e-16 ***
Lowest$FEddyMaxT      0.5794512  0.0200101   28.96   <2e-16 ***
Lowest$BingTavglag    0.1732817  0.0156687   11.06   <2e-16 ***
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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.11 on 884 degrees of freedom
Multiple R-squared:  0.8111,	Adjusted R-squared:  0.8105 
F-statistic: 1265 on 3 and 884 DF,  p-value: < 2.2e-16
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$$LordTmax = b_0 - (0.0044207 * HaleEddyDisch) + (0.5794512 * FEddyMaxT) + (0.1732817 * BingTavglag)$$

226 cfs/℃ with 95% confidence interval of 218 to 235

Application of model

- Kolesar Model 1:
  - LordTmax = 4.612 – 0.005118 StilDiscL + 0.8650 FishTavg + 0.02211 BingTavgL
  - 195 cfs/℃ with 95% confidence interval of 187 to 205

Application Assumptions

- Perfect prediction:
  - We know the conditions: avg. water temperature, avg. air temperature, etc.
- Simulated releases:
  - We know exactly how much water to release: given 1 cfs released from the reservoir decreases Lordville water temperature by - 0.005118 ℃
- The only additional releases for thermal mitigation were the ones supplied:
  - 6/9/2008, 7/6/2010, 7/22/2011, 6/20/2012, 7/17/2013, 7/23/2016
- No releases when CFS at Lordville > 2000 CFS assuming diminishing effects

No phase approach < 75 °F

	Simulated Releases	Actual Releases	Total Release needed to mitigate >75°F	Difference between used and bank
2008	3771	592	4363	-1863
2009	899	0	899	1601
2010	3771	543	4314	-1814
2011	430	817	1246	1254
2012	1583	365	1947	553
2013	20	671	690	1810
2014	0	0	0	2500
2015	137	0	137	2363
2016	117	510	628	1872
2017	0	0	0	2500
2018	332	0	332	2168

Phased approach <75°F <77°F

	Simulated Releases	Actual Releases	Total Release needed for phases	Difference between used and bank
2008	1876	592	2468	32
2009	899	0	899	1601
2010	2130	543	2673	-173
2011	156	817	973	1527
2012	567	365	931	1569
2013	0	671	671	1829
2014	0	0	0	2500
2015	137	0	137	2363
2016	0	510	510	1990
2017	0	0	0	2500
2018	117	0	117	2383

* If we dropped phases to <73°F & <75°F it would take more than 2x the water

No phase approach < 73°F

	Simulated Releases	Actual Releases	Total Release needed for phases	Difference between used and bank
2008	9086	592	9678	-7178
2009	2130	0	2130	370
2010	10004	543	10547	-8047
2011	1192	817	2009	491
2012	6292	365	6657	-4157
2013	723	671	1394	1106
2014	274	0	274	2226
2015	1485	0	1485	1015
2016	1837	510	2347	153
2017	176	0	176	2324
2018	2989	0	2989	-489

No phase approach < 68°F

	Simulated Releases	Actual Releases	Total Release needed for phases	Difference between used and bank
2008	36,225	592	36,817	-34,317
2009	10,375	0	10,375	-7,875
2010	36,538	543	37,081	-34,581
2011	10,082	817	10,899	-8,399
2012	40,485	365	40,850	-38,350
2013	7,874	671	8,545	-6,045
2014	5,881	0	5,881	-3,381
2015	10,922	0	10,922	-8,422
2016	27,042	510	27,552	-25,052
2017	12,388	0	12,388	-9,888
2018	18,601	0	18,601	-16,101