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Price and revenue projections under alternative policy shocks due to the coronavirus: Canadian lobster and snow crab

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ABSTRACT

The coronavirus will have serious consequences for the fishing industry. The purpose here is to simulate price and revenue outcomes for Canadian lobster and snow crab markets under alternative policy shocks due to the coronavirus. Predictions are based on three policy scenarios representing upper and lower bounds on the range of possible landings and economic outcomes for the period 2019–2021. Based on past research, demand equations for both the lobster and snow crab markets are used to empirically simulate price projections. The results for snow crab are startling with predicted serious declines in price and generated revenue, particularly for Quebec and Newfoundland and Labrador (NL). Compared to 2018, projections suggest a decline in average revenue for 2021 of –18% Gulf, –32% Maritimes, –53% Quebec, and –57% NL. The outcome for lobster is not as bleak, projections showing a 21% decline in revenue for 2020 but with recovery in 2021.

1. Introduction

The market impact of the SARS-CoV-2 virus that causes COVID-19 will be substantial and the fishing industry with its regional importance and international markets may experience serious price and revenue shocks. The coronavirus will affect the fishing sector through changes in aggregate economic variables with shocks to the demand structure and disruptions in the supply chain. Certainly, the seafood sector is continuously exposed to demand and supply shocks that effect prices and trade patterns. The COVID-19 shock, however, is far more extensive and comprehensive in restricting both supply and market access. The purpose for this paper is to simulate price outcomes for a number of alternative policy scenarios as a consequence of the coronavirus for the Canadian snow crab and lobster industries. Gordon [20,21] builds and estimates inverse demand equations for snow crab and lobster, where the main drivers are income, exchange rates and substitute effects. These equations will be used to evaluate market implications of the coronavirus on landed price and generated revenue under the alternative policy scenarios. The purpose here is to provide useful price and revenue outcomes as a result of the coronavirus to support policy planning for the Canadian snow crab and lobster industries. The paper may also be of interest to other fishery sectors and other countries as the results provide some indication of the effect of the COVID virus and its impact on markets.

Since the collapse of the groundfish fishery in the early nineties, crustaceans have developed into the most important Canadian fisheries in terms of export value. In 2008, groundfish accounted for only 9% of total value landed whereas shellfish reached 78% of total value landed. Lobster is the major export fishery with a value of $1.3 billion and a landed volume of 91 thousand tonnes. Snow crab follows with export earnings of $434.2 million on landed volume of 70 thousand tonnes.

Gordon [20,21] models price realizations in both the lobster and snow crab markets using inverse demand equations. The starting point is a general reduced form equation where real landed price is regressed on landed quantity, exchange rates between the Canadian dollar and currencies of export markets, and demand shift variables characterizing the main consumer markets. To be clear, the models are parsimonious yet useful models to predict trends and turning points in ex-vessel prices.

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evaluated under four specific policy shocks due to Coronavirus effecting US GDP, Canada-US exchange rate, Canada-Japan exchange rate and snow crab wholesale prices. In this way, the COVID shock is playing out partly as a demand shock modelled by exchange rates and income in the main market and partly as a supply shock as landings are reduced. The equations are used to simulate price outcomes based on three policy scenarios that summarize possible economic shocks of the coronavirus for aggregate economic variables. The impact of the coronavirus may force fundamental structural changes in demand relationships and supply chains. The empirical models used here, capture market structure and demand relationships as defined by the data period used in estimation.

The paper is organized as follows. The next section describes the Canadian snow crab and lobster fisheries and briefly outlines the price models used in policy simulation. Following this, three policy scenarios are developed and used in simulating alternative price and revenue projections. The final section offers summary comments.

2. The Canadian snow crab and lobster fisheries

Snow crab and lobster fisheries are important agents of employment and welfare for fishermen in the Maritimes, Newfoundland & Labrador, and Quebec regions of Canada. Management of the lobster fishery is broken down to 45 in-shore lobster areas with some 10,000 licensed fishermen [3,13-15]. The main instruments for regulation are input controls restricting fishing effort but no limits on actual harvest levels [36]. As such, current harvest levels may be correlated with current price and for empirical work, this will cause serious endogeneity issues that must be addressed [17]. There are restrictions and limits on the number of traps and seasonal closures. Seasonal closures are designed, among other things, to ensure a continuing supply of lobster throughout the year.

For snow crab, Atlantic Canada is divided into four management zones; Coastal Newfoundland, the Northern Gulf of St. Lawrence, the Southern Gulf of St. Lawrence, and Eastern Nova Scotia. The quantity and quality value of snow crab varies by region resulting in regional price differences [13]. Harvest occurs in select months of the year, usually April through August and varies by region. For each management zone, the fishery is regulated with individual vessel license quotas and empirically this allows us to avoid the endogeneity issue in demand estimation. In addition, there are restrictions on number of traps, size (minimum carapace 9.5 cm) and sex restrictions (only males are harvested), and seasonal closures [13].7 Harvesting soft-shelled crabs is restricted and area closures are used where harvest of soft-shelled crabs exceeds 20% of the catch. Department of Fisheries and Oceans (DFO) enforcement includes 100% dock-side monitoring.

Canada is a major player in the snow crab fishery accounting for about 60% of total world supply [45]. A large portion of harvest (67%) is exported, with the United States the largest market (83% of total exports). Japan and China also represent important markets (Fisheries and Ocean Canada 2016). Landings data are available annually on price and landed values by region for Canada and annual landings for the US for the period 1990–2018. The US (Alaska) is an important source of snow crab with large annual landings in the 1990’s but a serious stock collapse after 2000 greatly reduced harvest levels. Since 2013, a new source of supply is available from the Barents Sea. The Barents Sea data represent estimates of landings of snow crab by Norway and Russia as recorded by Opilio catch data and provided by DFO-NL region. This new supply of snow crab started in 2013 and early on supply was limited. But in the last few years’ landings increased and exceed US landings. A share of these landings enters the US market and Gordon [20] included Barents Sea landings to try and account for a price effect on the Canadian market.8

Fig. 1 reports annual landings of snow crab for Canada and US over the period of study. Barents Sea landings near the end of the period are also included. Notice the very large landings by the US in the early 1990s reaching a staggering harvest of 147 thousand tonnes in 1991, but with a serious decline in harvest after 2000. Average annual US harvest over the period 1990–1999 was 85 thousand tonnes compared to only 20 thousand tonnes over the period 2000–2013. Interestingly, after strong growth in the 1990s, Canadian landings have been stable at about 90 thousand tonnes annually declining somewhat in 2018. Barents Sea landings begin in 2013 and increase to over 20 thousand tonnes in 2015, declining somewhat by the end of the period.

To get a comparative idea of Canadian regional snow crab price and quantity differences, Table 1 reports aggregate summary statistics for price and landings for the full data period 1990–2018. Here we see that the Gulf region receives on average the highest price/kg and NL the lowest price across the four regions. On the other hand, NL is on average the largest producer of snow crab followed by the Gulf region, Québec.

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6 There is a growing literature showing the link between the COVID-19 pandemic and shocks to aggregate economic variables. The direct link is government policy response to the virus restricting gatherings, business closures, etc. causing an increase in unemployment and decline in GDP. Changes in exchange rates will reflect decline in trade and general fall in demand. The lobster industry is badly hit with closure of restaurants. See e.g., [23-25].

7 Stock assessments are conducted on a regular basis through the Canadian Science Advisory Secretariat, a scientific committee that includes internal and external experts, as well as fishermen [15].

8 The two fisheries are very different with lobster a high-valued fresh product with seasonal harvest to ensure supply in all months of the year, whereas snow crab is sold primarily as a frozen product harvested in select months of the year. For snow crab, there are qualitative differences across regions that effect price. The two products sell into separate markets with limited interaction.

9 Source: U.S. snow crab landings: https://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/monthly-landings/index

10 The price model used here is focused on the Canadian market but as Anderson et al. [1] make clear, seafood is a global market. It is also worth noting, that the Barents Sea supply although statistically important in estimation has a small measured effect on Canadian shore prices.
and a smaller fishery in the Maritimes. The lobster fishery is dominated by Canadian and US production, with the US and to a lesser degree Asia and Europe important consumer markets. Monthly observations on price and landed values are available for Canadian and US landings of lobster for the period 1990–2018.

Fig. 2 shows monthly real Canadian ex-vessel price variations over the period 1990–2018. Lobster is a very important high value species and we observe good growth in real average landed prices up to 2003 (reaching $20.1/kg) with a declining trend through 2013. Notice that after 2013 prices appear to show the start of a positive trend.

Fig. 3 shows the trend and variation overtime in monthly landings of Canadian and US lobster. Both series show a positive trend to landings but over the period Canada records an average monthly landing value of 4640 tonnes compared to US average landings at 3379 tonnes. The largest monthly catch for Canada occurred in May 2014 at 26,385 tonnes. For the US the largest monthly catch level occurred in August 2013 at 16,953 tonnes.

3. Price models for Canadian snow crab and lobster

The econometric profile for snow crab [20] is written as,

\[ P_s^t = \beta_0 + \beta_q q_T^t + \beta_{GDP} GDP_{us}^t + \beta_{Ex} Ex_{us}^t c_t + \beta_{Ex} Ex_{j}^t c_t + \beta_{Pwh} P_{wh}^t T_t + \epsilon_t \]  

where \( P_s^t \) is average real shore price of snow crab in Canadian dollars in the \( t \)th period, \( q_T^t \) is total landed harvest, \( GDP_{us}^t \) is real US GDP, \( Ex_{us}^t \) is exchange rate between the Canadian (c) dollar and currencies of export markets – US (us) and Japan (j), \( P_{wh}^t \) is annual real wholesale price of snow crab, and \( \epsilon_t \) is a disturbance term that reflects random stochastic elements that impact the real average shore price. Shifts in the demand curve are captured and modelled using US GDP, exchange rates for US and Japan, and wholesale prices. All variables are log transformed. It is important to mention, that statistically all variables defined in Eq. (1) are important regressors in explaining snow crab prices but US GDP is dominate in driving price determination and consequently will be the important variable in projecting the different policy price scenarios.

For policy purposes, Eq. (1) can measure the impact of the coronavirus through changes in landings, and demand shocks to US GDP, exchange rates and price affects from other markets. To support the use of Eq. (1) for policy purposes, Fig. 4 shows out-of-sample forecasting and confidence intervals (CI) for the period 1990–2018. The graph shows that the estimated equation does capture trend and turning points in the data series and the CI includes, for all observations, actual snow crab price.

For Canada, regional specific data is limited but we do have available regional price and quantity values that allows us to extend the predicted shore price in a simple framework to the regional level. The regional price of snow crab is a simple expression of average shore price and regional specific effects.

For lobster [21], the inverse demand equation is represented using a short-run error correction model [8–10,18,38]. Monthly observations on price and landed values are available for Canadian and US landings of lobster for the period 1990–2018. Canadian and US lobster landings are specified separately allowing for heterogeneous effects on Canadian price. The general error correction equation is writing as,

12 Although there is little competitive response between lobster and snow crab, snow crab does sell into a very competitive wholesale market. Many suppliers offering many different types of crab species characterize this market. The wholesale price of snow crab will reflect this competitive downstream market and is a major driver of Canadian shore prices for snow crab.

13 To generate out-of-sample forecasts, Eq. (1) is estimated using data only for the period 1990–2010 and then used to forecast out-of-sample for the period 2011–2018.

14 Gordon [20] provides detailed data descriptions, definitions and testing and is available on request.
Three alternative policy scenarios: snow crab.

Table 2a

| Three alternative policy scenarios: snow crab. | Upper bound | Base | Lower bound |
|-----------------------------------------------|-------------|------|------------|
| Gulf Landings 2019                           | 31.96%      | 31.96| 31.96      |
| Maritimes Landings 2019                      | 4.88        | 4.88 | 4.88       |
| Quebec Landings 2019                         | -17.59      | -17.59| -17.59     |
| NL Landings 2019                             | -8.42       | -8.42| -8.42      |
| Canadian Landings 2020                       | -25.0       | -5.0 | 0.0        |
| U.S. Landings 2021                           | 26.67       | 5.26 | 10.0       |
| NL Landings 2019                             | 46.74       | 46.74| 46.74      |
| Canadian Landings 2020                       | 23.0        | 23.0 | 23.0       |
| U.S. Landings 2021                           | -25.0       | 0.0  | 30.0       |
| Barents Sea Landings 2019                    | 54.59       | 54.59| 54.59      |
| Canadian Landings 2020                       | 1.4         | 1.4  | 1.4        |
| U.S. Landings 2021                           | 20.0        | 0.0  | 35.0       |

* % growth from previous year

\[
\Delta P_s = \alpha + \sum_{p=1}^9 \alpha_p \Delta P_{s-p-1} + \sum_{i=1}^4 \alpha_i \Delta Q_{LQ}^{ci} + \sum_{j=0}^9 \alpha_{s-j} \Delta Q_{LQ}^{s-j} + \sum_{i=1}^9 \alpha_{s} \Delta Q_{LQ}^{s} + \sum_{i=1}^9 \alpha_{LQ}^{si} \Delta Q_{LQ}^{si} + \gamma \left( P_{s-1} - \beta_s - \beta \cdot LQ_{s-1} \right) - \beta_{sLQ} \cdot LQ_{s-1} - \beta_{s} \cdot LQ_{s-1} - \beta_{s} \cdot LQ_{s-1} + \theta,
\]

where all variables have been previously defined. Similar to the snow crab regression, US GDP is the important regressor driving lobster price determination. The performance of the estimated equation is evaluated by graphing out dynamic forecasts for the period 2017(1) to 2018(12), as reported in Fig. 5. With dynamic forecasts, the one period ahead predicted price is used as a right-hand-side variable in predicting the next period. The figure shows that the estimated price model preforms well in dynamic forecasting in terms of capturing trends and turning points in the Canadian price series. The CI does include actual price over the forecast period.

In the next sections, we will use these demand relationships to offer price and revenue outcomes that capture current expectations and assumptions on the impact of the coronavirus.

4. Three policy scenarios

In this section, three policy scenarios are developed for snow crab to represent projections for landings and economic variables for the period 2019–2021. The three policy scenarios evolved from Fisheries and Oceans Canada/Pêches et Océans Canada discussions with policy experts, financial institutions and expectations on total allowable catch (TAC) and landings. The projections for aggregate economic variables are current expectations taking into account possible economic shocks of the coronavirus. Each scenario is a combination of shocks to landings and aggregate economic variables.

The three scenarios are defined as: (a) **Upper Bound**, generally reflects a more negative expansion of regional harvest under favourable economic factors, (b) **Base**, represents what is considered likely outcomes under general conditions, and (c) **Lower Bound**, a more positive expansion of regional harvest and unfavourable economic factors.

For snow crab, Table 2a reports scenarios for annual regional landings for Canada, and annual landings for US and Barents Sea. For regional landings, the 2019 landings are based on the percentage change in the total allowable catch (TAC), with **Upper and Lower Bounds** estimated based on historical growth rates. For 2020–21 regional landings scenarios are identical and defined as Canadian landings in Table 2a. Estimates for 2020, are based on likely expectations of a range of growth rates with the **Upper and Lower Bounds** representing severe regional scenarios on landings (–25% and 0%, respectively) with the **Base** period the most likely (–5.0%) outcome. For 2021, expectations are for a recovery of 5–26%.

For US landings, the 2019 landings are based on the percentage change in the TAC. For 2020, all three policy scenarios represent the assumption that landings are not significantly affected by coronavirus and that quota allocations are good estimates of landings. For 2021, landings are based on historical growth over the last 10 years of data; **Upper Bound** is the average of growth decreases and **Lower Bound** is the average of growth increases. The **Base scenario** is no change from 2020.

For Barents Sea landings, for 2019 data are obtained from Opillio - Qeana discussions with policy experts and US. For 2020, all three policy scenarios represent the assumption that landings are not significantly affected by coronavirus and that quota allocations are good estimates of landings. For 2021, landings are based on historical growth over the last 10 years of data; **Upper Bound** is the average of growth decreases and **Lower Bound** is the average of growth increases.

For lobster, Table 2b reports scenarios for annual landings for Canada and US. For US landings, the 2019 landings are based on preliminary 2019 data provided by DFO-NL region. For 2020, growth rates are expected to show only a moderate increase based on a 12.5% increase for the US. For 2021, all three policy scenarios represent the assumption that landings are not significantly affected by coronavirus and that quota allocations are good estimates of landings. For 2021, landings are based on historical growth over the last 10 years of data; **Upper Bound** is the average of growth decreases and **Lower Bound** is the average of growth increases.

For lobster, Table 2b reports scenarios for annual landings for Canada and US. For 2019, snow crab landings are based on preliminary 2019 catch data provided by DFO-NL region. For 2020, all three policy scenarios represent the assumption that landings are not significantly affected by coronavirus and that quota allocations are good estimates of landings. For 2021, landings are based on historical growth over the last 10 years of data; **Upper Bound** is the average of growth decreases and **Lower Bound** is the average of growth increases.

16 Favourable means a positive impact on regional shore price.
17 See. [https://www.highnorthnews.com/en/norway-increases-snow-crab-quotas-2020](https://www.highnorthnews.com/en/norway-increases-snow-crab-quotas-2020)
18 See. [https://www.seafoodconsulting.com/blog](https://www.seafoodconsulting.com/blog)
For 2020 and 2021, growth values are based on likely expectations of a range of growth rates with the Upper and Lower bounds representing severe regional scenarios on landings with the Base period again the most likely. Notice, the expectations are for a decrease in landings in 2020 with a recovery in 2021. The 2021 growth rates are calculated based on estimated growth rates prior to 2019.

For US landings, 2019 growth rates are based on landings in Maine, the largest US producer, which experienced a 17% decline in landings\(^{19}\) for 2019. Projections, for 2020 and 2021, are based on likely expectations of a range of growth rates with the Upper and Lower Bounds representing severe regional scenarios on landings with the Base period again the most likely. Expectations are for a decrease in landings in 2020 with a recovery in 2021.

The major economic variables influencing the snow crab and lobster markets are reported in Table 2c. The projections include expectations of the effect of the coronavirus on aggregate economic variables. The US GDP annual growth projections for 2019 are based on a combination of reports produced by the IMF, OECD, World Bank and Bank of Canada. The Base scenario is the average of the four rates, Upper Bound is the largest projected growth rate, and Lower Bound is the lowest projected growth rate. For 2020 and 2021, the US GDP projections are based on IMF expectations that provide an annual growth rate of 5.9% and 4.7%, respectively applied to all three scenarios.

The Canada-US and Canada-Japan exchange rates for 2019 are based on data provided by the OECD\(^{20}\) applied to all scenarios. Projections 2020 and 2021 are based on quarterly average expectations for six major banks in Canada. For Canada-US, the projections are applied to the Upper Bound and Base, but we allow for a moderate increase in exchange rate for the Lower Bound scenario for 2021. For Canada-Japan, the projections are applied to each scenario.

Finally, wholesale price changes for 2019 are based on the growth rates of Urner Barry\(^{21}\) wholesale prices for Gulf Lawrence cluster, 5-8 oz and NL cluster, 5-8 oz. Expectations are for a serious negative price shock to wholesale prices in 2020; a 25% decrease for the Upper Bound, a 30% decrease for the Base and a 35% decrease for the Lower Bound. For 2021, projections are for a slight positive rebound in prices of 4% points, applied to all three scenarios.

\(^{19}\) See, https://www.undercurrentnews.com/2020/03/06/maine-2019-lobsters-landings-off-17-but-couldve-been-worse/
\(^{20}\) See, https://stats.oecd.org/index.aspx?queryid=169#
\(^{21}\) See, Urner https://www.ubcomtell.com/History/1288 and https://www.ubcomtell.com/History/6563

| US GDP\(^{a}\) | 2019 | 2.62%\(^{b}\) | 2.54% | 2.33% |
| Canada-US Exchange rate | 2019 | 0.754 | 0.754 |
| Canada-Japan Exchange rate | 2019 | 82.17 | 82.17 |
| Wholesale price | 2019 | -0.23% \(^{a}\) | -0.23% |
| 2020 | -25% | -30% | -35.0% |
| 2021 | 4.0% | 4.0% | 4.0% |

\(^{a}\) % growth from previous year
\(^{b}\) Quarterly average prediction

5. Price and revenue projections to 2021

In this section, the estimated snow crab and lobster equations are used to simulate price projections based on the three policy scenarios presented. For comparative purposes, both real and nominal\(^{22}\) results are reported, where real prices have inflation removed and nominal prices have inflationary expectations included in the results. The CPI index is used to adjust for inflation, with the CPI for 2020 and 2021 based on an average of values reported by five major Canadian banks.

Snow crab price\(^{23}\) projections under the different policy scenarios are reported in Table 3, where Table 3a reports real prices and Table 3b reports nominal prices. As a reference point, the average real snow crab price in 2018 is $8.34 and the corresponding nominal price is $11.12. From the table, we observe a substantial decline in prices from 2018 to 2019 across all scenarios caused by large increases in landings from Canada (Gulf), US and Barents Sea. Prices are predicted to fall further in 2020, with the main drivers being the sharp fall in wholesale prices and the decrease in US GDP growth rates. On average across all scenarios we observe a 34% decrease in price for 2020 compared to 2019. The predictions suggest prices increase somewhat from 2020 to 2021, with increased growth rates of both wholesale prices and US GDP, but still price is substantially less than 2019. As expected, prices are projected to be higher for the Upper Bound scenario relative to Base and Lower bound. Nominal prices reported in Table 3b reflect the value and trends reported in Table 2a.

There is a large measure of uncertainty when projecting prices forward, where predictions of the future are based on past data, model structure, random errors in estimation and assumptions used for future projections. To represent uncertainty in price projections, Table 4 reports 95% confidence intervals (CI) about the nominal snow crab price projections presented in Table 3b.\(^{24}\) The width of the intervals show the

\(^{22}\) The purpose of nominal prediction is to introduce possible coronavirus effects on inflation.
\(^{23}\) As the regression is run in log values, the predicted prices are the extrapolated prices corrected for bias as reported in Wooldridge [46], p.205–209
\(^{24}\) The standard error of the forecast includes uncertainty in the expected price plus uncertainty in error variance, using Stata forecasting option stdf. 

### Table 2c

| Three alternative policy scenarios, economic variables. | Upper bound | Base | Lower bound |
|---------------------------------------------------------|-------------|------|-------------|
| US GDP\(^{a}\) | 2019 | 2.62%\(^{b}\) | 2.54% | 2.33% |
| 2020 | -5.9% | -5.9% | -5.9% |
| 2021 | 4.7%\(^{c}\) | 4.7% | 4.7% |
| Canada-US Exchange rate | 2019 | 0.754 | 0.754 |
| 2020 | 0.7353 | 0.7353 | 0.748 |
| 2021 | 0.7519 | 0.7519 | 0.755 |
| Canada-Japan Exchange rate | 2019 | 82.17 | 82.17 |
| 2020 | 77.08 | 77.08 | 77.08 |
| 2021 | 80.18 | 80.18 | 80.18 |
| Wholesale price | 2019 | -0.23% \(^{a}\) | -0.23% |
| 2020 | -25% | -30% | -35.0% |
| 2021 | 4.0% | 4.0% | 4.0% |

\(^{a}\) % growth from previous year
\(^{b}\) Quarterly average prediction

### Table 3a

| Snow crab predicted real shore price $/kg, three policy scenarios. | 2019 | 2020 | 2021 |
|---------------------------------------------------------------|------|------|------|
| Upper Bound | 6.25 | 4.59 | 4.65 |
| Base | 6.25 | 4.09 | 4.16 |
| Lower Bound | 6.24 | 3.64 | 3.66 |

### Table 3b

| Snow crab predicted nominal shore price $/kg, three policy scenarios. | 2019 | 2020 | 2021 |
|---------------------------------------------------------------|------|------|------|
| Upper Bound | 8.47 | 6.31 | 6.51 |
| Base | 8.47 | 5.63 | 5.83 |
| Lower Bound | 8.47 | 5.01 | 5.12 |

### Table 4

| Forecasting uncertainty in snow crab prices, 95% confidence intervals. | Upper bound | Base | Lower bound |
|---------------------------------------------------------------|-------------|------|-------------|
| 2019 | $10.40 | 6.90 | 6.90 |
| 2020 | 7.85 | 5.08 | 4.63 |
| 2021 | 8.06 | 5.26 | 4.71 |

\(^{a}\) Upper confidence interval, 95%
\(^{b}\) Lower confidence interval, 95%
Table 5
Forecasting uncertainty in snow crab nominal revenue, 95% confidence intervals.

| Policy scenarios | Upper bound | Base | Lower bound |
|------------------|-------------|------|-------------|
|                   | UCI        | Rev  | LCI        | UCI   | Rev  | LCI   |
| 2019              | 708.8      | 577.3| 470.2      | 708.5 |       |       |
| 2020              | 401.1      | 322.6| 259.5      | 452.9 |       |       |
| 2021              | 522.1      | 421.8| 340.1      | 491.9 | 397.4| 321.0 |

* Nominal Revenue, $ million
a Upper confidence interval, 95%
b Lower confidence interval, 95%

Table 6a
Predicted snow crab real revenue ($,000) by region.

| Policy scenarios | Gulf | Maritimes | Quebec | NL |
|------------------|------|-----------|--------|----|
| 2018             | $158,451 | $52,614  | $126,614 | $223,761 |
| 2019             | 181,744  | 49,956   | 85,720  | 132,999 |
| Upper Bound Base |       |          |        |      |
| 2020             | 101,192  | 27,814   | 47,728  | 74,052 |
| Lower Bound Base | 114,663  | 31,517   | 54,081  | 83,909 |
| 2021             | 107,996  | 29,685   | 50,937  | 79,031 |
| Upper Bound Base |       |          |        |      |
| 2018             | 129,748  | 35,664   | 61,196  | 4949 |
| Lower Bound Base | 122,685  | 33,722   | 57,865  | 89,780 |
| 2021             | 119,075  | 32,730   | 56,162  | 87,138 |

* Newfoundland & Labrador

Table 6b
Predicted snow crab nominal revenue ($,000) by region.

| Policy scenarios | Gulf | Maritimes | Quebec | NL |
|------------------|------|-----------|--------|----|
| 2018             | $211,998 | 69,998   | 168,818 | 298,347 |
| 2019             | 246,412  | 67,731   | 116,222 | 180,323 |
| Upper Bound Base |       |          |        |      |
| 2020             | 139,064  | 38,224   | 65,590  | 101,766 |
| Lower Bound Base | 157,576  | 43,313   | 74,322  | 115,313 |
| 2021             | 148,415  | 40,794   | 57,685  | 106,609 |
| Upper Bound Base |       |          |        |      |
| 2018             | 181,686  | 49,928   | 85,673  | 132,925 |
| Lower Bound Base | 171,837  | 47,233   | 81,048  | 125,750 |
| 2021             | 169,781  | 45,843   | 78,663  | 116,157 |

* Newfoundland & Labrador

extreme bounds of uncertainty in price projections and represents the range of likely future price outcomes under the three policy scenarios.

As price is only one part of the story, we report in Table 5 the range of values covering a 95% confidence interval about predicted snow crab nominal revenue for each policy scenario, over the period 2019–20. For comparative purposes the nominal value of snow crab revenue in 2018 was $748.3 million. Overall, the revenue projections are very sobering with serious declines in predicted revenue across all scenarios and over time. The model does predict moderate increases in revenue in 2021, but well short of 2018 earnings.

To provide more detail onpredicted revenue, we calculate for each of the regions in Canada annual real and nominal snow crab revenue generated under the different policy scenarios, for 2019–2021. Revenue projections are based on regional price predictions and landings scenarios described in Table 2a. The results are reported in Table 6, with Table 6a reporting snow crab real values and Table 6b nominal values. For comparison, actual revenue for each region for 2018 is also reported. Overall, the revenue projections show serious declines in predicted values across all regions and over time. The exception is the Gulf region in 2019, which enjoys a substantial increase in revenue (12%) as a result of large increases in landings, even though landing price has fallen. This fortunate turn of events disappears in 2020 with revenue falling on average by 40%. The interesting part of revenue is that it encompasses both changes in price and landings, and for 2020 revenue is hit by both a fall in price and landings. This works somewhat in our favour for 2021, where we predict a small increase both in price and landings and a moderate increase in revenue relative to 2020. Nevertheless, the seriousness of the predicted decline in revenue cannot be understated. Compared to 2018, the simulations suggest a decline in average revenue for 2021 of – 18% Gulf, – 32% Maritimes, – 53% Quebec, and – 57% NL. It is also important to note, that the lower bound for all regions and scenarios shows the extreme worst-case outcome.

Lobster average annual price projections under the different policy scenarios are reported in Table 7. As a reference point, in 2018 the average real lobster price is $11.59, and the corresponding nominal price is $15.45. A review of Table 7 shows that the price story for lobster is very different than snow crab. In general, predicted prices have trended downward over time and we do see variation in prices across the different policy scenarios. However, serious price declines have not been observed and, in fact, for 2019 prices are predicted higher on average than the base period 2018. We do observe a serious decline in predicted
price in 2020, reflecting the major decrease in growth of US GDP, even though both Canadian and US landings fall precipitously. For 2021 the situation is reversed and now we see good growth in US GDP countered by increased landings both in Canada and US, but with an overall increase in predicted price.

The range of uncertainty around the price projections is substantial and Fig. 6 reports monthly lobster price projections for the Base scenario case with confidence intervals for 2019–2021. To provide perspective and comparison, actual price realizations over the full period are reported. Consistent with Table 6, we observe a decline in price in 2020 followed by a recovery in 2021. Notice, that the range of uncertainty is substantial for 2020. For revenue outcomes, Table 8 reports for lobster average annual projected revenue, both real and nominal for the period 2019–2021. For comparison, the earned revenue in 2018 is reported in the table. Revenue projections for 2019 reflect the increase in price and we observe good increases in value across all policy scenarios. A very different story for 2020 with a serious decline in US GDP reducing projected revenue by 21% on average across the policy scenarios. This revenue shortfall is somewhat corrected in 2021 in response to the US GDP recovery.

Finally, Table 9 reports the range of uncertainty in projected nominal revenue across policy scenarios for 2019 and 2020. The upper confidence bound again showing a very favourable outcome but countered by worst case scenarios represented by the lower confidence bound.

6. Comments

In this paper, the impact of the coronavirus is measured indirectly in shocks to US GDP, Canada/US exchange rate, Canada/Japan exchange rate and the wholesale price of snow crab. Variations in these shocks are simulated under three policy scenarios using estimated demand equations representing the snow crab and lobster markets by Gordon [20,21]. The results for snow crab are startling with predicted major declines in prices across all three policy scenarios for 2020 and serious shortfalls in revenue for 2020 but significant recovery in 2021. Lobster is a high valued fresh product and suffered heavily with the health regulated closures of restaurants but price responded well with the predicted increase in GDP for 2021.

The price effects of coronavirus are serious but from a welfare point of view the impact on employment is perhaps more so. The employment effect is not only fishermen but the processing sectors and downstream supply chain. This is important future policy research.

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