A Comprehensive Assessment of Available Data Reflecting the State of Vancouver's Waterfront

Prepared for:

Georgia Strait Alliance
412 – 207 W Hastings St
Vancouver, BC V6B 1H7

Prepared by:

Tianna Peller, MEnvSc

Acknowledgements

We would like to acknowledge the following people/agencies for their assistance in providing guidance and data used in the creation of this report:

Lance Barrett-Lennard, Vancouver Aquarium

Qinghan Bian, BC Ministry of the Environment

Sonya Botwinski, Port Metro Vancouver

Peter Davidson, Bird Studies Canada

Bridget Doyle, Tsleil-Waututh Nation

Janice Dudas, Metro Vancouver

Alan Duncan, Vancouver Board of Parks and Recreation

Catherine Jardine, Bird Studies Canada

John Konovsky, Tsleil-Waututh Nation

Sabrina Lau Texier, Translink

Patrick Lilley, Kerr Wood Leidal

Andrew Ling, City of Vancouver

Steve Litke, Fraser Basin Council

Patrick Murphy, Port Metro Vancouver

David Robertson, City of Vancouver

Peter Ross, Vancouver Aquarium

Julie Saxton, Metro Vancouver

Diane Sutherland, BC Ministry of the Environment

Lastly, a big thank you to all of the stakeholders who have attended the Waterfront Forums and shared their ideas.

Cover page photo credits: Tianna Peller

List of Acronyms

AVSs	Acid volatile sulphides
BC	British Columbia
BC FLNR	British Columbia Ministry of Forests, Lands, and Natural Resource Operations
BC MOE	British Columbia Ministry of Environment
BIEAP	Burrard Inlet Environmental Action Program
CCG	Canadian Coast Guard
CH_4	Methane
CMN	Community Mapping Network
CO	Carbon monoxide
CO_2	Carbon dioxide
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSOs	Combined Sewer Overflows
DFO	Department of Fisheries and Oceans Canada
DPSIR	Driver-Pressure-State-Impact-Response
ECHO	Enhancing Cetacean Habitat and Observation Program
EEZ	Exclusive Economic Zone
EPHs	Extractable Petroleum Hydrocarbons
FREMP	Fraser River Estuary Management Program
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSA	Georgia Strait Alliance
ILWRMP	Integrated Liquid Waste and Resource Management Plan
LFVAQ	Lower Fraser Valley Air Quality Monitoring Network
LiDAR	Light Detection and Ranging
MCTS	Marine Communications and Traffic Services
N_2O	Nitrous oxide
NASP	National Aerial Surveillance Program
NEFC	Northeast False Creek
NH_3	Ammonia
NHC	Northwest Hydraulic Consultants
NHS	National Household Survey
NO_x	Nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
OECD	Organization for Economic Co-Operation and Development
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PM	Particulate matter
PMV	Port Metro Vancouver
PSC	Pacific Salmon Commission
PSMSL	Permanent Service for Mean Sea Level
PWP	PollutionWatch Project

SEFC	Southeast False Creek
SEI	Sensitive Ecosystem Inventory
SO_x	Sulphur oxides
SOPF	Ship-Source Oil Pollution Fund
SPES	Stanley Park Ecology Society
UBC	University of British Columbia
VCH	Vancouver Coastal Health
VOCs	Volatile organic compounds
VPB	Vancouver Park Board
WCMRC	Western Canada Marine Response Corporation

Table of Contents

List of Tables

List of Figures

Executive Summary

In 2013, the Georgia Strait Alliance (GSA) launched the Waterfront Initiative – a collaborative effort that brings together multi-jurisdictional stakeholders and citizens to define a common agenda and take action to ensure a diverse, thriving, and resilient waterfront for all (GSA, 2014). With an initial focus on the City of Vancouver, the Waterfront Initiative recognizes that Vancouver's waterfront is an integral part of the community and a place where people go to play, work, live, travel around, and connect with nature and history. However, with increasing pressures from urbanization, pollution, population and industrial growth, as well as intensifying conflicts over land use, Vancouver's shoreline is at risk. Additionally, the impacts of rising sea levels and climate change are also becoming threats to Vancouver's shoreline. Recognizing that integrated planning is essential to address the social, economic, and ecological threats to the shoreline, the Waterfront Initiative is focused on collectively creating a vision and plan for a prosperous and resilient waterfront.

GSA and its partners have identified five broad themes encompassing the importance of the waterfront, which the Waterfront Initiative will focus on (GSA, 2014):

1. Transportation on the Waterfront,
2. Access to Nature on the Waterfront,
3. Living on the Waterfront,
4. Working on the Waterfront, and
5. Flourishing Ecosystems on the Waterfront.

Early Waterfront Initiative documents suggested that issues of climate change could be listed under the flourishing ecosystems on the waterfront theme. However, many of the climate change data sources and potential indicators identified in this report apply to multiple themes; therefore, for the sake of this report, climate change has been incorporated as a sixth theme. Going forward, the Waterfront Network can decide whether to keep climate change as a sixth theme or to place each selected climate change indicator under an appropriate theme.

Since its launch, GSA has hosted four Waterfront Forums, bringing together stakeholders representing all levels of government, private sector, First Nations, and civil society. Waterfront Forums provide an excellent opportunity to discuss the five themes and to create a vision for Vancouver's waterfront and an action plan to make this vision a reality.

Throughout the conversations, participants have identified that moving forward with the discussion requires a better understanding of the waterfront. The preparation of a State of the Waterfront Report has been emphasized as a way of establishing a baseline and measuring progress through indicators. The Waterfront Initiative has recognized that a better understanding of the data sources available characterizing the waterfront, will not only provide insight into the current state of the waterfront, but will facilitate the

preparation of an informative and effective State of the Waterfront Report – a goal of the Waterfront Initiative in the near future.

This report has been prepared to identify existing datasets and ongoing monitoring programs that can reliably reflect the current state of Vancouver's waterfront. It focuses on identifying data sources that can quantify and qualify space for marine and wildlife habitat, recreation and cultural activities, residential use, industrial land and business, and transportation. The potential indicator that each data source could support is identified and discussed to facilitate future indicator selection and development by the Waterfront Initiative.

Overall, 92 potential indicators and their supporting data sources were identified across the Waterfront Initiative themes (Table 1). Some data sources provided baseline information, while other sources have data available for the past few decades.

Table 1. Potential indicators and supporting data sources for each Waterfront Initiative theme.

Theme	Potential Indicator	Data Source
Transportation on the Waterfront	Number and Type of Access Points (providing transportation services for people or cargo)	Translink; Aquabus; False Creek Ferries; Port Metro Vancouver
	Water-Based Transit Ridership	Translink
	Cruise Passenger Ridership	Port Metro Vancouver
	Number of Foreign Vessel Arrivals and Gross Tonnage	Port Metro Vancouver
	Harbour Aircraft Movements	Statistics Canada
	Number and Type of Recreational Vessels Moored	Valiance Maritime Consultants Limited
	Number and Type of Recreational Vessels Using Waterfront	Valiance Maritime Consultants Limited
	Fuel Type, Fuel Consumption, and Emissions of Marine Vessels	BC Chamber of Shipping; Metro Vancouver
	Number and Accessibility of Transit Vessels Operating	Translink; False Creek Ferries; Aquabus
	Number of Electric Transit Vessels Operating	Translink; False Creek Ferries; Aquabus
	Goods Transported via Short-Sea Shipping	Metro Vancouver
	Number of Recreational Boating Incidents	Vancouver Marine Communications and Traffic Services

	Sewage Discharge Regulations for Boats	Transport Canada
	Oil Pollution and Spills	Transport Canada's National Aerial Surveillance Program; Government of Canada's Ship-Source Oil Pollution Fund
Access to Nature on the Waterfront	Number and Area of Waterfront Parks	Vancouver Park Board; City of Vancouver
	Length and Type (hard or soft surfaced) of Waterfront Pathways	Vancouver Park Board; City of Vancouver
	Number and Type of Waterfront Special Events	Vancouver Park Board; UBC Fisheries Centre
	Green Transportation Accessibility	City of Vancouver; Translink
	Number of Public Docks, Boat Ramps, and Pump-Out Stations	City of Vancouver
	Number and Area of Public Beaches	City of Vancouver
	Seawall Traffic	City of Vancouver; CityStudio
	Number of Cultural and Heritage Spaces	City of Vancouver
	Number of Marinas and Slips	Valiance Maritime Consultants Limited
	Number of Yacht and Boat Clubs	Valiance Maritime Consultants Limited
	Number of Rental Facilities	Valiance Maritime Consultants Limited
	Recreational Fishing Effort	Fisheries and Oceans Canada
	Number and Area of Restored/Rewilded Waterfront Spaces	Potential sources: City of Vancouver; Vancouver Park Board; BC Ministry of the Environment; Port Metro Vancouver
	Number of Public Washrooms and Water Fountains	City of Vancouver
	First Nations' Fishery Catch	Fisheries and Oceans Canada
Living on the Waterfront	Zoned Residential Land	City of Vancouver
	Housing Costs	Statistics Canada (Census

		and NHS)
	Number and Type of Waterfront Units	Statistics Canada (Census)
	Number and Type of Affordable Housing Units	City of Vancouver
	Housing Tenure	Statistics Canada (Census and NHS)
	Number and Type of Housing Starts	Canada Mortgage and Housing Corporation
	Rental Unit Availability Rate	Canada Mortgage and Housing Corporation
	Housing Occupant Demographic	Statistics Canada (Census and NHS)
	Green Building Policies and Incentives	City of Vancouver
	Crime Rate	City of Vancouver
	Proportion of Occupant's Income Spent on Housing	Statistics Canada (Census and NHS)
	Access to Amenities	WalkScore; City of Vancouver
	Commuting Duration and Mode of Transportation	Statistics Canada (Census and NHS)
Working on the Waterfront	Industrial, Agricultural, and Commercial Waterfront Land	Metro Vancouver; City of Vancouver
	Economic Contribution of PMV	Port Metro Vancouver
	Economic Contribution of Ocean Sector	UBC Fisheries Centre
	Number and Type of Waterfront Businesses	City of Vancouver
	Authorized Industrial Effluent Discharges	BC Ministry of the Environment; BIEAP
	Oil Spill Response Capacity and Preparedness (Marine and Riverine)	Nuka Research and Planning Group; Western Canada Marine Response Corporation
	Rental Rates of Industrial Lands and Office Space	Colliers International
	Vacancy Rates of Industrial Lands and Office Space	Colliers International
	Net Absorption of Industrial Lands and Offices on the Market	Colliers International
	Number, Type, and Annual Capacity of Timber	BC Ministry of Forests, Lands, and Natural

	Processing Facilities	Resource Operations
	Number and Type of Aquaculture Facilities	Fisheries and Oceans Canada
	Number of Commercial Fishing Licenses (by fishery)	Fisheries and Oceans Canada
	Number and Type of Recreational Marine Operators and Charters	Valiance Maritime Consultants Limited
	Educational Opportunities Available to the Public to Learn about Industrial Activities and History	Port Metro Vancouver
	Number of Coast Guard Stations	Government of Canada Canadian Coast Guard – Western Region
Flourishing Ecosystems on the Waterfront	Water and Sediment Quality	See section 2.5.1
	Recreational Water Quality	Metro Vancouver
	Waterbird Abundance and Diversity	Audubon Society; Bird Studies Canada; Stanley Park Ecology Society
	Air Quality	Metro Vancouver
	Shoreline Habitat	BIEAP; FREMP; Metro Vancouver
	Southern Resident Killer Whale Population	Centre for Whale Research
	Fish Health and Tissue Contaminants	Metro Vancouver
	Eulachon Spawn	Fisheries and Oceans Canada; Moody (2008)
	Pacific Herring Stock and Catch	Fisheries and Ocean Canada
	White Sturgeon Populations	Fraser River Sturgeon Conservation Society
	Marine Mammal Occurrence	Raincoast Applied Ecology
	Pacific Salmon Abundance	Fisheries and Oceans Canada; Pacific Salmon Commission; various publications (see section 2.5.12)
	Species at Risk	BC Ministry of Environment Species and Ecosystems Explorer; Species at Risk BC
	Toxics in the Food Web	Various publications (see section 2.5.14)

	Underwater Noise Pollution	Erbe et al. (2012); Port Metro Vancouver ECHO Program
	Point Source Discharges	BIEAP; Moore (1993); UMA Engineering (1992)
	* Beach Spawning Forage Fish	Sea Watch Society
	*Nearshore Pollution	Vancouver Aquarium PollutionWatch Program
Climate Change on the Waterfront	**Climate Changes and Impacts**	
	Sea Level	National Oceanic and Atmospheric Administration
	Coastal Storm Surges	Storm Surge BC
	Snow Pack	BC Ministry of Forests, Lands, and Nature Resource Operations
	Precipitation Patterns and Extreme Rainfall Events	Environment Canada
	Sea Surface Temperature	Fisheries and Oceans Canada
	Ocean Salinity	Fisheries and Oceans Canada
	Ocean Acidity (pH)	Vancouver Aquarium
	Mitigation	
	Greenhouse Gas Emissions (produced by buildings, transportation, and waste sources)	CDP; City of Vancouver; Metro Vancouver; BC Ministry of the Environment
	Solid Waste Managed and Landfill Gas Captured	City of Vancouver
	Canopy Cover	City of Vancouver
	Electricity Consumption	CDP; City of Vancouver
	Adaptation	
	Buildings and People in Unprotected Floodplains	Northwest Hydraulic Consultants; City of Vancouver
	Value of Assets Exposed to Sea Level Rise	Organization for Economic Co-operation and Development
	Implemented Actions from the Climate Change Adaptation Strategy	City of Vancouver
	Flood-Proofing Policies	City of Vancouver
	Weather-Related Emergency Response Plans	City of Vancouver

	Shoreline Protection (Land Use Changes, Green Infrastructure, Grey Infrastructure, and Large Site Redevelopment)	City of Vancouver

*To be officially included on the indicator list once data is available or received.

The preparation of this list of data sources and potential indicators has been one of the first steps of the indicator development process for the Waterfront Initiative. Recommendations for the next steps of the development process include evaluating indicators against selection criteria; selecting sound analytical methods and conducting data analysis for selected indicators; and preparing the first State of the Waterfront report.

1. Introduction

1.1 The Georgia Strait Alliance and The Waterfront Initiative

The Georgia Strait Alliance (GSA) is a non-profit organization dedicated to protecting and restoring the marine environment and promoting sustainability of Georgia Strait, its adjoining waters, and communities. During its 25 years of operation, GSA has been an effective voice for communities who care about the waters of Georgia Strait and all the creatures that call it home. Through GSA's programs and initiatives, they strive to protect the diversity of wildlife and their habitat; restore the region's water and air quality; promote the social, cultural, economic and environmental sustainability of the region's communities; foster understanding and stewardship of the marine environment; and raise awareness of the links between the health of ecosystems and human communities.

In 2013, GSA launched the Waterfront Initiative – a collaborative effort that brings together multi-jurisdictional stakeholders and citizens to define a common agenda and take action to ensure a diverse, thriving, and resilient waterfront for all (GSA, 2014). With an initial focus on the City of Vancouver, the Waterfront Initiative recognizes that Vancouver's waterfront is an integral part of the community and a place where people go to play, work, live, travel around, and connect with nature and history. However, with increasing pressures from urbanization, pollution, population and industrial growth, as well as intensifying conflicts over land use, Vancouver's shoreline is at risk. Additionally, the impacts of rising sea levels and climate change are also becoming threats to Vancouver's shoreline. Recognizing that integrated planning is essential to address the social, economic, and ecological threats to the shoreline, the Waterfront Initiative is focused on collectively creating a vision and plan for a prosperous and resilient waterfront.

GSA and its partners have identified five broad themes encompassing the importance of the waterfront, which the Waterfront Initiative will focus on (GSA, 2014):

1. Transportation on the Waterfront,
2. Access to Nature on the Waterfront,
3. Living on the Waterfront,
4. Working on the Waterfront, and
5. Flourishing Ecosystems on the Waterfront.

Early Waterfront Initiative documents suggested that issues of climate change could be listed under the flourishing ecosystems on the waterfront theme. However, many of the climate change data sources and potential indicators identified here apply to multiple themes; therefore, for the sake of this report, climate change has been incorporated as a sixth theme. Going forward, the Waterfront Network can decide whether to keep climate change as a sixth theme or to place each selected climate change indicator under an appropriate theme.

Since its launch, GSA has hosted four Waterfront Forums, bringing together stakeholders representing all levels of government, private sector, First Nations, and civil society. Waterfront Forums provide an excellent opportunity to discuss the five themes and to create a vision for Vancouver's waterfront and an action plan to make this vision a reality.

Throughout the conversations, participants have identified that moving forward with the discussion requires a better understanding of the waterfront. The preparation of a State of the Waterfront Report has been emphasized as a way of establishing a baseline and measuring progress through indicators. The Waterfront Initiative has recognized that a better understanding of the data sources available characterizing the waterfront, will not only provide insight into the current state of the waterfront, but will facilitate the preparation of an informative and effective State of the Waterfront Report – a goal of the Waterfront Initiative in the near future.

1.2 Focus of this Report

This report has been prepared to identify existing datasets and ongoing monitoring programs that can reliably reflect the current state of Vancouver's waterfront. Following the Waterfront Initiative's themes, it focuses on identifying data sources that can quantify and qualify space for marine and wildlife habitat, recreation and cultural activities, residential use, industrial land and business, and transportation. Each data source and the potential indicator it could support are described in depth, to allow the robustness of the data source to be evaluated and to facilitate future indicator selection and development by the Waterfront Initiative. For each data source, the following information is presented:

- source of data,
- potential indicator supported,
- data description, and
- recommendations for indicator development.

In some instances, potential indicators overlap with more than one Waterfront Initiative theme. These potential indicators have been listed under the theme that the author perceived to be most relevant and a list of overlapping themes has been presented.

Serving as an initial step in the establishment of a State of the Waterfront report, the present work seeks to identify a list of potential indicators that would enable a baseline assessment of the waterfront and monitoring in the future. Existing data gaps will be identified to highlight the need for monitoring programs that do not currently exist and may be necessary to better understand the state of the waterfront. The report concludes by making recommendations for the next steps of the indicator development process.

1.3 Waterfront Management Plans

The Waterfront Network has emphasized the importance of gathering information on all of the waterfront management plans that exist for Vancouver's waterfront. Through the research conducted for this report, management plans relating to the waterfront in any way have been identified (see Supplementary Table). However, it should be noted that the list prepared is not exhaustive, but rather a working document requiring further investigation and input. The Waterfront Network is encouraged to identify any documents they are familiar with that have not been identified. Furthermore, the Waterfront Network will have the opportunity to shape the list. For instance, they can help determine whether the list should include all documents that overlap with the waterfront or whether it should be limited to documents that solely focus on the waterfront.

1.4 The City of Vancouver and its Waterfront

The City of Vancouver is a highly urbanized city with a population of 603,502 people (Statistics Canada, 2011a). It is the eighth largest Canadian municipality and has approximately 5,249 residents per square kilometer. The City of Vancouver is part of the Metro Vancouver area - home to approximately 2.4 million people, making it the third most populous metropolitan area in the country.

Almost completely surrounded by water, the City of Vancouver has a total of 67 km of unique waterfront (VPB, 2011; Figure 1). From Spanish Banks to Boundary Road, the northern shoreline of the City of Vancouver borders the Burrard Inlet, or more specifically the Outer Harbour, English Bay, False Creek, and the Inner Harbour sections of the inlet. As the Strait of Georgia connects with the Fraser River just south of the City of Vancouver, Vancouver's southern shores are situated along the interconnected marine, estuarine, and freshwater habitats of the Fraser River's northern arm.

1.5 Defining the City of Vancouver's Waterfront

For the purpose of this report, it is important to establish a working definition for the waterfront area. Given the variety of themes addressed, determining one specific, integrative definition is not a simple task. For example, living on the waterfront could easily be defined as only the properties located directly adjacent to the water's edge, while such a narrow definition for flourishing ecosystems on the waterfront would be limited, given the non-sedentary and dynamic nature of ecosystems. With that said, the following comprehensive definition has been devised:

Vancouver's waterfront represents the interface between the city's aquatic environment and adjacent uplands. This includes the sub-tidal, foreshore, backshore and adjacent upland areas.

For the purpose of this report, when identified data sources do not comply with this definition, the smallest geographic unit adjacent to the waterfront is used.

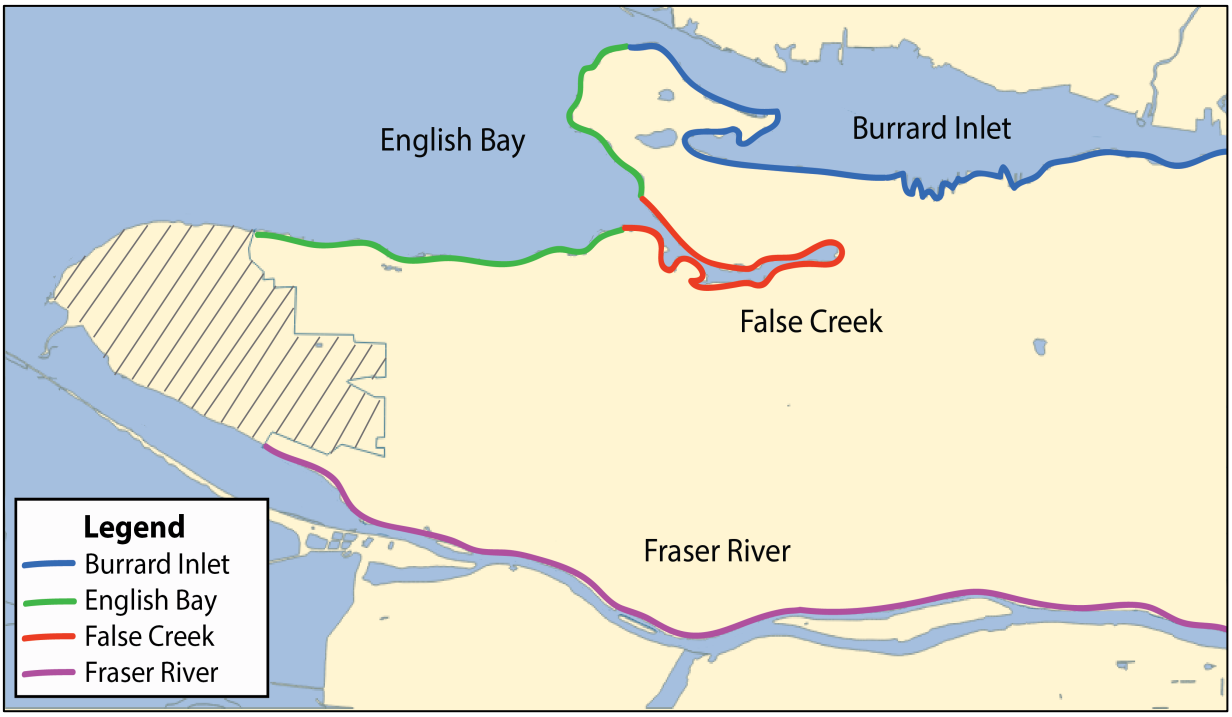

Figure 1. The City of Vancouver and its waterfront. Waterfront segments have been identified based on the body of water they border.

2.0 Available Data Sources and Potential Indicators

The following section outlines the sources of data available to reflect the state of the waterfront with regards to each theme. Each data source has been presented along with the potential indicator it could support.

2.1 Transportation on the Waterfront

The City of Vancouver, like many developed cities worldwide, suffers from immense traffic congestion. Vancouver's network of roads, bridges, and highways are relied on to get commuters to and from work, to allow the population to carry out their social activities, and to transport goods in and out of the city. Given the forecasted population increase over the next few decades, it is expected that more pressure will be placed on these road networks in the coming years.

Fortunately, Vancouver's waterfront provides excellent opportunities for water-based transportation - a means of reducing the pressure on land-based transportation. Today, Vancouver's waterfront is used to transport people via ferries and cruise ships, as well as goods via cargo ships. The identification of the following data sources and the potential indicators supported, will provide a better understanding of the current state of waterfront transportation in Vancouver and a means of assessing changes over time.

Table 2. Data sources and potential indicators for Transportation on the Waterfront.

Theme	Potential Indicator	Data Source
Transportation on the Waterfront	Number and Type of Access Points (providing transportation services for people or cargo)	Translink; Aquabus; False Creek Ferries; Port Metro Vancouver
	Water-Based Transit Ridership	Translink
	Cruise Passenger Ridership	Port Metro Vancouver
	Number of Foreign Vessel Arrivals and Gross Tonnage	Port Metro Vancouver
	Harbour Aircraft Movements	Statistics Canada
	Number and Type of Recreational Vessels Moored	Valiance Maritime Consultants Limited
	Number and Type of Recreational Vessels Using Waterfront	Valiance Maritime Consultants Limited
	Fuel Type, Fuel Consumption, and Emissions of Marine Vessels	BC Chamber of Shipping; Metro Vancouver
	Number and Accessibility of Transit Vessels Operating	Translink; False Creek Ferries; Aquabus
	Number of Electric Transit Vessels Operating	Translink; False Creek Ferries; Aquabus
	Goods Transported via Short-Sea Shipping	Metro Vancouver
	Number of Recreational Boating Incidents	Vancouver Marine Communications and Traffic Services
	Sewage Discharge Regulations for Boats	Transport Canada
	Oil Pollution and Spills	Transport Canada's National Aerial Surveillance Program; Government of Canada's Ship-Source Oil Pollution Fund

2.1.1 Number and Type of Access Points

Why Monitor the Number and Type of Access Points?

Water-dependent transportation requires access points where people or cargo can gain access to the watercraft from the land. A greater number of public access points can accommodate more routes and locations for water-dependent transit; while, a greater number of access points for cargo ships can increase cargo handling. Monitoring the

number and location of access points for water-dependent transportation is indicative of the availability of this form of transportation across the City of Vancouver.

Source of Data

Transit access point data was retrieved from publicly available system maps on the Translink, Aquabus, and False Creek Ferries websites (www.translink.ca; www.theaquabus.com; www.granvilleislandferries.bc.ca, respectively). Access point data for cruise and cargo ships was retrieved through publicly available system maps on the Port Metro Vancouver (PMV) website (www.portmetrovancouver.com).

Data Description

The available data reflects the current access points located on the city's waterfront. As changes are made and access points for transit, cruise ships, and/or cargo ships, are added, removed, and/or relocated, online system maps will be updated accordingly. The Aquabus and False Creek Ferries have maps specific to the Vancouver waterfront; while, Translink's map incorporates transit stops across the entire city. However, given the data is provided on a map, access points specific to the waterfront can easily be determined. All data sources were consulted to ensure the maps were up to date.

Recommendations on Indicator Development

As access points are added, removed, or re-located for transit, cruise, and/or cargo water-based transportation, online system maps will be updated as well. When indicators are monitored in the future, these maps can be consulted to identify any changes that have occurred regarding the number of access points. At times of indicator monitoring, Translink, The Aquabus, False Creek Ferries, and PMV would need to be contacted to ensure maps are up to date. In addition, a search would need to be conducted to investigate whether any new water-dependent transportation options became available since monitoring was last conducted.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Access to Nature on the Waterfront, and
- Working on the Waterfront.

2.1.2 Water-Based Transit Ridership

Why Monitor Water-Based Transit Ridership?

Transit ridership demonstrates the quantity of people using transit systems to move around the city. Ridership can be monitored over time or in comparison with other forms of transit or transportation. SeaBus ridership can be monitored to reflect the quantity of people using water-dependent transit in the City of Vancouver.

Source of Data

Annual SeaBus ridership data is publicly available and was retrieved from the Translink website (www.translink.ca). This data is also publicly available on the Metro Vancouver website (www.metrovancouver.org). Since ridership data from the two private ferry companies in the City of Vancouver are not publicly available, they could not be considered.

Data Description

Translink has monitored annual SeaBus ridership, including the number of passenger trips and the number of system boardings from 1989 to the present. Passenger trips is a measure of the number of riders on the system by mode where the fare was paid; whereas, system boardings is a measure of all riders using the system including transferees from other transit modes. Ridership is estimated through the use of Automatic Passenger Counters (Lau Texier, personal communication, June 8, 2015).

Recommendations on Indicator Development

In terms of data availability, SeaBus ridership would be a strong indicator, as data is available for the past 25 years and ridership will continue to be monitored in the future (Translink, 2014). In addition, currently SeaBus ridership is the only data source available that can reflect the volume of people using water-dependent transit in the City of Vancouver.

2.1.3 Cruise Passenger Ridership

Why Monitor Cruise Passenger Ridership?

The City of Vancouver has the largest cruise port in Canada and is the homeport for the Vancouver-Alaska cruise industry (InterVISTAS, 2013). Monitoring the quantity of cruise passengers provides an indication of the volume of people using water-based transportation in the City of Vancouver. As cruise ship riders are tourists, whether embarking, disembarking, or stopping over, they are specifically indicative of the volume of tourists using water-based transportation to enter, exit, or visit the City of Vancouver.

Source of Data

Cruise revenue passenger data is publicly available and was retrieved from the PMV website (www.portmetrovancouver.com). This data is also available on the Tourism Vancouver website (www.tourismvancouver.com).

Data Description

PMV monitors the annual number of revenue passengers passing through Vancouver's cruise ship terminal throughout the cruise season (April-October). Specifically, the

number of embarking, disembarking, and in-transit passengers are monitored separately. Revenue passengers are determined using cruise ship passenger counts.

Recommendations on Indicator Development

PMV releases cruise revenue passenger data every year and will continue to in the future. With that said, the data availability for this potential indicator is good and the data analysis does not require much effort, since annual totals have already been determined. As PMV releases the data every year, the Waterfront Initiative can retrieve the numbers and add them to the graphical representation of the data.

2.1.4 Number of Foreign Vessel Arrivals and Gross Tonnage (by carrier type)

Why Monitor the Number of Foreign Vessel Arrivals and Gross Tonnage?

Vancouver's coastal waters provide excellent opportunities for marine transportation, which has numerous economic advantages and beneficial environmental factors. The number of foreign vessel arrivals and their registered gross tonnage provides an indication of the number of cargo vessels dependent on the city's waterfront and the quantity of cargo transported to or from Metro Vancouver via water-dependent transportation.

Source of Data

Foreign vessel arrivals and registered gross tonnage data for 2012 – 2014 was retrieved from an annual statistics overview from PMV (PMV, 2014), available on the PMV website (www.portmetrovancouver.com). Data from 2008 – 2011 is available, but must be requested from PMV.

Data Description

PMV monitors the number of foreign vessel arrivals to PMV terminals and the registered gross tonnage carried by each vessel. Foreign vessels are classified as bulk carriers, container, ro-ro (roll-on/roll-off), tanker, passenger, or miscellaneous. However, since data regarding the total volume of cargo moving through each terminal is not available, it is not possible to calculate the total volume of cargo moving only through terminals located in the City of Vancouver. Therefore, the data presented is not specific to the City of Vancouver, and instead represent all the Metro Vancouver terminals.

Recommendations on Indicator Development

Data availability for this indicator is good as PMV publishes foreign vessel arrival and registered tonnage data annually. However, the indicator focuses on the Metro Vancouver region, not the City of Vancouver, as PMV does not release data for individual terminals to the public. A further investigation is recommended to determine whether a reliable methodology can be used to estimate the proportion of vessels and registered tonnage transported to the City of Vancouver terminals. If possible, this

methodology can be applied and if not, this potential indicator could still be used to reflect the region's waterfront as a whole.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Working on the Waterfront.

2.1.5 Harbour Aircraft Movements

Why Monitor Harbour Aircraft Movements?

Vancouver's waterfront is home to the Vancouver Harbour Flight Centre, which provides passenger transportation throughout the Pacific Northwest via seaplanes and helicopters. The number of aircraft movements from the Vancouver Harbour Flight Centre reflects the use of Vancouver's waterfront for air transportation.

Source of Data

Aircraft movement data for the Vancouver Harbour Flight Centre was retrieved from Statistics Canada's aircraft movement statistics, which are publicly available on the Statistics Canada website (www.statcan.gc.ca).

Data Description

Aircraft movement data for the Vancouver Harbour Flight Centre is available annually from 1997 to the present. The data represents the total number of aircraft movements to or from Vancouver Harbour, including both local and itinerant movements. Data outlining both the total number of monthly and annual aircraft movements is available.

Recommendations on Indicator Development

As Statistics Canada releases aircraft movement data every year and will continue to in the future, the data availability for this potential indicator is good. In addition, the data analysis is straightforward and does not require much effort since annual totals have already been determined. As data is released every year by Statistics Canada the Waterfront Initiative can retrieve the most recent numbers and add them to the graphical representation of the data.

2.1.6 Number and Type of Recreational Vessels Moored

Why Monitor the Number and Type of Recreational Vessels Moored?

Vancouver is home to many recreational boaters and similarly is an appealing boating destination for many tourists. Monitoring recreational vessel moorage provides an

indication of the number of recreational boaters using Vancouver's waters, as well as the demand for moorage in Vancouver's waters.

Source of Data

The data source is a report prepared by Valiance Maritime Consultants Limited (VMCL), which reviews marine recreational vessel activities in Burrard Inlet (VMCL, 2014). Likely a one-off study, VMCL has given no indication that their investigation will be replicated in the future.

Data Description

VMCL estimated the number of recreational boats that are docked at slips throughout English Bay and Burrard Inlet (VMCL, 2014). Recreational vessels included small commercial passenger vessels, small power and sailboats, kayaks, canoes, and open vessels of all types and sizes. The data are presented by area, including English Bay & False Creek, Inner Harbour, Coal Harbour, Central Harbour Private Docks, and Central Harbour Marinas. The data was collected in 2014 through desktop research, observations, and interviews.

Recommendations on Indicator Development

The available report provides a baseline for recreational vessel moorage in Vancouver; however, further studies will be necessary in order for this potential indicator to be monitored temporally. Since there is no indication of future studies being conducted by VMCL, prior to developing this indicator, it should be determined whether the Waterfront Initiative or another organization will be able to conduct further studies.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Access to Nature on the Waterfront.

2.1.7 Number and Type of Recreational Vessels Using the Waterfront

Why Monitor the Number and Type of Recreational Vessels Using the Waterfront?

Monitoring the number and type of recreational vessels using the waterfront reflects the number of people using the city's waters for recreational transportation. In addition, monitoring can indicate which type of recreational boats are most commonly used and whether recreational boat usage is changing over the years.

Source of Data

The data source is a report prepared by VMCL, which reviews marine recreational vessel activities in Burrard Inlet (VMCL, 2014). Likely a one-off study, VMCL has given no indication that their investigation will be replicated in the future.

Data Description

To better understand marine recreational traffic on Vancouver's waters, VMCL set up observers at the following locations: Ambleside Park, Lonsdale Quay, Cates Park, and Barnet Park. From July 12 to 20, 2014, observers at these locations documented the type, location (English Bay, Inner Harbour, Outer Harbour), and activity of any recreational boat they observed on the water. The results of these observations are presented in the VMCL report.

Recommendations on Indicator Development

Few studies have monitored the number of recreational boats on the water on any given day around Vancouver. This is likely because it is very difficult to reliably estimate how many recreational boats are used at various times and locations throughout the year, without continuous monitoring. Although the study presented here estimates the number of boats on the water over a nine-day period in the summer, these results cannot be extrapolated to estimate how many boats were on the water on other days of the year. With that said, this data source may not be robust enough to support an indicator. Instead, we suggest that the results from this study could serve as supplementary information for a related indicator (ie. Recreational Boats Moored).

In addition, since there is no indication of future studies being conducted by VMCL, it should be determined whether the Waterfront Initiative or another organization will be able to conduct further studies.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Access to Nature on the Waterfront.

2.1.8 Fuel Type, Fuel Consumption and Emissions of Marine Vessels

Why Monitor Fuel Type, Fuel Consumption and Emissions of Marine Vessels?

Ocean-going vessels and smaller marine vessels are regularly used in Vancouver to transport people and goods. Like cars, they require fuel and produce emissions, which have adverse effects on the environment. Monitoring fuel type, fuel consumption, and emissions can provide an indication of the fuel economy and efficiency of marine vessels, and whether the cleanest available fuel types are being used.

Source of Data

Emissions of Marine Vessels

Marine vessel emissions data are reported by Metro Vancouver in their Emissions Inventory. Emissions inventories can be publicly accessed on the Metro Vancouver website (www.metrovancouver.org).

Fuel Type, Fuel Consumption, and Emissions of Ocean-Going Vessels

The data is presented in the Ocean-Going Vessel Emissions Inventory prepared by the BC Chamber of Shipping. The inventory can be publicly accessed at www.cosbc.ca.

Data Description

Emissions of Marine Vessels

Metro Vancouver's Emissions Inventory has been conducted on a five-year interval from 1985 – 2010. The Emissions Inventory provides estimates for common air contaminants and greenhouse gas (GHG) emissions from marine vessels. The marine vessel classification includes ocean-going vessels, as well as transit and other smaller vessels operating in the Lower Fraser Valley. Specifically, the reports provide emissions estimates for carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), sulphur oxides (SO_x), volatile organic compounds (VOCs), inhalable and fine particulate matter (PM_{10} and $PM_{2.5}$ respectively) carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ammonia (NH_3).

In the 2010 Emissions Inventory, backcast estimates for 1985 to 2005 were made using historic data from the region. Forecast estimates from 2010 to 2030 were conducted by applying realistic growth assumptions to estimate emissions in the future. Therefore, in the 2010 inventory, annual emissions data are provided at a 5-year interval from 1985 to 2030 for the entire Lower Fraser Valley, including Metro Vancouver, Fraser Valley Regional District, and Whatcom County. Aside from the 2000 Emission Inventory, estimates are not provided specific to the City of Vancouver.

Fuel Type, Fuel Consumption, and Emissions of Ocean-Going Vessels

The BC Chamber of Shipping study reports the total volume of fuel used by ocean-going vessels, by fuel type (heavy fuel oil, marine gas oil, and distillate fuel oil), mode (underway, maneuvering, berthed, and anchored), and vessel class (bulk vessel, containership, cruise ship, general cargo, miscellaneous, motor vehicle carrier, and tanker). The average volume of fuel used per voyage is also reported. The smallest geographic scale for which this data is presented is the Lower Fraser Valley Region.

Emissions for NO_x, SO_x, CO_2, PM_{10}, $PM_{2.5}$, CO, CH_4, N_2O, and NH_3 are reported for ocean-going vessels for the Lower Fraser Valley and also specifically for Vancouver Harbour.

This study represents the conditions in 2005/2006.This was the last emissions inventory that was conducted by the BC Chamber of Shipping. An inquiry has been made to determine whether a new inventory will be completed in upcoming years.

Recommendations on Indicator Development

The BC Chamber of Shipping study provides a baseline of ocean-going vessel fuel consumption, fuel type, and emissions. Currently, however, it is unclear whether further studies will be completed in the future to make it possible to track temporal changes. On the other hand, the Metro Vancouver emissions inventory is conducted every five years, and there is no indication that this monitoring will end in the near future. Therefore, unless it is indicated that further studies in line with that of the BC Chamber of Shipping study are to be conducted, the Metro Vancouver emissions inventory will likely be a more consistent data source, despite its absence of focus on fuel consumption and fuel type.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Working on the Waterfront, and
- Climate Change on the Waterfront.

2.1.9 Number and Accessibility (to Bikes, Strollers, and Wheel Chairs) of Transit Vessels Operating

Why Monitor the Number and Accessibility (to Bikes, Strollers, and Wheel Chairs) of Transit Vessels Operating?

In a city surrounded by water on three sides, water-based transit can play a large role in moving people efficiently around the city. As the population increases and more drivers opt for transit options, water-based transit services may need to accommodate a larger volume of people. Monitoring the number of transit vessels operating can provide an indication of both the availability and efficiency of water-based transit options.

Source of Data

Translink, False Creek Ferries, and the Aquabus provide information on the number of transit vessels operating in their fleet. This information is available on the Translink, False Creek Ferries, and Aquabus websites (www.translink.ca; www.granvilleislandferries.bc.ca; www.theaquabus.com).

Data Description

Translink provides information on the number of SeaBus vessels operating between Downtown Vancouver and North Vancouver; while, False Creek Ferries and the Aquabus provide information on the number of ferries operating in False Creek. Information on the size of each respective fleet is available from the beginning of operation until the present time. In addition, each company can provide details on the number of boats that are bike, stroller, and wheelchair accessible.

Recommendations on Indicator Development

The size and characteristics of each transit fleet can easily be monitored over time using these sources. This will require compiling past information on the size of each fleet and contacting officials or monitoring the website of each transit provider, prior to completing each indicator report, to check for any changes or additions to their transit fleet. Additionally, at the time of updating the indicator report, an investigation will need to be conducted to see if any new transit providers are operating on Vancouver's waters.

2.1.10 Number of Electric Transit Vessels Operating

Why Monitor the Number of Electric Transit Vessels Operating?

As the world seeks to drastically reduce carbon dioxide emissions, electric vessels are becoming popular options in some parts of the world. Benefits of electric vessels include lower noise levels and no carbon dioxide emissions.

Source of Data

Translink, False Creek Ferries, and the Aquabus provide information on their transit fleets, including the number of vessels that are electric. This information must be requested from Translink, False Creek Ferries, and the Aquabus.

Data Description

Each transit provider can provide details on the number of electric vessels in their fleet at the present time, as well as the year when each electric vessel was added to their fleet.

Recommendations on Indicator Development

To develop this indicator, the data would need to be compiled from each transit provider. Additionally, prior to completing indicator reports, each transit provider would need to be contacted about any fleet changes that may have happened since the last report.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Climate Change on the Waterfront.

2.1.11 Goods Transported via Short Sea Shipping

Why Monitor Goods Transported via Short Sea Shipping?

Short sea shipping involves moving cargo by water over relatively short distances. Given Vancouver's close proximity to the United States, this includes both domestic and trans-border (United States) traffic. Short sea shipping is an alternative means to transporting goods via trucks, and can reduce traffic congestion, accidents, noise, and air emissions. It currently makes up approximately 26% of PMV's total traffic, in terms of weight (Metro Vancouver, 2015b); however, recent discussions have suggested that short sea shipping in the region can and should be expanded.

Source of Data

Metro Vancouver presented data on short sea shipping in a policy backgrounder published in 2014 titled "Short Sea Shipping in Metro Vancouver". The policy backgrounder can be publicly accessed here on the Metro Vancouver website (www.metrovancouver.org).

Data Description

The Metro Vancouver document reports the total volume of goods transported via short sea shipping from 2008 – 2014. The annual total volume is also broken down and presented as the total US volume and total domestic volume. The data presented is not specific to the City of Vancouver – it includes any short sea traffic arriving or departing from the Metro Vancouver region.

Recommendations on Indicator Development

The policy backgrounder by Metro Vancouver provides a baseline for short sea shipping volumes in Metro Vancouver. As short sea shipping is a popular topic, and will likely continue to be into the future, similar studies are expected to be prepared in the future as changes occur. As more reports are released, they should be collected and compiled along with the baseline data.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Working on the Waterfront, and
- Climate Change on the Waterfront.

2.1.12 Number of Recreational Boating Incidents

Why Monitor Number of Recreational Boating Incidents?

For the many boaters using Vancouver's waters, there is the potential for single boat or multiple boat incidents to occur. Boating related accidents can occur for a variety of reasons including careless or reckless operation, operator inattention, having no proper spotter, operator inexperience, and passenger recklessness. This potential indicator is reflective of the boating education of Vancouver's boating community.

Source of Data

Marine Communications and Traffic Services (MCTS), Canadian Coast Guard (CCG) Western Region monitors the number of vessel incident reports that are filed in the Vancouver area.

Data Description

Vancouver MCTS monitors the number of incident reports that they receive every year from vessel owners. Incident reports are generated when a recreational vessel requires a safety response of some level. Vancouver MCTS covers and receives incident reports for Howe Sound, English Bay, and waters inside Burrard Inlet. Although each incident is logged, details regarding the incident are not always provided.

Recommendations on Indicator Development

To continue with the development of this indicator, data on the number of incident reports filed each year with MCTS Vancouver should be collected and compiled. The number of boating incidents that occur each year in the Vancouver area could be plotted over time to identify any temporal trends.

2.1.13 Sewage Discharge Regulations for Boats

Why Monitor Sewage Discharge Regulations for Boats

Sewage dumping has long been a controversial issue in British Columbia. Since fecal contamination is often to blame for high bacterial counts and consequently, beach closures, it is often argued that sewage dumping should not be allowed in close proximity to the shore. Currently, in Canada, it is illegal to dump sewage from boats within three nautical miles of shore (unless pump-outs are not available, and you cannot get three miles off shore). However, it has recently been proposed that the minimum dumping distance should be decreased to one nautical mile from shore, making many people fear that beach closures will become more prevalent as a result. In response to this proposal, Vancouverites concerned with the status of the city's beaches have suggested that Burrard Inlet be off-limits to sewage dumping altogether.

Source of Data

Sewage discharge regulations are presented and described in Transport Canada's Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals. The regulations can be accessed on the Transport Canada website (www.tc.gc.ca).

Data Description

Transport Canada regulates sewage discharge through its Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals. The regulations outline the distance from shore for which sewage dumping from various vessels is allowed in Canada's oceans, as well as all other relevant dumping regulations.

Recommendations on Indicator Development

The data for this indicator is easily accessible through the described document from Transport Canada. The indicator could focus on the distance from shore for which sewage dumping is allowed. Prior to writing each indicator report, Transport Canada's regulations should be consulted to see whether any modifications have been made.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.1.14 Oil Pollution and Spills

Why Monitor Oil Pollution and Spills?

The Pacific Ocean is polluted with oil on a daily basis from oil spills and oil pollution resulting from various activities including routine shipping and dumping. Although oil spills get much of the attention, oil pollution contributes a high portion of overall oil input into marine environments (Bertazzon et al., 2014). Oil spills and pollution pose a major threat to marine ecosystems and coastal communities, as they can have wide ranging impacts on the marine environment.

Source of Data

Oil Pollution

Transport Canada's National Aerial Surveillance Program (NASP) maintains data on oily discharges in Canada's oceans. Data can be requested from Transport Canada. Additionally, a recent article prepared by Bertazzon et al. (2014) analyzed NASP data to investigate oil pollution in the Canadian Pacific region. This article can be accessed from ScienceDirect (www.sciencedirect.com).

Oil Spills

The Government of Canada's Ship-Source Oil Pollution Fund (SOPF) provides information on Canadian oil spill incidents. Information can be accessed here on the Government of Canada's SOPF website (www.sopf.gc.ca/en/home).

Data Description

Oil Pollution

Since 2003, NASP has extensively monitored and collected information on oily discharges in Canada's oceans, including the Pacific Coast. Specifically, NASP collects information on the number and location of oily discharge events counted by their surveillance teams, the type of vessel involved, and the estimated volume discharged. This information is available for the entire Pacific Coast and therefore, it is possible to only focus on events in the Vancouver Region.

Bertazzon et al. (2014) analyzed NASP data from 2008 to 2010 (inclusive) to investigate the intensity of oil discharge and the association between oily discharges and human maritime activities in three regions along the Pacific Coast (the northern coast, the Strait of Georgia, and the south-western coast of Vancouver Island). Oily discharges events off the Pacific Coast are presented spatially and human activities driving spatial patterns of oily discharges are identified.

Oil Spills

SOPF provides information on oil spill incidents that occur each year on the South Pacific Coast. Data are available from 2007 to the present. Oil spill incidents are presented by location, making it possible to focus solely on spills in the Georgia Strait or Vancouver region.

Recommendations on Indicator Development

This potential indicator could monitor the number of oily discharge events (pollution and spills) and the estimated volume of each event. This could be done individually, by vessel type, to identify any trends regarding which vessel types experience the most frequent discharge events. The number of discharge events occurring in the Vancouver area could also be compared with the number of discharge events in other coastal regions of the Pacific.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Working on the Waterfront, and
- Flourishing Ecosystems on the Waterfront.

2.1.15 Suggested Indicators with Insufficient Supporting Data

The Waterfront Network has suggested the following other potential indicators for Transportation on the Waterfront, which are not detailed here due to an absence of sufficient supporting data:

1. *Presence of Squatter Boats*

To the best of our knowledge, there are no datasets available providing information on squatter boats located around Vancouver.

2. *Sewage Dumping Rates*

Sewage dumping rates are very difficult to quantify because the majority of the time, dumping is not reported. To the best of our knowledge, there are no programs monitoring sewage dumping in the Vancouver area.

3. *Access Point Accessibility (ie. car, bike, and/or boat access)*

The number and location of access points has already been identified as an indicator. However, it has also been suggested to include information on access point accessibility. To the best of our knowledge, no analyses investigating the accessibility of access points have been completed. Likely, this would be a relatively simple analysis requiring interviews, observations, and some geospatial analyses. Furthermore, Walk Score, Bike Score, and Transit Score could be use as supplementary data sources.

4. *Recreational Vessel Fuel Use*

To the best of our knowledge, no studies have been completed investigating recreation vessel fuel use. It may be possible to receive information on the volume of fuel sold at water-based gas stations around Vancouver. However, it would still not be possible to determine the volume sold to recreational vessels versus other vessels (ie. commercial fishing vessels).

2.2 Access to Nature on the Waterfront

Access to nature on the waterfront not only plays an important role in enabling people to gather and recreate, but also to explore and learn about the environment. Given that one of Vancouver's claims to fame is the Seawall, it is well known that there is great recreational space on Vancouver's waterfront. However, providing recreational space along the waterfront is only one piece of the puzzle – physical access to both the waterfront and the water, space for arts and culture, as well as waterfront designs must also be considered.

Access to nature on the waterfront requires transit, bike, and pedestrian routes that can easily get people to the waterfront. Similarly, it requires spaces where people can dip their toes in the water, try water-based activities, take part in cultural events, and explore natural ecosystems. In a city almost completely bordered by water, it is important that accessible waterfront areas be distributed at all ends of the waterfront and not exclusively in some neighbourhoods. The identification of the following data sources and the potential indicators supported, will provide a better understanding of the current state of access to nature on the waterfront in Vancouver and a means of assessing changes over time.

Table 3. Data sources and potential indicators for Access to Nature on the Waterfront.

Theme	Potential Indicator	Data Source
Access to Nature on the Waterfront	Number and Area of Waterfront Parks	Vancouver Park Board; City of Vancouver
	Length and Type (hard or soft surfaced) of Waterfront Pathways	Vancouver Park Board; City of Vancouver
	Number and Type of Waterfront Special Events	Vancouver Park Board; UBC Fisheries Centre
	Green Transportation Accessibility	City of Vancouver; Translink
	Number of Public Docks, Boat Ramps, and Pump-Out Stations	City of Vancouver
	Number and Area of Public Beaches	City of Vancouver
	Seawall Traffic	City of Vancouver; CityStudio
	Number of Cultural and Heritage Spaces	City of Vancouver
	Number of Marinas and Slips	Valiance Maritime Consultants Limited
	Number of Yacht and Boat Clubs	Valiance Maritime Consultants Limited
	Number of Rental Facilities	Valiance Maritime Consultants Limited
	Recreational Fishing Effort	Fisheries and Oceans Canada
	Number and Area of Restored/Rewilded Waterfront Spaces	Potential sources: City of Vancouver; Vancouver Park Board; BC Ministry of the Environment; Port Metro Vancouver
	Number of Public Washrooms and Water	City of Vancouver

	Fountains	
	First Nations' Fishery Catch	Fisheries and Oceans Canada

2.2.1 Number and Area of Waterfront Parks

Why Monitor the Number and Area of Waterfront Parks?

Waterfront parks are places where people gather, recreate, and experience nature. Parks offer many reasons to gather on the waterfront, from picnic and play areas to off-leash dog parks. The number of and area covered by public waterfront parks in the City of Vancouver, provides an indication of the amount of recreation space available to the public on the waterfront. Monitoring waterfront park trends over time can indicate whether waterfront recreation space has been lost, gained, or remained the same.

Source of Data

Waterfront park data was retrieved from a Waterfront Inventory prepared by the Vancouver Park Board (VPB, 2011). The Waterfront Inventory is available to the public, but needs to be requested from the Vancouver Park Board. Geospatial park data was also retrieved online from the City of Vancouver's Open Data Catalogue.

Data Description

The Vancouver Park Board prepared a Waterfront Inventory in 2011 to examine the value of the waterfront as a natural, recreational, and cultural resource (VPB, 2011). The report outlines the total number and area of waterfront parks in the City of Vancouver in 2007, and specifically for each waterfront body within the city (Burrard Inlet, English Bay, False Creek, and the Fraser River). The number and size of parks were determined using GIS analysis.

Although this analysis has not been completed for the years following 2007, geospatial park data has been publicly available since 2009 through the City of Vancouver's Open Data Catalogue. Using the geospatial data available, the number of parks and area covered can be calculated. Parks data, in the Open Data Catalogue, is updated weekly and thus, could be used to update the parks information regularly and to monitor their status in the future (City of Vancouver, 2015a).

Recommendations on Indicator Development

The Vancouver Park Board's assessment of waterfront parks in the City of Vancouver provides a great baseline for this indicator. Since the City of Vancouver provides updated data, the same assessment could be done in the future using GIS analysis. This potential indicator could be updated annually, or at another time interval selected by the Waterfront Initiative.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.2.2 Length and Type (hard or soft surfaced) of Waterfront Pathways

Why Monitor the Length and Type of Waterfront Pathways?

Waterfront pathways in the City of Vancouver are a place where people can go, year-round, to walk, run, bike, and partake in many other activities. Additionally, waterfront pathways provide people with a way of travelling throughout the city, while exercising and experiencing nature. Monitoring the length of waterfront pathways over time provides an indication of the amount of recreation space on the waterfront enabling people to exercise and providing connections to different parts of the city. Furthermore, monitoring the characteristics of the pathway (ie. soft or hard surfaced) can reflect the adaptability of the city to climate change and sea level rise.

Source of Data

Waterfront pathway data was retrieved from the Waterfront Inventory prepared by the Vancouver Park Board (VPB, 2011). The Waterfront Inventory is available to the public, but needs to be requested from the Vancouver Park Board. Geospatial pathway data was also retrieved online from the City of Vancouver's Open Data Catalogue.

Data Description

The Vancouver Park Board's Waterfront Inventory determined the length of waterfront pathway in the City of Vancouver in 2006, using GIS analysis (VPB, 2011). The report specifically outlines the length of pathway directly adjacent to the water (no barrier between the water and pathway), and the length of pathway that detours from the water. Additionally, the Waterfront Inventory reports the amount of waterfront pathway that is hard and soft surfaced.

Although this analysis has not been completed for the years following 2006, the City of Vancouver has publicly available geospatial data for waterfront pathways available through their online Open Data Catalogue. This geospatial data can be used to quantify waterfront pathway length for the present and the future. The City of Vancouver states that this data is updated frequently in the normal course of business (City of Vancouver, 2015b).

Recommendations on Indicator Development

The Vancouver Park Board's assessment of waterfront pathways in the City of Vancouver provides a good baseline for this indicator. Since the City of Vancouver regularly updates the data, the same assessment could be done in the future using GIS

analysis. This potential indicator could be updated annually, or at another time interval selected by the Waterfront Initiative.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Flourishing Ecosystems on the Waterfront, and
- Climate Change on the Waterfront.

2.2.3. Number and Type of Waterfront Special Events

Why Monitor the Number and Type of Waterfront Special Events?

Whether it is an annual run, community event, or festival, special events enable people to gather, socialize, and celebrate life and culture. Monitoring the number of waterfront special events provides an indication of the opportunities available to gather and partake in cultural activities on the waterfront.

Source of Data

Data regarding the number of special events and attendees in waterfront parks or along the seawall was retrieved from the Vancouver Park Board's Waterfront Inventory (VPB, 2011). Special event data was also gathered from a recent economic analysis by Bjarnason et al. (2015).

Data Description

Special event data from the Waterfront Inventory were only available for 2005 (VPB, 2011). The inventory reported both the number of special events and the number of attendees. The number of events was determined based on the number of special event permits allocated; while, the number of attendees was determined by contacting the organizers after the events were held. The events reported were open to the public and had an estimated attendance of greater than 300 people. Furthermore, events were divided into four categories: 1) walk/run events; 2) community events; 3) festivals; and 4) sporting tournaments. The Waterfront Inventory presents the data in maps, showing the location of each event and the number of attendees.

Bjarnason et al. (2015) reported the number of waterfront special events and number of attendees in the City of Vancouver for 2014. The number of special events and attendees were calculated from survey data from the Vancouver Waterfront Survey (2014). In this report, special events were divided into six categories: 1) events on the water; 2) beach events; 3) running races (seawall); 4) triathlons (seawall and ocean); 5) community events/fundraisers (seawall, beaches, waterfront parks); and 6) arts/cultural (seawall, beaches, waterfront parks). With the exception of the events on the water category, the events reported had at least 1000 attendees.

Recommendations on Indicator Development

The special events indicator is unique in this theme because, unlike the others, it provides an indication of the quantity of people using the waterfront to partake in cultural activities. However, as both the works presented are not regular monitoring programs, there is no indication on whether this type of assessment will be conducted in the future. Additionally, if the analysis is conducted by a different source, event criteria may once again be changed, making it difficult to compare across years.

The Waterfront Initiative could conduct this analysis independently (annually or every couple of years) following the methods outlined by the Vancouver Park Board (VPB, 2011). This would entail gathering special event permit data from the City of Vancouver, and contacting event coordinators after each event occurred to determine the approximate number of attendees.

If a waterfront events analysis were to be conducted in the future, marine event permit data could be incorporated to supplement the City of Vancouver special event permits. PMV is responsible for issuing marine event permits for all organized activities that take place on the water. Using this data, an analysis of the number of organized events occurring on the water and the number of attendees would likely be possible. Marine event permit data has been requested from PMV, but not yet retrieved.

2.2.4 Green Transportation Accessibility

Why Monitor Green Transportation Accessibility?

When considering access to nature on the waterfront, being able to get to the waterfront is just as important as having sufficient waterfront recreational space. In terms of accessibility, what good is a beautiful waterfront park that cannot be easily accessed? The City of Vancouver's Greenest City 2020 Action Plan has made it a target that the majority (over 50%) of trips in Vancouver will be by foot, bicycle, and public transit by 2020 (City of Vancouver, 2015c). Since the City is promoting green transportation and striving to reduce the use of cars, accessibility to the waterfront via transit and bikes is very important. Monitoring transit and bike access to waterfront recreational spaces provides an indication of the physical accessibility of the waterfront to community members using green transportation.

Source of Data

Geospatial transit data has been retrieved from Translink's Google Transit Feed Specification (GTFS) real-time, which can be publicly accessed on the Translink website (www.translink.ca). Geospatial bike lane data has been retrieved online from the City of Vancouver's Open Data Catalogue.

Data Description

The geospatial transit data provides current details and locations of all the transit stops and routes in the City of Vancouver. As it is a live feed, when the data package is downloaded it reflects the most current stop locations and transit routes. As changes are made to stop locations and transit routes, the data is updated.

The geospatial bike lane data provided by the City of Vancouver details the locations of all the bike lanes across the City of Vancouver. The data reflects the present conditions and the City of Vancouver states that this data is updated frequently in the normal course of business (City of Vancouver, 2015b).

Recommendations on Indicator Development

This data enables an analysis of waterfront accessibility via transit and bikes. Analyses could provide reliable information on the number of transit stops in proximity to the waterfront (ie. directly across from the water or within 1-2 city blocks) and the number of bike lanes leading to the waterfront. However, given the overall theme is access to nature on the waterfront, a more informative analysis may reflect the number of transit stops within proximity of and the number of bike lanes leading to waterfront recreational spaces (ie. parks, beaches, pathways, etc.). This type of analysis would eliminate the consideration of green transportation to the waterfront in industrial, residential, or other areas without direct public access to waterfront space.

To reflect the accessibility of all waterfront segments, the data also facilitates the identification of transit and bike access to waterfront recreational space on all sides of the waterfront. The analysis could divide the waterfront into specific geographic categories to reflect the accessibility of all waterfront bodies (ie. Burrard Inlet, English Bay, False Creek, and the Fraser River).

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Flourishing Ecosystems on the Waterfront, and
- Climate Change on the Waterfront.

2.2.5 Number of Public Docks, Boat Ramps, and Pump-Out Stations

Why Monitor the Number of Public Docks, Boat Ramps, and Pump-Out Stations?

Just as it is important for people to have access to the waterfront from the land, it is important that the waterfront be physically accessible to boaters. The number of public docks and formal boat launches located around Vancouver, reflects the accessibility of the waterfront for boaters, and overall is indicative of the physical accessibility of the waterfront. Furthermore, the number of pump out locations on the city's waterfront

provides an indication of the opportunities available for public boaters to properly dispose of their waste, thereby protecting nature on the waterfront.

Source of Data

Data for public docks, boat ramps, and pump-out stations was retrieved from a map of public docks and formal boat launches and a list of sewage pump-out stations from the City of Vancouver website (www.vancouver.ca) and corroborated with the Vancouver Park Board's Waterfront Inventory (VPB, 2011). The City of Vancouver was consulted to ensure the map and list were current.

Data Description

The City of Vancouver provides detailed maps with current information on boat launches and public docks in the city, including location and the duration of moorage permitted at docks. The City of Vancouver also provides a list of the current pump out stations located on the city's waterfront. Additionally, the available maps and list enable division of the waterfront into specific geographic categories to reflect accessibility of all waterfront bodies (ie. Burrard Inlet, English Bay, False Creek, and the Fraser River).

The Vancouver Park Board's Waterfront Inventory provides a detailed inventory of waterfront structures in the City of Vancouver, including public docks and marinas. The Waterfront Inventory provides the locations of all marinas and docks in the city and outlines whether they are accessible to the public and/or available for moorage.

Recommendations on Indicator Development

Information on the number of public docks, boat launches, and pump-out stations is updated by the City of Vancouver as locations are added or removed. Therefore, the City of Vancouver could be consulted each time the indicator is monitored, to ensure the website information is up to date.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Transportation on the Waterfront.

2.2.6 Number and Area of Public Beaches

Why Monitor the Number and Area of Public Beaches?

Access to the water itself, allows people to play and explore in the city's coastal waters, while gaining an appreciation for these aquatic environments. Beaches provide waterfront recreational space where people can gain access to the water and partake in various recreational activities. The number of public beaches located on the City of

Vancouver's waterfront reflects the physical accessibility of the water itself, located along the city's waterfront.

Source of Data

Data on the number and locations of public beaches along the city's waterfront was retrieved from a list of public beaches from the City of Vancouver's website (www.vancouver.ca).

Data Description

The City of Vancouver provides a detailed list of beaches located in the city. The list reflects the current status of beaches in the city; however, will continue to be updated as beaches are added or removed.

Recommendations on Indicator Development

The City of Vancouver will continue to update the list of beaches as changes are made. Therefore, the City of Vancouver can be consulted whenever the indicator is monitored in the future to ensure the information is up to date.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.2.7 Seawall Traffic

Why Monitor Seawall Traffic?

Vancouver's Seawall is the longest uninterrupted waterfront path in the world, extending from Spanish Banks Park to the Vancouver Convention Centre. Seawall traffic reflects the number of people using waterfront recreational spaces in the City of Vancouver and can also provide an indication of the awareness of the public regarding available waterfront recreational spaces.

Source of Data

Seawall traffic data was retrieved from the Vancouver Park Board's Waterfront Inventory and from CityStudio.

Data Description

The Vancouver Park Board conducted a daylong (between 10 am and 5 pm) Seawall count on one mid-summer, sunny day in 2005. The count was conducted at various locations on the Seawall including the Stanley Park Entrance, English Bay, Third Beach,

Lumbermans Arch, Coal Harbour CC, Harbour Green, George Wainborn, David Lam, Creekside, Cambie Bridge south, Sutcliffe, Vanier, Kitsilano Beach, Jericho Beach, and Locarno Beach. The Fraser River was not surveyed due to the relatively lower volumes of people. The count classified Seawall users as pedestrians, cyclists, or inline skaters.

In 2013, CityStudio conducted a similar Seawall count on one sunny day in August from 11 am to 5 pm. Count locations include Harbour Green Park, Sunset Beach, Northeast False Creek (NEFC), Southeast False Creek (SEFC), Alder Bay, Kitsilano Beach, Stanley Park Lawn Bowling Club, and Stanley Park Rowing Club. The count classified Seawall users as pedestrians, cyclists, or others (including maintenance cars, wheelchairs, skateboarders, electric scooters, ice cream carts, and inline skaters).

Recommendations on Indicator Development

Seawall user counts have not been conducted consistently in the past making it hard to compare across the years. Furthermore, there is no indication regarding whether future counts will be conducted or whether any future counts will be compatible with previous counts. Currently, a baseline has been established for this potential indicator; however, further Seawall counts compatible with either of the studies presented will need to be conducted in the future in order for a temporal comparison to be possible.

2.2.8 Number of Cultural and Heritage Spaces

Why Monitor the Number of Cultural and Heritage Spaces?

Cultural and heritage spaces offer people the opportunity to learn about history and culture and partake in cultural activities. The number of cultural and heritage attractions on the waterfront reflects the opportunities available on the waterfront to immerse oneself in the city's culture and heritage.

Source of Data

Geospatial data was retrieved online from the City of Vancouver's Open Data Catalogue. Specifically, the *Cultural Spaces* and *Heritage Property* spreadsheets were downloaded.

Data Description

The *Cultural Spaces* data provides current information on cultural places across the City of Vancouver. Each place is classified as a specific type of cultural space, including museum/gallery, studio/rehearsal, community space, educational, theatre/performance, and café/restaurant/bar. Coordinates are provided for each cultural space, enabling a geospatial analysis to be conducted. The data reflects the current cultural spaces located in the city; however, will continue to be updated annually by the City of Vancouver (City of Vancouver, 2015d).

The *Heritage Property* data provides current information on the heritage properties across the City of Vancouver. Attributes reported for each heritage property include the address, building name, VHR (evaluation category on Heritage Registry), designation, name of zoning district, and the local planning area. Coordinates are provided for each heritage space, enabling a geospatial analysis to be conducted. The data reflects the current heritage properties in the City of Vancouver; however, the City of Vancouver will continue to update the data regularly.

Recommendations on Indicator Development

The data provided could be analyzed geospatially to determine the number of cultural and heritage spaces located on the city's waterfront. Since the type of cultural space is also provided, each type of cultural space could be monitored or selected types could be solely focused on.

2.2.9 Number of Marinas and Slips

Why Monitor the Number of Marinas and Slips?

Marinas are vital in waterfront cities where many boaters like to keep their boats in the water for long periods of time or even year-round. However, with limited waterfront space, obtaining a marina slip can be both competitive and expensive. In fact, to obtain a preferred moorage slip, it is currently not uncommon to wait one to five years (Singso, 2014). Monitoring the number of marinas and slips can reflect the availability of space for boaters to store their boats on the waterfront and whether the available space is changing over time.

Source of Data

The data is presented in a study prepared by Harald Singso for Valiance Maritime Consultants Limited (Singso, 2014). The report can be requested from Valiance Maritime Consultants Limited.

Data Description

The number of marinas in English Bay (including False Creek) and Coal Harbour are reported and mapped. The number of estimated slips in each marina is also reported. This data was collected in 2014 through desktop research, observations, and interviews and therefore, is only reflective of the conditions at this time.

Recommendations on Indicator Development

The study presented provides a baseline for marinas and slips in the city. However, for this to be an indicator, the data would need to be collected periodically throughout the future in order to monitor temporal changes. Therefore, before moving forward with this indicator, it should be determined whether the Waterfront Initiative or another source will be capable of collecting this data in the future.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Transportation on the Waterfront.

2.2.10 Number of Yacht and Boat Clubs

Why Monitor the Number of Yacht and Boat Clubs?

Yacht and boat clubs are types of sports clubs specifically related to the waterfront. They are located on the waterfront, their members engage in waterfront activities, and they often host events on the waterfront. Club members can enjoy a suite of benefits including access to equipment, facilities and social engagements. Yacht and boat clubs are a great way to be involved with waterfront activities and also to socialize with others who are interested in waterfront recreation.

Source of Data

The data is presented in a study prepared by Harald Singso for Valiance Maritime Consultants Limited (Singso, 2014). The report can be requested from Valiance Maritime Consultants Limited.

Data Description

The yacht and boat clubs located in English Bay (including False Creek) and Coal Harbour in 2014 are identified and mapped. The number of members and slips and a description of the facilities are presented for some, but not all clubs. This data was collected through desktop research, observations, and interviews.

Recommendations on Indicator Development

The study presented provides baseline information on the number of yacht and boat clubs in the city. However, for this to be an indicator, the data would need to be collected periodically throughout the future in order to monitor temporal changes. Therefore, before moving forward with this indicator, it should be determined whether the Waterfront Initiative or another source will be capable of collecting this data in the future.

2.2.11 Number of Waterfront Rental Facilities

Why Monitor the Number of Waterfront Rental Facilities?

For those looking to try a new waterfront activity, those who do not own equipment, and those visiting from out of town, rental facilities provide the equipment necessary for various waterfront activities. The number and locations of waterfront rental facilities can provide an indication of the accessibility of these facilities to the public.

Source of Data

The data is presented in a study prepared by Harald Singso for Valiance Maritime Consultants Limited (Singso, 2014). The report can be requested from Valiance Maritime Consultants Limited.

Data Description

Rental companies located on or near the waterfront in Vancouver are listed and mapped. Lessons offered by each rental company and their available rental equipment are also described. This information was collected in 2014 by desktop research, observations, and interviews.

Recommendations on Indicator Development

The study presented provides baseline information on the number and location of rental facilities in the city. However, for this to be an indicator, the data would need to be collected periodically throughout the future in order to monitor temporal changes. Therefore, before moving forward with this indicator, it should be determined whether the Waterfront Initiative or another source will be capable of collecting this data in the future.

2.2.12 Recreational Fishing Effort

Why Monitor Recreational Fishing Effort?

Source of Data

Fisheries and Oceans Canada (DFO) reports annual summaries of recreational fishing catch and effort. This data is publicly available on the DFO Pacific Region website (www.pac.dfo-mpo.gc.ca). Every five years, DFO also publishes the Survey of Recreational Fishing in Canada.

Data Description

Recreational fishing effort data, reported as number of recreational fishing boat trips, is available from 1982 to the present. Similarly, recreational catch statistics are available for the same time period for Chinook, Coho, Pink, Sockeye, Chum, Rockfish, and Lingcod. Groundfish and Halibut catch statistics are also presented from the late 1990s to the present. Both effort and catch statistics are presented by DFO statistical area. The statistical areas surrounding Vancouver are Areas 28 and 29, which encompass the Lower Mainland and Sunshine Coast. Therefore, this data is not specific to the city's waterfront.

The Survey of Recreational Fishing in Canada provides data on the number of active resident anglers in Canada by jurisdiction, participation rate, total fish harvest, and fish

retained. However, the smallest geographic scale for which this data is available is the province of British Columbia, which is segregated into freshwater and marine fisheries.

Recommendations on Indicator Development

To develop this indicator, data should be collected and compiled from DFO. Prior to completing subsequent indicator reports, DFO should be contacted in order to collect data for the years since the previous indicator report. Furthermore, the DFO online library should be accessed in order to download the most recent Survey of Recreational Fishing in Canada.

2.2.13 Number and Area of Restored/Rewilded Waterfront Spaces

Why Monitor the Number and Area of Restored/Rewilded Waterfront Spaces?

Humans have been impacting Vancouver's waterfront for centuries. We have built up the majority of the waterfront to make it more accessible and serve our needs and as a result, ecosystems have suffered and the way we experience nature in the city has been altered. Recent discussions by the Waterfront Network have suggested the importance of having rewilded spaces on the waterfront, where ecosystems can flourish and people can only observe from a distance. Rewilded and restored waterfront spaces not only provide productive habitat for fish and wildlife, they create new opportunities for people to experience nature.

Source of Data

At the present time, there is no one data source that explicitly outlines rewilded and/or restored spaces on the waterfront. However, since rewilding and restoration projects are always advertised to the public, with some desktop research and interviews with those who have jurisdiction of the waterfront, it would be straightforward to identify what projects have been completed or are underway. The City of Vancouver, Vancouver Park Board, BC Ministry of the Environment (BC MOE), and PMV would all be sources to consult with.

Data Description

Since no specific data source has been identified, no data description is available.

Recommendations on Indicator Development

As previously mentioned, with no specific data source available, the team or individual responsible for preparing the indicator report would need to conduct some desktop research and to consult with the various institutions with jurisdiction over Vancouver's waterfront for information on any projects. The indicator could focus on the number of waterfront spaces that have been restored/rewilded, the total waterfront area or length that has been restored/rewilded, and/or simply the description and other qualitative information about the new waterfront space.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Flourishing Ecosystems on the Waterfront, and
- Climate Change on the Waterfront.

2.2.14 Number of Public Washrooms and Water Fountains

Why Monitor the Number of Public Washrooms and Water Fountains?

Thinking about spending a day around the waterfront? You may be concerned with finding places to go to the washroom and fill up your water bottle. Monitoring the number and locations of public washrooms and water fountains provides an indication of the availability of these necessities on the waterfront.

Source of Data

Geospatial data was retrieved from the City of Vancouver's Open Data Catalogue. The specific data packages downloaded were the *drinking fountains package* and the *public places package*.

Data Description

The geospatial datasets provide the locations of water fountains and public washroom in the City of Vancouver. The data represents the present conditions and is updated regularly in the normal course of business (often weekly).

Recommendations on Indicator Development

The data provided could be analyzed geospatially to investigate the number and locations of public washrooms and water fountains on the waterfront. The analysis could also compare the accessibility of washrooms at water fountains along different parts of the waterfront (ie. Burrard Inlet, English Bay, False Creek, and the Fraser River).

2.2.15 First Nations' Fisheries Catch

Why Monitor First Nations' Fisheries Catch

Fishing is an integral part of First Nations' culture. Moreover, First Nations' people have constitutionally protected rights to fish for food, social, and ceremonial purposes, unless superseded by conservation (Garner and Parfitt, 2006). This potential indicator reflects the accessibility of nature on the waterfront to First Nations' people. Furthermore, since conservation can supersede the right to fish, this indicator can also indicate the health of fish species and the ecosystem as whole.

Source of Data

Data is provided by DFO and can be accessed here on the DFO Pacific Region website (www.pac.dfo-mpo.gc.ca).

Data Description

DFO provides first nations' fisheries catch data for the Lower Fraser River. Data is available annually, from 2004 to the present, and reports the total First Nations' salmon catch, by band, from Sawmill Creek to Vancouver. The region reported, most relevant to Vancouver's waterfront, would be the region below the Port Mann Bridge. Catch data is available for Chinook, Sockeye, Chum, Coho, Pink, and Steelhead salmon.

Recommendations on Indicator Development

Total First Nations' fisheries catch data could be plotted over time, by species, to identify any temporal trends.

2.2.16 Suggested Indicators with Insufficient Supporting Data

The Waterfront Network has suggested the following other potential indicators for this theme, which are not detailed here due to an absence of sufficient supporting data:

1. *Car Parking Availability*

There are a few data sources available relating to car parking availability on the waterfront; however, relying on them may be misleading because they do not enable a complete assessment of parking availability. Existing datasets include geospatial data for designated disability parking, motorcycle parking, parking meters, pay parking lots, and car share locations. These data sources are available through the City of Vancouver's Open Data Catalogue and VanMap. Yet, data on free parking near the waterfront is not available. Since free parking is available at a number of locations, for instance Riverfront Park and Locarno Beach, monitoring parking without the free parking spots would not be complete.

2. *Waterfront Awareness and Educational Opportunities*

To the best of our knowledge, no data is available regarding waterfront awareness or educational opportunities in the City of Vancouver.

3. *Recreational Waterfront Use*

The Vancouver Waterfront Survey (2014), conducted by the City of Vancouver, surveyed waterfront users, including whether they were locals or tourists, the amount of time spent on the waterfront during each visit, and the preferred use of waterfront amenities. The Vancouver Waterfront Survey, however, is unpublished and according to City employees, data will not be released at least until the National Energy Board

hearings are concluded. For now, this has been included as a data gap, since we are unsure when the data will be released and exactly what the survey results include.

2.3 Living on the Waterfront

Living on the waterfront has always been sought after as it often comes along with scenic views and quick access to the water. However, with limited space on the waterfront, and increasing competition between waterfront users, residential properties are often hard to come by. Waterfront Forum participants have emphasized the necessity of preserving or increasing residential space on the waterfront as pressure on the land increases (GSA, 2015).

As pressure on waterfront land increases, the prices of residential waterfront properties will likely continue to escalate, beyond the reach of many community members. It is important that residential lands be managed well in order to maximize space and provide accommodation opportunities within the reach of community members. For instance, veering away from single-use development and toward mixed-use development enables various uses to be incorporated into one space. The identification of the following data sources and the potential indicators supported, will provide a better understanding of the current state of living on the waterfront in Vancouver and a means of assessing changes over time.

Table 4. Data sources and potential indicators for Living on the Waterfront.

Theme	Potential Indicator	Data Source
Living on the Waterfront	Zoned Residential Land	City of Vancouver
	Housing Costs	Statistics Canada (Census and NHS)
	Number and Type of Waterfront Units	Statistics Canada (Census)
	Number and Type of Affordable Housing Units	City of Vancouver
	Housing Tenure	Statistics Canada (Census and NHS)
	Number and Type of Housing Starts	Canada Mortgage and Housing Corporation
	Rental Unit Availability Rate	Canada Mortgage and Housing Corporation
	Housing Occupant Demographic	Statistics Canada (Census and NHS)
	Green Building Policies and Incentives	City of Vancouver
	Crime Rate	City of Vancouver
	Proportion of Occupant's Income Spent on Housing	Statistics Canada (Census and NHS)

	Access to Amenities	WalkScore; City of Vancouver
	Commuting Duration and Mode of Transportation	Statistics Canada (Census and NHS)

2.3.1 Zoned Residential Land (area or length bordering the waterfront)

Why Monitor Zoned Residential Land?

The City of Vancouver is divided into many zoning districts – each defined with specific development purposes. Zoning is not set in stone, and districts can be re-zoned for various reasons, including to make the city more livable. With competition occurring for residential, recreational, commercial, and industrial waterfront land, zoning provides an indication of the amount of land allotted for residential use.

Source of Data

Geospatial data was retrieved from the City of Vancouver's Open Data Catalogue. The specific data package downloaded was the *zoning data package*.

Data Description

The *zoning data package* provides a layer detailing zoning regions across the City of Vancouver. The City of Vancouver states that this information is updated frequently in the normal course of business (City of Vancouver, 2015e).

Recommendations on Indicator Development

Although the zoning data is not specific to the waterfront, the length of zoned residential land adjacent to the waterfront could be calculated using GIS. Since the City of Vancouver updates the *zoning data package* regularly, this geospatial analysis could be conducted annually or every couple of years to monitor changes in allotted residential waterfront land.

2.3.2 Housing Costs

Why Monitor Housing Costs?

With a high demand for waterfront homes, housing prices can skyrocket. Monitoring housing costs on the waterfront can enable a temporal comparison of the price of living on the waterfront as well as a spatial comparison relative to other geographic areas. In addition, monitoring housing costs enables comparisons to be made between housing tenures.

Source of Data

Dwelling value and monthly shelter costs data for dissemination areas in the City of Vancouver was requested and retrieved from Statistics Canada. Specifically, this data comes from the Census and National Household Survey (NHS). Data from the NHS and the Census is available to the public on the Statistics Canada website (www.statcan.gc.ca/start-debut-eng.html); however, dissemination area data must be requested from Statistics Canada.

Data Description

Statistics Canada collected dwelling value and monthly shelter cost data as part of the mandatory Census, conducted every five years, from 1961 to 2006. However, in 2011, changes were made to the Census, involving certain questions, including the *value of dwelling* and *monthly shelter cost* questions, being transferred to the voluntary NHS from 2011 onward. Like the Census, the NHS is conducted every five years.

Value of dwelling refers to the dollar amount expected by the owner if the dwelling were to be sold and it considers the entire dwelling, including the land it is on and any other structure located on the property (ie. garage) (Statistics Canada, 2011b). Dwelling value data, for both the Census and NHS, is available at the dissemination area scale, which is defined as a small, relatively stable geographic unit with a population of 400 to 700 persons. Dissemination areas are the smallest standard geographic area for which all Census and NHS data are disseminated.

The average monthly shelter costs for owned dwellings are defined as the total of all shelter expenses paid by households that own their dwellings (Statistics Canada, 2011b). Total shelter expenses for owners include, where applicable, the mortgage payment, costs of electricity, heat, water, and other municipal services, property taxes, and condominium fees. The average monthly shelter costs for rental dwellings are defined as the average monthly total of all shelter expenses, paid by households that rent their dwelling. Total shelter expenses for renters include the monthly rent and costs of electricity heat, water, and other municipal services.

Note: The new federal leadership, elected in 2015, has stated that the NHS will be eliminated and the Census reinstated by 2016.

Recommendations on Indicator Development

The geospatial data provided by the Census and NHS could be analyzed to determine the average dwelling value and monthly shelter cost in only the dissemination areas adjacent to the waterfront. Based on the average values for each waterfront dissemination area, an average dwelling and monthly shelter cost value could be calculated across all waterfront dissemination areas. Furthermore, the average dwelling and monthly shelter cost values for specific segments of the waterfront (ie. Burrard Inlet, English Bay, False Creek, Fraser River) could also be calculated.

2.3.3 Number and Type of Waterfront Units

Why Monitor the Number and Type of Waterfront Units?

With pressure on waterfront land increasing, in addition to understanding the amount of land allotted for residential use, it is important to know the quantity and types of residential units available. The quantity of waterfront units reflects the availability of waterfront housing in the City of Vancouver.

Source of Data

Data was requested and retrieved from Statistics Canada's Census. Data from the Census is available to the public; however, dissemination area data has to be requested from Statistics Canada.

Data Description

Statistics Canada collects data on the total number and type of private dwellings located in Vancouver, every five years (from 1961 to 2011), as part of the Census. A private dwelling is defined as "a separate set of living quarters converted for human habitation in which a person or group of persons reside or could reside" and "must have a source of heat or power and must be an enclosed space that provides shelter from the elements" (Statistics Canada, 2011c).

For each private dwelling recorded, the type of dwelling is also determined. Dwelling types include single-detached house, apartment (five or more stories), movable dwelling, and other dwellings. The other dwelling category includes semi-detached houses, row houses, apartments in a duplex, apartments in a building that has fewer than five storeys, and other single-attached houses. Private dwelling data is available at the dissemination area scale, which is defined as a small, relatively stable geographic unit with a population of 400 to 700 persons. Dissemination areas are the smallest standard geographic area for which all Census data are disseminated.

Recommendations on Indicator Development

The geospatial data provided by the Census could be analyzed to determine the number and type (ie. single detached house, apartment, etc.) of residential units in the dissemination areas adjacent to the waterfront. Based on the number of units available for each waterfront dissemination area, the total number of units could be calculated across all waterfront dissemination areas. Furthermore, the number of residential units on specific segments of the waterfront (ie. Burrard Inlet, English Bay, False Creek, Fraser River) could also be calculated.

2.3.4 Number and Type of Affordable Housing Units

Why Monitor the Number and Type of Affordable Housing Units?

In Vancouver, non-market rental housing is available for residents who are unable to pay market-level rents. Non-market rental housing is categorized under affordable housing and is meant for households whose needs cannot be met by the marketplace (CMHC, 2015). In general, those eligible for non-market housing have incomes below certain limits (MNGH, 2015). Quantifying the number of non-market housing units available on Vancouver's waterfront would provide an indication of the opportunities available for low-income earners to live on the waterfront.

Source of Data

Geospatial data was retrieved from the City of Vancouver's Open Data Catalogue. The data package downloaded was the *Non-Market Housing package*. The same data can also be accessed through the City of Vancouver's online non-market housing inventory at http://app.vancouver.ca/NonMarketHousing_Net/default.aspx).

Data Description

The City of Vancouver keeps a complete inventory of all non-market housing properties, including those owned by the City of Vancouver and by other agencies. The data provides details about available non-market housing units, including the street address, the number of units available at each specific address, and the types of units available. The City of Vancouver states that the data is updated frequently in the normal course of business (City of Vancouver, 2015f).

Recommendations on Indicator Development

With the *Non-Market Housing package*, it is possible to determine how many non-market housing units are available on each waterfront body (ie. Burrard Inlet, English Bay, False Creek, and the Fraser River). Moreover, the number and type (bachelor, 1-bedroom, 2-bedroom, etc.) of non-market rental units located along the waterfront could be determined. As the City of Vancouver updates this data source regularly, a geospatial analysis could be conducted at a specified time interval.

2.3.5 Housing Tenure

Why Monitor Housing Tenure?

Housing tenure refers to the arrangements under which the household occupies a housing unit (ie. renting or owning). Monitoring housing tenure can provide an overview of the share of different tenure statuses among waterfront dwellers in the City of Vancouver.

Source of Data

Data were requested and retrieved from Statistics Canada's Census and NHS. Data from the Census and NHS are available to the public; however, dissemination area data has to be requested from Statistics Canada.

Data Description

The Statistics Canada Census collects housing tenure data for dwellings located in the City of Vancouver every five years (from 1981 to 2006). However, in 2011, the question was transferred to the NHS and will be monitored by the NHS in future years. Under both the Census and NHS, housing tenure is classified as rented or owned. Dwelling tenure data are available at the dissemination area scale, which is defined as a small, relatively stable geographic unit with a population of 400 to 700 persons. Dissemination areas are the smallest standard geographic area for which all Census data are disseminated.

Note: The new federal leadership, elected in 2015, has stated that the NHS will be eliminated and the Census reinstated by 2016.

Recommendations on Indicator Development

The geospatial data provided by the Census and NHS could be analyzed to determine the different tenure statuses in the dissemination areas adjacent to the waterfront. Based on the number of renters and owners in each waterfront dissemination area, the total number of renters and owners could be calculated across all waterfront dissemination areas. Furthermore, the number of renters and owners could be calculated for specific segments of the waterfront (ie. Burrard Inlet, English Bay, False Creek, Fraser River).

2.3.6 Number and Type of Housing Starts

Why Monitor the Number and Type of Housing Starts?

Residential space on Vancouver's waterfront is limited and with an additional million people projected to move to Metro Vancouver by 2040, competition for waterfront housing will likely escalate. Housing starts reflect the number of new housing units on which construction has been started and can be a sign of investment and new housing being created in Vancouver.

Source of Data

Canada Mortgage and Housing Corporation (CMHC) conducts monthly surveys on housing starts in Vancouver. This data can be accessed online through the CMHC Housing Market Information Portal at https://www03.cmhc-schl.gc.ca/hmiportal/en/.

Data Description

Housing start data is available for every month of the year. The 2014 and 2015 data is accessible from the Housing Market Information Portal, but data for prior years needs to be requested from CMHC. The total number of housing starts is reported by dwelling type (single, semi-detached, row, and apartment). The smallest geographic scale for which the data is available is the census tract division. Census tracts intersecting with the waterfront can be isolated and focused on.

Recommendations on Indicator Development

To move forward with the development of this indicator, data should be compiled for each waterfront census tract and continue to be compiled as new data are released. Since some tracts are larger than others, comparisons between different parts of the waterfront will not easily be made. Therefore, housing starts for all census tracts adjacent to the waterfront should be combined and focused on as a whole.

2.3.7 Rental Unit Availability Rate (by dwelling type)

Why Monitor Rental Unit Availability Rate?

In today's expensive housing market, many people are opting to continue renting instead of buying a home. However, finding a unit to rent, especially one on the waterfront, is also not an easy task, given the limited number of available rental units. Monitoring rental unit availability can reflect the demand for waterfront rental units.

Source of Data

CMHC conducts rental market surveys in Vancouver every year in April and October. This data can be accessed online through the CMHC Housing Market Information Portal at https://www03.cmhc-schl.gc.ca/hmiportal/en/.

Data Description

Availability and vacancy rates are reported by CMHC each year for the months of April and October. According to CMHC (2015), "a rental unit is considered available if the existing tenant has given, or has received, notice to move, and a new tenant has not signed a lease; or the unit is vacant." Whereas, according to CMHC (2015), "a unit is considered vacant if, at the time of the survey, it is physically unoccupied and available for immediate rental." Available and vacant units are further categorized as a bachelor, 1-bedroom, 2-bedroom, or 3-bedroom suites. Data is available at the census tract division scale. Therefore, census tracts intersecting with the waterfront can be isolated and focused on.

Recommendations on Indicator Development

To develop this indicator, data should be compiled from the CMHC Housing Market Information Portal and continue to be compiled as additional data is released. Furthermore, it should be determined whether both availability and vacancy rates will be focused on, or only one or the other. Since the data is available and easily accessible, it would not take much additional effort to focus on both availability and vacancy rates.

2.3.8 Housing Occupant Demographic

Why Monitor Housing Occupant Demographic?

Demographic monitoring of waterfront housing occupants is a way to investigate who is living on the waterfront and how this compares with other locations. For instance, demographic data enables an investigation of the age, income, education, profession, gender, ethnicity, and marital status of occupants.

Source of Data

Data were requested and retrieved from Statistics Canada's Census and NHS. Data from the Census and NHS are available to the public; however, dissemination area data has to be requested from Statistics Canada.

Data Description

The Statistics Canada Census collects occupant demographic data for the population of the City of Vancouver every five years. However, in 2011 many questions were transferred to the NHS. The Census and NHS have many questions relating to age, marital status, family size, mother tongue, official language knowledge, citizenship, immigrant status, place of birth, sex, ethnic origins, religious affiliation, level of education, field of study, occupation, employment status, income, proportion of income spent on housing, and a variety of other topics. Please refer to Statistics Canada's Census Program webpage for detailed information on the many questions asked (http://www12.statcan.gc.ca/census-recensement/index-eng.cfm?HPA).

Demographic data for Vancouver are available at the dissemination area scale, which is defined as a small, relatively stable geographic unit with a population of 400 to 700 persons. Dissemination areas are the smallest standard geographic area for which all Census data are disseminated.

Note: The new federal leadership, elected in 2015, has stated that the NHS will be eliminated and the Census reinstated by 2016.

Recommendations on Indicator Development

The geospatial data provided by the Census and NHS could be analyzed to investigate the occupant demographic in the dissemination areas adjacent to the waterfront. As

there are many questions in the Census and NHS, specific areas should be identified and focused on (ie. level of education, income, marital status, etc.). Furthermore, the demographic for specific segments of the waterfront could be investigated (ie. Burrard Inlet, English Bay, False Creek, Fraser River).

2.3.9 Green Building Policies and Incentives

Why Monitor Green Building Policies and Incentives?

In Canada, residential properties are responsible for a large portion of overall energy use and greenhouse gas emissions. As part of the City's Greenest City Action Plan, the City is working to reduce the amount of energy consumed by new homes 33% by 2020 and also to reduce greenhouse gas emissions from existing buildings by 20% over 2007 levels (City of Vancouver, 2015g). To meet these targets, the City of Vancouver is implementing a variety of incentives, green building programs and policies. The availability of incentives and green building programs reflects the opportunities and guidance available to assist Vancouverites with building green homes. Furthermore, green home building policies reflect all the green building requirements that must be complied with when building or renovating residential property in Vancouver and can indicate a variety of environmental benefits.

Source of Data

The City of Vancouver maintains updated information on green building policies and incentives. This information can be accessed on the City of Vancouver website (www.vancouver.ca) or requested by contacting Building and Development Services at the City of Vancouver.

Data Description

The City of Vancouver Zoning and Development Bylaw regulates residential property development in Vancouver. Therefore, green building policies that must be complied with for residential properties are explained in the bylaw, which can be accessed here. The City of Vancouver also advertises and describes all the incentives that are available to help offset the cost of making your home energy efficient.

Recommendations on Indicator Development

Both qualitative and quantitative data should be presented to support this indicator in order to highlight the potentially different magnitudes of individual policies and incentives. For instance, the number of green building policies and incentives that exist and the scope of each policy and incentive should be highlighted.

Additionally, prior to preparing indicator reports, the City of Vancouver should be consulted about any changes that have been made to green building policies. Similarly, an inquiry should be made with the City about all incentives that are available for green building and renovating.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Flourishing Ecosystems on the Waterfront, and
- Climate Change on the Waterfront.

2.3.10 Crime Rate

Why Monitor Crime Rate?

Crime is an issue that many people consider when deciding where to live in a city. Monitoring crime in waterfront neighbourhoods provides an indication of the quality of life for those living in these areas and also reflects whether the frequency of criminal acts is changing.

Source of Data

Geospatial data was retrieved online from the City of Vancouver's Open Data Catalogue. Specifically, the *Crime* spreadsheet was downloaded.

Data Description

The City of Vancouver maintains geospatial data for crime in Vancouver, which is provided to them by the Vancouver Police Department. Attributes of the geospatial dataset include the type of criminal activity, the date the crime took place, and the location and the coordinates of the crime. The types of criminal activities listed include commercial break and enter, residential break and enter, homicide, mischief, offence against a person, theft from vehicle, and other theft. The locations, however, of homicides and offences against a person are deliberately offset several blocks and to an intersection to provide privacy protection. This dataset is updated weekly, and is available from 2003 to the present.

Recommendations on Indicator Development

The data provided could be analyzed geospatially to investigate crime frequency and severity in waterfront neighbourhoods or within a certain distance from the shoreline. The analysis could also divide the waterfront into specific geographic categories to compare crime along different parts of the waterfront (ie. Burrard Inlet, English Bay, False Creek, and the Fraser River).

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Access to Nature on the Waterfront.

2.3.11 Proportion of Occupant's Income Spent on Housing

Why Monitor the Proportion of Occupant's Income Spent on Housing?

An ability to meet basic needs, including the need for housing, is an issue often associated with quality of life. CMHC estimates that spending 30% or less of household income on housing is affordable and will enable you to meet all other basic needs, thereby improving quality of life for the household. Monitoring the proportion of household income spent on housing is reflective of the quality and affordability of life for those living in waterfront neighbourhoods. In addition, it allows comparisons to be made with other areas of the city, as well as between housing tenures.

Source of Data

Data were requested and retrieved from Statistics Canada's Census and NHS. Data from the Census and NHS are available to the public; however, dissemination area data has to be requested from Statistics Canada.

Data Description

The Statistics Canada Census collects housing affordability data for the population of the City of Vancouver every five years. However, in 2011, many questions were transferred to the NHS. Until 2006, the Census collected and reported data on the percentage of the population spending greater than 30% of their income on shelter costs. Starting in 2011, however, the NHS began to collect and report this data instead of the Census.

Data for Vancouver are available at the dissemination area scale, which is defined as a small, relatively stable geographic unit with a population of 400 to 700 persons. Dissemination areas are the smallest standard geographic area for which all Census data are disseminated.

Note: The new federal leadership, elected in 2015, has stated that the NHS will be eliminated and the Census reinstated by 2016.

Recommendations on Indicator Development

The geospatial data provided by the Census and NHS could be analyzed to investigate the percentage of households, in the dissemination areas adjacent to the waterfront, spending greater than 30% of their income. Furthermore, the data analysis could involve investigating the proportion of household income spent on shelter costs by specific segments of the waterfront (ie. Burrard Inlet, English Bay, False Creek, Fraser River).

2.3.12 Access to Amenities

Why Monitor Access to Amenities?

Healthcare, recreational spaces, fitness centers, entertainment options, childcare facilities, and retail and other services are all amenities that people rely on. An ability to access these amenities in your own neighbourhood can enhance quality of life and livability by reducing dependency on vehicles and time spent in the car, improving social interactions with others in the community, and by increasing opportunities for physical activity.

Source of Data

Location of Amenities

Data was downloaded from the City of Vancouver's Open Data Catalogue. Specifically the *Bikeways, Greenways, Business Licenses, Community Centers, Community Food Markets and Farmer's Markets, Community Garden and Food Trees, Cultural Spaces, Parks, Off-Lease Dog Parks, and Schools* data packages were downloaded.

Walkability of Amenities

Data on walkability to services in Vancouver is provided by WalkScore and can be accessed on the WalkScore website (www.walkscore.com).

Data Description

Location of Amenities

The City of Vancouver's Open Data Catalogue provides data on the location of many amenities in the city including bikeways and greenways, businesses, community centers, community food markets and farmer's markets, community garden and food trees, cultural spaces, parks (including off-leash dog parks), and schools. All data packages provide the locations of the amenity across Vancouver.

Walkability to Amenities

WalkScore presents walkability data spatially through a map of Vancouver detailing Walk Scores for every part of the city. A Walk Score is a number between 0 and 100 and measures the walkability of any address. WalkScore analyzes walking routes to nearby amenities and awards points based on the distance to amenities in each category. Categories include dining and drinking, groceries, shopping, errands, parks, schools, and culture and entertainment. Scores represent the following walkabilities:

Walk Score	Walkability
90 - 100	**Walker's Paradise** Daily errands do not require a car
70 - 89	**Very Walkable** Most errands can be accomplished on foot
50 - 69	**Somewhat Walkable** Some errands can be accomplished on foot
25 - 49	**Car-Dependent** Most errands require a car
0 - 24	**Car-Dependent** Almost all errands require a car

Data Source: WalkScore, 2015

Similar to Walk Scores, Bike Scores and Transit Scores are also reported for every address in Vancouver using similar measurement schemes for biking and transit accessibility.

Recommendations on Indicator Development

Both sources of data could be used to monitor this indicator, as the sources nicely compliment one another. Walk Scores could be assigned to each waterfront neighbourhood and each neighbourhood could also be analyzed to specifically assess what amenities are available.

2.3.13 Commuting Duration and Mode of Transportation

Why Monitor Commuting Duration and Mode of Transportation?

Monitoring commuting duration and mode of transportation indicates whether waterfront dwellers are living close to their place of employment and how they choose to get to work – both of which have implications for GHG emissions.

Source of Data

Data were requested and retrieved from Statistics Canada's Census and NHS. Data from the Census and NHS are available to the public; however, dissemination area data has to be requested from Statistics Canada.

Data Description

The Statistics Canada Census collects data on commuting duration and mode of transportation for the population of the City of Vancouver every five years. However, in 2011, many questions were transferred to the NHS. The data are available at the dissemination area scale, which is defined as a small, relatively stable geographic unit with a population of 400 to 700 persons. Dissemination areas are the smallest standard geographic area for which all Census data are disseminated.

Note: The new federal leadership, elected in 2015, has stated that the NHS will be eliminated and the Census reinstated by 2016.

Recommendations on Indicator Development

The geospatial data provided by the Census and NHS could be analyzed to investigate the method of transportation people living on the waterfront choose to get to work as well as how long they spend getting to work. Furthermore, the data analysis could involve investigating commuting duration and mode of transportation by specific segments of the waterfront (ie. Burrard Inlet, English Bay, False Creek, Fraser River).

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Flourishing Ecosystems on the Waterfront, and
- Climate Change on the Waterfront.

2.3.14 Suggested Indicators with Insufficient Supporting Data

The Waterfront Network has suggested the following other potential indicators for this theme, which are not detailed here due to an absence of sufficient supporting data:

1. Vacant Waterfront Units

Recently, a couple of studies have been completed investigating vacant housing in Vancouver. These studies, however, have either looked at the entire City of Vancouver (Urban Futures Institute, 2013) or specific areas only (BTAworks, 2009). Methods have included analyzing Census data (Urban Futures Institute, 2013) and data from BC Hydro (BTAworks, 2009).

The City of Vancouver is currently investigating vacant housing in Vancouver. They have hired a consultant to analyze BC Hydro and Census data in order to estimate the current number of vacant housing units in Vancouver. Once the results are released (expected 2016), it can be determined whether the information could support a vacant housing on the waterfront indicator.

2. Housing Condition

To the best of our knowledge, data to support housing condition indicators (ie. dwellings in need of major repairs, overcrowded housing, etc.) is not available for the city's waterfront.

2.4 Working on the Waterfront

Waterfront and maritime industries are integral to Vancouver's well being. The city's waterfront provides jobs and offers a broad range of economic opportunities close to where people live. Industries range from container traffic and cruise ships to log-operations on the Fraser River or recreational boating and tourism. However, due to competition for land by various users, and a limited land base, industrial land on Vancouver's waterfront is under significant pressure to be converted to alternative uses with a higher land value. If industrial lands are not protected, job growth could slow and businesses could become discouraged to locate in the city.

The identification of the following data sources and the potential indicators supported, will provide a better understanding of the current state of working on the waterfront in Vancouver and a means of assessing changes over time.

Table 5. Data sources and potential indicators for Working on the Waterfront.

Theme	Potential Indicator	Data Source
Working on the Waterfront	Industrial, Agricultural, and Commercial Waterfront Land	Metro Vancouver; City of Vancouver
	Economic Contribution of PMV	Port Metro Vancouver
	Economic Contribution of Ocean Sector	UBC Fisheries Centre
	Number and Type of Waterfront Businesses	City of Vancouver
	Authorized Industrial Effluent Discharges	BC Ministry of the Environment; BIEAP
	Oil Spill Response Capacity and Preparedness (Marine and Riverine)	Nuka Research and Planning Group; Western Canada Marine Response Corporation
	Rental Rates of Industrial Lands and Office Space	Colliers International
	Vacancy Rates of Industrial Lands and Office Space	Colliers International
	Net Absorption of Industrial Lands and Offices on the Market	Colliers International
	Number, Type, and Annual Capacity of Timber Processing Facilities	BC Ministry of Forests, Lands, and Natural Resource Operations
	Number and Type of Aquaculture Facilities	Fisheries and Oceans Canada
	Number of Commercial	Fisheries and Oceans

	Fishing Licenses (by fishery)	Canada
	Number and Type of Recreational Marine Operators and Charters	Valiance Maritime Consultants Limited
	Educational Opportunities Available to the Public to Learn about Industrial Activities and History	Port Metro Vancouver
	Number of Coast Guard Stations	Government of Canada Canadian Coast Guard – Western Region

2.4.1 Industrial, Agricultural, and Commercial Waterfront Land (length or area bordering the waterfront)

Why Monitor Industrial, Agricultural, and Commercial Waterfront Land?

As competition for space on the waterfront for various uses increases, the pressure on existing lands becomes greater. Monitoring the amount of industrial, agricultural, and commercial waterfront land provides an indication of whether space for these sectors on the waterfront is increasing or decreasing.

Source of Data

Industrial, Agricultural, and Commercial Land Use

Geospatial land use data is available from Metro Vancouver's Open Data Catalogue (www.metrovancouver.org/data). Specifically, the *Land Use* dataset should be downloaded.

Industrial land use data from completed land use analyses are available from Metro Vancouver through the Industrial Lands Inventory Studies. The studies are publicly available and can be retrieved from the Metro Vancouver website (www.metrovancouver.org).

Zoned Industrial, Agricultural, and Commercial Land

Geospatial zoning data is available from the City of Vancouver's Open Data Catalogue. The specific data package to be downloaded is the *zoning data* package.

Data Description

Industrial, Agricultural, and Commercial Land Use

Metro Vancouver provides geospatial land use data for the entire Metro Vancouver region. Land uses are classified into a variety of categories, including agricultural,

commercial, industrial (and extractive industrial), residential, recreational, mixed residential, and undeveloped. The available geospatial data represents land uses in Metro Vancouver in 2015; however, the dataset is regularly updated by Metro Vancouver.

Additionally, Metro Vancouver conducted an Industrial Lands Inventory Study in 2005 and five years later in 2010 (Metro Vancouver, 2011; 2006). The studies estimate how much land is allocated for industrial use in Metro Vancouver, and specifically for each municipality, using a GIS-based parcel inventory. The studies consider industrial lands throughout the entire City of Vancouver and do not determine how much industrial land is specifically located on the waterfront. Furthermore, the studies outline how much of the allocated industrial land was being utilized for industrial activities and how much was vacant (Metro Vancouver, 2011). Industrial lands were identified as developed or vacant using a GIS parcel overlay with aerial orthophotos.

The following definitions were used to define industrial, developed industrial, and vacant industrial land (Metro Vancouver, 2011):

Industrial Land: Land designated by municipal Official Community Plans for industrial uses, or land zoned and utilized for industrial uses, such as processing, manufacturing, assembling, storage, transportation of goods or other industrial related uses.

Developed Industrial Land: Industrial land that is wholly or partially utilized for industrial related uses, which includes properties used for outdoor storage. A property is considered utilized when it has been cleared and worked with footings in place or if there is discernable (outdoor) storage on the site. This also includes office, retail, or institutional uses that are allowed within municipal industrial zones. Although these properties are classified as developed, they may be only partially utilized and have additional development capacity.

Vacant Industrial Land: Industrial land that is not utilized for industrial related uses. This includes industrial properties that are completely vacant as well as industrial properties currently utilized for residential and agriculture uses.

Zoned Industrial Land

The City of Vancouver provides a geospatial *zoning data* package for Vancouver, which could be used to quantify zoned industrial land directly adjacent to the waterfront (City of Vancouver, 2015e). The data represents the current zoned areas for Vancouver; however, the City of Vancouver updates this dataset regularly.

Recommendations on Indicator Development

The geospatial land use data provided by Metro Vancouver could be analyzed to investigate the area or length of industrial, agricultural, and commercial space adjacent to the waterfront in the City of Vancouver. The Metro Vancouver Land Use Inventory

studies could be used as a means to compare waterfront industrial lands with industrial lands in the whole city. A further geospatial analysis could be conducted using the City of Vancouver's *zoning data package.* Such an analysis could show the amount of land on the waterfront that is actually zoned for each use. .

2.4.2 Economic Contribution of Port Metro Vancouver

Why Monitor the Economic Contribution of Port Metro Vancouver?

Industrial lands are often a source of contention for people in Vancouver because they, among other reasons, take up valuable waterfront land and have a bad reputation for negatively impacting the environment. Waterfront industries, however, are integral to Vancouver's economy, offering jobs and economic benefits. Monitoring the economic contribution of PMV provides an indication of the economic impact of industrial waterfront activities in the City of Vancouver.

Source of Data

Data on the jobs supported by PMV as well as PMV gross domestic product (GDP) impact, wages, and economic output are available through economic impact studies prepared by InterVISTAS for PMV (InterVISTAS, 2009; 2013). Both reports are publicly available from the PMV website (www.portmetrovancouver.com).

Data Description

Following the amalgamation of the Lower Mainland Port Authorities, PMV commissioned InterVISTAS in 2008, to conduct a baseline study of the combined economic impact of the amalgamated port (InterVISTAS, 2009). Four years later, in 2012, InterVISTAS was commissioned again to conduct an economic impact study based on current port operations. Both studies report the number of jobs directly supported by PMV. Direct employment is defined as the jobs involved in moving goods to or though PMV, or located on port land (InterVISTAS, 2013).

Direct employment supported by PMV was determined using an employment survey (InterVISTAS, 2013). All PMV firms were given the employment survey and 83% of these firms completed it. Investigating and measuring the direct employment base of PMV augmented the employment survey. To adjust for part-time, seasonal, and contract employment, person years are also presented in the reports, referring to the full-time equivalents. Specifically, the report estimates the number of jobs in the City of Vancouver supported by PMV.

Next, the reports estimate the direct monetary economic impacts of PMV employment on the economy of Metro Vancouver communities, including the City of Vancouver, in GDP and economic output. In general, these two measures are less understandable by the public than employment figures and are also less accurate (InterVISTAS, 2013). Statistics Canada's economic multipliers for British Columbia were used to infer the direct economic activity generated by PMV in terms of economic output and GDP.

Recommendations on Indicator Development

The InterVISTAS studies are the only data sources providing economic information about PMV, as the raw data is not available to the public. PMV does not complete economic impact studies on a regular schedule, rather commissions them on a demand driven, needs basis (Murphy, personal communication, June 4, 2015). With that said, reports will likely be available every couple of years, in accordance with the needs of PMV. The Waterfront Initiative can retrieve these reports, as they become available, to monitor changes.

2.4.3 Economic Contribution of the Ocean Sector

Why Monitor the Economic Contribution of the Ocean Sector?

Vancouver's ocean sector collectively represents the many sectors with a dependency on the city's coastal waters. The ocean sector provides jobs and economic benefits to the City of Vancouver. Monitoring the economic contribution of the ocean sector can provide an indication of the number of people working on Vancouver's coastal waters and the economic impact of these activities.

Source of Data

The report by Bjarnason et al. (2015) is available from the Fisheries Economics Research Unit of the UBC Fisheries Centre. It can be accessed online at the UBC Fisheries Centre website (www.fisheries.ubc.ca).

Data Description

Few studies have investigated the economic impacts of the ocean sector in Canada, let alone in British Columbia. Prepared to address the potential economic impacts of an oil spill on the City of Vancouver's ocean sector, Bjarnason et al. (2015) provide a baseline for the marine economy in the City of Vancouver in 2013, based on the following five ocean-dependent marine industries:

1. commercial fishing,
2. port activities,
3. inner harbour transportation,
4. ocean-dependent tourism, and
5. ocean-dependent recreation.

For each ocean-dependent marine industry, economic values are expressed in terms of the total (direct, indirect and induced) economic effects on economic output value, person years of employment, and GDP. Given the extent and complexity of the methodology used to calculate economic values, the specific methods used have been excerpted from Bjarnason et al. (2015) and can be viewed in Appendix 1.

Recommendations on Indicator Development

Since a baseline has been established by Bjarnason et al. (2015), it is possible to continue monitoring the economic contribution of the city's ocean sector in the future. There is, however, no indication regarding whether or not follow-up studies will be conducted. Since the authors provide a detailed methodology on conducting the analysis and the underlying data sources are publicly available, the Waterfront Initiative could consider replicating the study in the future.

2.4.4 Number and Type of Waterfront Businesses

Why Monitor the Number and Type of Waterfront Businesses?

Industrial activities are just one of the many types of work taking place on Vancouver's waterfront. The waterfront also has space for restaurants, shops, recreational services and many other types of small and large businesses. As industrial activities are often focused on with respect to working on the waterfront, looking at the number and type of businesses located on the waterfront can reflect what other businesses operate in this space.

Source of Data

Annual data on issued business licenses was retrieved from the City of Vancouver's Open Data Catalogue (http://vancouver.ca/your-government/open-data-catalogue.aspx). Specifically, the *Business License* spreadsheet was downloaded.

Data Description

To legally operate a business in or from the City of Vancouver, a business license must be obtained. This includes home based, trades, construction, commercial, and industrial business. Annually, the City of Vancouver keeps track of every business license that has been approved in the City of Vancouver. This data is compiled into a database, which includes the business name, business type, number of employees, address, and location coordinates.

Recommendations on Indicator Development

The City of Vancouver's *Business License* data includes coordinates, making it possible to use GIS software to map the businesses. Using GIS, businesses located on the waterfront and their corresponding details (ie. number of employees, business type, etc.) could be identified. Since this data is available annually, the number of businesses operating on the waterfront could be monitored over time.

2.4.5 Authorized Industrial Effluent Discharges

Why Monitor Authorized Industrial Effluent Discharges?

Some industrial activities produce effluent that is most often discharged into a nearby waterbody. As effluents are discharged, the various contaminants they contain are released into the aquatic ecosystem. Monitoring authorized industrial effluent discharges can reflect the potential environmental impacts that some industries may be having on the waterfront.

Source of Data

The BC MOE is responsible for regulating industrial discharges into the environment. They provide data on the authorized industrial discharges for the City of Vancouver. This data can be accessed here from the Waste Management section of the BC MOE website.

In 2010, BIEAP prepared a study titled, “Burrard Inlet Point Source Discharge Inventory,” which investigated industrial effluents authorized to discharge into the Burrard Inlet. This study can be accessed from the BC MOE Ecological Reports Catalogue.

Data Description

The BC MOE provides data on all the active industrial effluent authorizations in Vancouver and the rest of British Columbia. The facility type, discharge point/source, discharge contaminant, discharge start and ends dates, and minimum, average, and maximum discharge rates are all reported. In addition, the address and coordinates of the facility are provided, making it possible to map the locations of each facility.

Using this data from the BC MOE, the Burrard Inlet Point Source Discharge Inventory investigated the effluents authorized to discharge into Burrard Inlet. The study reports the plant type, receiving habitat type (sea, creek, or ground), discharge volume (L/day), and monitoring parameters. Where possible, the study also analyzed and estimated authorized effluent loading rates for discharges in 2005.

Recommendations on Indicator Development

The BIEAP study provides a good baseline for authorized industrial effluent discharges. To continue developing this indicator, recent data from the BC MOE should be compiled and analyzed similar to the BIEAP study. The number of authorized effluent permits, discharge locations (and receiving habitat type), discharge volume, and contaminants discharged could be focused on. Furthermore, it should be decided whether to only focus on effluent permits issued to facilities in Vancouver, or to also include areas in close proximity to the city that share a waterbody (ie. Burnaby).

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.4.6 Oil Spill Response Capacity and Preparedness (Marine and Riverine)

Why Monitor Oil Spill Response Capacity and Preparedness (Marine and Riverine)?

Vancouver's waters are frequented by many vessels, including oil tankers and other large vessels with large fuel tanks, which expose them daily to the risk of oil spills. In addition, the proposed Trans Mountain Pipeline Expansion and tanker routes would involve a pipeline being situated in close proximity to Vancouver's waters and increase the amount of oil tankers. Whether the Trans Mountain Pipeline Expansion moves forward or not, it is imperative that Vancouver has a robust capacity to respond to oil spill incidents.

Source of Data

Response Capacity and Logistics

The data are reported in a report prepared by Nuka Research and Planning Group for Tsleil-Waututh Nation, City of Vancouver, and Tsawout First Nation titled, "Oil Spill Response Analysis". The report is publicly accessible from the City of Vancouver website (www.vancouver.ca).

Response Vessels

Data on spill response vessels was obtained from the Western Canada Marine Response Corporation (WCMRC) website (www.wcmrc.com). WCMRC was consulted to ensure information was up to date.

Data Description

Response Capacity and Logistics

The study presents a marine oil response capacity analysis that estimates the total capacity for mechanical recovery of major marine spills at the following areas along the proposed Trans Mountain tanker route: Central Harbour, Outer Harbour, Georgia Strait, Race Rocks, and Haro Strait. Response capacity is estimated for each site in both summer and winter conditions. The analysis is representative of current conditions and estimates how much oil would remain on the water and how much could be recovered 72 hours after an oil spill occurred.

The study also analyzes river response logistics for the Lower Fraser River to determine the minimum response time required to mobilize and deploy response resources. The type and quantity of equipment available by arrival time are also outlined.

Response Vessels

WCMRC is responsible for spill clean up on BC's west coast. WCMRC provides details on the number of spill response vessels located in Vancouver, as well as the type, size, speed, skimming capacity, and product capacity of each vessel. The data reflects the equipment available at the present time; however, WCMRC has confirmed that the list will be updated as vessels are added, removed, and/or replaced.

Recommendations on Indicator Development

The presented study provides a baseline for oil spill response capacity and preparedness for Vancouver's waters. Although it is uncertain what studies will be conducted in the future, spill preparedness is currently given a lot of attention and therefore, it is likely studies will be conducted regularly. Prior to indicator report writing, a desktop investigation for recent reports on spill preparedness should be conducted.

Since the most recent spill response vessel information is available from WCMRC, this potential indicator could be monitored regularly by requesting the most up to date information from WCMRC. The number and type of vessels could be monitored along with the combined product capacity - to provide an indication of the size of spill the vessels are capable of cleaning up.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Transportation on the Waterfront.

2.4.7 Rental Rates of Industrial Lands and Office Space

Why Monitor Rental Rates of Industrial Lands and Office Space?

As the demand for waterfront land grows, it is anticipated that pricing will continue to be driven higher. Monitoring the rental rates of waterfront office space and industrial lands on the market in Vancouver can reflect the demand for waterfront land.

Source of Data

Industrial and office rental rate data is available from Colliers International as reported in their Metro Vancouver Industrial Market Report and their Metro Vancouver Office Market Report. This data can be downloaded from the Colliers International website (www.collierscanada.com). Colliers International also has a property search tool that provides information on the rental rates of individual properties.

Data Description

Colliers International reports the weighted average asking net rent ($/square foot) for industrial lands and offices in the City of Vancouver four times a year (once each quarter). The data reflects the weighted average asking net rent individually for industrial lands and offices in the City of Vancouver, not just on the waterfront. Data is available for four annual quarters from 2010 to the present.

Using Colliers International's property search, which presents information spatially, the asking rental rate for industrial lands and offices on the market (including those recently leased) and located on the waterfront can be determined.

Recommendations on Indicator Development

To develop this indicator, data from 2010 to the present should be compiled from Colliers International. Annual trends should then be investigated by plotting rental rate against time.

2.4.8 Vacancy Rates of Industrial Lands and Office Space

Why Monitor Vacancy Rates of Industrial Lands and Office Space?

Vacancy rates are a measure of the percent of all lands or buildings that are vacant and available for rent. Low vacancy rates typically indicate that there is a high demand for these properties, and as a result it will be more difficult to successfully rent something. High vacancy rates, on the other hand, tend to reflect a lower demand for these types of properties.

Source of Data

Vacancy rate data for industrial lands and office buildings is available from Colliers International as reported in their Metro Vancouver Industrial Market Report and their Metro Vancouver Office Market Report. This data can be downloaded from the Colliers International website (www.collierscanada.com). Additionally, Colliers International has a property search tool that provides information on the number of vacant industrial lands and offices in Vancouver.

Data Description

Colliers International reports the vacancy rate for industrial lands and office space in the City of Vancouver four times a year (once each quarter). The data is presented as a percentage and reflects the individual vacancy rate of both industrial land and office space in the City of Vancouver, not just on the waterfront. Data is available for four annual quarters from 2010 to the present.

Using Colliers International's property search, which presents information spatially, the number of vacant industrial lands and offices for lease or for sale (including those

recently sold or leased) on the waterfront can be determined. The available square footage of each property is also reported.

Recommendations on Indicator Development

To develop this indicator, data from 2010 to the present should be compiled from Colliers International. Annual vacancy trends should then be investigated by creating figures that plot vacancy rate against time.

2.4.9 Net Absorption of Industrial Lands and Offices on the Market

Why Monitor Net Absorption of Industrial Lands and Offices on the Market?

Net absorption refers to the net change in physically occupied space over a certain period of time. In other words, net absorption indicates whether the occupied stock of a market increased or decreased. Positive net absorption reflects an increase in occupied space, while negative net absorption reflects a decrease. Therefore, monitoring net absorption rates is indicative of the demand for these spaces.

Source of Data

Net absorption data for industrial lands and office space is available from Colliers International as reported in their Metro Vancouver Industrial Market Report and their Metro Vancouver Office Market Report. This data can be downloaded from the Colliers International website (www.collierscanada.com).

Data Description

Colliers International reports the net absorption (square feet) of industrial lands and office space on the market in the City of Vancouver four times a year (once each quarter). In the final quarter of the year, the year-to-date net absorption is reported. The data reflects the net absorption of industrial land and office space on the market in the City of Vancouver, not just on the waterfront. Data is available for four annual quarters from 2010 to the present.

Recommendations on Indicator Development

To develop this indicator, data from 2010 to the present should be compiled from Colliers International. Net absorption trends should then be investigated by creating figures that plot net absorption against time.

2.4.10 Number, Type and Annual Capacity of Timber Processing Facilities

Why Monitor Number, Type and Annual Capacity of Timber Processing Facilities?

Every year, numerous logs are transported along the Fraser River to facilities where they can be processed, including facilities in Vancouver. This potential indicator reflects

the capacity of timber processing facilities on the Vancouver waterfront, as well as the number of facilities with log booming grounds along the Fraser River.

Source of Data

The BC Ministry of Forests, Lands, and Natural Resource Operations (BC FLNR) provides data on the number, location, and type of timber processing facilities in British Columbia in their annual Major Primary Timber Processing Facilities in British Columbia report. The report can be accessed here on the BC Provincial Government website.

Data Description

The Major Primary Timber Processing Facilities in British Columbia report provides a list of all the major primary timber processing facilities in British Columbia, by type and location (the municipality in which it is located). In addition, the estimated annual capacity of each individual mill is reported. Reports are prepared and released with updated information annually by the Ministry.

Recommendations on Indicator Development

This potential indicator could monitor the total number of timber processing facilities located on the Vancouver waterfront, by type. Furthermore, the total estimated annual capacity of the mills located on the Vancouver waterfront could also be monitored over time.

2.4.11 Number and Type of Aquaculture Facilities

Why Monitor the Number and Type of Aquaculture Facilities?

Aquaculture is the farming of any fish, shellfish, or aquatic plant in fresh or salt water, and has become a major industry in BC during the last couple decades. The aquaculture industry impacts the economy of BC by providing employment and contributing to GDP. However, aquaculture can also have many environmental and social impacts, including disease and parasite transfer to wild populations and issues over traditional livelihoods. Therefore, monitoring aquaculture facilities reflects not only the scale and extent of this sector in the Vancouver area but also the potential risks to the region.

Source of Data

DFO is responsible for licensing finfish and shellfish aquaculture facilities in British Columbia and therefore, they maintain information on the number and location of aquaculture facilities in the province. Reports and maps can be accessed here and lists of licensed facilities can be found here on the DFO Pacific Region website (www.pac.dfo-mpo.gc.ca).

Data Description

DFO prepares maps and reports that provide the number and location of finfish, shellfish, freshwater hatcheries and land-based aquaculture facilities in British Columbia. Using the maps, the number of facilities located in proximity to Vancouver can be identified. The maps represent the facilities present in 2014; however, DFO will update the data regularly.

DFO also provides lists of all the licensed aquaculture facilities in the Pacific Region. Lists are provided by aquaculture activity (finfish, shellfish, fresh-water/land-based and hatcheries) and the general location of each licensed facility is provided along with the species the license applies to.

Recommendations on Indicator Development

To develop this indicator, data should be compiled from DFO and the number and type of aquaculture facilities located near Vancouver can then be investigated. Facilities can be segregated by type of facility (freshwater, saltwater, or land-based) and by category of species (finfish, shellfish, marine plant). Before preparing each indicator report, DFO should be contacted to request recent information.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.4.12 Number of Commercial Fishing Licenses (by fishery)

Why Monitor the Number of Commercial Fishing Licenses?

Commercial fishing has long been a popular practice on Canada's West coast. As such, the government monitors the commercial fishing industry to ensure the conservation of heavily fished species. The number of commercial licenses granted by the government is monitored and many granted licenses limit fishing activities by area or species. Monitoring the number of commercial fishing licenses granted can reflect the scale of this sector in the Vancouver area and also the status of fish stocks.

Source of Data

DFO provides data on the number of commercial fishing licenses issued annually for the Pacific Region. Data summaries can be accessed here from the DFO website (www.dfo-mpo.gc.ca). Raw data can be accessed here from the Government of Canada Open Data Portal (www.open.canada.ca).

Data Description

The DFO data summaries report the number of commercial fishing licenses issued annually for the entire Pacific Region, from 1985 to the present. The number of commercial fishing licenses issued, by species, and the number of commercial fishing vessels registered, by size, are also reported for the Pacific Region from 1985 to the present.

The raw data includes all the available information for each commercial license issued in the Pacific Region from 1985 to the present, including the fishery, year, and area that the license was issued for. Therefore, licenses issued for the Vancouver area (areas 28 and 29), can be specifically focused on.

Recommendations on Indicator Development

Using the available raw data would enable a more specific investigation of commercial fishing licenses. For instance, licenses that permit fishing activity near Vancouver could be focused on to determine the extent of commercial fishing in the area and to monitor any trends. Furthermore, the number of licenses granted for the Vancouver area, by fishery could also be monitored.

2.4.13 Number and Type of Recreational Marine Operators and Charters

Why Monitor the Number and Type of Recreational Marine Operators and Charters?

Recreational marine operators and charters offer opportunities for the public to engage in waterfront activities, including water-based tours, fishing trips, nature expeditions, and sailing. Since owning a boat can be quite costly, marine operators and charters offer the public a chance to partake in these activities without having to own the equipment! Such activities are also popular choices among tourists eager to explore all the city has to offer. Monitoring the marine operators and charters operating in Vancouver reflects the scale of the waterfront tourism and recreational work on the waterfront.

Source of Data

The data is presented in a study prepared by Harald Singso for Valiance Maritime Consultants Limited (Singso, 2014). The report can be requested from Valiance Maritime Consultants Limited.

Data Description

The marine operators and charters located in the City of Vancouver in 2014 were reported, mapped, and described. This information was collected through desktop research, observations, and interviews.

Recommendations on Indicator Development

The study presented provides baseline information on the marine charters and operators in Vancouver. However, for this to be an indicator, the data would need to be collected periodically throughout the future in order to monitor temporal changes. Since there is no indication that future studies will be conducted, before moving forward with this indicator, it should be determined whether the Waterfront Initiative or another source will be capable of collecting this data.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Transportation on the Waterfront, and
- Access to Nature on the Waterfront.

2.4.14 Educational Opportunities Available to the Public to Learn About Industrial Activities and History

Why Monitor Educational Opportunities Available to the Public to Learn About Industrial Activities and History?

The Waterfront Network has expressed that although more and more goods and people are transported on Vancouver's waterways, there is little connection to the communities they are moving through. There is a need to strengthen the connection between communities and the working waterfront and education is a great step in helping the residents develop a better understanding of the industrial activities underway on the shore.

Source of Data

PMV provides qualitative information on the educational opportunities that they offer to the public. This information must be requested from the PMV Education Team.

Data Description

PMV provides descriptions of the various educational opportunities that they currently offer to the public. Descriptions include the location of the opportunity, the age group invited to attend, and the activities included.

Recommendations on Indicator Development

With this qualitative information, the indicator could focus on thoroughly explaining what educational opportunities exist for the public to learn more about waterfront industrial activities. Prior to writing up each indicator report, PMV's Education Team will need to be consulted about any new educational opportunities that may have been introduced.

Furthermore, an investigation could be done for educational opportunities that may have been introduced for other industrial waterfront activities (ie. fisheries or forestry).

2.4.15 Number of Coast Guard Stations

Why Monitor the Number of Coast Guard Stations?

The Canadian Coast Guard is responsible for supporting safe and efficient marine navigation. In 2013, the federal government closed the busiest coast guard station in Canada, the Kitsilano Coast Guard Station. This was a very controversial event that made many Vancouverites concerned that the closure would reduce the Coast Guard's ability to respond to marine emergencies and put additional lives in danger. Furthermore, after the 2015 MV Marathassa oil spill in English Bay, many, including the Vancouver mayor Gregor Robertson, placed blame on the closure of the Kitsilano Coast Guard Station for the slow response to the spill. In 2015, new federal leadership ordered the Kitsilano Coast Guard Station to be re-opened; however, as federal leadership can change every couple of years, Canada's Coast Guard Stations are always facing potential closures.

Source of Data

The Government of Canada's Canadian Coast Guard (CCG) – Western Region provides information on the location of coast guard stations in the Western Region. This information can be requested from CCG – Western Region.

Data Description

CCG – Western Region provides information on the number and locations of coast guard stations on the West coast, and also provides details on their fleet, including the number and function of vessels.

Recommendations on Indicator Development

This data is easily accessible from CCG. Prior to preparing each indicator report, CCG would simply need to be contacted to request updated information on coast guard station locations in the Western Region.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Transportation on the Waterfront.

2.4.16 Suggested Indicators with Insufficient Supporting Data

The Waterfront Network has suggested the following other potential indicators for this theme, which are not detailed here due to an absence of sufficient supporting data:

1. Industrial Land Usage

The Waterfront Network has emphasized the importance of having a better understanding of the proportion of industrial waterfront lands that are occupied by water-dependent industries. However, to the best of our knowledge, no supporting data is available.

2. Comprehensive Estimates for Waterfront Employment

Although ocean sector employment estimates are available, the Waterfront Network has suggested that more comprehensive estimates are needed because the available estimates leave out some important sectors. To the best of our knowledge, estimates that encompass a more comprehensive list of ocean sector employment relating to Vancouver's waterfront are not available.

2.5 Flourishing Ecosystems on the Waterfront

Ocean, estuarine, and river ecosystems are an important part of the natural environment in the City of Vancouver. These aquatic environments hold a diversity of habitats that are home to a vast array of species. However, anthropogenic activities, including development, waste disposal, and transport, are an immense threat to these ecosystems. Sustaining the biodiversity of our shoreline ecosystems depends on how we manage the relationship between our city and the aquatic environment.

The following data sources identified and the potential indicators supported, will provide a better understanding of the current state of flourishing ecosystems on Vancouver's waterfront and a means of assessing changes over time.

Table 6. Data sources and potential indicators for Flourishing Ecosystems on the Waterfront.

Theme	Potential Indicator	Data Source
Flourishing Ecosystems on the Waterfront	Water and Sediment Quality	See section 2.5.1
	Recreational Water Quality	Metro Vancouver
	Waterbird Abundance and Diversity	Audubon Society; Bird Studies Canada; Stanley Park Ecology Society
	Air Quality	Metro Vancouver
	Shoreline Habitat	BIEAP; FREMP; Metro Vancouver
	Southern Resident Killer Whale Population	Centre for Whale Research
	Fish Health and Tissue Contaminants	Metro Vancouver
	Eulachon Spawn	Fisheries and Oceans

		Canada; Moody (2008)
	Pacific Herring Stock and Catch	Fisheries and Ocean Canada
	White Sturgeon Populations	Fraser River Sturgeon Conservation Society
	Marine Mammal Occurrence	Raincoast Applied Ecology
	Pacific Salmon Abundance	Fisheries and Oceans Canada; Pacific Salmon Commission; various publications (see section 2.5.12)
	Species at Risk	BC Ministry of Environment Species and Ecosystems Explorer; Species at Risk BC
	Toxics in the Food Web	Various publications (see section 2.5.14)
	Underwater Noise Pollution	Erbe et al. (2012); Port Metro Vancouver ECHO Program
	Point Source Discharges	BIEAP; Moore (1993); UMA Engineering (1992)
	* Beach Spawning Forage Fish	Sea Watch Society
	*Nearshore Pollution	Vancouver Aquarium PollutionWatch Program

*To be officially included on the indicator list once data is available or received.

2.5.1 Water and Sediment Quality

Why Monitor Water and Sediment Quality?

The waters off Vancouver's shoreline are home to a wide variety of marine life as well as valuable fisheries. Water quality is the foundation for the aquatic life depending on these waters and poor water quality makes it difficult for species to thrive. Contaminated sediments are a threat to benthic organisms and eventually to aquatic ecosystems as a whole, as sediment contaminants can become resuspended into the water, exposing organisms in the water column to the contaminants. Monitoring the water and sediment quality of Vancouver's waters reflects the state of this aquatic environment that many organisms call home.

Source of Data

The following data sources identified report data for water and sediment sampling sites located in proximity to the City of Vancouver (North arm of the Fraser River, False Creek, Outer and Inner Harbour):

Metro Vancouver Monitoring

Raw data from the Fraser River Ambient Monitoring Program and the Burrard Inlet Ambient Monitoring Program are available through Metro Vancouver reports. Reports are available to the public but need to be requested from Metro Vancouver. The following reports for the Fraser River Ambient Monitoring Program are available for water and sediment quality:

Water Quality: ENKON, 2003; 2006; 2007b; 2008a; 2009; 2010a; 2012a; 2012b; 2014; G3 Consulting, 2004

Sediment Quality: ENKON, 2007a; Keystone, 2011

The following Burrard Inlet Ambient Monitoring Program water and sediment quality reports are available:

Water Quality: ENKON, 2008b; 2009; 2010b; 2011; 2012c; G3 Consulting, 2014; Keystone, 2009

Sediment Quality: Metro Vancouver, 2010; 2012

BC Ministry of Environment Monitoring

Data are presented in the following reports that are publicly available from the BC MOE website (http://www.gov.bc.ca/env/):

Swain, 1986; Swain and Walton, 1990; Swain and Walton, 1993; Swain et al., 1998; Sutherland, 2004; Bull, 2004; Bull and Freyman, 2013

Environment Canada Monitoring

The following reports prepared for Environment Canada are available online through the BC MOE Ecological Reports Catalogue (http://www.env.gov.bc.ca/ecocat/):

Goyette and Boyd, 1989; Boyd et al., 1998; Phippen, 2001

FREMP

The following reports were accessed online through the BC MOE Ecological Reports Catalogue:
FREMP, 1990; FREMP, 1996a; Drinnan and Humphrey, 1997

Data Description

Water and sediment sampling have been conducted in the Burrard Inlet and Fraser River for the past few decades by various agencies including Environment Canada, BC

MOE, the Fraser River Estuary Management Program (FREMP), and Metro Vancouver. Monitoring programs, however, have differed in terms of sampling locations, sampling frequency, and the parameters measured, making it challenging to establish a reliable baseline (Jacques Whitford, 2008). Given the vast amount of data sources available, and the complexity of compilation, the current work has focused on the most recent monitoring by Metro Vancouver and the BC MOE. The other sources have been identified above to facilitate an intensive analysis of water and sediment quality in the future.

Burrard Inlet Monitoring

BC Ministry of Environment

Water and sediment quality objectives were established for the Burrard Inlet in 1990 to protect aquatic life, wildlife, and primary contact recreation (Sutherland, 2004). To monitor attainment of these goals, comprehensive water monitoring was conducted by the BC MOE from 1990-1994, in 2002, and 2009. Sampling stations were located in the Outer Harbour, False Creek, Inner Harbour, Central Harbour, Port Moody arm, and Indian arm. Sediment sampling was conducted from 1990-1994 and in 2002. No sediment sampling occurred in 2009, due to budget constraints (BC MOE, 2013). In the future, the BC MOE will continue to monitor water and sediment quality as funding and resources are available (Sutherland, personal communication, May 26, 2015).

Of the locations sampled, six sites are located near the City of Vancouver shoreline. One site is located in the Outer Harbour (0300076), two in False Creek (E207815, E207814), and three in the Inner Harbour (E207813, E207818, E207819). Water quality is monitored for physical parameters, bacteriology, nutrients, dissolved oxygen, metals, and surfactants and sediment quality is monitored for physical parameters, bacteriology, nutrients, dissolved oxygen, metals, and surfactants.

Metro Vancouver

Recently, Metro Vancouver initiated an ambient monitoring program for the Burrard Inlet. The Ambient Monitoring Programs is part of the Integrated Liquid Waste and Resource Management Plan (ILWRMP) and has been designed to address the potential environmental impacts from storm and wastewater discharge (Metro Vancouver, 2010b). Monitoring results are compared with provisional water quality objectives and provincial guidelines for the protection of aquatic life, wildlife, and primary-contact recreation.

The Burrard Inlet Ambient Monitoring Program was initiated in 2007 and consistently conducts sampling at seven sites. Of the seven sites monitored in the Burrard Inlet, two are located directly off the shores of the City of Vancouver (Sites 2 and 3) and one is located in English Bay off the shore of West Vancouver (Site 1). Water and sediment sampling is conducted at the same sampling sites and the Burrard Inlet Ambient Monitoring Program does not do any monitoring in False Creek.

Water quality monitoring is conducted annually and monitored for physical parameters, bacteriology, nutrients, dissolved oxygen, metals, and surfactants. Sampling periods for water quality monitoring are selected to correspond with the historical period of heavy rainfall, as it is expected to trigger stormwater runoff and combined sewer overflows (CSOs) to Burrard Inlet. Each year, five water quality surveys are conducted from a boat, at one-week intervals, in order to determine compliance with 30-day average water quality objectives.

Sediment quality is sampled every three years for physical parameters, total organic carbon, bacteriology, nutrients, metals, organic contaminants, hormones and surfactants. Sediment sampling is conducted from a boat and at each sampling site three replicate sediment samples are each collected from three individual grab samples (ie. each replicate is a composite of three grab samples).

Fraser River Monitoring

BC Ministry of Environment

In 1985, water and sediment quality objectives were first set for the Fraser River, due to the potential for nutrient and contaminant input from anthropogenic activities (BC MOE, 2004). As a result, comprehensive water and sediment monitoring in the Fraser River was conducted by the BC MOE from 1987-1995 and in 2003. Monitoring sites were located in the Main Stem, Main arm, North and Middle arms, and in Sturgeon and Roberts Banks.

Of the locations sampled, one water quality station (0300002) and one sediment quality station (E206968) are located near the Vancouver shoreline. Water quality is monitored for physical parameters, bacteriology, nutrients, dissolved oxygen, metals, and surfactants; while, sediment quality is monitored for physical parameters, bacteriology, nutrients, dissolved oxygen, metals, and surfactants.

Metro Vancouver

Metro Vancouver initiated the Fraser River Ambient Monitoring Program in 2003 as part of the ILWRMP. Like the Burrard Inlet Ambient Monitoring Program, the program has been designed to address the potential environmental impacts from storm and wastewater discharge (Metro Vancouver, 2010b). The program consistently monitors seven sites, collecting water quality samples annually, and sediment samples every five years.

Of the sites monitored by the program, two water quality sampling sites are located in the North arm of the Fraser River adjacent to the City of Vancouver (Sites 6 and 7). Water quality sampling is conducted when flows are lowest in the lower Fraser River. Every year, five water quality surveys are conducted from a boat, at one-week intervals, in order to determine compliance with 30-day average water quality objectives. Water

quality samples are analyzed for physical parameters, bacteriology, nutrients, dissolved oxygen, metals, and surfactants.

Water and sediment sampling occur at different locations, and only one sediment sampling location is located near the shoreline of the City of Vancouver (Site 7). Sediment sampling is conducted during the annual low flow period in order to capture the ideal conditions for accumulation of the of fine sediment particles that typically hold the highest concentration of contaminants (ENKON, 2007a). Sediment sampling is conducted from a boat, and at each sampling site three replicate sediment samples are collected from three individual grab samples (ie. each replicate is a composite of three grab samples). The sediment samples are analyzed for physical parameters, total organic carbon, bacteriology, nutrients, metals, organic contaminants, hormones and surfactants.

Recommendations on Indicator Development

There is an abundance of water and sediment quality data available for a few sampling locations around the City of Vancouver. However, since data has been collected by various sources for the past few decades, at a variety of sampling locations, it is necessary to thoroughly compare data sets before compiling them. Therefore, it is recommended that an intensive analysis of water and sediment quality data be conducted, resulting in a data inventory for each sampling site located around the city's waterfront. Such a data inventory would facilitate an analysis of various water and sediment quality parameters, allowing historical trends for each sampling location to be presented. A better understanding of the long-term data collected at each sampling location will enable the most informative parameters to be selected as water and sediment quality indicators. In addition, an intensive analysis of water quality sampling would enable specific water quality parameters, reflective of climate change (pH, alkalinity, dissolved oxygen), to be monitored and used as climate change indicators.

2.5.2 Recreational Water Quality

Why Monitor Recreational Water Quality?

E. coli bacteria are a water quality indicator that reflect the presence of fecal contamination from human and animal sources. E. coli is a species of coliforms that live in the intestinal tract of warm-blooded animals and are excreted through feces. The presence of E. coli in the water is indicative of bacterial contamination and elevated levels can pose a threat to the health of those in contact with the water. In addition to the health risks, E. coli can cause cloudy water and an increased oxygen demand.

Source of Data

Raw E. coli data for City of Vancouver beaches are available from Metro Vancouver by request. Summarized data is presented in reports that are available from the Vancouver Coastal Health (VCH) website (www.vch.ca/).

Data Description

The bacteriological quality of local recreational waters is monitored on a weekly basis by Metro Vancouver (Metro Vancouver, 2013a). Monitoring is conducted throughout the beach season from May to September. Sampling sites have been added over the years of monitoring, and today there are 120 sampling sites in 40 locations across the Metro Vancouver Region. Of the 40 locations across the region, 13 are located in the City of Vancouver, including locations in English Bay, Burrard Inlet, and False Creek. The specific locations sampled are Third Beach, Second Beach, English Bay, Sunset Beach, Kitsilano Point, Kitsilano Beach, Jericho Beach, Locarno Beach, Spanish Banks, Crab Park, and West, Central and East False Creek.

In general, five samples are collected from two to four sites along each beach (or False Creek). Once collected, samples are analyzed for E. coli and the results are expressed as a geometric mean over a 30-day period. Fecal coliform was used as the indicator organism until 2013, at which point Metro Vancouver was directed to change indicators to E. coli, based on Health Canada's third edition of *Guidelines for Canadian Recreational Water Quality*.

Recommendations on Indicator Development

E. Coli data could be evaluated by graphing the percentage of time that beaches were acceptable for primary contact recreation or the number of days E. Coli counts exceeded the primary contact recreation standard. Since there are 13 sites located in the City of Vancouver, a few different sites could be selected that represent different parts of the city. Metro Vancouver collects this data weekly in the summer, making data availability for this potential indicator great.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Access to Nature on the Waterfront.

2.5.3 Waterbird Abundance and Diversity

Why Monitor Waterbird Abundance and Diversity?

Waterbirds have been identified as useful environmental indicators because they can reflect a suite of information about coastal ecosystems. With a dependency on their habitat functioning in specific ways, changes in waterbird abundance and diversity can be indicative of changes in ecosystem state. In addition, since many species of waterbirds are top predators, they are subject to the contaminant accumulation in their prey, making them useful indicators of changes occurring in lower trophic levels.

Source of Data

Christmas Bird Counts

Historical Christmas Bird Count data is publicly available on the Audubon Society website (www.audubon.org/bird/cbc/hr/). Christmas Bird Count data is provided by the National Audubon Society and through the generous efforts of Bird Studies Canada and countless volunteers across the western hemisphere.

BC Coastal Waterbird Survey

Waterbird Survey data is available through Bird Studies Canada and Environment Canada – Canadian Wildlife Service. This data is available to the public but needs to be requested from the Nature Counts website (www.bsc-eoc.org).

BC Beached Bird Surveys

BC Beached Bird Survey data is available through Bird Studies Canada. This data is available to the public but needs to be requested from the Nature Counts website.

Stanley Park Ecology Society

Great Blue Heron and bald eagle nest data, as well as winter waterbird survey data were retrieved from the Stanley Park Ecology Society (SPES). Great Blue Heron nest data was available for 2002 - 2009 through the Stanley Park State of the Park Report (SPES, 2010). The remaining Great Blue Heron nest data (2010 – 2014) was retrieved from the 2014 Heron Colony Final Report (SPES, 2014a). Bald eagle nest data was available for 2004 – 2014 through the Vancouver Bald Eagle Update report (SPES, 2014b). Winter waterbird survey data was available through the 2014 Winter Waterbird Survey report (SPES, 2014c). All reports are available on the SPES website (www.stanleyparkecology.ca).

Data Description

Christmas Bird Counts

Christmas Bird Counts are conducted by volunteers within a 24-km diameter circle. Count circles are not randomly located, rather are selected by the compiler, but are not permitted to overlap with any other count circle. Counts are conducted during a single calendar day from mid December to mid January. No single method is used to collect data – data is often collected on foot, in cars, or by people watching birds coming to feeders. All collected data are supplied to and stored by the National Audubon Society. Data can be downloaded from the National Audubon Society for counts located only in the City of Vancouver.

As this is a citizen science survey and there are no specific methods in place, it is likely that there are year-to-year inconsistencies in data collection methodologies, such as differences in observer effort. These inconsistencies will introduce some variability into the results.

BC Coastal Waterbird Survey

Bird Studies Canada and Environment Canada – Canadian Wildlife Service conduct the BC Coastal Waterbird Survey. This is a long-term, citizen science survey, involving coordinated volunteer counts, conducted on the second Sunday of the month from September through April (Badzinski et al., 2006). The species groups surveyed are loons, grebes, cormorants, herons, waterfowl (ducks, geese and swans), shorebirds, gulls, terns, alcids, and raptors. Sites monitored in Vancouver include Spanish Banks, Locarno Beach, Jericho Beach, Kitsilano West, Kitsilano East, Kitsilano Point, False Creek, English Bay Beach to Second Beach, Ferguson Point/3rd Beach, Prospect Point, Stanley Park East, Coal Harbour, Vancouver Harbour West, Vancouver Harbour East, and Vancouver 2nd Narrows.

BC Beached Bird Surveys

The BC Beached Bird Survey has been conducted by Bird Studies Canada since 2002. The goal of these surveys is to collect information on the causes and rates of seabird mortality in BC. Survey sites vary annually and include various locations across the City of Vancouver. These are citizen science surveys, which are conducted monthly for each site.

For each site, surveyors follow a predetermined route identifying any bird carcasses that may be present. In the event that beached birds are found, surveyors examine the carcass for oil or entanglements, the degree of emaciation, the condition of the carcass, the proportion of the carcass remaining, and cause of mortality (when possible).

Stanley Park Ecology Society

Regular nesting period (March – July) monitoring of the Great Blue Heron colony in Stanley Park began in 2004. SPES staff and volunteers conduct nest counts through two sampling methodologies - each conducted once every 2-4 weeks between March and July (SPES, 2014a). One methodology involves counting the total number of nests through ground observations, and the second methodology involves making nest observations from a rooftop overlooking the colony.

SPES has monitored bald eagle nests, during the breeding season, throughout the City of Vancouver since 2004. This monitoring is conducted with the assistance of volunteer monitors and in partnership with the Lower Mainland Wildlife Tree Stewardship program. The data includes the total number of nests observed, number of active nests, number of successful nests, and number of fledges.

Since 2008, SPES has conducted winter waterbird surveys annually, which involves quantifying the number of birds using the shoreline along the Stanley Park Seawall. Surveys are conducted by SPES staff and volunteers who walk the entire Stanley Park Seawall and count all the birds seen between the wall and 500m offshore. The area surveyed is divided into four zones in order to compare the habitat use of different bird groups. The total number of birds, number of species, and distribution of species within the four zones are reported. Surveys are conducted at the same time every year, following the same methodology.

Recommendations on Indicator Development

Peter Davidson of Bird Studies Canada has made recommendations on the most informative analyses for the Waterfront Initiative. It has been suggested that different guilds of birds be monitored, as comparing guilds has the benefit of suggesting where changes in the ecosystem may be occurring (Peter Davidson, personal communication, June 8, 2015). Focusing on benthic foragers, mid-water foragers, surface feeders and rocky shore specialists were suggested to be informative shoreline groups.

2.5.4 Air Quality

Why Monitor Air Quality?

Air quality can impact the health of humans, wildlife, and ecosystems, alike. Improved air quality can help sustain the delicate balance of ecosystem functions, increase socio-economic well-being, and reduce illness and associated health care costs.

Source of Data

Ambient air quality data was provided by Metro Vancouver as summarized in their annual Lower Fraser Valley Air Quality Monitoring Report (Metro Vancouver, 2006b; 2007; 2008; 2010c; 2010d; 2012b; 2013c; 2014a; 2014b). Monitoring reports for 2005 – 2013 were retrieved from the Metro Vancouver website (www.metrovancouver.org).

Data Description

Metro Vancouver manages the Lower Fraser Valley Air Quality Monitoring Network (LFVAQ), which monitors air pollutants at 27 sites in Metro Vancouver (Metro Vancouver, 2014a). Two of these sites are located in the City of Vancouver (Vancouver-Downtown and Vancouver-Kitsilano). The Vancouver-Downtown station was out of service in 2011 for renovation and landscaping activities at Robson Square (Metro Vancouver, 2013c). The air contaminants monitored include CO, NO_x, SO_x, VOCs, ground-level ozone, PM_{10}, $PM_{2.5}$, and NH_3. Stations continuously record air pollutants at hourly intervals, at some sites since 1992.

Recommendations on Indicator Development

Ambient air quality data can be compiled annually from the Metro Vancouver monitoring reports. The data can be compared to Metro Vancouver objectives for criteria air contaminants and to federal Canada-Wide Standards where applicable. Data can also be presented following the Air Quality Health Index which uses a scale of 0 (good) to >100 (very poor).

2.5.5 Shoreline Habitat

Why Monitor Shoreline Habitat?

Shoreline habitats are unique areas that support a great diversity of life. They are also greatly influenced by naturally occurring processes and human activities. Shoreline modifications and waterfront and harbor development can drastically alter shoreline habitat and consequently, have a devastating effect on aquatic life. Monitoring shoreline change provides an indication of the amount of suitable habitat remaining, capable of supporting biodiversity on the waterfront.

Source of Data

Burrard Inlet Environmental Action Program

The Burrard Inlet Shoreline Change – Baseline Assessment (Stantec, 2009) is publicly available and was retrieved from the BC MOE Ecological Reports Catalogue (http://www.env.gov.bc.ca/ecocat/). The habitat inventory conducted by BIEAP, is also available on the FREMP-BIEAP Atlas on the Community Mapping Network (CMN) website (www.cmnbc.ca/).

Fraser River Estuary Management Program

The initial habitat inventory conducted on the Fraser River (G.L. Wiliams, 1990), and the 1996, 2004, and 2006 updates (FREMP, 1996b; FREMP, 2005; and Chernoff & Duckham, 2007; respectively), can be accessed from the BC MOE Ecological Reports Catalogue. FREMP also made their habitat inventory available to the public through the FREMP-BIEAP Atlas on the CMN website.
Metro Vancouver's Sensitive Ecosystem Inventory

Sensitive ecosystem data is available through Metro Vancouver's Sensitive Ecosystem Inventory (SEI). The SEI mapping tool and all supporting documents can be accessed on the Metro Vancouver website (www.metrovancouver.org).

Data Description

Burrard Inlet Environmental Action Program

Stantec (2009) provided baseline information on the status of marine habitat and shoreline in the Burrard Inlet. Four data sources were used for the assessment, including a shoreline classification study (Haggarty, 2001), a historical analysis of shoreline change over time using aerial photographs from the 1930s and 2005 by Integrated Mapping Technologies, a habitat inventory/land use classification (Caslys Consulting, 2009), and a BIEAP 2009 field verification and ground-truthing. As the study was conducted for the Burrard Inlet, results are presented for the Burrard Inlet as a whole, and also for individual sections in the inlet. The only section reported specific to the City of Vancouver shoreline was False Creek. The Outer and Inner Harbour sections both include habitat on the North Shore of the Burrard Inlet (North Vancouver and West Vancouver).

To assess and quantify existing marine habitats, six habitat types were defined based on consultation with members of BIEAP's Plan Implementation Committee, GIS datasets and studies from the Burrard Inlet, and professional expertise and knowledge of the area (Stantec, 2009). The six habitat types selected were tidal flats/estuaries, beach, natural rocky intertidal, river/stream inputs, purpose built high value, and purpose built low value. Riparian habitat was also considered due to its significant effects on associated intertidal habitats. Natural shoreline was defined as an area that has been unaltered from its original state by anthropogenic activities; whereas purpose built shoreline was defined as any shoreline that has been altered by humans. Habitat types were quantified linearly, and where possible, by area.

Fraser River Estuary Management Program

In 2002, FREMP inventoried the intertidal and riparian habitat within its geographic boundaries for the first time since the 1980s (Chernoff & Duckham, 2007). Using orthophotos at a 1:20000 scale, similar habitats were grouped into polygons and were classified into four categories: First Order, Second Order, Community, and Dominant Species. To ensure the correct classifications had been determined, ground-truthing was conducted in 2006, and in 2007 habitat remapping was completed based on the field observations.

Metro Vancouver's Sensitive Ecosystem Inventory

From 2010 to 2012, an SEI was conducted by Metro Vancouver (Metro Vancouver, 2014c). The SEI identified and mapped ecologically significant and relatively unmodified sensitive ecosystems, as well as modified ecosystems, such as young forests. Terrestrial lands, rivers, freshwater bodies, intertidal and estuarine zones were all mapped using three main approaches: 1) existing Terrestrial Ecosystem Mapping (TEI), 2) SEI mapping from previous projects, and 3) mapping through image interpretation.

The SEI details the area covered by sensitive and modified ecosystems in the Metro Vancouver region. Since it is a geospatial data source, ecosystems on the City of Vancouver's waterfront can be focused on.

Recommendations on Indicator Development

Unfortunately, after the closure of BIEAP and FREMP, nobody has taken over the habitat inventories conducted by these programs. With that said, BIEAP and FREMP provided baseline data for this potential indicator, but likely will not provide habitat assessments in the future. Therefore, Metro Vancouver's SEI is the only data source currently available to monitor this potential indicator in the future. Since the BIEAP and FREMP inventories and the SEI classify habitat differently, a method would need to be devised to reconcile the sources.

The SEI was first conducted from 2010 to 2012 and it has been suggested that a complete review of the SEI be conducted every five years, or that portions of the SEI be reviewed and updated annually (Metro Vancouver, 2014c). Either way, the importance of keeping the SEI dataset current has been emphasized. With that said, this potential indicator could likely be updated approximately every five years in the future.

2.5.6 Southern Resident Killer Whale Population

Why Monitor the Southern Resident Killer Whale Population?

Killer whales are a top marine predator and an iconic species of the Salish Sea that occasionally visit the City of Vancouver's waters. Southern resident killer whales spend most of the spring/summer months (April to October) in the waters around southern Vancouver Island and northern Washington but have been spotted as far north as Haida Gwaii and as far south as California in the winter months (Vancouver Aquarium, 2011). The southern resident killer whale population has been listed as endangered in both Canada and the United States. Monitoring southern resident killer whale populations reflects the overall health of the marine ecosystem that the City of Vancouver is intricately connected to.

Source of Data

Southern resident killer whale data was retrieved from the Centre for Whale Research website (www.whaleresearch.com).

Data Description

Annual southern resident killer whale censuses have been conducted since 1974. In earlier years, this data was released through publications; however, today, all the census data is gathered by the Centre for Whale Research. Population data is gathered using photo-identification studies.

The Centre for Whale Research updates the southern resident killer whale population estimate twice a year (July 1 and December 31) and releases this data on their website. Additionally, the Centre for Whale Research provides population data on the different southern resident killer whale pods.

Recommendations on Indicator Development

Data for this potential indicator is publicly released on the same two days each year, making data easily accessible and reliable. Each year, as data is released it can be collected from the Centre for Whale Research website and added to the graphical representation for this indicator. Furthermore, the population of individual southern resident killer whale pods can also be monitored to track temporal changes in individual pod populations.

In addition to the presented population data, killer whale sightings near the City of Vancouver could be incorporated as a supplementary source showing the frequency of killer whale visits to the city. The Vancouver Aquarium established the Cetacean Sightings Network in 1999, which catalogues killer whale sightings, along with other cetacean sightings. The Cetacean Sightings Network reports details about the sighting including the location; therefore, sightings near Vancouver's waterfront could be monitored. Access to the Cetacean Sightings Network database has been requested.

2.5.7 Fish Health and Tissue Contaminants

Why Monitor Fish Health and Tissue Contaminants?

The condition of fish is reflective of the health of freshwater and marine ecosystems, as fish are dependent on their aquatic environments for survival. Monitoring both the health and tissue quality of fish can provide an indication of the environmental conditions of Vancouver's coastal waters.

Source of Data

Fish health and tissue contaminant data is available through Metro Vancouver's Fraser River and Burrard Inlet Ambient Monitoring Program reports.

Data Description

Metro Vancouver initiated the Fraser River Ambient Monitoring Program in 2003 and the Burrard Inlet Ambient Monitoring Program in 2007. As part of the monitoring program, fish are sampled once every five years. Fish are collected by beach seining using large nets that allows the capture of large and small fish. Once collected, fish are measured for fork length, whole body weight, liver weight, and gonad weight, and analyzed for moisture and lipid content, metals, dioxins and furans, PCBs, organochlorine pesticides, PBDEs, benzo[a]pyrene and chlorophenols.

Specifically, two sentinel species are focused on in the Fraser River: the Peamouth chub and Prickly sculpin (preferably) or alternatively the Largescale sucker. One species is focused on in the Burrard Inlet: the English sole. 30 males and 30 females of each species are collected from each sampling site.

In the Fraser River, sampling is conducted in three areas, including one area in the North arm along the City of Vancouver and partway into Burnaby. Sampling is conducted at seven sites in the Burrard Inlet, two of which are located near the shore of the City of Vancouver. To date, results have been published for monitoring in 2007 and 2012 for the Fraser River and in 2007 for the Burrard Inlet.

Recommendations on Indicator Development

Fish sampling will continue to be conducted every five years in both the Fraser River and Burrard Inlet. Therefore, as this data is published in Metro Vancouver reports, it can be gathered and used for assessments of the indicator's status. Since only one and two sampling cycles have been conducted for the Burrard Inlet and Fraser River, respectively, graphical representations of the results were not created. However, graphical representations could be used in the future to show temporal trends of fish health and tissue contaminants, as more sampling cycles are conducted.

2.5.8 Eulachon Spawn

Why Monitor Eulachon Spawn?

Eulachon (*Thaleichthys pacificus*) are a semelparous smelt that spawn only in a limited number of rivers in Western North America, from California to the Bering Sea. Given their high lipid content, they are an important prey item for a broad range of fish, mammal, and avian predators (DFO, 2015). This species, however, has experienced declines and local extirpation in some river systems. The Committee on the Status of Endangered Wildlife in Canada has assessed Eulachon in the Fraser River as Endangered. Monitoring Eulachon spawners is very important in determining whether population sizes in the Fraser are increasing.

Source of Data

DFO provides Eulachon spawner data. This data can be requested from DFO or accessed on their Pacific Region website (www.pac.dfo-mpo.gc.ca). Moody (2008) also presented historical Eulachon abundance estimates. This thesis can be accessed at the Thesis and Dissertations section of the UBC website (https://open.library.ubc.ca/cIRcle/collections/ubctheses).

Data Description

DFO has conducted Eulachon egg/larval abundance surveys in the North Arm of the Fraser River from 1995 to the present. From mid-April to mid-June, surveys are conducted by collecting samples 1-2 times per week at 17 stations in the Lower Fraser

River. The data collected in these surveys are used to estimate annual spawning stock biomass.

Moody (2008) analyzed available historical data to estimate an index of annual Eulachon abundance for the Fraser River. Using this index, Moody (2008) estimated Eulachon abundance status from 1881 to 2006.

Recommendations on Indicator Development

Spawning stock biomass data for the North Arm of the Fraser could be plotted against time to determine temporal trends. Since abundance status estimates from Moody (2008) are only available until 2008, they could be used as supporting information.

2.5.9 Pacific Herring Stock and Catch

Why Monitor Pacific Herring Stock and Catch?

Pacific herring (*Clupea pallasi*) are a pelagic fish species that migrate between inshore spawning and offshore feeding areas of the North Pacific Ocean (DFO, 2014). Five major and two minor stocks of Pacific herring are located in BC, including the Strait of Georgia stock. Pacific herring have been harvested commercially and by First Nations for many years. In 1967, the commercial fishery collapsed and was closed by the federal government. However, after a rapid rebuilding of Pacific stocks in the early 1970s, the commercial fishery was re-opened. Today, commercial, First Nations, and recreational fisheries harvest Pacific herring for a variety of uses. Monitoring the status of Pacific herring is an important part of ensuring stocks remain healthy and stable.

Source of Data

DFO maintains stock, catch and spawn data on Pacific herring. Stock and catch data has been presented annually in stock assessment reports, which can be accessed here on the DFO website. Spawn data can be accessed here, also on the DFO website.

Data Description

Pacific herring stock assessment reports have been prepared by DFO annually from 2004 to the present. The reports estimate spawning biomass for the Strait of Georgia stock. The combined total validated catch for the seine roe, gillnet roe, food and bait, and special use fisheries is also reported. DFO also collects herring spawn data, including Spawn Habitat Index, total length of spawning bed, mean width of spawning bed, mean number of egg layers, sea surface temperature, and spawn date. This data is available from 1958 to the present for individual DFO statistical areas, including the waters around Vancouver (areas 28 and 29). However, it should be noted that some years have zero values for all parameters and DFO cannot distinguish whether this is due to missing data (ie. the area was never inspected) or because the shoreline was inspected and there was no spawn.

Recommendations on Indicator Development

The estimated herring spawning biomass and catch (either total catch or by individual fishing methods) in the Strait of Georgia could be plotted over time to investigate temporal trends. Similarly, herring spawning grounds and characteristics could be monitored over time. The Spawn Habitat Index would indicate any trends with regards to the characteristics of the spawning bed; while the spawn date would indicate any variations in the time of year herring are spawning.

2.5.10 White Sturgeon Populations

Why Monitor White Sturgeon Populations?

White sturgeon (*Acipenser tranmontanus*) are the largest freshwater fish in North America. They are found in three rivers in British Columbia, one of which is the Fraser River, and have played a significant role in the province's cultural and social heritage, as well as the economy. However, the population of white sturgeon in the Lower Fraser River is dramatically smaller in size than its historic levels. Furthermore, the white sturgeon is classified as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada and as imperiled by the BC Conservation Data Centre.

Source of Data

The Fraser River Sturgeon Conservation Society provides data on white sturgeon populations in the Fraser River through their annual reports titled, "Status of White Sturgeon in the Lower Fraser River". Reports can be accessed from the society's website (www.frasersturgeon.com).

Data Description

The annual status reports present mean population estimates for the Lower Fraser River white sturgeon for four sampling regions. Sampling regions occur between hope and the mouth of the Fraser River. Mean population estimates by 20-cm size groups, as well as the estimated number of juvenile sturgeon, sub-mature sturgeon, and mature adult sturgeon are also reported. Population estimates are available from 2001 to the present, while estimates by group size and age group are available from 2004 to the present.

Recommendations on Indicator Development

Population estimates, by size and age group, could be plotted over time to identify any trends with regards to white sturgeon abundance, growth, or life cycle.

2.5.11 Marine Mammal Occurrence

Why Monitor Marine Mammal Occurrence?

Throughout history, many marine mammals have been known to frequent Vancouver's waters. However, after over a century of human activities taking a toll on Vancouver's aquatic habitats and species, some marine mammals are visiting the city's waters less often and others have vanished. Monitoring the occurrence of marine mammals can be reflective of the overall health of Vancouver's aquatic ecosystems.

Source of Data

Occurrence records are provided in a recent report prepared by Raincoast Applied Ecology titled, "Mammals of Vancouver and Point Grey". This report can be accessed here on the Raincoast Applied Ecology website (www.raincoastappliedecology.ca).

Data Description

The report presents a summary of historical and current presence of mammals in Vancouver and Point Grey. Mammals are further divided into a variety of categories including *seals and sea lions* and *whales and dolphins*. Mammal presence is classified historically and for the current time as present, not present, likely not present but unconfirmed, rare visitor (not an established population), and introduced (non-native). The report was prepared in 2012 and therefore is reflective of marine mammal presence in 2012.

Recommendations on Indicator Development

Raincoast Applied Ecology's study provides both a historical baseline and recent information on marine mammal presence in Vancouver. These data can be compared to identify any changes that may have occurred between these study periods. However, to develop this indicator, the presence of marine mammals will need to continue to be monitored in the future. It is likely that Raincoast Applied Ecology will continue to monitor the presence of marine mammals; therefore, they will need to be consulted in the future to inquire whether recent data on marine mammal presence is available.

2.5.12 Pacific Salmon Abundance

Why Monitor Pacific Salmon Abundance?

Pacific salmon are an iconic species of Western Canada. However, many salmon populations are in a state of decline, which is a major issue for our rivers and oceans. Similarly, declining salmon populations pose a major threat to other animals, ecosystems, and British Columbia's economy.

Source of Data

The Pacific Salmon Commission (PSC) and DFO collect data on Pacific salmon. PSC data can be requested directly from PSC or found in annual reports available on the PSC website (www.psc.org). DFO escapement data can be accessed from the Government of Canada's Open Data Portal (www.open.canada.ca/en/open-data).

The following are publications that have completed analyses using available salmon data:

Dorner et al. (2008);
English et al. (2008);
English et al. (2007);
English et al. (2006);
English et al. (2004);
Noble (2012); and
Ruggerone et al. (2010).

Data Description

PSC provides escapement, catch, and harvest rate estimates annually for Pacific salmon. Similarly DFO estimates total run size, harvest rates, catches, fishing effort, and escapement of Pacific salmon annually. Given the complicated process involved in reliably estimating trends in Pacific salmon abundance, experts are often hired to reconstruct salmon runs using this available data. The publications listed above (under the Source of Data section) are recently prepared studies involving run reconstructions of Pacific salmon in the Fraser River. Experts have suggested using these studies to monitor Pacific salmon abundance because they are the most reliable estimates available. Abundance estimates are generally available from the 1950s to the present time for Pink, Chum, Sockeye, and Chinook salmon.

Recommendations on Indicator Development

In developing this indicator, one or two species of salmon could be selected to focus on. For instance, other indicator programs in the Salish Sea have focused solely on Chinook salmon because their abundance has broader implications for the entire ecosystem. Once species have been selected, abundance can be monitored over time using the run reconstruction estimates. Prior to working on this indicator, DFO and PSC should be contacted to request any new reports that may have been completed because they are not always published.

2.5.13 Species at Risk

Why Monitor Species at Risk?

Habitat loss, degradation and fragmentation, land development, and invasive species introduction are all significant human-related threats affecting biodiversity along

Vancouver's waterfront. As a result, many waterfront species have become threatened to various degrees and without effective management, threatened species can disappear from an area altogether. Monitoring threatened species on Vancouver's waterfront can reflect the impact of human activities on waterfront habitats and biodiversity.

Source of Data

Data are available from the BC MOE online Species and Ecosystems Explorer (http://www.env.gov.bc.ca/atrisk/toolintro.html), as well as from the Species at Risk BC website (www.speciesatriskbc.ca).

Data Description

The BC MOE Species and Ecosystems Explorer is a system that analyzes species in BC by their conservation status. Conservation status searches can be conducted by species group, area (Ministry of Environment regions, forest districts, regional districts, or biogeoclimatic zones), and habitat type and/or subtype. The conservation status classification systems that can be applied include the BC list (red, blue, yellow, extinct), provincial status (SRank), global status (GRank), federal designation (SARA), and/or COSEWIC status. Search results are reflective of the current conditions.

The Species at Risk BC system is a similar tool that conducts conservation status analyses by municipality, habitat type, taxonomic group, and management category. The conservation status classification systems that can be applied include the BC list, federal designation, and COSEWIC.

Recommendations on Indicator Development

With the tools identified, the species at risk on Vancouver's waterfront and off the coast of Vancouver can be identified. Species that fall under one specific conservation category or a couple of categories could be monitored. For instance, according to provincial conservation status ranks, red listed species are extirpated, endangered, or threatened; while blue listed species are of special concern. Either the red list solely, or the blue and the red list could be focused on. In addition, other conservation status classification systems, as identified above, could also be used instead of or along with the BC list.

2.5.14 Toxics in the Food Web

Why Monitor Toxics in the Food Web?

When contaminants from various human activities make it into aquatic environments they are picked up by small organisms at the bottom of the food chain (producers) and accumulate in their tissues. Small fish that eat the producers can get a higher dose of the contaminant because of the large number or producers they eat during their life span. Larger fish and birds, that eat the small fish, receive an even higher dose. This

accumulation of toxins continues all the way to the top of the food chain. Therefore, monitoring toxics in the food web can reflect the amount of contaminants entering aquatic environments as well as the overall health of aquatic species, including marine birds.

Source of Data

The following is a list of papers prepared by DFO, Vancouver Aquarium, and Heron Working Group researchers, reporting data on toxics in the food web:

Addison and Ross (2000),
Cullon et al. (2009),
Krahn et al. (2007),
Miller et al. (2015)
Mos et al. (2010),
Mos et al. (2006),
Rayne et al. (2004),
Ross et al. (2013),
Ross et al. (2004), and
Ross et al. (2000).

Data Description

A substantial amount of research has been completed on the concentrations of persistent contaminants in killer whales, harbor seals, herring, and great blue heron in the Salish Sea. Contaminant concentration data is available from the 1980s to the present time and it is highly likely studies will continue to be produced every so often. For most of the research presented, samples have been collected across the Salish Sea; however the results often focus on individual samples, some of which were collected in the Vancouver area.

Recommendations on Indicator Development

Data from the various publications should be compiled and compared. Figures plotting contaminant concentrations over time in the different species for which data is available should be prepared to identify any trends. Recent publications may in fact already contain historical figures presenting trends in contaminant concentrations over time, so these could also be consulted.

2.5.15 Underwater Noise Pollution

Why Monitor Underwater Noise Pollution?

For marine mammals, sound is a primary means of commuting, learning, navigating and foraging. Anthropogenic ocean noise, however, has the potential to interfere with normal marine mammal activities, making it an issue of concern. Monitoring underwater noise

pollution can reflect the degree to which marine mammal activities may be impacted by anthropogenic ocean noise.

Source of Data

Baseline data is available in a recent study (Erbe et al., 2012) conducted by researchers from Curtin University, JASCO Applied Sciences, and the University of St. Andrews. Additionally, data will soon be available through the Enhancing Cetacean Habitat and Observation (ECHO) Program, an initiative led by PMV. Data is not yet available, but should be requested from PMV in the future.

Data Description

Cumulative sound exposure levels from vessel traffic from January to December 2008 are presented for Canada's Pacific Exclusive Economic Zone (EEZ). Data are presented spatially, making it possible to focus solely on the Vancouver area. Areas where the estimated annual average sound pressure level exceeded the EU Marine Strategy Framework Directive of 100 dB in 1/3-octave bands centered on 63 or 125 Hz are also presented.

The ECHO Program will investigate underwater noise in the Strait of Georgia by collecting data on ambient underwater noise conditions, identifying and quantifying underwater noise contributions from various vessel sectors, and using computer modeling to predict how various mitigation methods will reduce underwater noise.

Recommendations on Indicator Development

Erbe et al. (2012) provides a baseline for noise pollution in the Georgia Strait and more specifically, the Vancouver area. As data is released through the ECHO program, this data should be compiled and compared with the baseline data.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Transportation on the Waterfront, and
- Working on the Waterfront.

2.5.16 Point Source Discharges

Why Monitor Point Source Discharges?

Point source discharges release contaminants into the aquatic environment. Different types of point sources release various types and concentrations of contaminants. Point source pollution can affect aquatic organisms and ecosystems as whole and can also pose a threat to public health.

Source of Data

The following sources provide data for this potential indicator:

BIEAP (2010);
Moore (1993); and
UMA Engineering Ltd. (1992).

Data Description

UMA Engineering Ltd. prepared a report for Environment Canada in 1992 identifying the number and location of CSOs discharging into Burrard Inlet and the Fraser River (UMA Engineering, 1992). Where possible, discharge volumes, frequencies, and qualities are also presented.

Moore (1993) reports discharge flows and, where possible, contaminant loadings for industrial effluent discharges, municipal sewage effluent discharges, and wastewater treatment plants discharging into the Fraser River Estuary from 1990-1992. Discharges into the North Arm of the Fraser are specifically focused on.

BIEAP (2010) created an inventory of all point discharges into Burrard Inlet and their associated contaminant loading. The number and location of authorized effluents, combined sewer overflow outfalls, sanitary sewer overflows, storm water outfalls, and tributary streams were reported. Where possible, measured discharge volumes from 2005 were used to estimate contaminant loadings. Although the report focuses on all discharges to Burrard Inlet, discharges from the City of Vancouver are also specifically focused on.

Recommendations on Indicator Development

Baseline data for point source discharges to Burrard Inlet and the Fraser River are available. However, there is no indication that future inventories will be completed. Therefore, if this indicator were to be selected, the Waterfront Initiative may need to be responsible for producing future inventories.

2.5.17 Beach Spawning Forage Fish (to be added when data is received)

Forage fish are an essential component of marine ecosystems, as they provide critical food sources for larger fish and birds. Surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) are two common species inhabiting Vancouver's coast that spawn on gravel and sand beaches. Forage fish populations are impacted by changes that affect their spawning habits. For instance, hardening of the shoreline can lead to degraded spawning habitat quality.

Sea Watch Society has monitored surf smelt spawning in the Vancouver area for the past nine years. Reports and maps are currently being prepared and once they are received a description of the available data will be completed.

2.5.18 Nearshore Pollution (to be added when data is available)

Recently, the Vancouver Aquarium has launched the PollutionWatch Project (PWP) as part of the Ocean Pollution Research Program (Ross, personal communication, July 1, 2015). The goal of this project is to track ocean pollution along the coast of BC by measuring priority pollutants in sediments and mussels. This program will help inform oil spill assessments and monitoring, as well as contribute to knowledge on microplastics concentrations and distribution.

Data collection for PWP has already begun along regions of the BC coast and will begin along the City of Vancouver's shoreline in the near future. Once data becomes available for City of Vancouver sites, this potential indicator should be analyzed and officially included in the indicator list.

2.5.19 Suggested Indicators with Insufficient Supporting Data

The Waterfront Network has suggested the following other potential indicators for this theme, which are not detailed here due to an absence of sufficient supporting data:

1. *Sub-tidal and Intertidal Biodiversity*

To the best of our knowledge, no data is available to support a sub-tidal and intertidal biodiversity indicator.

2.6 Climate Change on the Waterfront

The scientific consensus is in, climate change is well underway and changing our planet. The impacts of climate change on humans and wildlife are already being felt around the globe and right here in Vancouver. As a low-lying city surrounded by water, Vancouver and its waterfront are likely to experience many impacts of the changing climate, including:

1) flooding and/or inundation due to sea level rise;
2) overland flooding due to increased frequency and intensity of precipitation; and
3) damage from increased storm frequency and intensity of wind and rainstorms.

Vancouver is currently leading Canada with its contribution to global climate change mitigation efforts with initiatives such as the Greenest City Action Plan. Moreover, Vancouver has acknowledged that mitigation efforts may reduce future climate change impacts, yet likely not prevent them. Accordingly, Vancouver is also committed to adapting to climate change, which has been demonstrated through the development of the Climate Change Adaptation Strategy.

Climate change indicators tend to fall under distinct categories and therefore, potential indicators for this theme will be discussed under the following three categories:

1) Climate Changes and Impacts,
2) Mitigation, and
3) Adaptation.

Table 7. Data sources and potential indicators for Climate Change on the Waterfront.

Theme	Potential Indicator	Data Source
Climate Change on the Waterfront	**Climate Changes and Impacts**	
	Sea Level	National Oceanic and Atmospheric Administration
	Coastal Storm Surges	Storm Surge BC
	Snow Pack	BC Ministry of Forests, Lands, and Nature Resource Operations
	Precipitation Patterns and Extreme Rainfall Events	Environment Canada
	Sea Surface Temperature	Fisheries and Oceans Canada
	Ocean Salinity	Fisheries and Oceans Canada
	Ocean Acidity (pH)	Vancouver Aquarium
	Mitigation	
	Greenhouse Gas Emissions (produced by buildings, transportation, and waste sources)	CDP; City of Vancouver; Metro Vancouver; BC Ministry of the Environment
	Solid Waste Managed and Landfill Gas Captured	City of Vancouver
	Canopy Cover	City of Vancouver
	Electricity Consumption	CDP; City of Vancouver
	Adaptation	
	Buildings and People in Unprotected Floodplains	Northwest Hydraulic Consultants; City of Vancouver
	Value of Assets Exposed to Sea Level Rise	Organization for Economic Co-operation and Development
	Implemented Actions from the Climate Change Adaptation Strategy	City of Vancouver
	Flood-Proofing Policies	City of Vancouver
	Weather-Related Emergency Response Plans	City of Vancouver
	Shoreline Protection (Land Use Changes, Green	City of Vancouver

	Infrastructure, Grey Infrastructure, and Large Site Redevelopment)	

Climate Changes and Impacts

Climate change refers to a long-term shift in weather conditions and can be monitored using a variety of climate indicators. Indicators falling under this category show the changes we are seeing now and the subsequent impacts. The majority of climate change indicators suggested by the Waterfront Network fall under this category.

2.6.1 Sea Level

Why Monitor Sea Level?

It has been projected that global sea levels will rise approximately 1 meter over the next century (BC MOE, 2015a). On the coast of BC, global changes as well as local effects influence sea level. As a coastal city, sea level rise poses a great threat to the City of Vancouver and its waterfront. Monitoring sea level rise shows how sea level has changed over time and ultimately reflects the physical changes of the city's waterfront.

Source of Data

Sea level data was retrieved from the National Oceanic and Atmospheric Administration (NOAA), which standardizes data from the Permanent Service for Mean Sea Level (PSMSL). Data are publicly available on the NOAA Tides and Currents website (www.tidesandcurrents.noaa.gov).

Data Description

The PSMSL has consistently collected sea level data on Vancouver's waterfront since the 1940s. The tidal gauge station collecting the data is station 822-071 and is located on the downtown Vancouver waterfront. The available sea level data for this station are presented as a monthly mean and annual mean. The NOAA standardizes this data by removing the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents.

Recommendations on Indicator Development

Sea level data is and will continue to be constantly collected at the City of Vancouver station by PSMSL. Data is added to the online database regularly (approximately every year). Therefore, the data availability for this indicator is consistent and data can be collected at regular time intervals.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Access to Nature on the Waterfront,
- Living on the Waterfront,
- Working on the Waterfront, and
- Flourishing Ecosystems on the Waterfront.

2.6.2 Coastal Storm Surges

Why Monitor Coastal Storm Surges?

A coastal storm surge is an abnormal rise of water over the predicted astronomical tide, and is primarily caused by the strong winds in a hurricane or storm. When storm surges are combined with high tides, especially King Tides, the conditions can cause coastal flooding and erosion. This potential indicator reflects the number of occasions where the waterfront was exposed to abnormal water levels, and as a result may have flooded or incurred damages.

Source of Data

Storm Surge BC provides data on storm surges. This information can be accessed from the Storm Surge BC website (www.stormsurgebc.ca).

Data Description

Storm Surge BC prepares an annual storm surge almanac, which identifies risk for storm surges in the coming season, but also documents storm surges that occurred in the previous season. Almanacs are available from 2013 to the present and provide information on storm surges at Point Atkinson (West Vancouver).

Recommendations on Indicator Development

Using the available information, the annual number of storm surges can be compared. Additionally, desktop research could be completed to search for information that could provide additional details for each storm event (ie. damages done). Since storm events are always reported in the media, archived information is likely to be available.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Access to Nature on the Waterfront,
- Living on the Waterfront,
- Working on the Waterfront, and
- Flourishing Ecosystems on the Waterfront.

2.6.3 Snowpack

Why Monitor Snowpack?

Snowpack refers to the total amount of snow and ice on the ground. Climate warming results in less snowpack because some places will get more rain instead of snow and also, snow melts faster because the air is warmer. Over the last century, BC has lost up to 50 percent of its snowpack (Live Smart BC, 2016). Faster melts have and will likely continue to cause floods along the Lower Fraser River.

Source of Data

Data is available from BC FLNR and can be accessed here on their website (bcrfc.env.gov.bc.ca).

Data Description

BC FLNR prepares reports with snowpack data for the Lower Fraser Valley. Eight reports are prepared annually, representing eight survey periods. Snowpack is presented as a percentage of normal snowpack, based on historical equivalents. Reports are available from 1997 to the present.

Recommendations on Indicator Development

Although eight different monitoring periods are available annually, selecting one time period to consistently monitor the percent change of snowpack would save time and be sufficient for showing trends. For instance, organizations on the US Pacific coast using snowpack as an indicator tend to focus on snowpack in the month of April. It would be beneficial to stay consistent with other indicator programs, in order to make geographical comparisons.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.6.4 Precipitation Patterns and Extreme Rainfall Events

Why Monitor Precipitation Patterns and Extreme Rainfall Events?

As air temperatures rise, more moisture evaporates from land and water into the atmosphere. When the atmosphere contains more moisture, it generally means that we can expect more precipitation and heavy downpours. An increase in the frequency and/or intensity of rain events may result in a greater number of floods and increased damages in the City of Vancouver.

Source of Data

Data is available from Environment Canada's Historical Climate Database. Data can be accessed from the Government of Canada's Climate website (http://climate.weather.gc.ca/).

Data Description

Environment Canada reports daily precipitation totals for the Vancouver Harbour weather station. Precipitation data for this station is available from1925 to the present.

Recommendations on Indicator Development

Precipitation patterns could be investigated by plotting total annual precipitation over time for the past few decades. To investigate extreme rainfall events, one-day precipitation events (ie. days with unusually high total precipitation) should be examined. Further analysis could then look at the proportion of annual precipitation that has come in the form of extreme rainfall events.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Access to Nature on the Waterfront,
- Living on the Waterfront,
- Working on the Waterfront, and
- Flourishing Ecosystems on the Waterfront.

2.6.5 Sea Surface Temperature

Why Monitor Sea Surface Temperature?

Water temperature regulates ecosystem functioning in a number of ways. Directly, water temperature can have physiological effects on marine organisms; while indirectly, temperature can affect marine organisms through habitat loss. Therefore, monitoring sea surface temperature can be reflective of the status of marine organisms and ecosystems.

Source of Data

DFO maintains data on sea surface temperature. Data can be accessed here on the DFO Pacific Region website (www.pac.dfo-mpo.gc.ca).

Data Description

Daily sea surface temperature has been measured at a variety of sites in BC. The site closest to Vancouver, which still collects data daily, is Entrance Island in the Georgia Strait. Data from this site are available from 1936 to the present.

Recommendations on Indicator Development

The average annual sea surface temperature could be plotted from 1936 to the present to determine whether there are any local observable trends.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.6.6 Ocean Salinity

Why Monitor Ocean Salinity?

Ocean salinity is the measure of salts dissolved in the ocean. Although the ocean is naturally salty, small variations in ocean surface salinity can cause differences in density, subsequently impacting water cycling and ocean circulation. When salinity and temperature increase, dissolved oxygen decreases, which can have very serious impacts on marine organisms. Salinity is influenced by a variety of factors including evaporation of ocean water, formation of sea ice, and also inputs of freshwater into the ocean. Therefore, monitoring ocean salinity is an indirect way of inferring changes in the hydrological cycle over the ocean.

Source of Data

DFO maintains data on ocean salinity off the coast of BC. Data can be accessed here on the DFO Pacific Region website (www.pac.dfo-mpo.gc.ca).

Data Description

Daily salinity observations have been carried out at a number of sites on the BC coast. The site closest to Vancouver, which still collects data daily, is Entrance Island in the Georgia Strait. Data from this site are available from 1936 to the present.

Recommendations on Indicator Development

Average salinity trends can be investigated by plotting the average annual salinity over time. Since salinity varies with depth, it should be ensured that all the data used are representative of the same depth.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.6.7 Ocean Acidity (pH)

Why Monitor Ocean Acidity?

As the concentration of CO_2 in the atmosphere increases, the amount of CO_2 absorbed by the oceans also increases. An increase in CO_2 absorption results in the reduction of the pH of the world's oceans – a process referred to as ocean acidification. Many marine organisms rely on a process known as calcification to make shells or supporting plates. As the oceans become more acidic, the calcification process is inhibited, which has direct impacts on the growth and survival of these organisms. Since many of these calcium dependent organisms form the primary production of the food chain, ocean acidification has the potential to affect all marine ecosystems. Therefore, monitoring the acidity of the ocean can reflect not only the changes in the chemistry of the ocean, but the status of calcium dependent organisms and marine ecosystems as a whole.

Source of Data

Ocean acidity data is available from the Vancouver Aquarium and must be requested.

Data Description

The Vancouver Aquarium has been monitoring pH in Vancouver Harbour since 1954. Modal pH and extreme ranges are reported.

Recommendations on Indicator Development

Annual modal pH and extreme range data could be plotted over time, from 1954 to the present, to identify any observable trends in pH.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

Mitigation

Climate change mitigation refers to efforts to reduce or prevent greenhouse gas emissions, intending to limit the magnitude of future warming. Although many of the following potential indicators may not appear to have any relation to Vancouver's

waterfront, they all indirectly affect the waterfront by working to reduce future climate change.

2.6.8 Greenhouse Gas Emissions (produced by buildings, transportation, and waste sources)

Why Monitor Greenhouse Gas Emissions?

Since the industrial era, human activities have been adding huge quantities of GHGs to the atmosphere, ultimately altering its composition. GHGs intercept and absorb infrared radiation, thereby trapping heat in the atmosphere and reflecting it back at the Earth. Besides altering Earth's energy budget, GHG emissions have been linked to changes in ecosystem level processes, air temperature and moisture, and sea-level rise. This potential indicator reflects Vancouver's local efforts to reduce GHGs and limit future climate changes.

Source of Data

Industrial Emissions

Industrial emissions data are publicly available here from the BC MOE website.

Total Estimated GHG Emissions and Smog-Forming Pollutants

The CDP (formerly the Carbon Disclosure Project) publishes GHG emissions estimates for Vancouver, as reported by the City of Vancouver municipal government. This data can be accessed here from the CDP website (www.cdp.net).

Total GHG emissions and smog-forming pollutants data was provided by Metro Vancouver as summarized in Metro Vancouver (2013b).

Data Description

Industrial Emissions

Since 2010, as part of the BC Reporting Regulation, any industrial facility operating in BC and emitting 10,000 tonnes or more of carbon dioxide equivalent (CO_2e) per year, must report their emissions to the provincial government annually. Once compiled, GHG emissions data is made available to the public by the BC MOE (Bian, personal communication, May, 2015). The address for each company is provided, enabling calculations of the number of companies in the City of Vancouver emitting 10,000 tonnes or more of CO_2e annually, and the combined CO_2e emissions of these companies.

Total Estimated GHG Emissions and Smog-Forming Pollutants

CDP reports GHG emissions estimates for the Vancouver, as reported by the City of Vancouver. GHG emissions totals are presented in CO_2e and include CO_2, CH_4, and N_2O. GHG emissions for Vancouver are broken down into three categories: buildings, transportation, and waste. Furthermore, GHG emissions estimates are provided for the municipal government's operations.

Metro Vancouver's Emissions Inventory has been conducted on a five-year interval from 1985 – 2010. The Emissions Inventory provides estimates for common air contaminants and GHG emissions. Specifically, the reports provide emissions estimates for carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), sulphur oxides (SO_x), volatile organic compounds (VOCs), inhalable and fine particulate matter (PM_{10} and $PM_{2.5}$ respectively) carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ammonia (NH_3). The Metro Vancouver Emissions Inventory also reports emissions results collectively as smog-forming pollutants, the sum of NO_x, $PM_{2.5}$, SO_x, VOCs, and NH_3. Three main categories are inventoried:

Industrial Sources: large industrial facilities or utilities operating under an air discharge permit.

Area Sources: light industrial, residential, commercial and institutional sources not normally operating under an air discharge permit.

Mobile Sources: passenger cars, trucks, buses, motorcycles, aircraft, marine vessels, railways, construction and lawn and garden equipment.

In the 2010 Emissions Inventory, backcast estimates for 1985 to 2005 were made using historic data from the region. Forecast estimates from 2010 to 2030 were conducted by applying realistic growth assumptions to estimate emissions in the future. Therefore, in the 2010 inventory, annual emissions data are provided at a 5-year interval from 1985 to 2030 for the entire Lower Fraser Valley, including individual estimates for Metro Vancouver, Fraser Valley Regional District, and Whatcom County. Aside from the 2000 Emission Inventory, estimates are not provided specific to the City of Vancouver.

Recommendations on Indicator Development

As with any emissions estimates, they are only as good as the underlying data and methods used to generate this data. Although estimation methods have improved over time, emissions will never be estimated with certainty. This does not mean emissions data is useless, rather suggests that data is most useful for identifying trends than precise emissions values.

Available annually and specifically for the City of Vancouver, industrial emissions would be relatively straightforward to monitor. GHG emissions for Vancouver could also be monitored by plotting GHG emissions over time for the years that data is available.

Emissions estimates could also be broken down by the end user (buildings, transportation, or waste), in order to get a better idea of the source of the emissions. Lastly, total GHG emissions and smog-forming contaminant estimates from Metro Vancouver could be used to demonstrate regional trends.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.6.9 Solid Waste Managed and Landfill Gas Captured

Why Monitor Solid Waste Managed and Landfill Gas Captured?

Landfills are a major source of CO_4 gas – a type of GHG. As waste decomposes in landfills, large quantities of CO_4 are emitted into the atmosphere. Limiting the amount of waste entering landfills and capturing landfill gases are two methods of reducing landfill emissions. Monitoring solid waste entering landfills and captured landfill gas reflects changes in GHG emissions from this source and also the efforts taken to reduce GHG emissions.

Source of Data

The City of Vancouver prepares an annual report for the Vancouver landfill with information on waste and landfill gases. The report can be accessed here on the City of Vancouver website (www.vancouver.ca).

Data Description

As part of the Greenest City 2020 Plan, the City of Vancouver is tracking the total amount of solid waste going to landfills and the volume of landfill gas collected and destroyed. Specifically, the annual reports present the amount of solid waste managed and landfill gas collected in Vancouver.

Recommendations on Indicator Development

The annual total of solid waste entering the Vancouver landfill and the annual total of landfill gas captured can be plotted over time, for the years data is available, to identify any trends. Prior to writing each indicator report, recent data should be compiled from the City of Vancouver annual landfill report.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.6.10 Canopy Cover

Why Monitor Canopy Cover?

Canopy cover is the North American standard for assessing urban forest performance. In addition to the social, aesthetic, and economic benefits, urban forests provide a whole suite of ecological benefits. Urban forests can improve air quality, urban climates, hydrology, energy demand and carbon sequestration, and biodiversity. Importantly, the hydrological benefits include reducing surface runoff, which in turn can reduce the contaminants entering Vancouver's waterways.

Source of Data

The City of Vancouver provides data on canopy cover in Vancouver. This data is presented in the City of Vancouver Urban Forest Strategy report which can be accessed here on the City of Vancouver website (www.vancouver.ca). Light Detection and Ranging (LiDAR) data can also be accessed from the City of Vancouver's Open Data Catalogue. Specifically, the *LiDAR 2013* data package should be downloaded.

Data Description

As part of the Urban Forest Strategy, the City of Vancouver is monitoring canopy cover in Vancouver. In 2013, they used LiDAR technology to estimate canopy coverage in Vancouver and each Vancouver neighbourhood. Furthermore, their analysis estimated the proportion of canopy cover that occurs on streets, in parks, and on private property. Historical canopy cover estimates for Vancouver are also reported for 1995 and 2006 in the Urban Forest Strategy report.

Recommendations on Indicator Development

Vancouver's canopy cover (expressed as a percentage) can be plotted over time, from 1995 to the present, to identify any coverage trends. Additionally, the location of the trees (whether they occur on streets, in parks, or on private property) can also be monitored. As Vancouver prepares updates on the Urban Forest Strategy, canopy cover data can continue to be compiled.

Overlaps with Other Themes

This potential indicator overlaps with the following theme:

- Flourishing Ecosystems on the Waterfront.

2.6.11 Electricity Consumption

Why Monitor Electricity Consumption?

Electricity consumption is an indicator of resource use. Monitoring electricity consumption in Vancouver by energy mix can reflect the energy efficiency of the city and highlight whether electricity is primarily generated from renewable or nonrenewable resources.

Source of Data

CDP provides data on electricity consumption and energy mix. Data can be accessed here from the CDP website (www.cdp.net).

Data Description

CDP provides annual responses, completed by the City of Vancouver municipal government, relating to GHG emissions in the City. Specifically, the responses report the amount of electricity consumed in Vancouver annually. Electricity consumption data reported by the City of Vancouver is based on data from BC Hydro. Energy mix of electricity at a city-wide scale is also reported. Data are available annually from 2012 to the present.

Recommendations on Indicator Development

City-wide electricity consumption and the energy mix used to generate electricity can be monitored over time.

Adaptation

Climate change adaptation refers to the actions taken to manage anticipated adverse effects of climate change. The adaptation indicators presented reflect the efforts underway in Vancouver to adapt to the predicted changes in climate, with a specific emphasis on changes that are expected to impact the waterfront (ie. sea level rise, coastal storm surges, increased intensity of storms, etc.).

2.6.12 Buildings and People in Unprotected Floodplains

Why Monitor Buildings and People in Unprotected Floodplains?

As a low-lying area, surrounded by water, Vancouver is anticipating that climate change may result in an increase in flooding events in the coming years. When flooding does occur, buildings and people in the floodplain are both at risk and therefore, it is important to limit both and/or protect areas designated as floodplains.
Adaptation responses to sea level rise and potential flooding are grouped into the following four categories (City of Vancouver, 2013):

1) Protect: Protect the coastline through structural mechanisms (ie. dikes).
2) Accommodate: Increase flood construction levels, add covenants for liability reduction and retrofit existing buildings.
3) Planned Retreat: Withdraw, relocate or abandon private or public assets due to coastal hazard.
4) Avoid: Identify future 'no build' zones or use land acquisition or restriction tools such as land trusts.

In the coming years, the City of Vancouver should begin to reduce the risk to people and buildings by following one or more of these responses. This potential indicator reflects how many people and buildings are still at risk to flooding events, as well as the progress made in adapting to climate change impacts.

Source of Data

Information is available through a report prepared by Northwest Hydraulic Consultants (NHC) for the City of Vancouver titled, "City of Vancouver Coastal Flood Risk Assessment". The report can be accessed on the City of Vancouver website (www.vancouver.ca).

Data Description

Using predictive models, the NHC study estimates the number of buildings in the City of Vancouver that would be damaged for four scenarios of flooding events. The total number of damaged buildings is reported by level of damage and occupancy type (agriculture, commercial, government, industrial, religious, and residential).

Recommendations on Indicator Development

The study completed by NHC provides a baseline for the number of buildings and people located in unprotected floodplains and therefore, vulnerable to flooding. As the City of Vancouver begins to prepare for potential flooding events, it is likely reports on the adaptation responses being used and the progress made in protecting people and buildings will be published. As this information becomes available comparisons with the baseline can be made.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Living on the Waterfront, and
- Working on the Waterfront.

2.6.13 Value of Assets Exposed to Sea Level Rise

Why Monitor Value of Assets Exposed to Sea Level Rise?

Many important assets are located in areas at risk of flooding or inundation due to sea level rise and/or storm surges. Monitoring the value of assets exposed to sea level rise reflects the measures implemented to protect the Vancouver's assets.

Source of Data

The Organization for Economic Co-operation and Development (OECD) provides estimates for the value of Vancouver's assets exposed to sea level rise and storm surges in their report titled, "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes". This report can be accessed here on the OECD website (www.oecd.org).

Hallegatte et al. (2013) also provides estimates for the value of Vancouver's assets exposed to sea level rise and storm surges. This article can be accessed from the Nature Climate Change journal.

Data Description

The OECD estimates the value of assets exposed to a 100-year flood, under three different scenarios. The first scenario provides an estimate based on the current climate and current population. The second scenario provides an estimate based on the current climate and future population (taking the estimated population growth into account). Lastly, the third scenario provides an estimate based on the future climate and future population. In this study, "current" reflects the conditions of the year 2005.

Hallegatte et al. (2013) estimates the present and future losses, in dollars, of 136 coastal cities, including Vancouver. Present losses are estimated based on the value of the city's assets, in 2005, exposed to a 100-year flood. Specifically, 100-year exposure ($), economic average annual losses ($), and the ratio of average annual losses to Vancouver's GDP are reported for present conditions. In addition, the same parameters are reported for 2050 under a variety of scenarios involving sea level rise and differences in levels of protection.

Recommendations on Indicator Development

Present estimates for the value of assets exposed to flooding can be used as a baseline. It is likely that more studies on asset exposure will be conducted in the future as cities start or continue protecting themselves against climate change. Therefore, as studies are published, estimates can be compared with the baseline to investigate the protection measures implemented.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Transportation on the Waterfront,
- Access to Nature on the Waterfront,
- Living on the Waterfront, and
- Working on the Waterfront.

2.6.14 Implemented Actions from the Climate Change Adaptation Strategy

Why Monitor Implemented Actions from the Climate Change Adaptation Strategy?

The City of Vancouver's Climate Change Adaptation Strategy is a comprehensive plan prepared by the municipal government regarding the actions Vancouver will take to adapt to the anticipated impacts of climate change. The plan is a great step towards adaptation; however monitoring the actions implemented is important to ensure progress toward adaptation continues.

Source of Data

Information is available through the annual evaluations of the Climate Change Adaptation Strategy prepared by the City of Vancouver. Documents should be requested from the City of Vancouver or found on their website (www.vancouver.ca).

Data Description

The City of Vancouver conducts an annual evaluation of the progress made on the Climate Change Adaptation Strategy. Progress reports include a review of adaptation actions that are underway or have been completed.

Recommendations on Indicator Development

Using the annual evaluations, the number of actions implemented and/or in progress can be identified and monitored over time. Additionally, a description of each action implemented and/or in progress can be identified to provide an idea of the scale of each action that has been taken.

2.6.15 Flood-Proofing Policies

Why Monitor Flood-Proofing Policies?

It is anticipated that sea level rise and storm surges will continue to increase flood risk along the City of Vancouver's coastline. Given this flood risk, it is imperative that the buildings built today are designed to be flood resilient throughout their lifespan. Monitoring flood-proofing standards reflects whether actions are being taken to ensure the buildings and structures being built are designed for flood resilience.

Source of Data

Information on flood-proofing policies is available in the City of Vancouver Building Bylaw. The bylaw can be accessed on the City of Vancouver website (www.vancouver.ca).

Data Description

The City of Vancouver Building Bylaw presents the flood construction levels for designated floodplains in the City of Vancouver. According to the City of Vancouver, flood construction level means "the minimum elevation of the underside of a floor system, or of the top of a concrete slab, of a building which is used or may be used for habitation, business, or for the storage of goods which may be damaged by flood water". The bylaw represents the current flood-proofing policies for the city; however, previous versions of the bylaw could be requested to determine what amendments have been made to flood construction levels.

Recommendations on Indicator Development

It is possible in the near future that new government documents will contain flood-proofing policies. Therefore, prior to completing each indicator report, the City of Vancouver must be contacted to see what changes have been made to flood-proofing policies.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Access to Nature on the Waterfront,
- Living on the Waterfront, and
- Working on the Waterfront.

2.6.16 Weather-Related Emergency Response Plans

Why Monitor Weather-Related Emergency Response Plans?

Emergency plans include the actions that should be taken and procedures that should be followed if an emergency were to take place. For the areas of Vancouver that have been identified as high exposure areas, at risk of experiencing various weather-related events (ie. flooding), it is important that emergency plans be created to ensure the safety of Vancouver's citizens.

Source of Data

Information on emergency response plans will be available from the City of Vancouver once plans are developed.

Data Description

Emergency response plans are currently not in place, and therefore, there is no description of this data source. However, as presented in the Sea Level Rise Strategy (City of Vancouver, 2014), the City is planning to pursue emergency response plans for areas of Vancouver already seeing climate change impacts (ie. Locarno Beach and Kits Point).

Recommendations on Indicator Development

This indicator could focus on the number of emergency response plans developed and/or the number/area of coastal locations in Vancouver with specific emergency response plans.

2.6.17 Shoreline Protection (Land Use Changes, Green Infrastructure, Grey Infrastructure, and Large Site Redevelopment)

Why Monitor Shoreline Protection?

Flood management can incorporate various methods of shoreline protection. The City of Vancouver's Sea Level Rise Strategy does just that, incorporating a variety of shoreline protection methods, including land use changes, green infrastructure (ie. wetland development), grey infrastructure (ie. dikes), and large site redevelopment. Different methods of shoreline protection can affect the waterfront's natural character and processes as well as public values. Monitoring shoreline protection on the waterfront can reflect the progress being made to protect the coast and whether or not the methods of shoreline protection selected will enhance or potentially take away from the waterfront.

Source of Data

Information will be available from the City of Vancouver, likely through documents updating the progress made on the Climate Change Adaptation Strategy and/or Sea Level Rise Strategy. Information can be requested from the City of Vancouver.

Data Description

Shoreline protection strategies are still largely in the discussion phase. As actions are taken toward shoreline protection, the City of Vancouver will have detailed information about the projects.

Recommendations on Indicator Development

This indicator could focus on the length of shoreline protected as well as the methods of protection used. For instance, the number of protective grey and green shoreline structures could be compared and/or the length of shoreline for which land use has been modified.

Overlaps with Other Themes

This potential indicator overlaps with the following themes:

- Transportation on the Waterfront,
- Access to Nature on the Waterfront,
- Living on the Waterfront,
- Working on the Waterfront, and
- Flourishing Ecosystems on the Waterfront.

2.6.18 Suggested Indicators with Insufficient Supporting Data

The Waterfront Network has suggested the following other potential indicators for this theme, which are not detailed here due to an absence of sufficient supporting data:

1. *Climate Change Awareness*

To the best of our knowledge, no data is available that could assist in monitoring climate change awareness in Vancouver.

2.7 Conclusions & Next Steps

This report has identified the following data sources and potential indicators for each of the Waterfront Initiative themes (Table 8).

Table 8. Potential indicators and supporting data sources for each Waterfront Initiative theme.

Theme	Potential Indicator	Data Source
Transportation on the Waterfront	Number and Type of Access Points (providing transportation services for people or cargo)	Translink; Aquabus; False Creek Ferries; Port Metro Vancouver
	Water-Based Transit Ridership	Translink
	Cruise Passenger Ridership	Port Metro Vancouver
	Number of Foreign Vessel Arrivals and Gross Tonnage	Port Metro Vancouver
	Harbour Aircraft Movements	Statistics Canada
	Number and Type of Recreational Vessels Moored	Valiance Maritime Consultants Limited
	Number and Type of Recreational Vessels Using Waterfront	Valiance Maritime Consultants Limited
	Fuel Type, Fuel	BC Chamber of Shipping;

	Consumption, and Emissions of Marine Vessels	Metro Vancouver
	Number and Accessibility of Transit Vessels Operating	Translink; False Creek Ferries; Aquabus
	Number of Electric Transit Vessels Operating	Translink; False Creek Ferries; Aquabus
	Goods Transported via Short-Sea Shipping	Metro Vancouver
	Number of Recreational Boating Incidents	Vancouver Marine Communications and Traffic Services
	Sewage Discharge Regulations for Boats	Transport Canada
	Oil Pollution and Spills	Transport Canada's National Aerial Surveillance Program; Government of Canada's Ship-Source Oil Pollution Fund
Access to Nature on the Waterfront	Number and Area of Waterfront Parks	Vancouver Park Board; City of Vancouver
	Length and Type (hard or soft surfaced) of Waterfront Pathways	Vancouver Park Board; City of Vancouver
	Number and Type of Waterfront Special Events	Vancouver Park Board; UBC Fisheries Centre
	Green Transportation Accessibility	City of Vancouver; Translink
	Number of Public Docks, Boat Ramps, and Pump-Out Stations	City of Vancouver
	Number and Area of Public Beaches	City of Vancouver
	Seawall Traffic	City of Vancouver; CityStudio
	Number of Cultural and Heritage Spaces	City of Vancouver
	Number of Marinas and Slips	Valiance Maritime Consultants Limited
	Number of Yacht and Boat Clubs	Valiance Maritime Consultants Limited
	Number of Rental Facilities	Valiance Maritime Consultants Limited
	Recreational Fishing Effort	Fisheries and Oceans Canada
	Number and Area of	Potential sources: City of

	Restored/Rewilded Waterfront Spaces	Vancouver; Vancouver Park Board; BC Ministry of the Environment; Port Metro Vancouver
	Number of Public Washrooms and Water Fountains	City of Vancouver
	First Nations' Fishery Catch	Fisheries and Oceans Canada
Living on the Waterfront	Zoned Residential Land	City of Vancouver
	Housing Costs	Statistics Canada (Census and NHS)
	Number and Type of Waterfront Units	Statistics Canada (Census)
	Number and Type of Affordable Housing Units	City of Vancouver
	Housing Tenure	Statistics Canada (Census and NHS)
	Number and Type of Housing Starts	Canada Mortgage and Housing Corporation
	Rental Unit Availability Rate	Canada Mortgage and Housing Corporation
	Housing Occupant Demographic	Statistics Canada (Census and NHS)
	Green Building Policies and Incentives	City of Vancouver
	Crime Rate	City of Vancouver
	Proportion of Occupant's Income Spent on Housing	Statistics Canada (Census and NHS)
	Access to Amenities	WalkScore; City of Vancouver
	Commuting Duration and Mode of Transportation	Statistics Canada (Census and NHS)
Working on the Waterfront	Industrial, Agricultural, and Commercial Waterfront Land	Metro Vancouver; City of Vancouver
	Economic Contribution of PMV	Port Metro Vancouver
	Economic Contribution of Ocean Sector	UBC Fisheries Centre
	Number and Type of Waterfront Businesses	City of Vancouver
	Authorized Industrial Effluent Discharges	BC Ministry of the Environment; BIEAP
	Oil Spill Response Capacity and Preparedness (Marine	Nuka Research and Planning Group; Western

	and Riverine)	Canada Marine Response Corporation
	Rental Rates of Industrial Lands and Office Space	Colliers International
	Vacancy Rates of Industrial Lands and Office Space	Colliers International
	Net Absorption of Industrial Lands and Offices on the Market	Colliers International
	Number, Type, and Annual Capacity of Timber Processing Facilities	BC Ministry of Forests, Lands, and Natural Resource Operations
	Number and Type of Aquaculture Facilities	Fisheries and Oceans Canada
	Number of Commercial Fishing Licenses (by fishery)	Fisheries and Oceans Canada
	Number and Type of Recreational Marine Operators and Charters	Valiance Maritime Consultants Limited
	Educational Opportunities Available to the Public to Learn about Industrial Activities and History	Port Metro Vancouver
	Number of Coast Guard Stations	Government of Canada Canadian Coast Guard – Western Region
Flourishing Ecosystems on the Waterfront	Water and Sediment Quality	See section 2.5.1
	Recreational Water Quality	Metro Vancouver
	Waterbird Abundance and Diversity	Audubon Society; Bird Studies Canada; Stanley Park Ecology Society
	Air Quality	Metro Vancouver
	Shoreline Habitat	BIEAP; FREMP; Metro Vancouver
	Southern Resident Killer Whale Population	Centre for Whale Research
	Fish Health and Tissue Contaminants	Metro Vancouver
	Eulachon Spawn	Fisheries and Oceans Canada; Moody (2008)
	Pacific Herring Stock and Catch	Fisheries and Ocean Canada
	White Sturgeon Populations	Fraser River Sturgeon Conservation Society
	Marine Mammal Occurrence	Raincoast Applied Ecology

	Pacific Salmon Abundance	Fisheries and Oceans Canada; Pacific Salmon Commission; various publications (see section 2.5.12)
	Species at Risk	BC Ministry of Environment Species and Ecosystems Explorer; Species at Risk BC
	Toxics in the Food Web	Various publications (see section 2.5.14)
	Underwater Noise Pollution	Erbe et al. (2012); Port Metro Vancouver ECHO Program
	Point Source Discharges	BIEAP; Moore (1993); UMA Engineering (1992)
	* Beach Spawning Forage Fish	Sea Watch Society
	*Nearshore Pollution	Vancouver Aquarium PollutionWatch Program
Climate Change on the Waterfront	**Climate Changes and Impacts**	
	Sea Level	National Oceanic and Atmospheric Administration
	Coastal Storm Surges	Storm Surge BC
	Snow Pack	BC Ministry of Forests, Lands, and Nature Resource Operations
	Precipitation Patterns and Extreme Rainfall Events	Environment Canada
	Sea Surface Temperature	Fisheries and Oceans Canada
	Ocean Salinity	Fisheries and Oceans Canada
	Ocean Acidity (pH)	Vancouver Aquarium
	Mitigation	
	Greenhouse Gas Emissions (produced by buildings, transportation, and waste sources)	CDP; City of Vancouver; Metro Vancouver; BC Ministry of the Environment
	Solid Waste Managed and Landfill Gas Captured	City of Vancouver
	Canopy Cover	City of Vancouver
	Electricity Consumption	CDP; City of Vancouver
	Adaptation	
	Buildings and People in	Northwest Hydraulic

	Unprotected Floodplains	Consultants; City of Vancouver
	Value of Assets Exposed to Sea Level Rise	Organization for Economic Co-operation and Development
	Implemented Actions from the Climate Change Adaptation Strategy	City of Vancouver
	Flood-Proofing Policies	City of Vancouver
	Weather-Related Emergency Response Plans	City of Vancouver
	Shoreline Protection (Land Use Changes, Green Infrastructure, Grey Infrastructure, and Large Site Redevelopment)	City of Vancouver

*To be officially included on the indicator list once data is available or received.

2.7.1 Data Gaps

Throughout the data collection process, the following data gaps have been identified:

Transportation on the Waterfront

The following indicators were suggested, but not included in the report because no supporting data is available:

- Presence of Squatter Boats,
- Sewage Dumping Rates,
- Access Point Accessibility (ie. car, bike, and/or boat access),
- Recreational Vessel Fuel Use, and
- Private Ferry Ridership.

Presence of Squatter Boats
Data for the presence of squatter boats and sewage dumping rates would be very difficult to collect because they would require continuous monitoring. For instance, the number of squatter boats on the water varies from day to day, and therefore, collecting data on the presence of squatter boats on any given day, could not reliably reflect how many squatter boats would be present the next day or any other day.

Sewage Dumping Rates
Similarly, since sewage dumping is not permitted within 3 miles of the waterfront, boats that do dump within 3 miles are not complying with regulations and therefore, would be highly unlikely to report details about their dumping.

Access Point Accessibility
Currently, no analysis has been done regarding the accessibility of waterfront access points around Vancouver to pedestrians, cars, bicycles, and boats. However, with interviews, observations, and some geospatial analysis, it should be relatively straightforward to gather current information on the accessibility of waterfront access points.

Recreational Vessel Fuel Use
Next, to the best of our knowledge, recreational vessel fuel use has never been analyzed. It may be possible to receive information on the volume of fuel sold at water-based gas stations around Vancouver. However, without making assumptions, it would still not be possible to determine the volume sold to recreational vessels versus other vessels (ie. commercial fishing vessels).

Private Ferry Ridership
Lastly, data from the private ferry companies operating in False Creek is not available to the public; therefore, all indications about water-dependent transit ridership have been made based on SeaBus ridership. The SeaBus is a great indicator to characterize the quantity of people using transit between the City of Vancouver and the North Shore; however, is likely not reflective of ridership in False Creek.

Access to Nature on the Waterfront

The following indicators were suggested for this theme, but not included in the report because no supporting data is available:

- Car Parking Availability,
- Waterfront Awareness and Educational Opportunities,
- Recreational Waterfront Use, and
- Physical Accessibility of the Water.

Car Parking Availability
Currently, there are a few available data sources relating to parking on the waterfront. Relying on these data sources, however, may be misleading because they do not provide information on all the parking availability on the waterfront and therefore, would greatly underestimate parking availability. Existing datasets include geospatial data for designated disability parking, motorcycle parking, parking meters, pay parking lots, and car share locations. Despite the presence of these data sources, information on free waterfront parking is not available. Since free parking is available at a number of locations, for instance Riverfront Park and Locarno Beach, monitoring parking without the free parking spots would not be complete.

Waterfront Awareness and Educational Opportunities
To the best of our knowledge, data on waterfront awareness or educational opportunities is not available. Gathering this information, would likely involve surveys (to assess waterfront awareness) and/or a comprehensive analysis of companies and

organizations in the city that offer educational opportunities to learn about nature on the waterfront.

Recreational Waterfront Use
Information on recreational waterfront use is not presently accessible, but may be in the coming year. The Vancouver Waterfront Survey (2014) conducted by the City of Vancouver, surveyed waterfront users about their use of the waterfront. The Vancouver Waterfront Survey, however, is unpublished and according to City employees, data will not be released at least until the National Energy Board hearings are concluded. For now, this has been included as a data gap, since we are unsure if the data will be released and exactly what the survey results include.

Physical Accessibility of the Water
A suite of potential indicators has been identified that reflect the physical accessibility of Vancouver's waterfront. However, aside from public beaches, none of the potential indicators presented are reflective of the physical accessibility of the water itself. Although public beaches do reflect the physical accessibility of the water itself, they are not the only shoreline treatment permitting access to the water. In 2011, the Vancouver Park Board investigated shoreline treatments along the waterfront, indicating which treatments permitted access to the water itself and which did not (VPB, 2011). Their analysis, however, has been said to be quite subjective and did not measure the lengths of each shoreline treatment. A reliable analysis of shoreline treatments or another potential analysis that could reflect physical access to the water itself would be a welcomed addition to this theme.

Living on the Waterfront

The following indicators were suggested for this theme, but not included in the report because no supporting data is available:

- Vacant Waterfront Units, and
- Housing Condition.

Vacant Waterfront Units
A couple of studies investigating vacant housing in Vancouver have been completed in recent years (Urban Futures Institute, 2013; BTAworks, 2009). However, these studies focused on the entire city (Urban Futures Institute, 2013) or solely downtown (BTAworks, 2009). The City of Vancouver has recently hired a consultant to analyze BC Hydro and Census data in order to estimate the current number of vacant housing units in Vancouver. Once the City releases the results of this investigation (expected in 2016), it can be determined whether the information could support a vacant housing on the waterfront indicator.

Housing Condition
Housing condition is often used as a housing indicator that reflects whether the housing is adequate for its occupants. For instance whether the house is in need of repair or

perhaps too small for the amount of people living in it. Data on housing condition is most often collected through surveys. However, to the best of our knowledge, there is no data available to support a housing condition indicator for waterfront homes.

Although large amounts of data are available from Statistics Canada and CMHC regarding living in the City of Vancouver, this data is not specific to the waterfront. The use of dissemination areas adjacent to the waterfront has been presented as they represent the smallest geographic scale with data available. Besides conducting a geospatial analysis of residential zoning along the waterfront, no data sources have been identified that could provide information at a smaller scale, specific to the waterfront.

Working on the Waterfront

The following indicators were suggested for this theme, but not included in the report because no supporting data is available:

- Industrial Land Usage, and
- Waterfront/Ocean-Sector Employment (comprehensive estimates).

Industrial Land Usage
Not all of the businesses located on the waterfront are dependent on the water. As Waterfront Forum participants have identified the importance of preserving waterfront space for companies that are dependent on the water itself (GSA, 2015), data that could identify which waterfront businesses are dependent on the water itself, and which are not would be useful for this theme. However, to the best of our knowledge, there is no supporting data available.

Waterfront/Ocean-Sector Employment (comprehensive estimates)
Although ocean sector employment estimates are available, the Waterfront Network has suggested that more comprehensive estimates are needed because the available estimates leave out some important waterfront/ocean sectors. To the best of our knowledge, estimates that encompass a more comprehensive list of ocean sector employment relating to Vancouver's waterfront are not available.

Flourishing Ecosystems on the Waterfront

The following indicator was suggested for this theme, but not included in the report because no supporting data is available:

- Intertidal and Sub-tidal Biodiversity.

Intertidal and Sub-tidal Biodiversity
Communities around the coast of BC have been collecting long-term data on the biodiversity of intertidal ecosystems – data that is not available for the shoreline of the

City of Vancouver. Along with data on intertidal ecosystems, data is absent for sub-tidal ecosystems.

Climate Change on the Waterfront

The following indicator was suggested for this theme, but not included in the report because no supporting data is available:

- Climate Change Awareness.

Climate Change Awareness
To the best of our knowledge, no data is available to support a climate change awareness indicator. Data for this potential indicator would likely best be collected through a survey.

2.7.2 Recommended Next Steps

The preparation of this list of data sources and potential indicators has been one of the first steps in the indicator development process for the Waterfront Initiative. The following discusses the recommended next steps for the indicator development process and ultimately for preparing a State of the Waterfront report.

Evaluation of the Proposed Indicators for a State of the Waterfront Report

The indicators identified in this report should be evaluated for use in a State of the Waterfront report – a form of State of the Environment report. State of the Environment reports have been prepared for decades by various geographic regions around the world. The main objectives of State of the Environment reporting are to (BIEAP, 2002):

- Increase the awareness of the public concerning conditions and trends;
- Help the public understand the relationships between human activities, and environmental quality and the sustainability of ecosystems;
- Provide a broad basis for improved decision making; and
- Serve as a monitoring tool to periodically review and update the various indicators considered.

To prepare a reputable State of the Waterfront report, the Waterfront Initiative should adhere to the following principles defined by the BC MOE (2015c):

- Based on open and best available data, information, and knowledge;
- Based on rigorous, transparent and repeatable scientific investigation;
- Includes consideration of community, social and traditional knowledge; and
- Utilizes leading edge, analytically sound science communication practices.

Following these principles, indicators for the State of the Waterfront report should be evaluated and selected in accordance with specific criteria. It is necessary that all

potential indicators be assessed against the criteria and those achieving the most criteria should be selected. Criteria vary across reports; however, often include (FBC, 2011; Yarnell, 2004):

Available – are the data available and easily accessible?
Understandable – can the data be understood by diverse audiences?
Relevant – does the indictor adequately reflect the theme it is intended to measure?
Scientifically credible – is the research, data and information recognized as a reliable and verifiable source?
Temporal – does the data have the potential to measure trends over time?
Comparable – can indicators be compared with other geographic locations?
Interesting and exciting – does the indicator resonate with the intended audience?

The preparation of a reputable State of the Waterfront report also requires the adoption of a conceptual structure that guides reporting. OECD has presented the Driver-Pressure-State-Impact-Response (DPSIR) framework to be used consistently as a conceptual structure for State of the Environment reporting internationally (BC MOE, 2015b). This framework is followed in BC for environmental reporting and describes human interaction with the environment by investigating the causes (drivers and pressures) and effects (state and impact) of activities occurring at the human-environment interface and the response society takes to address them (BC MOE, 2015b). When following the DPSIR framework, it is necessary to select indicators that can represent each of the following indicator categories (Gabrielsen & Bosch, 2003):

Drivers: Describe the socio-economic and socio-cultural forces driving human activities that increase or mitigate pressures on the environment.

Pressures: Describe developments in release of substances (emissions), physical and biological agents, the use of resources and the use of land by human activities.

State: Give a description of the quantity and quality of physical, biological, and chemical parameters in the specified area.

Impacts: Describe the effects of environmental degradation on the function of the environment and therefore, how humans can use the environment.

Response: Describe the response and attempts of people to prevent, compensate, or ameliorate changes in the state of the environment.

As this framework is consistently followed for State of the Environment reporting in geographic areas around the world, including Canada and more specifically British Columbia, it is recommended that the Waterfront Initiative follow this framework for the State of the Waterfront report.

Selection of Sound Analytical Methods, Data Analysis, and Report Preparation

Once a list of indicators has been identified, sound analytical methods will need to be selected for each indicator requiring analysis. Various analyses should be considered for indicators with complex datasets to ensure sound analytical methods are being used. In addition, benchmarks and standards should be established for a means of comparison. Experts or those most familiar with the datasets should be consulted for input when necessary.

Following the selection of sound analytical methods, an analysis of each supporting data source can be completed. The results of each analysis should let be broken down so that they are easy to understand by everyone, not only experts. Where possible, figures should be presented to provide a visual interpretation of the results to readers. Lastly, it is recommended that the State of the Waterfront report use a consistent, easy to understand system for presenting indicator trends. For instance, a color or symbol to show whether the trend suggests the issue is improving, getting worse, or changing very little. These systems are used by most indicator reports and make result interpretation simple and straightforward for the reader.

The following timeframe has been recommended for the actions leading to the first State of the Waterfront report:

Table 9. Recommended actions and time frame leading to the first State of the Waterfront report.

Actions	Accomplishments	Time Frame
Evaluation of Indicators	• Identify indicator selection criteria • Evaluate and select indicators using selection criteria	1-2 months
Selection of Sound Analytical Methods	• Select sound analytical methods to be used for the analysis of each selected indicator • Consult with experts and those most familiar with the data for input	1-2 months
Data Analysis and Report Writing	• Complete data analysis for each selected indicator • Prepare draft State of the Waterfront report • Receive input on draft report from Waterfront Network • Complete the first State of the Waterfront report	7-8 months

References

Addison, R.F., and Ross, P.S. 2000. Persistent Organic Pollutants (POPs) in British Columbia Harbour Seals and Killer Whales. Canadian Stock Assessment Secretariat Research Document 2000/171.

Aquabus. 2015. The Vancouver Aquabus. Accessed June 15, 2015 at http://theaquabus.com/.

Badzinski, S.S., Cannings, R.J., Armenta, T.E., Komaromi, J., and Davidson, P.J.A. 2006. The British Columbia Coastal Waterbird Survey: An evaluation of survey power and species trends after five years of monitoring. Technical Report Series No. 455. Canadian Wildlife Service, Pacific & Yukon Region, British Columbia and Bird Studies Canada. 100 pp.

Balanced Environmental Services, Inc. 2010. Burrard Inlet Point Source Discharge Inventory. Prepared by Balanced Environmental Services, Inc., North Vancouver, BC for Burrard Inlet Environmental Action Program, Burnaby, BC. 26 pp. + appendices.

BC Ministry of Environment (BC MOE). 2015a. Sea Level Rise and Storm Surges on the B.C. Coast. Accessed July 9, 2015 at http://www2.gov.bc.ca/gov/content/environment/climate-change/policy-legislation-programs/adaptation/sea-level-rise.

BC Ministry of Environment (BC MOE). 2015b. About Environmental Reporting. Accessed June 15, 2015 at http://www.env.gov.bc.ca/soe/about/.

BC Ministry of Environment (BC MOE). 2013. Status of Water Quality Objectives Attainment in Burrard Inlet and Tributaries 1990 to 2010.

BC Ministry of Environment (BC MOE and formerly MWLAP). 2004. Status of Water, Sediment, and Fish Quality in the Lower Fraser River (Hope to the mouth), from 1971 to 2003.

Bertazzon, S., O'Hara, P.D., Barrett, O., and Serra-Sogas, N. 2014. Geospatial analysis of oil discharges observed by the National Aerial Surveillance Program in the Canadian Pacific Ocean. Applied Geography 52: 78-89.

Bian, Q. Personal communication to Tianna Peller on May 19, 2015.

Bjarnason, H., Hotte, N., and Sumaila, U.R. 2015. Potential economic impact of a tanker spill on ocean-dependent activities in Vancouver, British Columbia.

Boyd, J., Baumann, J., Hutton, K., Bertold, S., and Moore, B. 1998. Sediment quality in Burrard Inlet using various chemical and biological benchmarks November 1998.

Prepared for Burrard Inlet Environmental Action Program by BIEAP Environmental Quality Objectives and Monitoring Action Team. 87 pp. + appendices.

BTAworks. 2009. Ownership, Occupancy, and Rentals: An Indicative Sample Study of Condominiums in Downtown Vancouver. Accessed January 9, 2016 at http://www.btaworks.com/wp-content/uploads/2009/12/btaworks_condo_study_report_final2.pdf.

Bull, J. and Freyman, L. 2013. Status of Water Quality Objectives Attainment in Burrard Inlet and Tributaries 1990 to 2010. Prepared for BC Ministry of Environment, Surrey, BC. 48 pp.

Bull, J. 2004. Status of Water, Sediment and Fish Quality in the Lower Fraser River (Hope to the mouth), from 1971 to 2003. Prepared for the BC Ministry of Environment (formerly MWLAP), Surrey, BC.

Burrard Inlet Environmental Action Program (BIEAP). 2002. Consolidated Environmental Management Plan for Burrard Inlet Part D: Implementing the Plan. Accessed June 15, 2015 at http://www.bieapfremp.org/bieap/pdf_files/PART%20D%20May02.pdf.

Canada Place. 2015. Cruise Ships Terminal. Accessed June 2, 2015 at http://www.canadaplace.ca/Facility/Cruise_Ship_Terminal.

Caslys Consulting Ltd. 2009. Burrard Inlet Air Photo-Based Land Cover Mapping Summary Report. Report prepared for the Burrard Inlet Environmental Action Plan. Burnaby, BC by Caslys Consulting Ltd. Saanichton, BC. March 2009. 29 pp.

Chernoff, K.J. and Duckham, C. 2007. FREMP Habitat Inventory Project. Prepared by Chernoff, K.J. and Duckham, C, BC Conservation Corps, for The Fraser River Estuary Management Program, Burnaby, BC.

City of Vancouver. 2013. Climate Change Adaptation Strategy. Accessed January 12, 2016 at http://vancouver.ca/files/cov/Vancouver-Climate-Change-Adaptation-Strategy-2012-11-07.pdf.

City of Vancouver. 2014. Sea Level Rise Strategy. Accessed January 12, 2016 at http://council.vancouver.ca/20140709/documents/cfsc2-presentation.pdf.

City of Vancouver. 2015a. Open Data Catalogue: Parks data. Accessed May 30, 2015 at http://data.vancouver.ca/datacatalogue/parks.htm.

City of Vancouver. 2015b. Open Data Catalogue: Greenways data package. Accessed May 29 at http://data.vancouver.ca/datacatalogue/greenways.htm.

City of Vancouver. 2015c. Green Transportation. Accessed June 2, 2015 at http://vancouver.ca/green-vancouver/green-transportation.aspx.

City of Vancouver. 2015d. Open Data Catalogue: Cultural spaces. Accessed July 21, 2015 at http://data.vancouver.ca/datacatalogue/culturalSpaces.htm.

City of Vancouver. 2015e. Open Data Catalogue: Zoning data package. Accessed June 1, 2015 at http://data.vancouver.ca/datacatalogue/zoning.htm.

City of Vancouver. 2015f. Open Data Catalogue: Non-market housing data. Accessed June 1, 2015 at http://data.vancouver.ca/datacatalogue/nonMarketHousing.htm.

City of Vancouver. 2015g. Green building and renovation. Accessed January 6, 2016 at http://vancouver.ca/home-property-development/green-building-and-renovating.aspx.

CMHC (Canadian Mortgage and Housing Corporation). 2015. About Affordable Housing in Canada. Accessed June 1, 2015 at http://www.cmhc-schl.gc.ca/en/inpr/afhoce/afhoce_021.cfm.

Cullon, D.L., Yunker, M.B., Alleyne, C., Dangerfield, N.J., O'Neill, S., Whiticar, M.J., and Ross, P.S. 2009. Persistent organic pollutants in Chinook salmon (*Oncorhynchus tshawytscha*): Implications for resident killer whales of British Columbia and adjacent waters. Environmental Toxicology 28: 148-161.

Davidson, P. Personal communication to Tianna Peller on June 7, 2015.

D.E. Park & Associates Ltd. 2014. The Economic Importance of the Lower Fraser River. Prepared for the Richmond Chamber of Commerce by D.E. Park & Associates Ltd.

Dorner, B., Peterman, M., and Haeseker, S.L. 2008. Historical trends in productivity of 120 Pacific pink, chum, and sockeye salmon stocks reconstructed by using a Kalman filter. Canadian Journal of Fisheries and Aquatic Sciences 65: 1842-1866.

Drinnan, R.W. and Humphrey, B. 1997. Water Quality in the Fraser River Estuary January 1993 to March 1994.

Elliot, J.E., Wilson, L.K., and Wakeford, B. 2005. Polybrominated Diphenyl Ether trends in eggs of marine and freshwater birds from British Columbia, Canada, 1979 – 2002. Environmental Science and Technology 39: 5584-5591.

Elliot, J.E., Harris, M.L., Wilson, L.K., Whitehead, P.E., and Norstrom, R.J. 2001. Monitoring temporal and spatial trends in polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in eggs of great blue herons (*Ardea Herodias)* on the coast of British Columbia, 1983-1998. A Journal of the Human Environment: 30(7): 416-428.

English, K.K., Bailey, R.E., and Robichaud, D. 2008. Assessment of Chinook returns to the Fraser River watershed using run reconstruction techniques: 1982-2007. Prepared by LGL Limited for Fisheries and Oceans Canada.

English, K.K., Richard, E.B., and Robichaud, D. 2007. Assessment of Chinook salmon returns to the Fraser River watershed using run reconstruction techniques: 1982-2004. Canadian Science Advisory Secretariat Research Document 2007/020.

English, K.K., Peacock, D., and Spilsted, B. 2006. North and central coast core stock assessment program for salmon. Prepared for Fisheries and Oceans Canada and the Pacific Salmon Foundation, Sidney, British Columbia.

English, K.K., Gazey, W.J., Peacock, D., and Oliver, G. 2004. Assessment of the Canadian and Alaskan sockeye stocks harvested in the northern boundary fisheries using run reconstruction techniques, 1982-2001. Pacific Salmon Comm. Tech. Rep. No. 13:93 p.

ENKON Environmental Limited. 2014a. Fraser River Ambient Monitoring Program 2013 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC. 101 pp. + Appendices.

ENKON Environmental Limited. 2014b. Fraser River Ambient Monitoring Program 2012 Fish Sampling. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC. 119 pp. + Appendices.

ENKON Environmental Limited. 2012a. Fraser River Ambient Monitoring Program 2011 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC. 83pp. + Appendices.

ENKON Environmental Limited. 2012b. Fraser River Ambient Monitoring Program 2012 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC. 84 pp. + Appendices.

ENKON Environmental Limited. 2012c. Burrard Inlet Ambient Monitoring Program 2011 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC. 67 pp. + Appendices.

ENKON Environmental Limited. 2011. Burrard Inlet Ambient Monitoring Program 2010 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC. 62 pp. + Appendices.

ENKON Environmental Limited. 2010. Burrard Inlet Ambient Monitoring Program 2009 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2010a. Fraser River Ambient Monitoring Program 2010 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC. 53 pp. + Appendices.

ENKON Environmental Limited. 2009. Fraser River Ambient Monitoring Program 2009 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2008a. Fraser River Ambient Monitoring Program 2008 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2008b. Burrard Inlet Ambient Monitoring Program 2007 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2007a. Fraser River Ambient Monitoring Program 2006 Sediment Monitoring. Prepared for the Greater Vancouver Regional District, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2007b. Fraser River Ambient Monitoring Program 2006 Water Column Monitoring. Prepared for the Greater Vancouver Regional District, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2007c. Fraser River Ambient Monitoring Program 2007 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2006. Fraser River Ambient Monitoring Program 2005 Water Column Monitoring. Prepared for the Greater Vancouver Regional District, Burnaby, BC by ENKON Environmental Limited, Surrey, BC.

ENKON Environmental Limited. 2003. Fraser River Ambient Monitoring Program 2003 Water Colum Monitoring. Prepared for the Greater Vancouver Regional District, Burnaby, BC by ENKON Environment, Surrey, BC.

Erbe, C., MacGillivray, A., and Williams, R. 2012. Mapping cumulative noise from shipping to inform marine spatial planning. J. Acoust. Soc. Am. 132(5): 423-428.

False Creek Ferries. 2015. Ferry Dock Locations. Accessed June 2, 2015 at http://www.granvilleislandferries.bc.ca/find_us.htm.

Fisheries and Oceans Canada (DFO). 2015. Recovery Potential Assessment for Eulachon – Fraser River Designatable Unit. Accessed January 12, 2016 at http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2015/2015_002-eng.pdf.

Fisheries and Oceans Canada (DFO). 2014. Stock Assessment and Management Advice for British Columbia Pacific Herring: 2014 Status and 2015 Forecast. Accessed January 12, 2016 at http://www.dfo-mpo.gc.ca/csas-sccs/publications/sar-as/2014/2014_060-eng.pdf.

Fraser Basin Council (FBC). 2011. Indicators Report 2011: Measuring & Reporting on Sustainability. Accessed June 15, 2015 at http://www.fraserbasin.bc.ca/_Library/Comm_Indicators/report_indicators_lessons_2011.pdf.

Fraser River Estuary Management Program (FREMP). 2005. Updating the FREMP Habitat Classifications.

Fraser River Estuary Management Program (FREMP). 1996a. FREMP Environmental Quality Report.

Fraser River Estuary Management Program (FREMP). 1996b. Updating the FREMP Habitat Inventory and Classification Maps, April 1996. Technical Report H-96-1. New Westminster, BC.

Fraser River Estuary Management Program (FREMP). 1990. Status on Water Quality in the Fraser River Estuary – 1990.

G.L. Williams & Associates Ltd. 1990. Habitat Inventory and Classification of Fraser River North and Middle Arms. Prepared for the North Harbour Commission, Richmond, BC and Department of Fisheries and Oceans, New Westminster, BC and Fraser River Estuary Management Program, New Westminster, BC by G.L Williams & Associates Ltd., Coquitlam, BC.

G3 Consulting Ltd. 2014. Burrard Inlet Ambient Monitoring Program 2012 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by G3 Consulting Ltd. Surrey, BC.

G3 Consulting Ltd. 2004. Fraser River Ambient Monitoring Program 2004 Water Column Sampling. Prepared for the Greater Vancouver Regional District (GVRD), Burnaby, BC by G3 Consulting Ltd., Burnaby, BC.

Gabrielson, P. and Bosch, P. 2003. Environmental Indicators: Typology and Use in Reporting.

Garner, K., and Parfitt, B. 2006. First Nations, Salmon Fisheries, and the Rising Importance of Conservation. Report to the Pacific Fisheries Resource Conservation Council. Accessed January 12, 2016 at http://www.dfo-mpo.gc.ca/Library/322561.pdf.

Georgia Strait Alliance (GSA). 2015. A Waterfront for All: Notes and Reflections from Georgia Strait Alliance's Waterfront Initiative Citizens' Forum. Accessed June 10, 2015

at https://georgiastrait.org/wp-content/uploads/2015/03/15.06.CitizensForum-Report-final.pdf.

Georgia Strait Alliance (GSA). 2014. A Waterfront for All: Notes and Reflections on Georgia Strait Alliance's first Waterfront Forum. Accessed June 8, 2015 at https://georgiastrait.org/wp-content/uploads/2015/03/Waterfront_Network_Forum_2014_Report_final.pdf.

Goyette, D. and Boyd. J. 1989. Distribution and Environmental Impact of Selected Benthic Contaminants in Vancouver Harbour, British Columbia, 1985 to 1987. Environment Canada, Conservation and Protection, Environmental Protection, Pacific and Yukon Region.

Haggarty, D.R. 2001. An evaluation of fish habitat in Burrard Inlet, British Columbia. MSc Thesis, Department of Zoology, University of British Columbia. 161 pp.

Hallegatte, S., Green, C., Nicholls, R.J., and Corfee-Morlot, J. 2013. Future flood losses in major coastal cities. Nature Climate Change 3: 802-806.

InterVISTAS. 2013. 2012 Port Metro Vancouver Economic Impact Study. Prepared for Port Metro Vancouver, Vancouver, BC. 104 pp.

InterVISTAS. 2009. 2008 Port Metro Vancouver Economic Impact Study. Prepared for Port Metro Vancouver, Vancouver, BC. 103 pp.

Jacques Whitford AXYS Ltd. 2008. Burrard Inlet Environmental Indicators Report: Public Consultation Document. Report prepared for Burrard Inlet Environmental Action Program, Burnaby BC by Jacques Whitford AXYS Ltd. Burnaby BC. February 2008. 47 pp.

Keystone Environmental Ltd. 2011. Report of Findings: Fraser River Ambient Monitoring Program 2011 Sediment Sampling. Prepared for Metro Vancouver, Burnaby, BC by Keystone Environmental Ltd., Burnaby, BC. 74 pp. + Appendices.

Keystone Environmental Ltd. 2009. Burrard Inlet Ambient Monitoring Program 2008 Water Column Monitoring. Prepared for Metro Vancouver, Burnaby, BC by Keystone Environmental Ltd., Burnaby, BC. 62 pp. + Appendices.

Krahn, M.M., Hanson, M.B., Baird, R.W., Boyer, R.H., Burrows, D.G., Emmons, C.K., Ford, J.K.B. et al. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Marine Pollution Bulletin 54: 1903-1911.

Lau Texier, Sabrina. 2015. Personal communication to Tianna Peller. June 8, 2015.

Leicester, G. 2002. Transit Ridership Trends in GVRD. Accessed May 29 at http://www.translink.ca/-/media/Documents/about_translink/media/2002/nov28/02112247report.pdf.

Live Smart BC. 2016. Effects of Climate Change. Accessed January 14, 2016 at http://www.livesmartbc.ca/learn/effects.html.

Metro Vancouver. 2015. Transit Ridership 1989-2014. Accessed May 28 at http://www.metrovancouver.org/services/regional-planning/PlanningPublications/TransitRidership.pdf.

Metro Vancouver. 2015b. Short Sea Shipping in Metro Vancouver. Accessed January 11, 2016 at http://www.mcivor-communications.com/pdf/Short_Sea_Shipping_Facts_in_Focus.pdf.

Metro Vancouver. 2014a. 2012 Lower Fraser Valley Air Quality Monitoring Report.

Metro Vancouver. 2014b. 2013 Lower Fraser Valley Air Quality Monitoring Report. Accessed June 2, 2015 at http://www.fvrd.bc.ca/services/airquality/Pages/default.aspx.

Metro Vancouver. 2014c. Sensitive Ecosystem Inventory for Metro Vancouver & Abbotsford 2010-2012 Technical Report. Accessed July 17, 2015 at http://www.metrovancouver.org/services/regional-planning/PlanningPublications/SEITechnicalReport.pdf.

Metro Vancouver. 2013a. Wastewater: The Greater Vancouver Sewerage & Drainage District Environmental Management and Quality Control Annual Report 2013.

Metro Vancouver. 2013b. 2010 Lower Fraser Valley Air Emissions Inventory and Forecast and Backcast: Final Report and Summarized Results. Accessed June 8, 2015 at http://www.metrovancouver.org/services/air-quality/AirQualityPublications/2010LowerFraserValleyAirEmissionsInventoryandForecastandBackcast.pdf.

Metro Vancouver. 2013c. 2011 Lower Fraser Valley Air Quality Monitoring Report.
Metro Vancouver. 2012a. Burrard Inlet Ambient Monitoring Program 2011 Sediment Sampling. Prepared by ENKON Environmental Limited, Surrey, BC.

Metro Vancouver. 2012b. 2010 Lower Fraser Valley Ambient Air Quality Report.

Metro Vancouver. 2011. Metro Vancouver 2010 Industrial Lands Inventory. Accessed June 1, 2015 at http://www.metrovancouver.org/services/regional-planning/PlanningPublications/MetroVancouver2010IndustrialLandsInventoryNov15-2011.pdf.

Metro Vancouver. 2010. Burrard Inlet Ambient Monitoring Program 2008 Sediment Sampling. Prepared by ENKON Environmental Limited, Surrey, BC.

Metro Vancouver. 2010b. Integrated Liquid Waste and Resource Management Plan (ILWRMP). Accessed June, 2015 at http://www.metrovancouver.org/about/publications/Publications/IntegratedLiquidWasteResourceManagementPlan.pdf.

Metro Vancouver. 2010c. 2008 Lower Fraser Valley Ambient Air Quality Report.

Metro Vancouver. 2010d. 2009 Lower Fraser Valley Ambient Air Quality Report.

Metro Vancouver. 2008. 2007 Lower Fraser Valley Ambient Air Quality Report.

Metro Vancouver. 2007. Lower Fraser Valley Ambient Air Quality Report 2006.

Metro Vancouver. 2006. Metro Vancouver 2005 Industrial Lands Inventory. Accessed June 1, 2015 at http://www.metrovancouver.org/services/regional-planning/PlanningPublications/IndustrialLandsInventoryforGreaterVancouver.pdf.

Metro Vancouver. 2006b. Lower Fraser Valley Ambient Air Quality Report 2005.

Miller, A., Elliot, J.E., Elliot, K.H., Guigueno, M.F., Wilson, L.K., Lee, S., and Idrissi, A. 2015. Brominated flame retardant trends in aquatic birds from the Salish Sea region of the west coast of North America, including a mini-review of recent trends in marine and estuarine birds. Science of the Total Environment 502: 60-69.

MNGH (BC Ministry of Natural Gas Development and Responsible for Housing). 2015. Affordable Market Housing. Accessed June 1, 2015 at http://www.housing.gov.bc.ca/MarketHousing/.

Moody, M.F. 2008. Eulachon past and present. Accessed January 12, 2016 at https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0070785.

Moore, K. 1993. Loadings estimated from authorized industrial effluents, the Greater Vancouver Sewerage & Drainage District wastewater treatment plants, and private municipal sewage discharges. Prepared by Karen Moore for Fraser River Estuary Management Program, New Westminster, BC.

Mos, L., Cameron, M., Jeffries, S.J., Koop, B.F., and Ross, P.S. 2010. Risk-based analysis of PCB toxicity in harbor seals (abstract). Integrated Environmental Assessment and Management 6: 631-640.

Mos, L., Morsey, B., Jeffries, S.J., Yunker, M., Raverty, S., De Guise, S., and Ross, P.S. 2006. Both chemical and biological pollution contribute to immunological profiles of free-ranging harbor seals (abstract). Environ. Toxicol. Chem. 25: 3110-3117.

Murphy, P. 2015. Personal communication to Tianna Peller on June 4, 2015.

Murray, C., Nelitz, M., and Pawley, K. 2007. Burrard Inlet Indicators Development – Indicator Data Collection and Analysis. Final Report Prepared by ESSA Technologies Ltd., Vancouver, BC for the Burrard Inlet Environmental Action Program, Burnaby, BC. 91 pp.

National Oceanic and Atmospheric Administration (NOAA). 2015. Mean Sea Level Trends 822-071 Vancouver, Canada. Accessed July 9, 2015 at http://tidesandcurrents.noaa.gov/sltrends/sltrends_global_station.htm?stnid=822-071.

Nautilus Environmental. 2009. Metro Vancouver Ambient Burrard Inlet Monitoring Program Fish Health Survey. Prepared by Nautilus Environmental, Burnaby, BC for Metro Vancouver, Burnaby, BC.

Noble, C. 2012. In-River Backwards Run Reconstruction of Fraser River Sockeye Fisheries from 2002 – 2009 and Initial Validation of the Fraser River Salmon Management Model (FRSMM). Masters Thesis.

Phippen, B. 2001. Assessment of Fraser River Water and Sediment Quality 2000. Prepared for the BC Ministry of Environment (formerly MWLAP).

Port Metro Vancouver (PMV). 2015. Terminals and Facilities. Accessed June 2, 2015 at www.portmetrovancouver.com/en/portusers/landoperations/terminalsandfacilities.aspx.

Port Metro Vancouver (PMV). 2014. Statistics Overview 2014. Accessed June 2, 2015 at http://www.portmetrovancouver.com/docs/default-source/about-facts-stats/2014-statistics-overview.pdf?sfvrsn=0.

Rayne, S., Ikonomou, M.G., Ellis, G.M., Barrett-Lennard, L.G., and Ross, P.S. 2004. PBDEs, PBBs, and PCNs in three communities of free-ranging killer whales (*Orcinus orca*) from the northeastern Pacific Ocean. Environ. Sci. Technol. 38: 4293-4299.

Ross, P. Personal communication to Tianna Peller on July 1, 2015.
Singso, H. 2014. Opportunities for Marine Recreational Activities in Burrard Inlet. Prepared for Valiance Maritime Consultants Limited.

Ross, P.S., Noel, M., Lambourn, D., Dangerfield, N., Calambokidis, J., and Jeffries, S. 2013. Declining concentrations of persistent PCBs, PBDEs, PCDEs and PCNs in harbor seals (*Phoca vitulina*) from the Salish Sea. Progress in Oceanography 115: 160-170.

Ross, P.S., Jeffries, S.J., Yunker, M.B., Addison, R.F., Ikonomou, M.G., and Calambokidis, J. 2004. Harbour seals (*Phoca vitulina*) in British Columbia, Canada, and Washington, USA, reveal a combination of local and global polychlorinated biphenyl, dioxin, and furan signals. Environ. Toxicol. Chem. 23: 157-165.

Ross, P.S., Ellis, G.M., Ikonomou, M.G., Barrett-Lennard, L.G., and Addison, R.F. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: effects of age, sex and dietary preference. Mar. Pollut. Bull. 40: 504-515.

Ruggerone, G.T., Peterman, R.M., Dorner, B., Myers, K.W., and Mantua, N.J. 2010. Abundance of Adult Hatchery and Wild Salmon by Region of the North Pacific. Prepared for the Gordon and Betty Moore Foundation, Presidio, San Francisco.

Stanley Park Ecology Society (SPES). 2014a. Heron Colony Final Report 2014. Accessed July 10, 2015 at http://stanleyparkecology.ca/wp-content/uploads/downloads/2014/09/Stanley-Park-Heron-Report-2014.pdf.

Stanley Park Ecology Society (SPES). 2014b. Vancouver Bald Eagle Update 2014. Accessed July 8, 2015 at http://stanleyparkecology.ca/wp-content/uploads/downloads/2015/01/Eagle-Report-2014-Final.pdf.

Stanley Park Ecology Society (SPES). 2014c. Winter Waterbird Survey 2014. Accessed July 9, 2015 at http://stanleyparkecology.ca/wp-content/uploads/downloads/2014/12/2014-Winter-Waterbird-Report-2.pdf.

Stanley Park Ecology Society (SPES). 2010. State of the Park Report for the Ecological Integrity of Stanley Park. Accessed July 10, 2015 at http://stanleyparkecology.ca/wp-content/uploads/downloads/2012/02/STATE-OF-THE-PARK-REPORT-for-EI-in-SP_Final2.pdf.

Stantec. 2009. Burrard Inlet Shoreline Change – Baseline Assessment: Final Report. Prepared by Stantec, Burnaby, BC for the Burrard Inlet Environmental Action Program (BIEAP), Burnaby, BC. 19 pp.

Statistics Canada. 2011a. 2011 Census for Vancouver CMA. 2011 Census data. Accessed June 8, 2015 at https://www12.statcan.gc.ca/census-recensement/2011/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=933.

Statistics Canada. 2011b. National Household Survey Dictionary 2011. Accessed June 8, 2015 at https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/98-301-X2011001-eng.pdf.

Statistics Canada. 2011c. Census Dictionary 2011. Accessed June 1, 2015 at http://www12.statcan.gc.ca/nhs-enm/2011/ref/dict/99-000-x2011001-eng.pdf.

Sutherland, D. Personal communication to Tianna Peller on May 26, 2015.

Sutherland, D. 2004. Water Quality Objectives Attainment Monitoring in Burrard Inlet in 2002. Prepared for BC Ministry of Environment (Formerly Ministry of Water, Land & Air Protection), Surrey, BC. 55 pp.

Swain, L.G. Walton, D.G., Phippen, B., Lewis, H., Brown, S., Bamford, G., Newson, D., and Lundmas, I. 1998. Water Quality Assessment and Objectives for the Fraser River from Hope to Sturgeon and Roberts Banks: First Update. Prepared for the BC Ministry of Environment.

Swain, L.G. and Walton, D.G. 1993. Chemistry and Toxicity of Sediments from Sloughs and Routine Monitoring Sites in the Fraser River Estuary – 1992. Prepared for the BC Ministry of Environment.

Swain, L.G. and Walton, D.G. 1990. Report on the 1989 Fraser River Sediment Monitoring Program. Prepared for the BC Ministry of Environment.

Swain, L.G.1986. A 1985 Survey of Metals, PCBs, and Chlorophenols in the Sediments, Benthic Organisms and Fish of the Lower Fraser River.

Translink. 2015. Google Transit Feed Specification. Accessed June 1, 2015 at http://www.translink.ca/en/Schedules-and-Maps/Developer-Resources.aspx.

Translink. 2014. 2013 Bus Service Performance Review: Summary Report. Accessed June 1, 2015 at http://www.translink.ca/-/media/Documents/plans_and_projects/managing_the_transit_network/2013%20BSPR/2013_bus_service_performance_review.pdf.

UMA Engineering Ltd. 1992. Combined sewer overflow inventory for the Fraser River Basin and Burrard Inlet. Prepared by UMA Engineering Ltd, Burnaby, BC for Environment Canada North Vancouver, BC.

Urban Futures Institute. 2013. Much Ado About Nothing: What the Census data say, and don't say, about foreign & temporary residents and unoccupied dwellings. Accessed January 6, 2015 at http://www.urbanfutures.com/foreign-unoccupied.

VMCL (Valiance Maritime Consultants Limited). 2014. A Review of Marine Recreational Vessel Activities in Burrard Inlet. Prepared for Trans Mountain Expansion Project.

Vancouver Aquarium. 2011. Southern Resident Population. Accessed July 9, 2015 at http://killerwhale.vanaqua.org/page.aspx?pid=1345.

Vancouver Park Board (VPB). 2011. Vancouver Waterfront Inventory.

WalkScore. 2015. Walk Score Methodology. Accessed January 4, 2015 at https://www.walkscore.com/methodology.shtml.

Yarnell, P. 2004. Environmental Monitoring and the Selection of Environmental Indicators: Preparing a State of the Environmental Report for the Burrard Inlet. Prepared by Yarnell and Associated, Vancouver, BC for Burrard Inlet Environmental Action Program, Burnaby, BC.

Appendix 1.

The following outlines and briefly describes the methodologies used by Bjarnason et al. (2015) to determine the economic contribution of each ocean-dependent industry.

From Bjarnason et al. (2015):

> Commercial fisheries
>
> The value of commercial fisheries was estimated using landed (ex-vessel) catch weight and value for the spot prawn and Dungeness crab fisheries in DFO fisheries management sub-areas adjacent to the City of Vancouver during the years 2000-2013 (Martin Huang, pers. comm., May 23, 2014 and June 10, 2014). Low and high estimates of annual landed values were determined using an average based on the six years with the lowest and highest catch values, respectively.
>
> Direct, indirect and induced economic impacts of the commercial fishing sector were estimated using input-output fishing, hunting and trapping multipliers for BC (Statistics Canada 2010).
>
> Port activities
>
> Estimated total output value, employment and contribution to GDP for port and cruise ship activities was previously reported by InterVISTAS Consulting (2008, 2012). These estimates formed the basis of the current analysis and were not reviewed or verified within the scope of the current analysis. Statistics Canada BC water transportation multipliers (Statistics Canada 2010) were used to estimate the value of direct, indirect and induced economic output value, employment and GDP.
>
> Inner Harbour transportation
>
> Given the difficulty of obtaining detailed financial information about floatplane operations, float plane industry revenues were used as a proxy for economic output value and have been estimated as the product of average ticket price (weighted by flight frequency) and annual passenger volumes for both commercial and sightseeing operations to and from CHX. Statistics Canada BC air transportation multipliers were used to calculate indirect and induced economic output value, employment and GDP (Statistics Canada 2010).
>
> Ocean-dependent tourism
>
> Economic output value, employment and GDP for ocean-dependent tourism was calculated for three separate activity categories: 1) on-water recreation (excluding swimming), ii) beach and seawall use (land-based waterfront

activities plus swimming), and iii) attendance at/participation in ocean-based waterfront events.

Economic output value was calculated for overnight visitors only for the on-water recreation category, and for both overnight tourists and day-visitors in i) the beaches and seawall use category, ii) and ocean-based and waterfront events category.

Total output value for overnight tourists' participation in on-water recreation was calculated as the product of average amount spent per day, total number of days in Vancouver, and total number of overnight tourists who participated in on-water recreation while on holidays, or whose motivation to visit Vancouver was to participate in on-water recreation (participation rates vs. travel motivation rates create a high-low range).

Total output value for overnight tourists and day-visitors' use of beaches and the seawall was calculated as the product of average amount spent per day (weighted by the amount of time spent at the waterfront, e.g. 0.3 representing a few hours) and total number of visitors who visited the beach or seawall while on holidays in Vancouver. A high-low range was created using the confidence interval from the usage ratio of day-visitors, to overnight tourists, to locals from the Vancouver Waterfront Survey (2014).

Total output value for overnight tourists and day-visitors' participation/attendance at ocean-based or waterfront events was calculated as the product of average amount spent per day and total number of visitors whose motivation to visit Vancouver was to participate in/attend an ocean-based or waterfront event, and total number of visitors who participated in/attended an ocean-based or waterfront event in Vancouver regardless of whether the event was a primary travel motivation (participation rates vs. travel motivation rates create a high-low range).

Overnight tourist expenditures are from Tourism Vancouver Overnight Visitor Profiles (2003-2013), with the exception of on-water recreation which are taken from the Non-Motorized Outdoor Recreation in BC study (SFU School of Resource Management 2012). Day-visitor expenditures are taken from the 2010 Travel Survey of Residents of Canada, analyzed by Destination British Columbia (2010). Day-visitor expenditures do not include lodging.

Total economic effects for overnight tourists participation in on-water recreation, and overnight tourists' use of the beach and seawall were calculated using multipliers derived from Tourism BC (2004) by Hotte and Sumaila (2012) for marine recreation in British Columbia. Statistics Canada multipliers for performing arts, spectator sports and related industries and heritage institutions (Statistics Canada 2010) were used to calculate indirect and induced economic output value, employment and GDP for overnight

tourists and day-visitors' participation in ocean-based and waterfront events and for day-visitors using Vancouver beaches and seawall. The growth rate applied is the tourism growth rate for Metro Vancouver based on 10 years of visitor data from 2003-2012 (Tourism Vancouver Visitor Stats)

Locals-Beaches and seawall

The economic contribution of local residents using the waterfront on their days off was calculated as the product of average local spending per day (weighted by the amount of time spent at the waterfront, e.g. 0.3 representing a few hours) and the total number of annual local waterfront users using the waterfront on their day off who reported that the waterfront was a) important to their decision to spend their day off in Vancouver, and that b) they would travel elsewhere if the waterfront were not available for use.

In including this calculation, we are implicitly assuming that locals have a choice in where to recreate on their days off. Local expenditures relating to enjoyment of waterfront amenities are akin to an export of goods and services, just as with tourism. This assumption is supported by the large number of locals who use the waterfront on their days off (95%), of whom 92 percent report that access to the waterfront is an important decision to stay in Vancouver on their days off, and of whom 69 percent said they would travel outside the City to pursue outdoor recreation activities if the waterfront were unavailable. Statistics Canada amusement and recreational industries multipliers (Statistics Canada 2010) were used to calculate indirect and induced economic output value, employment and GDP.