

Supplemental material

Analysis of count data with a very high incidence of zeros usually involves a log-linear regression model fit to either zero-inflated Poisson (ZIP) or zero-inflated negative binomial (ZINB) distributions (Ridout et al. 2001). If the count data are overdispersed, zero-inflated negative binomial distribution models are more appropriate (Ridout et al. 2001). To determine which distribution model was best fit to our data we used the SAS GENMOD procedure with a log link function and basin and year as class variables to calculate Pearson Chi-Square (X^2) values for both distribution models. Adequacy of each model fit was assessed by dividing X^2 by the degrees of freedom with scaled X^2 values closer to 1 indicating the best model fit. In all cases, the ZINB distribution provided a better fit (ZINB scaled X^2 basin = 1.08, year = 1.09 versus ZIP scaled X^2 basin = 1.34, year = 1.42).

Table S1. Regression parameter estimates calculated using the log-linear ZINB regression model in SAS GENMOD procedure.

The GENMOD Procedure								
Model Information								
Data Set	WORK.ONE							
Distribution	Zero Inflated Negative Binomial							
Link Function	Log							
Dependent Variable	PCTRepro							
Number of Observations Read 4018								
Number of Observations Used 4018								
Analysis Of Maximum Likelihood Parameter Estimates								
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq	
Intercept	1	2.5458	0.0740	2.4009	2.6908	1184.71	<.0001	
Year	2006	1	0.1971	0.0953	0.0104	0.3839	4.28	0.0386
Year	2007	1	0.3533	0.0901	0.1768	0.5299	15.38	<.0001
Year	2008	1	0.1550	0.1004	-0.0417	0.3517	2.38	0.1226
Year	2009	1	0.4235	0.0879	0.2512	0.5957	23.21	<.0001
Year	2010	1	0.3003	0.0908	0.1223	0.4783	10.93	0.0009
Year	2011	1	0.3589	0.0926	0.1774	0.5404	15.02	0.0001
Year	2012	1	0.3262	0.0879	0.1538	0.4986	13.76	0.0002

Analysis Of Maximum Likelihood Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits	Wald Chi-Square	Pr > ChiSq	
Year	2013	1	0.4438	0.0927	0.2621 0.6255	22.92	<.0001
Year	2014	1	0.2610	0.0995	0.0661 0.4560	6.89	0.0087
Year	2015	1	0.0835	0.1008	-0.1140 0.2810	0.69	0.4074
Year	2016	1	0.1562	0.1045	-0.0485 0.3610	2.24	0.1348
Year	2017	1	0.0142	0.0983	-0.1784 0.2068	0.02	0.8851
Year	2018	1	-0.0466	0.1256	-0.2929 0.1996	0.14	0.7105
Year	2019	0	0.0000	0.0000	0.0000 0.0000	.	.
Dispersion		1	0.2305	0.0118	0.2085 0.2548		

Note: The negative binomial dispersion parameter was estimated by maximum likelihood.

Analysis Of Maximum Likelihood Zero Inflation Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits	Wald Chi-Square	Pr > ChiSq
Intercept	1	0.9227	0.0350	0.8541 0.9913	694.65	<.0001

Analysis Of Maximum Likelihood Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits	Wald Chi-Square	Pr > ChiSq	
Intercept		1	2.9326	0.0449	2.8445 3.0206	4262.81	<.0001
Basin	BAR	1	-0.2329	0.0850	-0.3994 -0.0664	7.51	0.0061
Basin	BLK	1	-0.4980	0.1024	-0.6987 -0.2972	23.63	<.0001
Basin	CAL	1	-0.2458	0.0684	-0.3798 -0.1118	12.93	0.0003
Basin	CRN	1	-0.3886	0.0906	-0.5662 -0.2110	18.39	<.0001
Basin	DUC	1	-0.3883	0.0680	-0.5216 -0.2550	32.59	<.0001
Basin	EAG	1	-0.3880	0.0672	-0.5196 -0.2564	33.38	<.0001
Basin	JON	1	0.0890	0.0805	-0.0688 0.2468	1.22	0.2689
Basin	MAD	1	-0.2007	0.0657	-0.3295 -0.0719	9.33	0.0023
Basin	MAN	1	-0.3363	0.0885	-0.5098 -0.1628	14.44	0.0001

Analysis Of Maximum Likelihood Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq	
Basin	RAN	1	0.3721	0.0643	0.2460	0.4983	33.46	<.0001
Basin	RKB	1	-0.0439	0.0625	-0.1664	0.0785	0.49	0.4822
Basin	TWN	1	-0.1209	0.0660	-0.2502	0.0085	3.35	0.0670
Basin	WHP	0	0.0000	0.0000	0.0000	0.0000	.	.
Dispersion		1	0.1967	0.0104	0.1774	0.2182		

Note: The negative binomial dispersion parameter was estimated by maximum likelihood.

Analysis Of Maximum Likelihood Zero Inflation Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	0.9232	0.0350	0.8546	0.9918	695.68	<.0001

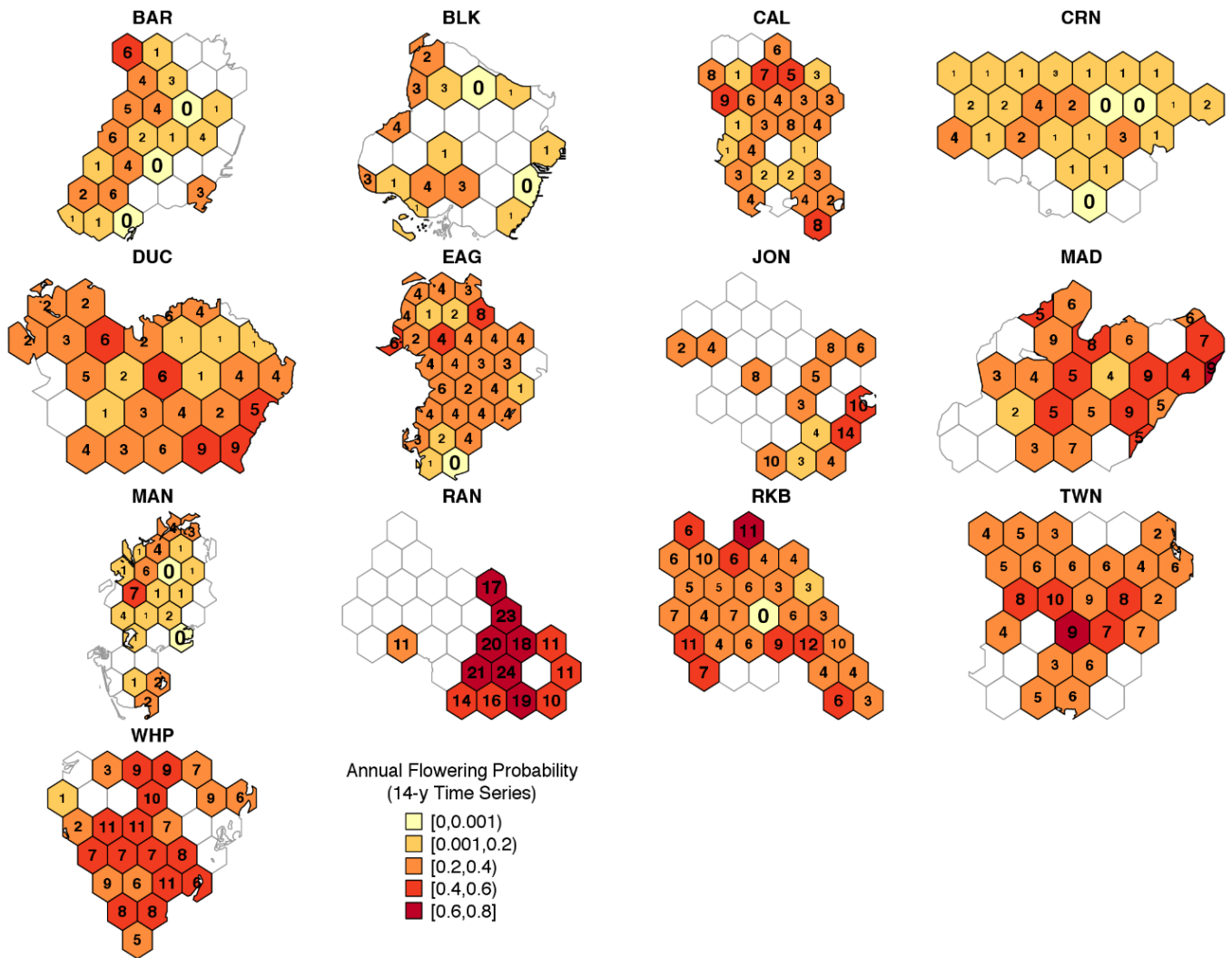


Figure S1. The flowering probability (i.e., at least one reproductive shoot at a site) of each hexagon in the Fisheries Habitat Assessment Program (FHAP), estimated from annual (May) sampling 2006-2019. Numbers show the mean percentage of reproductive shoots per flowering event scaled to the inverse of its coefficient of variation (CV).

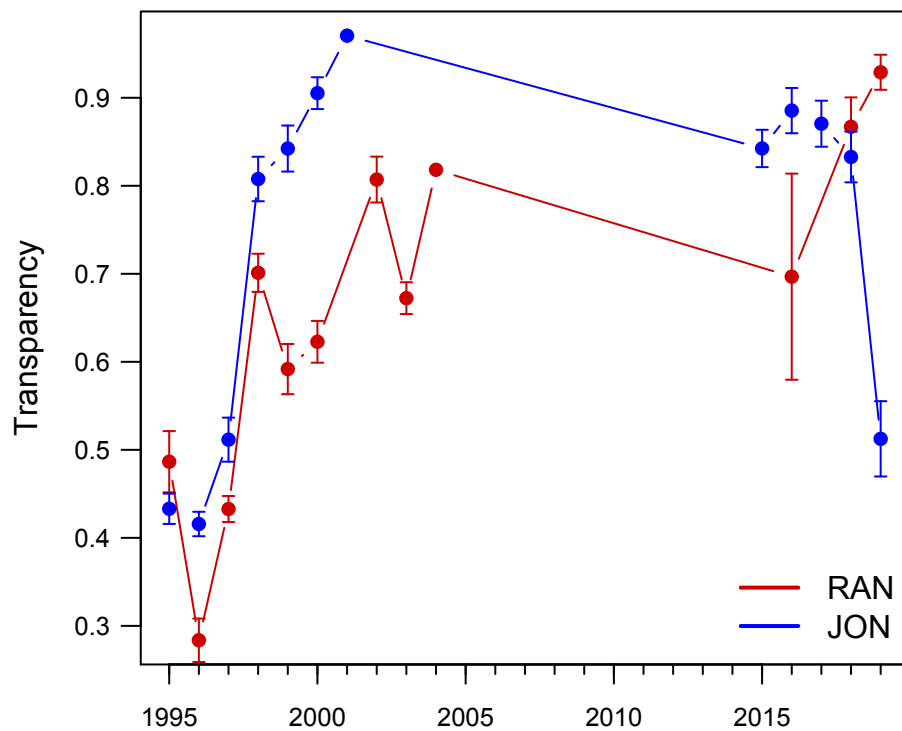


Figure S2. Basin-level mean (\pm se) water transparency (Secchi depth/water depth) during FHAP sampling in Rankin Lake (RAN; red) and Johnson Key (JON; blue) basins during May 1995-2019.