Economic Value of Pacific Herring in the Strait of Georgia

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### About the Author

Tim Cashion is a PhD student studying fisheries economics at the University of British Columbia, under the supervision of Rashid Sumaila. Tim's research at IRES and the Institute for the Oceans and Fisheries will continue to work on environmental and economic trade-offs in fisheries especially focusing on the impacts of fishing gear and reduction fisheries. Recently, Tim has worked for the Sea Around Us at UBC working on various projects including fish used for fishmeal and fish oil, analyzing trends in fisheries discards, and researching global fisheries gear use. Tim received a double major BA from Huron University College at the University of Western Ontario. Tim began his fisheries research during his masters at Dalhousie University focusing on the environmental and ecological impacts of reduction fisheries and seafood life cycle assessment.

Pacific Wild is a non-profit conservation organization based in British Columbia. We are committed to defending wildlife and their habitat on Canada’s Pacific Coast by developing and implementing conservation solutions in collaboration with First Nations communities, scientists, other organizations and individuals. Recently, we worked alongside the Heiltsuk First Nation to document the crucial importance of Pacific herring to the ecological and cultural integrity of British Columbia’s Central Coast.



# Executive Summary

The Pacific herring roe fishery (also known as the ‘sac roe’ fishery) is a longstanding fishery in areas all along the B.C. coast. As of 2019, its epicenter is the Strait of Georgia. Here, we investigate the economic value of the fishery within the context of other fisheries in the region and its history. In general, landings, overall value, and prices have declined for the sector over the past 20 years. This is a challenge to the B.C. seafood industry for severeal reasons. The herring roe fishery has a strategic importance to the fisheries and seafood processing sector, due to the employment it generates in the off-season. The decrease in herring roe catches has led to decreases in employment in the fish processing and export sectors. Those invested in the fishery have seen the decline in value as the licences and lease costs have decreased substantially with the decline in value of the herring catch. Finally, we investigate the costs of closing the fishery for the 2019 season, as a proposed means of herring stock recovery and protection of other species that rely on them.

## Terms & Notes

* Ex-vessel value -is the value of fish or seafood at its first point of sale (i.e., the price the fishers receive). Also known as the landed value.
* Unless otherwise stated, all values are expressed in real 2015 dollars to account for inflation over the time period studied.
* Tonnes refers to metric tonnes (1000 kilograms or 2204.6 lbs). Some data sources use short tons (2000 lbs) and this was converted to metric tonnes when necessary.

# Introduction

The Pacific herring (*Clupea pallasii*) roe fishery (sometimes referredd to as the ‘sac roe’ fishery) has a long history in British Columbia and is a valuable part of B.C.’s seafood exports. This fishery makes up the largest component of the Pacific herring fisheries in B.C., with respect to the quantity of fish harvested and also the value of the catch. The fisheries that harvest Pacific herring in B.C. include: roe herring undertaken with purse seines and gillnets, food and bait herring caught with purse seines, herring spawn on kelp, and special use herring captured with multiple methods. Each of these has their own specific (or multiple) licences within the category that allow fishers to fish for this purpose. This report focuses specifically on the seine and gillnet roe fishery, while including the food and bait fishery and spawn on kelp fisheries when important for context. We also focus on one key fishing ground for the roe fishery, the Strait of Georgia (Figure 1), where the fishery has been especially concentrated in recent years.

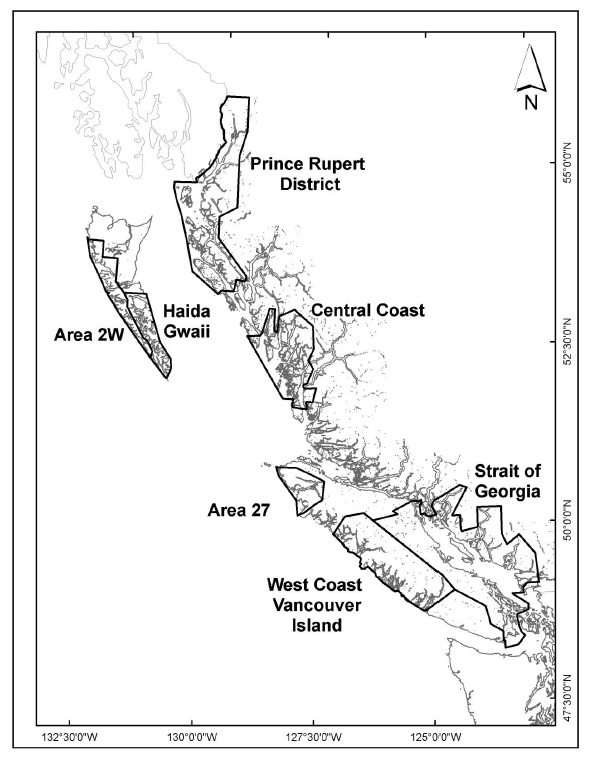


Figure 1 Figure 1. Map of roe herring fishing areas in British Columbia. Source: Fisheries and Oceans Canada, 2018.

# The Fisheries

In the 1950s and early 1960s, the Pacific herring fishery was the largest fishery in B.C. with catches often exceeding 200,000 tonnes (Herring School 2015). In 1967, the fishery collapsed coast-wide. Until that point, most of the fishery was used for the production of fishmeal and fish oil to support agriculture and livestock. The fishery was re-started in the 1970s with smaller catches destined for a high-value export of roe to the Japanese market. This fishery has proceeded to today being the main component of the herring fishery in B.C. (Figure 2), with other fisheries being of much less importance by catch and value. The exception to this is the spawn on kelp fishery which is fished both commercially and as a Food, Social, and Ceremonial (FSC) fishery by First Nations in B.C., for whom herring are an important source of nourishment and cultural value. The second largest component of the herring fishery in B.C. is the food and bait fishery. There are several other herring fisheries that fall under special use licences and are much smaller in tonnage and value than the three aforementioned components. They include human food and bait, sport fishing bait, personal use and fish for zoos and aquaria. Here we focus on the economically most important fishery: the herring roe fishery (Figure 4).

Figure 2 Catch of herring by fishery type. Source: B.C. Ministry of Agriculture, 2018.

For the 2019 season, the expected catch across all herring fisheries is approximately 30,000 tonnes (Figure 3). The only statistical areas open to the gillnet and seine roe fisheries is within the Strait of Georgia. Outside the Strait of Georgia, there are small fisheries as part of First Nations and commercial spawn on kelp fisheries (SOK), as well as Food, Social, and Ceremonial (FSC) fisheries. Other special use herring fisheries are predicted to total approximately 800 tonnes. Grouping these together, the only commercial fishing for herring outside the Strait of Georgia is for commercial spawn on kelp.

Figure 3 Expected catches (metric tonnes) of herring by area and fishery for the 2019 season areas. CC: Central Coast; HG: Haida Gwaii; PR: Prince Rupert; SOG: Strait of Georgia; WCVI: West Coast Vancouver Island. FSC: Food, Social, and Ceremonial; SOK: Spawn on Kelp. Source: DFO, 2018

Figure 4 Roe herring landings by gear in the Strait of Georgia. Source: Compiled season summary data from DFO reports.

# The Products

The main product of the roe fishery is the herring roe, or the eggs of the female fish. The roe is exported in both frozen and cured forms to Japan. In general, the decline in ex-vessel prices for herring in B.C. is attributed to a decline in demand from the Japanese market, potentially caused by a weakened Japanese economy and a change in tastes from older to younger generations (Newell 1999). There is a growing share of herring products exported outside of Japan, mainly to China and the USA (DFO 2018b).

While the roe are the backbone of the fishery, the majority by weight is the by-product of herring carcasses, which are processed into fishmeal and fish oil. There is limited information on the value of the carcasses, but according to one processor contacted during this study, carcasses generate no income for the processing company; rather, they are picked up by a reduction company for no cost. By all accounts, the carcasses from the roe herring fishery are reduced to produce fishmeal and fish oil in B.C. The fishmeal and fish oil are used primarily to produce salmon feed that is fed to B.C. farmed Atlantic salmon (McGrath, Pelletier, and Tyedmers 2015). Using information about the average industry aquaculture feed composition obtained from McGrath and colleagues (2015), we can estimate the amount of fishmeal produced on average from the roe herring fishery, and the amount likely required by the B.C. farmed salmon industry.

The carcass weight that is used for fishmeal is between 84% and 89% of the landed weight (McGrath, Pelletier, and Tyedmers 2015; Anonymous 2018). The feed conversion ratio (FCR), or the ratio of feed used per unit output of salmon, for farmed Atlantic salmon in B.C. was 1.313 in 2009 (Pelletier et al. 2009). The average annual amount of farmed Atlantic salmon produced in B.C. was 81,467 tonnes from 2014 to 2016 (AgriService B.C. 2017). A standard B.C. salmon feed contains 5% herring by-product meal and 2% herring by-product oil (McGrath, Pelletier, and Tyedmers 2015). Thus, we can estimate the herring fishmeal required:  
Herring FM Demand = FCR \* Salmon Production \* Herring FM %  
Herring FM Demand = 1.313 \* 81,467 tonnes \* 5%

We estimate the herring by-product meal demand to be 4,481 tonnes. Alternatively, we can estimate the amount of herring fishmeal and fish oil produced from the roe fishery by-products using the carcass weight an average roe herring landings for a similar time period (averaged for 2014 and 2015):  
Herring FM Supply = Roe herring landings \* Carcass weight \* Fishmeal yield  
Herring FM Supply = 14,746 tonnes \* 88% \* 19%

Herring FO Supply = Roe herring landings \* Carcass weight \* Fish oil yield  
Herring FO Supply = 14,746 tonnes \* 88% \* 5%

We estimate the herring by-product meal and oil supply as 2,452 and 645 tonnes, respectively. Based on current export prices for herring meal ($2,690) and herring oil ($3,146) from Canada (FAO 2016), the value of these combined products is estimated to be 8.6 million CAD.

# The Supply Chain

It is not only the fish harvesters themselves who are employed in the supply chair of the herring roe fishery in the Strait of Georgia, B.C. Here, we enumerate the number of types of jobs generated by the supply chain. We measure employment in full-time equivalents (FTEs) to standardize the importance of these various industries that are seasonal by nature. A standard measure of full-time equivalent is 2080 hours annually, defined as 40 hours per week for 52 weeks per year.

The combined fisheries for herring roe and food and bait generated 790 jobs during the fishing season, which is equivalent to 91 full-time jobs (GSGislason & Associates Ltd. 2015). The processing of herring generates more jobs, hours of work, and total income than those generated by the capture portion of the fishery. There are additional jobs generated through spin-off employment including transportation, unloading of herring, and marketing and sales, although these are a much smaller portion when compared to fishing and processing.

Figure 5 Processing employment by fishery type. Source: Estimated based on processing requirements in DFO, 2018.

Figure 6 Wage income from processing (inflation adjusted million $). Source: Estimated based on processing requirements in DFO, 2018.

Table 1

# Value of the Fisheries

To participate in the herring roe fishery, a fisher requires an active licence from DFO. At the beginning of the season, fishers are required to declare the area where they would like to fish that licence and the quota is distributed amongst the licences that are fishing in each of the management areas. The herring roe fishery is undertaken with gillnet (also known as drift nets) and purse seines. These are licenced separately.

Figure 7 Gillnet roe herring landings by area. Source: Compiled season summary data from DFO reports.

Figure 8 Seine roe herring landings by area. Source: Compiled season summary data from DFO reports.

The herring fishery is divided into five major management areas, or stock areas: Haida Gwaii, Prince Rupert District, Central Coast, West Coast of Vancouver Island, and Strait of Georgia. In the 1980s and 1990s, the catch was more evenly distributed amongst these areas, but as the herring populations declined in the other four management areas, the the catch became concentrated in the Strait of Georgia over time. These areas have been progressively closed to the roe herring fishery (although some have been assigned unfulfilled quota in recent years). The last year these roe herring fisheries operated in each of the areas were: 2000 for WCVI, 2002 for Haida Gwaii, 2016 for Central Coast, and 2018 for Prince Rupert District. For the roe herring fishery (seine and gillnet catches combined), in the Strait of Georgia accounted for 34% of the catches. By the year 2000, It accounted for over 50% of catches, and in 2018 it accounted for 96% of catches.

Now the most important area for the roe herring fishery is the Strait (Figure 11), and in 2019 there are no roe herring catches expected outside of the Strait of Georgia (DFO 2018b). The catches for the gillnet roe fishery have risen sharply in the past few years while the seine roe fishery landings have declined. The total quota assigned has fluctuated but the proportion used by the gillnet fishery has risen in recent years. This is partially attributed to an increasing number of seine roe licences being used to fish in the food and bait fishery instead of the roe fishery. At the beginning of each season, the initial allocation of herring roe catches by gear type is a 55:45 split for the seine roe fishery (DFO 2018b). However, seine licences can opt to have their quota switched to the food and bait fishery at the beginning of the season, although this does not change the total allowable catch for the season.

Figure 9 Roe herring quota issued in the Strait of Georgia by licence type. Source: Compiled season summary data from DFO reports.

Figure 10 Roe herring quota per licence in the Strait of Georgia by licence type. Source: Compiled season summary data from DFO reports.

Figure 11 Roe herring catches by major fishing area. Source: Compiled season summary data from DFO reports.

Over the past 10 years, the roe herring fishery has fluctuated between an ex-vessel value of 4 and 17 million CAD (Figure 12). Formerly the values were much higher, exceeding 100 million CAD in 1987. In addition, the wholesale value is substantially higher than the ex-vessel value as herring roe is a value-added product.

Figure 12 Ex-vessel value of herring fisheries. Source: B.C. Ministry of Agriculture, 2018.

As herring roe is a processed product, it naturally has a higher price than the raw material of whole herring. In addition, the wholesale value includes the value of the fishery derived from the processing of roe and production of fishmeal and fish oil from the herring by-products.

Figure 13 Wholesale value of herring fisheries. Source: B.C. Ministry of Agriculture, 2018.

The decline in total value of the herring roe fishery is both a function of a decline in landings, and a decline in ex-vessel prices received by fishers. There is some indication, however, that the catch prices reported by fishers does not necessarily indicate lower profitability, as processors have been more willing to pay fishers’ fees (e.g., licence costs and Dockside Monitoring Program costs), which lowers their cost of fishing (GSGislason & Associates Ltd. 2015). Thus, the ex-vessel price decreases may be partially or wholly offset by the increased costs covered by processors. The effect of this on total profitability is unknown at this time.

Figure 14 Ex-vessel price by fishery. Source: B.C. Ministry of Agriculture, 2018.

Within the roe fishery iteself, there are differences in the price for the catch. The seine fishery generally fetches a lower value than the gillnet fishery as the gillnet is more selective towards larger and older individuals, which have a higher proportion of roe to total body weight. This was confirmed by an industry expert, who estimates that 11-13% of the total seine catch by weight is roe, while the gillnet fishery is 14-16% roe by weight. In some years, this has led to price differences on the order of 3-4 times greater for gillnet than seine catches. While there are differences in the relative price of gillnet caught herring versus seine caught herring, they both follow the general trend of a large decline in ex-vessel prices over the past 25 years (Figures 14 and 15).

Figure 15 Coastwide ex-vessel price by gear for the roe fishery. Source: DFO, 2017

Figure 16 Value-added factor by fishery. Source: B.C. Ministry of Agriculture, 2018.

# Ownership and Licenses

The roe herring fishery is managed by a limited entry licence program. The total allowable catch (TAC) is set at the beginning of the season based on DFO stock assessments. Before the season begins, the licences must be pooled into self-selected groups for ease of management where the gillnet pools must have a minimum of 4 licences per pool, and the seine fishery must have at least eight licences per pool – but no more than 10 pools total are permitted in the Strait of Georgia (DFO 2018b). The TAC is then divided, based on the number of licences in each pool and the vessels within that pool can fish their quota with any of their vessels in that pool. Each seine or gillnet licence receives an equal proportion of the TAC for their fishery (seine and gillnet fisheries are managed separately), so pools with a greater number of licences have a larger portion of the total TAC for that fishery. A fisher with a seine roe licence can elect to fish instead in the food and bait fishery instead; in that case, the quota for that licence is switched from the roe fishery to the food and bait fishery.

While the total number of roe herring licenses is relatively constant, this does not have a strong relationship to the number of vessels actually fishing. Most seine vessels have two licenses stacked per vessel. In 2007, only 38 seine vessels registered landings, while the total fleet of 133 vessels owned 248 licenses (Nelson 2009a). The number of active fishing vessels in the seine fishery increased to 43 active vessels in 2009 (Nelson 2011a).

Figure 17 Total herring licenses by fishery type

The trend in licences by area should be interpreted with caution, as the field is blank for many of the entries in the commercial licence database (Fisheries and Oceans Canada 2018). However, there does appear to be movement of licences from closed management areas to the remaining fishing. This is not unexpected, as some of the main fishing areas, like Haida Gwaii, Central Coast, and the West Coast of Vancouver Island, have been closed for several years (Figure 18). This trend of licences moving in to the Strait of Georgia is apparent since 2000, and a more recent shift from Prince Rupert District into the Strait from 2014 onwards (Figure 19).

Figure 18 Net licence movement for the two main roe fishing areas.

Figure 19 Number of herring licences in the Strait of Georgia (excluding special use)

Table 2

The largest owner(s) of herring roe licences are the companies belonging to the Jim Pattison Group (Table 2). The concentration of licence ownership in this firm has grown over time and now represents 15% of total roe licences. The Pattison group is more heavily invested in the seine licences, which are worth more and account for more landings in the roe fisheries than the gillnet licences (Figure 20). Therefore, the Pattison Group’s expected quota for 2019 in the Strait of Georgia is 3,823 out of the total 19,498 metric tonnes (19.6%). Outside of those owned by the Jim Pattison Group, there is significant concentration in the top 10 largest herring licence holders (Table 2).

Figure 20 Herring licences owned by the Jim Pattison Group

A standard measure of inequality is the Gini index. The Gini index is a value between 0 and 1, where 1 represents perfect inequality and 0 represents perfect equality. This measure has been applied to fishing licences and fleets to measure equity. It was applied to the B.C. salmon and herring fisheries with data up to 2012, and there was found to be a large share of corporate control (Haas, Edwards, and Sumaila 2016). Corporate control in B.C. fisheries has become a concern among fisheries and society more broadly. Here we find there has been a significant increase in the inequality of the herring licence division over time occurring in both the seine and gillnet roe fisheries (Figure 21).

Figure 21 Gini coefficient for roe herring licences

The value of roe herring licences for both the gillnet and seine have declined substantially since high levels in the late 1990s and early 2000s. The outright licence fees are so much lower that the lease value of these licences has dropped to near zero. By industry accounts, there is very little leasing of licences in the gillnet fishery and almost none in the seine fishery (Nelson 2016).

Figure 22 Herring licence values by fishery type and fee. Source: Compiled from various reports of Nelson Bros Fisheries Ltd.

# How does the roe herring fishery stack up?

Based on data from B.C. statistics (AgriService B.C. 2018), wild salmon processing generates approximately 4x as much in wages as herring processing does. In 2016, when wild salmon and herring catches were comparable (24,700 tonnes and 24,100 tonnes, respectively), wild salmon generated 5.4x as many processing jobs (annual average of 1,400 compared to 332 for herring) (AgriService B.C. 2018). Similarly, the processing of salmon generates a greater value-added of just over $2,000 per tonne of salmon processed, while herring was $525 per tonne of herring.

Figure 23 Harvest and value (ex-vessel and wholesale) of B.C. seafood production averaged over 2014-2016. Source: BC AgriService 2017.

Compared to other valuable species in the Strait of Georgia, such as salmon, herring catches are higher in tonnage but lower in value (Figures 24 & 25).

Figure 24 Commercial salmon landings in the Strait of Georgia. Source: DFO, 2017.

Figure 25 Commercial salmon ex-vessel value in the Strait of Georgia. Source: DFO, 2017.

In addition to the commercial salmon fishery in the Strait of Georgia, there is a valuable recreational fishery for salmon in the Strait of Georgia. While other areas of the B.C. coast account for larger numbers of salmon caught by recreational fishers, the Strait of Georgia has the most fishing effort recorded in boat days for those areas with data (Note: North and Central coast data were not available for this year). One measure of the value of the recreational fisheries is the value they produce in fish themselves if the fish was sold commercially (Colquhoun and Ridge Partners 2015). This measure of value is crude and non-inclusive, as recreational fishing is not solely for the production of fish, and countless studies have shown that the value of recreational fishing to society far exceeds this ‘product’ value. Nevertheless, the product value of recreational tidal water salmon fisheries in B.C. is over 15 million dollars annually, with the Strait of Georgia accounting for 1.3 million dollars of this.

Figure 26 Recreational salmon landings (tidal water) in B.C. by area for 2009. JDFS: Juan de Fuca Strait; JS: Johnstone Strait; NC: North Central Coast; SoG: Strait of Georgia; WCVI: West Coast of Vancouver Island. Source: DFO, 2016

Figure 27 Recreational salmon value (tidal water) in B.C. by area for 2009. JDFS: Juan de Fuca Strait; JS: Johnstone Strait; NC: North Central Coast; SoG: Strait of Georgia; WCVI: West Coast of Vancouver Island. Source: Estimated based on commercial value of salmon and landings data from DFO, 2016

Figure 28 Recreational salmon fishing effort in the Strait of Georgia for 2009. JDFS: Juan de Fuca Strait; JS: Johnstone Strait; NC: North Central Coast; SoG: Strait of Georgia; WCVI: West Coast of Vancouver Island. Source: DFO, 2016

# Going forward: A look into closing the roe herring fishery

Pacific herring play an important role in many of their predators' diets, so we considered the economic cost of a temporary closure of the fishery, for the purpose of rebuilding herring stocks and protecting the integrity of the Strait of Georgia ecosystem. This section of the report details options based on previous instances of temporary fishery closures and licence buy-backs in Canada.

The first example draws directly from the B.C. herring fishery. In recent years, the roe herring fishery has had quota assigned to fishing areas where a fishery opening did not occur (Government of Canada 2014). Many fishers had purchases licences for these areas prior to the fishery opening and were not allowed to fish them. In these cases, the fishers were reimbursed for the cost of the licences (Government of Canada 2014), but not for any extra costs associated with preparing for the fishering season or the lost income of the fishery. In the case of the 2019 herring roe fishery in the Strait of Gerogia, we calculated the cost of reimbursement for the licences for the 2019 season is expected to be a maximum of 1,256,360 CAD (assuming that all licences are full fee, which gives a maximum value rather than the true value).

For a temporary closure, the government could act in ways that is has in the past when extenuating circumstances warranted a closure of a fishery. In this case, the compensation that fishers receive is closely in line with what fishers receive for employment insurance payments (Emery 1992; CBC News 2007). These payments take into account the regional rate of unemployment, earnings from fishing, earnings from other activities, and a predetermined allowed maximum weekly amount (Government of Canada 2019). The maximum weekly amount in 2019 is $1,021 a week (Government of Canada 2019). If a fisher’s total weekly earnings was less than this, they would use that amount in its place. The amount paid is 55% of the lower of the two numbers, thus making the maximum amount paid per fisher $562. As we determined the full-time equivalent contribution of the roe herring fishers in the Strait of Georgia and the processing jobs they generate, we can use these FTEs and the maximum weekly amount paid to compensate for the loss of this fishery to fishers and processors as has been done with other fishery closures (Emery 1992). Therefore, the cost of income supplements for a temporary closure of the fishery is estimated to be $175,344.

Licenses are retired in fisheries to reduce capacity to a more ecologically or economically sustainable level, or to permanently close the fishery. The roe herring fishery is a limited entry licence fishery, similar to the Pacific salmon fisheries in B.C. Therefore, we can use the salmon fishery licence buyback program as an option for this fishery, if there are believed to be benefits from reducing capacity. From 1996 to 2000, 1,406 salmon licences (34% of licenses in 1996) were retired at a total cost of $195 million dollars (~$138,000 per licence). As the roe herring licences are at a near all-time low cost, it would likely be less expensive to remove these licenses, especially considering there are fewer herring licenses to begin with (total roe herring licenses of 1,475). In addition, the average seine herring license is valued at approximately $50,000 and the average gillnet herring licence is valued at $25,000. Therefore, the cost of retiring these licenses would likely be less than it was for salmon. The effectiveness of a licene retirement program is predicated on the limiting of expansion of effort in the remaining fleet. Therefore, a licence retirment program would not be successful without additional caps on fishing capacity and effort.

It is important to note that these strategies may not fully consider the potential strategic importance of the herring roe fishery. The herring fishery may be of particular strategic importance as it is a fishing and processing activity that occurs at an off-peak time of year for the fishing industry, and keeps income flowing to keep people employed closer to year-round. This may be especially important for the administrative side of the industry and provides additional weeks of employment to fishers and processors (GSGislason & Associates Ltd. 2015). Without these additional weeks, the increased precariousness of employment could lead to higher turnover of staff.

# Conclusion

The commercial fishery for Pacific herring has a long history in Canada, and the herring roe fishery was the largest fishery in B.C. at one time. Over the 2000s, the roe herring fishery’s catches declined substantially and, although they have increased since 2011, the fishery is now closed in four of the province’s five management areas, because of declines in herring abundance. As of 2019, the entirety of the commercial herring roe catch will be from the population that spawns in the Strait of Georgia.

Since the 1990s, the value of the commercial herring roe fishery has declined alongside the decline in catches, but it has not seen a corresponding increase in recent years. This is due to reduction in the price paid to fishers (the ex-vessel value), and the decline in the global market value of herring roe, which is the main value-added product of the fishery. The combination of declining value and rising cost of fishing mean that fewer herring fishers now actively fish; multiple licenses are frequently stacked on a single boat to increase profitability. Concentration of license ownership continues to be a concern in the herring roe fishery; corporate control has significantly increased over time in ownership of both seine and gillnet licenses.

If a fishery closure is necessary to conserve the abundance of the herring population in the Strait of Georgia, the costs are unlikely to be prohibitive, due to the current low value of seine and gillnet licenses for herring roe and the relatively few full time-equivalent jobs generated by the fishery and associated supply chain. However, the herring roe fishery may retain a strategic importance, because it occurs in early spring, providing work and income for fishers and processors at a time when few other fisheries are operating.

# References

AgriService B.C. 2017. “British Columbia Seafood Industry - Year in Review 2016.” Victoria, B.C. <http://www.env.gov.bc.ca/omfd/reports/index.html>.

———. 2018. “2016 British Columbia Fish Processing Employment.” Victoria, B.C.: Government of B.C. [https://www2.gov.bc.ca/gov/content/industry/agriculture- seafood/statistics/industry-and-sector-profiles](https://www2.gov.bc.ca/gov/content/industry/agriculture-%20seafood/statistics/industry-and-sector-profiles).

Anonymous. 2018. “Personal Communication: Roe herring production values.”

B.C. Ministry of Agriculture. 2018. “British Columbia herring harvest, landed value and wholesale value (1985-2017).” Victoria: B.C. Ministry of Agriculture.

CBC News. 2007. “Feds fund compensation program for ice-stricken fishermen.” <https://www.cbc.ca/news/canada/newfoundland-labrador/feds-fund-compensation-program-for-ice-stricken-fishermen-1.664160>.

Colquhoun, Ewan, and Ridge Partners. 2015. “Measuring the economic value of recreational fishing at a national level.” Brisbane, Australia: Fisheries Research & Development Corporation. <www.frdc.com.au>.

DFO. 2010. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2010/2011.” Fisheries; Oceans Canada. <http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2013/herring-hareng-2012-2013-eng.pdf>.

———. 2011. “Pacific Region Integrated Fisheries Management Plan: Pacific Herring 2011/2012.” Fisheries; Oceans Canada. <http://www.dfo-mpo.gc.ca/Library/344588.pdf>.

———. 2012. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2012/2013.” Fisheries; Oceans Canada. <http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2013/herring-hareng-2012-2013-eng.pdf>.

———. 2015a. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2013/2014.” Fisheries; Oceans Canada. <http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2013/herring-hareng-2012-2013-eng.pdf>.

———. 2015b. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2014/2015.” Fisheries; Oceans Canada. <http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2013/herring-hareng-2012-2013-eng.pdf>.

———. 2015c. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2015/2016.” Fisheries; Oceans Canada. <http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2013/herring-hareng-2012-2013-eng.pdf>.

———. 2016. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2016/2017.” Fisheries; Oceans Canada. <http://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/2013/herring-hareng-2012-2013-eng.pdf>.

———. 2018a. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2017/2018.” Fisheries; Oceans Canada. doi:[10.4324/9780203928660](https://doi.org/10.4324/9780203928660).

———. 2018b. “Pacific Region Integrated Fisheries Management Plan Pacific Herring 2018/2019.” Vancouver, B.C.: Fisheries; Oceans Canada.

Emery, Claude. 1992. “The northern cod crisis (BP-313E).” Political; Social Affairs Division. <http://publications.gc.ca/Collection-R/LoPBdP/BP/bp313-e.htm>.

FAO. 2016. “Fishery Statistical Collections: Fishery Commodities and Trade. (1950-2015). Accessed through FishStatJ software.” Rome.

Fisheries and Oceans Canada. 2016. “Recreational Catch Statistics.” <http://www.dfo-mpo.gc.ca/stats/rec/pac/index-eng.html>.

———. 2017. “Summary Commercial Catch Statistics | Pacific Region.” <http://www.pac.dfo-mpo.gc.ca/stats/comm/summ-somm/index-eng.html>.

———. 2018. “Fishing Licence Statistics - Pacific Region.” <https://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-eng.cfm?pg=DldCommLics>.

Government of Canada. 2014. “Canada Gazette – Holders of the Commercial Roe Herring Fishing Licences Remission Order.” Ottawa, Canada. <http://www.gazette.gc.ca/rp-pr/p2/2014/2014-12-31/html/si-tr108-eng.html>.

———. 2019. “EI Fishing benefits - How much could you receive.” [https://www.canada.ca/en/services/benefits/ei/ei-fishing/benefit-amount.html https://web.archive.org/web/20190104235331/https://www.canada.ca/en/services/benefits/ei/ei-fishing/benefit-amount.html](https://www.canada.ca/en/services/benefits/ei/ei-fishing/benefit-amount.html%20https://web.archive.org/web/20190104235331/https://www.canada.ca/en/services/benefits/ei/ei-fishing/benefit-amount.html).

GSGislason & Associates Ltd. 2015. “The Importance of Herring to the BC Wild Seafood Industry.” Vancouver, BC.

Haas, Andrea R., Danielle N. Edwards, and U. Rashid Sumaila. 2016. “Corporate concentration and processor control: Insights from the salmon and herring fisheries in British Columbia.” *Marine Policy* 68. Elsevier: 83–90. doi:[10.1016/j.marpol.2016.02.019](https://doi.org/10.1016/j.marpol.2016.02.019).

Herring School. 2015. “Herring through time: Pacific herring: Past, Present and Future.” <http://pacificherring.org/timeline>.

McGrath, Keegan P., Nathan L. Pelletier, and Peter H. Tyedmers. 2015. “Life cycle assessment of a novel closed-containment salmon aquaculture technology.” *Environmental Science and Technology* 49 (9): 5628–36. doi:[10.1021/es5051138](https://doi.org/10.1021/es5051138).

Nelson, Stuart. 2006. “West Coast Fishing Fleet: An Analysis of commercial fishing licence, quota, and vessel values.” Surrey, B.C.: Nelson Bros Fisheries Ltd.

———. 2007. “West Coast Fishing Fleet: An Analysis of commercial fishing licence, quota, and vessel values.” Surrey, B.C.: Nelson Bros Fisheries Ltd.

———. 2008a. “An Analysis of: commercial fishing licence, quota, and vessel values.” Surrey, B.C.

———. 2008b. “West Coast Fishing Fleet: An Analysis of Commercial Fishing Licence, Quota, and Vessel Values.” Surrey, BC: Nelson Bros Fisheries Ltd.

———. 2009a. “Pacific Commercial Fishing Fleet: Financial Profiles for 2007.” Surrey, B.C.: Nelson Bros Fisheries Ltd.

———. 2009b. “West Coast Fishing Fleet: An Analysis of Commercial Fishing Licence, Quota, and Vessel Values.” Surrey, B.C.: Nelson Bros Fisheries Ltd.

———. 2010. “West Coast Fishing Fleet: Analysis of Commercial Fishing Licence, Quota, and Vessel Values.” Surrey, B.C.: Nelson Bros Fisheries Ltd.

———. 2011a. “Pacific Commercial Fishing Fleet: Financial Profiles for 2009. Prepared for Fisheries and Oceans Canada, Pacific Region.” Pacific Commercial Fishing Fleets Financial Profiles Series. Vancouver, B.C.: Nelson Bros Fisheries Ltd.

———. 2011b. “West Coast Fishing Fleet: An Analysis of Commercial Fishing Licence, Quota, and Vessel Values.” Surrey, B.C.: Nelson Bros Fisheries Ltd.

———. 2012. “West Coast Fishing Fleet: An Analysis of Commercial Fishing Licence, Quota, and Vessel Values.” Surrey, B.C.

———. 2013. “West Coast Fishing Fleet: An Analysis of Commercial Fishing Licence, Quota, and Vessel Values.” Surrey, B.C.

———. 2016. “West Coast Fishing Fleet: An Analysis of commercial fishing licence, quota, and vessel values.” Surrey, B.C.: Nelson Bros Fisheries Ltd.

Newell, D. 1999. “‘Overlapping territories and entwined cultures’: A voyage into the Northern BC Spawn-on-Kelp fishery.” In *Fishing Places, Fishing People: Traditions and Issues in Canadian Small-Scale Fisheries*, edited by R.E. Ommer and D. Newell, 121–44. Toronto: University of Toronto Press.

Pelletier, Nathan, Peter Tyedmers, Ulf Sonesson, Astrid Scholz, Friederike Ziegler, Anna Flysjo, Sarah Kruse, Beatriz Cancino, and Howard Silverman. 2009. “Not all salmon are created equal: life cycle assessment (LCA) of global salmon farming systems.” *Environmental Science & Technology* 43 (23): 8730–6. doi:[10.1021/es9010114](https://doi.org/10.1021/es9010114).