Figure D2-3. Chrysophyte biomass (mg/m³) from Whale Tail study area lakes since 2015.

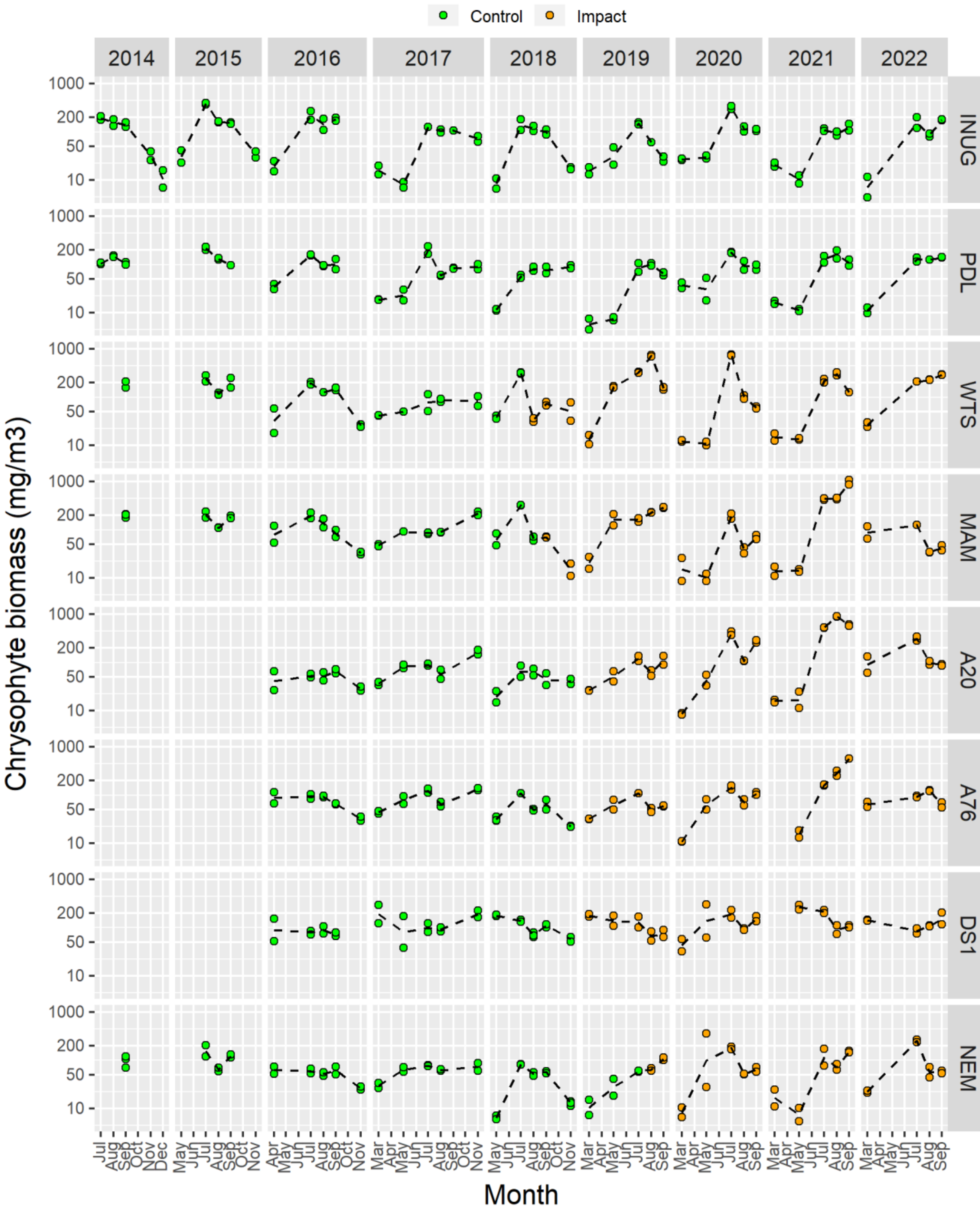


Figure D2-4. Diatoms biomass (mg/m³) from Whale Tail study area lakes since 2015.

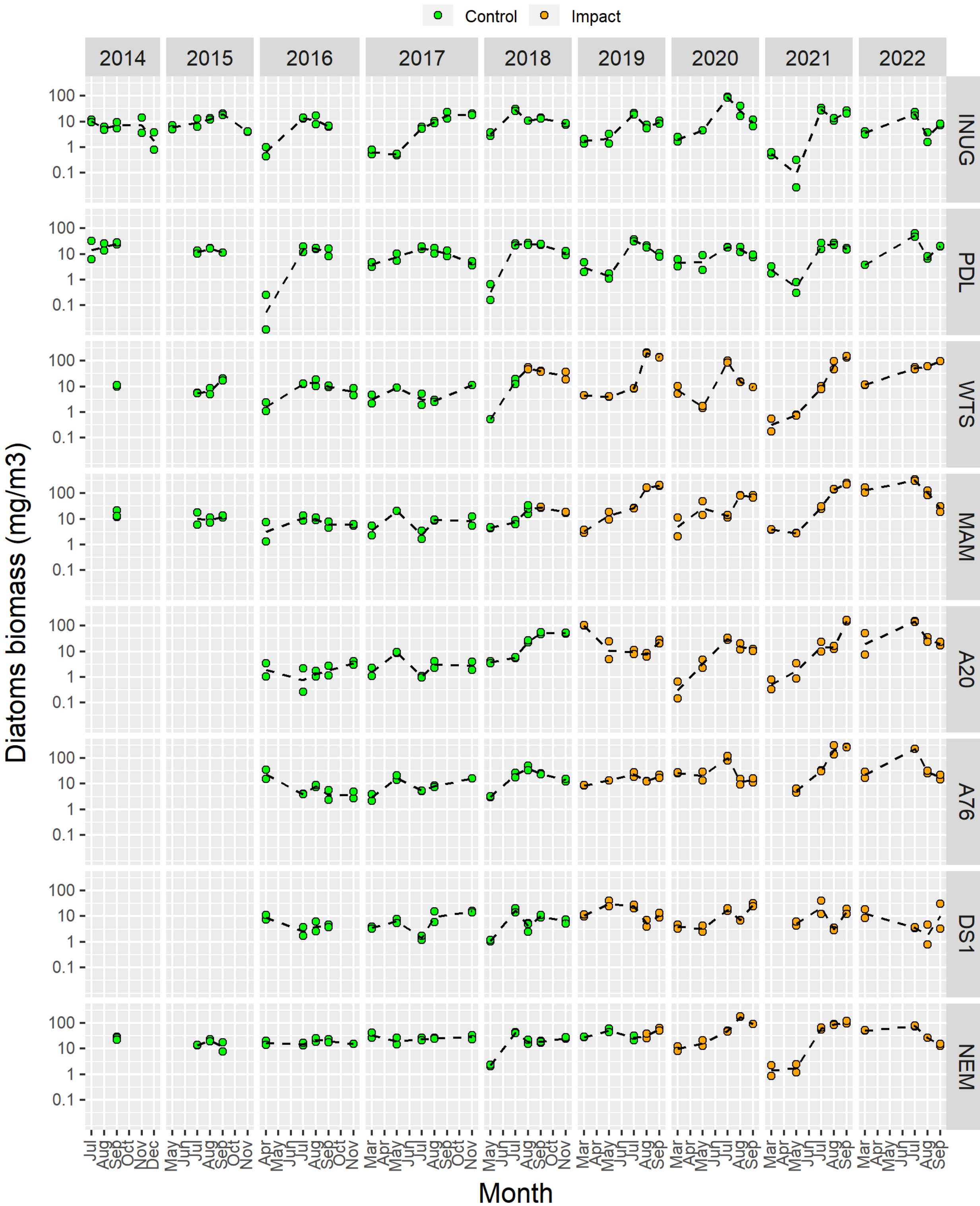


Figure D2-5. Cryptophytes biomass (mg/m³) from Whale Tail study area lakes since 2015.

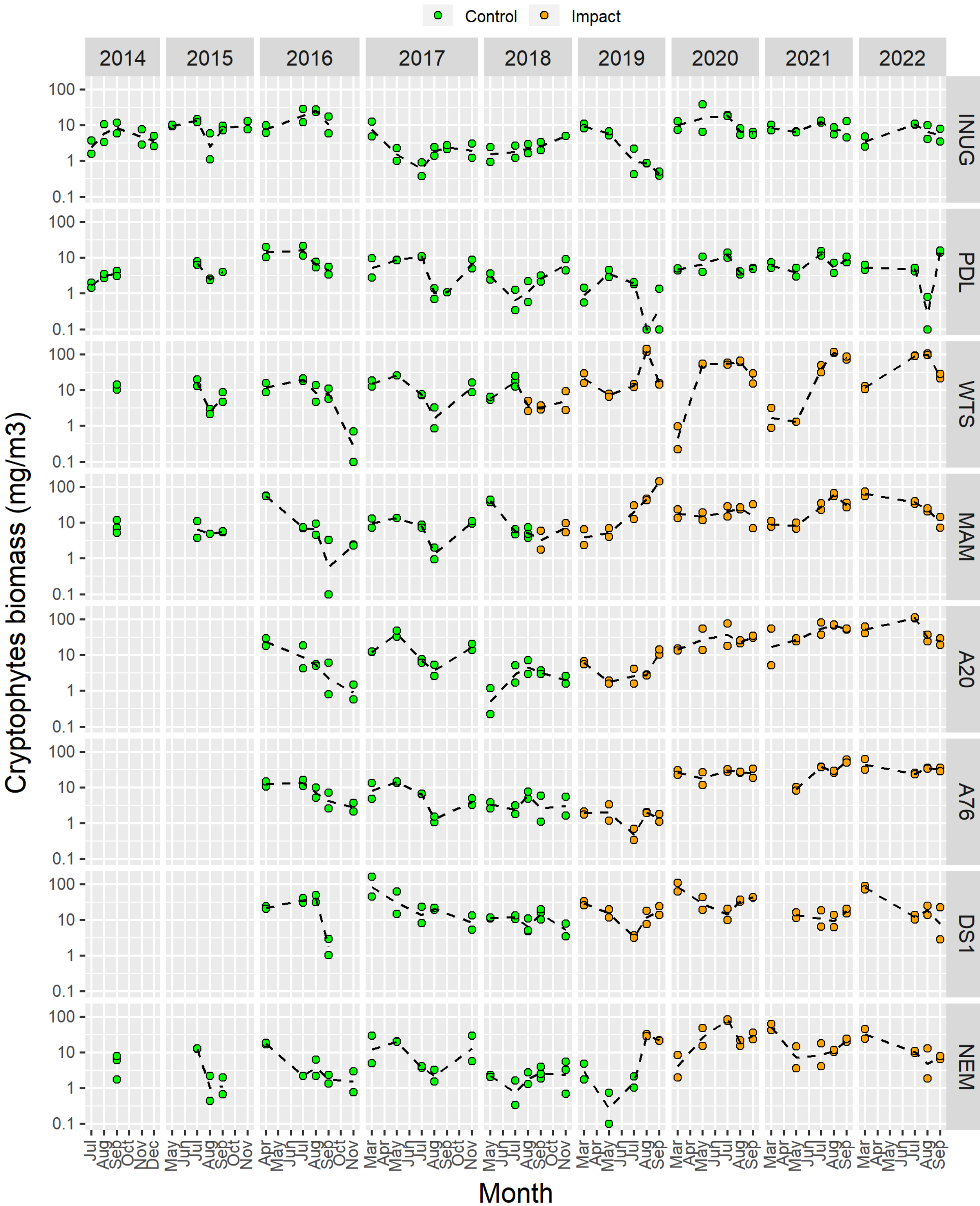


Figure D2-6. Dinoflagellates biomass (mg/m³) from Whale Tail study area lakes since 2015.

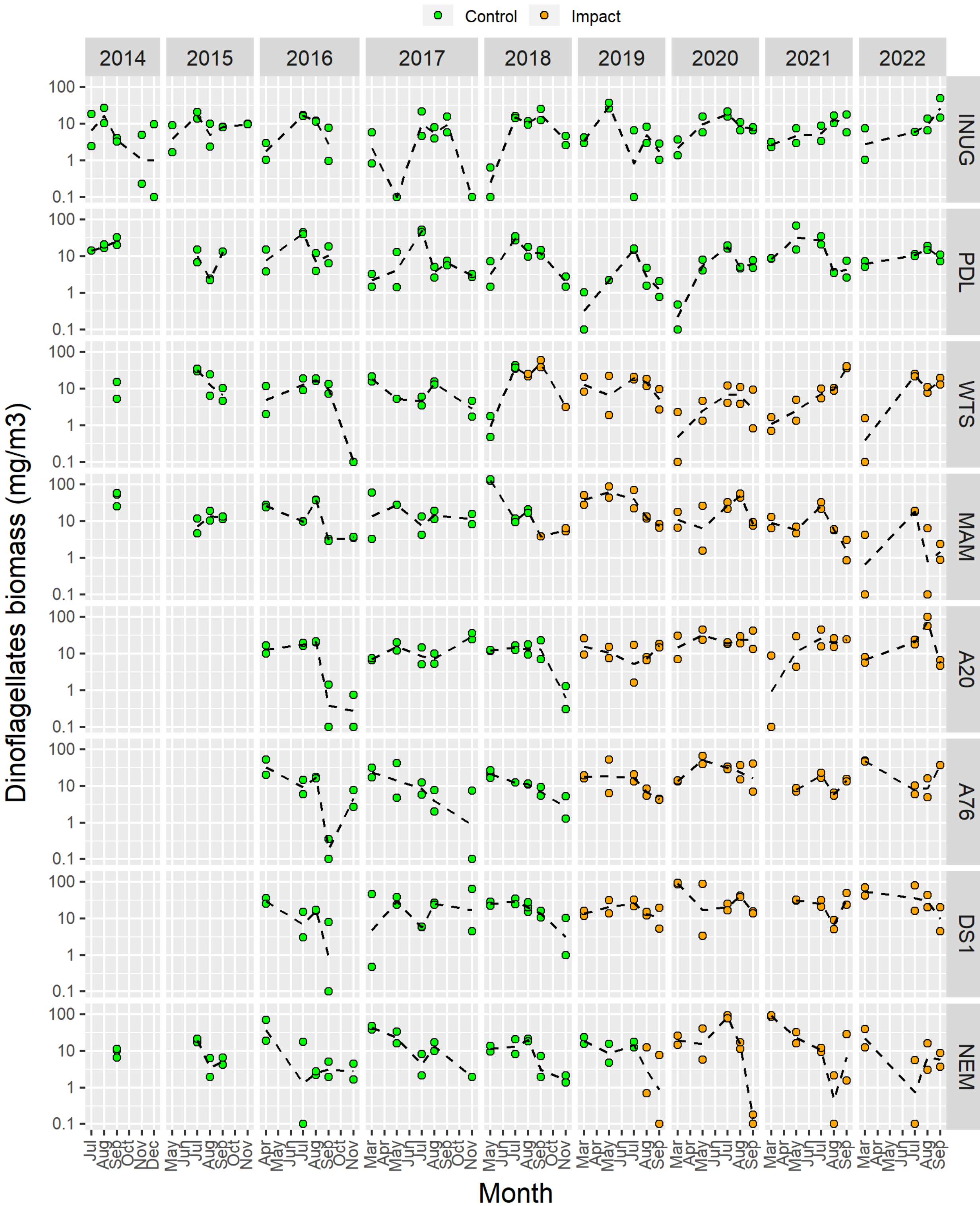


Figure D2-7. Phytoplankton density (cells/L) by major taxa group from Whale Tail study area lakes since 2015.

Figure D2-8. Relative phytoplankton density from Whale Tail study area lakes since 2015.

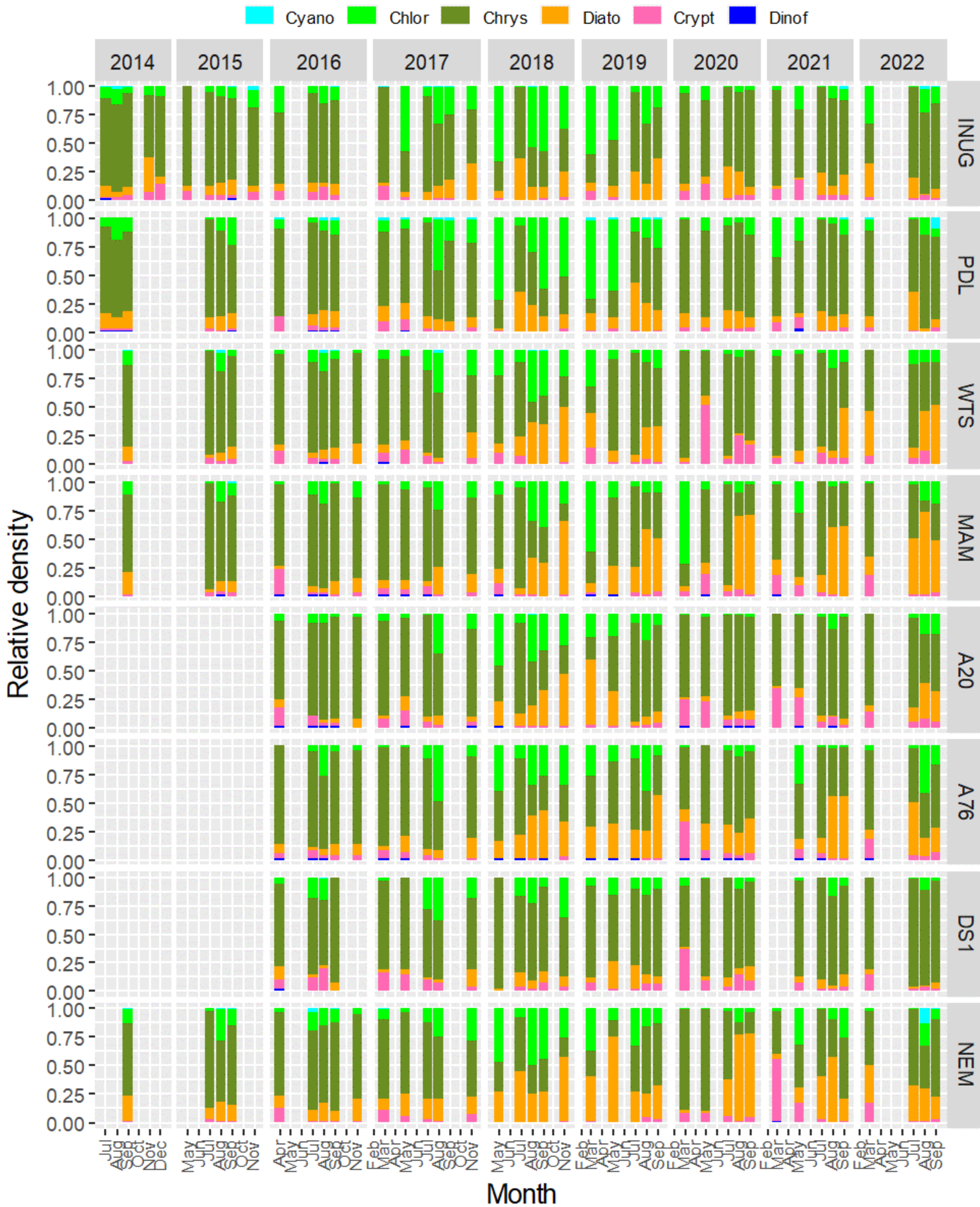


Figure D2-9. Cyanophyte density (cells/L) from Whale Tail study area lakes since 2015.

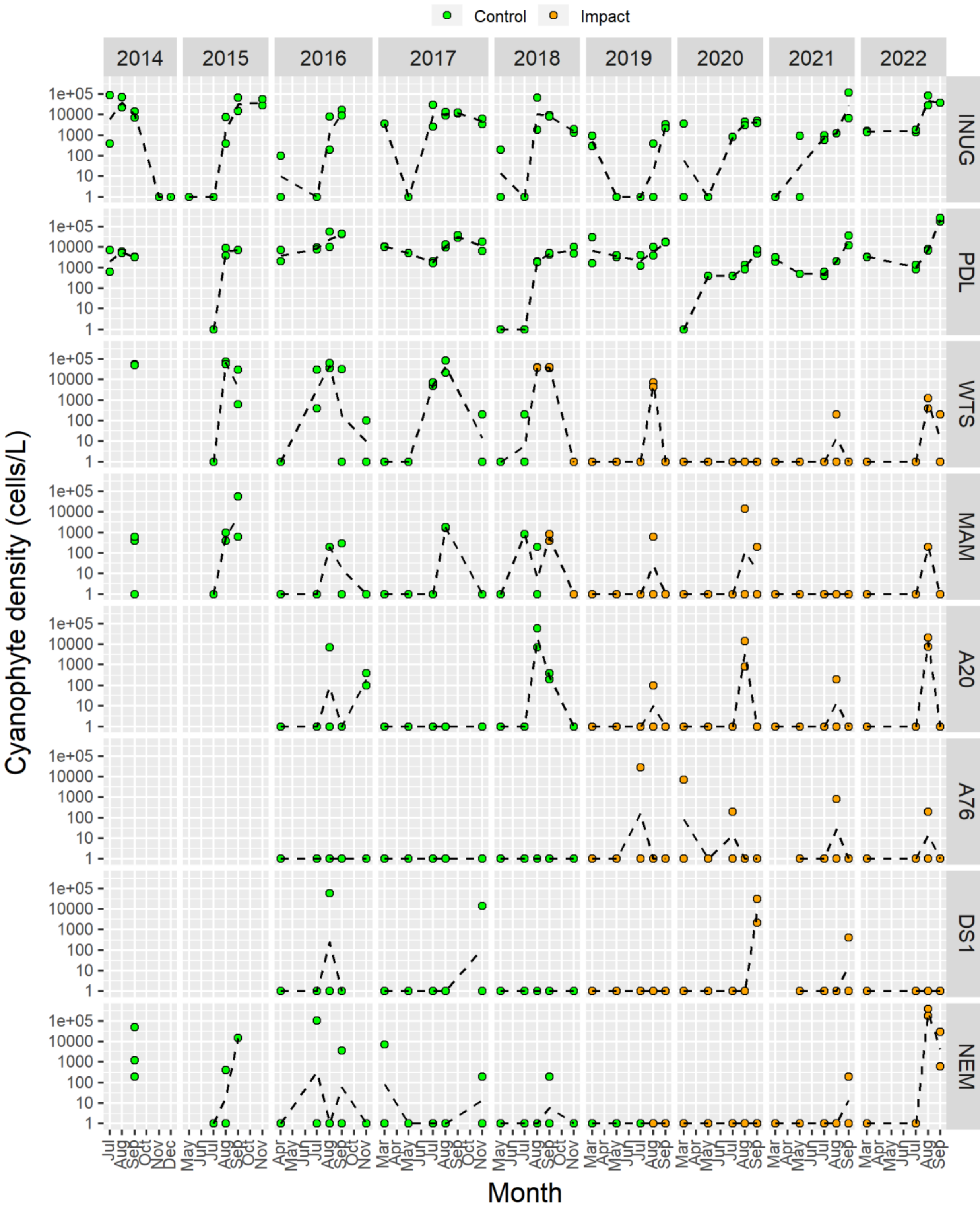


Figure D2-10. Chlorophyte density (cells/L) from Whale Tail study area lakes since 2015.

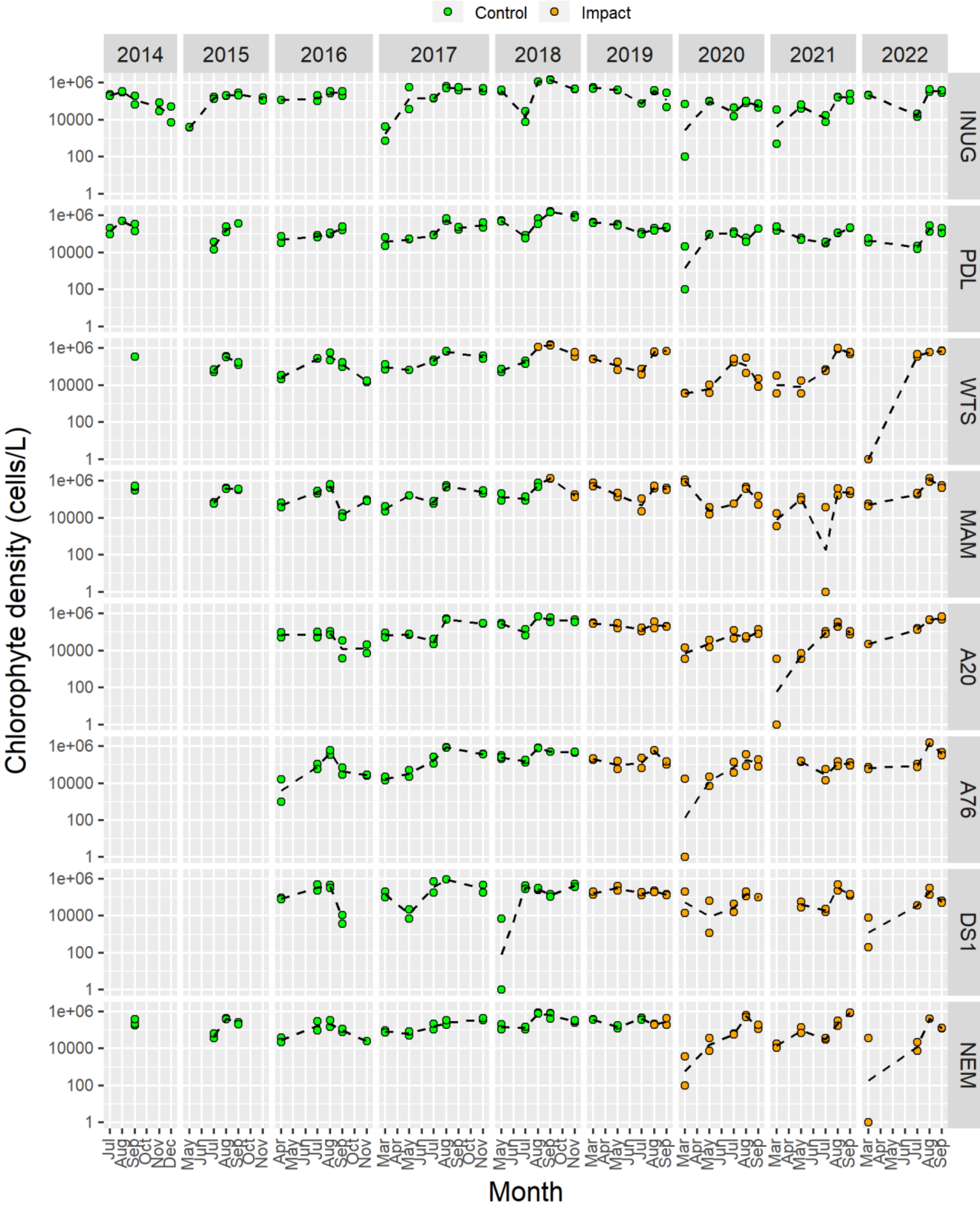


Figure D2-11. Chrysophyte density (cells/L) from Whale Tail study area lakes since 2015.

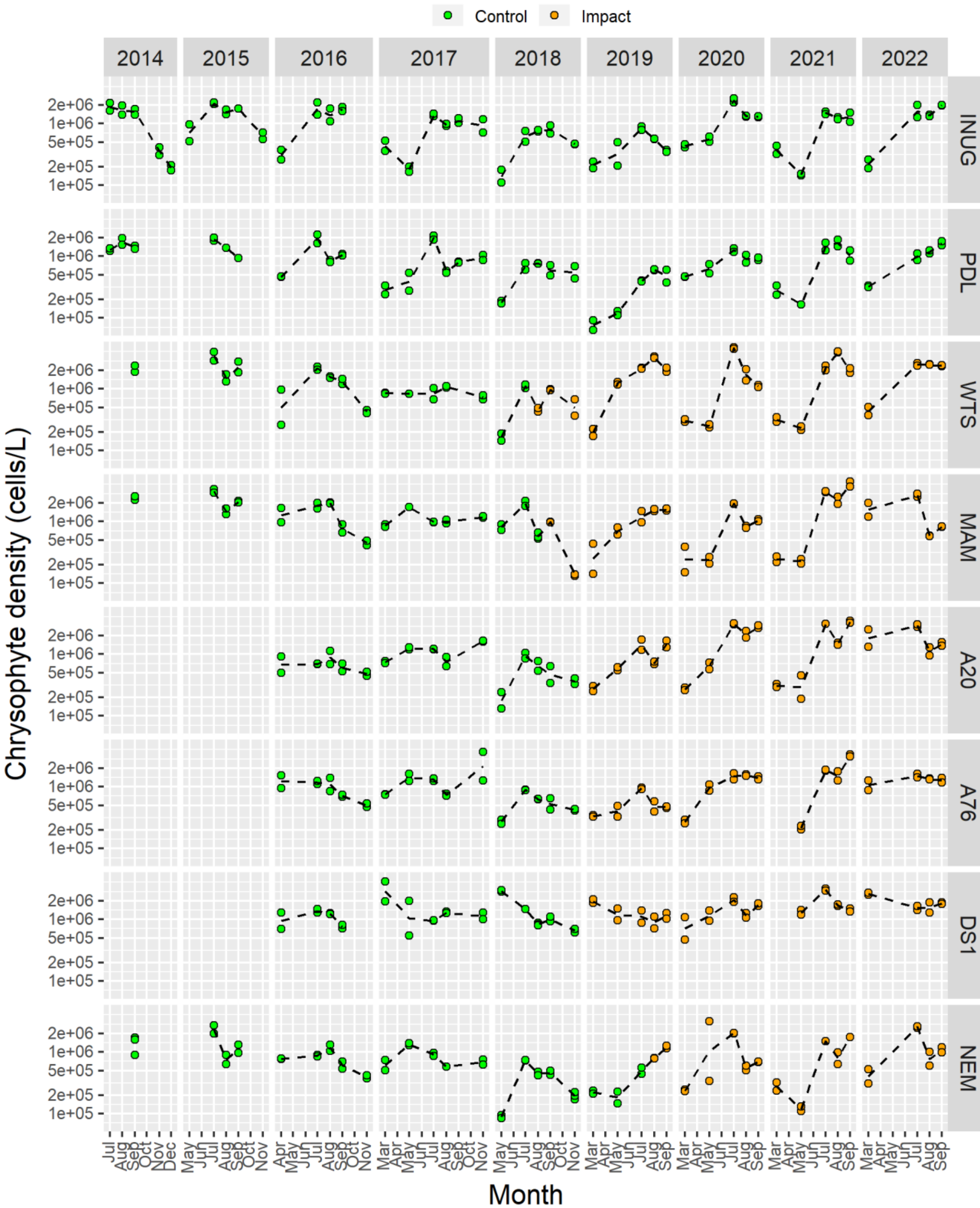


Figure D2-12. Diatoms density (cells/L) from Whale Tail study area lakes since 2015.

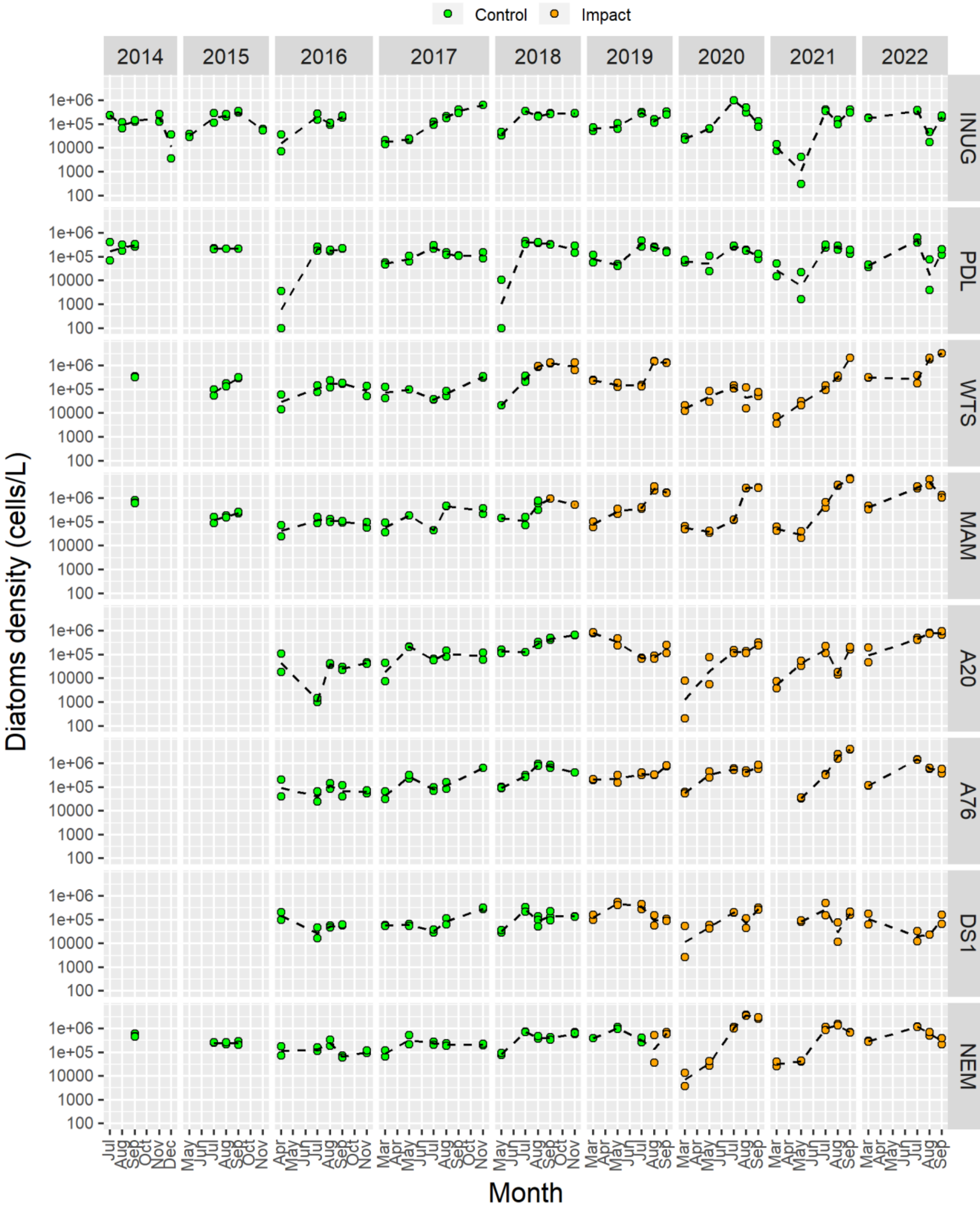


Figure D2-13. Cryptophytes density (cells/L) from Whale Tail study area lakes since 2015.

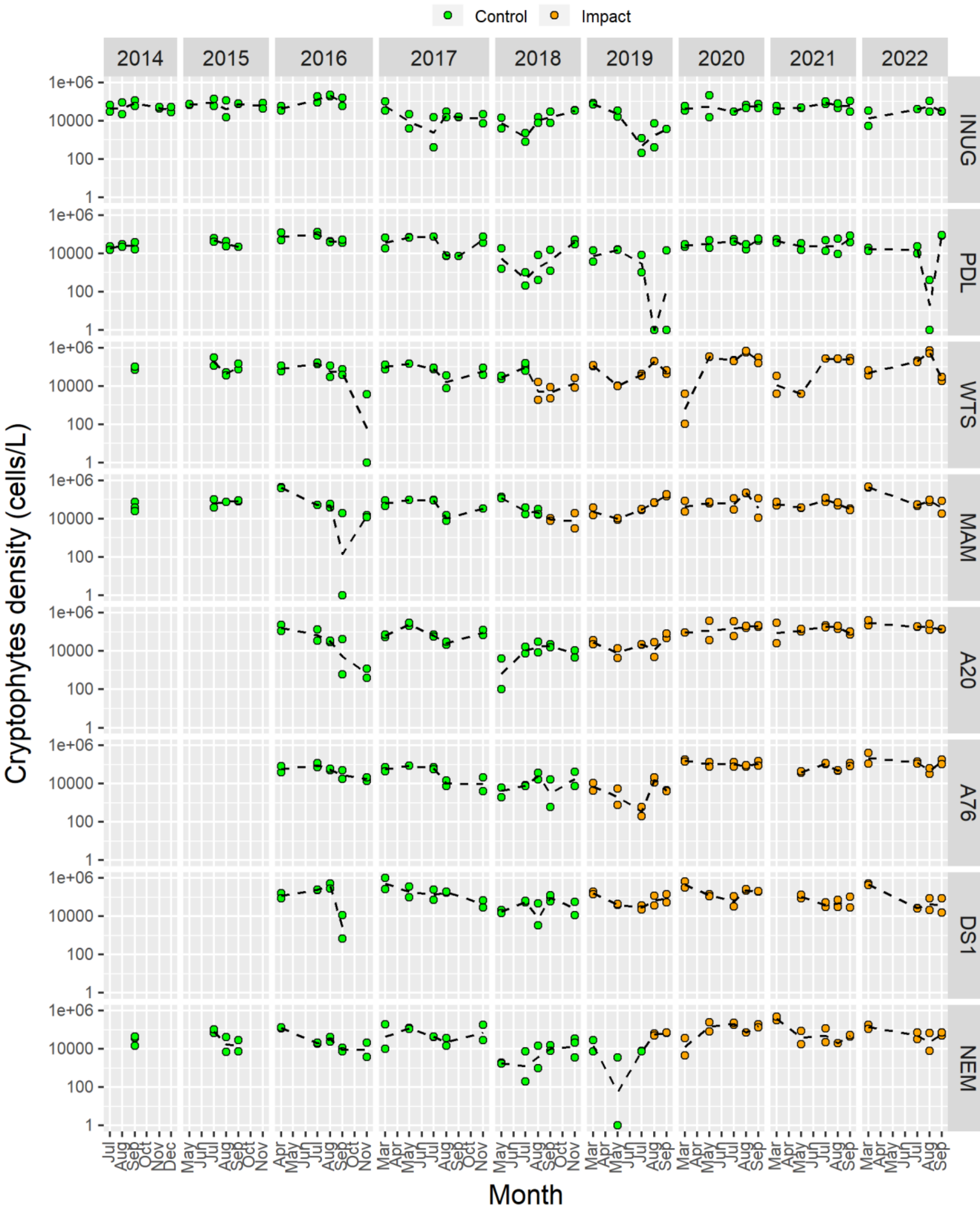


Figure D2-14. Dinoflagellates density (cells/L) from Whale Tail study area lakes since 2015.

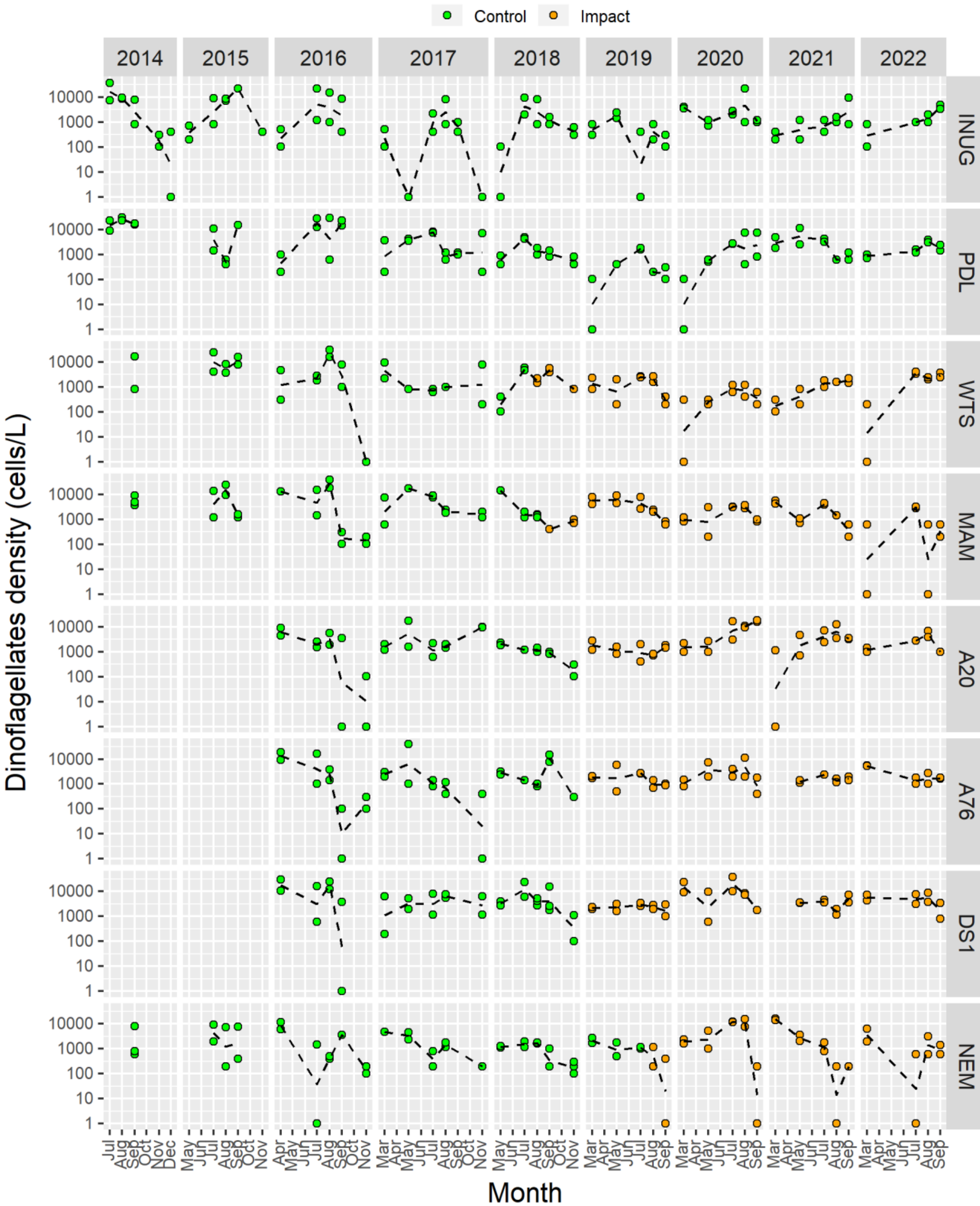
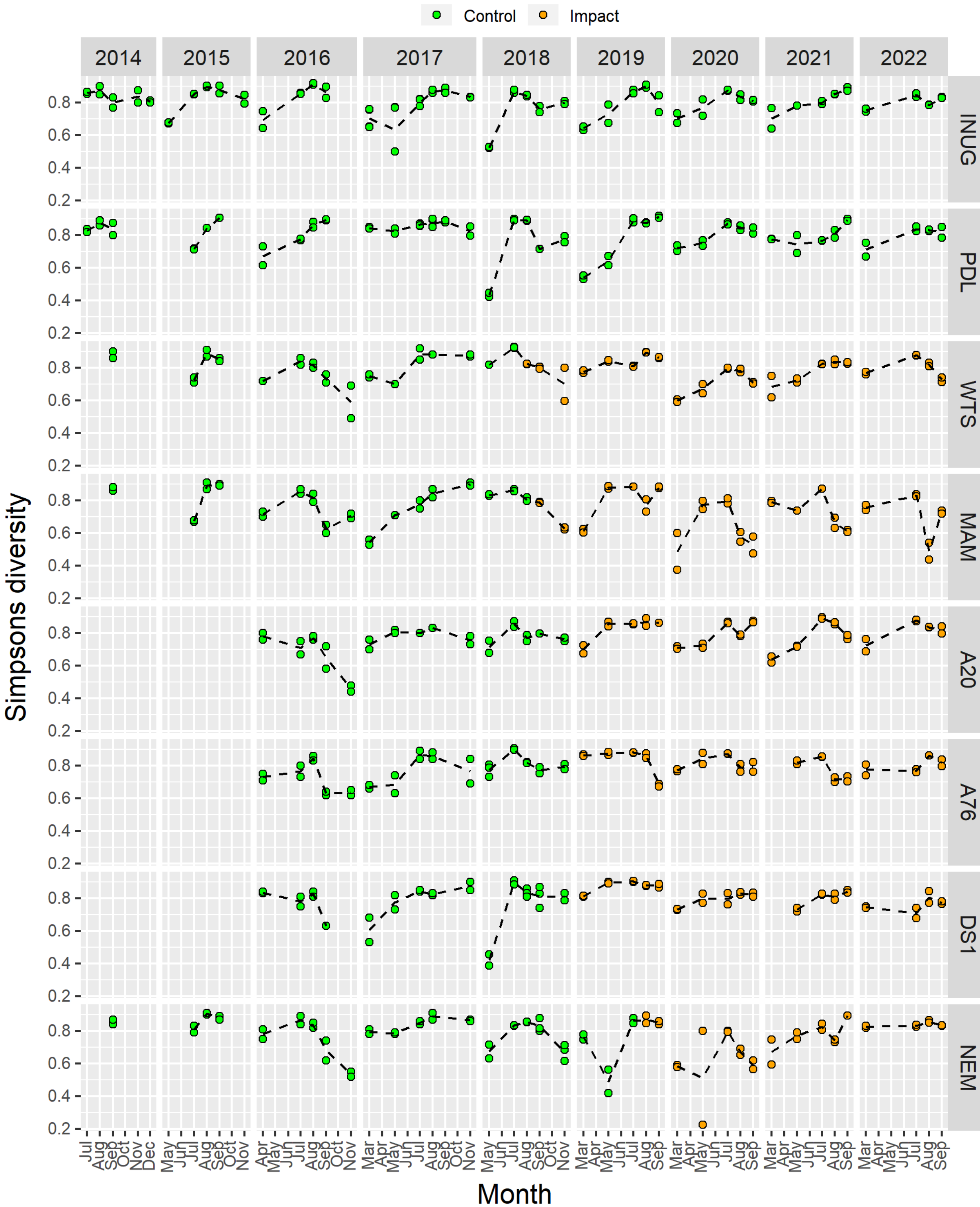


Figure D2-15. Simpsons' Diversity for the phytoplankton community from Whale Tail study area lakes since 2015.



Appendix D3
Phyto Data – Baker Lake

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Table D3-1. Phytoplankton density (cells/L), biomass (mg/m3), and diversity by major taxa group, Baker Lake, 2022.

Area-Replicate	Date	Phytoplankton Biomass (mg/m^3)							Taxa	Simpson's
		Cyanophyte	Chlorophyte	Chrysophyte	Diatom	Cryptophyte	Dinoflagellate	TOTAL	Richness	Diversity
Baker Akilahaarjuk Point										
BAP - 79	18-Jul-22	0	0	111	74	29	31	246	23	0.76
BAP - 80	18-Jul-22	0	0	94	63	21	15	192	25	0.77
BAP - 81	20-Aug-22	0	6	85	21	15	6	133	36	0.84
BAP - 82	20-Aug-22	0	3	86	19	25	5	138	33	0.83
BAP - 83	6-Sep-22	0	3	67	13	7	7	97	31	0.73
BAP - 84	6-Sep-22	0	1	67	15	5	8	96	32	0.73
Percent Density or Biomass		***<0.1***	***1.5***	***56***	***23***	***11***	***8.0***			
Baker Barge Dock										
BBD - 79	18-Jul-22	0	3	216	25	29	44	317	31	0.84
BBD - 80	18-Jul-22	0	1	218	40	34	21	314	31	0.86
BBD - 81	20-Aug-22	0	1	47	47	9	7	112	31	0.75
BBD - 82	20-Aug-22	0	3	138	28	19	3	191	34	0.80
BBD - 83	6-Sep-22	0	2	93	188	29	7	318	24	0.72
BBD - 84	6-Sep-22	0	0	78	228	17	5	328	23	0.66
Percent Density or Biomass		***<0.1***	***0.64***	***50***	***35***	***8.6***	***5.5***			
Baker Proposed Jetty										
BPJ - 79	18-Jul-22	0	1	133	31	34	8	208	28	0.86
BPJ - 80	18-Jul-22	0	2	147	24	15	31	218	31	0.86
BPJ - 81	20-Aug-22	0	4	67	46	35	5	157	32	0.79
BPJ - 82	20-Aug-22	0	5	119	15	20	4	163	36	0.75
BPJ - 83	6-Sep-22	0	7	205	23	12	7	255	35	0.75
BPJ - 84	6-Sep-22	0	4	91	26	11	13	146	32	0.79
Percent Density or Biomass		***<0.1***	***2.0***	***66***	***14***	***11***	***6.0***			
All Locations Relative Density or Biomass (%)		***<0.1***	***1.3***	***57***	***25***	***10***	***6.3***			

Table D3-1. Phytoplankton density (cells/L), biomass (mg/m3), and diversity by major taxa group, Baker Lake, 2022.

Area-Replicate	Date	Phytoplankton Density (cells/L)						
		Cyanophyte	Chlorophyte	Chrysophyte	Diatom	Cryptophyte	Dinoflagellate	**TOTAL**
Baker Akilahaarjuk Point								
BAP - 79	18-Jul-22	0	7,184	1,514,240	170,664	108,776	4,600	1,805,464
BAP - 80	18-Jul-22	0	14,368	1,389,128	207,184	51,104	2,200	1,663,984
BAP - 81	20-Aug-22	600	245,456	1,073,016	55,304	35,736	800	1,410,912
BAP - 82	20-Aug-22	200	216,720	1,101,552	22,184	164,648	600	1,505,904
BAP - 83	6-Sep-22	0	87,608	1,143,456	122,576	59,072	1,400	1,414,112
BAP - 84	6-Sep-22	0	93,392	1,157,024	79,072	44,104	800	1,374,392
Percent Density or Biomass		***<0.1***	***7.2***	***80***	***7.2***	***5.1***	***0.11***	
Baker Barge Dock								
BBD - 79	18-Jul-22	1,200	100,576	2,228,456	103,608	63,288	4,800	2,501,928
BBD - 80	18-Jul-22	200	28,936	1,893,008	310,944	196,384	2,400	2,431,872
BBD - 81	20-Aug-22	0	72,240	576,320	107,008	46,304	1,400	803,272
BBD - 82	20-Aug-22	0	151,464	1,485,304	68,504	120,744	600	1,826,616
BBD - 83	6-Sep-22	0	71,840	1,617,600	37,000	248,456	800	1,975,696
BBD - 84	6-Sep-22	0	43,104	1,638,352	50,984	132,312	600	1,865,352
Percent Density or Biomass		***<0.1***	***4.1***	***83***	***5.9***	***7.1***	***<0.1***	
Baker Proposed Jetty								
BPJ - 79	18-Jul-22	0	35,920	1,195,760	198,784	148,896	1,600	1,580,960
BPJ - 80	18-Jul-22	0	43,304	1,238,464	180,032	42,520	600	1,504,920
BPJ - 81	20-Aug-22	600	244,256	971,840	53,352	191,000	1,200	1,462,248
BPJ - 82	20-Aug-22	7,384	186,784	1,205,528	95,672	65,672	600	1,561,640
BPJ - 83	6-Sep-22	0	238,472	1,898,376	40,384	75,440	1,000	2,253,672
BPJ - 84	6-Sep-22	0	173,016	1,244,232	76,904	88,208	1,800	1,584,160
Percent Density or Biomass		***<0.1***	***9.3***	***78***	***6.5***	***6.1***	***<0.1***	
All Locations Relative Density or Biomass (%)		***<0.1***	***6.7***	***80***	***6.5***	***6.2***	***<0.1***	

Figure D3-1. Cyanophyte biomass (mg/m³) from Baker Lake since 2008.

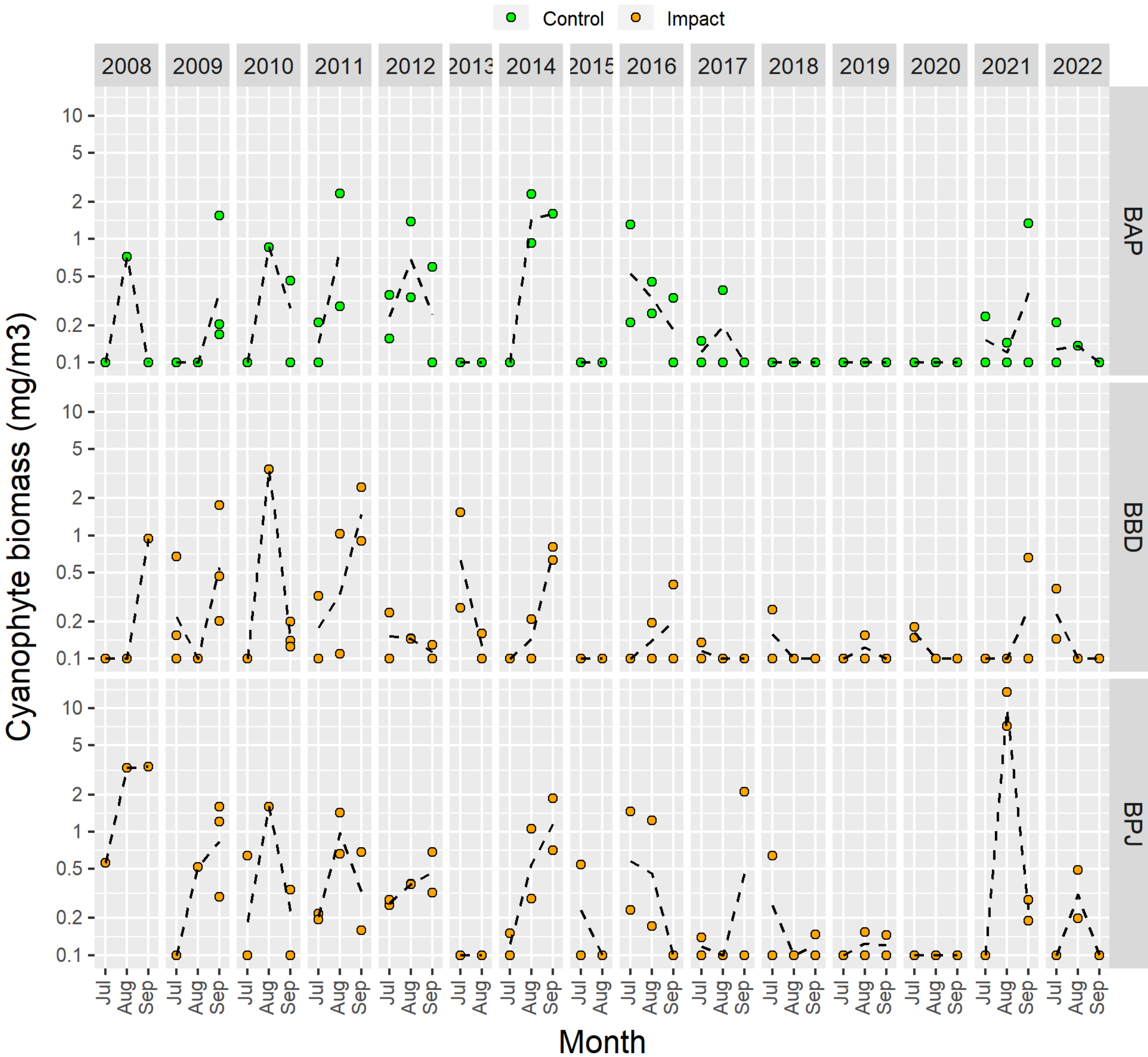


Figure D3-2. Chlorophyte biomass (mg/m³) from Baker Lake since 2008.

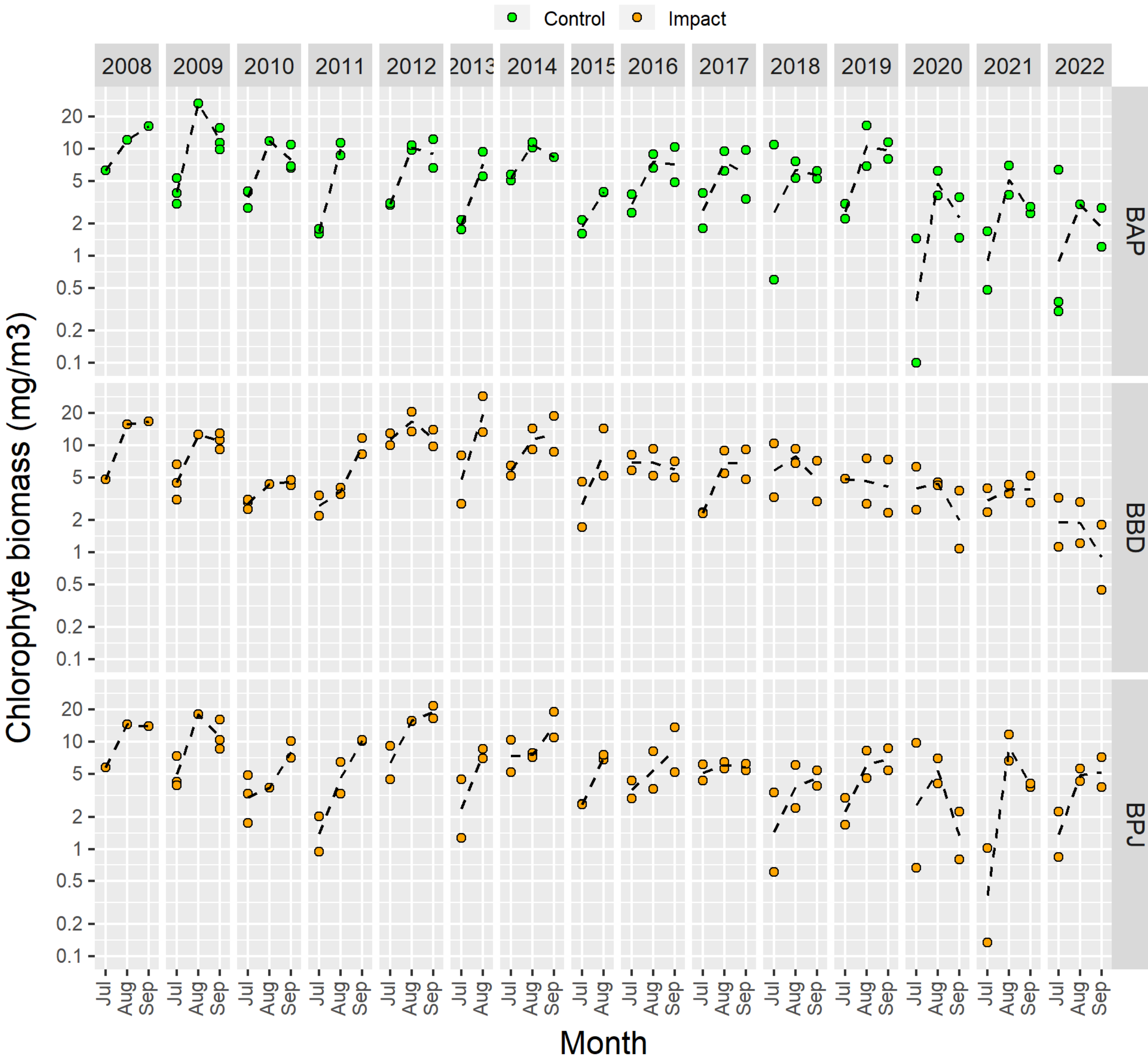


Figure D3-3. Chrysophyte biomass (mg/m³) from Baker Lake since 2008.

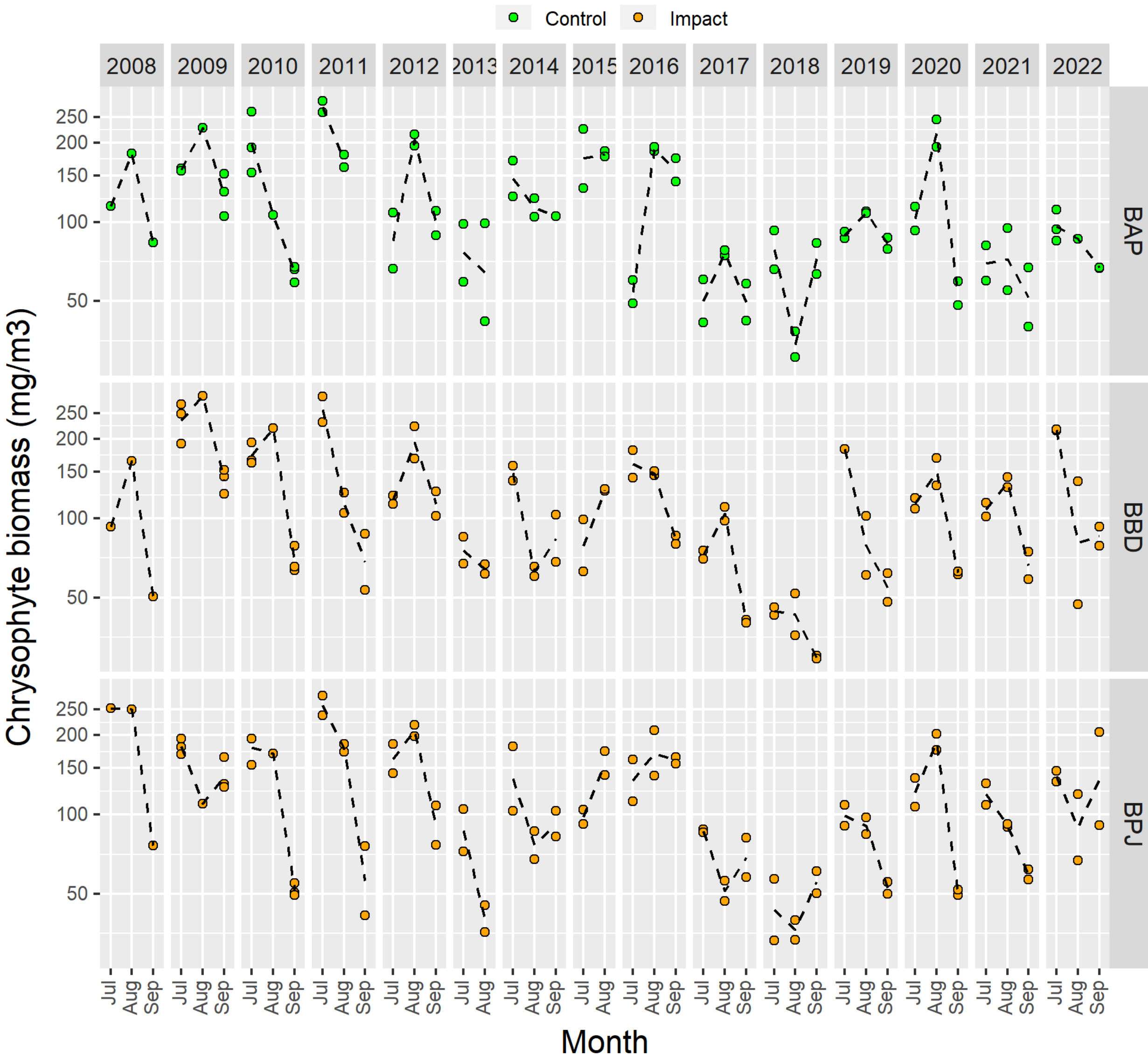


Figure D3-4. Diatoms biomass (mg/m³) from Baker Lake since 2008.

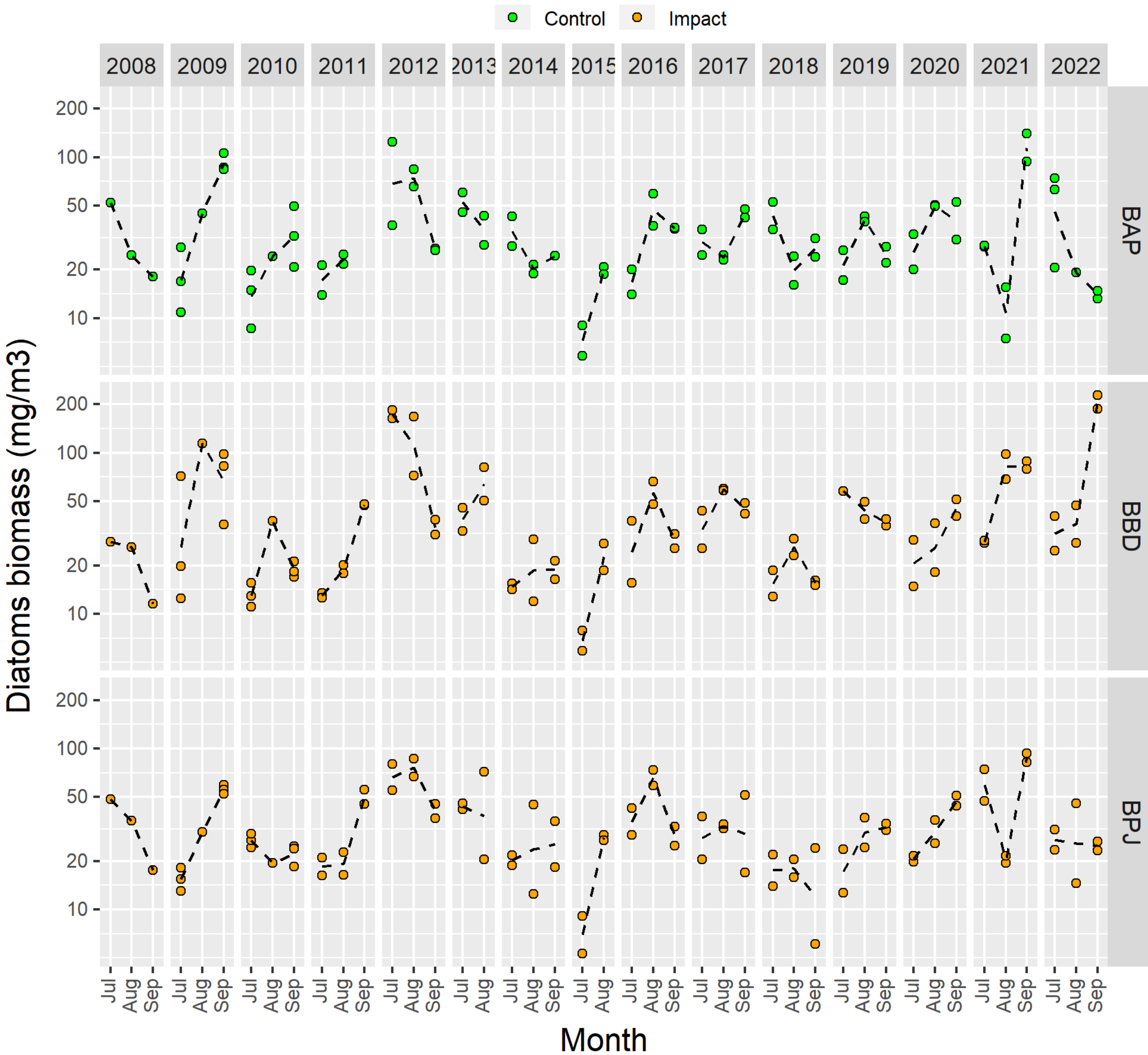


Figure D3-5. Cryptophytes biomass (mg/m^3) from Baker Lake since 2008.

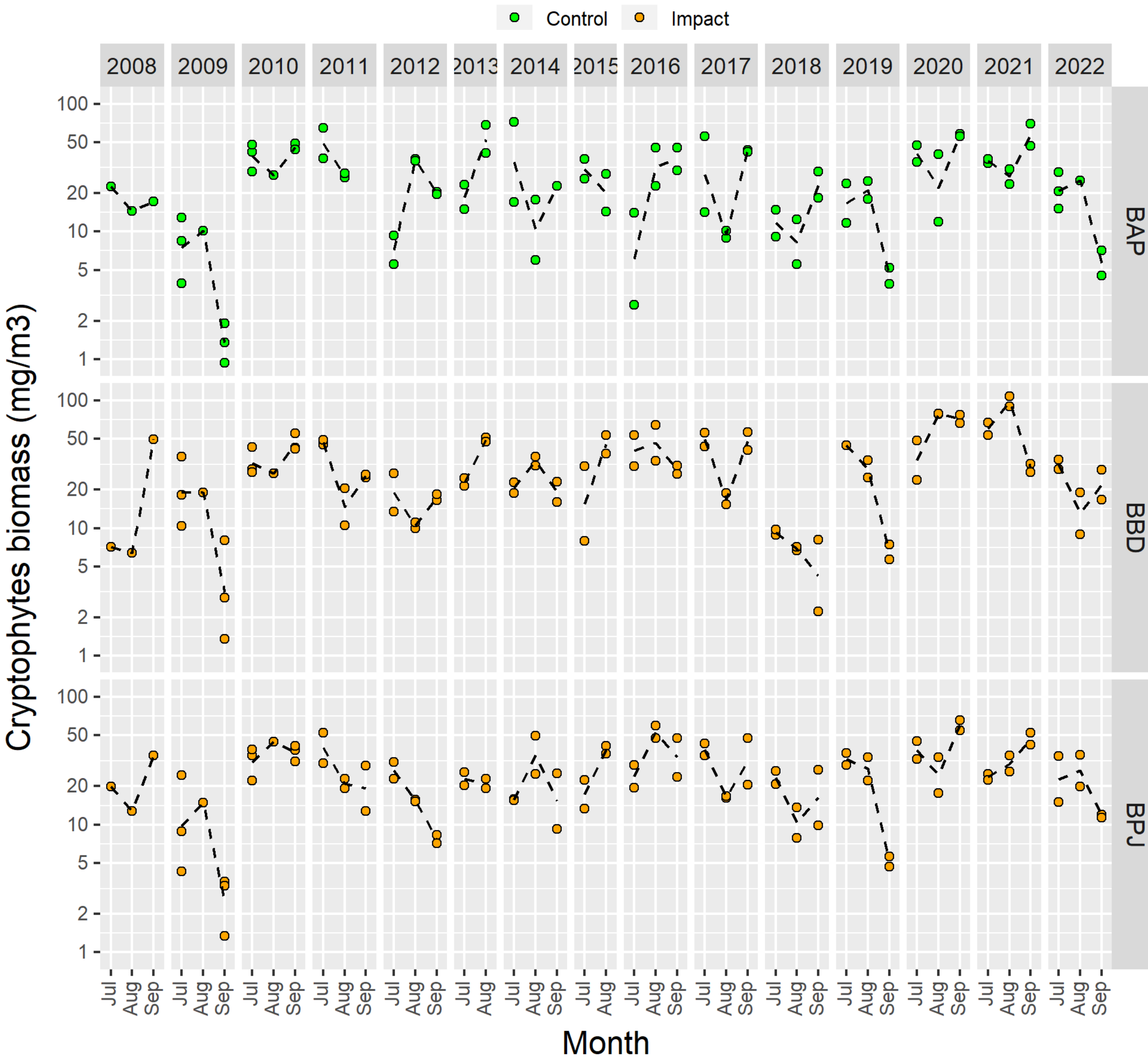


Figure D3-6. Dinoflagellates biomass (mg/m³) from Baker Lake since 2008.

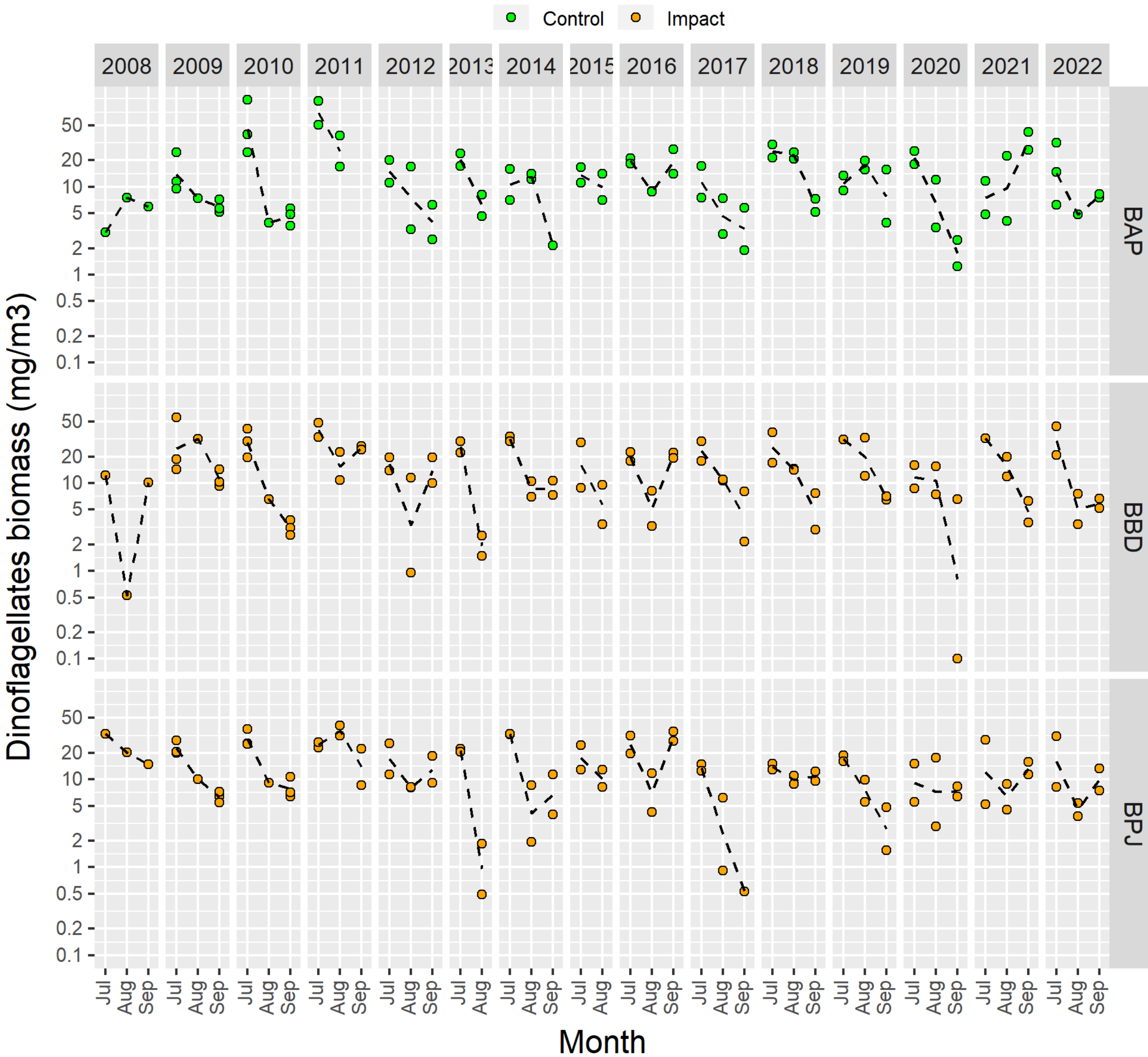


Figure D3-7. Phytoplankton density (cells/L) by major taxa group from Baker Lake since 2008.

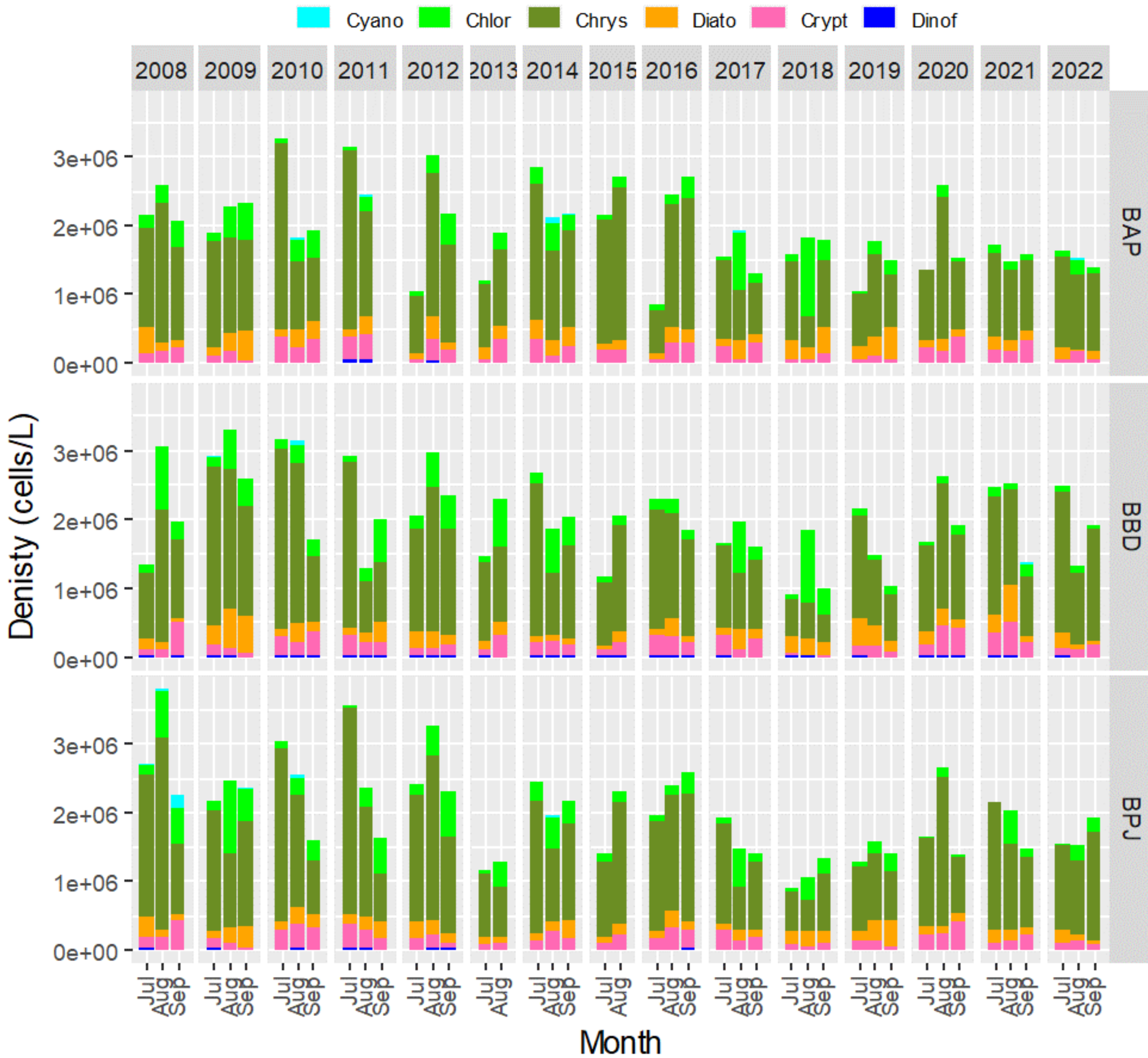


Figure D3-8. Relative phytoplankton density from Baker Lake since 2008.

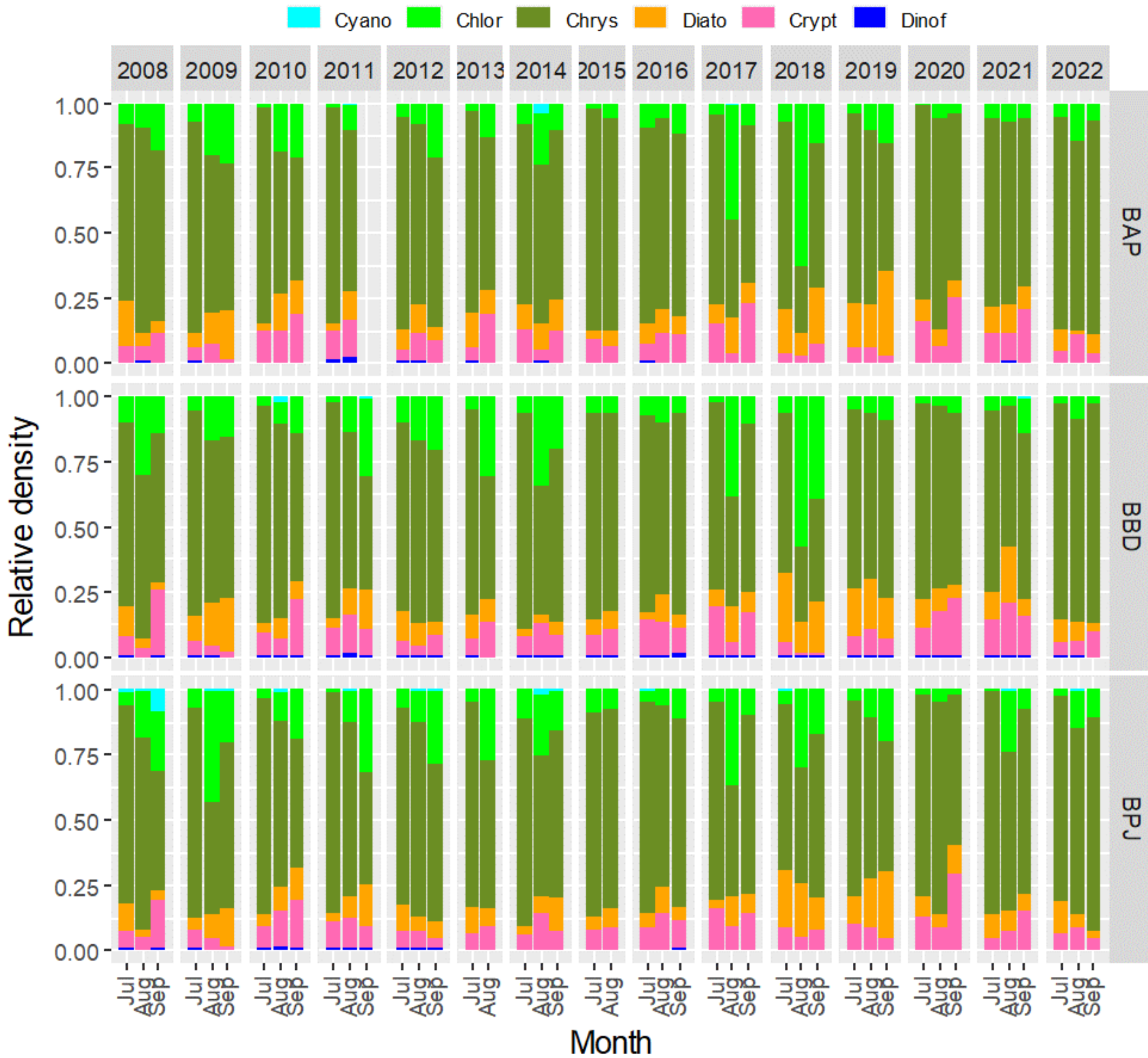


Figure D3-9. Cyanophyte density (cells/L) from Baker Lake since 2008.

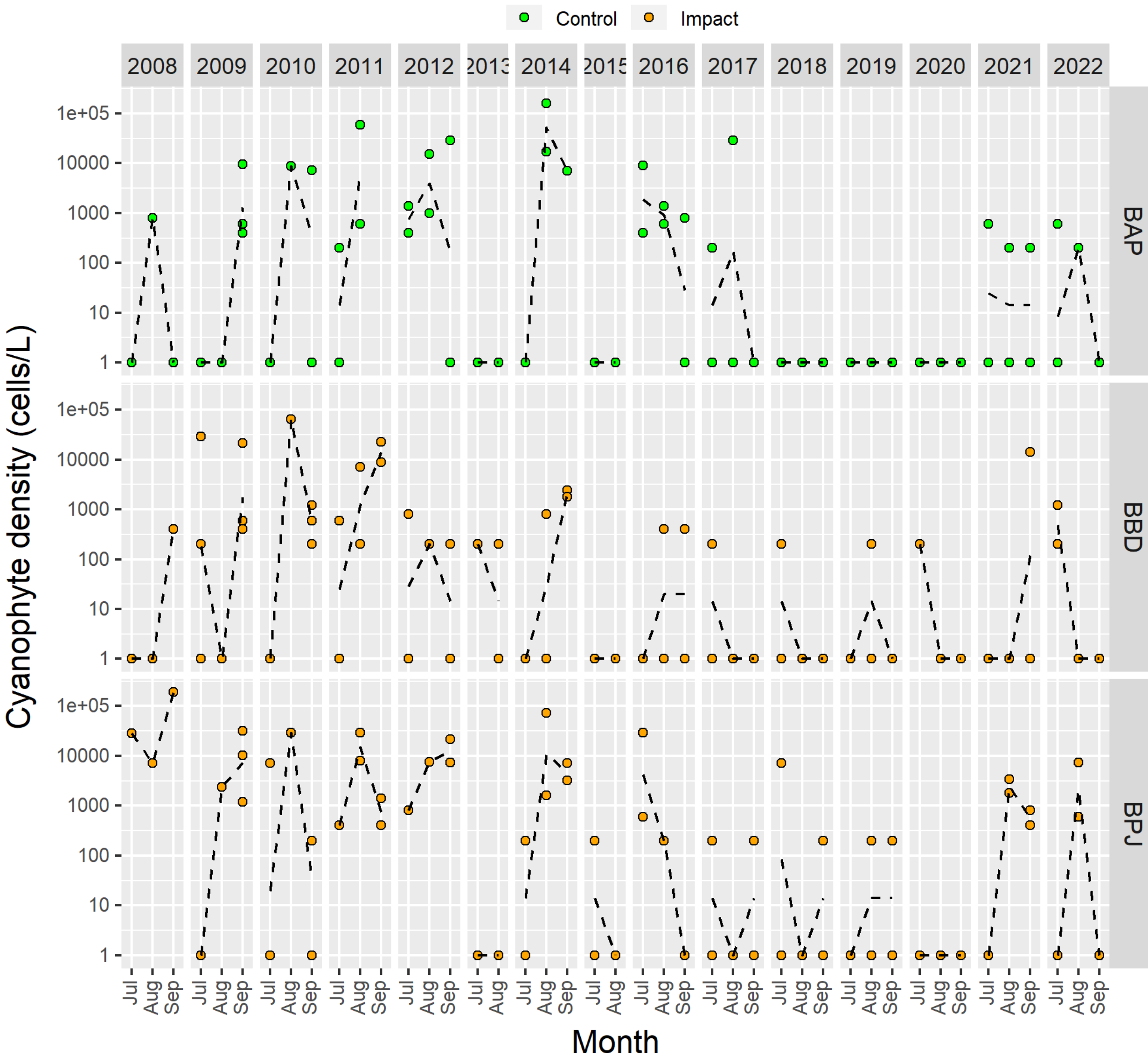


Figure D3-10. Chlorophyte density (cells/L) from Baker Lake since 2008.

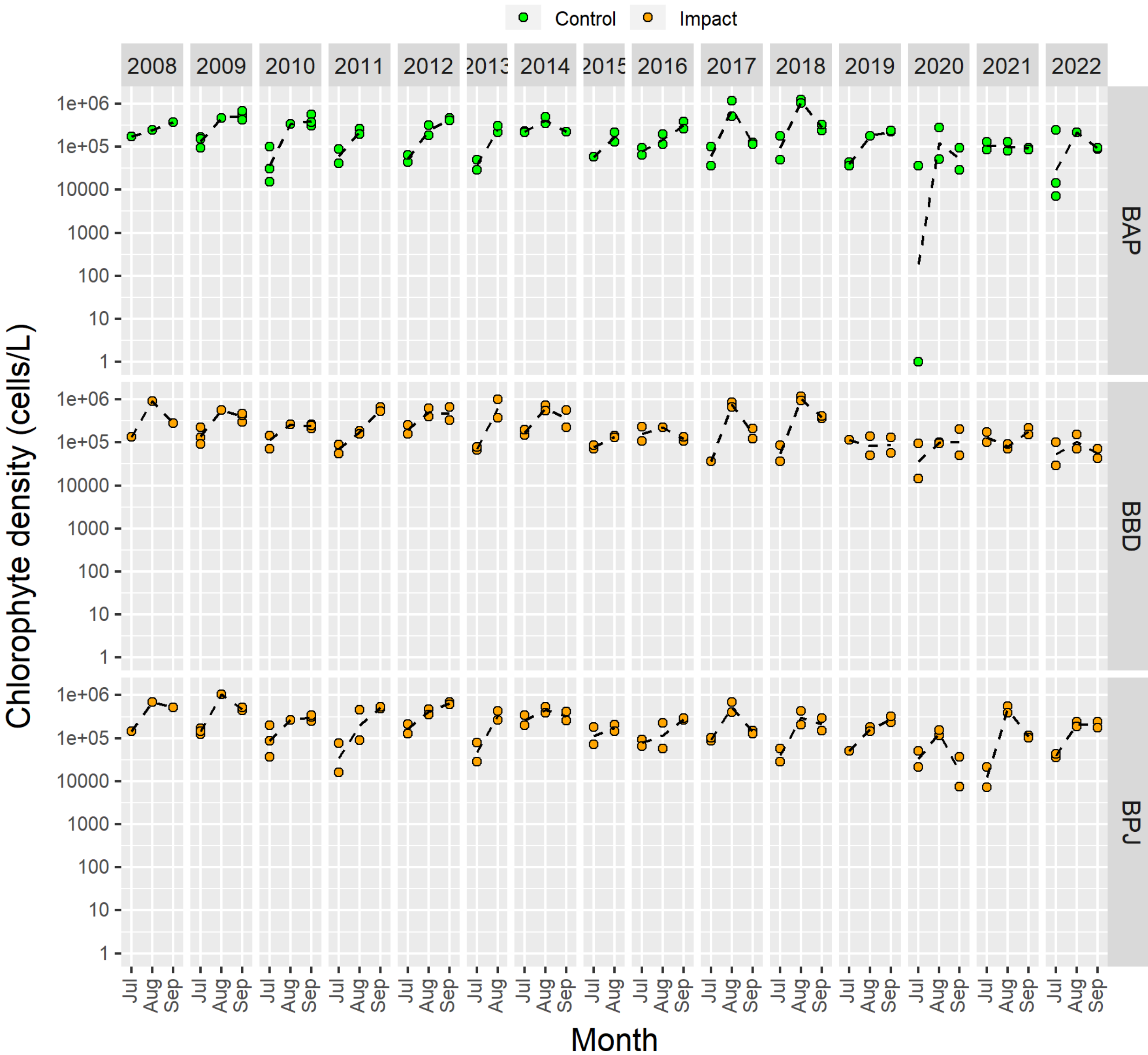


Figure D3-11. Chrysophyte density (cells/L) from Baker Lake since 2008.

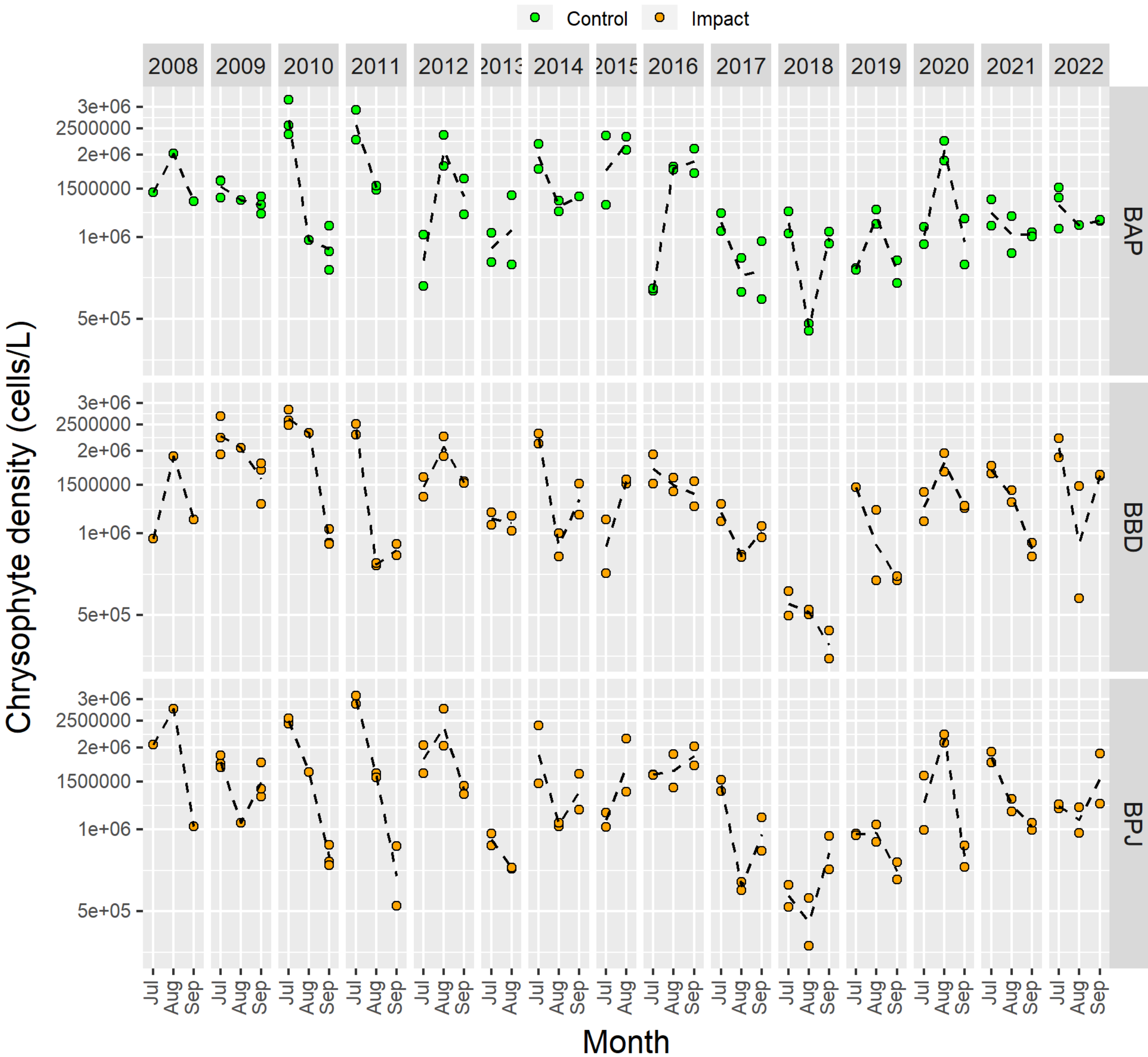


Figure D3-12. Diatoms density (cells/L) from Baker Lake since 2008.

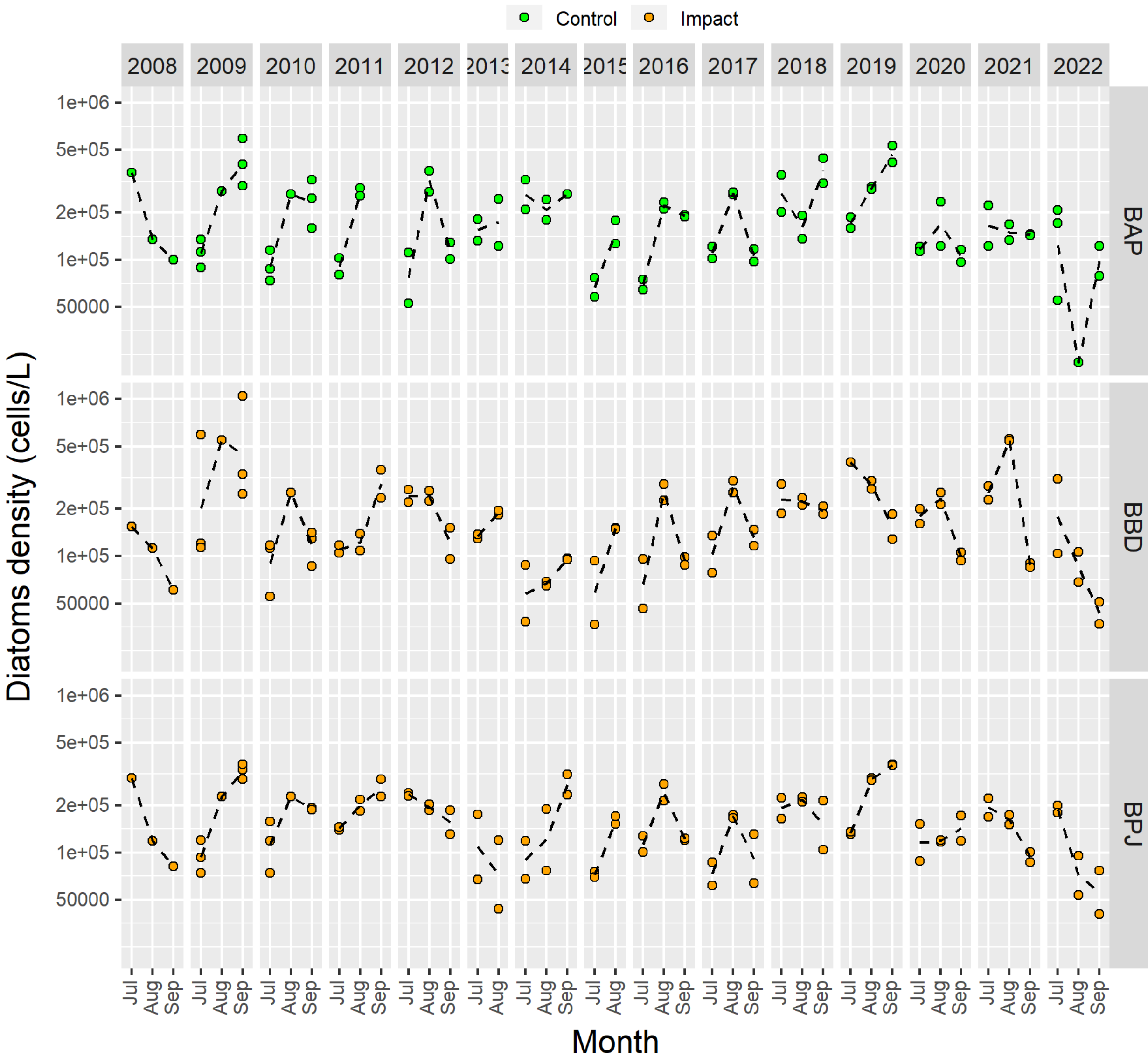


Figure D3-13. Cryptophytes density (cells/L) from Baker Lake since 2008.

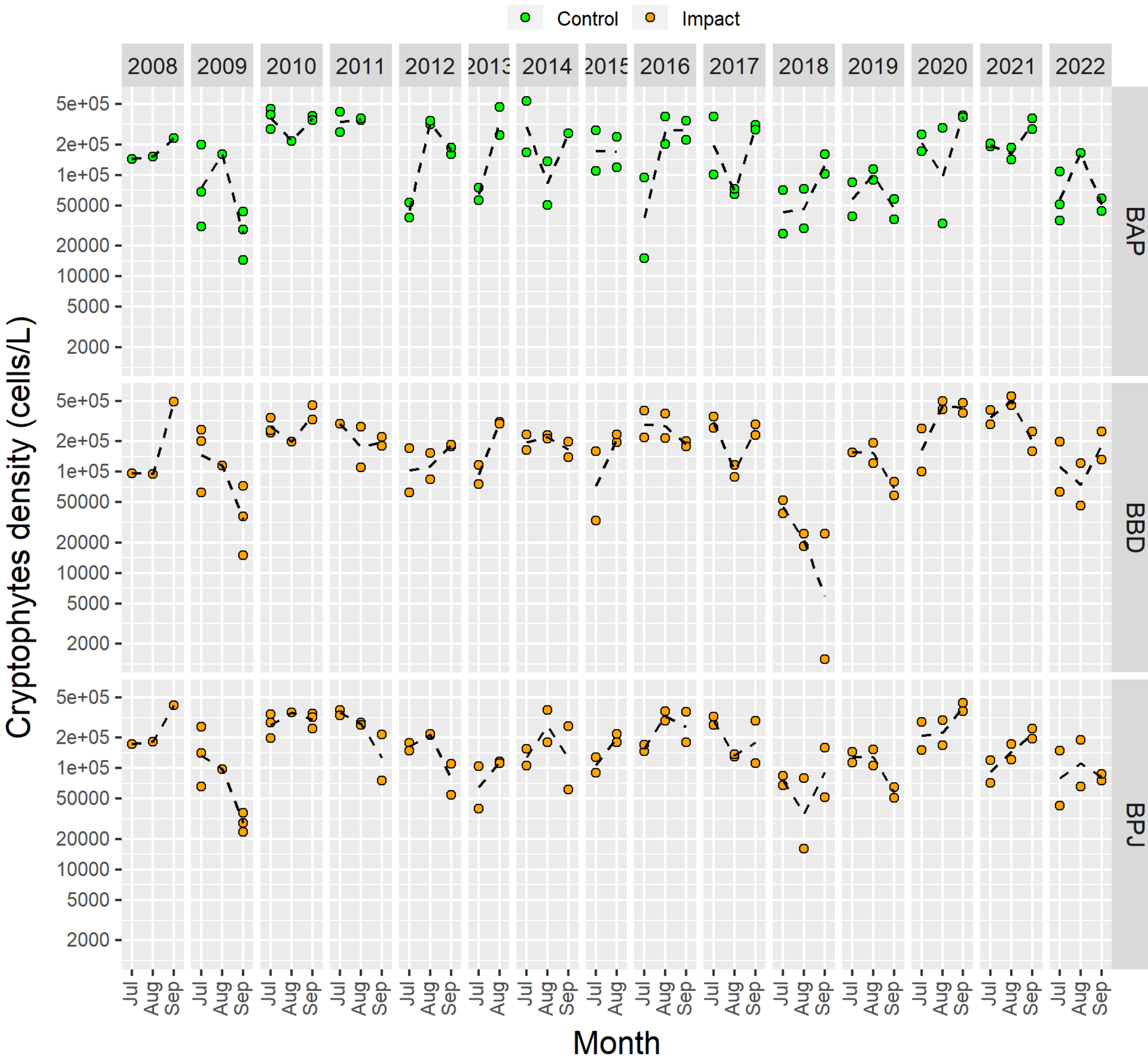


Figure D3-14. Dinoflagellate density (cells/L) from Baker Lake since 2008.

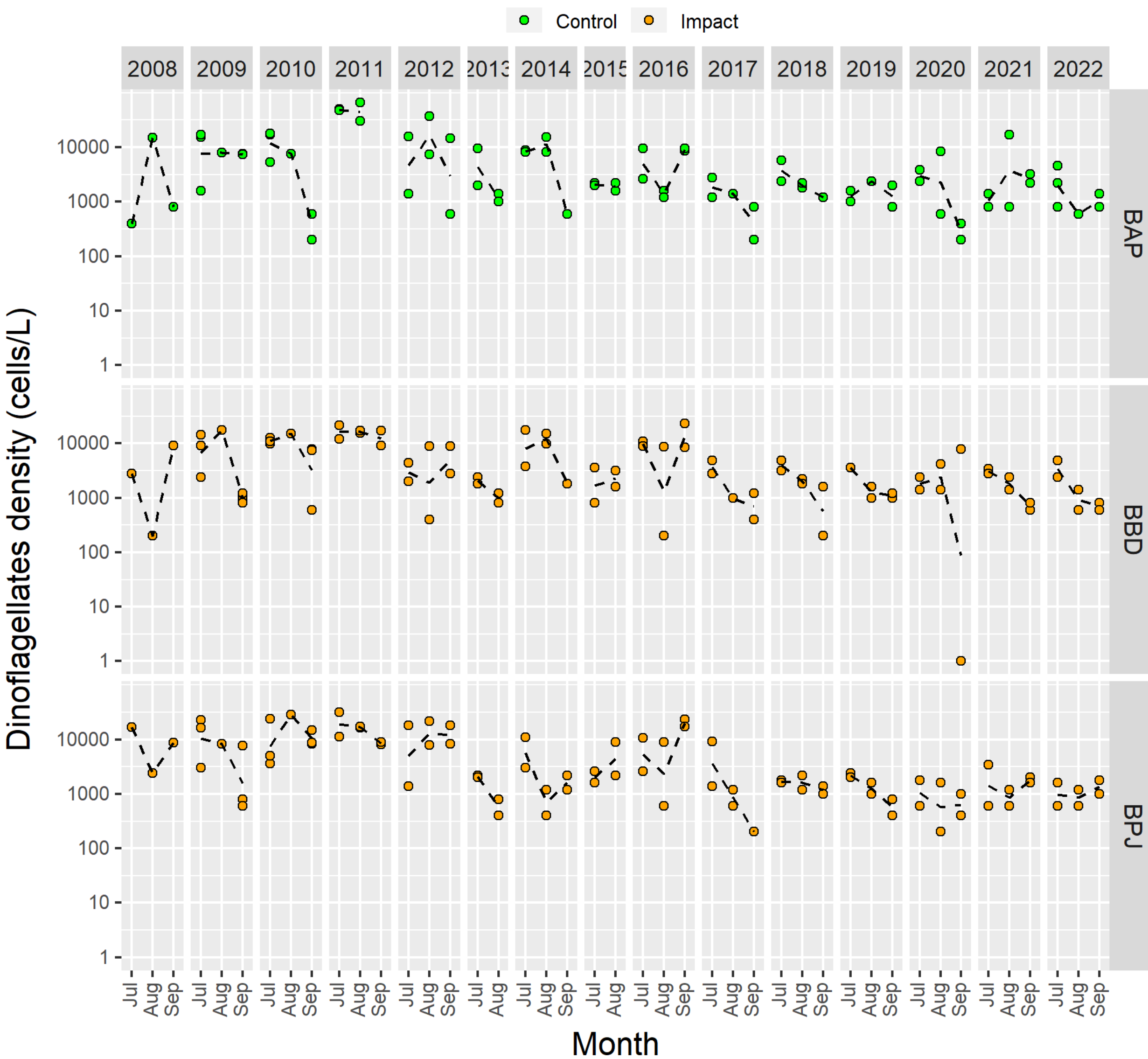
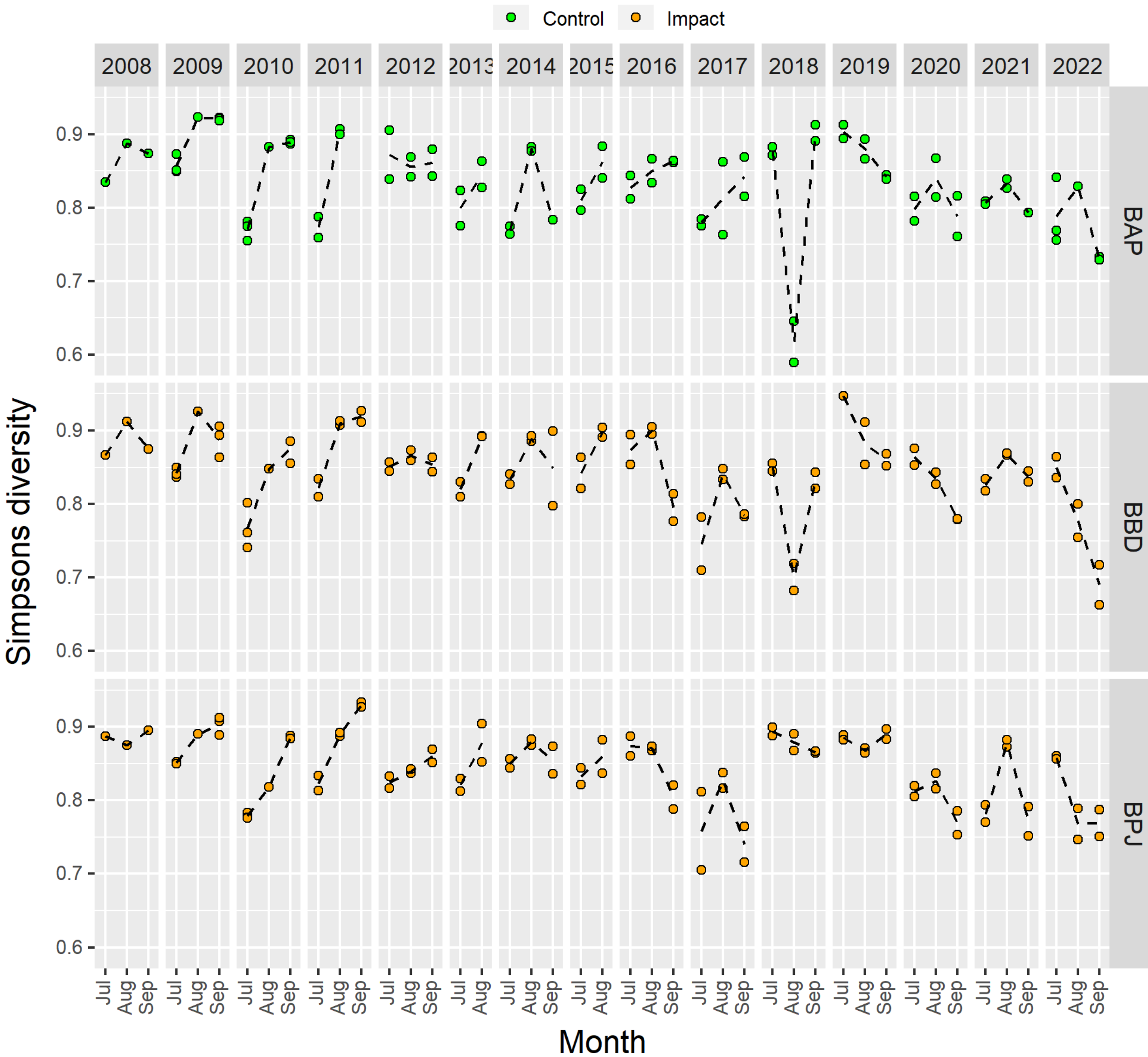


Figure D3-15. Simpsons' Diversity for the phytoplankton community from Baker Lake since 2008.



APPENDIX E
BENTHOS TAXONOMY DATA AND SUPPLEMENTAL PLOTS

Appendix E1

Benthos Data – Meadowbank Study Area Lakes

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Table E1-1. Benthic invertebrate abundance (#/m2) and richness (# taxa) by major taxa group, Meadowbank study area lakes, 2022.

Area-Replicate	Date	Depth (m)	Abundance (#/m^2)					Richness (# taxa)					Simpson's Diversity	Bray-Curtis Index
			Oligochaetes	Insects	Molluscs	Other Taxa[1]	TOTAL	Oligochaetes	Insects	Molluscs	Other Taxa[1]	TOTAL		
Inuggugayualik Lake														
INUG-1	14-Aug-22	8.4	65	391	283	0	739	3	6	2	0	11	0.85	0.13
INUG-2	14-Aug-22	7.8	22	239	304	22	587	1	4	3	1	9	0.87	0.17
INUG-3	14-Aug-22	8.3	43	1,326	326	22	1,717	2	8	3	1	14	0.77	0.33
INUG-4	14-Aug-22	8.4	43	1,087	196	22	1,348	1	7	3	1	12	0.73	0.35
INUG-5	14-Aug-22	9	43	870	457	22	1,391	1	10	3	1	15	0.91	0.19
Area Mean			***43***	***783***	***313***	***17***	***1,157***	***1.6***	***7.0***	***2.8***	***0.8***	***12.2***	***0.83***	***0.23***
Pipedream Lake														
PDL-1	15-Aug-22	7.3	43	1,217	261	22	1,543	2	8	1	1	12	0.71	0.46
PDL-2	15-Aug-22	7.0	22	370	239	0	630	1	6	2	0	9	0.85	0.15
PDL-3	15-Aug-22	7.5	65	739	478	0	1,283	2	7	2	0	11	0.81	0.34
PDL-4	15-Aug-22	7.0	65	196	326	22	609	1	3	2	1	7	0.77	0.18
PDL-5	15-Aug-22	6.8	0	870	217	0	1,087	0	4	2	0	6	0.62	0.43
Area Mean			***39***	***678***	***304***	***8.7***	***1,030***	***1.2***	***5.6***	***1.8***	***0.4***	***9.0***	***0.75***	***0.31***
Second Portage Lake														
SP-1	11-Aug-22	9	109	783	652	22	1,565	3	6	2	1	12	0.85	0.31
SP-2	11-Aug-22	6.9	22	1,239	391	87	1,739	1	7	2	1	11	0.86	0.40
SP-3	11-Aug-22	8.3	43	348	370	43	804	2	5	2	1	10	0.81	0.28
SP-4	11-Aug-22	8.3	22	457	261	0	739	1	6	2	0	9	0.81	0.31
SP-5	11-Aug-22	8.3	22	435	283	65	804	1	6	2	1	10	0.85	0.28
Area Mean			***43***	***652***	***391***	***43***	***1,130***	***1.6***	***6.0***	***2.0***	***0.8***	***10.4***	***0.84***	***0.31***
Third Portage Lake - East Basin														
TPE-1	13-Aug-22	7.8	304	2,913	522	0	3,739	3	8	2	0	13	0.81	0.63
TPE-2	13-Aug-22	8.9	391	1,957	457	0	2,804	3	9	2	0	14	0.84	0.49
TPE-3	13-Aug-22	8.5	174	2,087	500	43	2,804	5	8	2	1	16	0.82	0.51
TPE-4	13-Aug-22	8.4	43	2,217	696	22	2,978	1	10	2	1	14	0.75	0.58
TPE-5	13-Aug-22	6.8	65	543	239	22	870	1	5	2	1	9	0.78	0.44
Area Mean			***196***	***1,943***	***483***	***17***	***2,639***	***2.6***	***8.0***	***2.0***	***0.6***	***13.2***	***0.80***	***0.53***
Third Portage Lake - North Basin														
TPN-1	17-Aug-22	8.5	0	413	109	0	522	0	6	1	0	7	0.86	0.22
TPN-2	17-Aug-22	7.9	65	652	217	22	957	2	9	2	1	14	0.89	0.23
TPN-3	17-Aug-22	8.5	22	913	370	130	1,435	1	9	2	1	13	0.79	0.32
TPN-4	17-Aug-22	8.4	65	457	261	65	848	2	7	2	2	13	0.90	0.24
TPN-5	17-Aug-22	7.7	22	913	109	22	1,065	1	8	2	1	12	0.87	0.32
Area Mean			***35***	***670***	***213***	***48***	***965***	***1.2***	***7.8***	***1.8***	***1.0***	***11.8***	***0.86***	***0.27***
Wally Lake														
WAL-1	13-Aug-22	8.6	22	2,217	261	22	2,522	1	7	2	1	11	0.69	0.59
WAL-2	13-Aug-22	8	65	4,543	543	22	5,174	2	7	2	1	12	0.54	0.77
WAL-3	13-Aug-22	8.6	22	2,804	348	43	3,217	1	11	2	2	16	0.77	0.61
WAL-4	13-Aug-22	9.2	174	6,370	739	43	7,326	2	10	2	1	15	0.71	0.79
WAL-5	13-Aug-22	8.7	22	3,217	348	22	3,609	1	8	2	1	12	0.77	0.68
Area Mean			***61***	***3,830***	***448***	***30***	***4,370***	***1.4***	***8.6***	***2.0***	***1.2***	***13.2***	***0.69***	***0.69***

Notes:

1. "Other taxa" includes flatworms (Turbellaria) and arthropods (Acalyptonotidae, Hygrobatidae, Lebertiidae, Oxidae, Pionidae, Harpacticoida, O. Notostraca, and Gammaracanthidae).

Table E1-2. Raw benthic invertebrate data from the Meadowbank study area lakes 2022.

Program	Meadowbank									
Location	Inuggugayualik Lake					Pipedream Lake				
Station	INUG					PDL				
Control/Impact?	Control					Control				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22
Sample Depth (m)	8.4	7.8	8.3	8.4	9.0	7.3	7.0	7.5	7.0	6.8
ROUNDWORMS										
P. Nemata	1	1	2	-	-	15	1	1	1	5
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	-	-	-	-	-	-	-	-	-	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	-	-	-	-	-	-	-	-
F. Naididae										
S.F. Naidinae										
Nais	-	-	-	-	-	-	-	-	-	-
S.F. Tubificinae										
Tasserkidrilus americanus	1	-	1	-	1	-	-	-	-	-
immatures with hair chaetae	-	-	-	-	1	1	1	1	-	-
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus	1	1	-	2	-	-	-	-	-	-
F. Lumbriculidae										
Lumbriculus	1	-	1	-	-	1	-	2	3	-
LEECHES										
Cl. Hirudinea										
F. Piscicolidae										
immature	-	-	-	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										
F. Acalyptonotidae										
Acalyptonotus	-	-	-	-	-	-	-	-	-	-
F. Hygrobatidae										
Hygrobates	-	-	-	-	-	-	-	-	-	-
F. Lebertiidae										
Lebertia	-	-	-	-	-	1	-	-	1	-
F. Oxidae										
Oxus	-	1	1	1	1	-	-	-	-	-
F. Pionidae										
indeterminate	-	-	-	-	-	-	-	-	-	-
HARPACTICOIDS										
O. Harpacticoida	-	-	-	-	-	-	-	-	-	-
SEED SHRIMPS										
Cl. Ostracoda	2	1	1	3	1	20	8	8	6	8
INSECTS										
Cl. Insecta										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae										
immature	-	-	-	-	-	-	-	-	-	-
F. Limnephilidae										
Grensia praeterita	-	-	-	-	-	-	-	1	-	-
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae	-	1	-	-	5	-	-	-	-	-
S.F. Chironominae										
Chironomus	-	-	-	-	-	-	-	-	-	-
Cladotanytarsus	-	-	-	-	-	-	-	-	-	-
Constempellina	-	-	-	-	-	-	-	-	-	-
Corynocera ambigua	1	-	1	4	-	-	-	-	-	-
?Corynocera oliveri	-	-	-	-	-	-	-	-	-	-
Dicrotendipes	-	-	-	-	1	-	-	-	-	-
Micropsectra	8	6	35	31	12	1	1	1	-	-
Microtendipes	3	-	7	4	3	-	-	-	-	-
Paratanytarsus	-	-	2	-	-	1	-	-	-	-
Paratendipes	-	-	-	-	-	-	-	-	-	-
Sergentia	-	-	-	-	-	-	-	-	-	-
Stempellinella	-	-	-	-	-	-	-	-	-	-
Stictochironomus	3	2	7	5	9	34	6	20	6	30
Tanytarsus	-	-	-	1	2	-	-	1	-	-
S.F. Diamesinae										
Protanypus	-	-	1	1	2	-	1	-	-	3
Potthastia	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Abiskomyia	-	-	-	-	-	1	-	-	-	-
Cricotopus/Orthocladius	-	-	-	-	-	-	-	-	-	-
Heterotrissocladius	-	-	-	-	-	-	-	-	-	-
Mesocricotopus	-	-	-	-	-	-	-	-	-	-
Psectrocladius	-	-	-	-	-	1	-	-	-	-
Zalutschia	-	-	-	-	-	-	-	-	-	-
Orthocladiinae Genus "Greenland"	-	-	-	-	-	-	-	-	-	-
indeterminate	-	-	-	-	1	-	-	-	-	-
S.F. Prodiamesinae										
Monodiamesa	-	1	1	-	2	1	2	2	2	5
S.F. Tanypodinae										
Ablabesmyia	-	-	-	-	-	-	-	-	-	-
Procladius	2	-	7	4	2	15	4	6	1	2
Thienemannimyia complex	-	-	-	-	1	2	3	3	-	-
F. Empididae										
Chelifera/Metachela	1	1	-	-	-	-	-	-	-	-
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata	-	-	-	-	-	-	-	-	-	-
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
Pisidium/Cyclocalyx	10	7	8	5	9	12	9	8	12	6
Pisidium (Cyclocalyx/Neopisidium)	3	4	6	3	7	-	2	14	3	4
Sphaerium nitidum	-	3	1	1	5	-	-	-	-	-

Table E1-2. Raw benthic invertebrate data from the Meadowbank study area lakes 2022.

Program	Meadowbank									
Location	Inuggugayualik Lake					Pipedream Lake				
Station	INUG					PDL				
Control/Impact?	Control					Control				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22
Sample Depth (m)	8.4	7.8	8.3	8.4	9.0	7.3	7.0	7.5	7.0	6.8
R (Richness) - totals [2,3]										
Total	11	9	14	12	15	12	9	11	7	6
Oligochaete	3	1	2	1	1	2	1	2	1	0
Insect	6	4	8	7	10	8	6	7	3	4
Mollusc	2	3	3	3	3	1	2	2	2	2
Other[4]	0	1	1	1	1	1	0	0	1	0
Abundance (raw) - totals [5,6]										
Total	34	27	79	62	64	71	29	59	28	50
Oligochaete	3	1	2	2	2	2	1	3	3	0
Insect	18	11	61	50	40	56	17	34	9	40
Mollusc	13	14	15	9	21	12	11	22	15	10
Other[4]	0	1	1	1	1	1	0	0	1	0
N (Abundance) - #/m^2										
Total	739	587	1,717	1,348	1,391	1,543	630	1,283	609	1,087
Oligochaete	65	22	43	43	43	43	22	65	65	0
Insect	391	239	1,326	1,087	870	1,217	370	739	196	870
Mollusc	283	304	326	196	457	261	239	478	326	217
Other[4]	0	22	22	22	22	22	0	0	22	0

Notes:

1. Benthic invertebrate count data shown in this table are from composite of two grabs sieved to 500 µm.
2. Richness totals exclude P. Nemata, Cl. Ostracoda, indeterminates (O. Acarina, F. Lumbriculidae), immatures (S.F. Tubificinae, O. Acarina), and pupae.
3. Pupae and immatures (bolded values) are excluded from the richness totals if other life stages are present in the replicate sample.
4. Other Taxa include: Cl. Turbellaria, F. Acalyptonotidae, F. Hygrobatidae, F. Lebertiidae, F. Oxidae, F. Pionidae, O. Harpacticoida, O. Notostraca, and F. Gammaracanthidae.
5. Abundance totals exclude P. Nemata and Cl. Ostracoda.
6. Raw abundance from two grabs (grab area = 0.023 m^2).

Table E1-2. Raw benthic invertebrate data from the Meadowbank study area lakes 2022.

Program	Meadowbank									
Location	Second Portage Lake					Third Portage Lake - East Basin				
Station	SP					TPE				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	11-Aug-22	11-Aug-22	11-Aug-22	11-Aug-22	11-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22
Sample Depth (m)	9.0	6.9	8.3	8.3	8.3	7.8	8.9	8.5	8.4	6.8
ROUNDWORMS										
P. Nemata	2	6	3	11	5	-	5	5	7	2
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	-	-	-	-	-	-	-	-	-	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	-	-	-	-	-	1	-	-
F. Naididae										
S.F. Naidinae										
Nais	-	-	-	-	-	-	1	1	-	-
S.F. Tubificinae										
Tasserkidrilus americanus	-	-	-	-	-	-	-	-	-	-
immatures with hair chaetae	2	-	-	-	1	4	-	1	-	-
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus	2	1	1	-	-	2	16	3	2	-
F. Lumbriculidae										
Lumbriculus	1	-	1	1	-	8	1	2	-	3
LEECHES										
Cl. Hirudinea										
F. Piscicolidae										
immature	-	-	-	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										
F. Acalyptonotidae										
Acalyptonotus	-	-	-	-	-	-	-	-	-	1
F. Hygrobatidae										
Hygrobates	-	-	-	-	-	-	-	-	-	-
F. Lebertiidae										
Lebertia	-	-	-	-	-	-	-	2	1	-
F. Oxidae										
Oxus	1	4	2	-	3	-	-	-	-	-
F. Pionidae										
indeterminate	-	-	-	-	-	-	-	-	-	-
HARPACTICOIDS										
O. Harpacticoida	-	-	-	-	-	-	-	-	-	-
SEED SHRIMPS										
Cl. Ostracoda	8	12	1	-	-	122	136	114	40	35
INSECTS										
Cl. Insecta										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae										
immature	-	-	-	-	-	-	-	-	-	-
F. Limnephilidae										
Grensia praeterita	-	-	-	-	-	-	-	-	-	-
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae	-	2	-	1	-	2	9	3	2	1
S.F. Chironominae										
Chironomus	-	-	-	-	-	-	-	-	-	-
Cladotanytarsus	-	-	-	-	-	-	-	-	-	-
Constempellina	-	-	-	-	-	-	-	-	-	-
Corynocera ambigua	-	-	-	1	-	-	-	-	-	-
?Corynocera oliveri	-	-	-	-	-	-	-	-	-	-
Dicrotendipes	-	-	-	-	-	-	-	-	-	-
Micropsectra	7	18	3	1	2	4	10	5	20	-
Microtendipes	5	18	-	-	-	-	-	-	-	-
Paratanytarsus	-	1	1	-	1	62	43	47	60	17
Paratendipes	-	-	-	-	-	-	-	-	-	-
Sergentia	-	-	-	-	-	-	-	-	-	-
Stempellinella	-	-	-	-	-	-	-	-	-	-
Stictochironomus	6	2	2	2	3	32	9	11	3	1
Tanytarsus	-	4	-	-	-	2	1	1	2	-
S.F. Diamesinae										
Protanypus	1	-	-	1	1	-	-	-	3	-
Potthastia	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Abiskomyia	-	-	-	-	-	-	-	-	-	-
Cricotopus/Orthocladius	-	-	-	-	-	-	-	-	-	-
Heterotrissocladius	-	-	-	-	-	-	-	-	1	-
Mesocricotopus	-	-	-	-	-	-	-	-	-	-
Psectrocladius	-	-	-	-	-	-	-	-	-	-
Zalutschia	-	-	-	-	-	-	-	-	1	-
Orthocladiinae Genus "Greenland"	-	-	-	-	-	-	1	-	-	-
indeterminate	-	-	-	-	-	-	1	-	-	-
S.F. Prodiamesinae										
Monodiamesa	1	3	1	3	3	2	2	2	1	2
S.F. Tanypodinae										
Ablabesmyia	-	-	-	-	-	-	-	1	-	-
Procladius	16	9	9	12	10	12	11	20	7	1
Thienemannimyia complex	-	-	-	-	-	14	3	6	2	3
F. Empididae										
Chelifera/Metachela	-	-	-	-	-	4	-	-	-	-
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata	-	-	-	-	-	-	-	-	-	-
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
Pisidium/Cyclocalyx	16	12	13	8	10	12	11	14	24	6
Pisidium (Cyclocalyx/Neopisidium)	14	6	4	4	3	12	10	9	8	5
Sphaerium nitidum	-	-	-	-	-	-	-	-	-	-

Table E1-2. Raw benthic invertebrate data from the Meadowbank study area lakes 2022.

Program	Meadowbank									
Location	Second Portage Lake					Third Portage Lake - East Basin				
Station	SP					TPE				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	11-Aug-22	11-Aug-22	11-Aug-22	11-Aug-22	11-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22
Sample Depth (m)	9.0	6.9	8.3	8.3	8.3	7.8	8.9	8.5	8.4	6.8
R (Richness) - totals [2,3]										
Total	12	11	10	9	10	13	14	16	14	9
Oligochaete	3	1	2	1	1	3	3	5	1	1
Insect	6	7	5	6	6	8	9	8	10	5
Mollusc	2	2	2	2	2	2	2	2	2	2
Other[4]	1	1	1	0	1	0	0	1	1	1
Abundance (raw) - totals [5,6]										
Total	72	80	37	34	37	172	129	129	137	40
Oligochaete	5	1	2	1	1	14	18	8	2	3
Insect	36	57	16	21	20	134	90	96	102	25
Mollusc	30	18	17	12	13	24	21	23	32	11
Other[4]	1	4	2	0	3	0	0	2	1	1
N (Abundance) - #/m²										
Total	1,565	1,739	804	739	804	3,739	2,804	2,804	2,978	870
Oligochaete	109	22	43	22	22	304	391	174	43	65
Insect	783	1,239	348	457	435	2,913	1,957	2,087	2,217	543
Mollusc	652	391	370	261	283	522	457	500	696	239
Other[4]	22	87	43	0	65	0	0	43	22	22

Notes:

1. Benthic invertebrate count data shown in this table are from composite of two grabs sieved to 500 µm.
2. Richness totals exclude P. Nemata, Cl. Ostracoda, indeterminates (O. Acarina, F. Lumbriculidae), immatures (S.F. Tubificinae, O. Acarina), and pupae.
3. Pupae and immatures (bolded values) are excluded from the richness totals if other life stages are present in the replicate sample.
4. Other Taxa include: Cl. Turbellaria, F. Acalyptonotidae, F. Hygrobatidae, F. Lebertiidae, F. Oxidae, F. Pionidae, O. Harpacticoida, O. Notostraca, and F. Gammaracanthidae.
5. Abundance totals exclude P. Nemata and Cl. Ostracoda.
6. Raw abundance from two grabs (grab area = 0.023 m^2).

Table E1-2. Raw benthic invertebrate data from the Meadowbank study area lakes 2022.

Program	Meadowbank									
Location	Third Portage Lake - North Basin					Wally Lake				
Station	TPN					WAL				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22
Sample Depth (m)	8.5	7.9	8.5	8.4	7.7	8.6	8.0	8.6	9.2	8.7
ROUNDWORMS										
P. Nemata	7	1	-	6	1	1	7	1	1	2
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	-	-	-	2	-	1	-	1	-	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	-	-	-	-	-	-	-	1
F. Naididae										
S.F. Naidinae										
Nais	-	-	-	-	-	-	-	-	-	-
S.F. Tubificinae										
Tasserkidrilus americanus	-	-	-	-	-	-	-	-	-	-
immatures with hair chaetae	-	-	-	-	-	-	-	-	-	-
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus	-	2	-	1	-	-	2	-	3	-
F. Lumbriculidae										
Lumbriculus	-	1	1	2	1	1	1	1	5	-
LEECHES										
Cl. Hirudinea										
F. Piscicolidae										
immature	-	-	-	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										
F. Acalyptonotidae										
Acalyptonotus	-	1	6	1	-	-	-	1	2	-
F. Hygrobatidae										
Hygrobates	-	-	-	-	1	-	-	-	-	-
F. Lebertiidae										
Lebertia	-	-	-	-	-	-	1	-	-	1
F. Oxidae										
Oxus	-	-	-	-	-	-	-	-	-	-
F. Pionidae										
indeterminate	-	-	-	-	-	-	-	-	-	-
HARPACTICOIDS										
O. Harpacticoida	-	-	-	-	-	-	-	-	-	-
SEED SHRIMPS										
Cl. Ostracoda	32	11	11	4	22	2	12	21	19	14
INSECTS										
Cl. Insecta										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae										
immature	-	-	-	-	-	-	-	-	-	-
F. Limnephilidae										
Grensia praeterita	-	-	-	-	1	-	-	1	-	-
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae	-	-	-	1	5	1	1	-	-	1
S.F. Chironominae										
Chironomus	-	-	-	-	-	-	-	-	-	-
Cladotanytarsus	-	-	-	-	-	2	-	1	20	**1**
Constempellina	-	-	-	-	-	-	-	-	-	-
Corynocera ambigua	-	-	-	-	-	62	158	62	170	59
?Corynocera oliveri	-	-	-	-	-	-	-	-	-	-
Dicrotendipes	-	-	-	-	-	-	-	-	-	-
Micropsectra	4	3	4	2	13	8	2	10	6	17
Microtendipes	-	-	-	-	-	-	-	-	-	-
Paratanytarsus	-	1	-	1	3	3	8	16	53	15
Paratendipes	-	-	-	-	-	-	-	-	-	-
Sergentia	-	-	-	-	-	-	-	-	2	-
Stempellinella	-	-	-	-	-	-	-	-	-	-
Stictochironomus	5	6	26	5	-	15	26	28	16	46
Tanytarsus	-	4	1	5	-	6	7	3	16	5
S.F. Diamesinae										
Protanypus	-	-	-	-	-	-	1	-	-	2
Potthastia	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Abiskomyia	-	-	1	-	-	-	-	-	-	-
Cricotopus/Orthocladius	-	-	-	-	-	-	-	-	-	-
Heterotrissocladius	-	1	-	-	1	-	-	-	-	-
Mesocricotopus	-	-	-	-	-	-	-	-	-	-
Psectrocladius	1	1	2	-	1	-	-	1	-	-
Zalutschia	1	-	1	1	-	-	-	-	-	-
Orthocladiinae Genus "Greenland"	-	-	-	-	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-	-	-	-
S.F. Prodiamesinae										
Monodiamesa	-	1	1	-	2	-	-	2	2	-
S.F. Tanypodinae										
Ablabesmyia	-	-	-	-	-	-	-	-	2	-
Procladius	3	10	4	5	8	5	6	4	6	2
Thienemannimyia complex	5	3	2	1	8	-	-	1	-	-
F. Empididae										
Chelifera/Metachela	-	-	-	-	-	-	-	-	-	-
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata	-	-	-	-	-	-	-	-	-	-
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
Pisidium/Cyclocalyx	5	8	14	9	4	4	23	15	27	14
Pisidium (Cyclocalyx/Neopisidium)	-	2	3	3	1	8	2	1	7	2
Sphaerium nitidum	-	-	-	-	-	-	-	-	-	-

Table E1-2. Raw benthic invertebrate data from the Meadowbank study area lakes 2022.

Program	Meadowbank									
Location	Third Portage Lake - North Basin					Wally Lake				
Station	TPN					WAL				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22	13-Aug-22
Sample Depth (m)	8.5	7.9	8.5	8.4	7.7	8.6	8.0	8.6	9.2	8.7
R (Richness) - totals [2,3]										
Total	7	14	13	13	12	11	12	16	15	12
Oligochaete	0	2	1	2	1	1	2	1	2	1
Insect	6	9	9	7	8	7	7	11	10	8
Mollusc	1	2	2	2	2	2	2	2	2	2
Other[4]	0	1	1	2	1	1	1	2	1	1
Abundance (raw) - totals [5,6]										
Total	24	44	66	39	49	116	238	148	337	166
Oligochaete	0	3	1	3	1	1	3	1	8	1
Insect	19	30	42	21	42	102	209	129	293	148
Mollusc	5	10	17	12	5	12	25	16	34	16
Other[4]	0	1	6	3	1	1	1	2	2	1
N (Abundance) - #/m²										
Total	522	957	1,435	848	1,065	2,522	5,174	3,217	7,326	3,609
Oligochaete	0	65	22	65	22	22	65	22	174	22
Insect	413	652	913	457	913	2,217	4,543	2,804	6,370	3,217
Mollusc	109	217	370	261	109	261	543	348	739	348
Other[4]	0	22	130	65	22	22	22	43	43	22

Notes:

1. Benthic invertebrate count data shown in this table are from composite of two grabs sieved to 500 µm.
2. Richness totals exclude P. Nemata, Cl. Ostracoda, indeterminates (O. Acarina, F. Lumbriculidae), immatures (S.F. Tubificinae, O. Acarina), and pupae.
3. Pupae and immatures (bolded values) are excluded from the richness totals if other life stages are present in the replicate sample.
4. Other Taxa include: Cl. Turbellaria, F. Acalyptonotidae, F. Hygrobatidae, F. Lebertiidae, F. Oxidae, F. Pionidae, O. Harpacticoida, O. Notostraca, and F. Gammaracanthidae.
5. Abundance totals exclude P. Nemata and Cl. Ostracoda.
6. Raw abundance from two grabs (grab area = 0.023 m^2).

Figure E1-1. Oligochaete abundance (#/m²) from Meadowbank lakes since 2006.

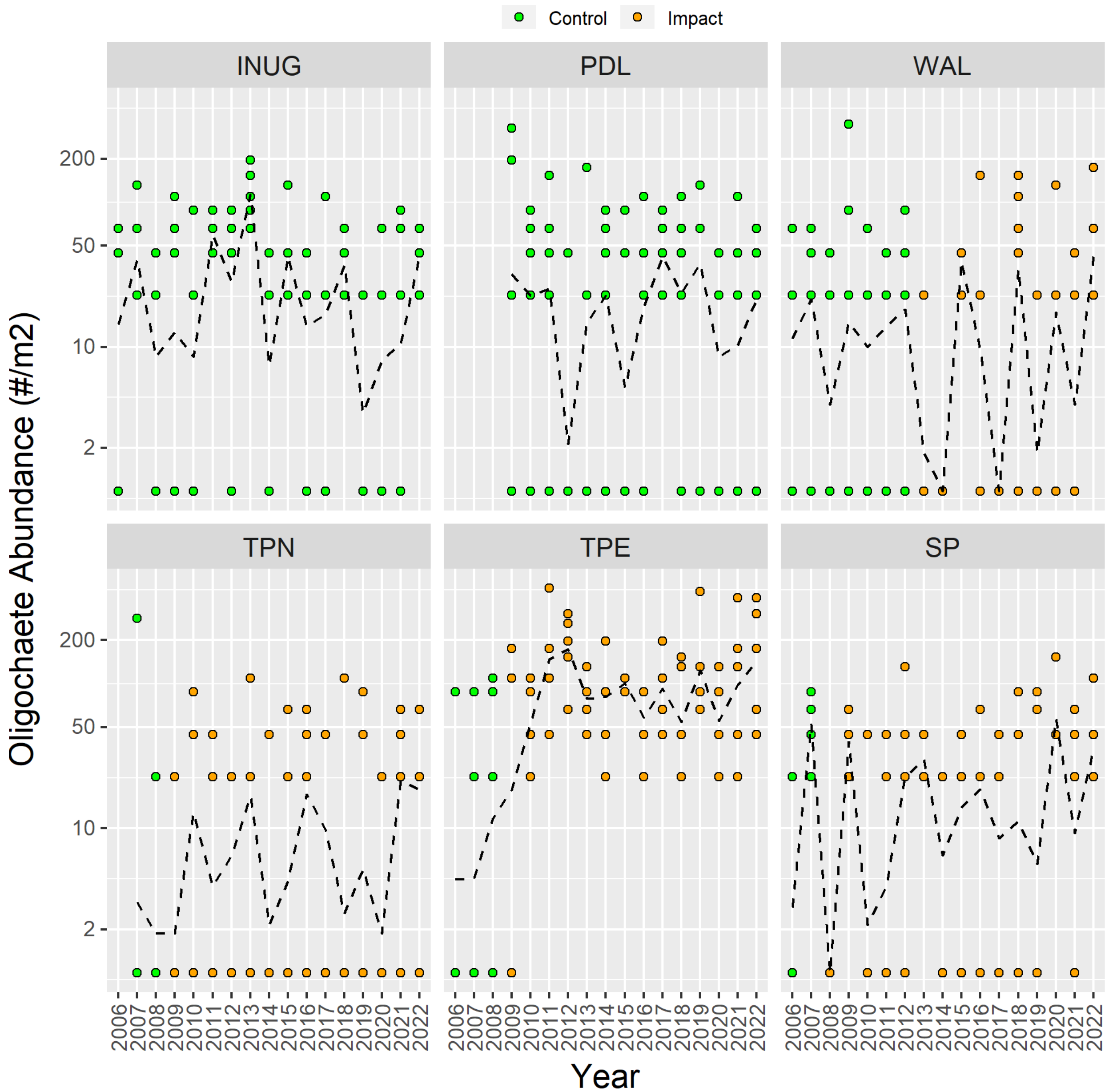


Figure E1-2. Insect abundance (#/m^2) from Meadowbank lakes since 2006.

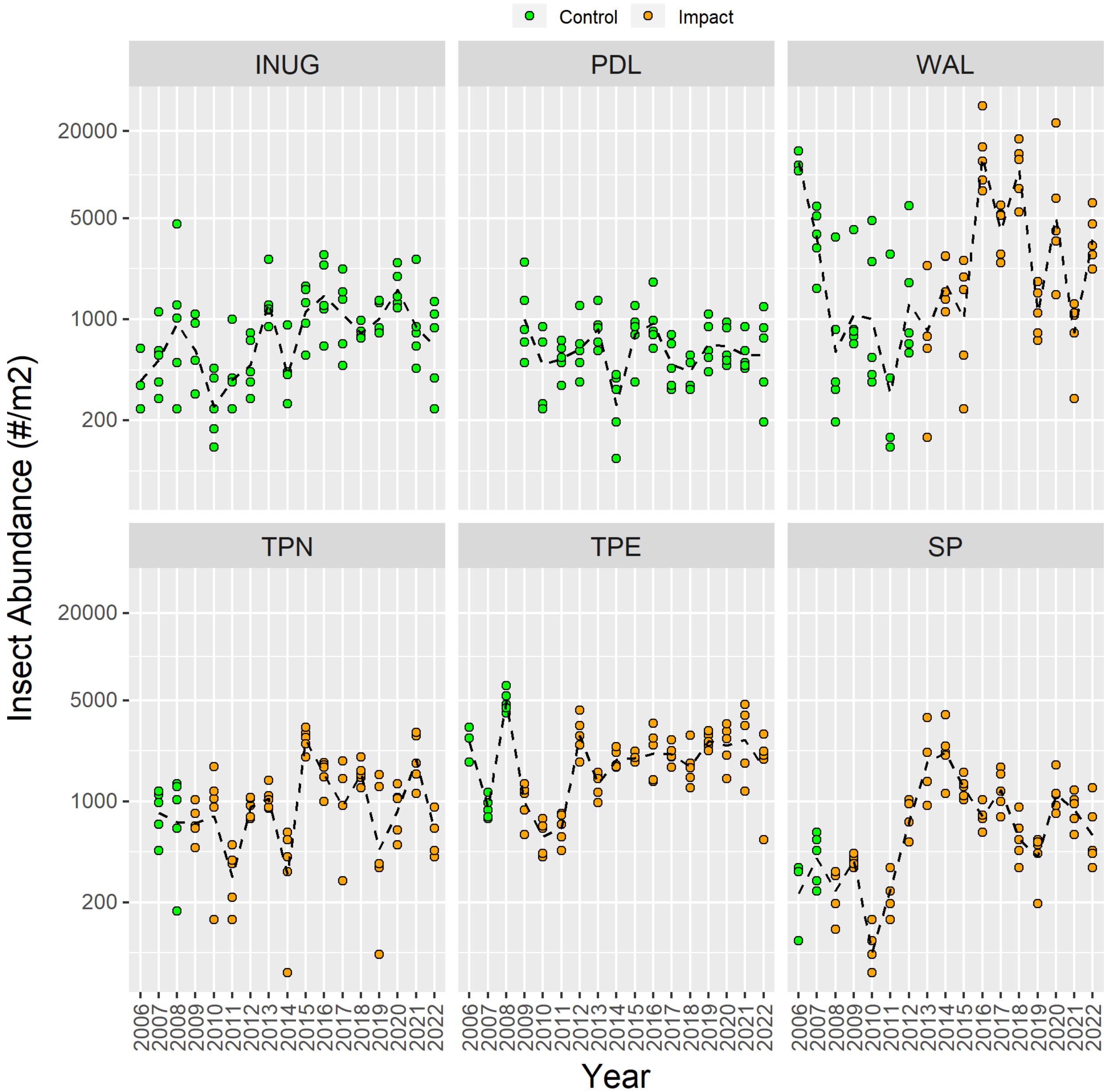


Figure E1-3. Mollusc abundance (#/m²) from Meadowbank lakes since 2006.

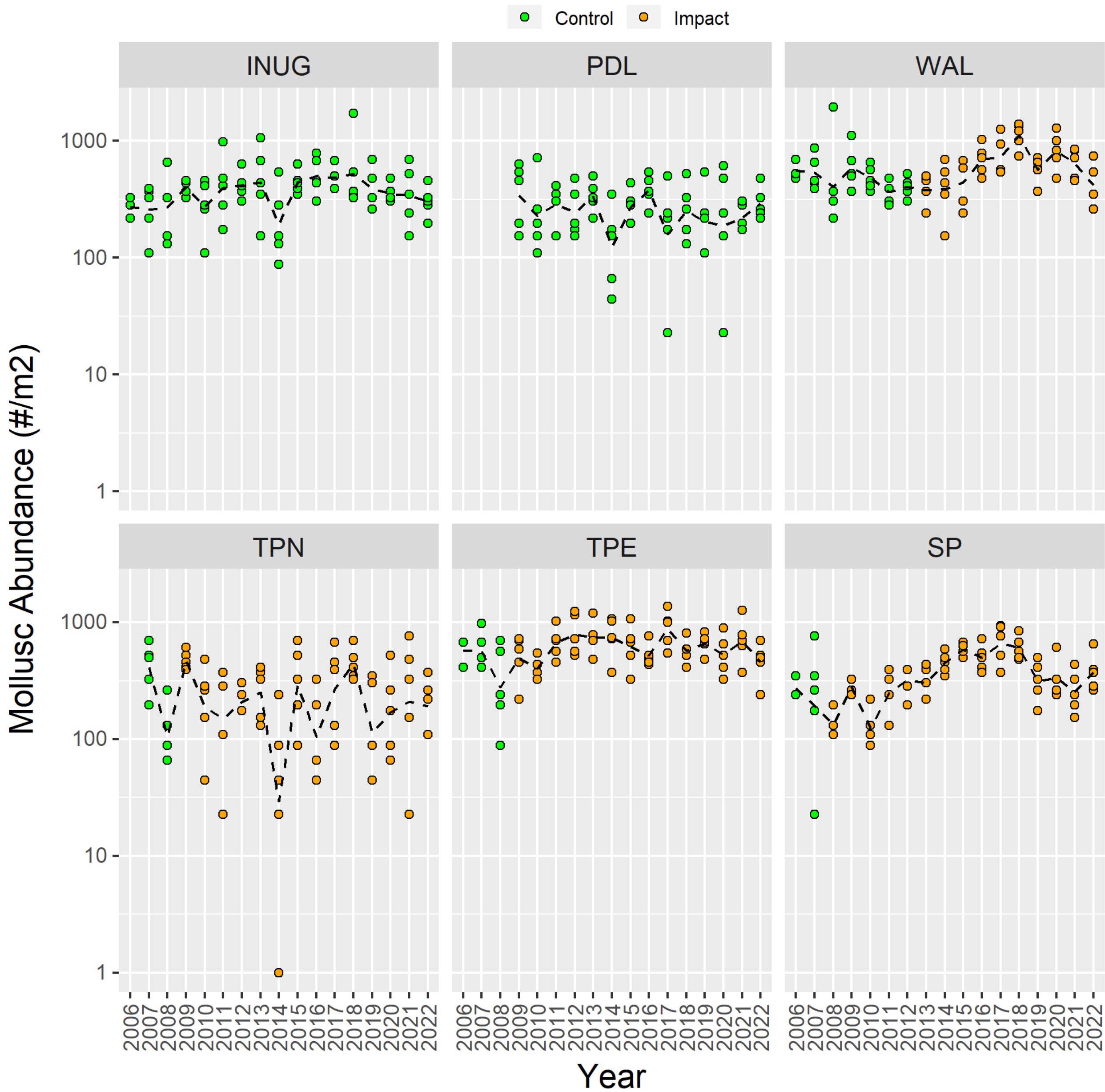


Figure E1-4. Other taxa abundance (#/m²) from Meadowbank lakes since 2006.

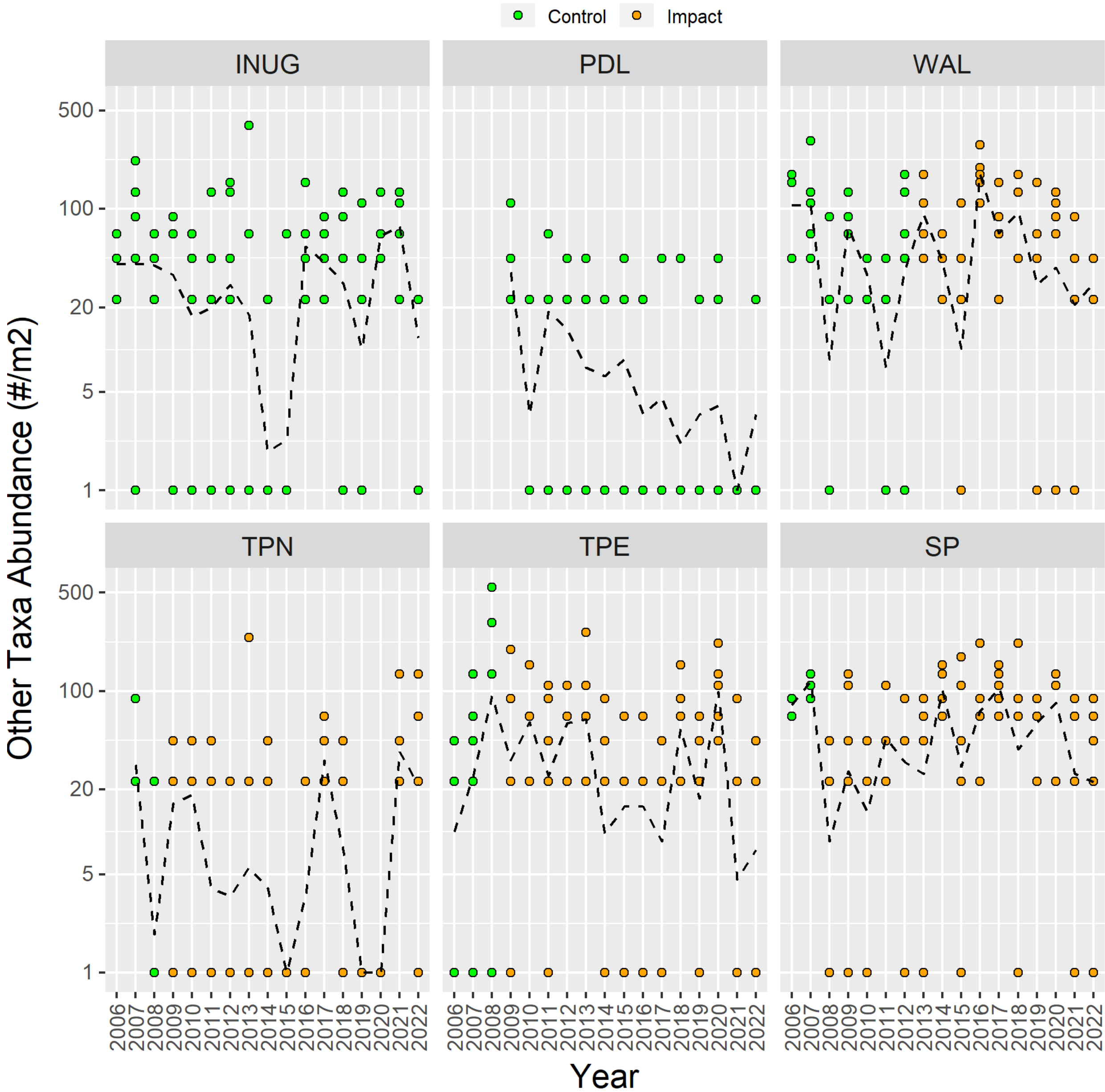


Figure E1-5. Oligochaete richness (# of taxa) from Meadowbank lakes since 2006.

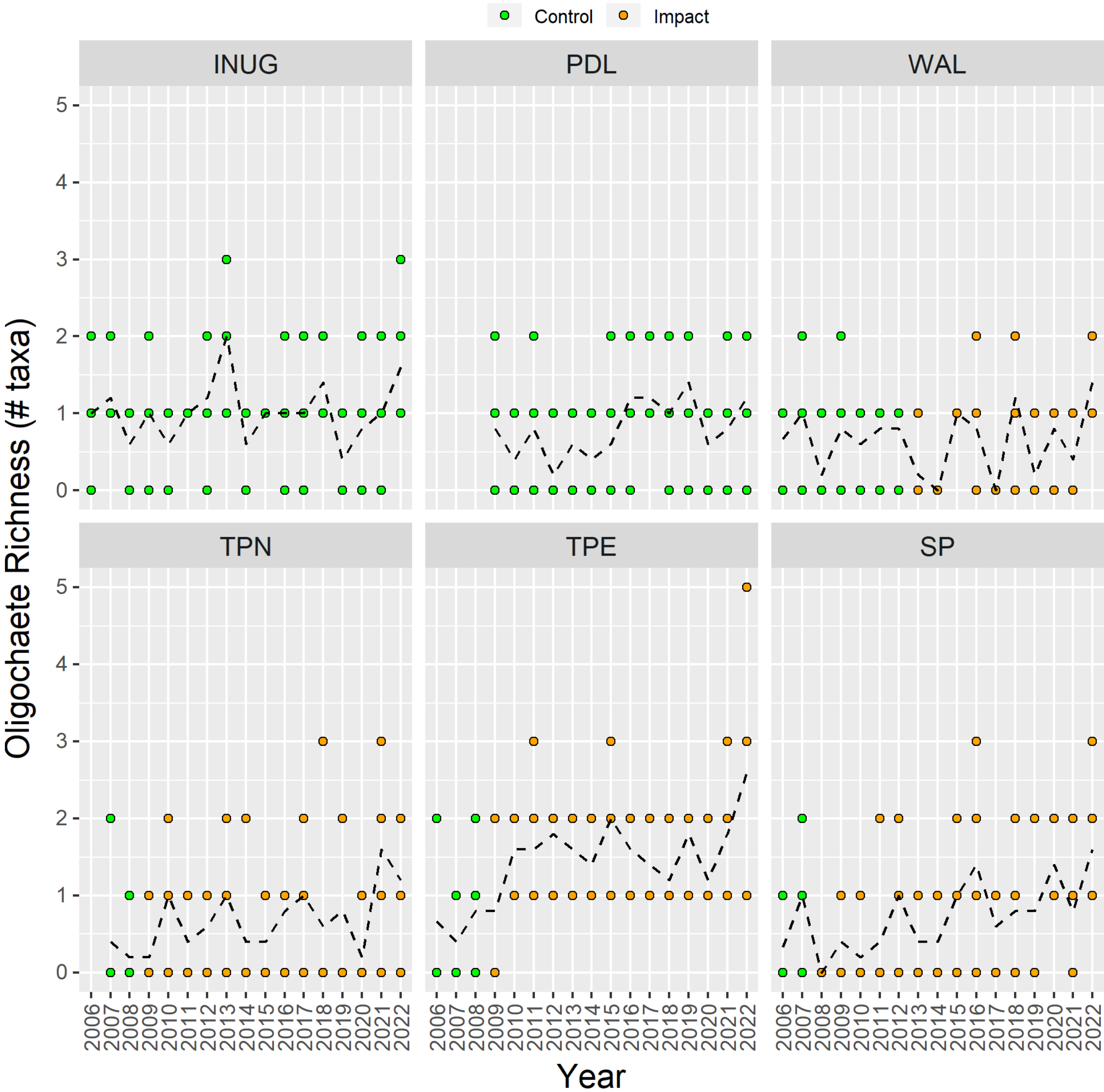


Figure E1-6. Insect richness (# of taxa) from Meadowbank lakes since 2006.

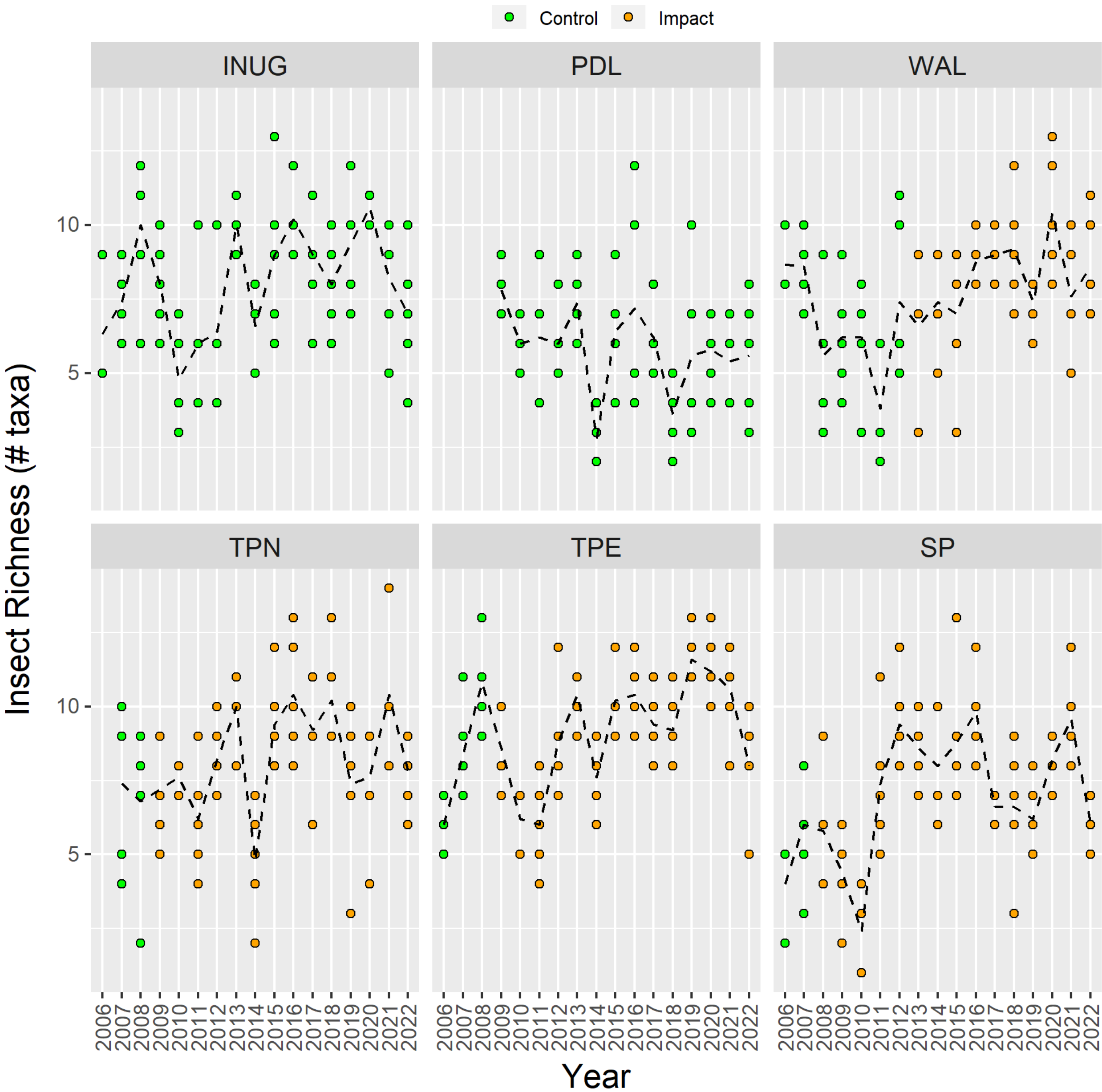


Figure E1-7. Mollusc richness (# of taxa) from Meadowbank lakes since 2006.

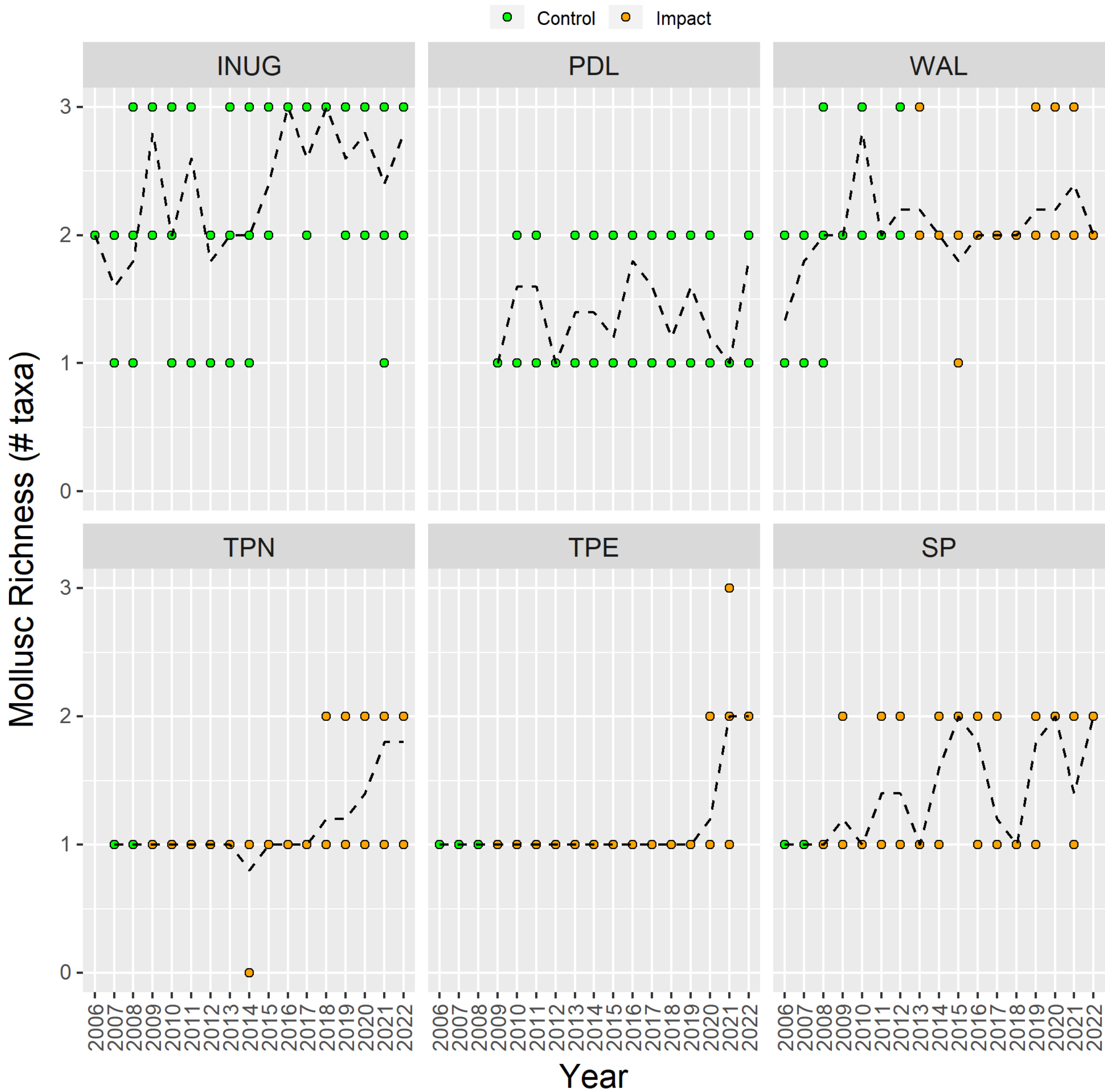


Figure E1-8. Other taxa richness (# of taxa) from Meadowbank lakes since 2006.

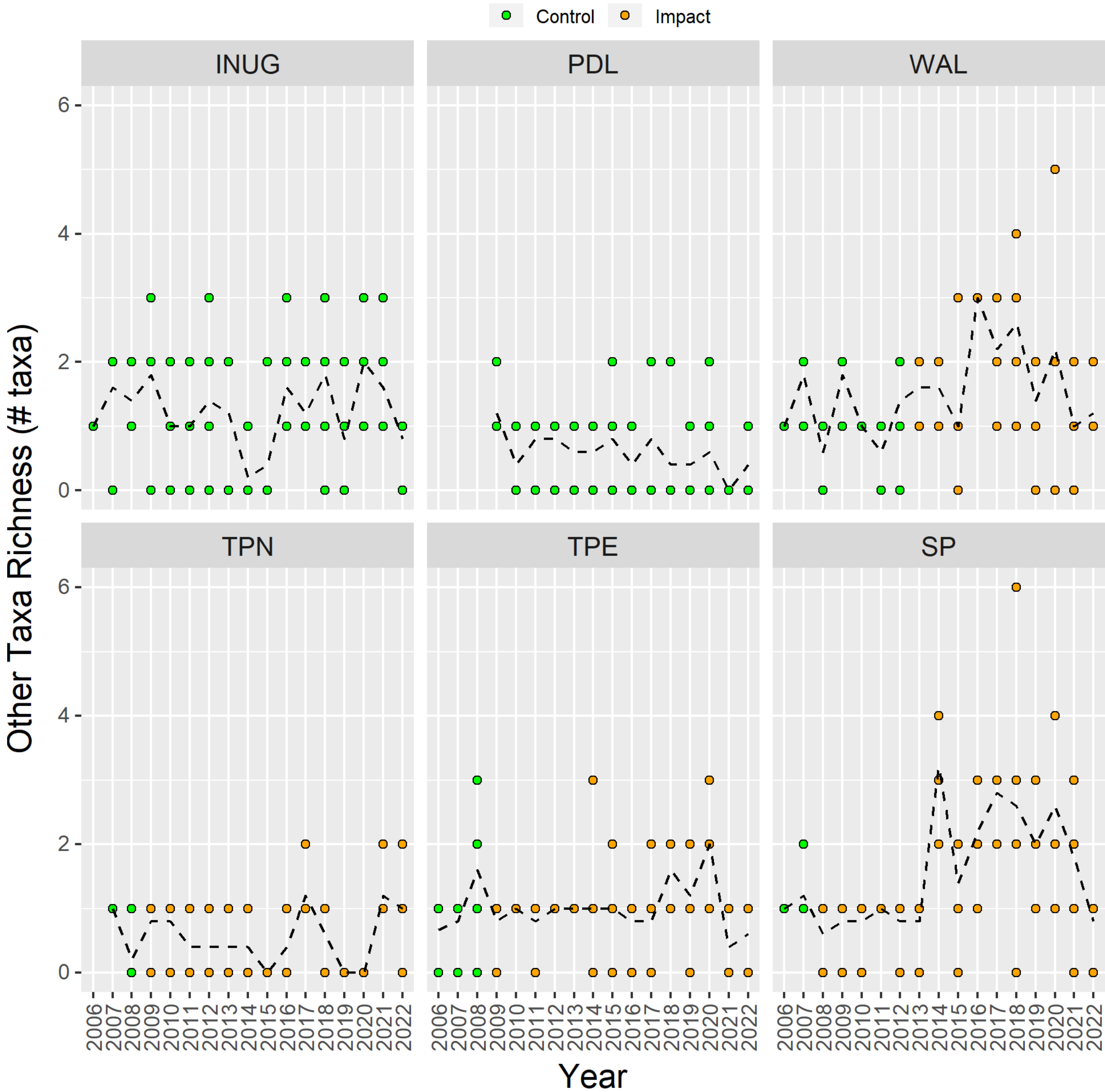


Figure E1-9. Simpsons' Diversity for the benthic invertebrate community at the Meadowbank lakes since 2006.

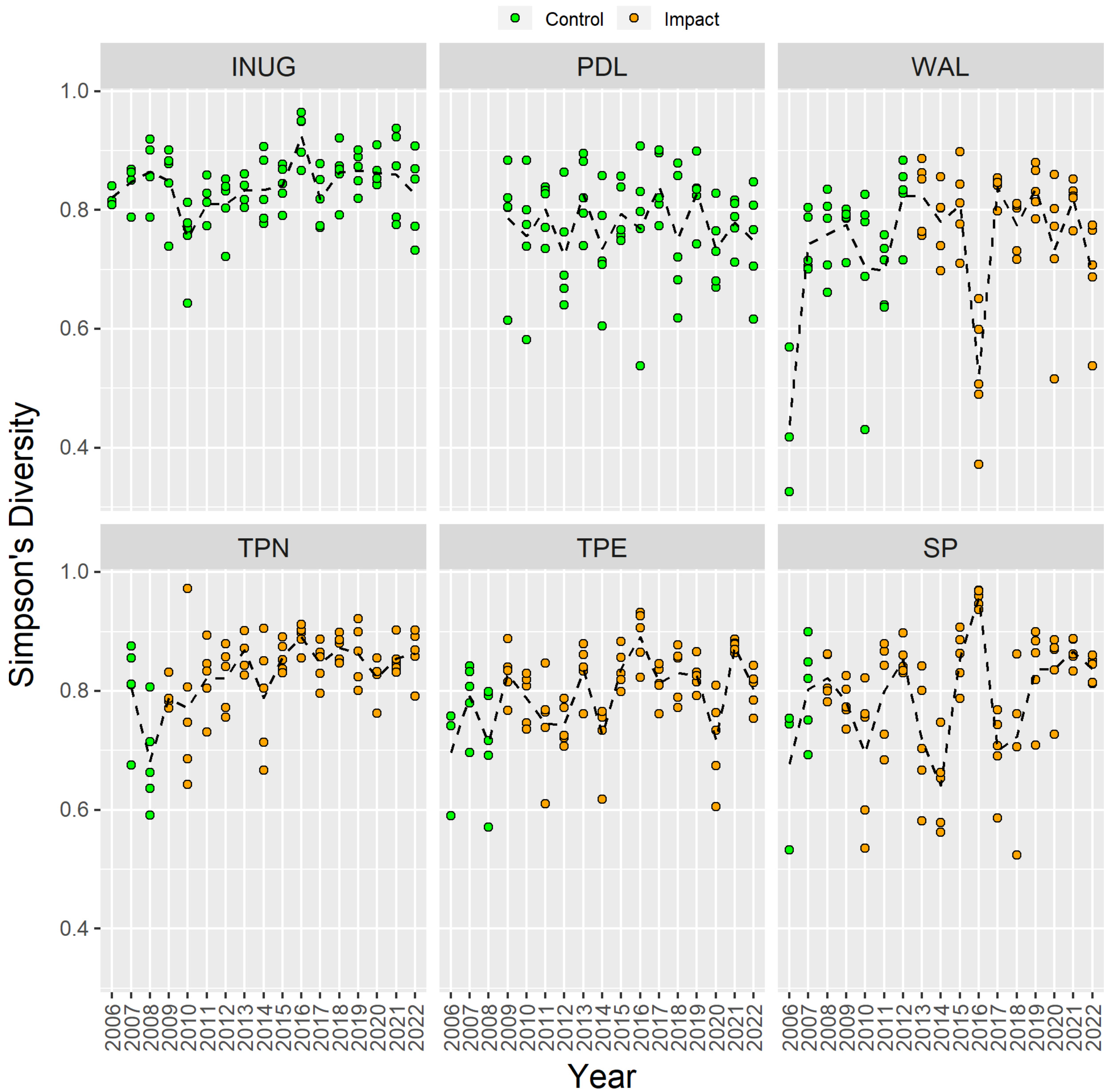
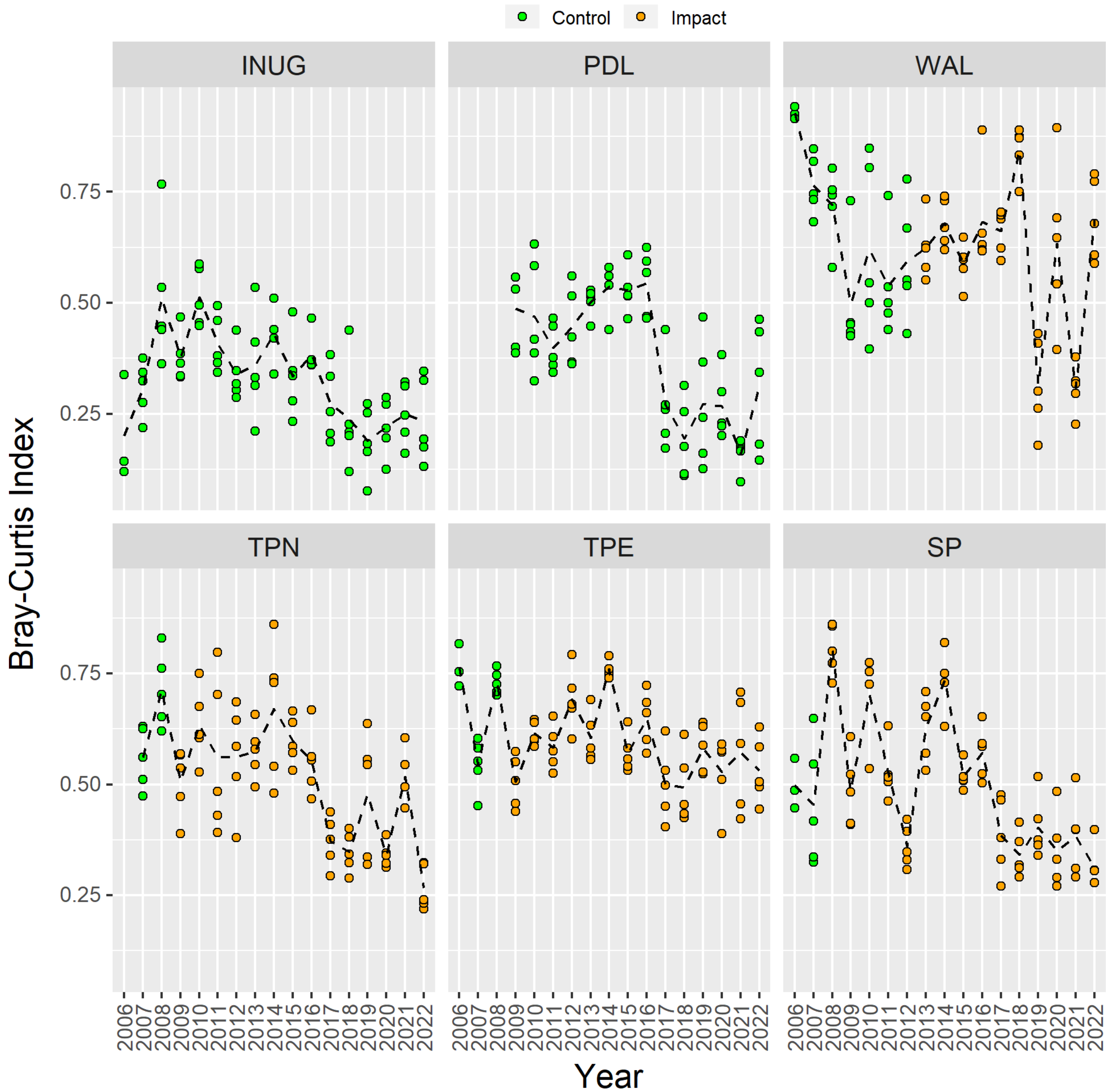


Figure E1-10. Bray-Curtis Index for the benthic invertebrate community at the Meadowbank lakes since 2006.



Appendix E2

Benthos Data – Whale Tail Study Area Lakes

LIST OF TABLES – APPENDIX E2

LIST OF FIGURES – APPENDIX E2

Table E2-1. Benthic invertebrate abundance (#/m2) and richness (# taxa) by major taxa group, Whale Tail study area lakes, 2022.

Area-Replicate	Date	Depth (m)	Abundance (#/m²)					Richness (# taxa)					Simpson's Diversity	Bray-Curtis Index
			Oligochaetes	Insects	Molluscs	Other Taxa[1]	TOTAL	Oligochaetes	Insects	Molluscs	Other Taxa[1]	TOTAL		
Whale Tail Lake - South Basin (WTS)														
WTS-1	14-Aug-22	9.3	22	696	1,435	87	2,239	1	5	3	3	12	0.80	0.55
WTS-2	14-Aug-22	8.4	109	6,283	1,891	152	8,435	1	7	3	3	14	0.62	0.83
WTS-3	14-Aug-22	9.5	239	3,065	2,152	0	5,457	2	11	3	0	16	0.87	0.69
WTS-4	14-Aug-22	8.3	22	6,174	1,826	174	8,196	1	7	3	3	14	0.58	0.81
WTS-5	14-Aug-22	9.4	22	2,500	1,130	109	3,761	1	9	3	4	17	0.71	0.65
	Area Mean		***82.6***	***3,743***	***1,687***	***104***	***5,617***	***1.2***	***7.8***	***3.0***	***2.6***	***14.6***	***0.72***	***0.70***
Mammoth Lake (MAM)														
MAM-1	15-Aug-22	8.4	130	9,348	2,087	130	11,696	2	9	2	3	16	0.75	0.84
MAM-2	15-Aug-22	7.7	43	9,913	1,435	130	11,522	1	11	3	2	17	0.73	0.83
MAM-3	15-Aug-22	7.9	130	11,174	2,087	87	13,478	2	11	3	1	17	0.71	0.85
MAM-4	15-Aug-22	8.2	304	10,609	2,696	87	13,696	2	13	3	2	20	0.74	0.85
MAM-5	15-Aug-22	9.2	43	13,522	1,217	522	15,304	1	11	3	3	18	0.72	0.87
	Area Mean		***130***	***10,913***	***1,904***	***191***	***13,139***	***1.6***	***11.0***	***2.8***	***2.2***	***17.6***	***0.73***	***0.85***
Lake A20														
A20-1	17-Aug-22	7.6	22	3,870	1,043	65	5,000	1	12	2	3	18	0.84	0.67
A20-2	17-Aug-22	8.0	0	2,087	478	65	2,630	0	10	2	2	14	0.79	0.49
A20-3	17-Aug-22	8.3	0	3,109	696	109	3,913	0	15	3	2	20	0.76	0.62
A20-4	17-Aug-22	8.2	22	2,196	522	43	2,783	1	7	2	1	11	0.60	0.63
A20-5	17-Aug-22	8.2	0	1,717	1,174	65	2,957	0	9	3	2	14	0.72	0.60
	Area Mean		***9***	***2,596***	***783***	***70***	***3,457***	***0.4***	***10.6***	***2.4***	***2.0***	***15.4***	***0.74***	***0.60***
Lake A76														
A76-1	16-Aug-22	8.9	174	17,478	1,304	43	19,000	3	9	3	1	16	0.65	0.90
A76-2	16-Aug-22	7.7	65	4,783	957	196	6,000	2	12	3	4	21	0.84	0.68
A76-3	16-Aug-22	8.0	65	7,174	717	174	8,130	1	9	2	4	16	0.54	0.81
A76-4	16-Aug-22	7.9	43	12,391	1,130	261	13,826	1	9	2	2	14	0.66	0.88
A76-5	16-Aug-22	8.0	1,022	17,848	1,043	87	20,000	3	14	2	2	21	0.80	0.90
	Area Mean		***274***	***11,935***	***1,030***	***152***	***13,391***	***2.0***	***10.6***	***2.4***	***2.6***	***17.6***	***0.70***	***0.84***
Lake DS1														
DS1-1	16-Aug-22	8.0	0	1,370	348	65	1,783	0	8	3	3	14	0.76	0.47
DS1-2	16-Aug-22	7.1	22	3,261	804	87	4,174	1	11	3	2	17	0.71	0.66
DS1-3	16-Aug-22	8.0	0	1,739	391	130	2,261	0	7	3	4	14	0.66	0.59
DS1-4	16-Aug-22	7.9	0	2,283	826	43	3,152	0	13	3	2	18	0.70	0.64
DS1-5	16-Aug-22	8.8	65	2,326	1,826	130	4,348	2	7	4	2	15	0.76	0.70
	Area Mean		***17.4***	***2,196***	***839***	***91***	***3,143***	***0.6***	***9.2***	***3.2***	***2.6***	***15.6***	***0.72***	***0.61***
Nemo Lake (NEM)														
NEM-1	15-Aug-22	8.9	22	3,087	1,609	43	4,761	1	8	3	2	14	0.84	0.69
NEM-2	15-Aug-22	8.5	0	4,935	978	43	5,957	0	7	3	2	12	0.71	0.76
NEM-3	15-Aug-22	8.6	65	3,283	935	87	4,370	1	7	3	2	13	0.84	0.66
NEM-4	15-Aug-22	6.7	22	2,804	783	87	3,696	1	9	2	1	13	0.77	0.62
NEM-5	15-Aug-22	7.0	*43*	*3,174*	*1,304*	*65*	*4,587*	*2*	*8*	*2*	*1*	*13*	*0.79*	*0.68*
	Area Mean		***30***	***3,457***	***1,122***	***65***	***4,674***	***1.0***	***7.8***	***2.6***	***1.6***	***13.0***	***0.79***	***0.68***

Notes:

1. "Other taxa" includes flatworms (Turbellaria) and arthropods (Acalyptonotidae, Hygrobatidae, Lebertiidae, Oxidae, Pionidae, Harpacticoida, O. Notostraca, and Gammaracanthidae).

Table E2-2. Raw benthic invertebrate data from the Whale Tail study area lakes, 2022.

Program	Whale Tail									
Location	Lake A20					Lake A76				
Station	A20					A76				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22
Sample Depth (m)	7.6	8.0	8.3	8.2	8.2	8.9	7.7	8.0	7.9	8.0
ROUNDWORMS										
P. Nemata	2	1	8	1	7	6	2	3	6	54
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	-	-	-	-	-	-	2	-	2	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	-	-	-	-	-	-	-	-
F. Naididae										
S.F. Naidinae										
Nais	-	-	-	-	-	2	-	-	-	31
S.F. Tubificinae										
Tasserkidrilus americanus	-	-	-	-	-	-	-	-	-	-
immatures with hair chaetae	1	-	-	-	-	4	2	-	-	2
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus	-	-	-	-	-	-	-	3	-	14
F. Lumbriculidae										
Lumbriculus	-	-	-	1	-	2	1	-	2	-
LEECHES										
Cl. Hirudinea										
F. Piscicolidae										
immature	-	-	-	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										
F. Acalyptonotidae										
Acalyptonotus	1	2	2	-	-	2	5	4	10	-
F. Hygrobatidae										
Hygrobates	1	-	-	-	-	-	-	1	-	-
F. Lebertiidae										
Lebertia	1	1	3	-	2	-	1	2	-	2
F. Oxidae										
Oxus	-	-	-	2	1	-	1	1	-	-
F. Pionidae										
indeterminate	-	-	-	-	-	-	-	-	-	-
HARPACTICOIDS										
O. Harpacticoida	-	-	-	-	-	-	-	-	-	2
SEED SHRIMPS										
Cl. Ostracoda	75	36	56	16	27	22	34	26	46	87
INSECTS										
Cl. Insecta										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae										
immature	2	-	1	-	-	-	-	-	-	-
F. Limnephilidae										
Grensia praeterita	-	-	-	-	-	-	-	-	-	**2**
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae	2	-	1	-	-	2	2	2	2	2
S.F. Chironominae										
Chironomus	-	-	-	-	-	-	-	-	-	2
Cladotanytarsus	-	-	-	-	-	-	-	-	-	-
Constempellina	-	-	-	-	-	-	-	-	-	-
Corynocera ambigua	34	3	6	7	2	482	38	39	198	249
?Corynocera oliveri	-	-	-	-	-	-	-	-	-	-
Dicrotendipes	2	-	-	-	-	8	1	-	-	-
Micropsectra	62	44	81	79	57	179	77	248	308	312
Microtendipes	-	28	1	-	-	-	2	-	-	19
Paratanytarsus	26	5	8	5	1	31	62	9	16	63
Paratendipes	-	-	-	-	-	-	-	-	-	-
Sergentia	-	-	2	-	-	-	-	-	-	38
Stempellinella	-	-	-	-	-	-	-	-	-	-
Stictochironomus	32	8	19	3	2	16	9	3	4	14
Tanytarsus	4	1	8	-	5	39	4	-	20	54
S.F. Diamesinae										
Protanypus	2	-	2	-	1	-	1	-	-	-
Potthastia	-	-	1	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Abiskomyia	-	1	1	-	-	8	6	5	8	2
Cricotopus/Orthocladius	-	-	-	-	-	-	-	-	-	-
Heterotrissocladius	1	-	-	-	-	-	-	-	-	-
Mesocricotopus	-	-	-	-	-	-	-	-	-	-
Psectrocladius	-	-	3	-	-	-	-	-	-	-
Zalutschia	-	-	-	1	-	-	-	2	-	19
Orthocladiinae Genus "Greenland"	-	-	-	-	-	-	-	-	-	2
indeterminate	-	-	-	-	-	-	-	-	-	-
S.F. Prodiamesinae										
Monodiamesa	2	1	2	5	3	-	4	8	6	-
S.F. Tanypodinae										
Ablabesmyia	-	-	-	-	-	-	-	-	-	-
Procladius	4	4	4	1	7	31	10	12	6	31
Thienemannimyia complex	5	-	3	-	1	8	4	2	2	12
F. Empididae										
Chelifera/Metachela	-	1	-	-	-	-	-	-	-	-
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata	-	-	-	-	-	-	-	-	-	-
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
Pisidium/Cyclocalyx	43	15	29	17	44	44	29	20	44	35
Pisidium (Cyclocalyx/Neopisidium)	5	7	2	7	9	8	12	13	8	-
Sphaerium nitidum	-	-	1	-	1	8	3	-	-	13

Table E2-2. Raw benthic invertebrate data from the Whale Tail study area lakes, 2022.

Program	Whale Tail									
Location	Lake A20					Lake A76				
Station	A20					A76				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	17-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22
Sample Depth (m)	7.6	8.0	8.3	8.2	8.2	8.9	7.7	8.0	7.9	8.0
R (Richness) - totals [2,3]										
Total	18	14	20	11	14	16	21	16	14	21
Oligochaete	1	0	0	1	0	3	2	1	1	3
Insect	12	10	15	7	9	9	12	9	9	14
Mollusc	2	2	3	2	3	3	3	2	2	2
Other[4]	3	2	2	1	2	1	4	4	2	2
Abundance (raw) - totals [5,6]										
Total	230	121	180	128	136	874	276	374	636	920
Oligochaete	1	0	0	1	0	8	3	3	2	47
Insect	178	96	143	101	79	804	220	330	570	821
Mollusc	48	22	32	24	54	60	44	33	52	48
Other[4]	3	3	5	2	3	2	9	8	12	4
N (Abundance) - #/m^2										
Total	5,000	2,630	3,913	2,783	2,957	19,000	6,000	8,130	13,826	20,000
Oligochaete	22	0	0	22	0	174	65	65	43	1,022
Insect	3,870	2,087	3,109	2,196	1,717	17,478	4,783	7,174	12,391	17,848
Mollusc	1,043	478	696	522	1,174	1,304	957	717	1,130	1,043
Other[4]	65	65	109	43	65	43	196	174	261	87

Notes:

1. Benthic invertebrate count data shown in this table are from composite of two grabs sieved to 500 µm.
2. Richness totals exclude P. Nemata, Cl. Ostracoda, indeterminates (O. Acarina, F. Lumbriculidae), immatures (S.F. Tubificinae, O. Acarina), and pupae.
3. Pupae and immatures (bolded values) are excluded from the richness totals if other life stages are present in the replicate sample.
4. Other Taxa include: Cl. Turbellaria, F. Acalyptonotidae, F. Hygrobatidae, F. Lebertiidae, F. Oxidae, F. Pionidae, O. Harpacticoida, O. Notostraca, and F. Gammaracanthidae.
5. Abundance totals exclude P. Nemata and Cl. Ostracoda.
6. Raw abundance from two grabs (grab area = 0.023 m^2).

Table E2-2. Raw benthic invertebrate data from the Whale Tail study area lakes, 2022.

Program	Whale Tail									
Location	Lake DS1					Mammoth Lake				
Station	DS1					MAM				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22
Sample Depth (m)	8.0	7.1	8.0	7.9	8.8	8.4	7.7	7.9	8.2	9.2
ROUNDWORMS										
P. Nemata	6	16	8	16	12	-	-	4	4	6
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	1	2	1	-	4	-	-	-	-	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	-	-	-	-	-	-	-	-
F. Naididae										
S.F. Naidinae										
Nais	-	1	-	-	1	-	-	-	-	-
S.F. Tubificinae										
Tasserkidrilus americanus	-	-	-	-	-	-	-	-	-	-
immatures with hair chaetae	-	-	-	-	2	2	2	-	-	-
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus	-	-	-	-	-	-	-	4	12	2
F. Lumbriculidae										
Lumbriculus	-	-	-	-	-	4	-	2	2	-
LEECHES										
Cl. Hirudinea										
F. Piscicolidae										
immature	-	-	-	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										
F. Acalyptonotidae										
Acalyptonotus	1	-	-	-	-	2	4	-	2	8
F. Hygrobatidae										
Hygrobates	1	-	-	-	-	-	-	-	-	-
F. Lebertiidae										
Lebertia	-	-	1	-	2	2	2	4	-	12
F. Oxidae										
Oxus	-	2	3	1	-	2	-	-	2	4
F. Pionidae										
indeterminate	-	-	1	1	-	-	-	-	-	-
HARPACTICOIDS										
O. Harpacticoida	-	-	-	-	-	-	-	-	-	-
SEED SHRIMPS										
Cl. Ostracoda	5	9	6	11	19	24	18	34	38	30
INSECTS										
Cl. Insecta										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae										
immature	-	-	-	-	-	-	-	-	2	-
F. Limnephilidae										
Grensia praeterita	-	1	-	-	-	-	-	-	-	-
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae	2	2	-	1	2	2	2	6	4	-
S.F. Chironominae										
Chironomus	-	-	-	-	-	-	-	-	-	-
Cladotanytarsus	-	-	-	-	-	-	-	-	-	-
Constempellina	-	1	-	-	-	-	-	-	-	-
Corynocera ambigua	1	3	-	1	-	238	258	308	301	330
?Corynocera oliveri	-	-	-	-	-	-	-	-	-	-
Dicrotendipes	-	-	-	1	-	-	2	8	4	2
Micropsectra	3	16	5	3	1	80	52	99	73	145
Microtendipes	-	-	-	1	-	12	11	11	10	12
Paratanytarsus	37	98	59	75	83	10	26	9	16	8
Paratendipes	-	-	1	-	-	-	-	-	-	-
Sergentia	-	-	-	1	-	-	-	-	-	-
Stempellinella	-	-	-	-	-	-	-	-	-	-
Stictochironomus	8	4	6	3	6	32	34	28	20	8
Tanytarsus	4	5	3	7	4	22	30	19	30	91
S.F. Diamesinae										
Protanypus	-	-	-	-	-	-	-	-	-	-
Potthastia	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Abiskomyia	-	-	-	1	-	-	7	6	2	2
Cricotopus/Orthocladius	-	-	1	2	-	-	-	-	-	-
Heterotrissocladius	2	7	-	1	1	-	-	-	-	-
Mesocricotopus	-	-	-	-	-	-	-	-	-	-
Psectrocladius	-	1	-	-	-	-	-	-	-	-
Zalutschia	-	-	-	-	-	-	-	-	2	-
Orthocladiinae Genus "Greenland"	-	-	-	-	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-	-	-	-
S.F. Prodiamesinae										
Monodiamesa	-	-	-	-	-	6	8	2	10	6
S.F. Tanypodinae										
Ablabesmyia	2	1	-	-	-	-	-	-	-	-
Procladius	4	11	5	7	8	20	12	4	8	14
Thienemannimyia complex	-	-	-	1	2	8	14	14	6	4
F. Empididae										
Chelifera/Metachela	-	-	-	-	-	-	-	-	-	-
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata	2	6	5	9	12	-	-	-	-	-
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
Pisidium/Cyclocalyx	13	25	3	24	47	92	44	52	74	48
Pisidium (Cyclocalyx/Neopisidium)	-	6	10	5	23	4	18	36	26	4
Sphaerium nitidum	1	-	-	-	2	-	4	8	24	4

Table E2-2. Raw benthic invertebrate data from the Whale Tail study area lakes, 2022.

Program	Whale Tail									
Location	Lake DS1					Mammoth Lake				
Station	DS1					MAM				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	16-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22
Sample Depth (m)	8.0	7.1	8.0	7.9	8.8	8.4	7.7	7.9	8.2	9.2
R (Richness) - totals [2,3]										
Total	14	17	14	18	15	16	17	17	20	18
Oligochaete	0	1	0	0	2	2	1	2	2	1
Insect	8	11	7	13	7	9	11	11	13	11
Mollusc	3	3	3	3	4	2	3	3	3	3
Other[4]	3	2	4	2	2	3	2	1	2	3
Abundance (raw) - totals [5,6]										
Total	82	192	104	145	200	538	530	620	630	704
Oligochaete	0	1	0	0	3	6	2	6	14	2
Insect	63	150	80	105	107	430	456	514	488	622
Mollusc	16	37	18	38	84	96	66	96	124	56
Other[4]	3	4	6	2	6	6	6	4	4	24
N (Abundance) - #/m²										
Total	1,783	4,174	2,261	3,152	4,348	11,696	11,522	13,478	13,696	15,304
Oligochaete	0	22	0	0	65	130	43	130	304	43
Insect	1,370	3,261	1,739	2,283	2,326	9,348	9,913	11,174	10,609	13,522
Mollusc	348	804	391	826	1,826	2,087	1,435	2,087	2,696	1,217
Other[4]	65	87	130	43	130	130	130	87	87	522

Notes:

1. Benthic invertebrate count data shown in this table are from composite of two grabs sieved to 500 µm.
2. Richness totals exclude P. Nemata, Cl. Ostracoda, indeterminates (O. Acarina, F. Lumbriculidae), immatures (S.F. Tubificinae, O. Acarina), and pupae.
3. Pupae and immatures (bolded values) are excluded from the richness totals if other life stages are present in the replicate sample.
4. Other Taxa include: Cl. Turbellaria, F. Acalyptonotidae, F. Hygrobatidae, F. Lebertiidae, F. Oxidae, F. Pionidae, O. Harpacticoida, O. Notostraca, and F. Gammaracanthidae.
5. Abundance totals exclude P. Nemata and Cl. Ostracoda.
6. Raw abundance from two grabs (grab area = 0.023 m^2).

Table E2-2. Raw benthic invertebrate data from the Whale Tail study area lakes, 2022.

Program	Whale Tail									
Location	Nemo Lake					Whale Tail Lake - South Basin				
Station	NEM					WTS				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22
Sample Depth (m)	8.9	8.5	8.6	6.7	7.0	9.3	8.4	9.5	8.3	9.4
ROUNDWORMS										
P. Nemata	-	-	-	1	-	2	-	-	1	-
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	1	-	-	-	-	-	4	-	2	1
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	-	-	-	-	-	-	-	-
F. Naididae										
S.F. Naidinae										
Nais	-	-	-	-	-	-	-	-	-	-
S.F. Tubificinae										
Tasserkidrilus americanus	-	-	-	-	-	-	-	-	-	-
immatures with hair chaetae	-	-	-	-	-	-	-	-	-	-
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus	1	-	-	-	1	1	5	9	-	1
F. Lumbriculidae										
Lumbriculus	-	-	3	1	1	-	-	2	1	-
LEECHES										
Cl. Hirudinea										
F. Piscicolidae										
immature	-	-	-	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										
F. Acalyptonotidae										
Acalyptonotus	1	1	3	4	3	1	2	-	2	1
F. Hygrobatidae										
Hygrobates	-	-	-	-	-	-	-	-	-	-
F. Lebertiidae										
Lebertia	-	-	-	-	-	2	-	-	-	2
F. Oxidae										
Oxus	-	1	1	-	-	1	1	-	4	1
F. Pionidae										
indeterminate	-	-	-	-	-	-	-	-	-	-
HARPACTICOIDS										
O. Harpacticoida	-	-	-	-	-	-	-	-	-	-
SEED SHRIMPS										
Cl. Ostracoda	26	42	31	56	32	33	62	67	37	23
INSECTS										
Cl. Insecta										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae										
immature	-	-	-	-	-	-	-	-	-	-
F. Limnephilidae										
Grensia praeterita	-	-	-	2	1	-	-	-	-	-
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae	-	-	-	-	-	1	-	3	1	-
S.F. Chironominae										
Chironomus	-	-	-	-	-	-	-	7	-	-
Cladotanytarsus	-	-	-	-	-	-	-	-	-	-
Constempellina	-	-	-	-	-	-	-	-	-	-
Corynocera ambigua	15	8	23	14	12	-	29	6	3	-
?Corynocera oliveri	-	-	-	-	-	2	2	12	12	2
Dicrotendipes	-	-	-	-	-	-	-	-	-	-
Micropsectra	27	136	58	72	80	10	230	50	234	85
Microtendipes	1	-	6	-	-	-	-	1	-	1
Paratanytarsus	4	2	-	2	2	-	-	7	6	-
Paratendipes	-	-	-	-	-	-	-	-	-	-
Sergentia	-	-	-	-	-	-	-	-	-	-
Stempellinella	-	-	-	-	-	-	-	-	-	9
Stictochironomus	42	37	25	17	15	1	5	13	12	4
Tanytarsus	21	17	21	3	10	11	16	31	3	7
S.F. Diamesinae										
Protanypus	-	-	-	-	-	-	-	-	-	-
Potthastia	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Abiskomyia	-	-	-	-	-	-	-	-	-	-
Cricotopus/Orthocladius	-	-	-	-	-	-	-	-	-	-
Heterotrissocladius	-	-	-	-	-	-	-	-	-	1
Mesocricotopus	-	-	-	-	-	-	-	-	-	-
Psectrocladius	-	-	-	-	-	-	-	-	-	-
Zalutschia	-	-	-	-	-	-	-	-	-	-
Orthocladiinae Genus "Greenland"	-	-	-	-	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-	-	-	-
S.F. Prodiamesinae										
Monodiamesa	-	-	-	1	-	-	2	3	-	1
S.F. Tanypodinae										
Ablabesmyia	-	-	-	-	-	-	-	1	-	-
Procladius	22	9	10	9	17	7	5	7	13	5
Thienemannimyia complex	10	18	8	9	9	-	-	-	-	-
F. Empididae										
Chelifera/Metachela	-	-	-	-	-	-	-	-	-	-
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata	-	-	-	-	-	-	-	-	-	-
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
Pisidium/Cyclocalyx	65	30	38	28	46	32	44	51	66	33
Pisidium (Cyclocalyx/Neopisidium)	5	14	4	8	14	29	30	40	15	14
Sphaerium nitidum	4	1	1	-	-	5	13	8	3	5

Table E2-2. Raw benthic invertebrate data from the Whale Tail study area lakes, 2022.

Program	Whale Tail									
Location	Nemo Lake					Whale Tail Lake - South Basin				
Station	NEM					WTS				
Control/Impact?	Impact					Impact				
Replicate	1	2	3	4	5	1	2	3	4	5
Date	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	15-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22	14-Aug-22
Sample Depth (m)	8.9	8.5	8.6	6.7	7.0	9.3	8.4	9.5	8.3	9.4
R (Richness) - totals [2,3]										
Total	14	12	13	13	13	12	14	16	14	17
Oligochaete	1	0	1	1	2	1	1	2	1	1
Insect	8	7	7	9	8	5	7	11	7	9
Mollusc	3	3	3	2	2	3	3	3	3	3
Other[4]	2	2	2	1	1	3	3	0	3	4
Abundance (raw) - totals [5,6]										
Total	219	274	201	170	211	103	388	251	377	173
Oligochaete	1	0	3	1	2	1	5	11	1	1
Insect	142	227	151	129	146	32	289	141	284	115
Mollusc	74	45	43	36	60	66	87	99	84	52
Other[4]	2	2	4	4	3	4	7	0	8	5
N (Abundance) - #/m²										
Total	4,761	5,957	4,370	3,696	4,587	2,239	8,435	5,457	8,196	3,761
Oligochaete	22	0	65	22	43	22	109	239	22	22
Insect	3,087	4,935	3,283	2,804	3,174	696	6,283	3,065	6,174	2,500
Mollusc	1,609	978	935	783	1,304	1,435	1,891	2,152	1,826	1,130
Other[4]	43	43	87	87	65	87	152	0	174	109

Notes:

1. Benthic invertebrate count data shown in this table are from composite of two grabs sieved to 500 µm.
2. Richness totals exclude P. Nemata, Cl. Ostracoda, indeterminates (O. Acarina, F. Lumbriculidae), immatures (S.F. Tubificinae, O. Acarina), and pupae.
3. Pupae and immatures (bolded values) are excluded from the richness totals if other life stages are present in the replicate sample.
4. Other Taxa include: Cl. Turbellaria, F. Acalyptonotidae, F. Hygrobatidae, F. Lebertiidae, F. Oxidae, F. Pionidae, O. Harpacticoida, O. Notostraca, and F. Gammaracanthidae.
5. Abundance totals exclude P. Nemata and Cl. Ostracoda.
6. Raw abundance from two grabs (grab area = 0.023 m^2).

Figure E2-1. Oligochaete abundance (#/m²) from the Whale Tail study lakes since 2015.

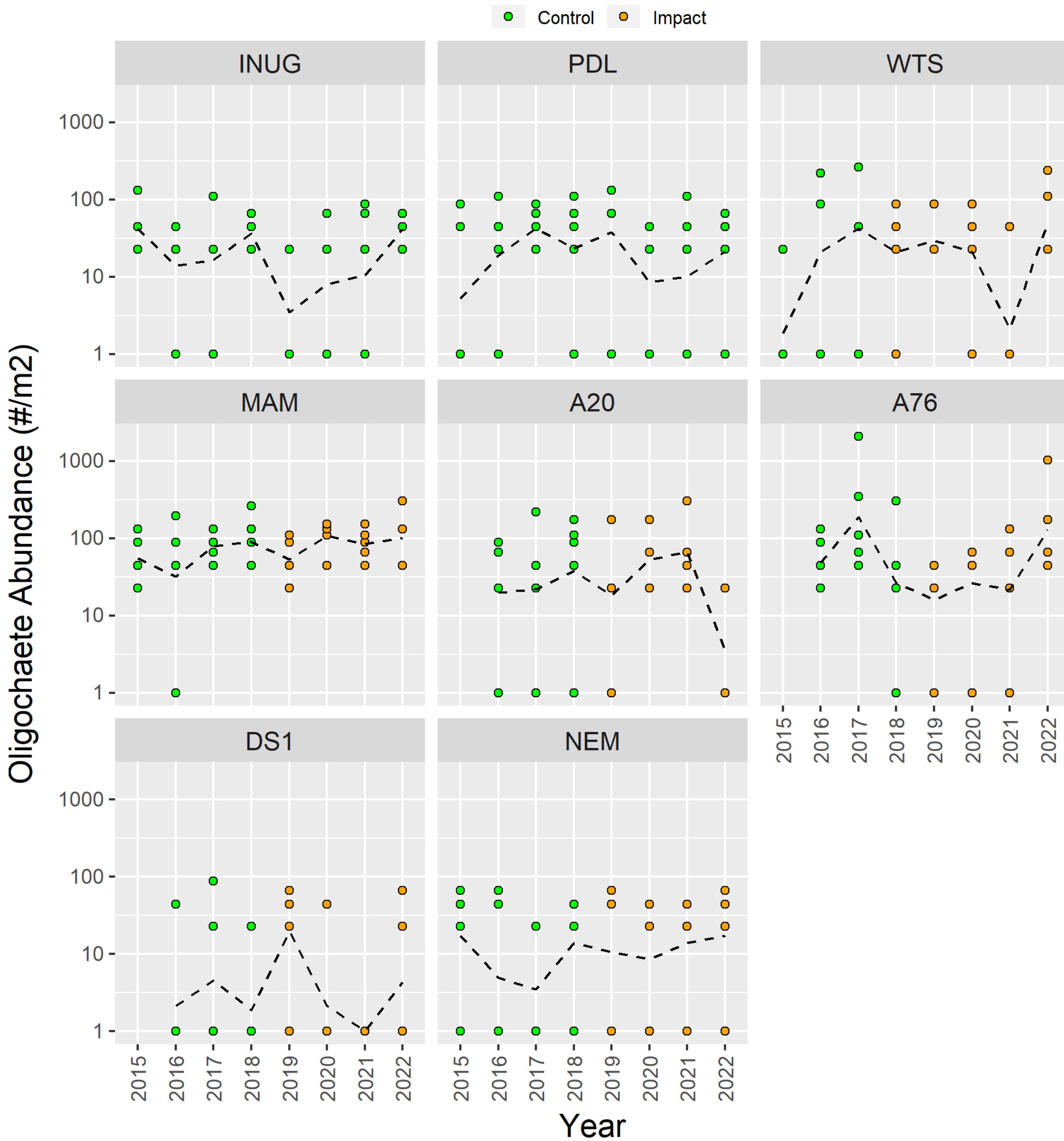


Figure E2-2. Insect abundance (#/m²) from the Whale Tail study lakes since 2015.

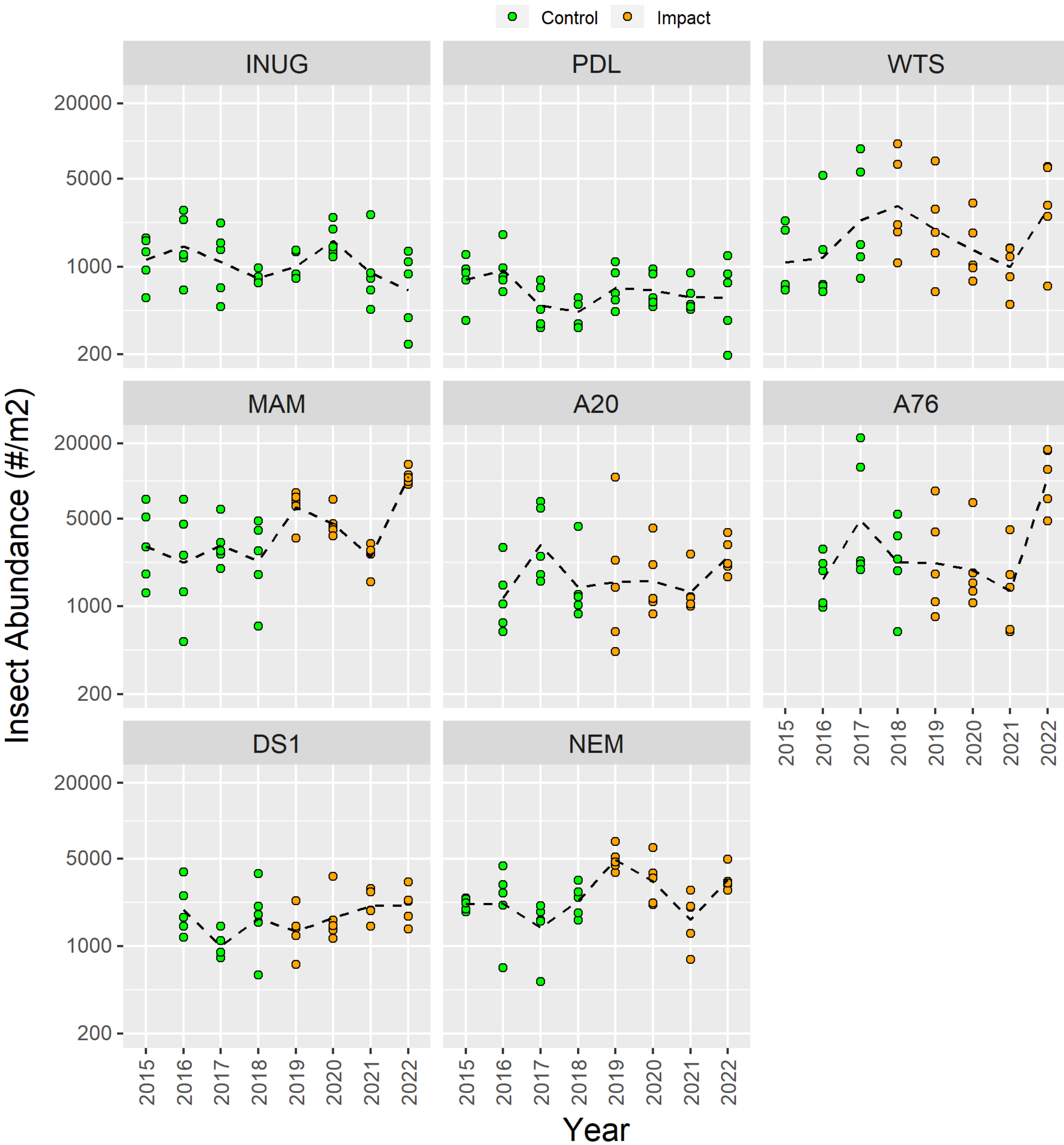


Figure E2-3. Mollusc abundance (#/m²) from the Whale Tail study lakes since 2015.

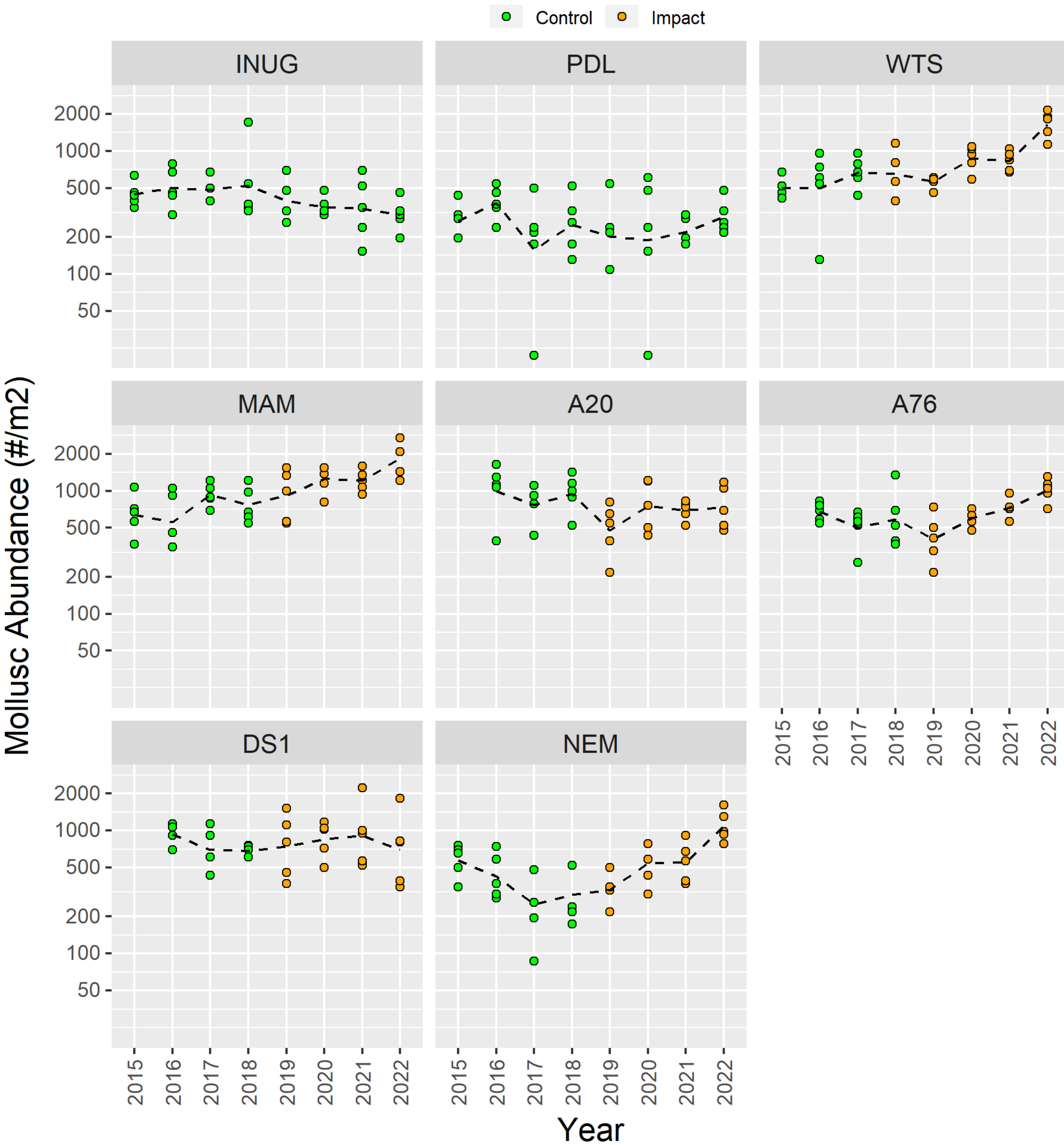


Figure E2-4. Other taxa abundance (#/m²) from the Whale Tail study lakes since 2015.

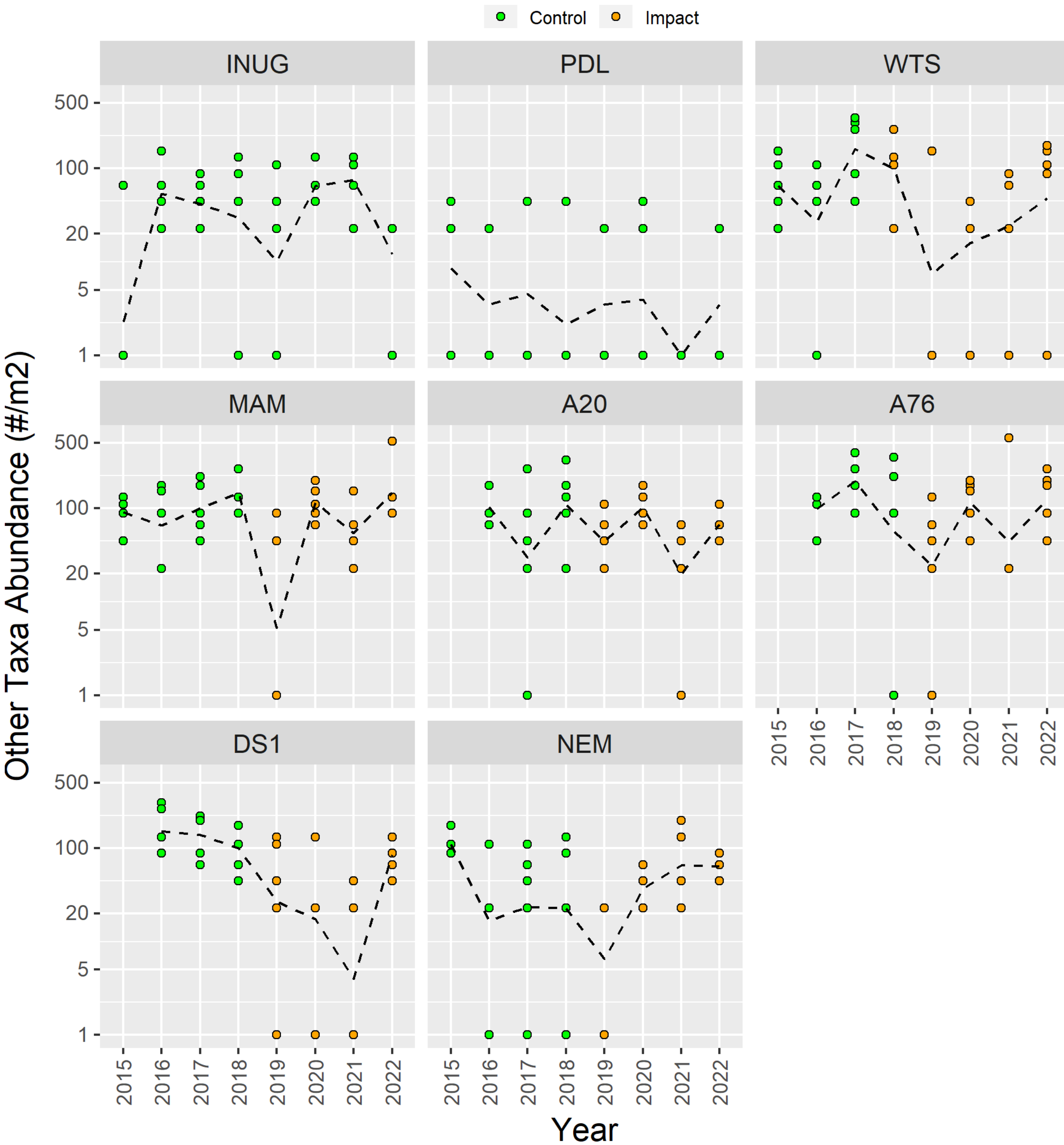


Figure E2-5. Oligochaete richness (# of taxa) from the Whale Tail study lakes since 2015.

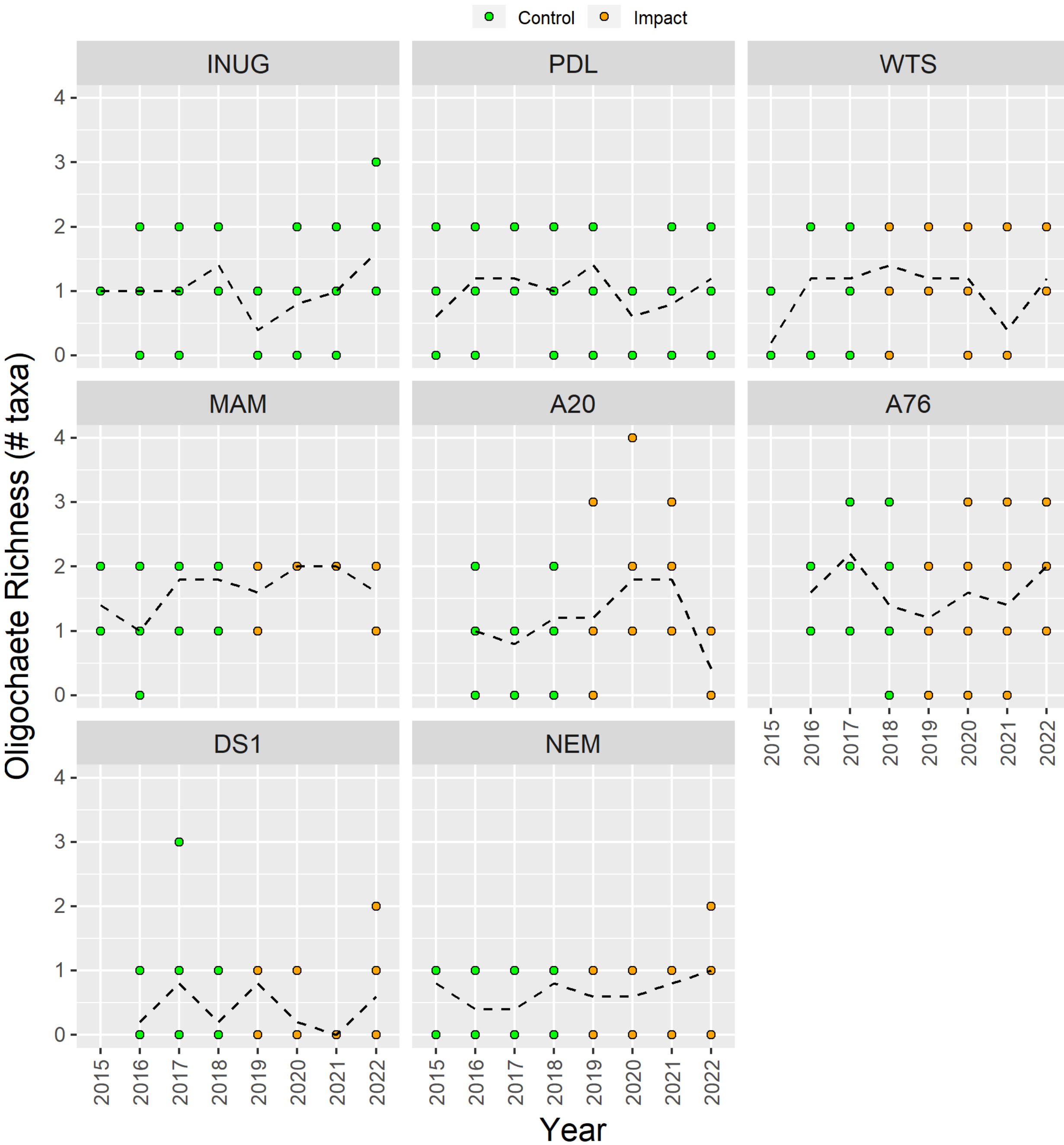


Figure E2-6. Insect richness (# of taxa) from the Whale Tail study lakes since 2015.

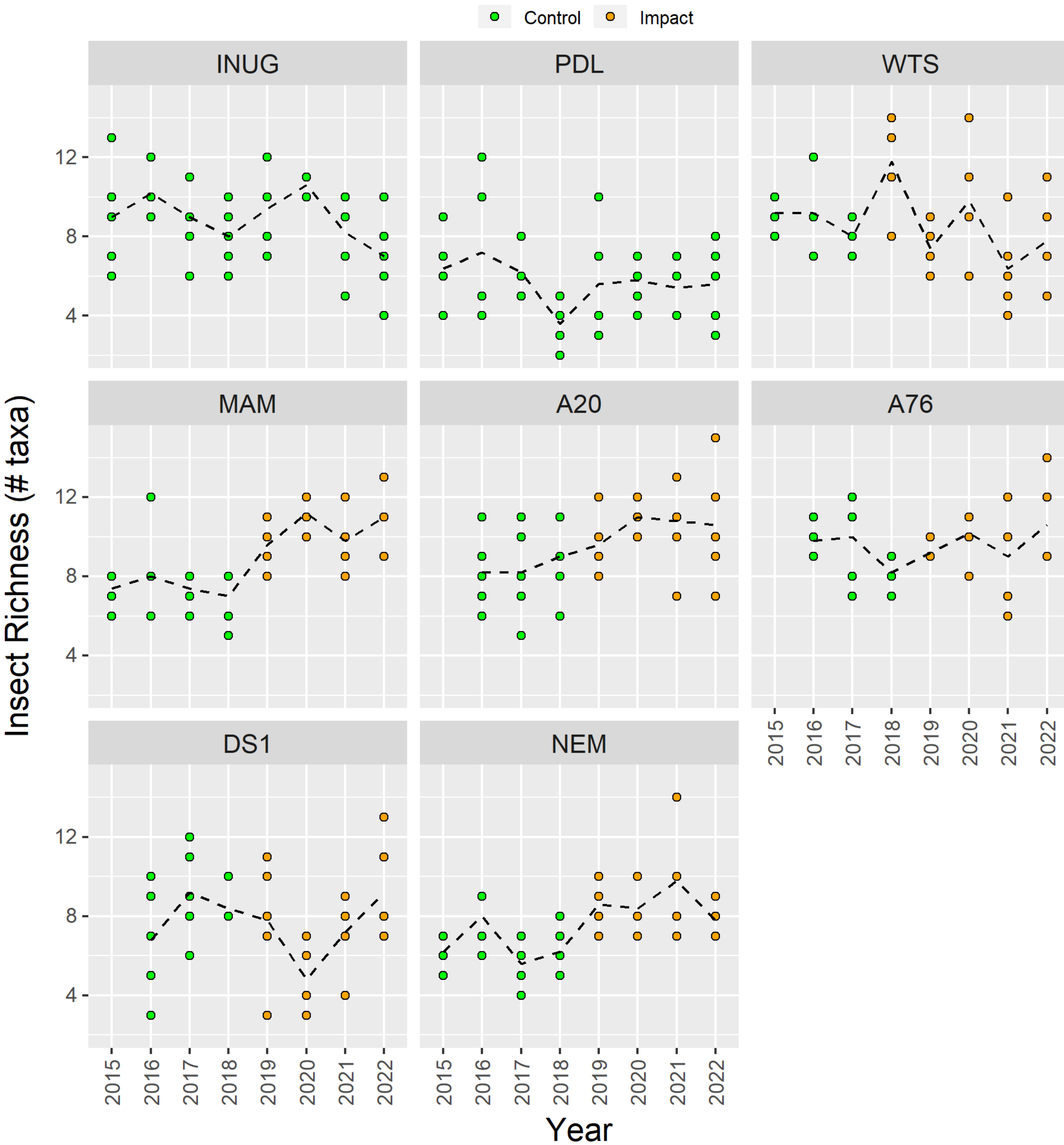


Figure E2-7. Mollusc richness (# of taxa) from the Whale Tail study lakes since 2015.

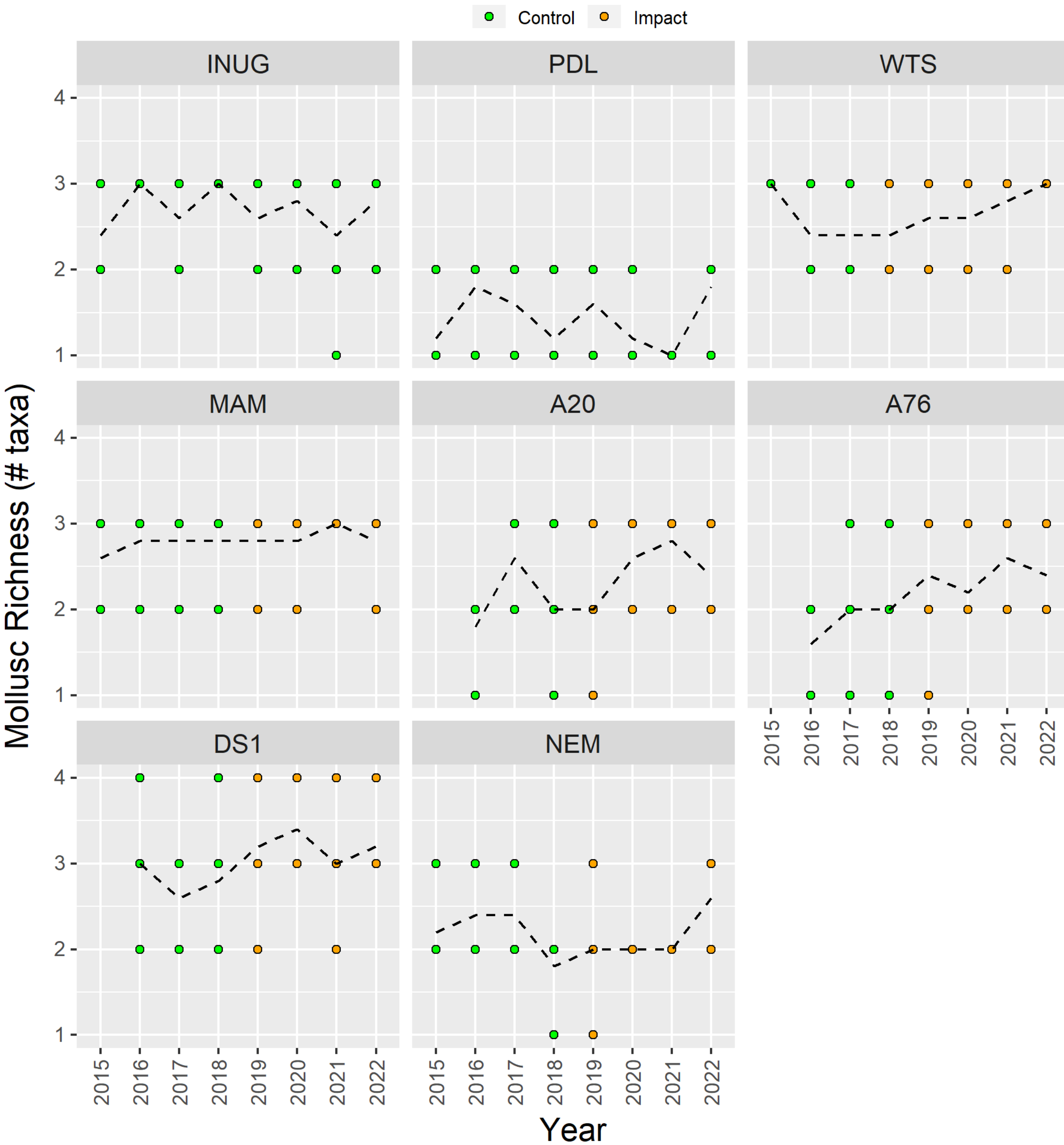


Figure E2-8. Other taxa richness (# of taxa) from the Whale Tail study lakes since 2015.

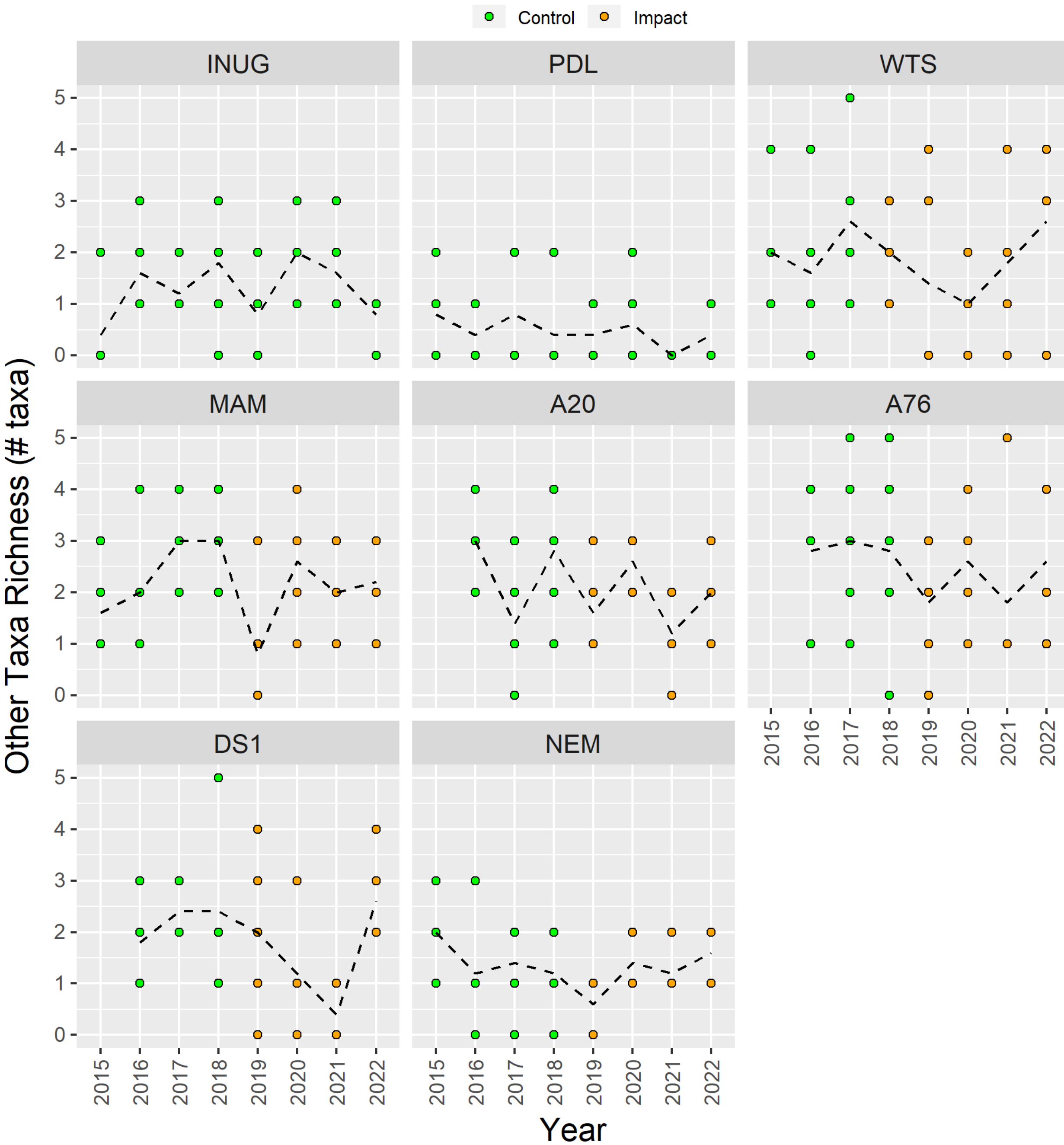


Figure E2-9. Simpson's Diversity for the benthic invertebrate community at the Whale Tail study lakes since 2015.

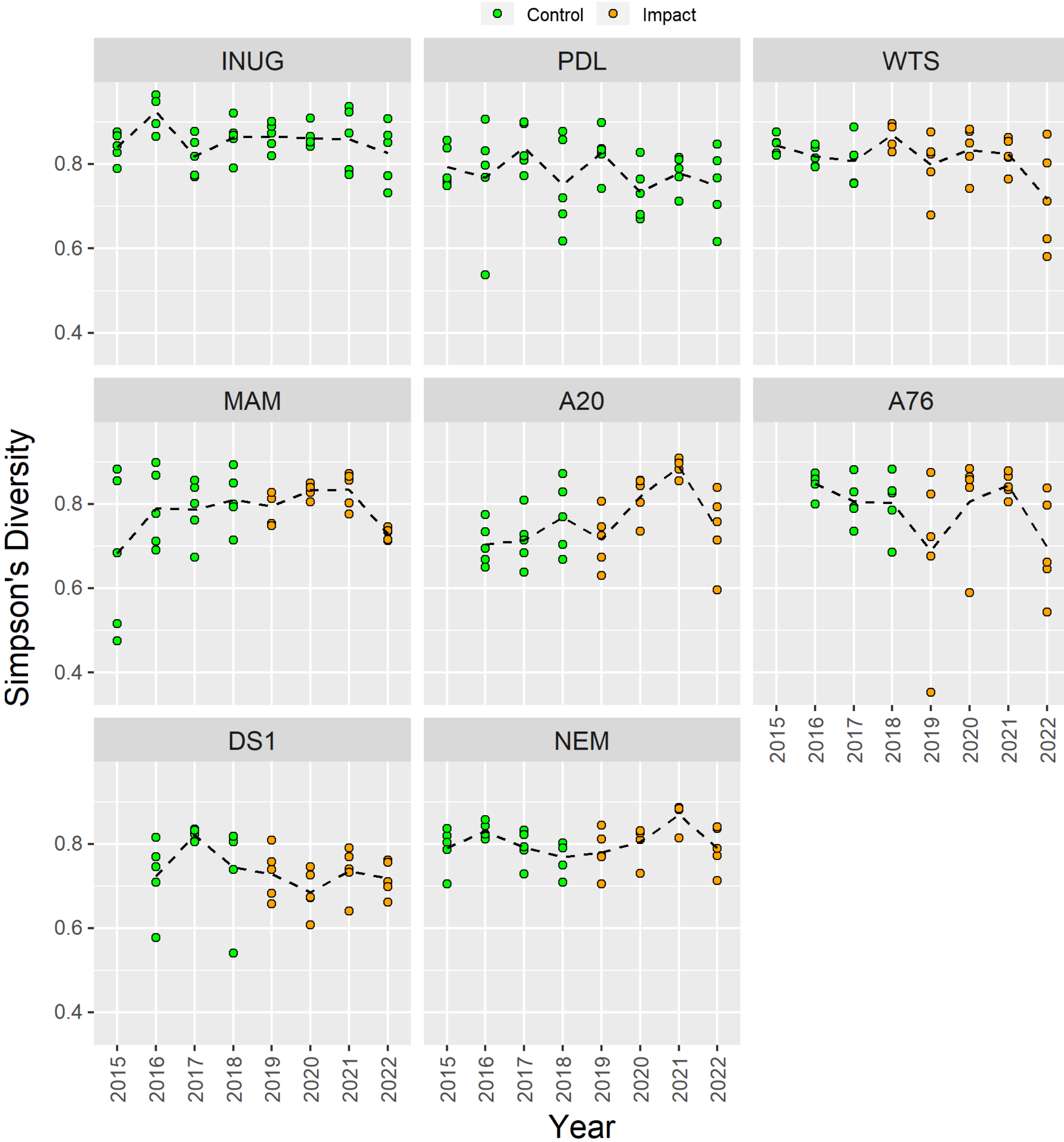
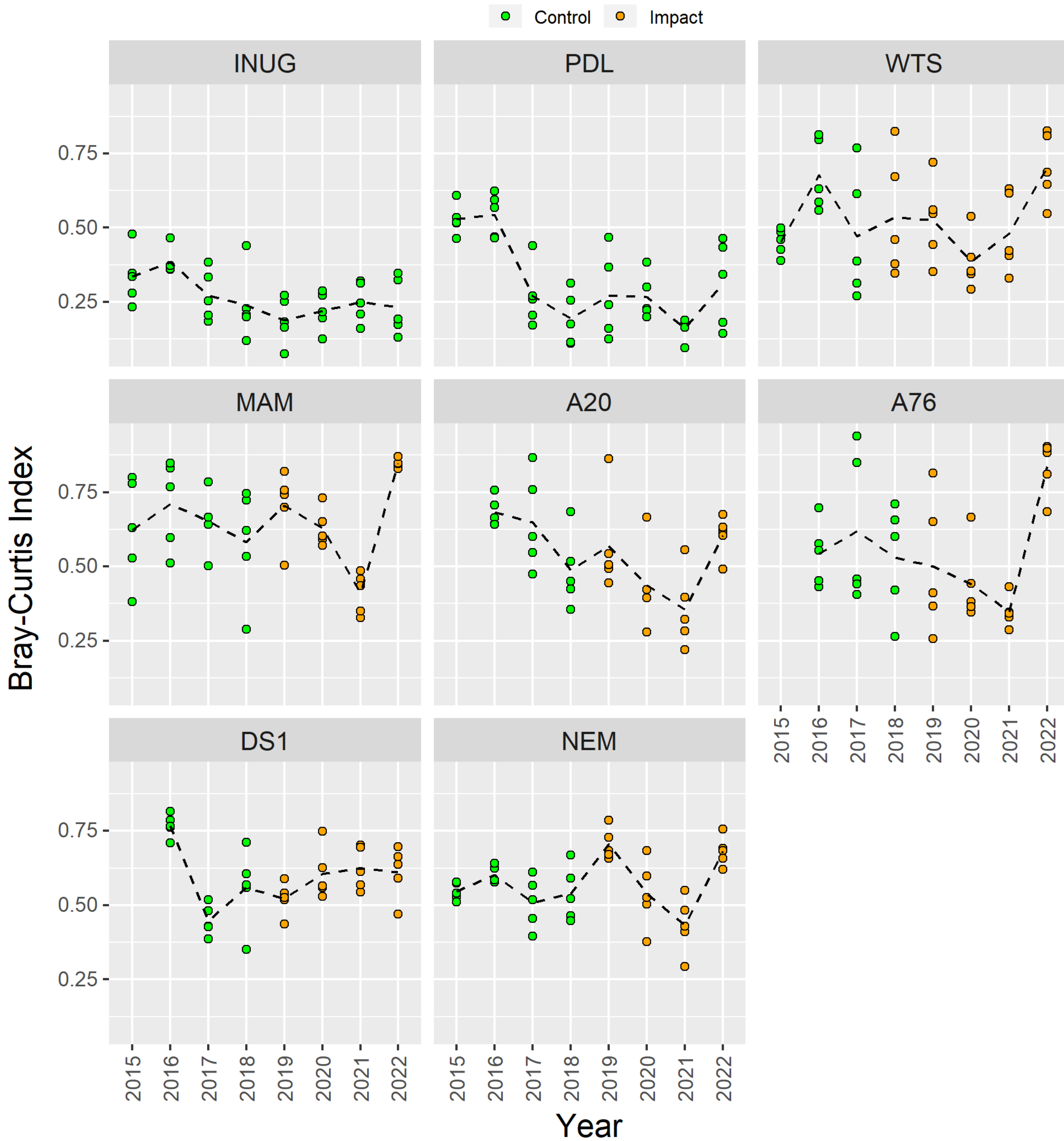


Figure E2-10. Bray-Curtis Index for the benthic invertebrate community at the Whale Tail study lakes since 2015.



APPENDIX F
2019 WATER QUALITY EFFECTS ASSESSMENT

TABLE OF CONTENTS

F.1 INTRODUCTION

This technical document was prepared by Azimuth Consulting Group Partnership (Azimuth) to provide context on the potential for adverse effects to lower trophic biota (i.e., phytoplankton, zooplankton and benthic invertebrates) due to changes in water parameters that do not have effects-based thresholds (e.g., water quality standards, guidelines or criteria).

F.1.1 Background

The decision framework for the CREMP incorporates the use of *thresholds* (i.e., typically CCME water quality guidelines or effects-based equivalents from other jurisdictions) and *triggers* (i.e., early warning limits typically set between baseline/reference conditions and the threshold for parameters with effects-based guidelines, or set at the 95th percentile of the baseline/reference conditions; see **Appendix I** in the 2020 CREMP report for details). To date, for parameters with effects-based thresholds, CREMP monitoring has shown that receiving environment water quality in the Meadowbank and Whale Tail Pit study lakes meets both the trigger and threshold values (i.e., well below water quality guidelines).

Mining-related increases, particularly at NF study areas, have been observed for some parameters without water quality guidelines, including total dissolved solids (TDS), total alkalinity, conductivity, hardness, and certain major ions (i.e., calcium, magnesium, potassium, and sodium). Most of these parameters also exceed predicted concentrations presented in the Meadowbank Final Environment Impact Statement (FEIS) (Cumberland, 2005). In addition, total silicon, which was not routinely measured during the baseline period and shows little in the way of temporal trends, exceeds FEIS predictions. Because silicon was not routinely included in the suite of analyses in the baseline water chemistry samples, the baseline water quality values for Third Portage Lake, Second Portage Lake, and Wally Lake were set to 0 mg/L. This approach resulted in an underestimate of future concentrations for Third Portage Lake, Second Portage Lake, and Wally Lake. Silicon is not recommended as a parameter for evaluating the accuracy of the water quality model predictions for the Meadowbank study area lakes given the underestimate in baseline water chemistry.

As described in the main report, biological monitoring conducted under the CREMP targets the phytoplankton and benthic invertebrate communities. Results to date indicate that communities in the NF areas are functionally intact, with major indices such as taxonomic richness and abundance remaining relatively stable across the more than a decade of events. Thus, the biological data indicate that current water quality in the NF study areas is not adversely affecting the health of phytoplankton and benthic invertebrate communities compared to baseline or reference conditions.

F.1.2 Rationale

Notwithstanding the evidence showing phytoplankton and benthos communities are similar to baseline/reference conditions, the Kivalliq Inuit Association (KIA), in their review of the 2018 annual report, recommended[1] that Agnico Eagle complete the following:

i. *Investigate the source of these parameter increases, their spatial extent and the reversibility of these trends.*
ii. *Discuss the implications of increased conductivity, calcium, magnesium, potassium, sodium, TDS and alkalinity at the near-field sites on lower trophic levels, specifically in terms of the community composition of phytoplankton, zooplankton and benthic invertebrates.*
iii. *In accordance with AEM Management Response Plan for the Meadowbank Mine Aquatic Environment Monitoring Program, that AEM increase monitoring frequency at the mid-field sites to determine the spatial extent of exceedances observed in the near-field during the open water season.*
iv. *Conduct an investigation of cause study for the observed changes in water chemistry and determine possible management strategies.*

This technical memorandum is meant to address recommendations i) and ii) above by providing a review of available literature on the effects of selected conventional and ionic compounds on lower trophic level community composition. The outcome of this technical review will help determine if increased monitoring frequency (point iii) and/or investigation of cause studies (point iv) should be considered to help inform adaptive management decisions.

F.1.3 Approach

As described in **Section F.1.1**, the following parameters have been shown to be exceeding baseline/reference conditions and/or FEIS predictions: total dissolved solids (TDS), total alkalinity, conductivity, hardness, certain major ions (i.e., calcium, magnesium, potassium, and sodium), and total silicon. Apart from total silicon, the rest of these parameters are inter-related to some extent or are not parameters of toxicological concern. Rationale for the approach used herein to cover the range of parameters is as follows:

[1] Recommendation 22 in the 2018 Annual Report Comments.

- *TDS* – this parameter is a measure of all dissolved constituents in water, but is comprised primarily of inorganic salts (mainly calcium, potassium, magnesium, sodium, bicarbonates, chlorides, and sulphates). Consequently, it essentially includes total alkalinity (the measure of a solution's ability to neutralize acid inputs), hardness (the sum of multivalent ions in solution), conductivity (the measure of a solution's ability to conduct electricity; correlated to dissolved salts), and major ions (concentrations of individual ions in solution). While a site-specific approach that considers the ratios of individual major ions is preferred from a technical perspective, it is not practical for a literature approach due to the sheer number of permutations across these constituents. Consequently, the literature review for the parameters mentioned herein focused on primarily on TDS.
- *Conductivity* – as mentioned above, this parameter is related to TDS and could therefore be excluded for singular focus. However, as there is some effects-based information available (e.g., US EPA 2016), we have included it for additional context.
- *Total silicon* – this parameter plays an important role as an essential dissolved element consumed by the phytoplankton group of algae called diatoms. Relative abundance of this primary producer can have effects on higher trophic level organisms and as community changes occur in response to elevated or reduced silicon.

F.2 LITERATURE REVIEW

A literature review was completed to assess the potential effects of TDS, conductivity and total silicon at different concentrations on fresh water aquatic life (e.g., phytoplankton, zooplankton, benthic invertebrates, and fish species) that may either reasonably be found in the Meadowbank study area lakes or be reasonably comparable. Preference was given to peer-reviewed literature and government sources including articles, studies, effects assessments, published guidance, and literature reviews. Other sources (e.g., unpublished "grey" literature) were also used where relevant.

F.2.1 Total Dissolved Solids

Solids in water can be measured as total solids, total suspended solids (TSS), or total dissolved solids. Total solids is the measure of all both TSS and TDS. TDS is the measure of all dissolved constituents of a solution which may be of anthropogenic origin such as mining activities or road salt-contaminated runoff or natural influences such as soils or geology (Weber-Scannel & Duffy 2007). The measurement of TDS is conducted by the removal of suspended solids by filtration through a 0.7-micron glass fiber filter followed by drying of the filtrate at 180 degrees Celsius. The dried filtrate residue is divided by the volume of water filtered to determine the concentration of TDS which is usually reported in mg/L (APHA 2017). TDS is comprised mainly of inorganic ions but can also include dissolved organic matter. The potential biological effects of TDS are, therefore, related to the specific composition of the ions, their speciation, and other solids present in water. TDS may also exhibit toxicity through osmotic stress (i.e., where cell desiccation occurs due to leakage Davies & Hall 2007). Except in conditions where ratios and speciation of ionic components are fairly stable, TDS may be a poor predictor of toxicity (Chapman & McPherson 2016).

Similar to conductivity, TDS may be used as a surrogate measure for salinity because this measure tends to provide an estimate of the ionic compounds present (USEPA 1999). While elevated concentrations of TDS may change the osmotic conditions whereby elevated concentrations of TDS leads to potential osmotic stress especially in ultra-oligotrophic lakes with naturally low TDS, the ratios of ions present in solution are important due to the presence of essential macro and micro-minerals (EPA 2002). Meadowbank and Whale Tail study areas feature ultra-oligotrophic lakes with naturally low TDS. Increased chemical density influences the osmotic regulation of metabolism and biotic distribution in aquatic communities (BC MOE 2013).

Due to the complex and variable composition of ions and dissolved solids measured as TDS, a generic TDS guideline for the protection of aquatic life must be overly protective to account for the most toxic potential combination to the most sensitive organisms and life stage (Weber-Scannell and Duffy 2007). Assigning a threshold concentration for TDS is difficult because the high site specificity of this parameter. This challenge is reflected in the absence of any federal water quality guideline, with the exception of an aesthetic objective of less than or equal to 500 mg/L, for TDS (Health Canada 1991). Regulation of TDS is also limited in other jurisdictions with few exceptions such as Alaska, where TDS may not exceed 500 mg/L without a special permit and 1,000 mg/L at any time (ADEC 2012).

The presence of dissolved ions in solution is essential for the survival of aquatic organisms and provides the basis for the lowest trophic residents in the form of mineral uptake. Macro-mineral uptake is required for the support of biochemical functions such as magnesium and potassium (EPA 2002). Another example of the important biological role of dissolved ions is the importance of chloride in osmoregulation (Elphick et al. 2010). Many communities have low sensitivity to TDS these may be more readily detected through biological monitoring which can detect the overall impact of changes of water quality in a system (Buikema et al. 1982). Toxicity is highly dependent upon both the composition of the residents of the system and the components, speciation, and ratios of the dissolved analytes.

Weber-Scannell and Duffy (2007) reviewed TDS toxicity to aquatic life and recommend deriving ion-specific limits for aquatic life (i.e., rather than for TDS) although this may not satisfy the potential osmotic regulation concerns. Mount et al. (1997) prepared and tested the toxicity of over 2,900 ionic solutions on Daphnids (*Ceriodaphnia dubia* and *Daphnia magna*). Their results suggested the following descending relative ion toxicity: potassium, bicarbonate and magnesium, chloride, sulphate. Neither sodium nor calcium resulted in significant effects (Mount et al., 1997). However, Mount et al. (1997) also found that the potential toxicity of chloride, sulphate, and potassium were reduced in solutions enriched with more than one cation. The inability to identify to attribute the toxicity of a specific constituent of TDS is inherent to the nature of the complex mixture this parameter measures with potential for effect masking, additive toxic effects, and synergistic toxic effects (Goodfellow et al. 2009). Timpano et al. (2010) examined the relationship between benthic macroinvertebrate community metrics in coal field streams and TDS. They caution that impacts from mine-related TDS is confounded because elevated TDS rarely occurs independently of other stressors. This study indicated several benthic macroinvertebrate richness measures were inversely correlated with TDS. Relative species abundance showed no correlation to TDS. Concentrations of TDS in the study streams ranged from 27.8 to 791.6 mg/L. The dominance of sulphate as a constituent in this study may reduce its relevance given the historically low sulphate concentrations in the Meadowbank study area lakes; in addition, the TDS concentrations are also notably higher than those found in the Meadowbank study area lakes.

The TDS review paper by Weber-Scannel and Duffy (2007) showed effects at concentrations less than 250 mg/L with a reported global mean in rivers of 120 mg/L. A TDS receiving environment benchmark 500 mg/L was adopted at Diavik (WLWB, 2013). Scannell and Jacobs (2001) completed a detailed review on the effects of TDS on aquatic life including fish, aquatic invertebrates, and algae focusing on Alaskan waters and TDS components that would be similar to those found in mine effluent. They found no effects to invertebrate growth and survival at concentrations below 1500 mg/L, that there was no reported range of concentrations that caused a toxic response in algae, and that fertilization and hatching rates in salmonids was the most sensitive life stage with affects at concentrations around 750 mg/L. They also concluded that toxicity was due primarily to ionic properties rather than osmotic effects. Chapman, Bailey, and Canaria (1999) completed an assessment of TDS toxicity associated with two mine effluents on chironomid (midge) larvae and early life stages of rainbow trout. They found no toxicity for rainbow trout at concentrations below 2,000 mg/L but did observe effects on chironomids at concentrations greater than 1,100 mg/L. A 2013 Effects Assessment report for the Snap Lake

Mine for De Beers Canada Inc. included results from a site-specific toxicity testing on phytoplankton, zooplankton, benthic invertebrates, and fish species and concluded that *Ceriodaphnia dubia* (a planktonic flea species) was the most sensitive test species and was affected by concentrations of 560 mg/L. A statistical review of the relationship between TDS in the range of 128 to 1,545 mg/L and phytoplankton (chlorophyll-a) in 25 Canadian Lakes by Prepas (1983) did not find a correlation.

Laboratory analysis for the 2019 CREMP water chemistry was completed by ALS Environmental, Burnaby, BC. As reported in the 2019 CREMP (Azimuth 2020), the maximum reported concentration in 2019 was 52.2 mg/L at WAL in March, consistent with the magnitude of concentrations reported in 2018. TDS concentrations in 2019 at other Meadowbank NF stations were as follows: TPE had a maximum of 23.9 mg/L; TPN a maximum of 24.1 mg/L; and SP had a maximum of 32.6 mg/L. The literature cited above suggests that the concentrations of TDS observed in the Meadowbank study area lakes are well below the concentrations where effects will occur. Furthermore, phytoplankton biomass and taxa richness have remained stable as has benthic invertebrate biomass and taxa richness confirming that primary productivity within the study area lakes is not exhibiting adverse effects from elevated TDS.

F.2.2 Conductivity

Much like TDS, specific conductivity has been used as a measurement of ionic strength (Cormier et al., 2012; USEPA, 2016). Conductivity is measured by passing an electrical current through a solution to determine conductance, or the reciprocal of resistance of a solution; therefore, it serves as an indirect measure of only ionic inorganic constituents. It does not have a relationship to dissolved organic compounds because these rarely dissociate (APHA 2018). The TDS method is applicable to waters that mostly contain calcium, magnesium, sodium, potassium, chlorate, sulphate, and chloride and TDS less than 2500 mg/L (APHA 2018). The concentration of all dissociated ions is inversely correlated to the electrical resistance of a solution. Because of the broad nature of TDS, the toxicity potential of a specific conductivity value depends on the toxicity of the ionic composition (USEPA 2016). There is no threshold for specific conductivity at the Meadowbank study area lakes and no federal guidelines.

Water quality parameters are useful indicators of potential effects of local environmental changes on freshwater ecosystems. Anthropogenic influences to water quality such as decreased dissolved oxygen is often correlated with a change in pH and an increase in conductivity, and nutrient concentrations (Leszczynska et al. 2019). The effects of these changes, especially if measured over time may not be detectable through biological monitoring. This is because aquatic communities acclimate to changes in water quality, especially those featuring natural seasonally or daily variability. Conductivity is an example of a naturally variable parameter that not only includes highly variable toxicity but also varies in measured value in response to natural system input fluctuations (i.e. freshet, rainfall, groundwater influence) (USEPA, 2016; Hood et al. 2006).

As indicated in the 2019 CREMP, some Meadowbank study area lakes have exhibited an increase in conductivity relative to baseline/reference conditions. The mean conductivity in WAL in 2019 was 47.1 µS/cm which was the highest mean value from the Meadowbank study area. The US EPA provided a draft field-based method for developing aquatic life criteria for specific conductivity in 2016. Cormier et al. used this approach and reviewed the relationship between specific conductivity in West Virginia coal field stream systems and macroinvertebrate health to create a species sensitivity distribution and derive a benchmark relationship. The authors determined that a bench mark of 300 µS/cm was appropriate to prevent the extirpation of 95% of invertebrate genera in the study area. These results were confirmed in a separate study by Clements and Kotalik (2015).

Michelutti et al. (2002) examined the limnological conditions in 34 lakes and ponds on Victoria Island (arctic Canada) and provided a mean specific conductance of 96.4 µS/cm. Dranga et al. (2017) reviewed and compiled limnological data from 1489 shallow lakes and ponds in northern Canada and found a range of conductivity with a low of 2.5 µS/cm and a mean specific conductivity of 166 µS/cm. The authors did not find an association between trophic level or vegetation cover and conductivity but did find conductivity was affected by geological area. In comparison, Ruhland et al. (2003) summarized limnological results from 21 Canadian arctic tundra lakes and found specific conductivity ranged from 7.3 to 98.8 µS/cm with a mean of 17.8 µS/cm. The results reported in the 2019 CREMP suggests that although conductivity in the near-field Meadowbank study area lakes may be elevated compared to baseline and reference, the conductivity remains relatively low compared to other arctic lakes.

F.2.3 Silicon

Elemental silicon is highly abundant. It is relative stable and does not occur in its free form in nature but combines with oxygen and other elements to form oxides or silicates (CCME 2008). The term “silica” is often used to refer to silicon in natural waters and is usually represented by the hydrated form of the oxide (CCME 2008). It is also an essential micronutrient, particularly for diatoms. Silicon limitations can play an important role in phytoplankton dynamics (Shatwell et al. 2013; Saros et al. 2013). A change in the silicon concentrations may impact the succession of different phytoplankton species and the ratio of silicon with different nutrients may influence the ratio of cyanobacteria to diatoms. However, phytoplankton dynamics are also heavily influenced by other factors including temperature and photoperiod (Shatwell et al. 2013). As a primary producer, diatom abundance has cascading effects to higher trophic levels and in some aquatic food chains silicon availability plays a significant role in energy transfer through effects on diatom productivity (Krause et al. 2018).

This literature review did not find any reports on potential toxic effects to aquatic receptors from low silicon concentrations similar to the concentrations observed in the Meadowbank study area lakes. In general, the conclusion of this the literature review was that there was little data to suggest potential toxicological effects from silicon to aquatic receptors at the range of concentrations that may reasonably be found in Canadian surface freshwater. There are no Canadian federal or provincial guidelines specifically for silicon in water to protect aquatic life. There are, however, several studies that report on the silica concentrations in Canadian surface waters including arctic regions. Natural silicon concentrations in Canadian surface waters are normally less than 5 mg/L silica but are highly variable ranging from 0.02 mg/L to 40 mg/L depending on region (CCME 2008). Antoniades et al. (2003) reported on chemical limnology of 24 ponds and one arctic lake from the Canadian high arctic. The authors did not report on silicon but did report that concentrations of silica (SiO_2) ranged from 0.01 to 4.05 mg/L with a mean of 1.42 mg/L and a median of 1.18 mg/L. Hamilton et al. (2001) report the physical and chemical limnology of 204 Canadian arctic lakes. They report silicate (SiO_2) concentrations for n=174 ranged from 0.05 to 6.7 mg/L with a mean of 1.1 mg/L.

The mean and median values from the arctic lake studies referenced above are higher than the silicon and silicate (SiO_2) trigger concentrations for the Meadowbank study area lakes. The concentrations in the Meadowbank lakes have remained low despite a statistically significant increase over baseline/reference conditions. The range of silicon concentrations was generally below the trigger of 0.2 mg/L with the exception of SP, which ranged up to 0.23 mg/L, and INUG, which ranged up to 0.21 mg/L. Silicate as SiO_2 was consistently below the trigger of 1.0 mg/L. Importantly, neither silicon nor silicate showed strong temporal trends associated with mining activity (see main report). Thus, the observed differences are more likely due to inherent spatial heterogeneity rather than to actual temporal changes.

The lack of substantial changes in total silicon (or silicate) suggest that changes to lower trophic communities at Meadowbank are unlikely. Based on this literature review the most likely impact from increases in total silicon would be to the phytoplankton assemblage. An increase in concentrations of silicon may favor diatoms whereas a decrease in silicon may favor cyanophytes. The species richness in the Meadowbank study area has remained relatively stable for all sample years, with no obvious changes in diatom biomass. Thus, the results of site-specific biological monitoring support the findings of the literature review that suggest changes to lower trophic communities are unlikely.

F.3 CONCLUSIONS

This literature review was conducted to provide some additional context to help assess the ecological significance of mining-related changes to water quality for parameters without effects-based water quality guidelines. The review results corroborate the findings of site-specific biological monitoring conducted under the CREMP. While changes in the parameters of interest (TDS, conductivity and total silicon) can affect lower trophic level communities, concentrations of these parameters at Meadowbank and Whale Tail remain well below concentrations associated with adverse effects reported in the literature.

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