

Twenty-first century mean sea level rise scenarios for Canada

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Fisheries and Oceans Canada

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TABLE OF CONTENTS

ABSTRACT	IX
RÉSUMÉ.....	IX
1. INTRODUCTION	2
2. DATA AND METHOD	2
2.1. TIDE-GAUGE DATA.....	4
2.2. GLACIAL ISOSTATIC ADJUSTMENT (GIA) MODEL AND GLOBAL POSITIONING SYSTEM(GPS) DATA.....	2
2.3. OCEAN AND LAND-ICE EFFECTS	2
2.4. COMPUTATION OF REGION SEA LEVEL CHANGE.....	3
3. REGIONAL SLR SCENARIOS	3
3.1. LOW SCENARIO	3
3.2. INTERMEDIATE SCENARIO.....	4
3.3. HIGH SCENARIO	4
3.4. AR4 A2 VERSUS AR5 RCP8.5.....	4
4. CONCLUSION AND DISCUSSION	4
ACKNOWLEDGMENTS	5
GLOSSARY OF TERMS	6
REFERENCES.....	7
TABLES	9

FIGURES	14
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LIST OF FIGURES

Figure 1: Map of the study region and the location of tide-gauge stations. CH: Charlottetown; HH: Harrington Harbour; PA: Point Atkinson; SJ: Saint John	14
Figure 2: Annual mean RSLs at selected tide-gauge stations across Canada for available periods. The exception is for Nain, where monthly mean RSLs are shown. See Fig. 1 for locations.....	15
Figure 3: Projected SLR by 2100 under the Lowest Scenario based on observed trends in the past. No projections are available for Ulukhaktok, Resolute, or Qikiqtarjuaq.	16
Figure 4: Projected SLR by 2100 under the Intermediate Scenario based on projections for IPCC AR5 RCP8.5.	17
Figure 5: Projected SLR by 2100 under the High Scenario based partially on projections for IPCC AR5 RCP8.5.	18
Figure 6: Projected SLR by 2100 under the Intermediate Scenario based on projections for A2..	19

LIST OF TABLES

Table 1: Locations of tide-gauge stations, and associated data periods if sufficiently long data records are available for calculating linear trends.	9
Table 2: Projected SLR (m) relative to 2010 for the Low Scenario based on observed trends in the past.....	10
Table 3: Projected SLR (m) relative to 2010 for the Intermediate Scenario based on projections for IPCC AR5 RCP8.5.	11
Table 4: Projected SLR (m) relative to 2010 for the High Scenario based partially on projections for IPCC AR5 RCP8.5.	12
Table 5: Projected SLR (m) relative to 2010 for the Intermediate Scenario based on projections for IPCC AR4 A2.	13

ABSTRACT

Regional mean sea levels in many coastal locations off Canada have been rising in the past century, similar to the rise in global mean sea level. Existing scientific literature and high profile assessments (such as by the Intergovernmental Panel on Climate Change) give a wide range of estimates for future global mean sea level rise. At the regional or local scales, the ranges of uncertainties are even larger. What Canada needs is a thorough compilation of plausible sea level rise (SLR) scenarios at actionable scales (i.e., local or regional). Here we develop regional mean SLR scenarios for Canada, Low, Intermediate and High, based on three global mean SLR scenarios. The global scenarios are adjusted for three factors that affect local mean sea levels. The first factor is the net effect of the glacial isostatic adjustment from a model, with its vertical land motion further replaced by satellite Global Positioning System (GPS) data. The second is the steric and dynamic ocean effect obtained from the ensemble of global climate models. The third is the model-based land-ice melt effect. The most significant SLR will be along the southeastern Atlantic coast, the Pacific coast and the Beaufort Sea coast. Under the Intermediate Scenario and the High Scenario, the mean SLR relative to land may be up to 0.6 and 2.0 m over 2010-2100, respectively. Given the great range of uncertainty in mean SLR projections, the proposed multiple plausible scenarios allow coastal engineers and managers to consider multiple future conditions and develop multiple response options. According to the risk tolerance of infrastructure they may find the most suitable option.

RÉSUMÉ

Au cours du siècle dernier, le niveau moyen de la mer a augmenté à l'échelle régionale dans de nombreuses zones côtières au large du Canada. Cette hausse correspond à celle qui sévit à l'échelle mondiale. La documentation scientifique et les évaluations majeures existantes (comme celles du Groupe d'experts intergouvernemental sur l'évolution du climat) offrent un large éventail d'estimations en ce qui concerne la hausse future du niveau moyen de la mer à l'échelle mondiale. À l'échelle régionale ou locale, ces incertitudes ou ces éventails sont encore plus grands. Le Canada a donc besoin d'une compilation exhaustive de scénarios vraisemblables concernant la hausse du niveau de la mer (HNM) à des échelles permettant de prendre des mesures (c.-à-d. locales ou régionales). Dans la présente étude, nous élaborons des scénarios de hausse moyenne régionale du niveau de la mer pour le Canada – soit faible, moyenne et élevée –, à partir de trois scénarios de HNM à l'échelle mondiale. Les scénarios à l'échelle mondiale sont ajustés selon trois facteurs qui influent sur les niveaux moyens locaux de la mer. Le premier facteur est l'effet net de l'ajustement isostatique glaciaire à partir d'un modèle, dans lequel le soulèvement des terres est aussi remplacé par les données satellitaires du système de positionnement global (GPS). Le deuxième est l'effet océanique stérique et dynamique obtenu à partir de l'ensemble des modèles climatiques mondiaux. Le troisième est l'effet modélisé de la fonte de la glace terrestre. La plus importante HNM aura lieu le long des côtes sud-est de l'Atlantique, sur la côte Pacifique et sur celle de la mer de Beaufort. Dans le contexte des scénarios de hausse intermédiaire et élevée, la hausse moyenne du niveau de la mer par rapport à la terre pourrait être de 0,6 m et 2,0 m entre 2010 et 2100, respectivement. En raison de la vaste plage d'incertitudes en ce qui concerne les projections de la hausse moyenne du niveau de la mer, les différents scénarios vraisemblables proposés permettront aux ingénieurs et aux gestionnaires côtiers de tenir compte des nombreuses conditions futures et d'élaborer autant d'options.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) projected global mean sea level rise (SLR) of 0.21-0.48 m over the 21st century under a median level emission scenario of A1B (Solomon et al., 2007). The IPCC Fifth Assessment Report (AR5) projected global mean SLR of 0.36-0.71 m and 0.52-0.98 m over the 21st century under Representative Concentration Pathway 4.5 (RCP4.5) (a median level emission scenario) and RCP8.5 (a high level emission scenario), respectively (Church et al., 2013). Slanger et al.'s (2014) latest work showed global mean SLR of 0.54 ± 0.19 m and 0.71 ± 0.28 m during the 21st century under RCP4.5 and RCP8.5, respectively.

The local sea level is measured relative to land (hereafter called relative sea level). Slanger et al.'s (2012) projections of mean SLR vary spatially from -3.91 to 0.79 m under A1B, with a global average of 0.47 m in the 21st century. For Eastern Canada, projected mean SLR over the 21st century varies spatially from nearly 0 to 0.7 m (Han et al., 2014). Thomson et al. (2008) also projected highly variable coastal sea level changes for Western Canada. The most recent study by Han et al. (2015) provided 21st –century sea level projections across Canada with spatial changes from -0.75 to 0.70 m. Elevation changes of infrastructure required to keep flooding risks unchanged under a changing climate are estimated based on historical tide gauge data, projected sea level rise and associated uncertainties for Eastern Canada (Zhai et al., 2013; 2015) and for Canada (Zhai et al., 2014).

Existing scientific literature and high profile assessments give a wide range of estimates for future global mean sea level rise. At the regional or local scales, the ranges or uncertainties are even larger. What is certain is that the increasing high mean sea level has increased the frequency, magnitude and duration of coastal flooding associated with a given storm in many coastal places around the world (UNESCO/ICO, 2010). At present, coastal engineers and managers are left to determine SLR estimates through their own interpretation of the scientific literature or the advice of experts on an ad-hoc basis. Given the large uncertainties, it is important to develop scenarios that describe future potential sea level conditions in a manner that supports decision making under uncertain conditions. In recognition of the importance of agreed upon SLR scenarios, NOAA recently established four global mean sea level rise scenarios for the United States over 1992-2100: Highest (2.0 m), Intermediate-High (1.2m), Intermediate-Low (0.5m) and Lowest (0.2m) (Parris et al., 2012). However, the determination of the global mean SLR scenarios is merely the very first step. What coastal engineers and managers need are mean SLR scenarios at local or regional scales. In a recent article, Hinkel et al. (2015) advise that upper and lower bound scenarios be considered depending on risk tolerance. They also advise that coastal planners should adjust infrastructure in the shorter term but keep open the option to adjust further a few decades from now as new information becomes available.

In this study, we develop regional SLR scenarios for Canada, by modifying aforementioned global-mean SLR scenarios. The modified global scenarios will be corrected for the factors that affect local mean sea levels, including vertical land motion, steric and dynamic ocean effect, and land-ice melt effect. Our objective is to provide plausible regional SLR scenarios at selected tide-gauge stations along the entire Canadian Coasts (Atlantic, Pacific, and Arctic) that can support coastal engineers and managers in the design and maintenance of coastal infrastructure under a changing climate.

2. Data and Method

2.1. TIDE-GAUGE DATA

We use annual-mean sea level data for most of the selected tide gauge stations (Fig. 1), which are provided by the Permanent Service for the Mean Sea Level (PSMSL, <http://www.psmsl.org/>). At Nain, monthly-mean instead of annual-mean PSMSL data are used to retain more data in the analysis. At Saint John, annual-mean sea levels are calculated from daily mean data provided by the Integrated Science Data Management of Fisheries and Oceans Canada (<http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/twl-mne/index-eng.htm>) if there are data for over 180 days in a year. At Point Atkinson, annual-mean sea levels are calculated from monthly-mean data provided by the Institute of Ocean Sciences if there are data for six or more months in a year. The data used start in different years but all end in 2011. See Table 1 for details. Linear trends of relative sea level (RSL) are derived from the tide-gauge data (Fig. 2) using a least squares fit over the length of each time series.

2.2 .GLACIAL ISOSTATIC ADJUSTMENT (GIA) MODEL AND GLOBAL POSITIONING SYSTEM (GPS) DATA

The GIA causes land subsidence (uplift) in the vertical that increases (decreases) RSL and a decrease (increase) in gravitational attraction that decreases (increases) sea surface topography and thus RSL. The vertical land motion is dominant over the change in sea surface topography. We use the GIA model (ICE-5G, VM2) results of Peltier (2004), which include the present-day vertical land motion (VLM) and the net RSL change associated with the GIA in a 1° longitude by 1° latitude grid. We also use the VLM derived from GPS (Craymer et al., 2011; Sellar et al., 2007) to replace the GIA model VLM. We first calculate the VLM difference by subtracting the model VLM from the GPS VLM. The VLM difference is then added to the net RSL change. The GPS data time series have an average duration of about 10 years. Unlike the GIA VLM, other VLM components contained in GPS data such as from tectonic movement along the Pacific coast may vary significantly during the projection period. Therefore it is necessary to revise projections when GPS data show significant change in the VLM rate.

2.3 .OCEAN AND LAND-ICE EFFECTS

We have considered the IPCC AR5 RCP8.5 high emission scenario, since projected global mean sea level rise for the past two decades closely follows the observed trend. Slanen et al.'s (2014) regional RSL projections from 1986-2005 to 2081-2100 are used, including an ensemble mean of 21 climate models (see their Online Resource Table 1) and a component for land-ice melt. There is no information provided for Hudson Bay and the Canadian Arctic Archipelago (CAA).

We have also considered the IPCC Fourth Assessment medium-high (A2) emission scenario, as in Slanen et al. (2012). The steric and dynamic ocean component is from an ensemble

average of sea surface height change between 1980-1999 and 2090-2099 from 8 global climate models for IPCC AR4 scenarios (Slangen et al., 2012). These 8 global models are: BCCR-BCM2.0, CGCM3.1 (T47), MRI-CGCM2.3.2, GFDL-CM2.0, GFDL-CM2.1, UKMO-HadCM3, MIROC3.2 (hires), ECHAM5/MPI-OM (see Table in Slangen et al. (2012) for more detail). The land ice melt component is also from Slangen et al. (2012).

2.4. COMPUTATION OF REGION SEA LEVEL CHANGE

Based on the IPCC AR5 assessment (Church et al., 2013), we first modify the four global mean sea level rise scenarios over 1992-2100 used in the United States (Parris et al., 2012). We have defined three global scenarios only: Low, Intermediate and High. For the Low Scenario, the regional SLR values are projected by using the past linear trends estimated from tide-gauge data at individual stations. For the Intermediate Scenario, we choose to use sea level projections from IPCC AR4 A2 and AR5 RCP8.5 emission scenarios. Our High Scenario is the same as the US Intermediate-High Scenario (1.2 m). We do not consider the US Highest Scenario (2.0 m), because this scenario is of low confidence according to the IPCC AR5 assessment (Church et al., 2013).

For the Intermediate Scenario, the regional SLR values will be projected by accounting for (1) the GIA effect derived from Peltier's model (2004), with the vertical land motion replaced by the Global Positioning System (GPS) data (Henton et al., 2006); (2) the steric and dynamic ocean effect obtained from the ensemble mean of global climate models under RCP8.5 from 1986-2005 to 2080-2099 (Slangen et al., 2014) and under A2 for the periods from 1980-1999 to 2090-2100 (Slangen et al., 2012); and (3) the model-based land-ice melt effects under RCP8.5 (Slangen et al., 2014) and under A2 (Slangen et al., 2012). The High SLR scenario is established to consider potential large uncertainty in the Antarctic ice sheet melt effect. Therefore we will keep the other effects unchanged, but adjust the global mean Antarctic ice sheet melt effect so that the total global mean SLR is 1.2 m for the High Scenario. We can then determine the Antarctic ice sheet melt effect for the High Scenario at each station, by assuming its spatial pattern will be the same as that of the Intermediate Scenario.

We calculate linear trends of the ocean and land-ice effects at each station, respectively. Using these linear trends and GIA and GPS rates, we can readily determine total sea level change between a given year and 2010, the current reference year used by the Canadian Hydrographic Service.

3. Regional SLR Scenarios

3.1. LOW SCENARIO

This SLR scenario is based on the past sea level trends. By 2100, the RSL rise is about 0.2-0.32 m at Nova Scotia (North Sydney, Halifax, and Yarmouth), New Brunswick (Saint John), Prince Edward Island (Charlottetown) and Newfoundland (St. John's, Argentia, and Port-Aus-Basques) sites (Table 2, Fig. 3). In contrast, sea level will fall by 0.18 m at Nain, Labrador. Along the northern Gulf of St. Lawrence, sea level change will be smaller. In the Pacific coast, the RSL change varies from -0.15 to 0.1 m. In the Canadian Arctic, the RSL will rise by 0.17 m at Tuktoyaktuk and fall by 0.1 m at Alert. The largest RSL fall is 0.85 m at Churchill.

3.2. INTERMEDIATE SCENARIO

By 2100, the RSL rise under RCP8.5 is 0.44 m at Port-aux-Basques to 0.61 m at Halifax and North Sydney along the southeastern Atlantic Canada (Table 3 and Fig. 4). In contrast, the global average is 0.47 m. The RSL rise is relatively small along the northeastern Gulf of St. Lawrence and Labrador, in part attributable to the land uplift due to GIA. In the Pacific coast, the projected RSL rise varies from -0.05 m at Tofino to 0.33 m in Point Atkinson. In the Canadian Arctic the RSL is projected to rise up to 0.46 m west of 100 °W and to fall up to 0.75 m elsewhere.

3.3. HIGH SCENARIO

By 2100, we will see RSL rise up to 2.0 m in Eastern Canada (Table 4, Fig. 5). Even along Labrador and northern Gulf of St. Lawrence coasts, the RSL rise is above the global average of 1.2 m. In the Pacific coast, the RSL rise will be 1.25 to 1.59 m. In the Canadian Arctic, a large rise of 1.61 m in the Beaufort Sea contrasts with a smaller one of up to 0.91 m in the east. The change in the overall RSL spatial pattern compared with that of the Intermediate Scenario is exclusively due to the accelerated melt of the Antarctic ice sheet. Canada is on the far side of this melt source, and therefore the accelerated melt causes sea level to rise by an extra amount in Canada.

3.4. AR4 A2 VERSUS AR5 RCP8.5

Under the Intermediate SLR scenario, the overall spatial pattern of projected RSL change for IPCC AR4 A2 (Table 5, Fig. 6) is similar to that for AR5 RCP8.5. Nevertheless, the latter has larger rise along the southeastern Atlantic coast and larger fall along the eastern high Arctic coast, which is associated with the projected larger contribution by the land-ice melt. There are also substantial quantitative differences at some specific sites, for example, rise of 0.2 m for A2 vs fall of 0.07 m for RCP8.5 at Nain over the 21st century under the Intermediate Scenario. In addition, the RSL projection at Churchill is available for the AR4 A2 (0.12 m).

4. Conclusion and Discussion

We have developed three regional SLR scenarios for Canada in the 21st century. Results from different sources that account for ocean-atmosphere interaction (from global AOGCMs), GIA and non-GIA vertical land motion (from model and GPS observations) and land-ice melt effects (model) are combined to provide projections of RSL change at selected tide-gauge stations across Canada from coast to coast to coast. Unlike the IPCC AR5 regional projections which come with statistical uncertainty, the present approach establishes different SLR scenarios to represent uncertainty.

The most significant RSL rise will be along the southeastern Atlantic coast, the Pacific coast and the Beaufort Sea coast. Under the Intermediate Scenario and the High Scenario, the RSL may rise up to 0.6 and 2.0 m over 2010-2100, respectively.

The Lowest Scenario is based on past linear trends in historical tide-gauge data and so should be treated as a likely lower bound. The Intermediate Scenario is based on state-of-the-art climate models and therefore may be considered most likely. The High Scenario considers possible accelerated Antarctic ice-sheet melt and may be treated as a likely upper bound.

Availability of regional mean SLR scenarios can strengthen the ability of government agencies and coastal communities to recognize, adapt and take advantage of sea level changes over time. The High Scenario is for where there is little tolerance for the risk. The Lowest Scenario is for where there is greater tolerance. Given the great range of uncertainty in SLR projections, the proposed multiple plausible scenarios will allow coastal engineers and managers to consider multiple future conditions and develop multiple response options. According to the risk tolerance of infrastructure they will be able to find the most suitable option to mitigate the risk to infrastructure.

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Glossary of terms

AR4 Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

AR5 Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Glacial isostatic adjustment (GIA), also called postglacial rebound, is the delayed response of the Earth to surface unloading caused by deglaciation at the end of the last Ice Age.

IPCC is the Intergovernmental Panel on Climate Change.

RCPs is the representative concentration pathways designed for AR5, and defined a set of four scenarios, based on the prescribed concentrations of greenhouse gases and aerosols.

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TABLES

Table 1: Locations of tide-gauge stations, and associated data periods if sufficiently long data records are available for calculating linear trends.

Station	ID	Lon	Lat	Start	End
Saint John	195	-66.06	45.27	1896	2011
Yarmouth	1158	-66.12	43.84	1967	2011
Halifax	96	-63.59	44.66	1896	2011
North Sydney	1299	-60.25	46.22	1971	2011
Port-Aux-Basques	392	-59.13	47.57	1959	2010
Argentia	1321	-53.983	47.3	1972	2011
St. John's	393	-52.71	47.56	1957	2011
Charlottetown	427	-63.12	46.23	1938	2011
Quebec	173	-71.167	46.833	1911	2011
Rimouski	1597	-68.52	48.48	1985	2011
Sept-iles	1322	-66.37	50.18	1973	2011
Nain	1029	-61.68	56.55	1963	2011
Prince Rupert	167	-130.33	54.317	1909	2011
Queen Charlotte city	829	-132.07	53.25	1966	2011
Bella Bella	984	-128.13	52.167	1962	2011
Point Atkinson	193	-123.25	49.333	1914	2011
Tofino	165	-125.92	49.15	1910	2011
Victoria	166	-123.37	48.417	1910	2011
Tuktoyaktuk	1000	-132.97	69.417	1962	2011
Ulukhaktok	1930	-118.27	71.233	N/A	
Churchill	447	-94.183	58.767	1940	2011
Resolute	863	-94.883	74.683	N/A	
Alert	1110	-62.317	82.5	1968	2007
Qikiqtarjuaq	1935	-64.117	67.867	N/A	

Table 2: Projected SLR (m) relative to 2010 for the Low Scenario based on observed trends in the past.

Year	2020	30	40	50	60	70	80	90	2100
Saint John	0.02	0.04	0.07	0.09	0.11	0.13	0.15	0.18	0.2
Yarmouth	0.04	0.07	0.11	0.14	0.18	0.22	0.25	0.29	0.32
Halifax	0.03	0.06	0.1	0.13	0.16	0.19	0.22	0.26	0.29
North Sydney	0.04	0.07	0.11	0.14	0.18	0.22	0.25	0.29	0.32
Port-Aux-Basques	0.03	0.05	0.08	0.1	0.13	0.16	0.18	0.21	0.23
Argentia	0.03	0.05	0.08	0.1	0.13	0.16	0.18	0.21	0.23
St. John's	0.02	0.05	0.07	0.09	0.12	0.14	0.16	0.18	0.21
Charlottetown	0.03	0.06	0.1	0.13	0.16	0.19	0.22	0.26	0.29
Quebec	-0.003	-0.006	-0.009	-0.01	-0.02	-0.02	-0.02	-0.02	-0.03
Rimouski	0.01	0.03	0.04	0.05	0.07	0.08	0.09	0.1	0.12
Sept-iles	0.02	0.03	0.05	0.07	0.09	0.1	0.12	0.14	0.15
Nain	-0.02	-0.04	-0.06	-0.08	-0.1	-0.12	-0.14	-0.16	-0.18
Prince Rupert	0.01	0.02	0.03	0.04	0.06	0.07	0.08	0.09	0.1
Queen Charlotte	-0.01	-0.02	-0.03	-0.04	-0.05	-0.06	-0.07	-0.08	-0.09
Bella Bella	-0.005	-0.01	-0.02	-0.02	-0.03	-0.03	-0.04	-0.04	-0.05
Point Atkinson	0.003	0.006	0.009	0.01	0.02	0.02	0.02	0.02	0.03
Tofino	-0.02	-0.04	-0.05	-0.07	-0.09	-0.11	-0.13	-0.14	-0.16
Victoria	0.006	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.05
Tuktoyaktuk	0.02	0.04	0.06	0.08	0.1	0.11	0.13	0.15	0.17
Ulukhaktok						N/A			
Churchill	-0.09	-0.19	-0.28	-0.38	-0.47	-0.56	-0.66	-0.75	-0.85
Resolute						N/A			
Alert	-0.01	-0.02	-0.03	-0.04	-0.06	-0.07	-0.08	-0.09	-0.1
Qikiqtarjuaq						N/A			

Table 3: Projected SLR (m) relative to 2010 for the Intermediate Scenario based on projections for IPCC AR5 RCP8.5.

Year	2020	30	40	50	60	70	80	90	2100
Saint John	0.05	0.11	0.16	0.22	0.27	0.32	0.38	0.43	0.49
Yarmouth	0.06	0.12	0.18	0.24	0.29	0.35	0.41	0.47	0.53
Halifax	0.07	0.14	0.2	0.27	0.34	0.41	0.48	0.54	0.61
North Sydney	0.07	0.13	0.2	0.27	0.34	0.4	0.47	0.54	0.61
Port-Aux-Basques	0.05	0.1	0.15	0.19	0.24	0.29	0.34	0.39	0.44
Argentia	0.06	0.11	0.17	0.22	0.28	0.34	0.39	0.45	0.5
St. John's	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.44	0.5
Charlottetown	0.07	0.13	0.2	0.26	0.33	0.4	0.46	0.53	0.59
Quebec	0.03	0.05	0.08	0.11	0.14	0.16	0.19	0.22	0.25
Rimouski	0.02	0.04	0.07	0.09	0.11	0.13	0.15	0.18	0.2
Sept-iles	0.01	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.06
Nain	-0.01	-0.02	-0.02	-0.03	-0.04	-0.05	-0.05	-0.06	-0.07
Prince Rupert	0.04	0.07	0.11	0.14	0.18	0.21	0.25	0.28	0.32
Queen Charlotte	0.03	0.06	0.09	0.11	0.14	0.17	0.2	0.23	0.26
Bella Bella	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03	-0.04	-0.04	-0.05
Point Atkinson	0.04	0.07	0.11	0.15	0.18	0.22	0.26	0.29	0.33
Tofino	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03	-0.04	-0.04	-0.05
Victoria	0.03	0.05	0.08	0.1	0.13	0.15	0.18	0.2	0.23
Tuktoyaktuk	0.05	0.1	0.15	0.21	0.26	0.31	0.36	0.41	0.46
Ulukhaktok						N/A			
Churchill						N/A			
Resolute						N/A			
Alert	-0.08	-0.17	-0.25	-0.33	-0.42	-0.5	-0.59	-0.67	-0.75
Qikiqtarjuaq	-0.04	-0.07	-0.11	-0.14	-0.18	-0.21	-0.25	-0.28	-0.32

Table 4: Projected SLR (m) relative to 2010 for the High Scenario based partially on projections for IPCC AR5 RCP8.5.

Year	2020	30	40	50	60	70	80	90	2100
Saint John	0.2	0.41	0.61	0.82	1.02	1.23	1.43	1.63	1.84
Yarmouth	0.21	0.42	0.63	0.85	1.06	1.27	1.48	1.69	1.9
Halifax	0.22	0.44	0.66	0.87	1.09	1.31	1.53	1.75	1.97
North Sydney	0.22	0.44	0.66	0.88	1.09	1.31	1.53	1.75	1.97
Port-Aux-Basques	0.2	0.4	0.6	0.8	1	1.2	1.39	1.59	1.79
Argentia	0.21	0.41	0.62	0.82	1.03	1.23	1.44	1.64	1.85
St. John's	0.2	0.41	0.61	0.82	1.02	1.22	1.43	1.63	1.84
Charlottetown	0.22	0.43	0.65	0.87	1.08	1.3	1.52	1.73	1.95
Quebec	0.18	0.35	0.53	0.71	0.89	1.06	1.24	1.42	1.59
Rimouski	0.17	0.34	0.51	0.68	0.85	1.02	1.18	1.35	1.52
Sept-iles	0.15	0.31	0.46	0.62	0.77	0.93	1.08	1.24	1.39
Nain	0.14	0.27	0.41	0.55	0.69	0.82	0.96	1.1	1.24
Prince Rupert	0.18	0.35	0.53	0.71	0.88	1.06	1.24	1.42	1.59
Queen	0.17	0.35	0.52	0.69	0.86	1.04	1.21	1.38	1.55
Bella Bella	0.14	0.28	0.42	0.55	0.69	0.83	0.97	1.11	1.25
Point Atkinson	0.18	0.36	0.54	0.73	0.91	1.09	1.27	1.45	1.63
Tofino	0.14	0.28	0.42	0.56	0.7	0.84	0.98	1.13	1.27
Victoria	0.17	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53
Tuktoyaktuk	0.18	0.36	0.54	0.72	0.9	1.08	1.26	1.44	1.61
Ulukhaktok									N/A
Churchill									N/A
Resolute									N/A
Alert	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.27
Qikiqtarjuaq	0.1	0.2	0.3	0.4	0.5	0.6	0.71	0.81	0.91

Table 5: Projected SLR (m) relative to 2010 for the Intermediate Scenario based on projections for IPCC AR4 A2.

Year	2020	30	40	50	60	70	80	90	2100
Saint John	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36
Yarmouth	0.04	0.09	0.13	0.17	0.22	0.26	0.3	0.34	0.39
Halifax	0.05	0.11	0.16	0.21	0.27	0.32	0.37	0.43	0.48
North Sydney	0.06	0.12	0.18	0.24	0.3	0.36	0.42	0.48	0.54
Port-Aux-Basques	0.04	0.07	0.11	0.15	0.19	0.22	0.26	0.3	0.34
Argentia	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.27
St. John's	0.04	0.07	0.11	0.15	0.18	0.22	0.25	0.29	0.33
Charlottetown	0.06	0.13	0.19	0.25	0.31	0.38	0.44	0.5	0.56
Quebec	0.03	0.06	0.1	0.13	0.16	0.19	0.22	0.26	0.29
Rimouski	0.04	0.08	0.11	0.15	0.19	0.23	0.27	0.3	0.34
Sept-iles	0.02	0.05	0.07	0.09	0.12	0.14	0.16	0.19	0.21
Nain	0	0	0	0	0	0	0.01	0.01	0.01
Prince Rupert	0.03	0.05	0.08	0.1	0.13	0.15	0.18	0.21	0.23
Queen Charlotte	0.02	0.03	0.05	0.07	0.09	0.1	0.12	0.14	0.16
Bella Bella	-0.02	-0.04	-0.05	-0.07	-	-0.11	-0.12	-0.14	-0.16
Point Atkinson	0.03	0.07	0.1	0.14	0.17	0.21	0.24	0.28	0.31
Tofino	-0.02	-0.04	-0.06	-0.09	-0.11	-0.13	-0.15	-0.17	-0.19
Victoria	0.05	0.09	0.14	0.19	0.23	0.28	0.32	0.37	0.42
Tuktoyaktuk	0.06	0.11	0.17	0.22	0.28	0.34	0.39	0.45	0.51
Ulukhaktok	0.01	0.03	0.04	0.06	0.07	0.09	0.1	0.12	0.13
Churchill	0.01	0.03	0.04	0.06	0.07	0.08	0.1	0.11	0.12
Resolute	-0.04	-0.09	-0.13	-0.17	-	-0.26	-0.3	-0.34	-0.39
Alert	-0.03	-0.07	-0.1	-0.13	-	-0.2	-0.23	-0.27	-0.3
Qikiqtarjuaq	-0.05	-0.1	-0.15	-0.2	-	-0.31	-0.36	-0.41	-0.46

Figures

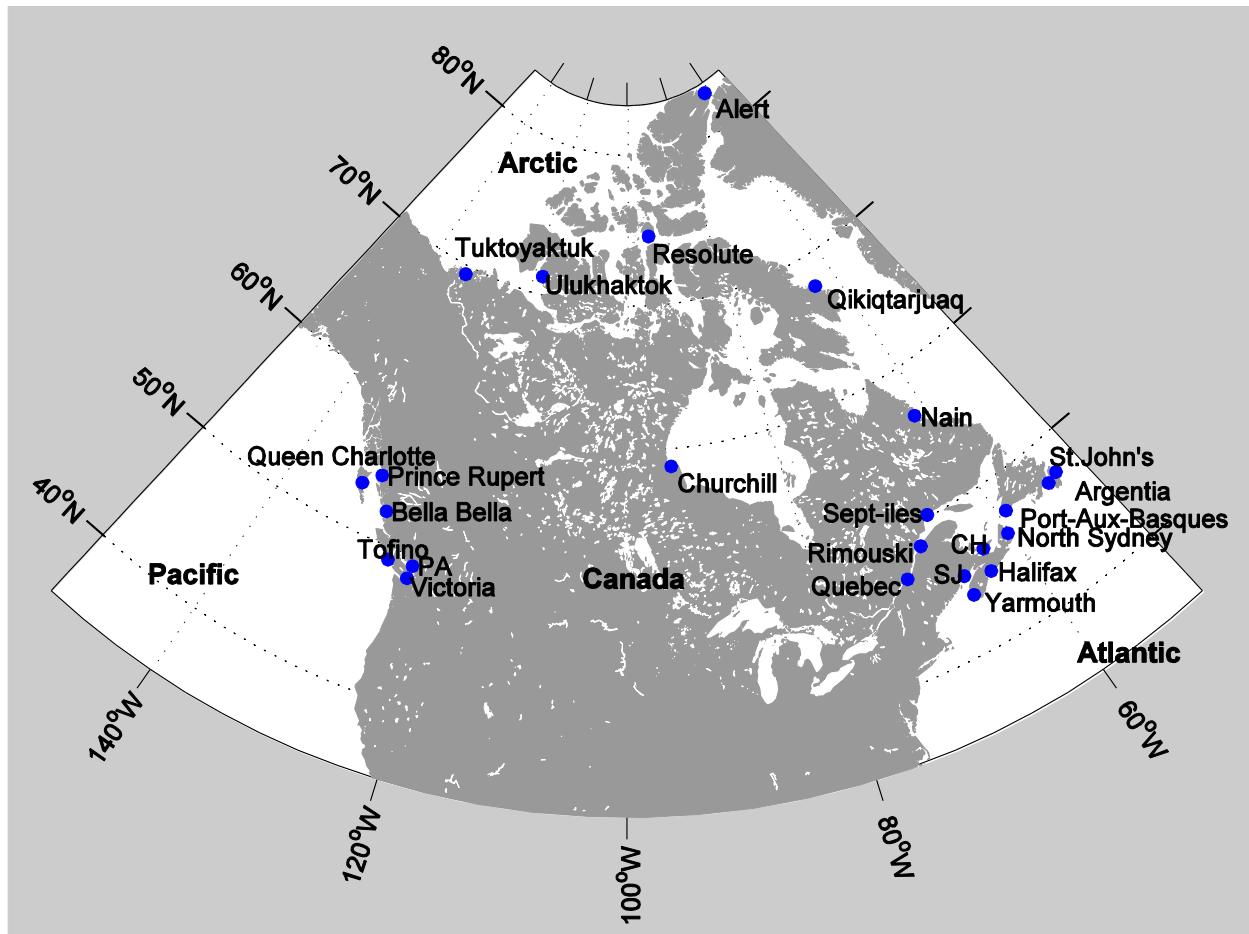


Figure 1: Map of the study region and the location of tide-gauge stations. CH: Charlottetown; HH: Harrington Harbour; PA: Point Atkinson; SJ: Saint John.

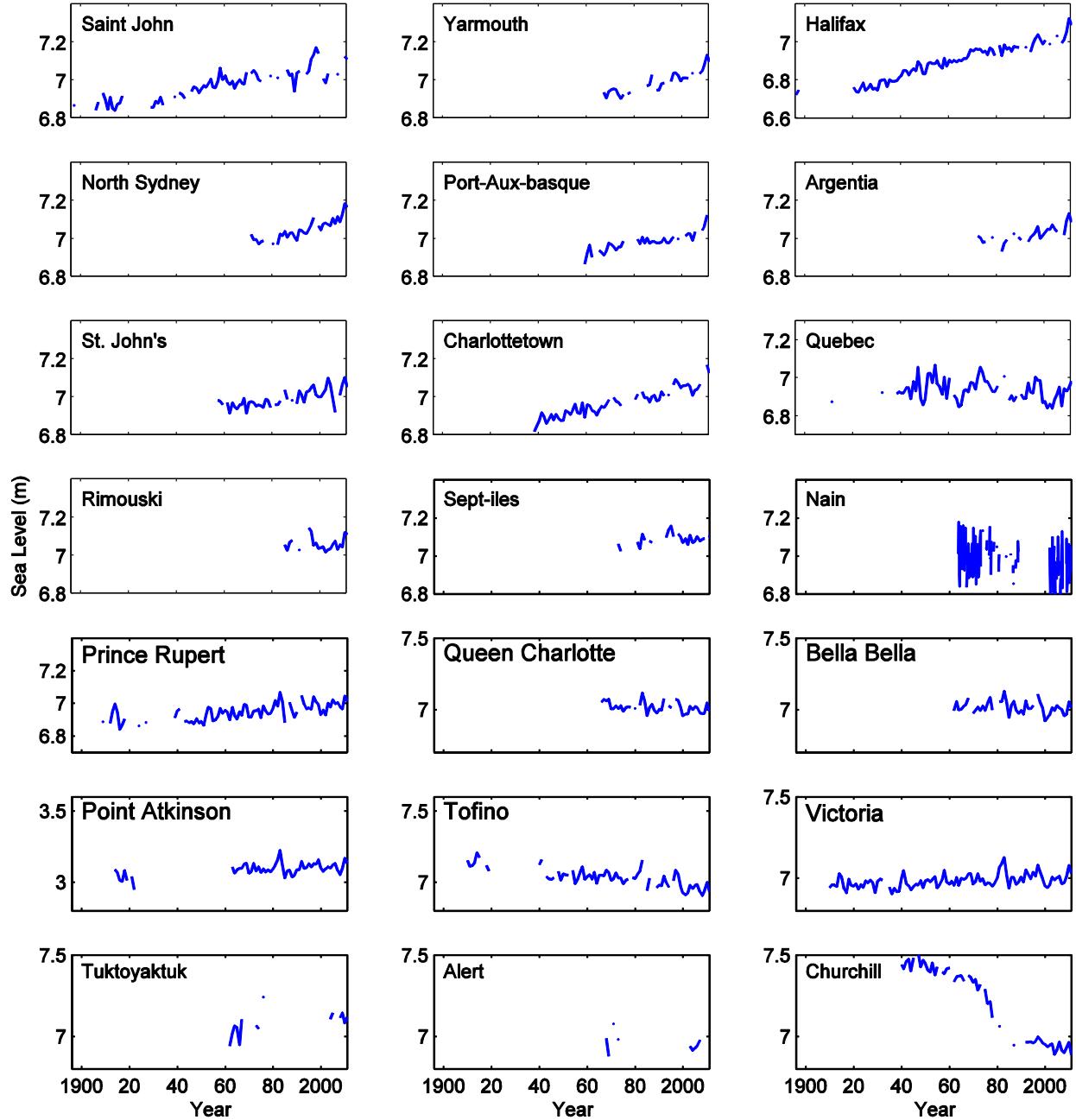


Figure 2: Annual mean RSLs at selected tide-gauge stations across Canada for available periods. The exception is for Nain, where monthly mean RSLs are shown. See Fig. 1 for locations.

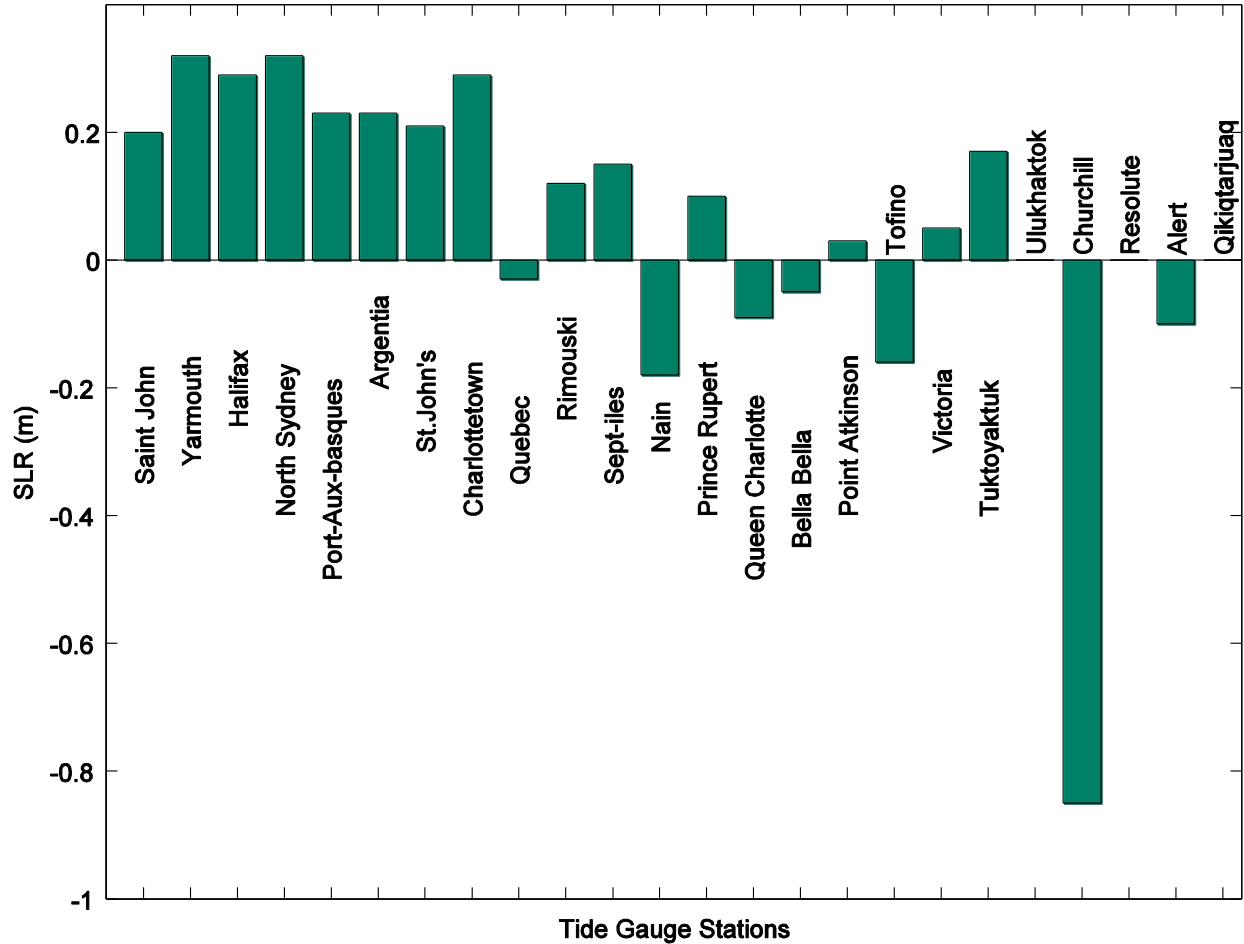


Figure 3: Projected SLR by 2100 under the Lowest Scenario based on observed trends in the past. No projections are available for Ulukhaktok, Resolute, or Qikiqtarjuaq.

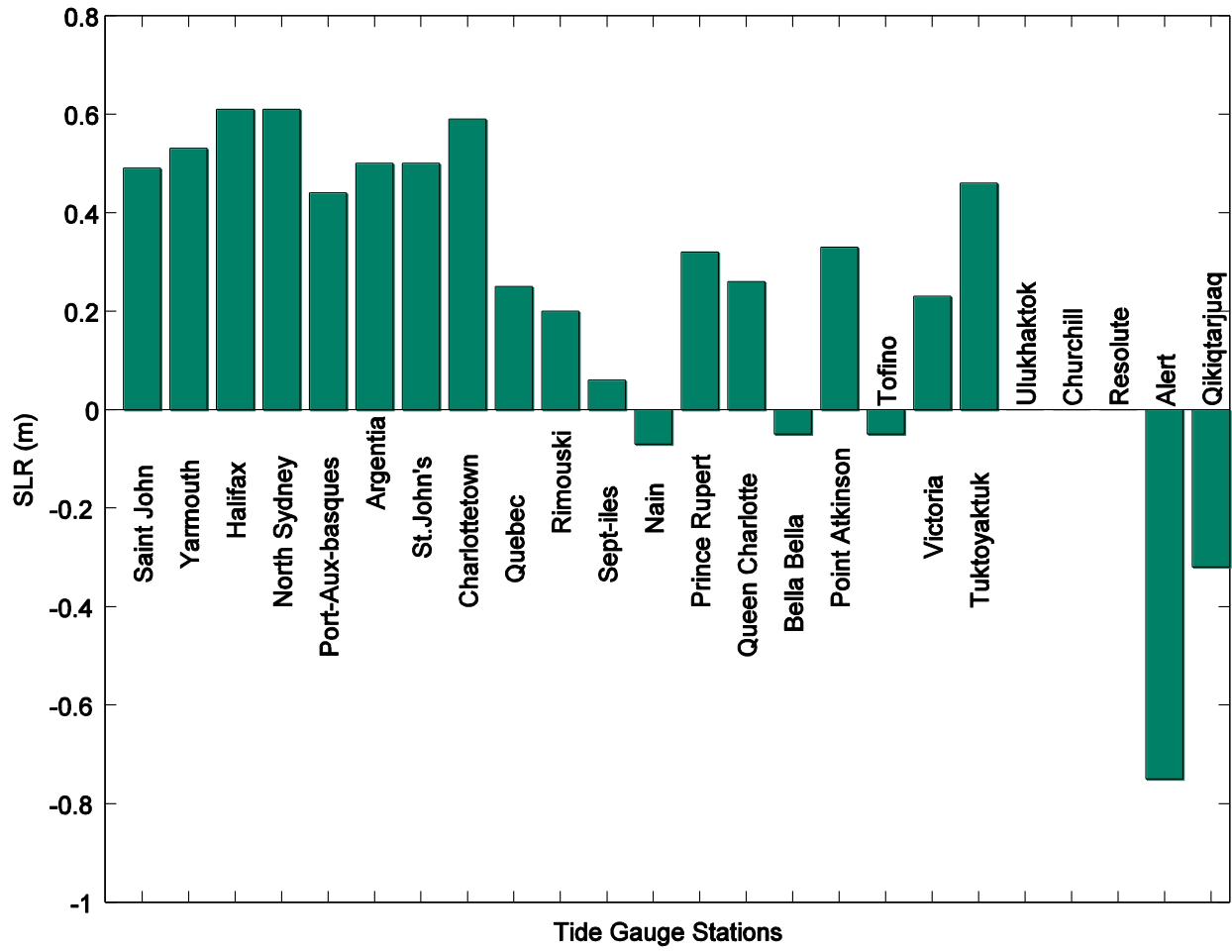


Figure 4: Projected SLR by 2100 under the Intermediate Scenario based on projections for IPCC AR5 RCP8.5.

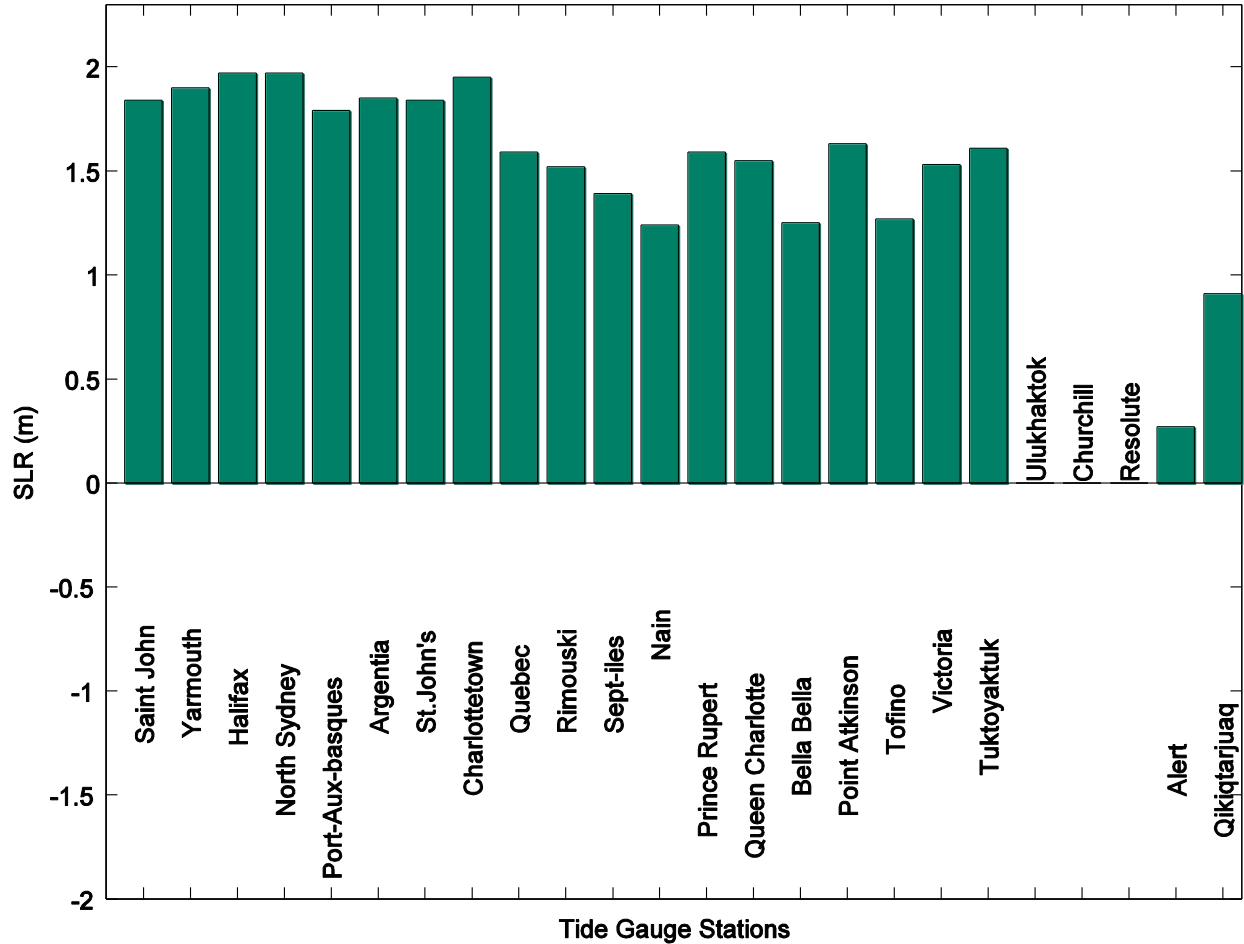


Figure 5: Projected SLR by 2100 under the High Scenario based partially on projections for IPCC AR5 RCP8.5.

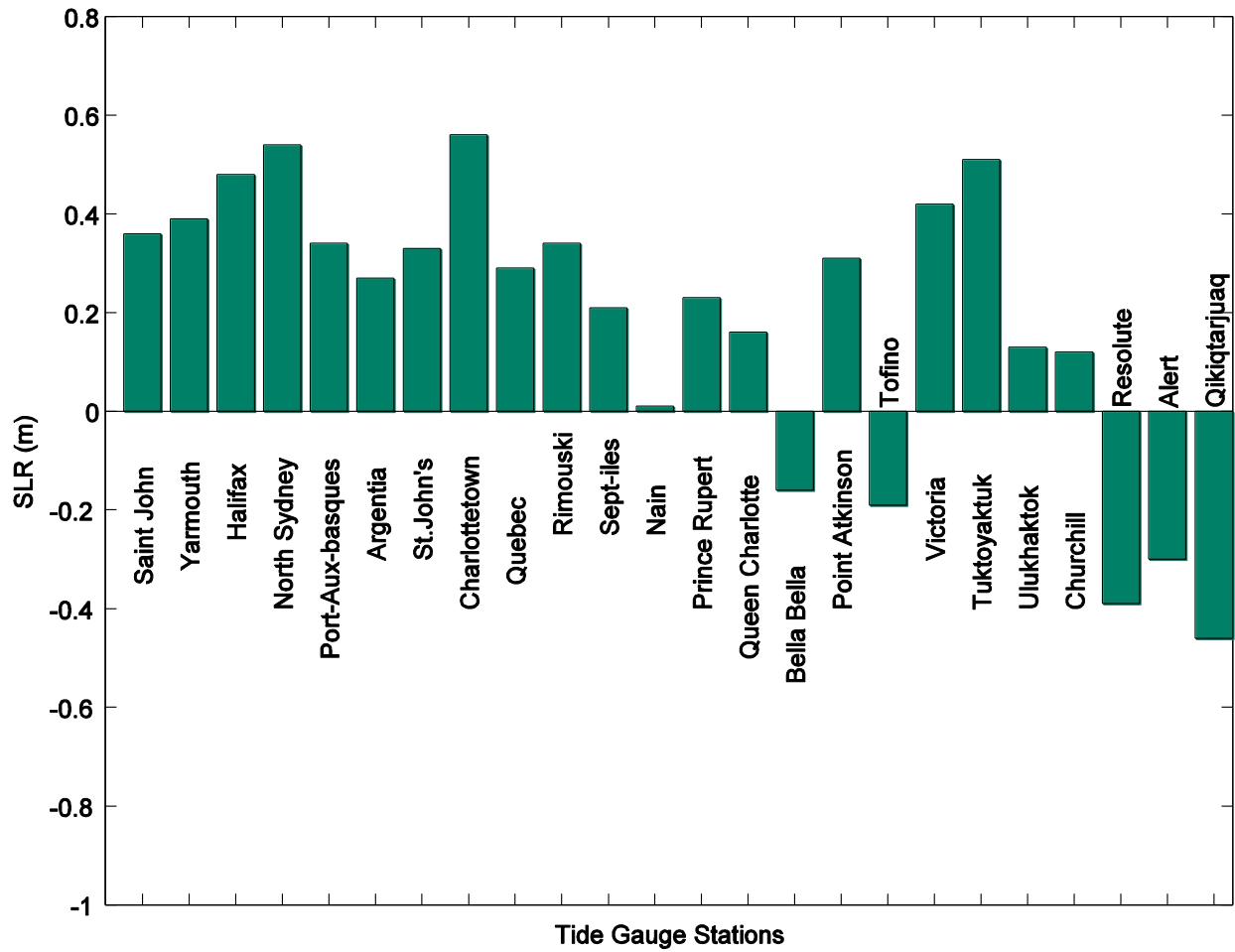


Figure 6: Projected SLR by 2100 under the Intermediate Scenario based on projections for A2.