

# Large-scale degradation of a kelp ecosystem in an ocean warming hotspot

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## Supplement 1. Long-term monitoring of kelp abundance

Table S1. Records of kelp biomass and cover at 3 sites in Nova Scotia between 1949 and 2014. Samples were collected from quadrats (N = sample size). Sites are on the southwestern coast (Whitehead Island, WI) and along the central Atlantic Coast (Little Duck Island, LDI; Mill Cove, MC) of Nova Scotia. Data are mean (+ SE); dash indicates no data.

Year	Month	Site	Depth (m)	Quad. (m <sup>2</sup> )	N	Biomass (kg m <sup>-2</sup> )	Cover (%)	Source
1949	Sum. <sup>a</sup>	WI	5–10	0.42 <sup>b</sup>	–	19.4 (0.33)	90 <sup>c</sup>	MacFarlane 1952
1978	–	WI	10	1	10–15	–	78 (5)	Wharton & Mann 1981
1979	7,8	WI	4.5–8	0.25	–	4.64 (0.71)	–	Tremblay & Chapman 1980
1983	8	WI	8–10	1	12	3.81 (0.14)	72.7 (21)	Scheibling 1986
2014	11	WI	5–8	1	25	2.9 (0.95)	60 (10)	This study
1984	7	LDI	8–10	1	12	8.21 (0.9)	95 (6.4)	Scheibling et al. 1999
1992	9–10	LDI	6, 8	1	10	3.94 (0.97)	75.7 (3.1)	Scheibling et al. 1999
1993	6–10	LDI	6, 8	1	10	3.79 (0.85)	65.4 (5.9)	Scheibling et al. 1999
1994	6,8–10	LDI	6, 8	1	10	0.9 (0.04)	27.5 (4.1)	Scheibling et al. 1999
1995	6–7,10	LDI	6, 8	1	14	4.1 (0.67)	76.3 (11.4)	Scheibling et al. 1999
1997	7,9,10	LDI	6	1	10	4.01 (0.66)	39.1 (7.7)	Kelly et al. 2011
1998	6–10	LDI	8	1	10	2.64 (0.42)	43.5 (6.5)	Kelly et al. 2011
1999	6–8,10	LDI	8	1	5	0.4 (0.01)	36.6 (5.4)	Kelly et al. 2011
2000	8	LDI	6, 8	1	9	0.3 (0.13)	13.4 (2.7)	Kelly et al. 2011
2002	8	LDI	6, 8	1	16	0.07 (0.02)	3.1 (0.2)	Kelly et al. 2011
2008	8	LDI	8	1	8	2.36 (0.38)	–	Kelly et al. 2011
2014	8	LDI	8	1	8	0.21 (0.04)	2.4 (0.5)	This study
1968	Sum. <sup>a</sup>	MC	4–8	0.25	31	16 (0.4)	–	Mann 1972
1973	6–8	MC	4–12	0.5	5	20.1 (9.2)	–	Breen & Mann 1976
1977	Sum. <sup>a</sup>	MC	8	0.25	10	3.6 <sup>c</sup>	–	Chapman 1981
1982	Sum. <sup>a</sup>	MC	4–14	80 <sup>d</sup>	1	–	60 (0)	Moore & Miller 1983
1992	10	MC	8	1	10	4.94 (0.71)	91.5 (5.5)	Scheibling et al. 1999
1993	6,8–9	MC	8	1	10	2.1 (0.48)	65.6 (8.9)	Scheibling et al. 1999
1994	6,8–9	MC	6–10	1	10	0.97 (0.22)	33.5 (5.3)	Scheibling et al. 1999
1995	6,8,10	MC	6–10	1	10	4.7 (0.95)	45.8 (9.4)	Scheibling et al. 1999
2005	10–11	MC	4, 8	–	73	–	66.8 (1.6)	Saunders & Metaxas 2008

2006	10–11	MC	4, 8	–	44	–	41.2 (1.6)	Saunders & Metaxas 2008
2008	7,9	MC	4, 6	0.5	16–18	0.39 (0.06)	–	Krumhansl et al. 2011
2009	8–9	MC	4, 6	0.5	16–18	1.97 (0.43)	–	Krumhansl et al. 2011
2010	6	MC	8	1	8	3.7 (0.77)	46.6 (9.5)	C. Feehan <sup>c</sup>
2012	6	MC	8	1	10	0.07 (0.004)	–	J. O'Brien <sup>c</sup>
2014	6,7,11	MC	8	1	8	0.1 (0.02)	16.9 (6.5)	This study

<sup>a</sup>Sampled during summer (Sum), exact months not available. <sup>b</sup>Kelp collected with 0.42 m<sup>2</sup> metal grab from a wooden dory. <sup>c</sup>SE not available. <sup>d</sup>Cover measured along transect. <sup>e</sup>Unpublished data.

## LITERATURE SOURCE

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## Supplement 2. Location of long-term study sites and coastal survey sites

Table S2. Locations of study sites along the southwestern and central Atlantic coast of Nova Scotia. Long-term study sites are Whitehead Island (WI), Little Duck Island (LDI), and Mill Cove (MC). Coastal surveys were at 7 sites in 1982 (Moore & Miller 1983) and 2014 (this study), and at 23 sites in 2000 and 2007 (Watanabe et al. 2010), and in 2014 (this study). Grids used for SST analysis that encapsulate sites in headlands (H), outer bays (O) and inner bays (I) are numbered east to west. Site numbers and grid locations correspond to Fig. S1.

Site	#	SST Grid	Latitude (°N)	Longitude (°W)	Long-term	Coastal Surveys			
						1982	2000	2007	2014
Whitehead I	1	WI	43.665	65.867	✓			✓	✓
Puddingpan I	2	H1	44.061	64.564			✓	✓	✓
E Spectacle I	3	H2	44.250	64.330			✓	✓	✓
W Ironbound I	4	H2	44.238	64.276			✓	✓	✓
Pt Enrage	5	H2	44.270	64.250			✓	✓	✓
Rose Bay	6	O1	44.293	64.248			✓	✓	✓
The Ovens	7	O1	44.325	64.259			✓	✓	✓
Feltzen South	8	O1	44.332	64.282			✓	✓	✓
Cross I	9	O2	44.317	64.174			✓	✓	✓
Little Duck I	10	O2	44.365	64.183	✓		✓	✓	✓
Hell Racketts	11	-	44.399	64.207		✓			✓
Sheep L	12	I1	44.503	64.268			✓	✓	✓
Graves Shoal	13	I1	44.548	64.197			✓	✓	✓
Coachman's L	14	I2	44.493	64.177			✓	✓	✓
Little Tancook I	15	I2	44.475	64.138		✓	✓	✓	✓
Flat I	16	O3	44.429	64.130		✓	✓	✓	✓
E Ironbound I	17	O3	44.438	64.097			✓	✓	✓
Tilley Pt	18	I3	44.538	64.016			✓	✓	✓
Mill Cove	19	I4	44.592	64.058	✓	✓	✓	✓	✓
Luke I	20	I3	44.576	63.939			✓	✓	✓
Shut-in I	21	I3	44.542	63.954		✓	✓	✓	✓
Woody I	22	H3	44.449	63.714			✓	✓	✓
Terrence Bay	23	-	44.469	63.691		✓			✓
Sambro I	24	-	44.438	63.565		✓			✓
Gill Cove	25	H4	44.485	63.535			✓	✓	✓
Duncan's Cove	26	H4	44.498	63.525			✓	✓	✓

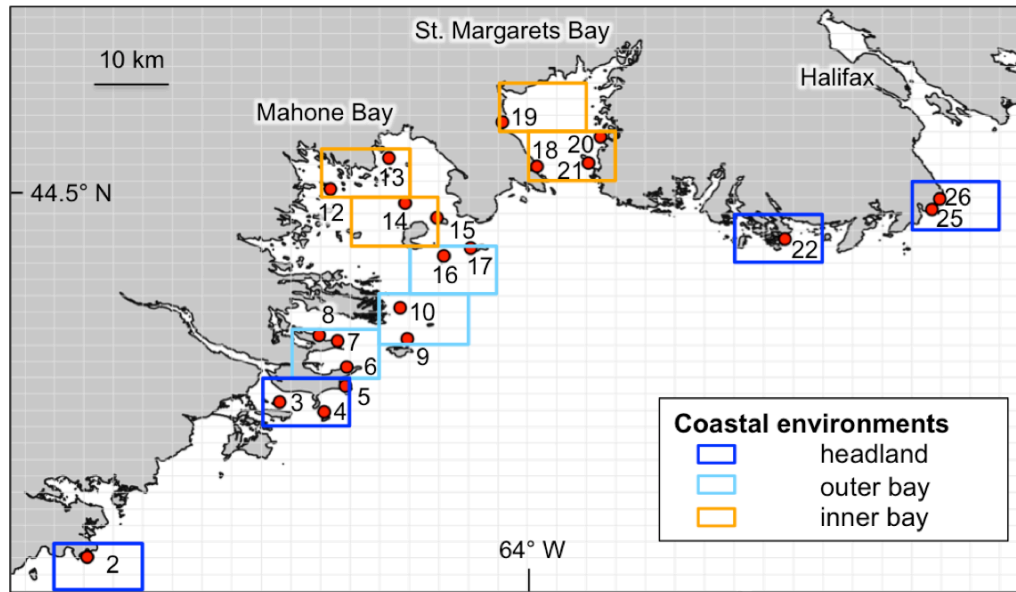


Fig. S1. Numbered locations of sites on the central Atlantic coast surveyed in 2000 and 2007 (Watanabe et al. 2010), and resurveyed in 2014 (this study). Grids used for SST analysis that encapsulate headland, outer bay and inner bay coastal environments are indicated. For site names and coordinates see Table S2.