Out of Stock: The Impact of Climate Change on British Columbia's Staple Seafood Supply and Prices

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Highlights

- Ocean physics and chemistry is being affected significantly by carbon dioxide (CO_2) emissions, impacting key marine and coastal organisms, ecosystems and the services they provide us, including seafood.
- These impacts will occur across all latitudes, including in the waters of British Columbia and Canada.[i] This will have direct impacts on the fish species that are consumed by residents of B.C.
- The supply of B.C.'s "staple seafood" species such as Pacific salmon (e.g., sockeye and chum), Pacific halibut, groundfish species (e.g. sablefish), Pacific hake, crabs and prawns will be affected.
- This study predicts that by 2050:
  - We could see a 21-per-cent decline in sockeye, a 10-per-cent decline in chum, and a 15-per-cent decline in sablefish stocks.
  - Prices of iconic West Coast species such as sockeye, chum and sablefish are projected to increase by up to $1.33, $0.77 and $0.64 per pound for sockeye, chum and sablefish, respectively, under climate change scenario alone.
  - Climate change will add pressure on already skyrocketing prices, contributing to an increase of more than 70 per cent in the price per pound in 2015 dollars of B.C.'s iconic species such as sockeye and chum salmon.
  - For the 10 staple seafood species of British Columbia, the net change in price attributable to climate change could cost British Columbians up to $110 million a year in 2015 dollars.
- To begin to solve the problem, federal and provincial governments and private actors (businesses, NGOs and individuals) need to work together to make rapid reductions in CO_2 emissions and eventually atmospheric CO_2 drawdown, and instate other measures to protect ocean health.
- Without action, there will be massive and mostly irreversible impacts of climate change on ocean ecosystems and the fish they provide.

Introduction

Climate science and marine ecosystem research informs us that marine fish species are already being impacted[ii] and that they would continue to come under increasing stress over the course of the 21st century as global climate change, ocean acidification and de-oxygenation combine with other stresses on the ocean. These factors will change the primary productivity, growth and distribution of fish populations, resulting in changes in the potential yield of exploited marine species worldwide, including in the waters of B.C. and Canada.[iii] The ultimate impact of climate change on the biophysics and ecology for people is through economic (e.g. prices, cost of fishing changes),[iv] social and cultural channels.[v]

Given these predicted changes and the fact that marine fish species provide us benefits such as seafood, jobs and profits,[vi] it is important for the public to understand how these changes would affect their pocketbooks.

Statistics Canada reported recently that the price of food is increasing at an alarming rate in Canada. For instance, they reported an increase in the price of fresh and frozen fish of 38% between April 2000 and April 2015.[vii]

The objective of *Out of Stock: The Impact of Climate Change on British Columbia's Staple Seafood Supply and Prices* is therefore twofold. First, we estimate the impact of climate change on the prices of the main fish species (by value) consumed by residents of B.C. (what we define as the staple seafood species of B.C.). Second, we estimate how climate change would likely affect the seafood budget of residents of B.C. via its impacts on fish prices. We address these questions using the best available data and by making reasonable assumptions.

Estimating the impact of climate change on seafood prices in B.C. would inform the public and policy-makers, and contribute to local dialogue and debate on not only the problems we face with increasing global warming but also how this would affect us directly in terms of dollars and cents. This would provide a basis for B.C. residents to discuss possible solutions, and how they can contribute to mitigating and adapting to climate change.

Methods

Our analysis is based on secondary research and data that are used to forecast the likely effects on seafood supply changes as a result of climate change to the people of B.C. We evaluate changes to the main fish species consumed by residents of B.C. under the current high emissions trajectory (Representative Concentration Pathway 8.5, RCP8.5 of the IPCC). To do this, we draw on the latest and best available science in the latest Intergovernmental Panel on Climate Change (IPCC) assessment report and the wider literature.[viii]

Seafood consumption in B.C.

The Department of Fisheries and Oceans reports that in 2013, Canadians consumed about 7.74 kg of seafood per person per year.[ix] On the other hand, the Food and Agricultural Organization of the United Nations states that the average per capita food fish supply in Canada is 22.6 kg per capita per year (FAO 2013). This apparent discrepancy is due to the fact that the DFO numbers are expressed in edible weight and are not adjusted for losses, such as waste and/or spoilage in stores, households, private institutions or restaurants or losses during preparation. FAO's numbers are simply the available global catch of fish to Canadians divided by the population of the country. For our analysis, we use the FAO numbers since they represent the estimated catch from the ocean.

The total quantity of seafood consumed by British Columbians is, therefore, about 104,667 tonnes per year (that is, 22.6 kg per capita per year multiplied by 4.61 million people living in B.C.[x]).

Staple seafood species of B.C.

Given that our goal is to determine how climate change is likely to impact the household budgets of residents of B.C. via its impacts on fish prices, we define the "Staple Seafood Species" of B.C. as those that residents spend the most on. The top 10 species groups that generate the highest landed values and therefore on which residents of Vancouver spend the most on are considered the staple seafood species of the region. Table 3 indicates the species groups that made it to the list. They are:

- halibut,
- geoducks,
- prawns,
- crabs,
- tuna,
- sablefish,
- rockfish,
- hake,
- sockeye salmon,
- chum salmon.

Sources of B.C.'s seafood supply

As Canada has the longest coastline in the world, bordering three oceans (Pacific, Atlantic and Arctic), the country therefore sources a good chunk of the fish consumed from its waters. But Canada is also big on the fish trade, exporting a large proportion of the fish it catches while importing a sizable amount of the fish consumed domestically from other countries.

B.C. waters as a major source

The total annual marine fish caught and landed in B.C. is approximately 168,800 tonnes in 2011.[xi] About 80% of fish caught in B.C. waters are destined for exports. Thus, we assume that the remaining 20% are consumed locally in B.C. This works out to 33,754 tonnes (i.e., the total annual marine fish catch in B.C. multiplied by 20%). Therefore, the amount of seafood from B.C. waters consumed by British Columbians is about 32% of the total seafood consumption in B.C.

Imports as an important source

To meet its seafood demand of 104,667 tonnes per year, B.C. consumes seafood not only from its waters but also from other countries. We estimated the amount of seafood consumed in B.C. that is imported from other countries by prorating the quantity of imported seafood by Canada. The United States, which contributes about 36% of the total imported seafood, is the top country from which Canada and therefore B.C. imports most of its seafood.[xii] The second top importing country is Thailand (13%), followed by China, Peru and Chile at 12%, 11% and 4%, respectively. The remaining 23% is contributed by other countries combined. This means that the effect of climate change on the price of fish available to British Columbians depends partly on how it affects fish populations in the waters of these countries too.

The total amount of imported seafood was estimated by using the total amount of imported seafood to Canada and the proportion of the country's population that resides in B.C. (i.e., 13.2% of the total population in Canada). Thus, the total amount of seafood from other countries consumed in B.C. is estimated at 47,173 tonnes per year (Table 1).

Table 1. Major importing countries and the quantity imported

Country	Imports into Canada in 2008 (tonnes)*	Imports consumed in B.C. (tonnes)
United States	169,000	22,023
Thailand	62,000	8,079
China	58,000	7,558
Peru	54,000	7,037
Chile	19,000	2,476
Total	**362,000**	**47,173**

The rest of Canada also contributes

We treat the contribution of the rest of Canada as a residual. That is, we deduct from the total consumption of seafood by British Columbians, the contribution from B.C. waters and imports and the remainder is then assumed to be the contribution from the rest of the country. Based on this, 9,946 tonnes per year is assumed to come from the rest of Canada. Hence, 32% of the seafood consumed by British Columbians comes from B.C. waters; 58% from imports, 10% from the rest Canada. Table 2 provides the quantity of B.C. staple seafood species by source.

Table 2. Sources of seafood in B.C.

Sources of Seafood	Quantity of seafood (tonnes)	Percentage of total seafood consumption in B.C.
B.C. waters	33,754	32.2
United States	21,922	20.9
Rest of Canada	9,946	9.5
Thailand	8,043	7.7
China	7,524	7.2
Peru	7,005	6.7
Chile	2,465	2.4
Other countries	14,010	13.4
Total	**104,667**	**100**

Climate change impacts on the supply of B.C.'s staple seafood species

Scientists have demonstrated that warming and acidification of surface ocean waters will increase as CO_2 emissions increase.[xiii] Our knowledge of these impacts is based on modeling, fieldwork and lab experiments. Uncertainty and short-term variability (like unpredictable ocean cycles) makes predictions difficult. This short-term fluctuation is the reason why climate models have a hard time predicting changes over 10-15 years, but do very well with predictions several decades into the future, as the work of the IPCC illustrates. Consequently, findings in the literature suggest that under current rate of emissions, many marine organisms will have very high risk of impacts by 2050,[xiv] and that the seafood we obtain from ocean ecosystems will as a result be impacted. This risk increases as we continue to pump CO_2 into the atmosphere.

These impacts are likely to be cumulative or synergistic with other human impacts, such as overexploitation of living resources, habitat destruction and pollution. In addition, impacts of climate change on food supply and food prices are going to be not only on seafood but also on agriculture via its impacts on water, energy, etc.

Given the difficulty in making short-term predictions, we use model results for 2050 in this analysis, and focus on the 10 staple seafood species identified above. We explore the potential consequences of continuing on the current high emissions trajectory (Representative Concentration Pathway 8.5, RCP8.5) where the average temperature could increase by as much as 5°C by the end of the 21st century.

The projected potential catch change for each of the staple species under these scenarios was estimated, in the waters of the rest of Canada and in the waters of importing countries, by using an updated set of results reported in Cheung et al. 2010[xv]). The models were used to estimate the changes in maximum catch potential based on projected changes in species' distribution and primary productivity. The models applied in these papers simulate how changes in temperature and oxygen content (represented by O_2 concentration) as well as other variables such as ocean current patterns, salinity, and sea ice extent, would affect growth and distribution of marine fishes and invertebrates (Cheung et al. 2011[xvi]), whereas the empirical model projects species' maximum catch potential (MSY) based on the total primary productivity within its exploitable range, the area of its geographic range, and its trophic level.

With this information, we calculated the changes in the potential catch of each of the 10 staple seafood species from all seafood sources under climate change in the 2050s, the closest year for which reasonable model predictions of the impact of climate change can be made. This does not mean that the impacts of climate change on fish prices and household budget would not be felt in the next 10 years. It is just that this time period is too short for modellers to capture the changes with reasonable certainty.

Economic impacts of climate change

For most goods, including seafood, the price of the good is determined, for the most part, by the interplay between supply and demand. This class of goods are known as normal goods; the price of the good increases when the supply of the good decreases and vice versa, everything else staying equal. Most fish species consumed by residents of B.C. are normal goods.

Factors other than quantity supplied that affect fish prices include personal income and the supply of other animal protein types (e.g. beef, chicken). To isolate the impact of climate change on fish prices through changes in supply, we have to keep all other factors that can affect price constant. Economists employ econometric models to study and estimate demand functions.[xvii]

Climate change effects on B.C.'s staple seafood prices
Several economists have studied the sensitivity of fish prices to changing quantities of fish supplied to the market. Examples of earlier studies that estimate the effects that changing quantities (amongst other factors caused by changing quotas) have on prices are Bartend and Bettendorf 1989;[xviii] Burton, 1992,[xix] Jaffrey et al. 1999[xx]).

Bartend and Bettendorf (1989) studied the sensitivity of fish prices to quantities for the eight major types of fish (haddock, cod, whiting, redfish, plaice, sole, ray, and turbot) landed at Belgian fishing ports. They found that as the aggregated quantity of fish increases the normalized price goes down. By the same token, price increases with a decrease in aggregate quantity supplied. This "supply-price" dynamics has actually been observed in real life. For example, the ex-vessel price of Atlantic cod landed in the United States rose from USD 2,327 per tonne to USD 3,465 per tonne in 2005 real dollars between 1996 to 2006 when the abundance of this species declined.[xxi]

Burton (1992) developed an empirical analysis of the demand for wet fish in the United Kingdom using both the direct and indirect Translog models. He aggregated the fish he studied into the following four groups:

1. White: cod, saithe, haddock, hake;
2. Smoked White: smoked cod, smoked haddock;
3. Fat: Herrings, kippers, mackerel, smoked mackerel;
4. Other: plaice, skate, lemon sole, whiting, rock salmon.

For these groups of species, Burton estimated, among other things, the flexibilities – both own and cross – with respect to the quantity of fish supplied to the market.[xxii] He estimated the own flexibilities for Groups 1, 2, 3 and 4 to be -0.48, -0.26, -0.49 and -0.31, respectively. The cross flexibilities were estimated to be -0.46, -0.11, -0.05 and -0.30 for Groups 1, 2, 3 and 4, respectively. These numbers were all negative as expected and the estimates were similar to those reported by Bartend and Bettendorf (1987). Note that a flexibility of 0.48 means that a 10% change in quantity will result in a 4.8% change in price.

The study by Jaffrey et al. (1999) set out to estimate the own and cross-price flexibilities for four high valued species (bass, lobster, sole and turbot) landed in the United Kingdom. They developed a system of equation models using the vector error correction model (VECM) approach. Their analysis suggests that a 10% reduction in bass landings will in the long run increase its normalized price by about 4% while a 10% reduction in lobster landings will increase the price of bass by only 1.5%, an indication that lobster is a mild substitute for bass. Next, a 10% reduction in landings of lobster will increase its normalized price by 1.9%. Also, the authors found that a 10% reduction in the landings of sole will increase its price by 2.5%, whereas a 10% reduction in landings of turbot will increase the price of sole by just 1.0%. Lastly, a 10% reduction in landings of turbot will increase its own price by almost 3%. A 10% reduction in landings of sole will also result in about a 2.2% increase in the price of turbot.

We used the above numbers to assume a range of percentage changes in price that would result as the supply of seafood changes. The assumed numbers are reported in Table 5 for each of the listed B.C. staple seafood species.

Climate change effects on B.C. household budgets

Price elasticity is defined as the percentage change in quantity demanded of a good or service divided by the percentage change in its price, all things remaining constant. If demand for a good is *inelastic* (that is, the price elasticity of demand is less than 1), an increase in price of fish due to climate change can, at least, partly be transferred to consumers by producers.

In this case, the price effect is stronger than the quantity effect. If demand for a good is *elastic* (that is, the price elasticity of demand is greater than 1), an increase in price implies the price effect is stronger than the quantity effect with the implication that the price increase is more difficult to transfer to consumers since consumers are able to reduce their consumption of fish to offset the increase in price. If the demand for the good is *unit-elastic* (that is, the price elasticity of demand is 1), an increase in price does not change household budgets for the fish or the total revenue received by fishing companies. In this case the price and quantity effects offset each other.

Economists study price and expenditure elasticities, as well as elasticities of substitution between fish products and other protein commodities in order to understand the relationship between supply and demand for fish products. Results reported in Wellman (1992)[xxiii] indicate that with the exception of shellfish, demand for the various fish products is relatively inelastic. The author also found that cross-price elasticities are generally moderate while expenditure elasticities are large and positive for fresh fish and shellfish.

In another study of elasticities and household expenditures, Cheng and Capps (1988)[xxiv] found that the main factors explaining the variation of expenditures on seafood commodities were own price, household income, household size, and seasonality. They also found that own-price elasticities ranged from -0.45 for flounder/sole to -1.13 in the case of oysters. Furthermore, they found that cross-price effects of red meat and poultry were not statistically significant.

To determine how much households actually spend on the staple seafood of B.C., we need to determine how much they pay for fish at the end of the fish chain i.e., at the retail stage. A number of studies have looked at the split of the retail value of fish that accrues to the fishing and post-harvest sectors. An example of such a study is one done on Alaska salmon. The study found that between 29 – 40% of the retail value of salmon is kept by the fishing sector with the remainder captured by the post-harvest sector.[xxv] Based on our knowledge of fish chain analysis, we assumed for this study that the split is 30:70 in favour of the post-harvest. This assumption can easily be modified and the analysis redone quickly.

Key Results

Depletion of supply and increases in costs

Considering the combined climate change impact on all sources, we find the catch of the iconic West Coast sockeye salmon drops up to 21%, followed by sablefish (15%) and chum salmon (9%) by 2050.

Consequently, the prices of iconic West Coast species such as sockeye salmon, sablefish and chum are projected to increase by up to $2,925, $1,703 and $1,397 per tonne under the climate change scenario analysed. This change is equivalent to an increase per pound of $1.33, $0.77 and $0.64 for sockeye salmon, halibut and sablefish, respectively in 2015 dollars.

For the 10 staple seafood species of British Columbia, the net change in price attributable to climate change could cost British Columbians up to $110 million a year in constant 2015 dollars.

When the additional impact of climate change is considered along with projections from Statistics Canada's reported price increase of 38% for fish over the past five years,[xxvi] the predicted impact on B.C. pocketbooks is staggering.

With time, climate change will add pressure on prices, contributing a projected increase of more than 70% in the price per pound of sockeye and chum salmon by 2050.

B.C. consumption and value of seafood

The total amount of seafood consumed in B.C. is reported in Table 3 together with the contributions from the three main sources. We see from the table that B.C. is estimated to source about 32% of the main species of fish it consumes from the waters of B.C., 58% from imports and the remainder from the waters of the rest of Canada (10%).

Table 3. Total B.C. consumption of seafood

Seafood group	B.C. seafood consumed in B.C. (tonnes)	Rest of Canada seafood consumed in B.C. (tonnes)	Imported seafood consumed in B.C. (tonnes)	Total consumption (tonnes)
Halibut	800	195	1,829	2,824
Geoducks	320	0	0	320
Prawns	560	3434	10,974	14,968
Crabs	1,000	2257	2,439	5,696
Tuna	1080	13	3,658	4,751
Sablefish	440	0	0	440
Rockfish	3,600	0	0	3,600
Hake	11,080	182	0	11,262
Sockeye	600	0	1,871	2,471
Chum	1160	0	3,616	4,776
Total	**20,640**	**6082**	**24,387**	**51,109**

The bulk of fish consumed in B.C. comes from the 10 top species defined here as the staple seafood species because most expenditures on seafood are on these. We see from Table 3 that a total of just over 51 thousand tonnes of these 10 species are supplied to the B.C. market at a value (at the dock) of about $349 million a year (Table 4).

Table 4. Price and landed value of B.C.'s staple seafood species

Seafood group	Price ($/tonne)	Landed value of B.C. seafood consumed in B.C. ($)	Landed value of rest of Canada seafood consumed in B.C. ($)	Landed value of imports consumed in B.C. ($)
Halibut	11,400	9,120,000	2,220,107	20,850,944
Geoducks	25,813	8,260,000	0	0
Prawns	14,286	8,000,000	49,059,016	156,774,019
Crabs	6,500	6,500,000	14,672,580	15,851,595
Tuna	5,315	5,740,000	70,878	19,441,914
Sablefish	12,364	5,440,000	0	0
Rockfish	1,444	5,200,000	0	0
Hake	298	3,300,000	54,235	0
Sockeye	4,067	2,440,000	0	7,607,103
Chum	1,828	2,120,000	0	6,609,450
Total		**56,120,000**	**66,076,816**	**227,135,025**
			Grand Total	**349,331,841**

Changes in catch and supply

Our climate model of marine ecosystems and fisheries indicate numerous impacts (see Table 5):

- Within B.C. waters, four of the 10 stable seafood species would likely see decreases in catch with warming under the scenario explored. The species with the highest potential decrease in catch is the iconic West Coast sockeye salmon while the catch of crabs would increase the most.
- In the waters of the rest of Canada, seven of the species would likely decrease in catch under both scenarios, with only two projected to see increases under both scenarios. One species under only one scenario is projected to see an increase in its catch.
- For the waters of countries that B.C. imports fish from, all but one of the six imported species group would suffer a loss in catch, and even for this one (tuna), there is a decrease in catch under only one scenario.

Table 5. Change in catch potential under different climate change scenarios

Seafood group	Change in catch potential in B.C. waters		Change in catch potential in rest of Canada waters		Change in catch potential from imports	
	(RCP26) (%)	(RCP85) (%)	(RCP26) (%)	(RCP85) (%)	(RCP26) (%)	(RCP85) (%)
Halibut	11.3	10.2	-20	-18	-1.5	-8.0
Geoducks	-5.0	-9.4	-5	-9	0.0	0.0
Prawns	8.8	3.3	-5	-4	-3.2	-11.2
Crabs	18.7	36.7	-11	-12	-7.3	-15.0
Tuna	6.5	3.3	-2	5	-3.2	1.8
Sablefish	-5.0	-14.9	-5	-15	0.0	0.0
Rockfish	7.8	8.5	8	9	0.0	0.0
Hake	-6.8	-7.9	-7	-8	0.0	0.0
Sockeye	-22.7	-36.1	-23	-36	-11.5	-15.5
Chum	4.8	8.0	5	8	-11.5	-15.5

In Table 6, we report the changes in the supply of the staple seafood species of B.C. from all sources. In the last two columns of the table, we make the assumption, because of the uncertainty in the model projections, that any change in supply that is below 5% can be considered as no change in potential catch. With this assumption, we considered changes in catch for only 7 of the 10 species, and for all but one species, the projected change in catch from all sources of seafood to British Columbians is negative.

Table 6. Change in seafood supply under different scenarios

Seafood group	Change in supply under RCP 26 in the 2050s (%)	Change in supply under RCP 85 in the 2050s (%)	Change in supply under RCP 26 considering uncertainty (%)	Change in supply under RCP 85 in the 2050s (%)
Halibut	1	-4	0	0
Geoducks	-5	-9	-5	-9
Prawns	0	-9	0	-9
Crabs	0	0	0	0
Tuna	0	0	0	0
Sablefish	-5	-15	-5	-15
Rockfish	8	9	8	9
Hake	-7	-8	-7	-8
Sockeye	-14	-21	-14	-21
Chum	-8	-10	-8	-10

Changes in B.C. seafood prices and budgets

In the first and second columns of Table 7, we report a range for the expected change in price for a 1% drop in the supply of each of the 10 species based on our review of the literature. We see from the table that for species such as halibut, a range of 0.5 – 1.00 is assumed; for crabs and prawns, 0.25 – 0.75 and salmon, 0.75 – 1.25. The rest of the table contains estimates of the percentage change in prices as a result of changes in supply attributed to climate change.

Table 7. Percentage change in price due to change in supply

Seafood group	Effect of a 1% decrease in supply on price (%)		Change in price under RCP 26 in the 2050s (%)		Change in price under RCP 85 in the 2050s (%)	
	Low	High	Low	High	Low	High
Halibut	-0.5	-1	0	0	0	0
Geoducks	-0.25	-0.75	-1.3	-3.8	-2.4	-7.1
Prawns	-0.25	-0.75	0	0	-2.3	-6.8
Crabs	-0.25	-0.75	0	0	0	0
Tuna	-0.25	-0.75	0	0	0	0
Sablefish	-0.5	-1	-2.5	-5.0	-7.5	-14.9
Rockfish	-0.5	-1	3.9	7.8	4.3	8.5
Hake	-0.5	-1	-3.4	-6.8	-3.9	-7.9
Sockeye	-0.75	-1.25	-10.7	-17.8	-15.4	-25.7
Chum	-0.75	-1.25	-5.7	-9.5	-7.4	-12.3

In Table 8, we report the changes in price per tonne and the landed value for each of the stable seafood species of B.C. We see that only the price of rockfish is projected to decrease and that the change in landed value ranges from about $9 to $33 million a year depending on the scenario and whether the change in price is on the low or high ends.

Table 8. Change in price per tonne of fish due to change in supply

Seafood group	Change in price under RCP 26 in the 2050s ($)		Change in price under RCP 85 in the 2050s ($)		Change in landed values under RCP 26 in the 2050s ($)		Change in landed values under RCP 85 in the 2050s ($)	
	Low	High	Low	High	Low	High	Low	High
Halibut	0	0	0	0	0	0	0	0
Geoducks	143	428	268	804	45,600	136,800	85,728	257,184
Prawns	0	0	259	777	0	0	3,874,835	11,624,504
Crabs	0.3	0.9	0.0	0.0	1,704	5,111	0	0
Tuna	0.1	0.3	-0.1	-0.3	480	1,440	-481	-1,442
Sablefish	284	567	851	1,703	124,825	249,649	374,653	749,305
Rockfish	-443	-887	-486	-971	-1,596,456	-3,192,912	-1,748,304	-3,496,608
Hake	387	774	447	895	4,358,770	8,717,539	5,039,226	10,078,451
Sockeye	1,218	2,030	1,755	2,925	3,008,574	5,014,290	4,335,514	7,225,857
Chum	647	1,078	838	1,397	3,090,119	5,150,199	4,004,625	6,674,374
Total					**9,033,616**	**16,082,118**	**15,965,795**	**33,111,626**

From Table 9 we see that the changes in catches stemming from climate change results in a net increase in the expenditure by households in B.C. of between $30 to $110 million a year in constant 2015 dollars depending on the scenario and whether the change in price is on the low or high ends.

Table 9. Estimated change in household seafood budget in B.C. under the business-as-usual scenario

Seafood group	Change in consumer budgets for seafood ($)		Change in consumer budgets for seafood ($)	
	Low	High	Low	High
Halibut	0	0	0	0
Geoducks	152,000	456,000	285,760	857,280
Prawns	0	0	12,916,116	38,748,348
Crabs	5,679	17,037	0	0
Tuna	1,601	4,802	-1,602	-4,807
Sablefish	416,082	832,165	1,248,842	2,497,683
Rockfish	-5,321,520	-10,643,040	-5,827,680	-11,655,360
Hake	14,529,232	29,058,465	16,797,419	33,594,838
Sockeye	10,028,581	16,714,301	14,451,713	24,086,189
Chum	10,300,398	17,167,330	13,348,749	22,247,914
Total	**30,112,053**	**53,607,060**	**53,219,316**	**110,372,085**

Recommendations

The ocean provides compelling arguments for rapid reductions in CO_2 emissions and eventually atmospheric CO_2 drawdown. Climate change also provides a strong reason for protecting our marine ecosystems from other stressors and pressures such overfishing, habitat destruction, oil spills and other sources of pollutants.

To begin to solve the problem at hand, this report provides six key recommendations.

- The federal and provincial governments need to work, both individually and collectively with the international community, to immediately and substantially reduce CO_2 emissions.
- The federal and provincial governments need to improve the management of Canada's three oceans and freshwater systems by eliminating harmful fisheries subsidies such as those for fuel, and by investing in science and monitoring activities such as those provided by the coast guards.
- Policy and management regimes need to be put in place to make our ocean and freshwater systems resilient to shocks such as those from climate change and ocean acidification – at least 10% of these systems, as agreed by the global community, need to be protected.
- Governments, businesses, NGOs and individuals must work together to reduce the incidence of oil spills and other pollutants such as effluent and plastics in marine ecosystems.
- Private actors (businesses, NGOs and individuals) need to make conscious effort to reduce their carbon footprint.
- Consumer behaviours need to modified for the coming changes and challenges. With the help of sea choice and certification programs, consumers should ensure that they purchase fish and fish products that come from sustainable sources.

These actions would help prevent the massive and mostly irreversible impacts of climate change on ocean ecosystems and the fish they provide.

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