Manuscript JEMA-D-16-01438R1 – Supplemental Data: Ecological network development

Ecopath Inputs

Basic inputs

Ecopath requires three of the following four categories to be entered for each species or functional group: biomass (t/km^2), P/B (t/km^2/year), Q/B (t/km^2/year), and EE. The production/biomass (P/B) ratio is the equivalent to the total mortality rate (Z) (Allen 1971, Merz and Myers 1998) and includes the quantity harvested by fishing (F), predation (M2), net migration (NM), biomass accumulation (BA), and other mortality (M0) (Eq. S-1):

(Eq. S-1) $$P/B = Z = F + M2 + NM + BA + M0.$$

The consumption/biomass ratios are only entered for secondary consumers; this value cannot be entered for primary producers (Pauly et al. 2000). The ecotrophic efficiency (EE) is a unit-less value representing the amount of production that is used or harvested from the system (Pauly et al. 2000). This value cannot be directly measured but varies between 0 and 1, and (1 – EE) provides the "other mortality" value. By providing three of these values, the fourth can be calculated by the software, using the following generalized formula: Production = Catch + biomass accumulation + predation mortality + net migration + other mortality.

This predation mortality term is the parameter that links all of the groups to one another (Pauly et al. 2000). Additional inputs include the proportion of the model area where a species occurs. For example, rooted macrophytes are limited to the photic zone of a lake or reservoir, so this may only be one-third of the total surface area, in which you would enter 0.334 for that species. The production/consumption (P/Q) ratio can be entered if either P/B or Q/B inputs are left blank. In the current analysis, all P/Q values were calculated by the software and not used as inputs in any of the models.

The values for unassimilated consumption were attained from the literature and varied from 0.15 to 0.40, depending on the species or functional group. The default value of 0.2 (Winberg 1956) was used when no estimate from the literature could be found. It was assumed there was detritus import to the system based on the nature of the reservoirs as "flood-control" reservoirs; it is realistic to assume both detritus and sediment are loaded into the system, particularly after precipitation events. An example of the basic input data for the initial Ecopath models can be found in Table S-1.

Diet composition

A diet composition matrix was compiled and included all species or groups used in each model. Quantification of diet composition is difficult, so these values were adjusted during the process of balancing each model. The diet for each predator group summed to 1, with the awareness that species or functional groups excluded from the current model may be included in a predator's diet under natural circumstances. If it is believed these non-included groups are particularly important to a diet, a proportion value was entered in the "import" row for that species. This is one of the problems of modeling open systems where it is not practical to include everything. One example of this is the inclusion of terrestrial insects in the diets of fish like largemouth bass. While terrestrial insects were not included in any of our models, we could account for their importance by including a percentage in the "input" category for the largemouth bass diets. An example of a diet composition matrix for one reservoir (Conestoga Lake) can be found in Table S-2.

Other production

Immigration and emigration rates were kept at zero for these initial models. The lakes are not naturally connected, so there is little chance fish are able to move between lakes during natural weather conditions (we ignored the influence of floods in the current research). Biomass accumulation is only possible to estimate when we have more than one biomass estimate for a given species or group. As we relied on single estimate values, we do not include accumulation values; however, with additional site-specific data collection, this would be possible in future adaptations of the model.

Fishery

Estimates for catch, harvest, and discard rates were gathered from Martin (2013), as part of the Nebraska state creel project. These values were assumed constant over time, because they represent a "snapshot" of the fishery and we do not have long-term data at this time. However, because the creel project is ongoing, it will be possible to include varying fishery information in future adaptations of the model. All fishing effort in the Salt Valley is recreational rather than commercial, so no values were placed on the recreational fishery regarding market price and profits. The fishery information used in the development of the initial Ecopath models can be found in Table S-3.

Pedigree

The input information was collected from a variety of sources with varying degrees of confidence. We used the pedigree function in Ecopath to estimate the overall confidence of the data for each reservoir. Pedigree information can be used for identifying where future research would be most beneficial when trying to improve these models.

Initial Ecopath Model Outputs

Tables and flow matrices

Once a mass-balanced model has been achieved, Ecopath provides a number of output materials. The first is a summary of the table of input values, including the results of the values calculated by the software (Table S-4). Next is a table with the total flows to detritus (t/km^2/year), the net efficiency, and the omnivory index for each species or functional group (Table S-5), followed by a table that outlines types of mortality for each group included in the model and a matrix clarifying mortality rates for all predator/prey relationships (Table S-6).

Perhaps most importantly, Ecopath also provides an energy-flow matrix depicting total flows between each predator/prey combination, as well as flows to detritus (Table S-7), and it calculates a table outlining respiration and assimilation values for each species or functional group, as well as respiration/assimilation, production/respiration, and respiration/biomass ratios for each compartment (Table S-8).

Flow diagrams and model statistics

To visually understand the characteristics of the model, a flow diagram is produced for each, in which nodes represent each compartment and weighted links indicate how much energy is flowing between these compartments. The nodes placement in relation to the y-axis signals the calculated trophic level for that compartment, and the size of the node represents the species or functional group’s biomass in the system (Figure S-1).

A table of important model statistics includes total values for consumption, exports, respiration, production, flows to detritus, as well as total system throughput for each reservoir as a whole. It also includes important comparative information, including ratios, net system production, and connectivity values (Table S-9).

Network analysis

The network analysis tool provides a way to analyze each model in terms of flows among trophic levels. Whereas the initial results described provide information for individual compartments, this aggregation by trophic level is important because species may be have different calculated trophic levels depending on each reservoir's specific biotic composition. This type of aggregation allows a different type of comparison between different reservoirs. Absolute flows broken down by trophic levels are shown in Table S-10, and Table S-11 shows the total consumption, export, respiration, flow to detritus, and total throughput aggregated by each trophic level. To help visualize how the flows in Table S-11 are distributed by each trophic level, Lindeman spines are also developed by the software (Figure S-2). Mixed trophic impact matrices elucidate indirect effects species or functional groups have on one another (Figure S-3).

Transfer efficiency is an important metric in network analysis. The transfer efficiency is the ratio of the energy consumed by one trophic level to the amount of energy that is successfully transferred to the next highest trophic level (Pauly et al. 2000) (Table S-12). Additional metrics included in the network analysis output are keystoneness of each compartment (Table S-13), ascendancy, and information on the number of cycles and pathways present in each food web (Table S-14). Two keystone indices are given. The first is the keystone index, represented by $KSi = \log [\varepsilon i \ (1-pi)]$, over the relative total impact (Libralato et al. 2006). The second keystone index is the keystone index, represented by $KSi = \log [\varepsilon i * 1/pi]$, over the relative total impact (Power et al. 1996).

Secondary Ecopath Model Outputs

Outputs from the secondary Ecopath models were similar to those generated from the initial Ecopath models, allowing efficient side-by-side comparisons. Conestoga Lake was used in all of the following tables and figures for consistency, but each procedure was completed for each of the 19 lakes and was completed multiple times, based on the type of model being analyzed.

References

Allen, K.R. 1971. Relation between production and biomass. Journal of the Fisheries Research Board of Canada 28:1573-1581.

Libralato, S., V. Christensen, and D. Pauly. 2006. A method for identifying keystone species in food web models. Ecological Modelling 195:153-171.

Martin, D.R. 2013. Spatial and temporal participation in recreational fishing. University of Nebraska-Lincoln, PhD Dissertation.

Merz, G., and R.A. Myers. 1998. A simplified formulation for fish production. Canadian Journal of Fisheries and Aquatic Sciences 55: 478-484.

Pauly, D., V. Christensen, and C. Walters. 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. ICES Journal of Marine Science: Journal du Conseil 57:697-706.

Power, M.E., D. Tilman, J.A. Estes, B.A. Menge, W.J. Bond, L.S. Mills, G. Daily, J.C. Castilla, J. Lubchenco, and R.T. Paine. 1996. Challenges in the quest for keystones. Bioscience 46:609-620.

Winberg, G.G. 1956. Rate of metabolism and food requirements of fishes. Fisheries Research Board of Canada, Translation Series No. 194 (from Intensivnost obmena i pischevye petrebrosti ryb. Nauchnye Trudy Belorusskovo Gosudarstvennovo Universiteta imeni V.I. Lenina, Minsk).

Table S-1. The input data table for Conestoga Lake. Known values are entered and all blank values (depicted with ".") are calculated by the software.

Group name	Biomass in habitat area (t/km^2)	Production/ biomass (/year)	Consumption/ biomass (/year)	Ecotrophic efficiency	Other mortality	Production/ consumption	Unassimil./ consumption	Detritus import (t/km^2/year)
Predatory birds	0.0100	0.30	5.00	.	.	.	0.20	.
Walleye	0.4000	0.90	6.00	.	.	.	0.20	.
Largemouth Bass	1.1000	2.00	6.00	.	.	.	0.20	.
Channel Catfish	1.3500	2.20	8.00	.	.	.	0.20	.
Crappie	0.5000	3.00	8.00	.	.	.	0.20	.
Bluegill	0.6000	3.20	8.00	.	.	.	0.20	.
Freshwater Drum	0.5000	1.00	3.52	.	.	.	0.20	.
Flathead Catfish	0.6000	1.00	3.60	.	.	.	0.20	.
Common Carp	1.4000	3.00	8.00	.	.	.	0.20	.
Chinese Mystery Snail	0.0003	3.00	10.00	.	.	.	0.20	.
Benthic Macroinvertebrates	.	35.00	120.00	0.90	.	.	0.25	.
Copepods	.	20.00	100.00	0.95	.	.	0.30	.
Cladocerans	.	20.00	100.00	0.95	.	.	0.30	.
Autotrophs	.	250.00	.	0.99	.	.	0.00	.
Detritus	2.0000	.	.	.	.	.	0.20	2.00
Sediment	5.0000	.	.	.	.	.	0.00	1.00

Table S-2. The input diet composition matrix for Conestoga Lake. Columns represent predators and rows represent prey. Each column sums to one, indicating 100% of that predator’s diet.

	Prey (down)\ predator (across)	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Predatory birds	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Walleye	0.050	0.05	0	0	0	0	0	0	0	0	0	0	0
3	Largemouth Bass	0.050	0.05	0.05	0.050	0	0	0	0	0	0	0	0	0
4	Channel Catfish	0.005	0	0	0	0	0	0	0	0	0	0	0	0
5	Crappie	0.050	0.05	0.05	0.050	0	0	0	0	0	0	0	0	0
6	Bluegill	0.050	0.05	0.05	0.050	0.05	0	0	0	0	0	0	0	0
7	Freshwater Drum	0	0.05	0	0	0	0	0	0	0	0	0	0	0
8	Flathead Catfish	0	0	0	0.050	0	0	0	0	0	0	0	0	0
9	Common Carp	0	0	0	0.001	0	0	0	0	0	0	0	0	0
10	Chinese Mystery Snail	0.001	0	0	0	0	0	0	0	0	0	0	0	0
11	Benthic Macroinvertebrates	0.250	0.40	0.30	0.300	0.30	0.30	0.80	0.4	0.4	0	0	0	0
12	Copepods	0.100	0.05	0.10	0	0.20	0.30	0	0	0	0.3	0	0	0
13	Cladocerans	0.100	0.05	0.10	0	0.20	0.30	0	0	0	0.3	0	0	0
14	Autotrophs	0.250	0.10	0.10	0.200	0.05	0.05	0	0.2	0.3	0.3	0.60	1	1
15	Detritus	0	0	0.10	0.100	0	0.05	0.10	0.2	0.2	0.1	0.25	0	0
16	Sediment	0	0	0	0	0	0	0.05	0.1	0.1	0	0.1	0	0
17	Import	0.094	0.15	0.15	0.199	0.20	0	0.05	0.1	0	0	0.05	0	0
18	Sum	1	1	1	1	1	1	1	1	1	1	1	1	1

Table S-3. Fishery information used for Conestoga Lake. Discards are fish that were caught and then released. Landings are fish that were caught and harvested. Fishing data are from Martin (2013).

Group name	Discards (t/km²)	Landings (t/km^2)
Predatory birds	0	0
Walleye	0	0
Largemouth Bass	0.237	0.011
Channel Catfish	2.475	0.431
Crappie	0	0
Bluegill	0.293	0.0447
Freshwater Drum	0	0
Flathead Catfish	0	0
Common Carp	3.631	0.557
Chinese Mystery Snail	0	0
Benthic Macroinvertebrates	0	0
Copepods	0	0
Cladocerans	0	0
Autotrophs	0	0
Detritus	0	0
Sediment	0	0
Sum	6.636	1.0437

Table S-4. The basic-estimates output table for Conestoga Lake. Bolded values were calculated by the software.

Group name	Trophic level	Biomass in habitat area (t/km²)	Biomass (t/km²)	Production/ biomass (/year)	Consumption/ biomass (/year)	Ecotrophic efficiency	Production/ consumption
Predatory birds	**2.95**	0.0100	0.0100	0.3	5.00	**0.00**	**0.06**
Walleye	**3.14**	0.4000	0.4000	0.9	6.00	**0.34**	**0.15**
Largemouth Bass	**2.90**	1.1000	1.1000	2.0	6.00	**0.56**	**0.33**
Channel Catfish	**2.83**	1.3500	1.3500	2.2	8.00	**0.98**	**0.28**
Crappie	**2.99**	0.5000	0.5000	3.0	8.00	**0.66**	**0.38**
Bluegill	**2.90**	0.6000	0.6000	3.2	8.00	**0.80**	**0.40**
Freshwater Drum	**2.84**	0.5000	0.5000	1.0	3.52	**0.24**	**0.28**
Flathead Catfish	**2.44**	0.6000	0.6000	1.0	3.60	**0.90**	**0.28**
Common Carp	**2.40**	1.4000	1.4000	3.0	8.00	**1.00**	**0.38**
Chinese Mystery Snail	**2.60**	0.0003	0.0003	3.0	10.00	**0.06**	**0.30**
Benthic Macroinvertebrates	**2.00**	**0.4947**	**0.4947**	35.0	120.00	0.90	**0.29**
Copepods	**2.00**	**0.1593**	**0.1593**	20.0	100.00	0.95	**0.20**
Cladocerans	**2.00**	**0.1593**	**0.1593**	20.0	100.00	0.95	**0.20**
Autotrophs	**1.00**	**0.3021**	**0.3021**	250.0		0.99	
Detritus	**1.00**	2.0000	2.0000			**0.90**	
Sediment	**1.00**	1.0000	5.0000				

Table S-5. Key indices output for Conestoga Lake.

	Group name	Biomass accumulation (t/km²/year)	Biomass accumulation rate (/year)	Net migration (t/km²/year)	Flow to detritus (t/km²/year)	Net efficiency	Omnivory index
1	Predatory birds				0.003	0.075	0.477
2	Walleye				0.718	0.188	0.397
3	Largemouth Bass				2.280	0.417	0.398
4	Channel Catfish				2.224	0.344	0.523
5	Crappie				1.308	0.469	0.218
6	Bluegill				1.350	0.500	0.090
7	Freshwater Drum				0.732	0.355	0.134
8	Flathead Catfish				0.492	0.347	0.241
9	Common Carp				2.241	0.469	0.240
10	Chinese Mystery Snail				0.001	0.375	0.240
11	Benthic Macroinvertebrates				16.574	0.389	0.002
12	Copepods				4.937	0.286	
13	Cladocerans				4.937	0.286	
14	Autotrophs				0.755		
15	Detritus	1.083	0.541	-2.000			0.570
16	Sediment			-1.000			0.152

Table S-6. Output table outlining different mortality rates for each species/functional group within Conestoga Lake.

Group name	Production/ biomass (Z)	Fishing mortality rate	Predation mortality rate (/year)	Other mortality rate (/year)	Fishing mortality/ total mortality	Proportion natural mortality
Predatory birds	0.30			0.30	0.00	1.00
Walleye	0.90		0.31	0.59	0.00	1.00
Largemouth Bass	2.00	0.23	0.90	0.87	0.11	0.89
Channel Catfish	2.20	2.15	0.00	0.05	0.98	0.02
Crappie	3.00		1.99	1.02	0.00	1.00
Bluegill	3.20	0.56	1.99	0.65	0.18	0.82
Freshwater Drum	1.00		0.24	0.76	0.00	1.00
Flathead Catfish	1.00		0.90	0.10	0.00	1.00
Common Carp	3.00	2.99	0.01	0.00	1.00	0.00
Chinese Mystery Snail	3.00		0.17	2.83	0.00	1.00
Benthic Macroinvertebrates	35.00		31.50	3.50	0.00	1.00
Copepods	20.00		19.00	1.00	0.00	1.00
Cladocerans	20.00		19.00	1.00	0.00	1.00
Autotrophs	250.00		247.50	2.50	0.00	1.00

Table S-7. Output table illustrating energy flow values between predator and prey groups in Conestoga Lake. Predators are in columns and prey are in rows.

	Prey \ predator	1	2	3	4	5	6	7	8	9	10	11	12	13	15	16
1	Predatory birds														0.00	
2	Walleye	0.00250	0.12												0.36	0.36
3	Largemouth Bass	0.00250	0.12	0.33	0.54										1.14	1.14
4	Channel Catfish	0.00025													1.11	1.11
5	Crappie	0.00250	0.12	0.33	0.54										0.65	0.65
6	Bluegill	0.00250	0.12	0.33	0.54	0.20									0.67	0.67
7	Freshwater Drum		0.12												0.37	0.37
8	Flathead Catfish				0.54										0.25	0.25
9	Common Carp				0.01										1.12	1.12
10	Chinese Mystery Snail	0.00005													0.00	0.00
11	Benthic Macroinvertebrates	0.01250	0.96	1.98	3.24	1.20	1.44	1.41	0.86	4.48					4.97	11.60
12	Copepods	0.00500	0.12	0.66		0.80	1.44				0.00				1.48	3.46
13	Cladocerans	0.00500	0.12	0.66		0.80	1.44				0.00				1.48	3.46
14	Autotrophs	0.01250	0.24	0.66	2.16	0.20	0.24		0.43	3.36	0.00	35.62	15.93	15.93	0.45	0.30
15	Detritus			0.66	1.08		0.24	0.18	0.43	2.24	0.00	14.84				
16	Sediment							0.09	0.22	1.12		5.94				
17	Import	0.00470	0.36	0.99	2.15	0.80	0.00	0.09	0.22	0.00	0.00	2.97	0.00	0.00	0.00	0.00
18	Sum	0.05000	2.40	6.60	10.80	4.00	4.80	1.76	2.16	11.20	0.00	59.37	15.93	15.93	14.06	24.49

Table S-8. Respiration and assimilation output table for Conestoga Lake.

Group name	Respiration (t/km²/year)	Assimilation (t/km²/year)	Respiration/ assimilation	Production/ respiration	Respiration/ biomass (/year)
Predatory birds	0.04	0.04	0.93	0.08	3.70
Walleye	1.56	1.92	0.81	0.23	3.90
Largemouth Bass	3.08	5.28	0.58	0.71	2.80
Channel Catfish	5.67	8.64	0.66	0.52	4.20
Crappie	1.70	3.20	0.53	0.88	3.40
Bluegill	1.92	3.84	0.50	1.00	3.20
Freshwater Drum	0.91	1.41	0.64	0.55	1.82
Flathead Catfish	1.13	1.73	0.65	0.53	1.88
Common Carp	4.76	8.96	0.53	0.88	3.40
Chinese Mystery Snail	0.00	0.00	0.63	0.60	5.00
Benthic Macroinvertebrates	27.21	44.53	0.61	0.64	55.00
Copepods	7.96	11.15	0.71	0.40	50.00
Cladocerans	7.96	11.15	0.71	0.40	50.00
Autotrophs					
Detritus					
Sediment					

Table S-9. Network statistics output table for Conestoga Lake.

Parameter	Value	Units
Sum of all consumption	134.994	$t/km^2/year$
Sum of all exports	27.753	$t/km^2/year$
Sum of all respiratory flows	63.901	$t/km^2/year$
Sum of all flows into detritus	48.187	$t/km^2/year$
Total system throughput	274.835	$t/km^2/year$
Sum of all production	113.474	$t/km^2/year$
Mean trophic level of the catch	2.600	
Gross efficiency (catch/net p.p.)	0.102	
Calculated total net primary production	75.534	$t/km^2/year$
Total primary production/total respiration	1.182	
Net system production	11.633	$t/km^2/year$
Total primary production/total biomass	9.971	
Total biomass/total throughput	0.028	/year
Total biomass (excluding detritus)	7.576	t/km^2
Total catch	7.680	$t/km^2/year$
Connectance Index	0.332	
System Omnivory Index	0.204	

Table S-10. Absolute flows (output table) separated by trophic level for Conestoga Lake. Units for all values are in t/km^2/year.

Group name / Trophic level	I	II	III	IV	V	VI	VII
Predatory birds	0	0.01	0.02	0.01	0.00	0.00	0
Walleye	0	0.32	1.61	0.45	0.02	0.00	0
Largemouth Bass	0	1.71	4.20	0.67	0.02	0	0
Channel Catfish	0	4.27	4.68	1.77	0.09	0.00	0
Crappie	0	0.26	3.52	0.23	0	0	0
Bluegill	0	0.49	4.31	0	0	0	0
Freshwater Drum	0	0.29	1.47	0	0	0	0
Flathead Catfish	0	1.23	0.93	0	0	0	0
Common Carp	0	6.86	4.34	0	0	0	0
Chinese Mystery Snail	0	0.00	0.00	0	0	0	0
Benthic Macroinvertebrates	0	59.37	0	0	0	0	0
Copepods	0	15.93	0	0	0	0	0
Cladocerans	0	15.93	0	0	0	0	0
Autotrophs	75.53	0	0	0	0	0	0
Detritus	20.75	0	0	0	0	0	0
Sediment	26.35	0	0	0	0	0	0
Total	122.60	106.60	25.09	3.12	0.13	0.00	0

Table S-11. Total import, consumption, export, flow to detritus, respiration, and production flow values separated by trophic level for Conestoga Lake. Units for all values are in t/km^2/year.

Trophic level/ Flow	Import	Consumption by predators	Export	Flow to detritus	Respiration	Throughput
VII		0	0	0	0	0
VI		0	0.0003	0.0004	0.0010	0.0020
V		0.002	0.0218	0.0273	0.0611	0.1120
IV		0.108	0.4070	0.6680	1.3440	2.5270
III		2.226	2.1840	5.1670	8.5070	18.0800
II		16.230	2.0970	22.2700	37.1400	77.7400
I	0	74.780	0	0.7550	0	75.5300
Sum	0	93.340	4.7100	28.8900	47.0500	174.0000

Table S-12. Transfer efficiencies per trophic level in Conestoga Lake.

Source\trophic level	II	III	IV	V	VI	VII
Producer	23.6	24.4	20.4	21.0	22	
Detritus	27.1	24.4	20.2	21.1		
All flows	24.5	24.4	20.4	21.0	22	

Proportion of total flow originating from detritus: 0.33

Transfer efficiencies (calculated as geometric mean for Trophic levels II-IV)

From primary producers: 22.7%
From detritus: 23.7%
Total: 23.0%

Table S-13. Keystone indices for each species or functional group in Conestoga Lake. Keystone indices are described in the text.

Group name	Keystone index	Keystone index #2	Relative total impact
Predatory birds	-0.00132	2.879	1
Walleye	-0.325	0.976	0.5
Largemouth Bass	-0.547	0.36	0.333
Channel Catfish	-0.135	0.699	0.893
Crappie	-0.606	0.604	0.266
Bluegill	-0.409	0.728	0.424
Freshwater Drum	-1.15	0.06	0.0759
Flathead Catfish	-1.174	-0.0368	0.0729
Common Carp	-0.476	0.346	0.411
Chinese Mystery Snail	-2.994	1.409	0.00102
Benthic Macroinvertebrates	-0.245	0.969	0.61
Copepods	-0.503	1.184	0.322
Cladocerans	-0.503	1.184	0.322
Autotrophs	-0.0655	1.351	0.897

Table S-14. Output table on cycles and pathway lengths for Conestoga Lake.

Parameter	Value	Units
Throughput cycled (excluding detritus)	0.45	t/km²/year
Predatory cycling index	0.25	% of throughput without detritus
Throughput cycled (including detritus)	13.96	t/km²/year
Finn's cycling index	5.2	% of total throughput
Finn's mean path length	2.926	none
Finn's straight-through path length	2.465	without detritus
Finn's straight-through path length	2.774	with detritus

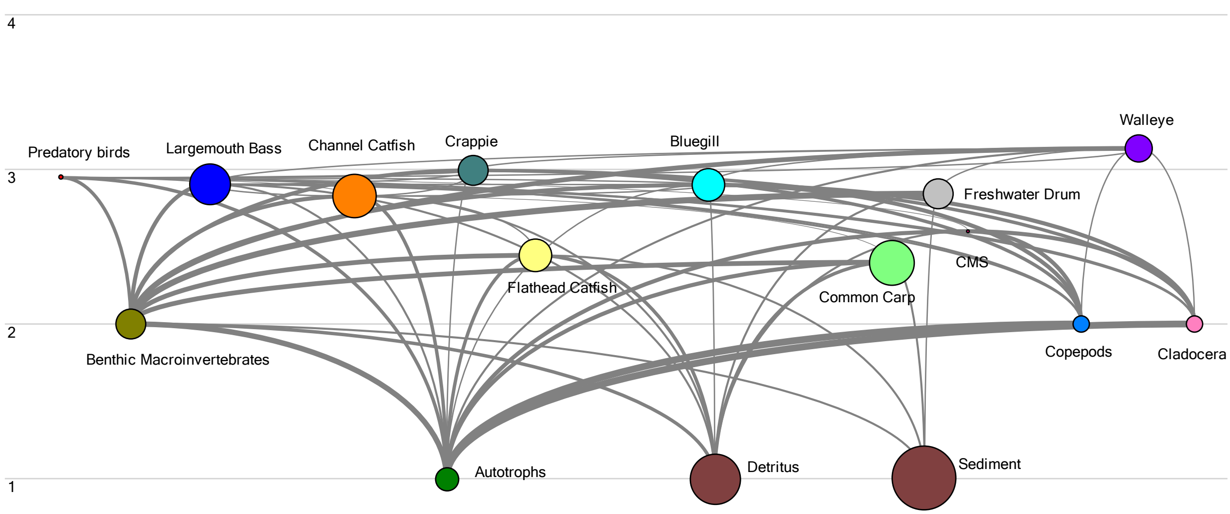

Figure S-1. Flow diagram output for Conestoga Lake. Calculated trophic levels are on the y-axis, and node size is scaled to that species' biomass. Weighted links between nodes represent the energy flow between nodes.

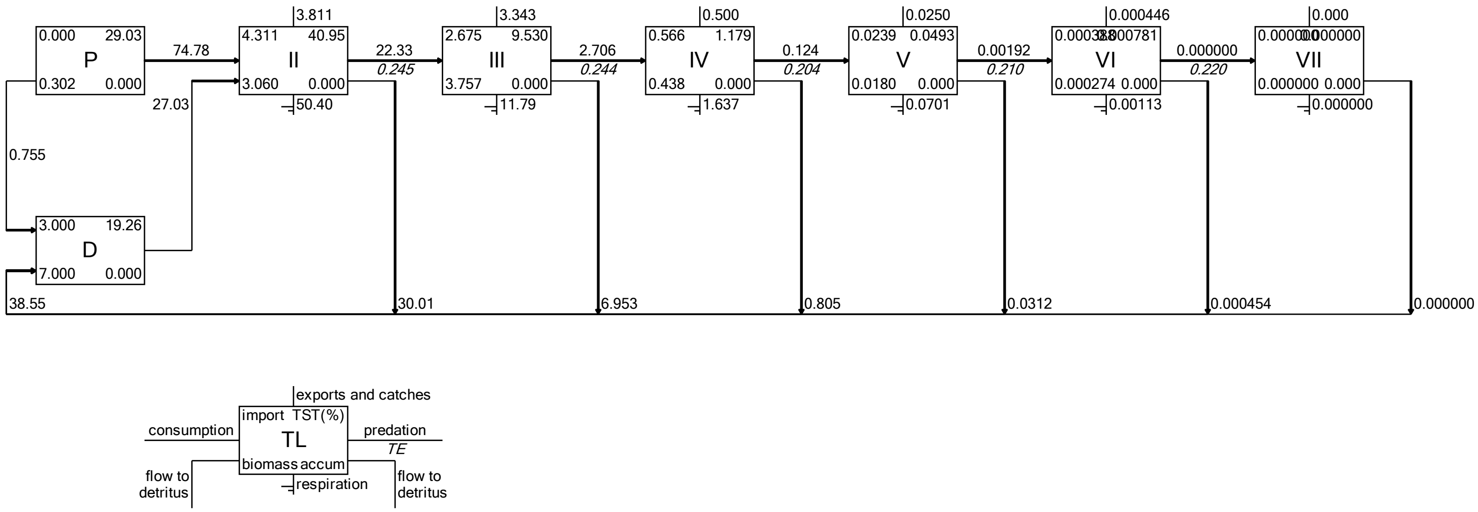

Figure S-2. A Lindeman spine produced for Conestoga Lake. Flow values for consumption, respiration, export, predation, flows to detritus, and imports are given, as well as total system throughput and biomass accumulation values.

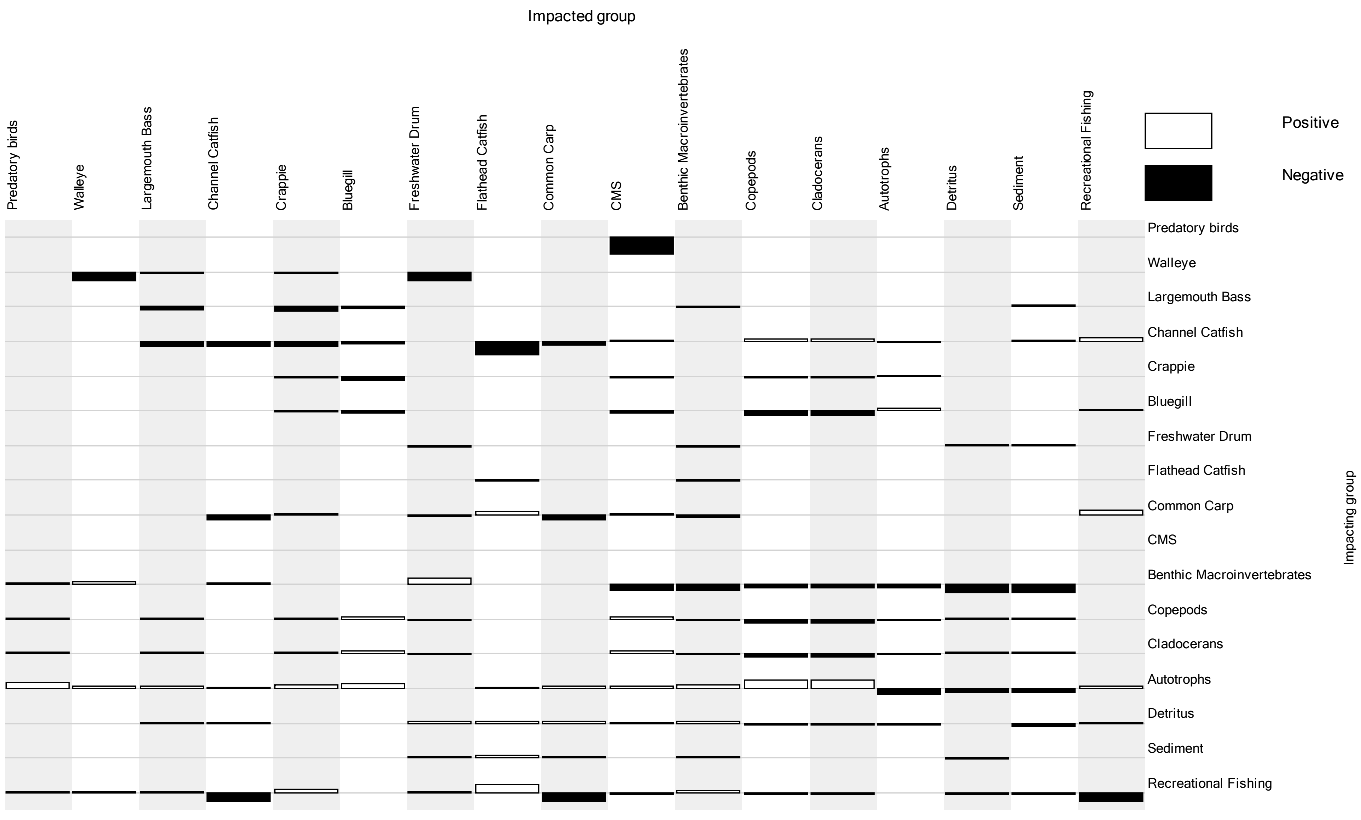

Figure S-3. Mixed trophic impact plot produced for Conestoga Lake. The color and size of the rectangle indicates how the group in a given row impacts the group in each column. The larger the box, the greater the impact. Black boxes are negative impacts and white boxes are positive impacts. (Chinese mystery snail is abbreviated as CMS in this figure.)