Potential economic impact of a tanker spill on ocean-dependent activities in Vancouver, British Columbia

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Executive Summary

More than a million people live in the vicinity of the Burrard Inlet, 600,000 of whom reside in the City of Vancouver. The sandy beaches, seawall and calm ocean waters skirting Vancouver's shoreline not only contribute to Vancouver's reputation as one of the world's most 'Liveable Cities', but also drive the local economy. Ocean-dependent economic activities in the City are estimated to directly employ four percent of Vancouver's population. When indirect and induced values are also considered, the Burrard Inlet provides employment for approximately eight percent of the City's population. The performance of these five ocean-dependent economic activities (commercial fishing, port activities, inner harbour transportation, tourism, recreation) are closely linked to the condition of the marine environment.

The proposed expansion of the existing Kinder Morgan Trans Mountain pipeline from Edmonton, Alberta to Burnaby, British Columbia, and associated six-fold increase in tanker ship traffic in Burrard Inlet to more than 300 vessels per year, has raised concerns about the potential economic impacts of a spill on the region. A hydrocarbon spill has the potential to adversely affect ocean-dependent activities in the City of Vancouver, including five key industries: 1) commercial fishing; 2) port activities (shipping and cruises); 3) inner harbour transportation; 4) tourism (on-water recreation, ocean-based and waterfront events, visiting beaches and seawall); and 5) local use of the waterfront.

While an attempt has been made to quantify the economic benefits of the Trans Mountain Expansion Project by Kinder Morgan Canada, no attempt has been made to quantify the potential economic costs of a hydrocarbon spill. This report provides an assessment of the potential economic cost of a hydrocarbon spill in the Burrard Inlet on five key ocean-dependent economic activities within the City of Vancouver in order to inform the National Energy Board's (NEB) assessment of the potential costs and benefits of the proposed Trans Mountain Expansion Project (TMEP).

In this report, economic values are expressed in terms of total (i.e. direct, indirect and induced) economic effects on indicators (i.e. economic output value, employment and gross domestic product, "GDP") for ocean-dependent economic activities. Ocean-dependent activities in Vancouver are estimated to currently contribute a total of $6,430-$6,700 million Canadian Dollars (CAD)[1] in output value, 32,520-36,680 PYs of employment and $3,061-$3,261 million in GDP to the Vancouver economy each year.

According to Hodgson (2014), the construction and operation phases of the proposed Trans Mountain Expansion Project are estimated produce total

[1] All monetary values are in Canadian dollars unless otherwise indicated.

economic effects of $2,700 million in output value, 5,758 PY in employment and $1,800 million in GDP to the Vancouver economy, in present value terms, over a 25-year period. It is worth noting that estimates provided by Hodgson (2014) have not been verified within this study. Rather, this report analyses three potential spill scenarios: no spill (no hydrocarbon spill), a hydrocarbon spill in May (16,000 m^3 spill at the First Narrows) and a hydrocarbon spill in October (16,000 m^3 spill at the First Narrows).

Vancouver's ocean-dependent economic activities are estimated to experience larger losses under a May spill scenario than an October spill scenario because approximately 50 percent of ocean-dependent economic activity occurs between May 15 and September 1 each year. Total economic losses resulting from a May spill are estimated to be 115-175 percent higher than those from an October spill.

Differences in impacts between May and October spill scenarios are due to seasonal variations in economic activity in Vancouver's five key ocean-dependent economic activities. Dungeness crabs are harvested year-round; however, the months of May through October tend to be the most productive for commercial fishermen (DFO 2009). The commercial spot prawn season opens on or after May 1 each year and closes by the end of June (DFO 2014). Floatplane transportation is highly seasonal, a May spill would affect 44 percent of annual revenues, whereas an October spill would affect 11 percent of annual revenues[2]. The majority of on-water recreation and waterfront (beaches and seawall use) in Vancouver occurs between the months of May and September and a spill in May would result in greater tourism losses than a spill in October with impacts being felt during peak tourist season. Waterfront and water-based events occur predominantly in the late spring, summer and early fall with only 13 percent of economic output value occurring prior to May 1 in an average year, therefore a spill in May has the potential to generate a greater economic impact than a spill in October since it precedes the event season.

In the event of a May spill, Vancouver's ocean-dependent economy could suffer total losses in the range of $380-$1,230 million in output value, 3,238-12,881 PY of employment and $201-$687 million in GDP. Under this scenario, 45 percent of output value, 138 percent of employment and 40 percent of the contribution to GDP from the proposed Trans Mountain Expansion Project, as estimated by Hodgson (2014) would be lost to the spill by the five economic activities studied in this report.

[2] Based on author's calculation of passenger data provided by Stephanie Isted, Harbour Air, pers. comm., June 24 and 27, 2014.

In the event of an October spill, Vancouver's ocean-dependent economy could suffer total losses in the range of $215-$1,020 million in output value, 1,972-11,216 PY of employment and $115-$575 million in GDP. Under this scenario, 38 percent of output value, 120 percent of employment and 34 percent GDP from the proposed Trans Mountain Expansion Project, as estimated by Hodgson (2014), would be lost to the spill.

The projected losses from a hydrocarbon spill are substantial given the study's narrow focus on the impact to the market values of only five key ocean-dependent economic activities in the City of Vancouver. The value of socio-economic impacts to local residents whose employment is not linked to the Burrard Inlet has not been assessed in this study, including impacts on human health, real property values, community cohesion, local non-tourism businesses, general well-being of the residents in the City of Vancouver, the 'Greenest City' brand and environmental damages. This study also does not include the costs of a spill response, clean-up and litigation activities. Ocean-dependent economic activities in Vancouver encompass only a portion of the local economy that could experience losses from a hydrocarbon spill in the Burrard Inlet. Still, the potential impacts of an oil spill runs into hundreds of million dollars.

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1. Introduction

This report provides an assessment of the potential economic cost of a hydrocarbon spill in the Burrard Inlet on five key ocean-dependent economic activities within the City of Vancouver in order to inform the National Energy Board's (NEB) assessment of the potential costs and benefits of the proposed Trans Mountain Expansion Project (TMEP). Trans Mountain Pipeline ULC has applied to the National Energy Board for a Certificate of Public Convenience and Necessity pursuant to Section 52 of the *NEB Act*.

The Burrard Inlet is an inlet of the Pacific Ocean that is located between the Cities of Vancouver and North Vancouver, in the Province of British Columbia, Canada (Phippen 2001). Unlike many inlets along Canada's west coast, the Burrard Inlet is relatively shallow, receives considerable freshwater inflows from the Fraser River and, for the most part, is unbounded by steep cliffs (Thomson 1981). The Inlet consists of several reaches that are demarcated by infrastructure developments along its shores: i) the Outer Harbour, which includes the densely populated areas of English Bay and False Creek and stretches from Point Atkinson to the First Narrows Bridge; ii) the Inner Harbour which extends between the First and Second Narrows Bridges and; iii) the Central Harbour which includes the portion between Second Narrows and Roche Point in Deep Cove; iv) the Port Moody Arm terminating at the east end of the inlet; and v) the Indian Arm which stretches north from Deep Cove (Figure 1) (Thomson 1981; Phippen 2001).

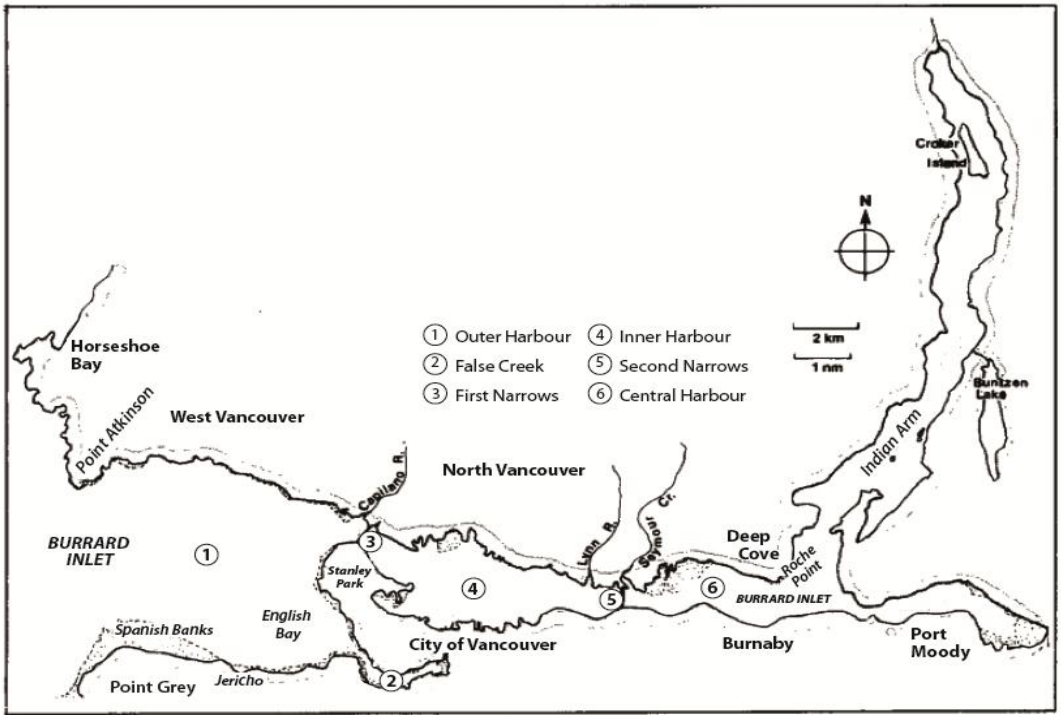

Figure 1. Map of the Burrard Inlet (Adapted from Phippen 2001)

With its sandy beaches and scenic backdrop of the North Shore Mountains and city skyline, the Outer Harbour is actively used by locals and tourists year-round and is one of the most densely populated areas of the Province (Phippen 2001). The Inner Harbour, by comparison, is heavily used by pleasure craft and by commercial vessels accessing Port Metro Vancouver (Phippen 2001). Much of the Inner Harbour has been heavily industrialized using landfill and dredging (Phippen 2001). One major exception is Stanley Park, a 1,000-acre public park that encompasses the spit of land that connects the First Narrows Bridge to the City of Vancouver.

The waters and surrounding lands of Burrard Inlet are within the traditional territories of the Tsleil-Waututh ("The People of the Inlet"; TWN website), Musqueam ("People of the River Grass"; Musqueam website) and Squamish ("Mother of the Wind"; Tourism Squamish website) First Nation peoples. Generations of these peoples have inhabited and cared for the area since time immemorial.

Modern settlements now surround the Burrard Inlet, including the Cities of Vancouver (pop. 603,500), Burnaby (pop. 223,200), Port Moody (pop. 33,000); the City (pop. 48,000) and District (pop. 84,500) of North Vancouver; the Municipality of West Vancouver (pop. 42,500); the Village of Belcarra (pop. 690); the Tsleil-Waututh Nation (pop. 500); and Electoral Area A (pop. 13,000). Ocean-dependent economic activities including shipping, cruise ship operations, marine transportation, marine tourism and commercial and recreational fishing all contribute to the economies of these communities and to the City of Vancouver's reputation as one of the world's "Most Livable" cities (EIU 2013).

Kinder Morgan Canada Inc. (KMC) currently owns and operates the Trans Mountain Pipeline, which transports crude oil and refined hydrocarbon products from Edmonton, Alberta to the Westridge Marine Terminal in Burnaby, British Columbia for shipment via tankers (KMC website). Approximately five Panamax and Aframax class tankers per month currently depart the Westridge Marine Terminal (Lewis 2013), bound for international markets.

The Trans Mountain Expansion Project (TMEP; Figure 2), proposed by Trans Mountain Pipeline ULC (TMP), would nearly triple the capacity of its pipeline from 47,690 cubic metres per day (m^3/d) (300,000 barrels per day; bbls/d) to 141,500 m^3/d (890,000 bbls/d) (TMP 2013) and increase the number of tankers from five to 34 per month[3] (TMP 2013b, p.*A-68). Among other developments, TMEP would require construction of three new berths at the Westridge Marine Terminal, each capable of accommodating Aframax class tanker vessels, and two new 3.6 kilometer (km) buried pipeline segments between the Burnaby Terminal and the Westridge Marine Terminal (TMP 2013).

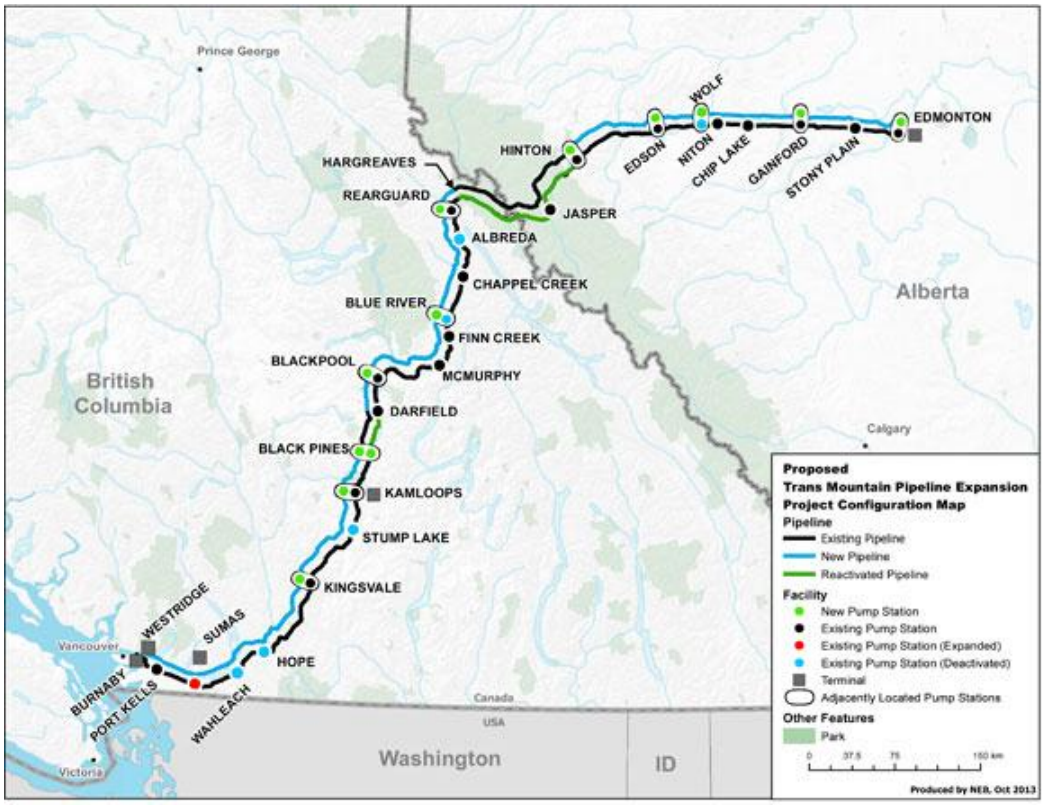

Figure 2. Map of the proposed Trans Mountain Expansion Project
(Source: NEB 2013).

Kinder Morgan Canada pipeline operations have been ongoing since 1956 and TMP projects that the TMEP will generate employment through both project activities (e.g. construction and operations) and supply chain effects (TMP 2013). However, the City of Vancouver, among others, has expressed concerns about the potential increased risk of a tanker spill associated with TMEP. In its Application to Participate in the National Energy Board (NEB) review of TMEP, the City of Vancouver noted that it is the most densely populated urban marine

[3] In 2013, 48 crude oil tankers called on Port Metro Vancouver or approximately 1.5% of all foreign vessel traffic (PMV FAQ: Tanker Safety 2014).

centre in Canada, with many residences and businesses that depend on access to Burrard Inlet, and that its $3,600 million/year tourism industry relies on parks, beaches, the 22 kilometer seawall and waterways (City of Vancouver 2013).

This report provides an assessment of the potential economic cost of a hydrocarbon spill in the Burrard Inlet for five key ocean-dependent economic activities in the City of Vancouver. Economic costs only comprise a portion of total costs that would arise from a hydrocarbon spill, and additional costs include social, environmental and economic externalities that would be incurred by local businesses and local government. Assessing these externalities requires estimating impacts to both market and non-market values, including the use of valuation methods. This report assesses potential economic costs associated with a spill and does not include values for externalities associated with a spill (e.g. environmental damage, loss of option values, human health implications).

Several previous tanker spills offer case studies from which to base assumptions about the potential economic impacts of a tanker spill in the Burrard Inlet. These include the *Exxon Valdez* oil spill (EVOS), which released 260,000 bbls of crude oil into Prince William Sound (PWS), Alaska in 1989; the *Deepwater Horizon* oil spill, which discharged 4.9 million bbls into the Gulf of Mexico from April 20-July 15, 2010; and the *Cosco Busan* spill, which released 1,380 bbls of heavy fuel oil into San Francisco Bay on November 7, 2007. Average values for duration and cost of impacts are drawn from these and other major oil spills for comparison.

Economic values are expressed in terms of total (i.e. direct, indirect and induced) economic effects on indicators (i.e. economic output value, employment and gross domestic product, "GDP") for ocean-dependent economic activities. Estimates include effects on local residents and visitors, both within the City of Vancouver and in other jurisdictions as a result of activities within the City of Vancouver.

The potential impact of a tanker spill was estimated based on assumed (i) durations of marine and coastal area closures; and (ii) market recovery times, by ocean-dependent activity. Estimates of regional economic benefits resulting from the TMEP were calculated using projected regional employment and project-related expenditures reported by Hodgson (2014) in "The Trans Mountain Expansion Project: Understanding the Economic Benefits for Canada and its Regions," which was prepared on behalf of TMEP.

2. Background

2.1. Marine Industries

2.1.1. Commercial fishing

Commercial fisheries within the Burrard Inlet are limited to Dungeness crab (*Metacarcinus magister*) and Spot prawn (*Pandalus platyceros*) and this occurs within the Department of Fisheries and Oceans Canada (DFO) Management Area 28, sub-areas 6-14 (DFO 2014).

The commercial Dungeness crab fishery in the Burrard Inlet is composed of a small commercial fleet of approximately three vessels (Mackenzie 2010). Landed prices for Dungeness crab have risen dramatically in recent years due to growing demand from China, particularly in Shanghai (CBC News 2014). Dungeness crab stocks are believed to be fully exploited (DFO 2000). The fishery is currently managed using a size limit, limited commercial licensing, trap limits, soak limits, sex restrictions, soft-shell restrictions and gear restrictions and all commercial fishers must carry a valid category "R" fishing license (DFO 2014). Such measures are intended to protect the breeding stock and maintain the population. Dungeness crabs are fished year-round; however, the months of May through October tend to be the most productive for commercial fishers (DFO 2009).

The commercial Spot prawn fishery is managed using seasonal and in-season area closures, gear marking and limits, trap mesh size requirements, size limits, daily fishing time restrictions and a daily catch limit (DFO 2014). The season opens on or after May 1 each year, to allow for sufficient prawn growth resulting in increased catch weight and value, and closes by the end of June (DFO 2014).

False Creek Harbour Authority in Vancouver provides long-term moorage for commercial fishing boats and access to the False Creek Fishermen's Wharf, which has been preserved for residents and tourists in Vancouver. The Wharf offers the opportunity to purchase fresh BC fish and seafood straight from commercial fishing boats and is a venue for themed events to support the fishing industry, such as the annual Spot Prawn Festival.

Seafood caught in Burrard Inlet may be processed at one of several processing facilitates in the Lower Mainland of BC. Processors located in Vancouver include Aero Trading, Albion Fisheries, Canadian Fishing Company (Canfisco), Coldfish, Ocean Master Foods International, Organic Ocean, SM Products Ltd., Worldwide Seafoods, 7Seas and many others. For the purpose of this study, the value of seafood processing, marketing, transportation, wholesale, retail and services are assumed to be indirectly linked to the value of fish that are commercially caught within Burrard Inlet. Value that is generated in other jurisdictions is traced back to the original source (*i.e.* Burrard Inlet), where the fish are caught.

Hatchery production

Since 1971, DFO has operated the Capilano River Hatchery along the north shore of Burrard Inlet (DFO 2014). The Hatchery is credited with re-introducing Chinook salmon to the Capilano watershed and supports recreational fishing of coho and steelhead in Burrard Inlet. It also receives more than 200,000 visitors each year (DFO web). In the fall, salmon returning to the Capilano River support a food, social and ceremonial (FSC) fishery for the Squamish First Nation.

Burrard Inlet is also home to several salmon habitat enhancement projects and community-run hatcheries. Volunteer-operated projects exist at Mackay Creek, Morten Creek, Reed Point, Richards Creek and Seymour River (DFO 2014). The Vancouver Aquarium and FortisBC also operate private salmonid enhancement projects.

Mossom Creek Hatchery, established in 1976 and operated by the Burrard Inlet Marine Enhancement Society (BIMES), is the longest running community hatchery in the DFO Salmonid Enhancement Program (Mossom Creek Hatchery website). BIMES focuses on education and stewardship activities in the Burrard Inlet area through programming for students and community members. The Mossom Creek Hatchery building was destroyed by fire in December 2013; however, fundraising efforts are underway to rebuild the facility.

Similarly, Noons Creek Hatchery, established in 1978 and operated by the Port Moody Ecological Society (PMES), is an active learning centre for students, community groups and other visitors (PMES website). The facility also includes a water quality lab that supports a water monitoring program in Noons Creek and other nearby streams and hosts the annual Fingerling Festival. The hatchery raises thousands of young coho and chum salmon each year.

The value of local habitat enhancement projects and community hatcheries are not included in the analysis since the majority of these projects operate outside of the city of Vancouver and fall outside of the geographic scope of this study (e.g. Port Moody).

Monitoring and enforcement

DFO operates three offices whose jurisdiction includes the Burrard Inlet: the Pacific Regional Headquarters in Vancouver, the Center for Aquaculture & Environmental Research in West Vancouver and the Capilano Fish Hatchery. Research, monitoring and enforcement related to fisheries are indirectly linked to commercial and recreational fishing activities.

Food, social and ceremonial fisheries

First Nations' harvest for food, social and ceremonial (FSC) purposes may occur by designated individuals under an authorized aboriginal communal license or harvest document or under fishery treaty agreements (DFO 2014). First Nations' communal licenses and harvest documents identify the locations where FSC fishing can occur; typically, these locations are close to the specific First Nation's reserve lands. The legal right of First Nations to fish for food, social and ceremonial (FSC) purposes was enshrined by the Supreme Court of Canada in 1992 (Robinson Consulting & Associates 2012). FSC fisheries have legal priority over commercial and recreational fisheries.

While not a market-based industry, fishing provides First Nations communities in the region with a source of food and holds spiritual and cultural significance. Indian Arm, in particular, is an important hunting and fishing area for the Coast Salish First Nation, including the Tsleil-waututh, Musqueam and Squamish bands (BC Parks 2014). Designated members of these bands engage in annual FSC salmon and crab fisheries for the community (TWN 2014). Fish are then distributed fresh, canned, smoked or frozen to community members, depending on the time of year, to increase access to seafood species harvested within their traditional territory.

There is no comprehensive, multi-species, published FSC catch data for DFO Management Area 28. Furthermore, the value of FSC catch cannot be estimated using methods applied to commercial catch (e.g. ex-vessel prices) because of the many social, cultural, educational and other benefits associated with FSC fishing (Hotte & Sumaila 2012). FSC fishing contributes considerably to the health and well-being of First Nations communities and the educational, social and cultural values of FSC fishing activities are irreplaceable (Hotte & Sumaila 2012). In the absence of adequate valuation methods to account for these benefits, the value of FSC fisheries is not included in this study.

2.1.2. Port activities

Port Metro Vancouver operates as a non-shareholder, financially self-sufficient corporation reporting to the Federal Minister of Transport. Port Metro Vancouver is the busiest port in Canada and handled 19 percent of Canada's total trade in goods in 2013 while supporting trade with 160 economies worldwide (PMV 2013).

Port Metro Vancouver's operations in the City of Vancouver's Inner Harbour encompass the South Shore Trade Area, which runs the length of the Vancouver waterfront from the Second Narrows bridge to Canada Place and includes two waterfront parks; New Brighton Park in East Vancouver and Crab Park in Gastown. This area houses 10 of Port Metro Vancouver's 28 terminals. Port Metro Vancouver is engaged in both shipping and cruise operations.

Shipping

There are five bulk terminals in the South Shore Trade Area. The Alliance Grain Terminal is a leading Canadian farmer-directed agri-business and one of Canada's largest grain businesses handling wheat, barley, canola and pulses for export mainly to Asia and the Pacific Rim (PMV web). Viterra Inc. owns and operates Canada's largest grain handling network and its Cascadia terminal handles wheat, durum, canola, barley, rye, oats and by-products while its Pacific Elevator terminal handles canola, flax, peas, and various bulk manufactured agri-forage and by-products (PMV website). Lantic Inc. refines, processes, distributes and markets Rogers Sugar brand products in Western Canada and imports bulk raw sugar (PMV website). West Coast Reduction is the largest independent renderer in Western Canada and handles inedible tallow, feather meal, poultry meal, blood meal, fish meals, and fish oil (PMV website).

There are two container terminals in the South Shore Trade Area. Canterm's container facility, operated by DP World, handles cargo for some of the world's largest shipping lines while Vanterm, operated by TSI Terminal Systems Inc. handles containerized cargo, project cargo and bulk oils (PMV website).

Port Metro Vancouver handled 135 million metric tonnes of cargo in 2013 (PMV 2013)[4]. Although Port Metro Vancouver's total cargo volume hit a low of 102 metric tonnes in 2009 due to the global economic turndown (InterVISTAS 2012), annual cargo tonnage has been increasing steadily with 2013 volumes representing a 32 percent increase over 2009 volumes.

[4] Author's calculations based on Port Metro Vancouver Facts and Stats 2013

Cruises

Vancouver is also home to two cruise ships ports operated by Port Metro Vancouver, both operating out of downtown Vancouver. Port Metro Vancouver's cruise ship terminals have been a leading homeport for the Alaskan cruise market for over 20 years and in 2013, Vancouver was named the Top North American Home Port by TripAdvisor's cruise critic (Trip Advisor 2013). Vancouver's two downtown cruise terminals, located at Canada Place and Ballantyne Pier, welcomed 235 vessels carrying more than 813,000 passengers in 2013 (PMV 2014). Round-trip cruises to Alaska comprise 50 percent of cruise itineraries, one-way cruise trips to Alaska comprise 40 percent of cruise itineraries, while the remaining traffic is in-transit, repositioning and Pacific-Northwest cruises (InterVISTAS 2012).

The cruise industry is an important driver for Vancouver's tourism industry as cruise travellers often spend one night or more in Vancouver prior to boarding, or after disembarking the vessel. A Vancouver cruise industry economic impact assessment estimated the average additional spending per passenger, per visit in Vancouver at $316 while the average spending per crew member, per visit was $103 (InterVISTAS 2012). A study by Scarfe (2011) suggests that homeports capture 8.5 times the economic benefits of port-of-call ports such as Victoria.

The Vancouver cruise industry has been on an overall decline since its peak in 2002 when it processed over one million revenue passengers (PMV 2014), a decline that has been largely attributed to the emergence of the Port of Seattle as an alternative homeport for the Alaskan market (InterVISTAS 2012). The Vancouver Alaskan Cruise industry experienced a steep slump from 2010-2012 hitting a low of 579,000 passengers in 2010 (PMV 2014). Although the industry has not recovered to its 2002 peak, passenger volumes in 2013 indicate a 22 percent increase over 2012 volumes and 2014 passenger volumes are expected to match 2013 volumes (PMV 2014). Passenger volumes for 2013 (actual) and 2014 (projected) are slightly above the 10-year average of 806,000 revenue passengers.

2.1.3. Inner Harbour transportation

Vancouver's Inner Harbour is a bustling transportation hub offering public transportation via Seabus between North Vancouver and downtown Vancouver and regular commercial and sightseeing seaplane service to Vancouver Island, the Sunshine Coast and Whistler. False Creek is home to two water taxi services, False Creek Ferries and the Aquabus.

Seabus

Translink operates three commuter ferries on a 12-minute route that ferries passengers across 3.2 km of ocean between the Lonsdale Quay in North Vancouver and Waterfront Station in Downtown Vancouver. A total of 16,000 passengers travel on the Seabus' 120 sailings daily, amounting to six million passenger trips per year (Metro Vancouver 2014). In the event of a Seabus service disruption, Translink offers a commute option via bus across the Lions Gate Bridge to Waterfront Station (Translink, pers. comm., June 15, 2014). Buses carry fewer passengers than a Seabus vessel, so it is expected that commuters would experience travel delays with subsequent impacts to the Vancouver economy. It is also possible that the Lions Gate and Ironworkers Memorial bridges may be closed in the event of a hydrocarbon spill, which would prevent any travel between the North Shore and Vancouver resulting in a larger disruption to the Vancouver economy. The economic impact to the City of Vancouver resulting from Seabus service disruption due to a hydrocarbon spill has not been included in the analysis. The data required to estimate the magnitude and duration of the impact of a hydrocarbon spill (e.g. proportion of Seabus passengers whose final destination is Vancouver, emergency transportation plan in the event of Seabus disruption, cost of emergency transportation options) was not available, and collection of primary data was beyond the scope of the analysis.

Floatplanes

The Vancouver Harbour Flight Centre (CHX) is located in the heart of Downtown Vancouver, adjacent to the Vancouver Convention Centre, and houses 18 seaplane slips. It offers a permanent home to four floatplane operators and processed 282,414 passengers in 2013 (Marty Allard, pers. comm., Aug. 15, 2014).

With a fleet of 34 aircraft, Harbour Air is the largest carrier at CHX and offers commercial float plane service on regularly scheduled flights between downtown Vancouver and Victoria, Nanaimo, Comox, the Gulf Islands and Sechelt. All aircrafts are available for sightseeing as well as private charter flights. Harbour Air also operates WestCoast Air and Whistler Air (Harbour Air website). Seaair Seaplanes offers up to 12 scheduled daily flights from downtown Vancouver to Nanaimo during peak season and a wide variety of charter services which have become a major component of the company's

business (Seaair website). Tofino Air offers charter service to downtown Vancouver (Tofino Air web) while Salt Spring Air offers scheduled service between Salt Spring Island and downtown Vancouver (Salt Spring Air website).

Scheduled commercial flights are popular with business travellers, leisure travellers and tourists alike, as they offer the convenience of downtown-to-downtown air service. All airlines also offer a wide variety of charter and sightseeing services which range from 30-minute panoramic tours of the city and mountains (approx. $112 per person), to remote scenic experiences at isolated alpine lakes (approx. $325), to combination packages which include return air transport to a neighbouring community combined with a second activity such as whale watching ($429), kayaking ($160) and fishing (prices on request based on destination) (Harbour Air website). Vancouver-based floatplane carriers report that 95 percent of sightseeing/scenic passengers are tourists (Stephanie Isted, pers. comm., June 24, 2014; June 27, 2014). Seaplane sightseeing service is highly seasonal and in 2013, 54 percent of scenic flights took place during the summer, 27 percent during the spring, 12 percent during the fall and 7 percent during the winter.[5]

False Creek Water Taxis

False Creek Ferries and the Aquabus operate water-based point-to-point transit and sightseeing services in False Creek. Adult fares range from $3.25 to $5.50 per person depending on the route with options for purchasing day/month/year passes (False Creek Ferries and Aquabus website). Service is offered between many False Creek locations: Granville Island, David Lam Park, Spyglass Place, Stamp's Landing, The Village (Olympic Village), Plaza of Nations, Hornby Street, Maritime Museum and Vancouver Aquatic Centre. False Creek Ferries and the Aquabus serve tourists and residents and contribute to the marine economy, however lack of publicly available data regarding ridership forces the exclusion of these operations from the study. Since the economic contribution of water taxis to the ocean economy is quite small, the results of this analysis are not expected to be significantly affected.

[5] Author's calculations based on passenger statistics provided by Harbour Air through personal communication with Stephanie Isted on June 24 and June 27, 2014.

2.1.4. Ocean-dependent tourism

Tourism is a major economic driver in BC with 6.5 percent of British Columbians being employed in tourism-related activities in 2012 (Hallin 2014). Within BC, the Vancouver, Coast & Mountains Region[6] (VCM) employs 64 percent of the province's tourism sector (Tourism BC 2012).

On average, Metro Vancouver[7] attracts over eight million overnight visitors per year (Tourism Vancouver 2012) while the Vancouver, Coast & Mountains Region captures 57.8 percent of tourism business in the Province of BC (Destination BC 2012). Outdoor recreation activities were reported as the primary motivator for 48 percent of those likely to take a trip to the Vancouver, Coast & Mountains Region, followed by experiencing scenery and nature (32%) and to relax and unwind (16%) (Tourism BC 2012). Water-based outdoor activities motivated 33 percent of Canadian travellers' vacation plans, while 64 percent reported participating in water-based outdoor activities even if they were not the primary reason for travel (Tourism BC, TAMS CAD 2007).

American visitors to BC were highly active in outdoor activities while on trips, when compared to the average US pleasure traveller to all Canadian destinations, and outdoor activities motivated 25 percent of American travel to BC, while 52 percent of American travellers to BC participated in water-based outdoor activities while on vacation (Tourism BC, TAMS US 2007). Overnight visits to Metro Vancouver based on geographic origin indicates that 32 percent of visitors are from BC, 30 percent from elsewhere in Canada (outside of BC), 23 percent from the US and 15 percent from outside Canada and the US (Tourism Vancouver 2011). Canadian and US visitors to Metro Vancouver represent 85 percent of total visitors.

In the Travel Activities and Motivation Survey for Canadian Tourists (TAMS CAD 2007), British Columbia was overwhelmingly rated as the most appealing of all the Canadian provinces to visit with 70 percent of respondents rating BC as very appealing. When choosing a destination to visit, feeling safe at the destination (66%) and not having any health concerns at the destination (50%) were very important considerations in deciding where to travel (Tourism BC, TAMS CAD 2007).

[6] Vancouver, Coast & Mountains Tourism Region (VCM) is one of six recognized tourism regions in British Columbia. The region encompasses four destination areas: Metro Vancouver, Sea to Sky Country (including Whistler Resort), Mighty Fraser Country (including the Fraser Canyon) and the Sunshine Coast.

[7] The Greater Vancouver Regional District is also referred to as Metro Vancouver and includes the municipalities of Anmore, Belcarra , Bowen Island, Burnaby, Coquitlam, Delta, Langley, Lions Bay, Maple Ridge, New Westminster, North Vancouver, Pitt Meadows, Port Coquitlam, Port Moody, Richmond, Surrey, Tsawwassen, Vancouver, West Vancouver, White Rock, Electoral Area A, Abbotsford.

In 2013, overnight visitors to Vancouver spent an average of $92.38 per person, per night with an average trip duration of 4.6 days (Tourism Vancouver Visitor Profiles 2008-2011). BC residents' same-day expenditures while leisure travelling in the Vancouver, Coast & Mountains Region were $73.66 per person (Destination BC 2010).

This study estimates the contribution of the ocean and waterfront to tourism in Vancouver. Ocean-dependent tourism is examined in three distinct categories: 1) on-water recreation (i.e. marine recreation); 2) waterfront park, beach and seawall use; and 3) ocean-based and waterfront events.

2.1.5. Ocean-dependent recreation

The calm ocean waters surrounding Vancouver are a mecca for watersport enthusiasts. From skimboarding on the tidal flats of Spanish Banks to kayaking or dragon boating through the waters of False Creek, to stand-up paddleboardling and paddleboard yoga in English Bay, Vancouver residents and visitors participate in a wide range of watersports, which gives rise to a bustling regional ocean-dependent recreation economy.

A total of 91 percent of British Columbians participate in some form of outdoor activity on an annual basis (Sorensen-Lawrence and Tourism BC 2013). As expected for a community in such close proximity to the water, Vancouver, Coast & Mountains (VCM) residents participate in ocean-dependent outdoor activities at a much higher rate than the BC population. The most popular outdoor activity in the region was hiking (53%) followed by ocean-side beach activities (48%) and over one-quarter of the VCM population reported swimming in the ocean (Sorensen-Lawrence and Tourism BC 2013). Other notable ocean-dependent activities with high participation rates include whale watching or marine based wildlife watching (16%) and motorized boating on the ocean (14%) (Sorensen-Lawrence and Tourism BC 2013). It is interesting to note that freshwater beach activities (including picnicking) at a lake or river were the 3rd most popular activity (46%) in the VCM region and swimming in a lake or river ranked fifth for the region (43%) (Sorensen-Lawrence and Tourism BC 2013). The high participation rates for both ocean-dependent and freshwater activities illustrate the vast opportunities for outdoor water-based recreation in the Vancouver, Coast & Mountains Region and the ample options available for Vancouver residents to recreate on the water in neighboring municipalities. A 2012 study from Simon Fraser University reports that 17.7 percent of the Metro Vancouver population participates in sea kayaking or canoeing for an average of 2.1 days per year and 28.5 percent spend an average of 4.6 days per year on the water fishing (Kux & Wolfgang 2012).

The most current census estimates the City of Vancouver's population at 603,502. Table 1 summarizes Vancouver residents' participation in ocean-dependent recreation in Vancouver based on participation rates reported by Sorensen-Lawrence and Tourism BC (2013). This is a snapshot of Vancouver residents' participation ocean-dependent recreation and does not include sports for which there was not publicly available data such as paddleboarding, skimboarding and sailing.

Table 1: Vancouver resident participation in ocean-dependent recreation (annual)

Activity	***Rate (%)***	***Total Participation ('000s)***
Ocean-side beach activities (incl. picnicking)	48	290
Swimming in the ocean	28	169
Whale watching/marine-based wildlife viewing	16	97
Motorized boating on the ocean	14	84
Sea kayaking/canoeing	18	109
Ocean fishing	18	169

(Data sources: Statistics Canada 2011; Kux and Wolfgang 2012; Sorensen-Lawrence and Tourism BC 2013)

Canadian and American overnight visitors' travel motivations and participation rates for ocean-dependent recreation are taken from Statistics Canada Travel Activities and Motivation Surveys (Tourism BC, TAMS CAD and US 2007). Table 2 reports the percentage of overnight travelers visiting a Canadian destination whose trip was motivated by a specific ocean-dependent activity, and the percentage of overnight travelers visiting a Canadian destination who participated in certain ocean-based activity even if this activity was the not a trip motivator.

Table 2: Overnight visitor participation in ocean-dependent recreation (%)

	Canadian Travellers		American Travellers	
Activity	***Motivated***	***Participated***	***Motivated***	***Participated***
Salt water fishing	1	4	2	7
Ocean kayaking	1	4	0	2
Motor boating	4	17	2	9
Sailing	1	4	1	3
Scuba-ocean	1	3	1	3
Sunbathing/ sitting on beach	17	39	12	28
Whale watching	3	11	n/a	n/a
Swimming in ocean	8	27	8	27

(Data sources: Tourism BC - Travel Activity and Motivation Surveys for CAD and US Travellers 2007)

Tourism Vancouver Island conducted a visitor exit study in 2007 which analyzed the motivation and travel experiences of tourists visiting the Vancouver Island Region from off-Island. No similar study exists for the Metro Vancouver Region, but given the similarities of the two coastal regions, important parallels can be drawn relating to tourists' travel motivations. Three percent of travellers reported "marine activities" to be their primary trip motivator (Tourism Vancouver Island 2007).

Although overnight tourist participation in ocean-dependent recreation in Vancouver is well understood, day-visitor travel to Vancouver from neighbouring municipalities to participate in ocean-dependent recreation is not well documented (excluding day-visitor beach and seawall use which is covered in a subsequent section). Lack of primary data regarding day-visitor participation in ocean-dependent recreation forces the exclusion of these activities from the study, as the collection of primary data was outside the project scope.

A 2005 Destination BC study reported that the Vancouver, Coast & Mountain Region is home to 204 ocean based outdoor business operations. Operations by category are provided below with the number of operators in brackets: Salt Water Fishing-No Lodge (37), Salt water Ocean Kayaking (48), Boat Charters (77), Scuba Diving (24), Marine Wildlife Viewing (2), Sail Cruising (30) and Pocket Cruising (7).

Recreational fishing

Several species are caught recreationally within the Burrard Inlet, including Dungeness crab (Metacarcinus magister), spiny dogfish (Squalus acanthias), Chinook salmon (Oncorhynchus tshawytscha), coho salmon (Oncorhynchus kisutch), pink salmon (Oncorhynchus gorbuscha), sockeye salmon (Oncorhynchus nerka), chum salmon (Oncorhynchus keta) and several species of groundfish, such as sablefish (Anoplopoma fimbria) (DFO 2013). The fishing of any rockfish (e.g. canary, China, copper, rougheye) or lingcod (Ophiodon elongatus), including catch and release, is prohibited in Burrard Inlet (DFO 2014); however, catches do occur and some are reported. Catches of bivalves (e.g. clams, mussels) is also not permitted in Burrard Inlet due to sanitary concerns and crabs may not be caught at nighttime (DFO 2014). Safety-related closures along navigational paths are also in effect.

All recreational fishers must hold a British Columbia Tidal Waters Sport Fishing License. All five salmon species are subject to seasonal restrictions and daily catch limits and fishing hooks must be barbless (DFO 2014). Other species, such as Spot prawns, are also subject to a daily catch limit, but may be caught throughout much of the year (DFO 2014). Between 1999 and 2009, annual

reported recreational catches in Area 28, which includes Burrard Inlet and Howe Sound, ranged from less than 5,000 pieces of fish to more than 63,000 pieces (DFO 2013), indicating inter-annual variation in catch and/or reporting. DFO notes that there is "limited information on recreational catch and effort" of the prawn and shrimp recreational fishery (DFO 2014). Recreational catch reporting has been mandatory since 2013 under the Tidal Waters Sport Fishing License so future research is needed as the data becomes available on the economic value of the recreational fishery (DFO 2014).

Recreational fishing is a leisure activity and a source of food for personal consumption for a diverse group of residents and tourists (i.e. non-residents) of the region (DFO 2014). Off-shore fishing charter operators based in Vancouver also take clients outside the Burrard Inlet for fishing, but generate revenue within the City of Vancouver. The Capilano River hatchery provides locals the opportunity to fish for salmon from spring until late fall (Hsu, 2014). Other popular fishing areas are the Ambleside and Dundarave piers in West Vancouver and Belcarra Regional Park near Port Moody (Hsu 2014).

Beaches, waterfront parks and seawall

With ten sandy beaches[8] skirting the shoreline from Kitsilano to the West End (Figure 3), Vancouver has been named one of the world's Top 10 Beach Cities by National Geographic.[9]

Figure 3: Map of Vancouver beaches and seawall.

[8] Beaches included in this study are Spanish Banks Extension, Spanish Banks West, Spanish Banks East, Locarno, Jericho, Kits, Sunset, English Bay, Second, Third.

[9] See: http://travel.nationalgeographic.com/travel/top-10/beach-cities-photos/

Vancouver beaches attract over three million users per year,[10] waterfront parks attract another five million[11] and the seawall, a scenic 22 kilometer path which meanders the city's waterfront, attracts another 2.7 million users per year.[12] Vancouver beaches are popular with local residents and on an average day from the end of May to September, 54 percent of beach users are locals, another 23 percent are day-visitors from outside the City of Vancouver and the remaining 23 percent are overnight tourists (Vancouver Waterfront Survey 2014). Locals make up 64 percent of seawall users, while day-visitors make up 13 percent of users, and overnight visitors make up 23 percent (Vancouver Waterfront Survey 2014).

The Vancouver Waterfront Survey (2014) suggests that 68 percent of local beach and seawall users visited the waterfront for a few hours or less each visit, with most staying for a few hours, while 27 percent reported staying half a day or more. Day visitors spent the most time at the beach or seawall with 36 percent spending half a day or more (64 percent a few hours or less) per visit, while 30 percent of overnight visitors spent half a day or more at the waterfront (70 percent a few hours or less) per visit.

Local residents who were surveyed on the Vancouver waterfront ranked their preferred use of waterfront amenities as follows: seawall (40%), beach/sand (28%), grassy areas (18%), courts and recreational facilities (7%) and in/on the water (7%) (Vancouver Waterfront Survey 2014). Day visitors and overnight visitors reported similar preferences.

Almost all of the Vancouver residents surveyed on the beaches and seawall during July 2014 (96% of respondents) reported spending some of their days off at the waterfront, and on any given day between May and September, it is estimated that 66 percent of total "local" waterfront users are there on a day off (Vancouver Waterfront Survey 2014). Locals who spent some of their days off at the beach were asked about the importance of the waterfront in their decision to spend their days off in Vancouver with 80 percent of respondents reporting that the waterfront was very important to this decision, 12 percent reporting that it was somewhat important, two percent reporting that it was not very important and one percent reporting that it was not important at all[13]. Locals who used the waterfront on some of their days off were also asked if they would be willing to travel for waterfront/outdoor recreation if the

[10] Annual beach usage reported by the City of Vancouver's official lifeguard counts from Victoria Day to Labour Day. Counts do not include grass/park users as these areas are not guarded.
[11] Waterfront park usage derived from the Vancouver Waterfront Survey 2014. See appendix I for a detailed description of methods used to develop this estimate.
[12] Seawall usage estimated from Historic Seawall Counts – City of Vancouver Transportation Survey 2003-2006. See appendix I for a detailed description of methods used to develop this estimate.
[13] 5% of respondents did not respond to the question relating to the importance of the waterfront in their decision to spend their days off in Vancouver

waterfront in Vancouver was unavailable for use. Of the locals who reported that the waterfront was either very important or somewhat important in their decision to stay in Vancouver on their days off, 50 percent said they would travel to pursue outdoor recreation elsewhere if the waterfront were closed, while 19 percent said that they would travel but were not sure how often. Of those who would travel, 30 percent would be willing to travel 30 minutes or less, 40 percent would travel up to one hour, 22 percent would travel one-two hours, five percent would travel two-three hours and three percent would travel three hours or more.

These figures suggest broad participation in many forms of ocean-dependent recreation by Vancouver residents, which would be disrupted in the event of a waterfront closure.

Typically, economic impact analysis does not include expenditure by residents on activities within their home region since only tourism expenditures can be considered an export of goods and services resulting in direct economic impact. Tourism activity produces a gain or loss in the local economy while recreation by residents creates a transfer of revenue within the region but no associated gain or loss.

The current analysis, supported by data from the 2014 Vancouver Waterfront Survey, suggests that expenditures by residents on some waterfront activities are also an export of goods and services that produce a gain or loss in the local economy. Since many local waterfront users state that access to the waterfront is a key determinant of their decision to recreate in Vancouver on their days off, and that they would be willing to travel to pursue outdoor recreation elsewhere, it is assumed that a closure of the waterfront would lead some residents to pursue outdoor recreation elsewhere and would result in a loss to the Vancouver economy.

Ocean-based and waterfront events

Every year, the City of Vancouver hosts hundreds of events from community street parties, to music and cultural festivals, to world class sporting events like the BMO Vancouver Marathon and the Rio Tinto Dragon Boat Festival. This analysis carves out the economic impact of events that are linked to the ocean environment, either directly (take place on the water), or indirectly (take place on the beach or the seawall). The events that have been included for analysis are inextricably linked to the waterfront environment and therefore reliant on access to the waterfront and the health of the ocean environment for their success. Ocean-dependent events have been organized into six categories, with the number of events and attendance/participation reported in Table 3.

Table 3: Ocean-based and waterfront events* in Vancouver

Type of Event	***# of Events***	***Attendance/ Participation***[+]
Events on the Water	20	428,200
Beach Events	5	58,300
Running Races (seawall)	12	182,000
Triathlons (seawall and ocean)	2	2,600
Community Events/Fundraisers (seawall, beaches, waterfront parks)	8	39,000
Arts/Cultural (seawall, beaches, waterfront parks)	2	134,000

** events noted above with the exception of 'events on the water' have 1000+ attendees/participants per event*

[+] attendance/participation rates include locals, day-visitors and overnight visitors and are reported by City of Vancouver and/or event organizers. This report attempts to include all events that take place on the water regardless of size, but given the difficulty of securing reliable attendance data for small events, the total number of events that take place on or near the water and thus the number of attendees/participants are conservatively estimated. A complete list of events included in this analysis is available in Appendix II.

Travel activity and motivation surveys indicate that festivals and events motivated 16 percent of Canadian travellers' holiday plans, while 43 percent attended or participated in a festival or event while on holiday (Tourism BC TAMS CAD 2007). Fireworks displays motivated three percent of Canadian travel, while another 15 percent of travellers attended a fireworks event while on holidays. Attendance at amateur sporting events motivated five percent of Canadian travellers while 11 percent attended an amateur sporting event. US visitors to BC have similar travel habits with 55 percent of American visitors to BC attending a fair or festival (includes fireworks, community events and free outdoor concerts).

Ocean-based and waterfront events in the City of Vancouver attract local residents, day-visitors who come to Vancouver for an event but do not spend the night in Vancouver, as well as overnight visitors who come to Vancouver for an event and spend at least one night in Vancouver. Aggregated spectator/participant composition for each type of event is provided in Table 4. The percentage of day visitors and overnight visitors motivated to travel because of the event is provided in brackets (expressed as a percentage of total attendees).

Table 4: Ocean-based and waterfront events: participation and motivation rates for locals, day-visitors, and overnight visitors.

Event Type	***Local (%)***	***Day Visitor (%) (primary travel motivation, %)***	***Overnight Visitor (%) (primary travel motivation, %)***
Events on the Water	50	30 (24)	20 (7)
Beach Events	75	13 (11)	12 (5)
Running Races/Triathlons	44	44 (100)	12 (100)
Community Events/Fundraisers	50	30 (25)	20 (9)
Arts/Cultural	50	30 (25)	20 (9)

(Data source: Attendance at events and travel motivation calculated by analyzing survey data from the Vancouver Waterfront Survey 2014 and from data provided by event organizers regarding registration and attendance at events. Detailed methodology in Appendix I).

In 2013, ocean-dependent events in the City of Vancouver attracted 417,000 tourists of whom 306,000 were primarily motivated to come to the City to attend or participate in the event.[14] Apart from running races and triathlons, where all out of town participants are deemed to be motivated to travel to participate in the event, more than 80 percent of day-visitor event attendees/participants are motivated to travel to the city for ocean-based and waterfront events while 40 percent of overnight visitors are motivated to travel to the city for ocean-based and waterfront events.[15]

[14] Tourist attendance/participation in ocean-based and waterfront events for 2013 was calculated by applying travel motivation data obtained through the Vancouver Waterfront Survey (2014) to attendance/participation rates as reported by event organizers in 2013.

[15] Author's calculations based on Vancouver Waterfront Survey (2014) and attendance data provided by event organizers. Running and triathlon events were deemed to motivate 100% of out of town race tourism since athletes must pre-register for the events.

2.2. Proposed Trans Mountain Expansion Project

If approved, the Trans Mountain Expansion Project (TMEP) will generate economic activity (i.e. output value, employment and GDP) associated with development and operation of the expanded Westridge Marine Terminal and pipeline facilities. Capacity of the existing Burnaby tank farm will also be expanded with the addition of 14 new tanks, which will increase the number of tanks from 13 to 27 and the total terminal capacity from 1,685,000 barrels to 4,020,000 barrels (TMP 2013, p. 2-23).

TMP (2013) outlines the development period for the Westridge Marine Terminal, which is expected to begin in Q4 2015 and extend through late 2017, followed by demolition of the existing berth. Construction of TMEP is expected to occur between May 2016 and July 2017 (TMP 2013). Once development is complete, TMEP will enter the operations phase. The existing Trans Mountain Pipeline (TMPL) has been operating for 60 years (TMP 2013); TMP anticipates that TMEP will remain operational for a minimum of 50 years (TMP 2013).

Hodgson (2014) estimated the total potential economic activity generated by the project across Canada and at the provincial level over a 25-year period (2012-2037), including development and operations phases, using information provided by TMP and Statistics Canada Input/Output Multipliers.

Total expenditure on the proposed TMEP during the development phase is estimated at $5,500 million (TMP 2013) over a seven-year period (2012-2018), including planning, procurement and construction. Adjusted for price increases and exclusive of financing costs, Hodgson (2014) bases the economic analysis of project benefits on expenditures of $4,600 million in 2012 dollars. Hodgson (2014) estimates that, during the development phase, the project will generate a nation-wide total of 58,037 PYs of total employment (35,864 PYs in BC), including employment generated through higher netbacks on oil and expected increases in royalty and tax revenues to provincial (Alberta and Saskatchewan) and federal governments. The proposed TMEP is also estimated to contribute $4,900 million to GDP ($2,900 million in BC) (Hodgson 2014).

Economic impacts of the operations phase are attributed to labour, facilities maintenance and other inputs. The analysis in the TMP application includes two scenarios of economic impact during the operations phase: i) a minimum estimate, which includes only existing, signed contracts and commitments; and ii) a maximum estimate, which assumes that the pipeline is fully utilized (Hodgson 2014). Currently, 80 percent of the nominal capacity of the expanded system is committed through written contracts (TMP 2013, p.2-36).

These two scenarios project total employment across Canada during project operations at 50,273 PYs and 65,184 PYs (30,269 PYs to 39,246 PYs in BC), respectively, including employment resulting from higher netbacks and increased government revenues. Project operations are estimated to contribute between $13 billion and $17 billion to Canada's GDP ($8.5 billion to $11.0 billion in BC) (Hodgson 2014).

2.3. A summary of previous case studies: tanker spill impacts

Spills can occur for a number of reasons; for example, tankers can collide or be damaged in storms and accidents can occur in the storage, transportation and/or loading of oil for transit (Burgherr 2007). These incidents can have significant ecological, social and economic impacts, which are affected by the amount of oil spilled, the location of the spill, the proximity to sensitive ecosystems and the choice and success of cleanup efforts (Burgherr 2007).

Assessing the impacts of other oil spills provides insight into the potential impacts that could occur in the Burrard Inlet. In this section, seven spills – Houston Ship Channel, Mississippi River, Kalamazoo River, Sabine-Neches Waterway, *Cosco Busan*, *Exxon Valdez* and *Deepwater Horizon* – are briefly described to provide examples of their economic, environmental and social impacts. The economic impacts of these spills are summarized in Table 5 and underpin analysis of potential economic impacts of a spill in Burrard Inlet in this study.

2.3.1. Houston Ship Channel spill, 2014

In March 2014, an oil tanker and a barge collided, spilling 4,000 barrels of oil into the Houston Ship Channel near Houston, Texas (Rice et al. 2014). Spilled oil, in the form of tar balls, washed up on nearby beaches two days after the event.

In the wake of the incident, Coast Guard officials closed the channel to all vessels including passenger ferries (Rice et al. 2014). The closure was implemented to aid authorities' efforts to contain and recover spilled oil. Despite clean-up efforts, oil spread up to 19 kilometers into nearby Galveston Bay due to wind and wave action. The Channel remained closed to all vessels for a period of three days, causing delays for approximately 100 vessels, including cruise ships (Cook 2014; Fitzsimmons 2014; Kuo 2014). The Port of Houston Authority estimated the economic impact of ship closures at $330 million per day (Powell 2014). With a total reported annual economic impact of $178.5 billion USD in 2011 (Port of Houston Authority 2012), equivalent to a total of $184.9 billion USD in 2013 or $506 million per day, the economic impact of a port closure can be estimated as approximately 65 percent of the average daily output value of the Port of Houston.

2.3.2. Mississippi River spill, 2014

A 104-kilometer section of the Mississippi River, including the Port of New Orleans, was closed to all ship traffic in February 2014 following a collision between a barge and a towboat (McConnaughey 2014a). Approximately 750 barrels of oil were spilled near Vacherie, 50 kilometres west of New Orleans. The closure remained in place for two days and delayed passage for at least 30 vessels (McConnaughey 2014b).

2.3.3. Kalamazoo bitumen spill, 2010

There has only been one instance of a diluted bitumen spill in a marine environment, which occurred in July of 2010 in the Kalamazoo River in Michigan, USA. The spill lasted for over 17 hours before an emergency response team arrived at the scene, and over 20,000 bbls of oil were spilled into the river affecting approximately 65 km of shoreline (Dollhupf & Durno 2011). Some 30 to 50 households were evacuated immediately following due to a high level of benzene in the air (>1 part per million). Residents with water wells near the river were advised not to use the water until the wells could be tested. Members of communities along the impacted waterways experienced health impacts such as headache, nausea and respiratory symptoms, which are consistent with known health effects associated with acute exposure to crude oil (Stanbury et al. 2010).

Unlike crude oil, which is less dense than water, the denser diluted bitumen sank to the bottom of the river, making cleanup efforts extremely difficult (Dollhupf & Durno 2011). Traditional methods of cleanup like booming sensitive environments and using chemical dispersants to break down the oil could not be used in the cleanup response in the Kalamazoo. Instead, non-traditional methods like sediment flushing, raking, aeration and dredging were used and continue to be used to clean oil off the bottom of the river bed. Recovery efforts are still in process, with dredging continuing in sections of the river four years after the initial spill. The overall cost of the spill cleanup and recovery was initially estimated to be $550 million USD in 2010; this estimate was revised to $765 million USD in 2011 (Enbridge Energy LP 2011) and then to $1,000 million USD in 2013 (Shogren 2013).

2.3.4. Deepwater Horizon oil spill, 2010

On April 20, 2010 the mobile offshore drilling unit Deepwater Horizon exploded, caught fire and subsequently sank while drilling a well for BP in the Macondo prospect (*Deepwater Horizon* Oil Spill Trustee Council 2012). The incident killed 11 men and injured 17 others and resulted in the release of an estimated five million bbls of oil into the Gulf of Mexico over nearly three months.

The Deepwater Horizon well was the first large deep-sea spill in history (Schrope 2014). Soon after the event, researchers found evidence that a substantial portion of the oil was suspended in layers of deep ocean water in a highly diffuse form. BP, the primary operator of the well, denied the finding; however, it was later established that more than one-third of the oil (approximately two million bbls) was deposited in patches across at least 3,200 km^2 of deep-sea sediments (Schrope 2014). The impact of this oil on deep sea ecosystems is not yet known.

Several important commercial and recreational fisheries exist within the Gulf of Mexico. Approximately 33 percent of commercial landings and 44 percent of recreational catch comes from the Gulf of Mexico (*Deepwater Horizon* Oil Spill Trustee Council 2012).

On April 29, 2010, a state of emergency was declared in Louisiana due to predictions that the oil slick would reach the coast (CNN 2010). Widespread commercial fishing area closures were implemented on May 2, 2010 (NOAA Fisheries 2014), affecting blue crab, royal red shrimp and other fisheries. Closures in the immediate area of the spill location remained in place until April 19, 2011 (NOAA Fisheries 2014).

The 2012 Natural Resource Damage Assessment update reports that the full extent of impacts of the Deepwater Horizon spill may not be known for many years due to its geographic size, three-dimensional nature and ecological complexity (*Deepwater Horizon* Oil Spill Trustee Council 2012). Potential natural resource injuries span five states (i.e., Florida, Alabama, Mississippi, Louisiana and Texas) and their waters, as well as federal waters. BP initially estimated its cost of claims for economic losses suffered by businesses at $7,800 million USD; however, the company revised this estimate to $9,200 million USD in 2014 following a series of legal appeals (Crooks 2014).

2.3.5. Sabine-Neches waterway spill, 2010

Ship traffic within the Sabine-Neches Waterway, Texas, was restricted for four days in January 2010 following an oil spill that occurred when a barge collided with a tanker (Gonzalez and Malik 2010; Reuters 2010). Limited ship traffic was permitted passage after a four-day full closure. The incident resulted in 11,000 barrels of oil being spilled into the waterway, which is used to transport hydrocarbons to four refineries. The restrictions on shipping forced a decrease in activity at one or more refineries.

2.3.6. *Cosco Busan* tanker spill, 2007

In 2007, the *Cosco Busan* cargo ship struck the Bay Bridge in San Francisco and spilled 53,000 gallons of bunker fuel into the harbor for nearly an hour. Nearly 1,400 hectares of shoreline habitat was affected by the spill, including critical spawning areas for Pacific herring (*Cosco Busan* Oil Spill Trustees 2012).

Though the *Cosco* spill was a relatively small event compared to other oil spill events in the past few decades, it is one of the few examples of a spill in a high density urban environment. For this reason, the spill serves as an important case study in assessing the potential impacts of a tanker spill in Burrard Inlet. The San Francisco Bay Area is home to 7.15 million people (United States Census Bureau 2010) and hosts approximately 17 million tourists each year (San Francisco Travel 2014). Similar to the Vancouver area, San Francisco tourism is built on both the cultural experience of the city as well as the natural beauty of the surrounding areas. Tourists and residents alike use the shoreline for walking, bicycling, wind-surfing and boating (*Cosco Busan* Oil Spill Trustees 2012).

An analysis of the impact of the oil spill on recreational usage of the coast found that over one million user-days had been lost due to the accident. Using a benefit transfer valuation of these lost user-days, the total value of trips lost was estimated at $18.8 million USD. Sixty-two percent of survey participants reported that their outdoor recreation had been affected by the spill. Commercial and recreational fisheries were closed immediately after the spill, from November 14 through November 29, 2007. After the closure was lifted, an advisory was issued to commercial and recreational fishers to avoid exposure of catches to these residual impacted areas. Cleanup efforts lasted for more than a year, with beach closures continuing throughout the recovery process. Overall, cleanup of the *Cosco Busan* tanker spill was over $70 million USD, including $32.3 million USD in natural resource damages (*Cosco Busan* Oil Spill Trustees 2012).

2.3.7. *Exxon Valdez* oil spill, 1989

The *Exxon Valdez* spill in the spring of 1989 was the largest oil spill in the United States until the Deepwater Horizon oil spill of 2010. The *Exxon Valdez* tanker spilled 350,000 barrels of oil into the Prince William Sound of Alaska which affected 2,100 km of coastline. The ecological impacts were severe, including significant losses to wildlife; 250,000 seabirds, 2,800 sea otters, 300 harbour seals, 250 bald eagles and 22 killer whales were killed due to the spill (National Park Service 2009).

The cleanup costs for the Exxon Valdez spill came to $2,100 million USD with a criminal fine of $25 million USD paid by Exxon and/or its insurers (Cohen 2010). The active cleanup lasted for about two years through the spring of 1991 while recovery projects are still occurring more than 20 years later.

Many industries were affected by the spill, most notably tourism and commercial/recreational fishing. The losses to commercial fishermen were due to the closures of the salmon, herring, crab, shrimp, rockfish and sablefish areas in 1989 (Exxon Valdez Oil Spill Trustee Council 2009). Some of these areas remained closed into 1990. Some fish populations recovered over a matter of years, while others such as the Pacific herring population had not recovered even 20 years later. The herring commercial fishery has been closed for 13 out of the past 19 years (Exxon Valdez Oil Spill Trustee Council 2009). Overall the estimated loss to commercial fishers was $6.4-$41.8 million USD in 1989 and $11.1-$44.5 million USD in 1990, primarily due to the loss of sockeye and pink salmon harvests.

Recreational fishers were also affected by closures. The number of non-resident fishing days fell by 25 percent after the spill (Oxford Economics, 2010). The decline is attributed to area closures, fear of contamination, unavailability of boats, and increased traffic at sites outside the spill boundaries. An estimated 127,527 sport fishing trips were lost in 1989 and 40,669 in 1990, contributing to an economic loss of $3.6-$50.5 million (*Exxon Valdez* Oil Spill Trustee Council 1994).

Tourism businesses related to recreational fishing trips, as well as other marine recreational activities such as kayaking and bird watching were also impacted. Tourism businesses reported a 50 percent decline in business in 1992 as compared to before the spill (*Exxon Valdez* Oil Spill Trustee Council 1994). Of the surveyed businesses, 43 percent felt they had been significantly affected by the oil spill (*Exxon Valdez* Oil Spill Trustee Council 1994).

2.4. Burrard Inlet tanker spill modelling

The transport and fate of diluted bitumen in the marine environment differs from that of conventional oil, resulting in different rates of dispersion and evaporation and relative proportions of surface and subsurface hydrocarbons following a spill. Weathering and transport would also be affected by prevailing conditions (e.g. wind, current, tides, temperature) at the time of the spill (Short 2015) and during the subsequent response and clean-up. Under experimental conditions, both conventional crude oil and dilbit products have been found to float on sediment-free saltwater; however, the presence of fine sediments in saltwater combined with "high-energy wave action" caused mixing with dilbit and sinking or dispersal of "tarballs" (floating, heavily-weathered oil) (Environment Canada 2013). Under wave action, chemical dispersants were found to be effective with conventional crude oils, but of limited effectiveness for dispersing dilbit. The rate and extent of evaporation also differs between conventional oil and dilbit.

In addition to differences in chemical composition between the two products, weathering and transport are also affected by prevailing conditions (i.e. wind, current, tides, temperature) at the time of a spill and during the ensuing response and clean-up. Thus, the impacts of a spill in Burrard Inlet will be different from those previously described (i.e. Kalamazoo River, *Cosco Busan*, *Exxon Valdez* and *Deepwater Horizon*). However, impacts experienced during previous spills can provide an important starting point to estimate potential impacts of a spill in Burrard Inlet.

Genwest (2015) created a two-dimensional model to analyze the spill trajectories of four oil spill scenarios in the Burrard Inlet. A spill of 16,000 cubic metres (m^3) was modeled at each of three locations: i) First Narrows Bridge; ii) Second Narrows under the Canadian National Railway Bridge; and iii) Outer Harbour at Anchorage #8. A fourth spill of 8,000 cubic metres (m^3) was modeled at the Westridge Marine Terminal. Scenario modeling was conducted using GNOME (General NOAA Operational Modeling Environment) and incorporated physical transport processes (e.g. tidal currents), a constant wind, and historical observed wind and tide data (Genwest 2015).

Based on results from the four spill scenarios, Genwest concludes that the unique geophysical setting of the Burrard Inlet can result in distinctive behavior of oil in the event of a spill. The confined setting of the inlet can result in oil spreading quickly with potential to affect the entire inlet from the Port Moody and Indian Arms, to the Outer Harbour and beyond (Genwest 2015). Winds and tides are major drivers of oil movement in the inlet with strong winds tending to strand oil on the leeward shore while weak winds allow tidal currents to distribute oil over a larger area (Genwest 2015). Stochastic modeling also revealed that a substantial amount of oil was beached under the spill scenarios at the Westridge Marine Terminal, First Narrows and Second Narrows (Genwest 2015).

The GenWest spill models assume that no weathering of oil takes place and that no spill response is conducted, and these assumptions enable the model to produce a clear picture of possible dispersion patterns within the inlet in the event of a spill. An unmitigated response was also used by TMP (2013, p. 7-158) in its marine spill scenarios to assess spill risk. While it is unlikely no response would occur, this assumption explores the potential extent of impacts that could occur in the event of a spill. Spill response along the BC coast is provided by Western Canada Marine Response Corporation, which must maintain the ability to respond to a marine spill of up to 10,000 tonnes, as required by Transportation Canada.

3. Methods

3.1. Calculating the economic contribution of existing ocean-dependent activities

The baseline for the marine economy in the City of Vancouver has been calculated using three economic indicators: total revenue (value of total output), employment (in person years, 'PYs'), and contribution to GDP (value of total output less the cost of intermediate output, 'GDP'). It should be noted that profit was not included as one of the indicators due to the unavailability of published, publicly available data regarding operating costs for several industries. The effect on taxes was also excluded because the analysis was performed at the municipal level and insufficient data was available to identify impacts of the project on municipal tax revenues.

Even though the effect of a spill can last longer, a time horizon of 25 years was modeled to reflect the projected time horizon employed by Kinder Morgan in their application when forecasting the economic benefits of the Trans Mountain Pipeline (Hodgson 2014). The three indicators – total output, employment and contribution to GDP – are evaluated using methods previously employed by Cisernos-Montemayor and Sumaila (2010), Dyck and Sumaila (2010), Harper et al. (2011) McCrea-Strub et al. (2011) and Sumaila et al. (2012).

This study assesses the following ocean-dependent economic activities within the City of Vancouver: 1) commercial fishing occurring in the Burrard Inlet; 2) Port Metro Vancouver's City of Vancouver operations and cruise ship activities; 3) marine transportation in the Burrard Inlet; 4) ocean-dependent tourism in Vancouver and; 5) local use of the waterfront. Ocean-dependent tourism encompasses several sub-sectors that are defined as tourist participation in on-water recreation, tourist use of Vancouver beaches and the seawall, and tourist participation in ocean-based or waterfront events. 'Tourists' in the latter two categories include day-tourists and overnight tourists.

For each of the economic indicators (i.e. total output value, employment, GDP), we calculate the i) direct; ii) direct and indirect; and iii) direct, indirect and induced effects of economic activities. Direct effects measure jobs, total output value and GDP resulting from the economic activity of businesses operating within the industries studied. Indirect effects measure jobs, total output value and GDP in related industries that supply goods and services to the primary industry studied. The commercial fishing industry, for example, supports firms involved in seafood processing, marketing, distribution and retail (Dyck and Sumaila 2010). Induced effects result from expenditure of income and wages earned through direct and indirect employment by ocean-dependent activities (BC MoE 2007). A detailed description of the analytical methods applied in this study, by industry, are included in Appendix I.

3.1.1. 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).

3.1.2. 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.

3.1.3. 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).

3.1.4. Ocean-dependent tourism

Economic output value, employment and GDP for ocean-dependent tourism was calculated for three separate activity categories: i) 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).

3.1.5. 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.

3.2. The value of the proposed Trans Mountain pipeline project

Estimated economic benefits of TMEP within BC have been published in Hodgson (2014) on behalf of TMP. The current analysis does not provide verification of these estimates. In order to estimate the economic benefit of the project within Vancouver and provide a benchmark for the current analysis, it is assumed that (i) there is a linear relationship between the economic indicators (i.e. output value, employment, GDP) at the national (i.e. Canada), provincial (e.g. BC), regional (e.g. Metro Vancouver) and local (e.g. Vancouver) levels; ii) the proportion of workers employed in Metro Vancouver relative to Canada as a whole during the development phase (25 percent, Sedley 2013; Hodgson 2014) also holds true for the operations phase; iii) the proportion of overall employment in Vancouver relative to Metro Vancouver also holds true for the TMEP (InterVistas 2013); and iv) the Statistics Canada Provincial Input/Output Multipliers are relevant at the local level. These assumptions are utilized in the absence of available information in TMP (2013) regarding benefits of TMEP at the regional and local levels and available input/output multipliers for Vancouver.

Economic benefits associated with the Trans Mountain Expansion Project (TMEP) across Canada and within British Columbia, including direct output value during both the construction and operations phases and total economic effects on employment and GDP, have been estimated by Hodgson (2014). The analysis encompassed a 25-year period from 2012-2037, including project development and operations phases, based on information provided by TMP and Statistics Canada's Input/Output Multipliers. Hodgson (2014) also estimated potential benefits to provincial (Alberta and Saskatchewan) and federal governments and resulting from royalty and corporate income tax payments; however, the effect on taxes was also excluded because the analysis was performed at the municipal level and insufficient data was available to identify impacts of the project on municipal tax revenues.

The estimated expenditure of $4,580 million in 2012 dollars across Canada for project development from Hodgson (2014), based on TMP (2013), is adjusted to $4,620 million in 2013 dollars for the current analysis. Approximately 69.5 percent ($3,200 million) of this development expenditure is estimated to occur in BC (Hodgson 2014).

Hodgson (2014) estimates additional annual direct output value and employment at $644 million and 342 PYs, respectively, during project

operations, of which approximately 71 percent ($457 million in output value, 242 PYs of employment) will occur in BC.

3.3. Derivation of oil spill impacts

3.3.1. Spill modelling

Potential impacts of a tanker spill in Burrard Inlet are expected to be different than those of historical freshwater and marine spills (e.g. *Exxon Valdez*, *Cosco Busan*); however, previous spills can provide some insight into the potential magnitude and duration of such a spill.

The potential range of behaviour, fate and treatment options for a diluted bitumen spill in Burrard Inlet has been characterized by Short (2015). Behaviour of spilled diluted bitumen is characterized by rapid evaporation of gas condensate components and increasing density of remaining surface oil, leading to submergence. Oil on the surface of the ocean is expected to either submerge in the form of tarballs or become stranded on shorelines; a portion of the stranded oil would re-float back into the ocean. Under worst-case conditions (i.e. warm summer temperatures, moderate winds), diluted bitumen may begin to submerge within 24 hours of the initial spill.

Genwest (2015) modeled oil spill trajectories for four oil spill scenarios in the Burrard Inlet and concludes that the models "provide a realistic representation of the behavior of oil spills in Burrard Inlet [and] can therefore be used to realistically evaluate the possible extent of oil spread resulting from a spill at the Terminal, Second Narrows, First Narrows, and the Outer Harbour locations."(p8)

The First Narrows spill scenario was identified as having high potential to cause severe economic disruption to the City of Vancouver and thus is the spill scenario used in this economic analysis to identify the possible high end of the range of impacts to the Vancouver economy in the event of a spill. Section 3.3.2 describes how this spill scenario is used to create a range (from positive to negative) of potential economic impacts of a hydrocarbon spill in the Burrard Inlet.

Using Genwest's model, the City of Vancouver's GIS and CAD department created an oil spill analysis map which shows the percentage of oil in each of the three zones of the Burrard Inlet (i.e. Outer Harbour, Inner Harbour, other areas which includes Central Harbour, Port Moody Arm and Indian Arm) 24 hours after a spill at the First Narrows (Figure 4). To create this map, the 16,000 m^3 spill was represented by 8,000 splots (2000 m^3 per splot). Wind and tide data was drawn from twelve randomly selected dates in the period from January through December 2005 to create SPLOT location maps which

represented where oil would end up under different environmental conditions during the year. These 12 SPLOT files, representing a random date from each month of the year 2005, were combined and the total number of splots that landed in each of the three zones were calculated to arrive at a percentage distribution. Figure 4 shows that virtually all stretches the City of Vancouver waterfront could be affected by a spill at the First Narrows at any time of year.

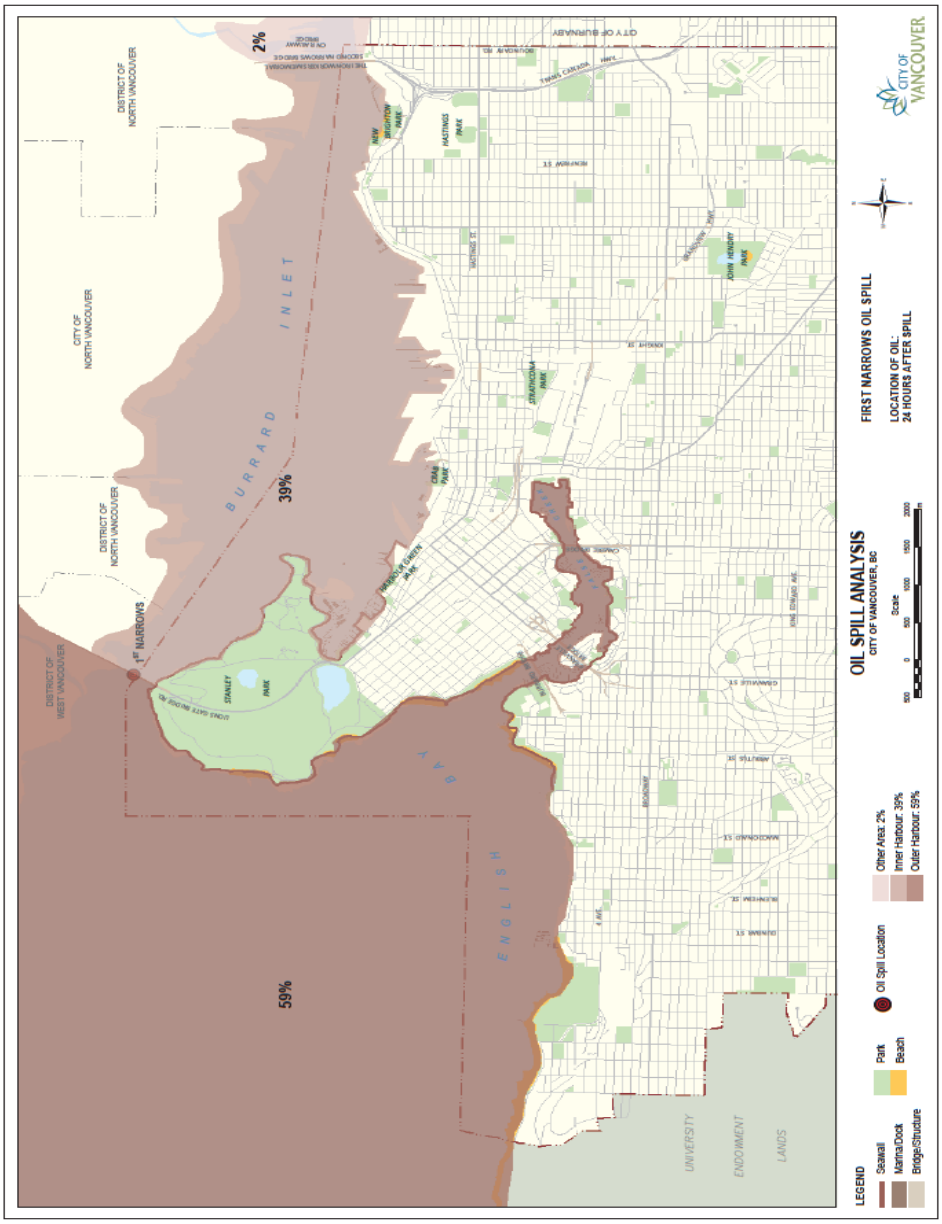

Figure 4: Dispersion of oil after 24 hours from a 16,000 m^3 spill at the First Narrows.

3.3.2. Spill scenarios

The economic effects of a hydrocarbon spill on Vancouver's five key ocean-dependent economic activities have been estimated under three scenarios:

"no spill," "spill in May" and "spill in October." These scenarios were identified to characterize a range of potential economic impacts of TMEP on the City of Vancouver, ranging from positive (i.e. no spill) to negative (i.e. spill in May or October). These scenarios are representative of possible future outcomes from TMEP; true economic impacts of the project may be expected to occur somewhere within this range.

The "no spill" scenario presents a 25-year baseline for projected industry development in the absence of a tanker spill, against which to compare the potential tanker spill impacts. Average annual growth rates derived from historical data were used to project future conditions for the economic indicators (i.e. economic output, employment and GDP) of Vancouver's five key ocean-dependent economic activities and does not address potential future growth in existing or new ocean-dependent activities.

Two spill scenarios, one in May and one in October, were modeled and incorporate the ranges of impact from Table 5 (i.e. one-year year recovery period for cruise industry for the low impact scenario, and five-year recovery period for the high impact scenario) applied to the range of economic values for each industry. Both spills were modeled to occur in the year 2018.

3.3.3. Seasonal impacts of a hydrocarbon spill

Economic impacts of these hypothetical spills in May and October capture seasonal differences in economic activity within the City of Vancouver. Based on dispersion modelling results obtained from GenWest (2015), it is assumed that the spill affects all of Burrard Inlet; this assumption supports estimation of impacts under the worst-case scenario. By comparing the "no spill," "May spill" and "October spill" scenarios, it is possible to identify a range of impacts (i.e. from best to worst case).

Dungeness crabs are harvested year-round; however, the months of May through October tend to be the most productive for commercial fishermen (DFO 2009). The commercial spot prawn season opens on or after May 1 each year and closes by the end of June (DFO 2014). Floatplane transportation is highly seasonal, a May spill would affect 44 percent of annual business, whereas an October spill would affect 11 percent of annual business [16] (Stephanie Isted, pers. comm., June 24 and 27, 2014).

The majority of on-water activities and waterfront usage (beaches and seawall) in Vancouver occurs between the months of May and September and a spill in May would result in greater tourism losses than a spill in October with impacts being felt during peak tourist season. Waterfront and water-based

[16] Calculations based on monthly sightseeing passenger volumes provided by Harbour Air, and thus we are assuming commercial passenger flights follow the same distribution.

events occur predominantly in the late spring, summer and early fall with only 13 percent of economic output value occurring prior to May 1 in an average year, therefore a spill in May has the potential to generate a greater economic impact than a spill in October because it precedes the event season.

3.3.4. Industry growth rates

Impact modeling assumed an average annual growth rate of-3.57 percent for commercial fisheries based on annual average catch from 2007–2012 for Dungeness crab and spot prawns (Ministry of Agriculture 2011). Industry growth for Vancouver port operations was calculated using the annual change in total cargo volume from 2008-2013 (PMV Monthly Container Stats). Cruise ship growth was initially estimated using 10 years of annual passenger data but this yielded a negative growth rate that was not supported by current literature, which suggests that the Vancouver cruise industry is in recovery from its low in 2010 (PMV 2014). An annual growth rate of zero percent has been used and indicates that the industry remains stable but is not demonstrating signs of growth.

The CHX floatplane transportation growth rate was estimated using commercial air transportation annual passenger volumes from 2010-2014 reported by Transportation Canada (Transport Canada). Multi-year passenger data for CHX was not available. The growth rate for all tourism related activities are assumed to be equal to the growth rate for tourism for Metro Vancouver and are based on 10 years of visitor data from 2003-2012 (Tourism Vancouver Visitor Stats). Industry growth in local use of beaches and seawall are assumed to be equal to the annual population growth rate for the City of Vancouver from 2006-2011 (Statistics Canada 2011). In these last two cases, participation rates are assumed to remain constant with growth being driven by increases in annual tourist and population growth, respectively.

Rates of economic growth, by industry, are applied to initial industry output value for the year 2013 using the following equation:

$$N_{i,t} = N_{i,o}(1 + r)^t$$

Where *i* represents the indicators (i.e. output value), r is the rate of growth and t = 0…24 (in years). Annual values for direct, indirect and induced output value, employment and GDP are calculated for the period 2013–2037.

Methods for analyzing spill impacts were based on those used by Sumaila et al. (2012). All scenarios employ ex-ante forecasting of growth (i.e. using historical data to forecast future growth) for each industry over a 25-year time period.

3.3.5. Calculating potential impacts on ocean-dependent economic activities

Potential impacts of a spill were modeled numerically, by activity, and category, where applicable, based on market recovery times listed in Table 5. These impacts are based on the case studies identified in Section 2.3. Ecological recovery times, while independent from market recovery times and not analyzed in this study, are nonetheless relevant; for example, ecological recovery is one factor that affects how quickly markets for seafood products recover following a hydrocarbon spill.

Table 5: Assumed industry growth rates, spill impacts and market recovery times

Industry	***Annual Growth Rate (%)***	***Segment***	***Market Impact***	***Impact Duration***
Commercial fishing	-3.57	Dungeness Crab, Spot Prawn	Closure of all affected areas in Year 1, -50% in Year 2 (catch)[17]	1-2 years[18]
Port activities	0.5	Shipping	Closure of all affected areas;-65% per day (output value)[19]	2-4 days[20]
	0	Cruises	20% in Year 1 (# of tourists)[21]	1-5 years[22]
Inner Harbour transportation	2.95	Float plane travel	15% in Year 1 (# of travellers)[23]	3 months[24]
Ocean-dependent tourism	0.09	Shoreline use (tourists)	20% in Year 1 (# of tourists)[25]	2-8 years[26]
Locals-Beaches and seawall	0.9	Shoreline use (locals)	38% in Year 1 (# of trips) [27]	8 months[28]

[17] Freese & O'Claire (1995)
[18] Freese & O'Claire (1995)
[19] Port of Houston Authority (2012); Powell (2014).
[20] Cook (2014); Kuo (2014); McConnaughey (2014b).
[21] Oxford Economics (2009).
[22] Oxford Economics (2009).
[23] Aldy (2013).
[24] Aldy (2013).
[25] EVOS Trustee Council (2010); Oxford Economics (2009).
[26] Oxford Economics (2009).
[27] Stratus Consulting (2010).
[28] Stratus Consulting (2010).

Real (i.e. inflation-adjusted) ex-vessel prices, seaplane fares and tourism expenditures are held constant and impacts are assumed to diminish following a linear impact gradient (e.g. over a four-year recovery period, impacts will diminish by 25% each year). Only existing industries are included in the analysis; potential impacts to proposed projects or projects currently under development in Vancouver are excluded.

The present value of the economic indicator (i) for the five ocean-dependent economic activities (α) and the proposed Trans Mountain Expansion Project under each of the three spill scenarios were calculated over time (t), expressed as:

$$PV_i = \sum_{t=0}^{T} d^t \, X_{i,\alpha,t}$$

where $X_{i,\alpha,t}$ represents the value of the economic indicator i (i.e. output value, GDP), $\forall i \neq$ employment, α denotes the industry t = 0…24 (in years) and the parameter d is the discount factor determined using the appropriate rate of discount applicable to the region. The values of these indicators were calculated for a 25-year time period (2013-2037) using a real discount rate of three percent which is a rate considered reasonable for environmental projects (Heal 2000; Sumaila & Walters 2005). Economic impacts associated with tanker spill scenarios are calculated and reported as the difference between present values (calculated over 25 years) of total economic indicators (i.e. direct, indirect and induced; economic output, GDP and employment) under the three spill scenarios (i.e no spill, May spill, October spill).

4. Results

4.1. Baseline values of ocean based industries

The economic indicators (i.e. economic output, employment, GDP) for the five ocean-dependent economic activities (commercial fishing, port and cruise ship activities, transportation, marine tourism [seawall and beaches, on-water activities and waterfront events] and local use of the waterfront) analyzed in this study and total (i.e. direct, indirect and induced) economic effects are reported in the following sections.

Table 6: Current baseline for ocean-dependent economic activities within the City of Vancouver (2013)

Industry	***Value of output*** *(2013, million)*	***Employment*** *(PYs)*	***Contribution to GDP*** *(2013, million)*
Commercial fishing	1-3	5-16	0.6-0.7
Port activities*	5,836	25,932	2,693
- shipping	4,884	20,173	2,160
- cruises	952	5,759	533
Inner Harbour transportation[#]	74	300	30
Ocean-dependent tourism[+]	377-620	5,171-9,126	259-444
- on-water recreation	26-136	510-2,700	22-117
- beaches and seawall	292-402	4,001-5,502	204-281
- ocean-based/waterfront events	59-82	661-924	33-46
Locals-Beaches and seawall	145-170	1,114-1,307	78-92
Total All Industries	6,433-6,703	32,523-36,681	3,061-3,261

Numbers may not add up due to rounding

** Figures reported by InterVISTAS Consulting 2008, 2012. A range of values was not provided.*
[#] Estimates are based on CHX passenger data from 2013. Multi-year data was not available and thus, a range of values is not provided.
[+] Sum of Tourism-waterfront events, on-water activities, beaches and waterfront (not including cruise ship tourism)

Ocean-dependent activities contribute a total of $6,430–$6,700 million in output value, 32,523-36,681 PYs of employment and $3,060 -$3,260 million in GDP to the Vancouver economy each year. Based on a proportion of working age individuals (74.6%) (Statistics Canada Census 2011) and a regional unemployment rate of (5.9%) (Service Canada 2015), ocean-dependent activities are estimated to directly employ four percent of the Vancouver population. When indirect and induced values are also considered, ocean-dependent activities provide employment for an equivalent of eight percent of the Vancouver population.

4.1.1. Commercial fishing

The average crab vessel has 2-8 crew members[29] on board including the captain (Yonis 2010). A 2007 report by Nelson Brothers Fisheries Ltd. suggests that crew shares made up of 25 percent of a vessel's net revenue in the Burrard Inlet (area J) (Nelson 2007) The average prawn vessel has 6 crew members, with 27 percent of a vessel's net revenue made up of crew shares (Nelson 2009).

Processing facilities tend to concentrate around sources of reliable products and in 2008, almost 40 percent of the crab processors were located within the Greater Vancouver Region (Yonis 2010). Processing of wild shellfish generated 746 PY of employment in BC (13% of total fish processing sector employment) in 2008 (Yonis 2010). Dungeness crab processing, and prawn processing contribute 43 percent and 7 percent towards total wild shellfish processing, respectively, in the province (Yonis 2010; DFO 2014/15).

Commercial fishing in the Burrard Inlet[30] contributes $619,000-$1.8 million in direct economic output value, 3-9 PY of direct employment and $353,000-$1 million in direct GDP to Vancouver's economy. When indirect and induced effects are considered, commercial fishing contributes $1 million-$3 million in total output value, 5-16 PY of total employment and $600,000-$1.7 million in total GDP.

[29] Average crew of 2 reported by DFO 2010, crew of 8 reported by Stuart Nelson 2007
[30] Attributed to the City of Vancouver, see appendix for methodology

4.1.2. Port activities

Shipping

Port employment includes all jobs that are involved in moving goods to or through Vancouver-based Port operations, jobs that are located on Port land and off-site employment at firms that facilitate and monitor Vancouver Port trade. Direct employment includes stevedors, manufacturers and processers, shippers, insurance brokers and underwriters, tug operators, accommodation providers, ship builders, bulk terminal operators, dredgers, port authority and government workers, marina operators, freight forwarders, ship brokers skip chandlers, customs brokers and others.

Total direct Port employment is made up of 78 percent on-site employment and 22 percent off-site employment (InterVISTAS 2012). Operations at the Vancouver port terminals represented approximately 35 percent of total Port Metro Vancouver activity in 2012 (InterVISTAS 2008 2012).

Port operations within the city of Vancouver contribute $2,440 million in direct economic output value, 9,200 PY of direct employment and $893 million in direct GDP to Vancouver's economy. When indirect and induced effects are considered, these operations contribute $4.88 billion in total output value, 20,173 PY of total employment and $2,160 million in total GDP.

Cruises

The economic impact of cruise ship activity at Port Metro Vancouver has three basic sources; spending by passengers while in port, spending by the ship's crew while in port, and spending by the cruise line while in port (InterVISTAS 2012).

Spending by passengers include expenditures on items such as lodging, food and beverage, retail and tours and transportation, estimated to be approximately $315.96 per passenger and amounting to $173.8 million in 2012 (InterVISTAS 2012). Vancouver welcomed 812,398 cruise ship passengers in 2013 and expects the same for 2014.

Crew spending is estimated to be $102.90 per crew member and consists of the same categories as passenger spending, without lodging since crew have accommodation on the ship while at port. Total crew spending in 2012 was $16.2 million. Spending by cruise lines at port in Vancouver amounted to $416 million in 2012. Cruise line expenditures include transportation and warehousing, food and beverage to restock the ship while in port, fuel, travel agent commissions, vessel repair and maintenance, and machinery and equipment.

Direct output value, employment and GDP from cruise operations in Vancouver are $547 million, 3,676 PY and $298 million respectively. When indirect and induced effects are considered, total output value, employment, and GPD from cruise operations in Vancouver are $952 million, 5,759 PY and $533 million.

4.1.3. Inner Harbor transportation

Commercial and sightseeing seaplane operations out of Vancouver Harbour Flight Centre generated an estimated $34 million in passenger revenues in 2013 based on CHX reported passenger volume of 282,414 fare paying passengers. The average 2013 fare for commercial flights was $124 per one-way trip, while the average fare for scenic tours was $181[31]. 2013 CHX seaplane operations created 118 direct jobs and contributed $10 million to local GDP. Jobs include pilots, flight attendants, maintenance crew and administrative staff at CHX. CHX serves a large number of tourists, especially on scenic flights where tourists are estimated to comprise 95 percent of passenger volume (Personal correspondence with Harbour Air). Tourists travelling on commercial flights make-up approximately 45 percent of passengers which translates to a total contribution from tourists to industry revenues of $18 million, 62 PY of employment and $5 million in GDP per year.

When indirect and induced effects are considered, floatplane transportation through CHX contributes $73 million in total output value, 300 PY of employment and $30 million in GDP.

4.1.4. Ocean-dependent tourism

Ocean-dependent tourism (i.e. on-water recreation, beach and seawall usage, and attendance at/participation in ocean-based and waterfront events) in Vancouver contribute $194-$324 million in direct output value, 2,587-4,448 direct jobs and $95-$158 million in direct GDP to the city's economy. Although there were many studies examining the travel behavior and economic impact of tourism in the Metro Vancouver region and Vancouver, Coast & Mountains Region, there was no specific information on visits to the City of Vancouver. Given this limitation, this study estimates the total number of overnight visitors to the City of Vancouver based on Vancouver Visitor Centre statistics. Visitor Centre traffic statistics are based on the number of visitors who speak to a representative at each tourism BC Visitor Centre and as such, our estimates are likely conservative.

[31] The average fare for scenic tours is representative of 'flight only' tours and does not account for scenic flights that incorporate a secondary activity such as kayaking or whale watching.

On-water recreation only includes activities engaged in by overnight tourists and does not account for economic activity generated by day-visitors in Vancouver's coastal waters. It generates economic activity through direct participation in marine-based activities such as kayaking, recreational fishing, sailing, motorized boating and whale watching as well as tourists' expenditures on accommodation, transportation, food and beverage, entertainment and retail.

Tourists' use of beaches, waterfront parks and the seawall captures use by both day-visitors and overnight tourists. Day-visitors contribute $148-$203 million in total output value, 1,134-1,560 PY of total employment and $102-$141 million in GDP to the Vancouver economy. Overnight tourists contribute $145-$200 million in total output value, 2,862-3,933 PY of total employment and $97-$135 million in total GDP to Vancouver's economy.

Day-visitors and overnight tourists' participation/attendance at waterfront and water-based events generates $58-$82 million in total output value, 661-924 PY of total employment and $32-$46 million in total GDP.

Although the current analysis did not uncover any studies which examined the economic impact of all ocean-based or waterfront event on the City of Vancouver, several studies have analyzed the economic impact of individual events in the city and comparisons with these findings suggest that our estimates are extremely conservative. A study commissioned by the Vancouver Marathon Society pegs the economic impact of the BMO Marathon at $53.6 million per year (Vancouver Marathon 2013). The Honda Celebration of Lights reports that it contributes $39 million in incremental tourism and hospitality spending to Vancouver each year (Honda Celebration of Lights web). This study suggests comparatively lower economic effects for these events, likely because we have only included day and overnight tourist participant/attendee related spending in our analysis.

Overall ocean-dependent tourism (on-water activities, beaches and seawall, ocean-based and waterfront events) are the third largest contributor to output value and GDP of the ocean-dependent economy in Vancouver, after Port Metro Vancouver shipping and cruise operations. Employment generated by ocean-dependent tourism is estimated to be larger than employment generated by the cruise industry (5,171-9,126 PY and 5,759 PY, respectively). If economic activity generated by local use of the waterfront (described in section 4.1.5) is included, ocean-dependent tourism becomes the second largest contributor to ocean-dependent GDP and employment, after Port Metro Vancouver shipping operations.

4.1.5. Locals–Beaches and seawall

The Vancouver waterfront and marine environment provides a wealth of benefits to the local population, most of which are not measured in this study. We have captured the economic effect of being a 'tourist in your own town' by examining local use of the waterfront on days off from work. Local use of the beaches, seawall and waterfront in this context, contributes $144-$170 million in total output value, 1,110-1,300 PY of total employment and $78-$92 million in GDP.

4.2. Value of the proposed Trans Mountain Expansion Project

Based on numbers reported by Hodgson (2014) and the assumptions referenced in Section 3.2, the economic benefits of TMEP to the Vancouver economy is assumed to generate a total of $2,700 million in output value, 9,346 PYs of employment and $1,700 million in GDP to the Vancouver economy.

Table 7: Present value of economic effects of TMEP within Vancouver over a 25-year period.

Type of Impact	***Value of output*** *(2013, million)*	***Employment*** *(PYs)*	***Contribution to GDP*** *(2013, million)*
Direct	1,220	5,758	1,081
Direct and Indirect	2,146	7,555	1,452
Total	2,717	9,346	1,701

4.3. Economic impact of a tanker spill

4.3.1. No spill

The "no spill" scenario presents a 25-year baseline for projected industry development in the absence of a tanker spill, against which to compare the potential tanker spill impacts. Under this scenario, the Vancouver economy would enjoy all of the current economic benefits of ocean-dependent activities while gaining all of the projected benefits estimated by Hodgson (2014) and TMEP (2013) associated with the proposed TMEP[32].

4.3.2. Spill in May

The Vancouver economy could experience large losses under a May spill scenario since approximately 50 percent of ocean-dependent economic activity occurs between May 15 and September 1 each year. Durations of potential market impacts are reported in Table 8.

[32] Note: The estimated economic benefits of the proposed TMEP are not included in the baseline calculation but are treated separated and reported in Table 7 (present value over 25 years).

A spill of 16,000 m^3 at the First Narrows could close DFO Management Area 28, sub-areas 6-14 resulting in no spot prawn or Dungeness catch by commercial fisheries during the season and reduced catch the following year. Commercial fisheries closures would reduce revenues to local fishers for the duration of any negative market and ecosystem impacts. The Vancouver shellfish processing sector is reliant on biomass from outside DFO Management Area 28, and experience increased losses due to reduced catch in other DFO Management areas that are not covered in this study.

Effects on port shipping operations are assumed to be short in duration (i.e. between two and four days) based on previous spill events in other locations. The length of closure could easily exceed four days if the First Narrows were closed to facilitate spill response and clean-up, and an extended closure could have a much larger impact on the Vancouver economy than reported in this study. Impacts on port operations are assumed to affect 65 percent of daily output value.

Commercial floatplane operations could also be affected more severely under a May spill scenario as impacts would be felt during the busiest quarter of annual operations. Cancelled flights and fewer passengers would result in reduced revenues over a three-month period.

Impacts on the cruise ship industry, ocean-dependent tourism (on-water recreation, beaches and seawall, and ocean-based and waterfront events) and local use of the beaches, waterfront and seawall would be felt immediately in the event of a spill in May (i.e. preceding the tourist season). Lower tourism participation would result in reduced revenues generated through these activities. Based on historical spill events in other locations, duration of the recovery period for the tourism sector could be between one and five years for the cruise industry, two and eight years for ocean-dependent tourism and up to eight months for local use of the waterfront.

Table 8: Present value of losses to ocean-dependent activities in the City of Vancouver over a 25-year period; May spill scenario.

Industry	***Value of output*** *(2013, millions)*	***Employment (PYs)***	***Contribution to GDP*** *(2013, millions)*
Commercial Fishing			
Direct	0.4-2.4	3-15	0.2-1.4
Direct and Indirect	0.6-3.6	4-22	0.3-2
Total	0.7-4.1	4-25	0.4-2.2
Port Activities-Shipping			
Direct	4-23	18-103	1-8
Direct and Indirect	8-44	37-211	3-19
Total	10-55	50-283	4-25
Port Activities-Cruises			
Direct	92-272	413-1,277	34-100
Direct and Indirect	177-525	843-2,605	75-223
Total	221-655	1,131-3,494	102-302
Inner harbour transportation			
Direct	2	9	1
Direct and Indirect	4	18	1
Total	5	23	2
Tourism-On-water recreation			
Direct	4-57	69-1,111	2-27
Direct and Indirect	5-83	114-1,832	4-54
Total	7-100	156-2,526	6-86
Tourism-Beaches and seawall			
Direct	38-151	583-2,443	18-72
Direct and Indirect	59-233	926-3,880	35-137
Total	74-294	1,228-5,146	52-205
Tourism-Waterfront events			
Direct	7-30	142-607	4-16
Direct and Indirect	12-47	181-773	6-26
Total	15-60	203-864	8-34
Local-Beaches and seawall			
Direct	22-26	250-293	11-13
Direct and Indirect	37-43	366-429	19- 22
Total	48-57	443-519	26-31
Total losses-all industries			
Direct	170-563	1,487-5,857	71-238
Direct and Indirect	302-982	2,488-9,796	144-484
Total	380-1,230	3,238-12,881	201-687

The present value of total losses to output values resulting from a tanker spill in this scenario is estimated to be in the range of $380-$1,230 million while 3,238-12,881 PY of employment could be lost within Vancouver. The present value of lost GDP is estimated to be in the range of $201-$687 million. Notwithstanding the narrowness of the current analysis in terms of the number of ocean-related economic activities covered, these losses are large compared to the potential economic benefits of the Trans Mountain Expansion Project.

4.3.3. Spill in October

Under an October spill scenario, the closure of DFO Management Area 28, sub-areas 6-14 would occur after the spot prawn and Dungeness crab harvest, resulting in slightly smaller losses of revenue than a May spill. The effects of an October spill, however, could be felt during the following year, hence there is not a substantial difference between the estimated losses under the May and October spill scenarios.

Effects on shipping operations are assumed to be the same in spring and fall, with a minimum two-day closure and a maximum four-day closure, leading to an estimated reduction in output value of 65 percent per day.

Commercial floatplane operations are not estimated to be affected as severely under an October scenario because commercial ridership reaches its seasonal peak during the summer.

Impacts on cruises and ocean-dependent tourism (on-water recreation, beaches and seawall, and ocean-based and waterfront events) could be experienced during spring and summer of the year following an October spill event. The estimated economic impact is slightly less severe than under a May spill scenario, since the industry may not suffer lost revenues during the year of an October spill event.

Local use of the beaches, waterfront and seawall may be less severely impacted under an October spill scenario and there may be no immediate economic losses because local use of the waterfront during the late fall and winter is at its seasonal low. Impacts may be relatively short in duration (e.g. eight months) and felt only in late spring of the following year.

Table 9: Present value of losses to ocean-dependent activities in the City of Vancouver over a 25-year period; October spill scenario.

Industry	***Value of output*** *(2013, millions)*	***Employment (PYs)***	***Contribution to GDP*** *(2013, millions)*
Commercial Fishing			
Direct	0.4-2	2-14	0.2-1
Direct and Indirect	0.6-3	4-21	0.3-1.8
Total	0.7-3.7	4-24	0.4-2
Port Activities-Shipping			
Direct	4-23	18-103	1-8
Direct and Indirect	8-44	37-211	3-19
Total	10-55	50-283	4-25
Port Activities-Cruises			
Direct	47-223	218-1,078	17-82
Direct and Indirect	91-430	445-2,200	38-183
Total	113-537	597-2,959	52-248
Inner harbor transportation			
Direct	0.6	2	0.2
Direct and Indirect	1	5	0.4
Total	1.3	6	0.5
Tourism-On-water recreation			
Direct	2-49	32-997	0.8-23
Direct and Indirect	2-72	53-1,644	2-47
Total	3-87	73-2,266	3-75
Tourism-Beaches and seawall			
Direct	25-131	401-2,192	12-63
Direct and Indirect	39-203	637-3,481	23-119
Total	10-52	845-4,618	35-179
Tourism-Waterfront events			
Direct	5- 26	98-545	3-14
Direct and Indirect	8-41	125-694	4-23
Total	10-52	139-776	6-29
Local-Beaches and seawall			
Direct	13-14	145-165	6-7
Direct and Indirect	21-23	213-242	11-12
Total	27-31	258-293	15-17
Total losses-all activities			
Direct	97-470	918-5,096	41-199
Direct and Indirect	170-818	1,518-8,496	82-405
Total	215-1,024	1,972-11,216	115-575

4.3.4. Spill impacts comparison: May vs. October

Table 10 presents a comparison of the estimated present value of losses to ocean-dependent activities in Vancouver in the event of spill at the First Narrows in May (spring) and in October (fall) over a 25-year period.

Table 10: Comparison of estimated present value economic impacts of May and October spill scenarios

Losses	*Value of output (2013, millions)*	*Employment (PYs)*	*Contribution to GDP (2013, millions)*
Total Losses-Spill in May	380-1,230	3,238-12,881	201-687
Total Losses-Spill in October	215-1,024	1,972-11,216	115-575
Difference between seasons	165-206	1,266-1,666	86-112
May losses as % of October losses	120-170	115-164	119-174

If spill size is held constant, Vancouver's five key ocean-dependent economic activities are estimated to experience greater losses in the event of a spill in May, compared to a spill in October, due to the seasonality of output value of ocean-dependent economic activities in Vancouver. Commercial fisheries (i.e. spot prawn and Dungeness crab), Inner Harbour transportation, cruises, ocean-dependent tourism (on-water recreation, beaches and seawall, ocean-based and waterfront events) and local use of the beaches, waterfront and seawall could all experience greater losses in the event of a spill in May, which would have an immediate effect on output value.

5. Discussion and conclusion

The Burrard Inlet supports direct employment of approximately 18,000 people per year; a number equal to four percent of the population of Vancouver. When indirect and induced values are also considered, the Burrard Inlet provides employment for an equivalent of eight percent of the population of Vancouver.

Based on unverified estimates provided by Hodgson (2014), the proposed Trans Mountain Expansion Project is estimated to generate a total of $2,700 million in output value, 9,346 PYs of employment and $1,700 million in GDP to the Vancouver economy.

In the event of a tanker spill of 16,000 m^3 in May (i.e. spring), the five ocean-dependent economic activities considered within the scope of this analysis could suffer losses of $380-$1,230 million in output value, 3,238-12,881 PY of employment and $201-$687 million in GDP. When the upper ranges of the losses estimated for the five economic activities evaluated in this analysis are considered, under this scenario, 46 percent of total output value, 138 percent of employment and 40 percent of GDP from the proposed Trans Mountain Expansion Project (TMEP) could be lost due to the spill.

In the event of a spill of the same size at the same location in October (i.e. fall), the Vancouver economy could experience total losses of $215-$1,020 million in output value, 1,126-1,972 PYs of employment and $115-$575 million in GDP due to spill effects on the five ocean-dependent economic activities evaluated in this analysis. Here, the percentages of the projected benefits from the TMEP that could be lost due to a spill are 38 percent of total output value, 120 percent of total employment and 34 percent of GDP, respectively.

The high employment losses estimated (i.e. 138% and 120%) result from impacts to sectors that generate high employment per unit output value, which is typical of the tourism and events sectors. These activities account for a substantial portion of the ocean-dependent economy in Vancouver. It is worth noting that the above projected percentage losses account for only a portion of the total economic impact to the city of Vancouver due to a spill since this analysis focused only on five ocean-dependent economic activities and does not encompass the costs of spill clean-up and litigation or the value of spilled product. These costs will vary with spill conditions, volume and location, among other factors, but would impose considerable expenses on the project proponent; local, provincial and federal governments; industry groups; local businesses; and local communities.

The estimates presented for the three scenarios within this analysis (i.e. no impact, spill in May, spill in October) provide a range (i.e. positive to negative) of potential economic impacts of TMEP on the value of ocean-dependent activities within the City of Vancouver. The likelihood of each potential release scenario has not been estimated within the scope of this analysis. Estimates of likelihood could be determined for each scenario through a formal risk assessment to provide additional characterization of spill scenarios.

This study focused on impacts to ocean-dependent economic activities within the City of Vancouver; however, several other communities are also located in proximity to the Burrard Inlet and would be impacted by a tanker spill. This includes the Tsleil-Waututh, Musqueam and Squamish First Nations peoples who depend on the Burrard Inlet for food as well as social and ceremonial purposes.

The value of socio-economic impacts to local residents whose employment is not linked to the Burrard Inlet has also been largely ignored in this study, including impacts on human health, real property values, community cohesion, local non-tourism businesses and general well-being of the residents in the City of Vancouver.

For example, survey data from the City of Vancouver shows that more than five million people use Vancouver's shorelines during the year, of which 23 percent are engaging in exercise (Vancouver Waterfront Survey 2014). Approximately 16,000 local residents use the shoreline an average of 19 days per month for exercise and deem the waterfront to be 'very important' to their decision to exercise (Vancouver Waterfront Survey 2014).

The health benefits of physical activity are well documented (Warburton et al. 2006; Haskell et al. 2007) and inactivity is estimated to account for approximately 2.5 percent of Canadian health care costs (Birmingham 1999; Katzmarzyk et al. 2000; Oldridge 2008). The Canadian Society for Exercise Physiology (CSEP 2011) estimates that at least 150 minutes of moderate- to vigorous-intensity activity per week is necessary to produce health benefits. The health benefits of park usage have been measured in terms of reduced health care costs (Bedimo-Rung et al. 2005; Bauman et al. 2008; The Trust for Public Land 2011), increased workplace productivity and reduced employee absenteeism (Shepard 1992; Cadilhac et al. 2011). If it is assumed that the average person in Vancouver costs the Canadian medical system $5,775 per year (CIHI 2013), then these individuals would be expected to incur $93 million in health care expenses each year. However, by enabling 16,000 individuals to perform physical activity three or more times per week, Vancouver's beaches, Seawall and grassy areas reduce these costs by an estimated $2 million per year. These values may be at risk if residents cease to use Vancouver's coastal areas for exercise in the event of a tanker spill. Further, health care costs associated with exposure to spilled hydrocarbons and fumes could compound health care costs.

The values presented in the study provide a very conservative first estimate of total output value, employment and contribution to GDP resulting from five ocean-dependent economic activities in the City of Vancouver. Analysis of the present values of existing ocean-dependent economic activities in the future was conducted using historical growth rates and does not address potential future growth in existing or new ocean-dependent activities.

As noted in Sumaila et al. (2012) and Hotte & Sumaila (2012; 2013), the input-output analysis method employed in this study has been subject to criticism. Christ (1955), Grady & Muller (1988) and de Mesnard (2002) conclude that the use of multipliers overlooks the effects of changing prices on impacts, fails to address aggregate interactions and assumes stability of technical coefficients over time and across industries. The methods used in this study assume constant prices and do not address potential impacts of a tanker spill on ex-vessel prices received by commercial fishers or the average daily value of tourism expenditures. Price decreases resulting from diminished product quality (e.g. seafood, tourism experience) could lead to additional economic impacts to the local economy in the event of a tanker spill.

This study's narrow focus on five key ocean-dependent economic activities in the City of Vancouver only addresses a small portion of the total economic impacts of the proposed project and the potential impact of a tanker spill. Investigation of impacts to additional values, including those related to social, cultural and ecological values to residents and non-residents, would provide a more complete estimate of the total potential economic impact of a spill.

While this analysis focused on the benefits of the TMEP relative to the potential economic costs of a tanker spill at the local level, the broader distribution of costs and benefits is not addressed herein. According to a study by Goodman & Rowan (2014), conducted in collaboration with The Centre for Public Policy Research at Simon Fraser University, BC will receive less than two percent of the total revenue generated by the Trans Mountain Expansion Project over its lifespan. In comparison, the oil and gas industry will retain 68 percent of total revenue and Alberta and other provinces will receive 31 percent in the form of royalties, corporate income taxes and transfer payments. Thus, it is projected that the citizens of Metro Vancouver will bear a disproportionate share of the risk of a spill relative to project benefits.

References

Aldy, J.E. (2013) The Labor Market Impacts of the 2010 Deepwater Horizon Oil Spill and Offshore Oil Drilling Moratorium. August 15, 2013 Draft. http://www.iza.org/conference_files/environment2013/aldy_j8983.pdf

Aquabus website: www.theaquabus.com

Bauman, A., Rissel, C., Garrard, J., Ker, I., Speidel, R. and E. Fishman (2008) Cycling: getting Australia moving. Barriers, facilitators and interventions to get more Australians physically active through cycling. Melbourne: Cycling Promotion Fund. Retrieved on July 7, 2014 from http://www.cyclingpromotion.com.au/images/stories/downloads/CPFHlthRpr0

BC Ministry of Agriculture (2007) 2007 British Columbia Seafood Industry Year in Review. http://www.env.gov.bc.ca/omfd/reports/YIR-2007.pdf

BC Ministry of Agriculture (2008) 2008 British Columbia Seafood Industry Year in Review. http://www.env.gov.bc.ca/omfd/reports/YIR-2008.pdf

BC Ministry of Agriculture (2009) 2009 British Columbia Seafood Industry Year in Review. http://www.env.gov.bc.ca/omfd/reports/YIR-2009.pdf

BC Ministry of Agriculture (2010) 2010 British Columbia Seafood Industry Year in Review. http://www.agf.gov.bc.ca/stats/YinReview/Seafood-YIR-2010.pdf

BC Ministry of Agriculture (2011) 2011 British Columbia Seafood Industry Year in Review. http://www.env.gov.bc.ca/omfd/reports/Seafood-YIR-2011.pdf

BC Ministry of Agriculture (2012) 2012 British Columbia Seafood Industry Year in Review. http://www.agf.gov.bc.ca/stats/YinReview/Seafood-YIR-2012.pdf

BC Ministry of Environment (2007) British Columbia's Fisheries and Aquaculture Sector, 2007 Edition, Chapter 10. Input/Output Multipliers. Victoria, BC: BC Stats. Retrieved on January 5, 2015 from http://www.env.gov.bc.ca/omfd/reports/BC-FisheriesAquaculture-Sector-2007.pdf.

BC Parks (2014) Indian Arm Provincial Park. http://www.env.gov.bc.ca/bcparks/explore/parkpgs/indian_arm/

Bedimo-Rung, A.L., Mowen, A.J. and D.A. Cohen (2005) The Significance of Parks to Physical Activity and Public Health: A Conceptual Model. *American Journal of Preventive Medicine* 28(2S2): 159-168.

Birmingham, C.L., Muller, J.L., Palepu, A., Spinelli, J.J. and A.H. Anis (1999) The cost of obesity in Canada. *Canadian Medical Association Journal* 160: 483-488.

Cadilhac, D.A., Cumming, T.B., Sheppard, L., Pearce, D.C., Carter, R. and A. Magnus (2011) The economic benefits of reducing physical inactivity: an Australian example. International Journal of Behavioural Nutrition and Physical Activity 8(1): 99DOI: 10.1186/1479-5868-8-99

Canadian Institute for Health Information (2013) National Health Expenditure Trends, 1975 to 2013. http://www.cihi.ca/CIHI-ext-portal/internet/EN/Home/home/cihi000001

Canadian Society for Exercise Physiology (2011) Canadian Physical Activity Guidelines and Canadian Sedentary Behaviour Guidelines. http://www.csep.ca/CMFiles/Guidelines/CSEP_Guidelines_Handbook.pdf

CBC News (May 6, 2014) "Canadian Dungeness crab doubles in price." http://www.cbc.ca/news/canada/british-columbia/canadian-dungeness-crab-doubles-in-price-1.2634156

Christ, C.F. (1955) A review of input-output analysis. In Input–output analysis: an appraisal. Princeton University Press, Princeton, N.J. pp. 137–182. http://www.nber.org/chapters/c2866.

Cisneros-Montemayor, A., Sumaila, U.R. (2010) The economic value and potential threats to marine ecotourism in Belize. In: Palomares, M., & Pauly, D. (Eds.), Too Precious to Drill: the Marine Biodiversity of Belize. Fisheries Centre Research Reports, Vol. 19, No. 6, 161-166.

City of Vancouver (February 10, 2013) Application to Participate (A57557). Project Name: Trans Mountain Pipeline Expansion Project; Company: Trans Mountain Pipeline ULC; File Number: OF-Fac-Oil-T260-2013-03 02. https://docs.neb-one.gc.ca/ll-eng/llisapi.dll/fetch/2000/90464/90552/548311/956726/2392873/2394379/2414840/Application_To_Participate_-_A3U0H3.pdf?nodeid=2414643&vernum=-2

CNN (April 30, 2010) "Oil slick just a few miles from Louisiana coast," CNN.com. http://edition.cnn.com/2010/US/04/29/louisiana.oil.rig/

Cook, L. (March 25, 2014) "Houston Ship Channel Partially Reopens After Oil Spill," *Wall Street Journal*. http://online.wsj.com/articles/SB10001424052702304679404579461543331217048

Cosco Busan Oil Spill Trustees (2012) *Cosco Busan Oil Spill Damage Assessment and Restoration Plan/Environmental Assessment.* California Department of Fish and Game, California State Lands Commission, National Oceanic and Atmospheric Administration, United States Fish and Wildlife Service, National Part Service, Bureau of Land Management. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=42442&inline=true

Crooks, E. (May 20, 2014) US court rejects BP appeal to limit Deepwater Horizon costs, *Financial Times*. http://www.ft.com/cms/s/0/acb3442a-dfd0-11e3-a4cf-00144feabdc0.html-axzz3HgPqFOYu

Deepwater Horizon Pil Spill Trustee Council (2012) Natural Resource Damage Assessment April 2012 Status Update for the Deepwater Horizon Oil Spill. http://www.gulfspillrestoration.noaa.gov/wpcontent/uploads/FINAL_NRDA_StatusUpdate_April2012.pdf

de Mesnard, L. (2002) Note about the concept of net multipliers. *Journal of Regional Science* 42(3): 545-548. doi:10.1111/1467-9787.00271.

Destination BC (2005) Characteristics of the Commercial Nature Based Tourism Industry in British Columbia.

Destination BC (2010) Travel Survey of Residents of Canada; analyzed by Destination British Columbia.

DFO (1990) Survey of Recreational Fishing in Canada. http://www.dfo-mpo.gc.ca/stats/rec/canada-rec-eng.htm

DFO (1995) Survey of Recreational Fishing in Canada. http://www.dfo-mpo.gc.ca/stats/rec/canada-rec-eng.htm

DFO (2000) Stock Status Report C6-14 (2000) Dungeness Crab Coastal Fisheries License Areas B,E,G,H,I, J. http://www.dfo-mpo.gc.ca/csas/Csas/status/2000/c6-14e.pdf

DFO (2000) Survey of Recreational Fishing in Canada. http://www.dfo-mpo.gc.ca/stats/rec/canada-rec-eng.htm

DFO (2005) Survey of Recreational Fishing in Canada. http://www.dfo mpo.gc.ca/stats/rec/canada-rec-eng.htm

DFO (2014) BC Sport Fishing Guide, Tidal waters. Area 28 (Lower Mainland/Sunshine Coast). http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s28-eng.html

DFO (2014) Pacific Region-2014 Crab Integrated Fisheries Management Plan. http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2014/crab-crabe-2014-eng.pdf

DFO (2009) Underwater world – Dungeness crab. http://www.dfo-mpo.gc.ca/science/publications/uww-msm/articles/dungenesscrab-crabedesneiges-eng.html

DFO (2014) Integrated Fisheries Management Plan Summary-Prawn & Shrimp (Pandalus spp.) by Trap, Pacific Region 2014/2015. http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2014/prawnshrimp-trap-crevette-casier-sm-eng.pdf

DFO (2014) Integrated Fisheries Management Plan Summary-Prawn & Shrimp (Pandalus spp.) by Trap, Pacific Region 2014/2015. http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2014/prawnshrimp-trap-crevette-casier-sm-eng.pdf

DFO (2014) Capilano River Hatchery. http://www.pac.dfo-mpo.gc.ca/sep-pmvs/projects-projets/capilano/capilano-eng.html

DFO (2014) Current valid Salmonid Enhancement Program (SEP) British Columbia Aquaculture License Holders (as at July 1, 2014). http://www.pac.dfo-mpo.gc.ca/aquaculture/licence-permis/docs/sep-pmvs-eng.html

DFO (2014) Pacific Region-2014 Crab Integrated Fisheries Management Plan. http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2014/crab-crabe-2014-eng.pdf

DFO Website/Capilano Hatchery: http://www.pac.dfo-mpo.gc.ca/sep-pmvs/projects-projets/capilano/capilano-eng.html

DFO (2013) Recreational catch statistics. Georgia Strait Creel Summary. Annual Summaries of Catch and Effort 1981-2009. http://www.pac.dfo-mpo.gc.ca/stats/rec/gs/index-eng.html
DFO (2014) BC Sport Fishing Guide, Tidal waters. Area 28 (Lower Mainland/Sunshine Coast). http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s28-eng.html

DFO (2014) BC Sport Fishing Guide, Tidal waters. Area 28 (Lower Mainland/Sunshine Coast). http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s28-eng.html

DFO (2014) BC Sport Fishing Guide, Tidal waters. Area 28 (Lower Mainland/Sunshine Coast). http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s28-eng.html

DFO (2014) Integrated Fisheries Management Plan Summary-Prawn & Shrimp (Pandalus spp.) by Trap, Pacific Region 2014/2015. http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2014/prawnshrimp-trap-crevette-casier-sm-eng.pdf

DFO (2013) Recreational catch statistics. Georgia Strait Creel Summary. Annual Summaries of Catch and Effort 1981-2009. http://www.pac.dfo-mpo.gc.ca/stats/rec/gs/index-eng.html

DFO (2014) Pacific Region-2014 Crab Integrated Fisheries Management Plan. http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2014/crab-crabe-2014-eng.pdf

Dollhopf, R. & M. Durno (2011) *Kalamazoo River/Enbridge Pipeline Spill 2010.* 2011 International Oil Spill Conference. Retrieved from http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-2011-1-422

Dyck, A., Sumaila, U.R. (2010) Economic impact of ocean fish populations in the global fishery. *Journal of Bioeconomics* 12: 227-243.

Enbridge Energy LP (2011) FERC Financial Report FERC Form No. 6: ANNUAL REPORT OF OIL PIPELINE COMPANIES and Supplemental Form 6-Q: Quarterly Financial Report. US Department of Energy Federal Energy Regulatory Commission. FERC FORM No. 6/6-Q (ED. 02-04). http://s3.documentcloud.org/documents/365744/enbridge-ferc-filing-5-18-12.pdf

Environment Canada (2013) Properties, Composition and Marine Spill Behaviour, Fate and Transport of Two Diluted Bitumen Products from the Canadian Oil Sands. Federal Government Technical Report. ISBN 978-1-100-23004-7. 87 pp. http://publications.gc.ca/site/eng/457066/publication.html

EPA (2013) *Memo to Mr. Jose W. Fernandez and Dr. Kerri-Ann Jones.* Washington D.C.: United States Environmental Protection Agency .

Fitzsimmons, E.G. (March 25, 2014) "Shipping Channel Opens Partially After Huge Oil Spill in Galveston Bay," *New York Times*. http://www.nytimes.com/2014/03/26/us/shipping-channel-still-closed-after-huge-oil-spill-in-galveston-bay.html?_r=0

Freese, J.L., O'Clair, C.E. (1995) Exxon Valdez Oil Spill: State/Federal Natural Resources Damage Assessment Final Report. Injury to Crabs Outside Prince William Sound. Fish/Shellfish Study Number 22. Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Retrieved on September 24, 2012 from http://www.evostc.state.ak.us/Files.cfm?doc=/Store/FinalReports/1992-FS22-Final.pdf.

Garza-Gil, M.D., A. Prada-Blanco and M.X. Vazquez-Rodriguez (2006) Estimating the short-term economic damages from the Prestige oil spill in the Galician fisheries and tourism. *Ecological Economics* 58(4): 842-849.

Genwest Systems Inc. (2015) Oil Spill Trajectory Modeling Report in Burrard Inlet for the Trans Mountain Pipeline Expansion Project. Prepared under contract for Gowlings Lafleur Henderson LLP. 139pp.

Gonzalez, A. and N. Malik (January 24, 2010) "Collision Causes Crude Oil Spill in Texas," *Wall Street Journal*. http://online.wsj.com/articles/SB10001424052748704562504575021540843701582

Goodman, I. and R. Brigid (2014) Economic Costs and Benefits of the Trans Mountain Expansion Project (TMX) for BC and Metro Vancouver. The Goodman Group, Ltd., in collaboration with The Centre for Public Policy Research, Simon Fraser University. 70 pp. http://www.sfu.ca/content/dam/sfu/mpp/HomepageFeatureArticles/Economic Costs and Benefits of the Trans Mountain Expansion Project %28TMX%29 for BC and Metro Vancouver_20141110.pdf

Grady, P. and Muller, A.R. (1988) On the use and misuse of input-output based impact analysis in evaluation. *Can. J. Program Eval.* 3(2): 49-61. http://global-economics.ca/input.output.multipliers.pdf.

Granville Island Ferries website: http://www.granvilleislandferries.bc.ca

Hallin, Lillian (2014) 2012 Tourism Indicators. Prepared for Destination BC by BC Stats.

Harbour Air website: http://www.harbourair.com

Harper, S., Zeller, D., Sumaila, U.R. (2011). Under the threat of oil: assessing the value and contribution of Belizean fisheries. In: Palomares, M.L.D., Pauly, D. (Eds.), Too Precious to Drill: the Marine Biodiversity of Belize. Fisheries Centre Research Reports, Vol. 19, No. 6, 152-160.

Haskell, W.L., Lee, I.-M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., Macera, C.A., Heath, G.W., Thompson, P.D. and A. Bauman (2007) Physical Activity and Public Health: Updated Recommendation for Adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise* **39**(8): 1423-1434. DOI: 10.1249/mss.0b013e3180616b27

Haynes, E., Ruteki, T., Murphy, M., and Urban, D. (1995) Exxon Valdez Oil Spill State/Federal Natural Resource Damage Assessment Final Report. Impacts of the Exxon Valdez Oil Spill on Bottomfish and Shellfish in Prince William Sound. Fish/Shellfish Study 18. US. National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska. http://www.arlis.org/docs/vol1/33088144.pdf

Heal, G. (2000) Valuing ecosystem services. Ecosystems 3: 24-°©-30. DOI: 10.1007/s100210000006.

Hodgson, G. (November 21, 2014) The Trans Mountain Expansion Project: Understanding the Economic Benefits for Canada and its Regions. Conference Board of Canada. Update to Appendix B In: Kinder Morgan Canada (December 2013) Trans Mountain Expansion Project-An Application Pursuant to Section 52 of the National Energy Board Act. Volume 2: Project Overview, Economics Volume & General Information.
https://docs.neb-one.gc.ca/ll-eng/llisapi.dll/fetch/2000/90464/90552/548311/956726/2392873/2451003/2558406/B286-2_-_Report_-_Conference_Board_of_Canada_-_A4F2K9.pdf?nodeid=2557744&vernum=-2

Honda Celebration of Lights Website http://hondacelebrationoflight.com/p/about

Hotte, N. & Sumaila, U.R. (2012) Potential economic impact of a tanker spill on ocean-based industries in British Columbia. *Fisheries Centre Research Reports* 20(7), 45 pp. ISSN 1198-6727. http://www.fisheries.ubc.ca/webfm_send/155.

Hotte, N. & Sumaila, R. (2013) How much could a tanker spill cost British Columbians? *Environment, Development, and Sustainability*. DOI 10.1007/s10668-013-9468-7.

InterVISTAS (2009) 2008 Port Metro Vancouver Economic Impact Study. http://www.portmetrovancouver.com/docs/default-source/about-facts-stats/2009-01-12_Intervistas_-Port_Metro_Vancouver_Economic_Impact_Study_FINAL_REPORT.pdf?sfvrsn=0

InterVISTAS (2013) 2012 Port Metro Vancouver Economic Impact Study. http://portmetrovancouver.com/docs/default-source/about-facts-stats/2012-port-metro-vancouver-economic-impact-study.pdf

Katzmarzyk, P.T., Gledhill, N. and R.J. Shephard (2000) The economic burden of physical inactivity in Canada. *Canadian Medical Association Journal* **163**(11): 1435-1440.

Kinder Morgan Canada Website:
http://www.kindermorgan.com/business/canada/transmountain.cfm

King, T.L., B. Robinson, M. Boufadel and K. Lee (2014) Flume tank studies to elucidate the fate and behavior of diluted bitument spilled at sea. *Marine Pollution Bulletin* 83(1): 32-37.

Kuo, V. (March 25, 2014) "Dead, oiled birds sighted 3 days into Texas oil spill cleanup," *CNN US*. http://www.cnn.com/2014/03/25/us/texas-port-houston-oil-spill/

Kux, Stephen & Haider. Wolfgang (2012) Non-Motorized Outdoor Recreation in British Columbia in 2012: Participation and Economic Contributions. Prepared for the Federation of Mountain Clubs of British Columbia.

Lewis, J. (March 16, 2013) Kinder Morgan's pipeline ambitions on West Coast raises oil tanker concerns. The National Post. http://business.financialpost.com/2013/03/16/kinder-morgans-pipeline-ambitions-on-west-coast-raises-oil-tanker-concerns/?__lsa=1241-21c8

Loureiro, M.L., A. Ribas, E. Lopez and E. Ojea (2006) Estimated costs and admissible claims linked to the Prestige oil spill. *Ecological Economics* 59(1): 48-63.

McCrea-Strub, A., K. Kleisner, R. Sumaila, W. Swartz, R. Watson, D. Zeller and D. Pauly (2011) Potential Impact of the Deepwater Horizon Oil Spill on Commercial Fisheries in the Gulf of Mexico. *Fisheries* 32: 332-336.

McConnaughey, J. (February 24, 2014) "Lower Mississippi River back open after oil spill," *Associated Press*. http://www.huffingtonpost.com/huff-wires/20140224/us--mississippi-river-oil-spill/?utm_hp_ref=travel&ir=travel

McConnaughey, J. (February 24, 2014) "Oil spill shuts part of Mississippi River," *Associated Press*. http://www.ctvnews.ca/business/oil-spill-shuts-part-of-mississippi-river-1.1700936

Mackenzie, C. (2010) The Dungeness crab (Metacarcinus magister) fishery in Burrard Inlet, B.C.: constraints on abundance-based management and improved access for recreational harvesters. http://rem-main.rem.sfu.ca/theses/MackenzieCameron_2010_MRM478.pdf

Metro Vancouver (2014) Transit Ridership: 1989-2013 Passenger Trips. http://www.metrovancouver.org/about/publications/Publications/TransitRidership.pdf

Mills, M.J. (1992) Alaska Sport Fishing in the Aftermath of the Exxon Valdez Oil Spill. Special Publication No. 92-05. Alaska Department of Fish and Game. http://www.sf.adfg.state.ak.us/FedAidPDFs/sp92-05.pdf

Mossom Creek Hatchery website: http://www.mossomcreek.org/mossom-offered-75000-matching-grant/

Musequem website: http://www.musqueam.bc.ca/

National Geographic-Top 10 City Beaches. Retrieved July 10, 2014 from http://travel.nationalgeographic.com/travel/top-10/beach-cities-photos/

National Research Council (2013) An Ecosystem Services Approach to Assessing the Impacts of the Deepwater Horizon Oil Spill in the Gulf of Mexico. National Academies Press. 246 pp. ISBN: 978-0-309-28845-3 http://www.nap.edu/

NEB (2013) Proposed Trans Mountain Pipeline Expansion Project Configuration Map. http://www.neb-one.gc.ca/clf-nsi/rthnb/pplctnsbfrthnb/trnsmntnxpnsn/trnsmntnxpnsn-eng.html#s6

NEB (2014) Hearing Order OH-001-2014- Application for Trans Mountain Expansion Project (A59503). https://docs.neb-one.gc.ca/ll-eng/llisapi.dll/fetch/2000/130635/2485159/C289-3-3_-_Attachment_to_Province_of_BC_Motion_%231_-_Organizational_Chart_for_Comments_on_Inadequacy_of_IR_Responses_-_A3Y8R4.pdf?nodeid=2484776&vernum=-2

Nelson, Stuart (2008, rev. 2009) Pacific Commercial Fishing Fleet: Financial Profiles Report 2007. *Prepared for Department of Fisheries and Oceans Canda.*

Nelson, Stuart (2011) Pacific Commercial Fishing Fleet: Financial Profiles for 2009. Prepared for Fisheries and Oceans Canada, Pacific Region. Pacific Commercial Fishing Fleets Financial Profiles Series, 2011-4.

NOAA Fisheries (2014) Deepwater Horizon/BP Oil Spill: Closure Information website. http://sero.nmfs.noaa.gov/deepwater_horizon/closure_info/index.html

Oldridge, N.B. (2008) Economic burden of physical inactivity: Healthcare costs associated with cardiovascular disease. *European Journal or Preventative Cardiology* 15(2): 130-9.

Oxford Economics (2009) Potential Impact of the Gulf Oil Spill on Tourism. https://www.ustravel.org/sites/default/files/page/2009/11/Gulf_Oil_Spill_Analysis_Oxford_Economics_710.pdf

Phippen, B. (2001) Assessment of Burrard Inlet Water and Sediment Quality 2000. Prepared for the Water Protection Branch, Ministry of Water, Land, and Air Protection, Victoria, BC. http://www.env.gov.bc.ca/wat/wq/objectives/burrardinlet/index.html

Port Moody Ecological Society (PMES) website: http://noonscreek.org/about-us/

Port of Houston (2012) The Economic Impact of the Port of Houston. http://www.portofhouston.com/static/gen/about-us/Misc/PHA-EconomicImpact-2012-Summary.pdf

Powell, B. (March 25, 2014) Flights Over Houston Ship Channel to Assess Reopening," *Bloomberg Businessweek*. http://www.bloomberg.com/news/2014-03-24/houston-channel-shut-third-day-after-4-000-barrel-oil-spill-1-.html

Reuters (January 29, 2010) UPDATE 1-Texas waterway to fully reopen to ships in a week, *Reuters*. http://www.reuters.com/article/2010/01/29/tanker-collision-texas-idUSN2912414520100129?type=marketsNews

Rice, H., A. Hassan and L. Olsen (March 23, 2014) "Ship Channel remains closed after oil spill," Houston Chronicle. http://www.chron.com/news/houston-texas/houston/article/Ship-Channel-remains-closed-after-oil-spill-5342986.php

Robinson Consulting & Associates Ltd. (2012) PNCIMA Socio-economic Cultural Overview & Assessment Report. http://pncima.org/media/documents/secoa/secoa-final-mar-1-12.pdf

Salt Spring Air website: http://www.saltspringair.com

San Francisco Tavel (2014) San Francisco Visitor Industry Statistics. http://www.sanfrancisco.travel/san-francisco-visitor-industry-statistics

Scarfe, Brian (April 2011) Costs and Benefits of Cruise Ship Tourism in Victoria. Prepared for the James Bay Neighbourhood Association.

Schrope, M. (2014) Deepwater Horizon gunk settled far and wide. Nature. doi:10.1038/nature.2014.16225

Sea Air website: www.seairseaplanes.com

Service Canada (2015) EI Economic Region of Vancouver-Unemployment Rate and Benefit Table (for the perio dof March 15, 2015-April 11, 2015)

Shepard, R.J. (1992) A critical analysis of work-site fitness programs and their postulated economic benefits. *Medicine and Science in Sports and Exercise* **24**(3): 354-370.

Shogren, E. (2013, April 24) EPA: Tar Sands Pipelines Should be Held to Different Standards. *NPR*. Retrieved from http://www.npr.org/2013/04/24/178844620/tar-sands-pipelines-should-get-special-treatment-epa-says

Short, J.W. (2015) Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary. Prepared for Tsleil-Waututh Nation, City of Vancouver and Living Oceans Society

Smith, M. (April 29, 2013) "Empty nets in Louisiana three years after the spill," CNN.com http://edition.cnn.com/2013/04/27/us/gulf-disaster-fishing-industry/

Sorensen-Lawrence, Liddie and Tourism BC (January 2013) 2009-2010 Outdoor Recreation Study: BC Resident Participation. *Ministry of Jobs, Tourism and Innovation, Victoria.*

Stanbury, M., K. Hekman, E. Wells, C. Miller, S. Smolinske and J. Rutherford (2010) Acute Health Effects of the Enbridge Oil Spill. Michigan Department of Community Health
http://www.michigan.gov/documents/mdch/enbridge_oil_spill_epi_report_with_cover_11_22_10_339101_7.pdf

Statistics Canada, Industry Accounts Division (2010) Provincial Imput-Output Multipliers, 2010. British Columbia.

Statistics Canada (2011 A) Focus on Geography Series, 2011 Census: Census Metropolitan area of Vancouver, British Columbia. http://www12.statcan.gc.ca/census-recensement/2011/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=933

Statistics Canada (2011 B) Focus on Geography Series, 2011 Census: Census subdivision of Vancouver, CY-British Columbia. http://www12.statcan.gc.ca/census-recensement/2011/as-sa/fogs-spg/Facts-csd-eng.cfm?LANG=Eng&GK=CSD&GC=5915022

Stratus Consulting (2010) Appendix J: Damage Estimate for Shoreline Recreation. In: Cosco Busan Oil Spill Trustees. 2012. Cosco Busan Oil Spill Final Damage Assessment and Restoration Plan/Environmental Assessment. Prepared by California Department of Fish and Game, California State Lands Commission, National Oceanic and Atmospheric Administration, United States Fish and Wildlife Service, National Park Service, Bureau of Land Management. http://www.dfg.ca.gov/ospr/NRDA/cosco_busan_spill.aspx

Sumaila, U.R., Cisneros-Montemayor, A.M., Dyck, A., Huang, L., Cheung, W., Jacquet, J., Kleisner, K., Lam, V., McCrea-Strub, A., Swartz, W., Watson, R., Zeller, D., Pauly, D. (2012). Impact of the Deepwater Horizon well blowout on the Economics of U.S. Gulf fisheries. Can. J. Fish. Aquat. Sci. 69(3): 499-510. ISBN 10.1139/f2011-171.

Sumaila, U.R. and Walters, C. (2005) Intergenerational discounting: a new intuitive approach.
Ecological Economics 52: 135-142. doi:10.1016/j.ecolecon.2003.11.012.

TAMS CAD-Tourism BC (May 2007) Travel Activities and Motivations of Canadian Residents: An Overview. *Research Services, Tourism British Columbia, Victoria.*

TAMS US-Tourism BC (May 2007) Travel Activities and Motivations of US Residents: Resident Profile. *Research Services, Tourism British Columbia, Victoria.*

The Economist Intelligence Unit (2013) Global Liveability Ranking and Report August 2013. http://www.eiu.com/Handlers/WhitepaperHandler.ashx?fi=WEB_Liveability_rankings_Promotional_August_2013.pdf&mode=wp&campaignid=Liveability2013

The Trust for Public Land (2011) The Economic Benefits of Seattle's Parks and Recreation System. http://www.recpro.org/assets/Library/Economic_Impact/economic_benefits_seattles_parks-rec_system_2011.pdf

Thomson, R.E. (1981) Oceanography of the British Columbia Coast. *Canadian Special Publication of Fisheries and Aquatic Sciences* 56, 291 pp. http://www.dfo-mpo.gc.ca/Library/487.pdf

Tourism BC (2012) In-Market Research Report: Vancouver, Coast and Mountains.

Tourism BC (May 2012) The Value of Tourism in British Columbia – Trends from 2000 – 2010. *Ministry of Jobs, Tourism and Innovation.*

Tourism Squamish website: http://www.tourismsquamish.com/squamish-nation

Tourism Vancouver (2008-2011) Overnight Visitor to Metro Vancouver – Visitor Profile. Adapted from Statistics Canada, 2008 International Travel Survey Microdata (66C001) and/or 2008 Travel Survey of Residents of Canada Microdata (87M006XDB96000).
Tourism Vancouver (2011) Market Origin of Overnight Visitors to Greater Vancouver. http://www.tourismvancouver.com/includes/content/images/media/docs/ytd_visitor_volume_2011.pdf

Tourism Vancouver (2012) Monthly Overnight Visitor Volumes 1994 – 2012. http://www.tourismvancouver.com/includes/content/images//media/docs/historical_monthly_visitors.pdf

Trans Mountain Pipeline ULC (December 2013) Trans Mountain Expansion Project-An Application Pursuant to Section 52 of the National Energy Board Act. Volume 2: Project Overview, Economics Volume & General Information.

Trans Mountain Pipeline ULC (December 2013) Trans Mountain Expansion Project-An Application Pursuant to Section 52 of the National Energy Board Act. Volume 5B: ESA – Socio-Economic.

Trans Mountain Pipeline ULC (December 2013) Trans Mountain Expansion Project-An Application Pursuant to Section 52 of the National Energy Board Act. Volume 7: Risk Assessment and Management of Pipeline and Facility Spills.

Trans Mountain Pipeline ULC (December 2013) Trans Mountain Expansion Project-An Application Pursuant to Section 52 of the National Energy Board Act. Volume 8A: Marine Transportation.

Trip Advisor (2013) Editor's Pick Awards. http://www.cruisecritic.com/editors-picks/

TWN (2014) Food Fish webpage. http://www.twnation.ca/en/Band%20and%20Community/Services%20and%20Programs/Food%20Fish.aspx

TWN website: http://www.twnation.ca/

United States Census Bureau (2010) Census 2000 SF1, SF3, DP1-DP4, Census 2010 DP-1, American Community Survey 2006-2010. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml

Vancouver Marathon (2013) Press Release: BMO Vancouver Marathon Brings over 50 Million to Metro Vancouver. http://www.bmovanmarathon.ca/bmo-vancouver-marathon-brings-over-50-million-to-metro-vancouver/

Vancouver Waterfront Survey (2014). Developed by UBC and administered by the City of Vancouver. Unpublished data.

Warburton, DER, Nicol, CW and S.S.D. Bredin (2006) Health benefits of physical activity: the evidence. *Canadian Medical Association Journal* **174**(6): 801-809. DOI: 10.1503/cmaj.051351

Port Metro Vancouver Cruise Statistics Reports (2008-2013) Accessed September 6, 2014 from portmetrovancouver.com

Port Metro Vancouver (Oct 2014) *Frequently Asked Questions: Tanker Safety PDF*. http://www.portmetrovancouver.com/docs/default-source/port-users/frequently-asked-questions-on-tanker-navigation-safety.pdf?sfvrsn=4

Port Metro Vancouver News Release (2014) *Cruise Season Shows Continued Strength* Available at http://www.portmetrovancouver.com/en/about/news/2014/04/28/2014-cruise-season-shows-continued-strength

Port Metro Vancouver (2013) Port Metro Vancouver Sustainability Report. http://www.portmetrovancouver.com/about/news/2014/06/03/port-metro-vancouver-releases-2013-sustainability-and-financial-reports

Port Metro Vancouver website (bulk facilities) http://www.portmetrovancouver.com/en/portusers/landoperations/terminalsandfacilities/bulk.aspx

Port Metro Vancouver website (container facilities) http://www.portmetrovancouver.com/en/portusers/landoperations/terminalsandfacilities/container.aspx

Yonis, Ramzi (2010) The Economics of British Columbia's Crab Fishery: Socio-Economic Profile, Viability, and Market Trends. Statistical and Economic Analysis Series Publication No. 1-4. *Department of Fisheries and Oceans Canada.*

Appendix I: Analytical methods

A.1 Commercial fishing

Each of the indicators (i.e., total output value "x," employment "y," GDP "z") is assumed to be related to total commercial catch (C) as follows (Sumaila et. al 2012):

$$x = C \cdot p$$
$$y = x \cdot M^{f}{}_{d,di,dii}$$
$$z = x \cdot M^{f2}{}_{d,di,dii}$$

where p is the ex-vessel price per tonne and $M^{f}{}_{d,di,dii}$ and $M^{f2}{}_{d,di,dii}$ represent the economic impact multipliers for direct, direct and indirect, and direct, indirect and induced employment and GDP, respectively, for fishing, hunting and trap (Statistics Canada 2010). Provincial multipliers are used to estimate direct impacts; National multipliers are used for indirect and induced impacts.

Landed (ex-vessel) weight and value data for spot prawns and Dungeness crab, two commercial fisheries that are active in DFO Management Area 28, were obtained from DFO for 2000-2013 (Martin Huang, pers. comm., May 23, 2014 and June 10, 2014). In sub-areas where fewer than three commercial fishing vessels are active in a given year, catch cannot be disclosed by DFO as per the "three-party rule." In these cases, data were aggregated for Burrard Inlet (Area 28, sub-areas 7-14). Catch attributed to the City of Vancouver was estimated based on the mapped area of those sub-areas (i.e. 7, 8, 9 and 10) that are adjacent to the shoreline of Vancouver as a proportion of the total mapped area of Burrard Inlet; this method assumes even distribution of catch across Burrard Inlet. Thus, the value of half of the catch from sub-areas 7, 9 and 10 and all of the catch from sub-area 8 is allocated to the City of Vancouver for this analysis. Low and high estimates of annual landed values were estimated based on average values from the lowest and highest six years of data. All annual landed values were adjusted to 2013 CAD using the Consumer Price Index (CPI) for British Columbia (Statistics Canada 2014).

Employment figures, as well as indirect and induced economic impacts of the commercial fishing sector, were estimated using input-output multipliers for fishing, hunting and trapping[33] (Statistics Canada for British Columbia (direct, direct and indirect effects) and Canada (direct, indirect and induced effects).

[33] Statistics Canada fishing, hunting and trapping provincial multiplier BS114000.

A.2 Port activities

A.2.1 Shipping

Direct, indirect and induced output value, employment and GDP attributed to Port Metro Vancouver, including associated Canadian rail and trucking activity, were reported by InterVISTAS (2008, 2012). These studies provide a breakdown of direct employment from Port operations, by location, for 16 Metro Vancouver municipalities. Total economic activity associated with the Port within the City of Vancouver was estimated as proportion of total Port operations (i.e. an estimated 35% of total economic activity). Economic output value at Port Metro Vancouver attributed to the City of Vancouver and Statistics Canada multipliers for water transportation[34] were used to estimate the direct, indirect and induced output value, employment and GDP for Vancouver-based Port operations (excluding cruise ship activity). The 2013 baseline was estimated by adjusting 2011 economic output value (InterVISTAS 2012) to 2013 dollars.

The growth rate of economic activity at Port Metro Vancouver was estimated using the annual change in total cargo volume from 2007-2013. The overall trend for Port Metro Vancouver offers a more conservative estimate than that of container and bulk cargo attributed only to the seven port terminals located within Vancouver.

Economic activity attributed to the cruise industry was subtracted from the total economic activity reported by InterVISTAS (2008, 2012). The contribution of the cruise industry to output value, employment and GDP in the City of Vancouver is reported separately.

A.2.2 Cruises

InterVISTAS (2008, 2012) reports economic impacts of cruise activities at the provincial level and does not provide a municipal breakdown of direct economic impacts for cruise operations. InterVISTAS (2008, 2012) derived estimates of direct employment in the cruise industry from a cruise sector model developed by Business Research and Economic Advisors (BREA) and adjusted the results for 2011 using Vancouver passenger revenue data.

[34] Statistics Canada water transportation provincial multiplier BS114000

Since all of Port Metro Vancouver's cruise ship facilities are located in downtown Vancouver, all direct economic activity relating to cruise ship activity and operations is assumed to occur within the City of Vancouver. Because cruise ship passenger traffic increased by 22 percent from 2011 to 2013 (Port Metro Vancouver Cruise Ship Statistics), simply updating the 2011 economic impacts to 2013 dollars would have underestimated the baseline for the analysis. Therefore, the baseline for cruise activity in 2013 was calculated by adjusting total 2011 economic output value, reported by InterVISTAS Consulting (2008, 2012), to 2013 dollars and converting this output value to a dollar value per passenger per passenger for 2011. Dollar value per passenger was then multiplied by the number of passengers in 2013 to provide a baseline for the analysis. Statistics Canada water transportation multipliers[35] were used to calculate direct, indirect and induced output value, employment and GDP (Statistics Canada).

The growth rate of the cruise industry was estimated using average annual passengers from 2003 to 2013. The 10-year annual passenger average was 99 percent of 2013 passengers which indicates the industry is experiencing a growth rate near or close to zero over the long term. An annual growth rate of approximately 0 percent indicates that the industry remains stable but is not demonstrating signs of growth.

A.3 Inner Harbour transportation

Given the difficulty of obtaining detailed financial information for floatplane operations, industry revenues are used as a proxy for economic output value ("x") and have been estimated using the following formula:

$$x = F \cdot p$$

where *F* represents annual number of passengers at Vancouver Harbour Flight Centre (CHX) and *p* represents the average commercial fare for flights departing CHX. Data was collected for 2013. The average commercial fare, weighted for flight frequency, is $124.

Sightseeing passenger volumes were calculated using monthly passenger data from 2013 provided by Harbour Air (Stefani Isted, pers. comm., June 24 2014 and June 27 2014) for sightseeing passengers out of CHX and the average price of a sightseeing fare is $181. Sightseeing packages that incorporate non-flight related activities such as kayaking and whale watching were excluded.

[35] Statistics Canada water transportation provincial multiplier BS114000

Direct, indirect and induced employment "y" and GDP "z" are assumed to be related to total industry output value ("x") as follows:

$$y = x \cdot M^{a}{}_{di,dii}$$
$$z = x \cdot M^{a2}{}_{di,dii}$$

where $M^{a}{}_{di,dii}$ and $M^{a2}{}_{di,dii}$ represent Statistics Canada multipliers for direct indirect, and direct, indirect and induced economic impacts of air transportation [36] (Statistics Canada 2010). Multipliers for direct effects on Provincial employment and GDP were not available for air transportation; however, combined direct, indirect and induced direct effects across all provinces are reported.

The contribution of tourism to commercial floatplane operations was calculated using the 2008 Vancouver Island Visitor Exit Survey (Tourism Vancouver Island 2008), which reported the proportion of tourists that arrived and departed Vancouver Island via float plane. No similar exit survey exists for Metro Vancouver; however, most commercial floatplane flights operate from Vancouver to Vancouver Island. Therefore, data from the Vancouver Island Exit survey are assumed to reflect the behavior of tourists using floatplane services to and from Downtown Vancouver. The survey reports that 2 percent of tourists arrive on Vancouver Island via floatplane, while 1.5 percent of tourists depart Vancouver Island via floatplane.

The growth rate of CHX floatplane transportation was estimated using commercial air transportation annual passenger volumes from 2010-2014, reported by Transportation Canada (Transportation in Canada Reports 2010-2014). Multi-year passenger data for CHX was not available.

A.4 Ocean-dependent tourism

This study estimates the economic contribution of the ocean environment to tourism revenues in Vancouver. Tourism revenues have been calculated for the following categories: on-water activities, beaches and seawall, water-based and waterfront events.

[36] Statistics Canada air transportation provincial multiplier BS481000

Since tourism affects multiple sectors (e.g. local transportation, retail, hospitality), goods (e.g. souvenirs, clothing, electronics), and service providers (e.g. arts, airlines, tour companies), total output value is most easily and accurately estimated using average daily per capita tourism expenditure. This approach eliminates the need to evaluate the relative contributions of non-resident tourists and local residents to each business or sector individually.

For this study, tourists are defined as either overnight-visitors or day-visitors. Overnight visitor daily per capita expenditure was derived from Vancouver Overnight Visitor Profile data (Tourism Vancouver). Average daily expenditures from 2008-2011 were adjusted to 2013 Canadian dollars using the CPI to provide a baseline annual estimate for 2013. Average day-visitor expenditure was obtained from the 2010 Travel Survey of Residents of Canada, analyzed by Destination British Columbia (2011), adjusted to 2013 Canadian dollars using the CPI. This estimate is consistent with daily expenditure estimates for Non-Motorized Outdoor Recreation in BC (SFU School of Resource Management 2012). The exceptions are average daily expenditures overnight visitors participating in on-water activities, which were obtained from the 2012 SFU FMCBC study for multi-day water activities (p.38) rather than the Destination BC spending estimates.

The growth rate for tourism in Vancouver is assumed to be the same as the growth rate for tourism in Metro Vancouver and was estimated using overnight visitor data from Tourism Vancouver for the Metro Vancouver region for the years 2003-2012.

A.4.1. On-water activities

Economic output value "x", Employment "y" and GDP "z" are assumed to be related to average daily tourist expenditure (E) as follows:

$$x = E \cdot (n \cdot r) \cdot d$$
$$y = x \cdot M^{m}{}_{d,di,dii}$$
$$z = x \cdot M^{m2}{}_{d,di,dii}$$

where *n* represents the total average number of tourists per year, *r* represents the percentage of tourists whose primary travel motivation is marine recreation, *d* represents the average length of stay. $M^{m}{}_{d,di,dii}$ and $M^{m2}{}_{d,di,dii}$ represent economic impact multipliers for direct, direct and indirect, and direct, indirect and induced employment and GDP, respectively. Statistics Canada does not report multipliers for tourism activities; therefore, multipliers for marine tourism were based on those developed by Hotte and Sumaila (2012) for marine recreation in British Columbia, derived using a ratio of client expenditure to employment and GDP and based on data reported by Tourism BC (2004).

The average number of visitors to the City of Vancouver ("n") was estimated using Vancouver Visitor Centre statistics for 2004-2013 (Tourism BC 2014),[1] adjusted to account for the ratio of tourists who use visitor information centers (23%) to those who do not use visitor centers (77%) as reported in the Travel Activities and Motivations of Canadian Residents Survey (2007). It is assumed that tourists visiting large cities, such as Vancouver, are less likely to use tourist information centers less than tourists visiting smaller cities due to the availability of comprehensive online tourism resources to assist tourists with trip planning, as well as extensive concierge services at hotels. Therefore, the baseline estimate of the total number of tourists to the city of Vancouver is believed to be conservative. This study does not estimate the economic contribution of day-visitor participation in marine recreation and thus, the economic impact of marine recreation is likely underestimated.

Low and high rates for marine recreation as a primary travel motivation ("r") in Vancouver are three percent (low) and 14 percent (high). The low estimate is from the 2008 Vancouver Island Visitor Exit Survey Report (Tourism Vancouver Island 2008) and reflects the percentage of tourists whose primary travel motivation was listed as *marine activities*. The high estimate for travel motivation was calculated by aggregating travel motivation categories in Destination BC's Travel Activities and Motivation Survey (2007). *Sunbathing/sitting on a beach* and *swimming in the ocean* are not included in Destination BC (2007) and are considered separately (see Section A4.3).

The importance of marine recreation as a primary travel motivation is assumed to remain constant over time for this analysis. Increased participation in marine recreation activities is assumed to be due to the growth of regional tourism and equal to the tourism growth rate.

A.4.2. Waterfront events

Economic output value "x", employment "y" and GDP "z" are assumed to be related to average daily tourist expenditures for day visitors (E_1) and overnight visitors (E_2), respectively, as follows:

$$x = E_{1,2} \cdot \left(n_{1,2} \cdot r_{1,2}\right) \cdot d_{1,2}$$
$$y = x \cdot {M^e}_{d,di,dii}$$
$$z = x \cdot {M^{e2}}_{d,dii,dii}$$

where *n* represents the total average number of tourists (spectators and participants) for all waterfront events, *r* represents the percentage of tourists whose primary travel motivation was to attend or participate in a waterfront or water-based event (low estimate), or the percentage of tourists who participated in or attended a waterfront or water-based event (high estimate), and *d* represents the average length of stay (assumed to be one day for all events).

$M^{e}_{d,di,dii}$ and $M^{e2}_{d,di,dii}$ represent Statistics Canada economic impact multipliers for direct, direct and indirect, and direct, indirect and induced employment and GDP, respectively, associated with performing arts, spectator sports and related industries and heritage institutions[37]. These multipliers do not capture the indirect and induced effect of tourists spending on accommodation services.

The primary input to economic impact assessments for events is the economic activity generated by direct expenditure from external sources relating to an event. This effect can be broken down into two revenue streams: contributions from event organizers and contributions from visitors (i.e. participants, event officials, media and spectators)[1] (Ramchandani 2012). Due to data constraints, the economic contribution of event officials and media were excluded from this analysis; only direct expenditures of visiting participants and visiting spectators are included.

The relative composition of participants and spectators at events was assigned to one of three categories, based on the type of event: i) Vancouver residents; ii) Metro Vancouver residents (i.e. day-visitors); and iii) visitors from outside Metro Vancouver (i.e. overnight-visitors).

Annual events that occur on or near the waterfront were assigned to one of the following four categories: i) water-based; ii) run/triathlon; iii) sports/fundraising; and iv) community/arts.

For events with paid entry (e.g. running races, Dragon Boat regattas, volleyball tournaments), one of two methods was employed to calculate participant composition: either race organizers provided a composition breakdown for paid participants based on their records; or the researchers categorized participants and spectators using composition data from online race results and associated registration information. From this information, participants were observed to account for a relatively smaller portion of total attendees. Spectator attendance was estimated using a ratio of participants to spectators derived from surveys collected by the City of Vancouver during summer 2014 (Vancouver Waterfront Survey 2014). Attendance by residents, day-visitors and overnight visitors, respectively, including both participants and spectators, at events without paid entry was also estimated using survey data collected by the City of Vancouver (Vancouver Waterfront Survey 2014) for water-based events, sport/fundraising events and community/arts events.

[37] Statistics Canada performing arts, spectator sports and related industries and heritage institutions provincial multiplier BS71A00

The low estimate includes only spending by day visitors and overnight visitors whose primary travel motivation was attendance or participation in a waterfront or water-based event. The high estimate includes spending by day-visitors and overnight-visitors whose primary travel motivation was something other than a water-based or waterfront event, but who also attended a water-based or waterfront event.

Tourism participation rates for waterfront events are assumed to remain constant over time; increased participation and attendance are assumed to be driven by growth in regional tourism and, therefore, equal to the tourism growth rate.

A.5 Beach and seawall usage

Annual beach usage was estimated using data for the years 2007-2013 from the City of Vancouver's lifeguard counts for all major city beaches (Spanish Banks, Spanish Banks Extension, Locarno, Jericho, Kits, Sunrise, Sunset, 1st, 2nd and 3rd) for the summer season (i.e., from the May Long Weekend to Labour Day Long Weekend, plus or minus several weeks). Since lifeguard counts only provide an estimate of the number of beach users, this data was combined with survey data from the City of Vancouver's Waterfront Usage Survey (2014) to generate an estimate of waterfront park users. City of Vancouver survey data provided separate counts for beach and grass users taken during July 2014, which supported determination of a ratio of beach users to grass users. This ratio was applied to the lifeguard count to estimate total waterfront usage. Ratios are assumed to remain constant throughout the year.

Summer (i.e. high season) seawall usage was calculated using average daily seawall user (or "head") counts from 2003, 2004 and 2005, obtained from raw data from the City of Vancouver's Seawall Historic Head Counts. To avoid double counting, user counts by location were grouped into five sub-areas (i.e. Jericho/Spanish Banks, Kits Beach/Kits Point, Granville Island/Creekside, Yaletown/Downtown, English Bay/Stanley Park). The average daily number of users was multiplied by the average number of days of the summer season to generate a low (i.e., summer only) estimate of annual seawall usage. Due to data constraints, annual usage does not include usage outside of the peak period and is therefore an underestimate of total seawall usage. This estimate of annual summer beach and seawall usage is consistent with an estimate used by the Vancouver Board of Parks and Recreation (Sean Healy, pers. comm., June 17 2014).

Using data from the Vancouver Waterfront Survey (2014), a ratio of residents to day-visitors to overnight visitors at the waterfront was estimated for this analysis. A confidence interval was used to provide low and high estimates for baseline waterfront usage in all categories (i.e. residents, day-visitors and overnight-visitors).

Users were then grouped into two categories: those who spent three or fewer hours at the waterfront, and those who spent a half day or more at the waterfront. For the first category 33 percent of total daily expenditures were considered waterfront related, and in the second 66 percent of total daily expenditures were considered waterfront-related.

Average day-visitor and local resident expenditure was obtained from Destination BC (2010). Average overnight visitor spending was calculated from Tourism Vancouver's overnight visitor profile (Tourism Vancouver 2008-2011).

Growth for overnight and day-visitors was calculated as the tourism growth rate (Tourism Vancouver 2003-2012), and this assumes that the usage of the waterfront by tourists will remain constant overtime. Growth for local residents was calculated as the population growth in Metro Vancouver from 2006-2011 (Statistics Canada 2011)

Economic output value "x", employment "y" and GDP "z" are assumed to be related to average daily tourist expenditures for day-visitors (E_3) and overnight-visitors (E_4) and locals ($E_{5)}$ to the Vancouver waterfront as follows:

$$x = (E_{d,o,l} \cdot s_{1,2}) \cdot (n_{d,o,l})$$
$$y = x \cdot M^{b}{}_{d,di,dii}$$
$$z = x \cdot M^{b2}{}_{d,di,dii}$$

where $E_{d,o,l}$ represents average daily expenditure for day-visitors, overnight-visitors, and local residents, $s_{1,2}$ represents the percentage of average daily expenditure related to waterfront activity based (33% or 66%), $n_{d,o,l}$ represents the total annual average number of day-visitors, overnight visitors and locals to waterfront parks, seawall and beaches respectively. For day-visitors and local residents, $M^{b}{}_{d,di,dii}$ and $M^{b2}{}_{d,di,dii}$ represent Statistics Canada economic impact multipliers for employment and GDP, respectively, associated with Performing arts, spectator sports and related industries and heritage institutions[38] (Statistics Canada 2010) . Since these multipliers do not capture the indirect and induced effects of tourist spending on accommodations and other services provided to overnight visitors, the multipliers for marine tourism ($M^{m}{}_{d,di,dii}$ and $M^{m2}{}_{d,di,dii}$) from Hotte and Sumaila (2012) are applied to revenues from overnight-tourists.

[38] Statistics Canada performing arts, spectator sports and related industries and heritage institutions provincial multiplier BS71A00

Appendix II: List of water-based and waterfront events in Vancouver

Ocean Based Events	Location	Date (2013)
Polar Bear Swim	English Bay	01-Jan
Heads Up The Creek	Vanier Boat Launch	10-Mar
Junior & Sprint Regatta	Creekside Park	04-May
Dragon Zone Spring Sprint	Creekside Park	05-May
FCRCC Spring Regatta	Athlete Village	
Day Sails In Support of Local Charities	Harbour Green Dock	08-13 May
FCRCC Knockout Regatta	Creekside Park	11-May
Dragon Zone Spring Sprint	Crrekside Park	12-May
False Creek Women's Regatta	Creekside Park	25-May
Dragon Zone 500 Metre Regatta	Creekside Park	07-09 Jun
Variety Boat for Hope		12-Jun
Rio Tinto Alcan Dragon Boat Festival	Creekside Park	20-24 Jun
July 1st Crab Festival	Portside Park	01-Jul
Paddlefest 2012	Jericho Sailing Centre	06-Jul
Easter Seals Waves Regatta	Hastings Mill Park	12-Jul
Celebration of Light	Stanley Park	27 Jul-3 Aug
Jericho Stand Up Paddle Board Races	Jericho Park	24-Aug
Kayak for a Cure	Jericho West Field	25-Aug
Day of the Longboat	Jericho Sailing Centre	21-29 Sep
HMCS Oriole Charity Day Sails	Harbour Green Dock	08-15 Oct

Beach Events	Location	Date (2013)
Vancouver Open	Kitsilano Park	11-14 Jul
Soccer Express / Umbro Beach Soccer Blast	Spanish Banks Park	09-11 Aug
KitsFest	Kitsilano Park	08-12 Aug
Beach Volleyball National Championships	Spanish Banks	20-26 Aug
Sandcastle Competition	Spanish Bank West	26-Jul

Running Events/Triathlons	Location	Date (2013)
First Half Half Marathon	Roundhouse Turntable Plaza	10-Feb
Vancouver Sun Run	Stanley Park Seawall	April
BMO Vancouver Marathon	Stanley Park	04-05 May
Scotiabank Vancouver Half Marathon	Spanish Banks	22-23 Jun
Lululemon Sea Wheeze Half Marathon	Stanley Park Seawall	10-Aug
Rock'n'Roll Half Marathon	Stanley Park Seawall	26-Oct
Vancouver Historic Half	Stanley Park Seawall	24-Nov
Subaru Vancouver Triathlon	Locarno Trails & Park	12-Jul
Vancouver Triathlon	Ceperley Park	02-03 Sep
Spring Run Off 8km	Lumberman's Arch	24-Mar
Granville Island Turkey Trot	False Creek Seawall	14-Oct
James Cunningham Seawall Race	Ceperley Park	26-27 Oct
Energizer Night Race	Ceperley Picnic Site	02-Nov

Fundraisers/Walks/Community	Location	Date (2013)
World Partnership Walk	Lumberman's Arch	25-26 May
PMC Sierra Science Fair Sun Run	Seawall	25-May
Walk with the Dragon	Lumberman's Arch	20-21 Jul
Underwear Affair	Seawall	05-Jul
Paws for a Cause	Lumberman's Arch	07-08 Sep
Scotiabank AIDS Walk for Life	Sunset Beach	21-22 Sep
BC Walk Now for Autism Speaks	Lumberman's Arch	28-29 Sep
Cad Breast Cancer Run for the Cure		05-Oct

Arts and Music Festivals	Location	Date (2013)
Bard on the Beach	Vanier Park	15 Jun-05 Sept
Vancouver Folk Music Festival	Jericho Beach Park	18-20 Jul