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Late Holocene intensification of the westerly winds at the subantarctic Auckland Islands (51° S), New Zealand

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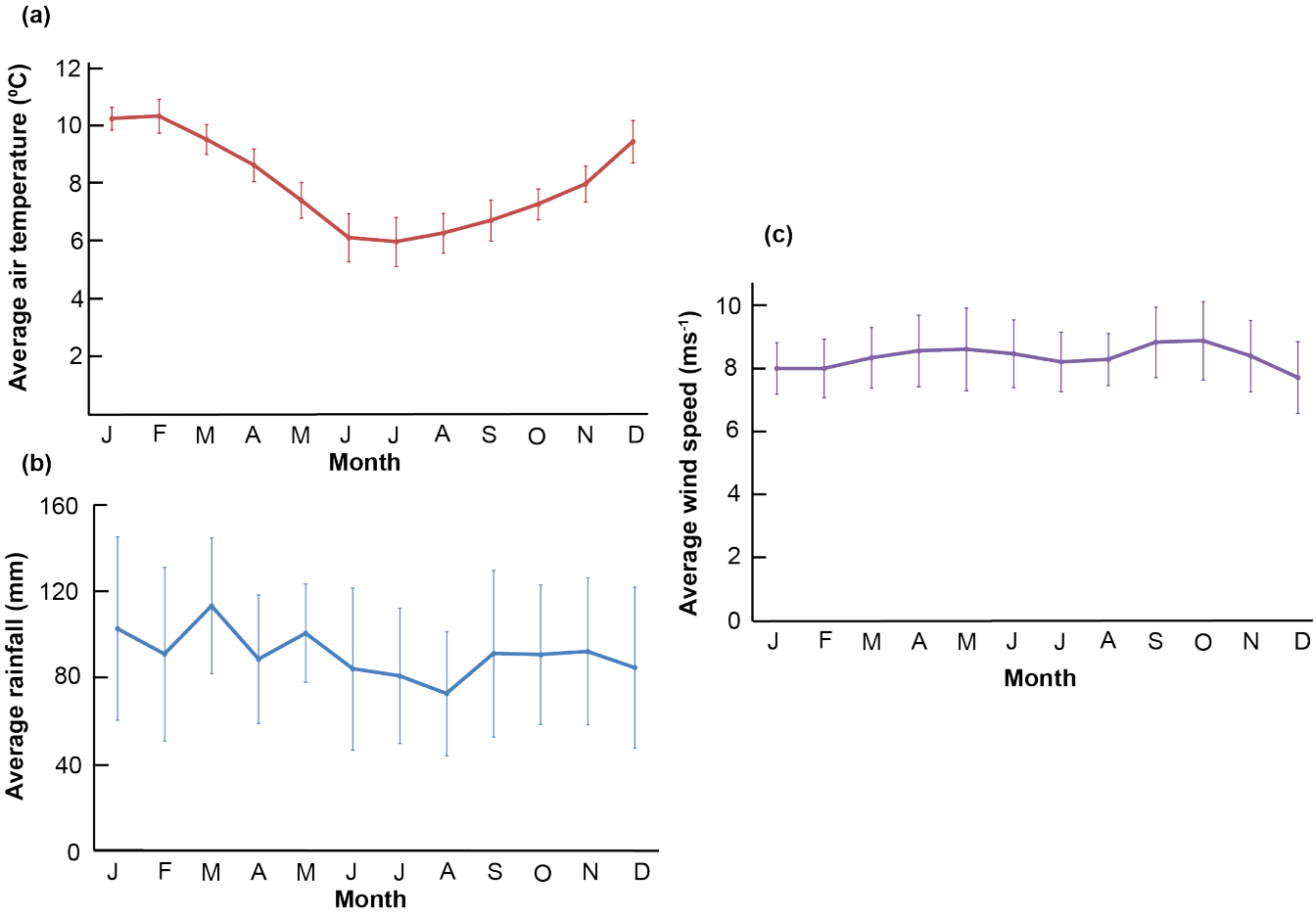

Fig. S1. Weather data from Enderby Island (50º 28'58'' S, 166º 18'00'' E; Auckland Islands group) from the Cliflo Database (http://cliflo.niwa.co.nz). (a) Average monthly air temperature; (b) average monthly rainfall; (c) average monthly wind speed. Averages include data from 1992-2016. Error bars represent 1σ.

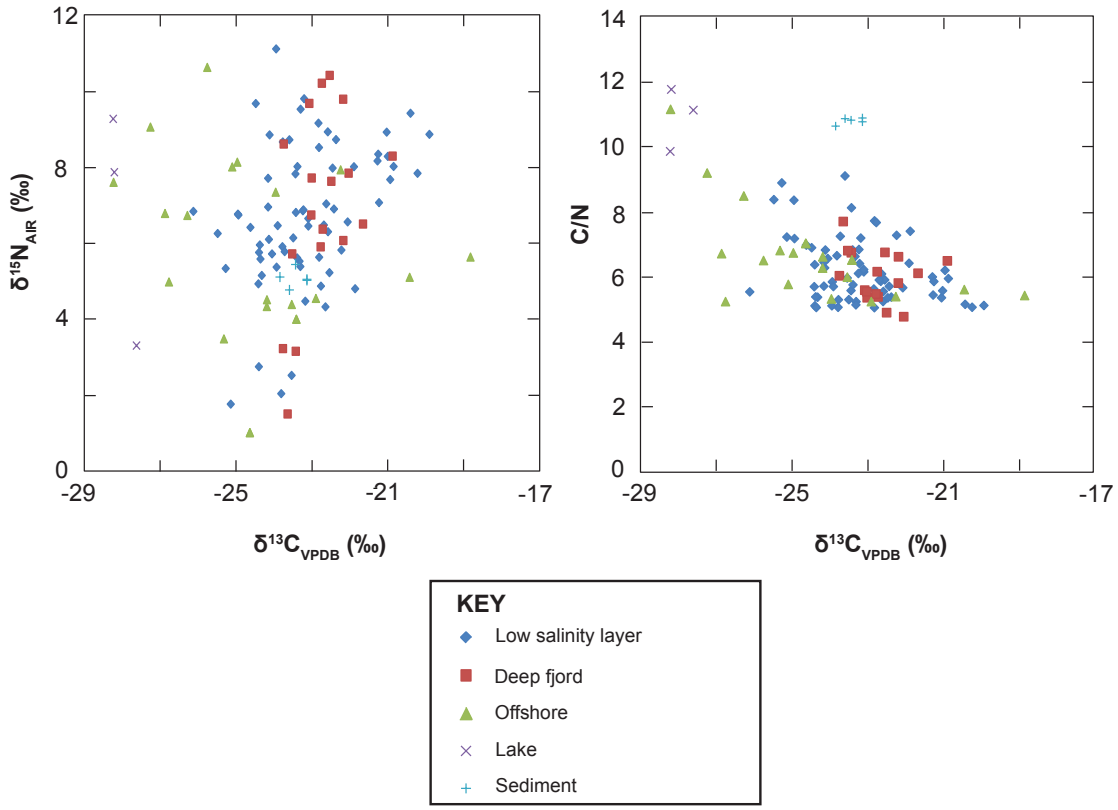

Fig. S2. Stable carbon and nitrogen isotopes (left) and atomic C/N (right) of particulate organic matter (OM) and sediment samples from the Auckland Islands. Low salinity surface layer= particulate OM samples from <10m in Hanfield and Norman Inlets (CTD_006 and CTD_007); deep fjord= particulate OM samples from >10m in Hanfield and Norman Inlets (CTD_006 and CTD_007); offshore= particulate OM samples from the adjacent continental shelf (CTD_003); lake= particulate OM samples from Lakes Hinemoa, Tutanekai, and Speight on the main island; sediment= core-top sediment samples from Hanfield Inlet (14PL001, 18, 19 and 20G1, 36B2). There is no obvious difference in isotopic properties of particulate OM for the low salinity layer and deep fjord. See Table S2 for data.

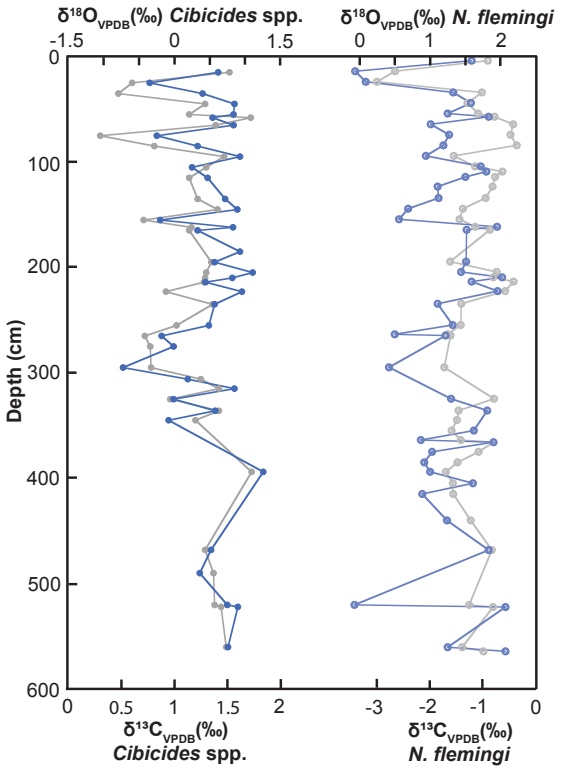

Fig. S3. Downcore variations in $\delta^{13}C$ and $\delta^{18}O$ for epifaunal *Cibicides* spp. (left) and infaunal *Nonionellina flemingi* (right), 36P4, Hanfield Inlet. Solid circles represent *Cibicides* spp. and open circles represent *N. flemingi.* Blue indicates $\delta^{18}O$ and grey is $\delta^{13}C$. See text for error for duplicate measurements and note the disturbance in the core at ~420cm. Both isotopes for *Cibicides* spp. show similar trends downcore, with more positive (negative) $\delta^{13}C$ corresponding to more positive (negative) $\delta^{18}O$. The $\delta^{18}O$ profiles for both species show similar trends downcore, but $\delta^{13}C$ profiles do not (see Fig. 8).

Table S1. All samples used in the current study. G= grab sample; CTD= Conductivity, Temperature, Depth sample; B= box-core sample; P= piston-core sample. Number indicates the order of sampling at that site. C/N= bulk carbon and nitrogen analysis; FI= benthic foraminiferal stable carbon and oxygen isotope geochemistry; WI= stable carbon and oxygen isotope geochemistry of water; PP= physical properties. All samples were collected from R/V *Polaris II* on expeditions 14PL001 and 15PL001.

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Cruise	Latitude	Longitude	Site & Sample ID	Location	Water depth (m)	Core length (m)	Description/ Additional Info	Analyses	Sampling Resolution
14PL001	-50° 43'03.8"	166° 10' 17 "	14G1	Norman Inlet	46.6	_	Grey fine sand	FI	_
14PL001	-50° 44' 18.4"	166° 07' 25.1"	18G1	Hanfield Inlet	45.8	–	Dark brown silt and fine sand	C/N	_
14PL001	-50° 44' 14.8"	166° 07' 53.4"	19G1	Hanfield Inlet	49.7	_	Dark brown silt	C/N	_
14PL001	-50° 44' 13.7"	166° 07' 58.9"	20G1	Hanfield Inlet	53.5	–	Dark brown silt	C/N	_
14PL001	-50° 42' 54"	166° 06' 14.3"	35G1	Norman Inlet	31.7	_	Brown mud	FI	_
14PL001	-50° 44' 19.1"	166° 07' 21.4"	36G1	Hanfield Inlet	44.5	_	Dark brown silt	FI	_
14PL001	-50° 44' 19.4"	166° 07' 20.8"	36B2	Hanfield Inlet	37.1	0.1	2 cores subsampled	C/N, FI	Every cm
14PL001	-50° 44' 19.2"	166° 07' 21"	36P4	Hanfield Inlet	44.4	5.7	Dark brown silt and fine sand	PP, C/N, FI	Every 5cm for C/N and every 10cm for FI
14PL001	-50° 44' 14.1"	166° 07' 56.2"	39G1	Hanfield Inlet	51.8	–	Dark brown silt and fine sand	FI	_
14PL001	-50° 44' 14.5"	166° 07' 56.2"	39P4	Hanfield Inlet	52.3	5.53	Dark brown silt and fine sand and dark clay/ silt	PP	_
14PL001	-50° 42' 54"	166° 06' 10.8"	CTD_001	Norman Inlet	43.5	_	Site 35	WI, C/N	
14PL001	-50° 44' 19.2"	166° 07' 21"	CTD_002	Hanfield Inlet	44.5	_	Site 36	WI, C/N	
14PL001	-50° 44' 8.4"	166° 12' 28.8"	CTD_003	Open ocean (between Hanfield and Norman)	67	–	_	WI, C/N	_
14PL001	-50° 44' 18.6"	166° 07' 22.2"	CTD_004	Hanfield Inlet	40	_	Site 36	WI, C/N	
15PL001	-50º42’54”	166º06’54”	CTD_006	Norman Inlet		_	_	WI	
15PL001	-50º44’28”	166º07’81”	CTD_007	Hanfield Inlet		–	_	WI	

Table S2. Water and particulate organic matter isotope results from CTD samples collected on 14PL001 and 15PL001.

Cruise	Sample	Location	Weather conditions	Water column depth (m)	$\delta^{15}N_{AIR}$ (‰)	$\delta^{13}C_{VPDB}$ (‰)	C/N	$\delta^{18}O_{VSMOW}$ (‰)	$\delta^{13}C_{DICVPDB}$ (‰)
14PL001	CTD_001	Norman Inlet	Light rain	2	5.94	-24.41	5.43	-0.08	1.23
14PL001	CTD_001	Norman Inlet	Light rain	4	5.75	-24.43	5.16	-0.24	1.51
14PL001	CTD_001	Norman Inlet	Light rain	8	5.57	-24.39	5.11	-0.13	1.35
14PL001	CTD_001	Norman Inlet	Light rain	12	_	_	_	-0.17	1.48
14PL001	CTD_001	Norman Inlet	Light rain	14	_	_	_	-0.06	1.29
14PL001	CTD_001	Norman Inlet	Light rain	35	8.60	-23.78	6.08	-0.26	0.64
AVERAGE					6.47	-24.25	5.45	-0.16	1.25
14PL001	CTD_002	Hanfield Inlet	Moderate rain	1	6.29	-22.62	5.60	-0.28	0.03
14PL001	CTD_002	Hanfield Inlet	Moderate rain	4	5.22	-22.58	5.96	-0.12	-0.95
14PL001	CTD_002	Hanfield Inlet	Moderate rain	26.3	4.94	-23.31	6.19	-0.23	-
14PL001	CTD_002	Hanfield Inlet	Moderate rain	43.5	5.71	-23.56	6.86	-0.1	1.21
AVERAGE					5.54	-23.02	6.15	-0.18	0.10
14PL001	CTD_004	Hanfield Inlet	Dry	1.3	4.86	-22.8	7.72	-0.19	1.31
14PL001	CTD_004	Hanfield Inlet	Dry	2.1	7.02	-22.66	6.14	-0.17	0.46
14PL001	CTD_004	Hanfield Inlet	Dry	29.1	1.50	-23.68	7.75	-0.27	1.23
14PL001	CTD_004	Hanfield Inlet	Dry	36	3.22	-23.8	8.93	-0.24	0.03
AVERAGE					4.15	23.24	7.64	-0.22	0.76
14PL001	CTD_003	Offshore, between Hanfield and Norman Inlets	Dry	2.1	6.55	-21.73	5.72	-0.23	1.16
14PL001	CTD_003	Offshore, between Hanfield and Norman Inlets	Dry	10.1	6.47	-21.39	5.95	-0.13	-1.01
14PL001	CTD_003	Offshore, between Hanfield and Norman Inlets	Dry	21.9	6.36	-23.69	5.43	-0.13	1.33
14PL001	CTD_003	Offshore, between Hanfield and Norman Inlets	Dry	59.9	7.62	-22.09	4.95	-	-
14PL001	CTD_003	Offshore, between Hanfield and Norman Inlets	Dry	59.9	5.89	-18.70	5.52	-	-
AVERAGE					6.58	-21.52	5.51	-0.16	0.49

Cruise	Sample	Location	Weather conditions	Water column depth (m)	$\delta^{15}N_{AIR}$ (‰)	$\delta^{13}C_{VPDB}$ (‰)	C/N	$\delta^{18}O_{VSMOW}$ (‰)	$\delta^{13}C_{DICVPDB}$ (‰)
15PL001	CTD_006	Norman Inlet	Rainy and windy	2.5	7.06	-21.28	5.91	0.30	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	2.5	-	-	-	0.28	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	8.2	8.33	-21.30	5.49	0.28	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	8.2	-	-	-	0.27	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	14.4	6.50	-21.70	6.16	0.24	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	14.4	-	-	-	0.29	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	27.8	8.28	-20.92	6.54	0.24	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	27.8	-	-	-	0.20	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	45.0	6.06	-22.21	6.67	0.30	-
15PL001	CTD_006	Norman Inlet	Rainy and windy	45.2	9.78	-22.22	5.86	0.31	-
AVERAGE					7.67	-21.61	6.11	0.27	
15PL001	CTD_007	Hanfield Inlet	Dry	2.1	9.79	-23.24	6.46	0.26	-
15PL001	CTD_007	Hanfield Inlet	Dry	2.1	-	-	-	0.19	-
15PL001	CTD_007	Hanfield Inlet	Dry	6.4	8.71	-23.63	9.16	0.24	-
15PL001	CTD_007	Hanfield Inlet	Dry	6.4	-	-	-	0.21	-
15PL001	CTD_007	Hanfield Inlet	Dry	7.6	6.80	-23.46	8.18	0.27	-
15PL001	CTD_007	Hanfield Inlet	Dry	7.6	-	-	--	0.23	-
15PL001	CTD_007	Hanfield Inlet	Dry	10.1	9.67	-23.11	5.64	0.20	-
15PL001	CTD_007	Hanfield Inlet	Dry	10.1	-	-	-	0.18	-
15PL001	CTD_007	Hanfield Inlet	Dry	30.3	-	-	8.73	0.24	-
15PL001	CTD_007	Hanfield Inlet	Dry	10.3	-	-	-	0.19	-
15PL001	CTD_007	Hanfield Inlet	Dry	45.0	7.84	-22.08	4.82	0.29	-
15PL001	CTD_007	Hanfield Inlet	Dry	45.0	-	-	-	0.29	-
AVERAGE					7.81	-23.10	7.17	0.23	

Table S3. Benthic foraminifer stable isotope results ($\delta^{13}C$ and $\delta^{18}O$) from core 36P4, Hanfield Inlet.

Cruise	Core	Av depth (cm)	Age (cal yr BP)	Species	$\delta^{13}C$VPDB(‰)	$\delta^{18}O$VPDB(‰)
14PL001	36P4	15	515.6	*Cibicides*	1.52	0.62
14PL001	36P4	25	606.55	*Cibicides*	0.53	-0.28
14PL001	36P4	25	606.55	*Cibicides*	0.67	-0.42
14PL001	36P4	35	707.1	*Cibicides*	0.47	0.40
14PL001	36P4	45	805.9	*Cibicides*	1.29	0.85
14PL001	36P4	55	898.7	*Cibicides*	1.14	0.84
14PL001	36P4	58	932.4	*Cibicides*	1.72	0.54
14PL001	36P4	65	1053.2	*Cibicides*	1.39	0.84
14PL001	36P4	75	1223.85	*Cibicides*	0.30	-0.25
14PL001	36P4	85	1394.1	*Cibicides*	0.81	0.33
14PL001	36P4	95	1564.85	*Cibicides*	1.47	0.93
14PL001	36P4	105	1734.85	*Cibicides*	1.30	0.25
14PL001	36P4	115	1902.8	*Cibicides*	1.14	0.47
14PL001	36P4	135	2203.35	*Cibicides*	1.22	0.72
14PL001	36P4	145	2337.4	*Cibicides*	1.41	0.89
14PL001	36P4	155	2477.7	*Cibicides*	0.71	-0.20
14PL001	36P4	162	2575.15	*Cibicides*	1.16	0.83
14PL001	36P4	165	2616	*Cibicides*	1.14	0.33
14PL001	36P4	185	2895.3	*Cibicides*	_	0.93
14PL001	36P4	195	3034.1	*Cibicides*	1.35	0.57
14PL001	36P4	205	3172.1	*Cibicides*	1.30	1.11
14PL001	36P4	210	3242.1	*Cibicides*	1.29	0.82
14PL001	36P4	214	3297.05	*Cibicides*	1.28	0.44
14PL001	36P4	223	3421.2	*Cibicides*	0.92	0.96
14PL001	36P4	235	3569.3	*Cibicides*	1.36	0.57
14PL001	36P4	255	3808.25	*Cibicides*	1.02	0.49
14PL001	36P4	265	3931.55	*Cibicides*	0.72	-0.18
14PL001	36P4	275	4051.65	*Cibicides*	0.77	-0.01
14PL001	36P4	295	4245.75	*Cibicides*	0.78	-0.73
14PL001	36P4	306	4320.55	*Cibicides*	1.25	0.19
14PL001	36P4	315	4386.55	*Cibicides*	1.42	0.85
14PL001	36P4	325	4460.2	*Cibicides*	0.96	-0.01
14PL001	36P4	336	4541.75	*Cibicides*	1.42	0.58
14PL001	36P4	345	4609.7	*Cibicides*	1.20	-0.08
14PL001	36P4	394		*Cibicides*	1.73	1.26
14PL001	36P4	468		*Cibicides*	1.29	0.52
14PL001	36P4	490		*Cibicides*	1.37	0.36
14PL001	36P4	520		*Cibicides*	1.38	0.75

14PL001	36P4	522		*Cibicides*	1.44	0.90
14PL001	36P4	560		*Cibicides*	1.49	0.76
14PL001	36P4	5		*N. flemingi*	-0.91	1.59
14PL001	36P4	15	515.6	*N. flemingi*	-2.66	-0.06
14PL001	36P4	25	606.55	*N. flemingi*	-3.00	0.09
14PL001	36P4	35	707.1	*N. flemingi*	-1.02	1.33
14PL001	36P4	45	805.9	*N. flemingi*	-1.29	1.58
14PL001	36P4	55	898.7	*N. flemingi*	-1.09	1.25
14PL001	36P4	58	932.4	*N. flemingi*	-0.78	1.83
14PL001	36P4	65	1053.2	*N. flemingi*	-0.43	1.01
14PL001	36P4	75	1223.85	*N. flemingi*	-0.48	1.27
14PL001	36P4	85	1394.1	*N. flemingi*	-0.36	1.19
14PL001	36P4	95	1564.85	*N. flemingi*	-1.55	0.94
14PL001	36P4	105	1734.85	*N. flemingi*	-1.15	1.72
14PL001	36P4	110	1819.5	*N. flemingi*	-0.63	1.80
14PL001	36P4	115	1902.8	*N. flemingi*	-0.77	1.50
14PL001	36P4	124	2047.15	*N. flemingi*	-0.82	1.11
14PL001	36P4	135	2203.35	*N. flemingi*	-0.95	1.12
14PL001	36P4	145	2337.4	*N. flemingi*	-1.38	0.69
14PL001	36P4	155	2477.7	*N. flemingi*	-1.44	0.56
14PL001	36P4	162	2575.15	*N. flemingi*	-1.03	1.89
14PL001	36P4	162	2575.15	*N. flemingi*	-1.26	2.01
14PL001	36P4	165	2616	*N. flemingi*	-0.87	1.52
14PL001	36P4	195	3034.1	*N. flemingi*	-1.62	1.51
14PL001	36P4	205	3172.1	*N. flemingi*	-0.74	1.44
14PL001	36P4	210	3242.1	*N. flemingi*	-1.18	1.88
14PL001	36P4	210	3242.1	*N. flemingi*	-0.44	2.16
14PL001	36P4	214	3297.05	*N. flemingi*	-0.42	1.59
14PL001	36P4	223	3421.2	*N. flemingi*	-0.50	1.96
14PL001	36P4	223	3421.2	*N. flemingi*	-0.66	1.96
14PL001	36P4	235	3569.3	*N. flemingi*	-1.41	1.11
14PL001	36P4	255	3808.25	*N. flemingi*	-1.42	1.32
14PL001	36P4	264	3919.75	*N. flemingi*	-1.67	0.50
14PL001	36P4	265	3931.55	*N. flemingi*	-1.61	1.22
14PL001	36P4	275	4051.65	*N. flemingi*	-1.94	0.49
14PL001	36P4	295	4245.75	*N. flemingi*	-1.73	0.42
14PL001	36P4	306	4320.55	*N. flemingi*	-2.16	1.03
14PL001	36P4	325	4460.2	*N. flemingi*	-0.79	1.30
14PL001	36P4	325	4460.2	*N. flemingi*	_	1.30
14PL001	36P4	336	4541.75	*N. flemingi*	-1.46	1.81

14PL001	36P4	345	4609.7	*N. flemingi*	-1.49	_
14PL001	36P4	355	4683.1	*N. flemingi*	-1.59	1.62
14PL001	36P4	364	4753.35	*N. flemingi*	-1.42	0.87
14PL001	36P4	366		*N. flemingi*	-0.80	1.90
14PL001	36P4	375		*N. flemingi*	-1.08	1.03
14PL001	36P4	385		*N. flemingi*	-1.48	0.92
14PL001	36P4	394		*N. flemingi*	-1.7	1.00
14PL001	36P4	405		*N. flemingi*	-1.57	1.61
14PL001	36P4	415		*N. flemingi*	-1.56	0.89
14PL001	36P4	440		*N. flemingi*	-1.23	1.24
14PL001	36P4	468		*N. flemingi*	-0.83	1.83
14PL001	36P4	520		*N. flemingi*	-1.26	-0.07
14PL001	36P4	522		*N. flemingi*	-0.81	2.07
14PL001	36P4	560		*N. flemingi*	-1.39	1.25
14PL001	36P4	564		*N. flemingi*	-0.99	2.07