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Socio-economic Contribution of Small-scale Versus Large-scale Fisheries in British Columbia

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Abstract

This research aims to determine the socio-economic contribution of small-scale fisheries in British Columbia. In order to do so, a definition of small-scale fisheries is needed, as there is currently no national working definition of this sector in Canada. First, we apply three approaches presented in the literature to split British Columbia's fishing fleets into small- and large-scale sectors. Second, we overlap the results from the three approaches to categorize BC's fisheries into small- and large-scale. Third, we evaluate the socio-economic contribution of small- and large-scale fisheries identified by the three approaches. We show that many of British Columbia's fisheries can be classified as small-scale. From these analyses, we also demonstrate that the small-scale sector receives a higher average price per pound of landed catch than the large-scale sector. However, the large-scale sector consumes less fuel per tonne of landed catch than small-scale fisheries, which does not fit with the trend in the fuel consumption of global large-scale fisheries reported in the literature. Individuals own most of the vessels in the small-scale sector, many of which are located outside Greater Vancouver. In contrast, companies own nearly all of the large-scale vessels and the majority of these companies are located in Greater Vancouver.

1 Introduction

Small-scale fisheries (SSF) have been estimated to represent 90% of fishing vessels worldwide (Béné et al. 2007; FAO, 2010), which produce 25-50% of the global catch of fish and shellfish (Pauly, 1997; Berkes *et al.,* 2001; Teh *et al.*, 2011; Guyander *et al.* 2013; FAO, 2014a; Pauly & Zeller, 2016). The contribution of SSF increases globally to two thirds when considering catch use for direct human consumption (FAO, 2014a). These fisheries can be linked to a strong local community, providing self-employment to many (FAO, 2014b). The definition of small-scale fisheries continues to invoke debate in the academic arena. However, there is general consensus among fisheries scientists that these fisheries are socially and economically important to communities and regions across the globe. A table presented in Thomson (1980) was one of the first examples of comparing small- and large-scale fisheries side by side to demonstrate the contribution of SSF relative to large-scale fisheries (LSF). This first effort to compare LSF versus SSF was followed with updated and slightly different comparisons at global level by Berkes et al. (2001) and Jacquet and Pauly (2008). There have also been regional comparisons for the American Northeast Atlantic and Brazil (Therkildsen, 2007; Damasio et al., 2016).

Small-scale fishing is a term that is used in the fisheries literature without much explanation of what and who this term encompasses. Some argue that attempts to define SSF may delay work to assist management, and stress the need to use a flexible definition (Allison and Ellis 2001; Garcia et al., 2008; Sumaila, 2017). Much of the work carried out by those in support of a flexible definition focus on fisheries in developing nations where such definitions may be useful in improving management (Andrew et al., 2007; Béné et al. 2010; Ratner & Allison, 2012). Others argue that in order to improve fisheries governance, SSF should be more precisely described by values of social justice and ecological sustainability (Johnson, 2006). Small-scale fisheries have become vastly important on a global scale in the last three decades, creating a need for definitions of small-scale fishing even more important.

Many of the world's developed nations with 'industrialized fleets' may be considered LSF on a global scale. However, in many of the world's largest and most industrialized fishing nations there are still fishers participating in SSF, which may look different from those of developing nations. The differences between SSF and LSF are not always visually obvious and require further consideration. The European Union (EU) defines SSF as fishing with vessels that are less than 12m in length and use passive gears (Martín, 2012). Small-scale fleets are generally associated with generating socio-economic benefits within the associated communities while typically creating less environmental impacts (Guyander *et al.* 2013) all of which are prevalent in industrialized nation's fleets. The importance of SSF has been widely explored without first making the distinction of who and what is included in the category. This represents a gap in the literature that this study will attempt to fill.

In order to determine the socio-economic importance of the SSF sector in British Columbia (BC), it is important to determine the proportion of the fishery that fits the description of SSF and LSF), respectively. A definition for SSF in BC, or even Canada as a whole, would serve to identify who fits into this distinction. Garcia et al. (2008) argue that many fishers in small-scale fisheries lack the capacity to come together and lobby for their interests to the government. By identifying which fisheries belong to SSF in BC, and therefore, which fishers are working in SSF, they may see an opportunity to come together collectively and protect their interests in the fishery.

Understanding what SSF in BC may look like and what it may include creates space for productive policy and management debate as argued by Natale et al. (2015). Creating a definition of SSF for BC fisheries and determining their socio-economic contributions should provide a bargaining tool for those involved, producing an opportunity for further discussion within the industry. Not all of BC's fisheries have the same socio-economic concerns and by grouping small-scale enterprises under the same management as the large-scale ones, the government is perhaps missing an opportunity for socio-economic development in communities that depend on SSF. It is the convention in the small-scale fisheries literature to

analyze small and large-scale fisheries as sectors. In keeping with this convention, the socio-economic analysis of fisheries in BC will be organised around small and large-scale sectors rather than by fishery or groups of fishers as in more traditional economic analysis.

2 Method

2.1 Application of approaches

2.1.1 Cumulative percent distribution

Using the methods proposed by Ruttan et al. (2000) and improved upon and applied in Sumaila et al. (2001), Therkildsen (2007) and Damasio et al. (2016), the distinction between SSF and LSF is made using landed weight or value as the basis for splitting. It is thought that smaller vessels will land a smaller catch corresponding to a smaller landed value (Ruttan et al., 2000). The cumulative percent distribution method has created distinct SSF and LSF categories for developed countries' fisheries, including, Canada, Norway (Sumaila et al., 2001), Gulf of Maine, George's Bank (Ruttan et al., 2000) and New England (Therkildsen, 2007). Therefore, we use it to explore how to distinguish SSF and LSF for BC's fisheries. We have chosen to use catch for this method as opposed to landed value. This is a result of many small boat fisheries operating in BC, which catch small amounts of high value species. The use of landed value for the cumulative percent distribution would skew these fisheries making them larger scale than what they actually are.

As a federal institution, DFO must operate within the confines of the 3-Party Privacy Policy, which stipulates that the federal government will not provide information about any fishery or group of vessels with three or fewer participants. It is assumed that if there are three or fewer participants, one could identify the participants and therefore, what they are catching. The need for privacy notwithstanding, protecting the privacy of those exploiting a public resource seems contradictory to how the public should be informed of their resource. As a result of the policy, all vessel combinations with three or fewer vessels active in the 2013 fishing season are

not included in the analysis. This will likely affect the results in an unknown way. However, there is no legal way around this and we completed the analysis with the information that is publically available, complimented with the additional information that DFO was willing to share. In order to acquire data in a useable format for the application of this method, a formal catch statistics request was made to DFO. This data consists of species landings (both weight and value) by all active vessels in each target fishery for the 2013 season, which was the most recent and complete year of data at the beginning of this research. It should be noted that 2013 was not a salmon dominant year and therefore the results of this research will reflect that. However, 2014 was a salmon dominant year, unfortunately data for this season was not available in time for this analysis. Fortunately, the approach can be re-run with new data without much difficulty.

The Pacific fleet in BC is split into fishery combinations consisting of licence category, vessel length category and gear type. The fishery combinations are denoted by their licence prefix code (Table 1) and vessel length category code (Table 2). For example, one fishery combination would be all salmon seiners between 35' and 45'11'' and it would be denoted as AS2 (Tables 1 & 2). These combinations are ordered in ascending order for catch and the proportion of catch of each fishery is calculated from the total catch in 2013. A cumulative total of fishery combination proportions of catch are calculated (Figure 1). Ruttan et al. (2000), Sumaila et al. (2001) and Therkildsen (2007) set the cut off point between SSF and LSF at 50% of the cumulative proportion. However, it is worth noting that a break at 50% of the cumulative value is not necessarily appropriate for BC's fleet, still, we have chosen to maintain 50% cumulative landed value as the split for SSF and LSF in BC.

Table 1 DFO licence prefixes[1]

Fishery	*Licence prefix code*
Salmon gillnet	AG
Salmon seine	AS
Salmon troll	AT
Schedule II species hook and line	C
Schedule II species tuna	CT
Aboriginal salmon gillnet	FAG
Aboriginal salmon seine	FAS
Aboriginal salmon troll	FAT
Aboriginal sablefish longline and trap	FK
Aboriginal halibut hook and line	FL
Aboriginal crab trap	FR
Aboriginal prawn trap	FW
Aboriginal rockfish hook and line	FZN
Geoduck dive	G
Herring gillnet	HG
Herring seine	HS
Sablefish longline and trap	K
Halibut hook and line	L
Northern Native Fishing Co. salmon gillnet	NAG
Crab trap	R
Shrimp trawl	S
Herring spawn on kelp	SOK
Groundfish trawl	T
Prawn trap	W
Green urchin dive	ZA
Red urchin dive	ZC
Rockfish hook and line	ZN

[1] DFO 'Commercial Licence Prefix Categories' http://www.pac.dfo-mpo.gc.ca/fm-gp/licence-permis/lpc-eng.html (Accessed 14 October 2017).

Table 2 Vessel length categories[2]

Vessel length category (feet)	Vessel length category (metres)	Vessel length code
< 35	< 10.7	1
35 - 45	10.7 - 13.7	2
45 - 65	13.7 - 19.8	3
65 - 100	19.8 - 30.5	4
> 100	> 30.5	5

2.1.2 Vessel length split

This method draws inspiration from current policies in place in Atlantic Canada to protect the interests of inshore, independent fishers. Canada has never managed their fisheries as a whole; each ocean and each stock is managed separately. Atlantic Canada has historically been managed quite differently from Pacific Canada. In fact, DFO acknowledges that management has been executed in a piecemeal and patchy fashion (Day, 1995; DFO, 2012). Therefore, policies outlining fisheries management on Canadian coasts are different and reflect the patchy DFO practices.

Atlantic fishers have always had a strong lobbying presence and fisheries organizations such as the Maritime Fishermen's Union have been lobbying for owner-operator policies since the 1970s (Barnett et al., 2016). Former Minister LeBlanc introduced the original fleet separation policy to the Atlantic in 1979, which has evolved over the last several decades to the Policy for Preserving the Independence of the Inshore Fleet in Canada's Atlantic Fisheries (PIIFCAF) (Cooper & Clift, 2012; Barnett et al., 2016). In its 1979 form, corporations were prohibited from holding licences on vessels under 65 feet (Barnett et al., 2016). In 1989, the fleet separation and owner-operator policy became a blanket policy for all of the Atlantic with specifics for each region within the Atlantic (Barnett et al., 2016). The blanket policy was expanded in 1996 as the 'Core Policy', which resulted in the loss of institutions representing fishers' interests (Barnett et al., 2016).

[2] DFO 'Vessel Information' http://www.dfo-mpo.gc.ca/stats/commercial/licences-permis/pacific-pacifique/pacfleet-eng.htm (Accessed 14 October 2017).

Processors were still tightly involved in the ownership of the commercial fleet in the Atlantic fishing industry. This issue became too great and a multi-stakeholder Atlantic Fisheries Policy Review was conducted[3]. Atlantic fishers were unhappy with industry consolidation and vertical integration, which limit equitable access and wealth across Atlantic regions (Barnett et al., 2016). PIFFCAF has been designed to cope with a set of evolving policies starting in the early 1980s (Cooper & Clift, 2012).

PIIFCAF was implemented in 2007 to promote the independent inshore sector in Atlantic Canada by creating an 'Independent Core'[3]. This addition to the fleet separation policies required licence holders to state whether they are party to and terminate Controlling Agreements as of April 24, 2014 (Barnett et al., 2016). PIIFCAF states that vessels under 65 feet (19.8 m) are not to be owned by processing firms and instead, operators own them. This method divides BC's target fisheries at a 19.8 m cut-off point, with all vessels under 19.8 m being considered small-scale and all of those above 65' being considered large-scale.

2.1.3 Point-based framework

A point-based framework developed by García-Flórez et al. (2014) for defining SSF and LSF fleets in Europe provides a third approach to splitting a fleet into SSF and LSF. As European countries are often considered developed, this approach may be useful for the Pacific fleet in BC. We have omitted fishing licenses allowed per year and daily landings used by García-Flórez et al. (2014) because they are not relevant for the BC fleet. In BC, one can own licenses across a number of different target fisheries or fishing areas for one fishery as long as an individual has the capital required. We have also omitted daily landings and, instead use average catch/vessel because the data for the latter are more readily available. This analysis considers additional economic features as important to determining 'small-scaleness'. These features include capital

[3] DFO 'Policy for Preserving the Independence of the Inshore Fleet in Canada's Atlantic Fisheries' http://www.dfo-mpo.gc.ca/fm-gp/initiatives/piifcaf-pifpcca/piifcaf-policy-politique-pifpcca-eng.htm (Accessed January 2016).

costs of fuel per year, gross-revenue, licence value, vessel replacement cost and whether the fishery is managed under ITQs or not.

The overall vessel length is differentiated based on vessel size categories used by DFO. Economic variables such as costs of licence and vessel as well as gross revenue were taken from Pacific fleet financial profiles as well as a DFO statistic request (GSGislason and Associates Ltd., 2008; GSGislason and Associates Ltd., 2011; Nelson, 2011; DFO, 2016a). ITQs are generally associated with large-scale vertically integrated fisheries with quota consolidation (McCay, 1995; Eythórsson, 2000; Scholz et al., 2004; Ecotrust, 2008; Sumaila, 2010; Robertson et al., 2015; Haas et al., 2016).

The use of point-based framework for distinguishing between SSF and LSF is the most data intensive method used in this analysis. This method would work nicely if all fisheries had equal amounts of data available. However, that is not the case and indicators for some fisheries were estimated using data from similar fisheries. For example, we used the halibut hook and line fishery (L) crew estimates for Schedule II Species fisheries (C and CT) as these fisheries take place on similar or the same vessels. There is a maximum point sum of 39 and we have assumed 25 to be the dividing point total between SSF and LSF. All fisheries with 24 or less points are considered SSF and all fisheries with 25 and above points are considered LSF (Table 3).

Table 3 Point-based framework for separating the Pacific Fleet. A fishery will be assigned a point based on where it falls on the scale for each feature. The totals will range from 9 to 39. Everything scoring 24 and below

points is considered SSF. Note that blanks appear under the Gear and ITQ features, as they are categorical and non-numerical categories.

	Points				
Features	1	2	3	4	5
Overall vessel length (m)	<35	35-45	45-65	65-100	>100
Type of Gear		Passive		Seine/Active	
Catch/Vessel (t)	<100,000	100,000-300,000	300,000-700,000	700,000-1,000,000	>1,000,000
Crew Numbers	<2	3	4	5	>6
Gross Revenue per harvester ($)	<50,000	50,000-250,000	250,000-1,000,000	1,000,000-2,000,000	>2,000,000
Licence Value ($)	<150,000	150,000-250,000	250,000-500,000	500,000-1,000,000	>1,000,000
Vessel Replacement Cost ($)	<137,000	137,000-218,000	218,000-500,000	500,000-750,000	>750,000
ITQ fishery	No		Partial		Full

2.1.4 Overlap of approaches

The approaches used for dividing the fishing fleet into small- and large-scale have innate strengths and weaknesses. So, the results of the three methods above were overlapped to reduce the impact of outlier fisheries (Figure 1). For example, a fishery may be considered small-scale using the cumulative percent distribution method because this fishery does not catch a large total landed weight. However, the point-based framework method may consider the same fishery large-scale as it factors in the high cost of participating in this fishery. To eliminate cases like these, we assumed that only fisheries in the intersection of all three circles are small-scale (Figure 1).

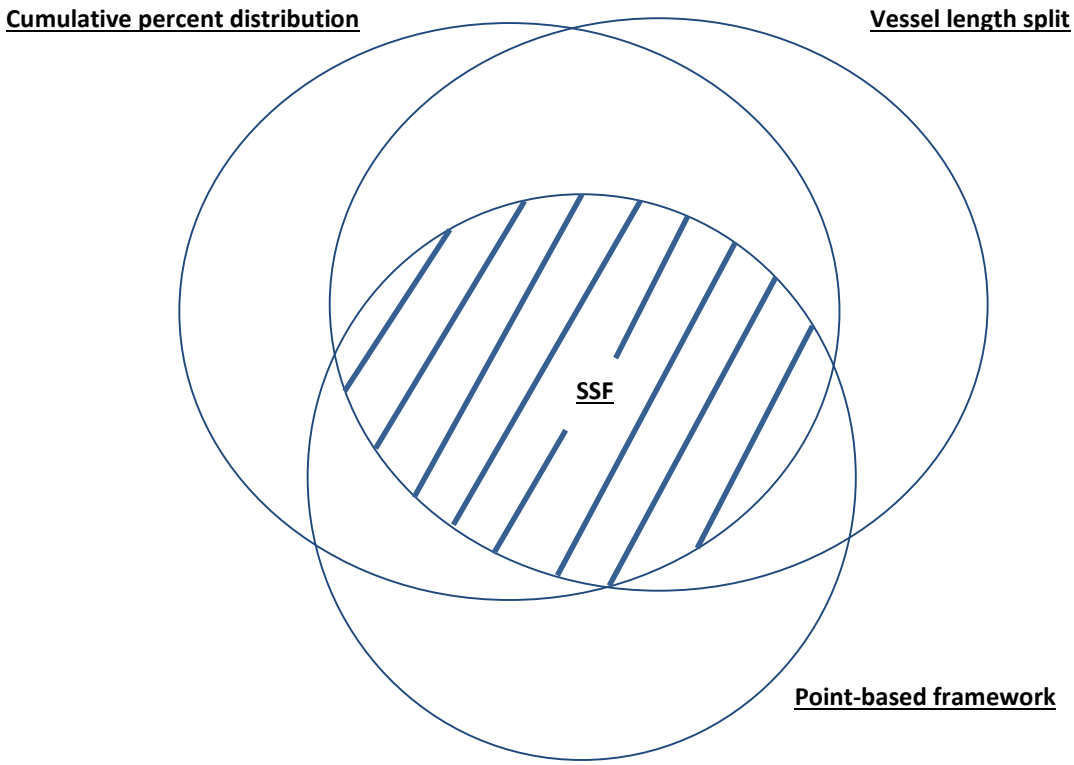

Figure 1 Example Venn diagram for approach overlap of results

2.2 Socio-economic evaluation of small- and large-scale fisheries

Once the fleet has been split according to the methods above, the small- and large-scale sectors of the fishery are compared via a number of socio-economic features. These features are adopted from previous assessments of global small- and large-scale fisheries (Thomson, 1980; Berkes et al., 2001; Jacquet and Pauly, 2008). The features are divided into three general categories, i.e., physical vessel, economic and social features. Vessel features are frequently used to determine the scale of a fishery (FAO & Worldfish, 2008; Macfadyen et al., 2011; Teh et al., 2011; Martín, 2012; Sumaila et al., 2012; Guyader et al., 2013). Physical vessel features' data is relatively easily acquired for BC's fleet. Vessels participating in SSF and LSF are compared by average vessel length participating in the sector, gear employed, as well as gross tonnage and engine power (García-Flórez et al., 2014). The comparison of these features can determine the contribution of the two sectors to society's goals for fisheries.

Comparison of the economic features of small- and large-scale sectors allows for the importance of these fisheries to the economy to be analysed. The economic and social features covered in the analysis are fuel spending, capital input, yield, employment and ownership type and location (Berkes & Kislalioglu, 1989; Johnson, 2006; Chuenpagdee, et al. 2006; Guyader et al., 2013; Sumaila et al., 2016). In BC, there are many barriers to entering the fishery and analysis of capital requirements for the target fisheries provides important insight into the financial limitations to new entrants. The analysis of ownership provides insight on who owns licenses and vessels as well as where these are owned. With this analysis, it can be seen which fisheries are important to small communities along the coast.

3 Data

These methods require landings and landed value of fisheries based on target fishery and vessel length. We submitted a formal catch statistic request to DFO to obtain the necessary data. The data obtained included the number of licensed and active vessels in each category for the 2013 fishing season. Landings data is publicly available through DFO's webpage. However, the formats by which the data is provided are limited and a DFO catch statistic request provided additional data for landed weight and value of species by target fishery and vessel length category.

Data for vessel characteristics were acquired through cross-referencing vessel names and Vessel Registration Numbers (VRN) through DFO's vessel database[4] and Transport Canada's vessel database[5]. These databases also provided a wide range of ownership information. However, this is only the case for vessel based licensed fisheries (i.e. salmon, crab and prawn). There will be some missing ownership data for party-based licensed fisheries (i.e. herring). However, the majority of BC's vessels operate within vessel-based licensed fisheries and therefore, most vessels will be accounted for in this analysis. Crew/employment estimates were

[4] DFO 'Licensed Fishing Vessel Search' http://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-eng.cfm?pg=VesselSearchForm (Accessed 14 October 2017).
[5] Transport Canada 'Vessel Registration Query System' http://wwwapps.tc.gc.ca/Saf-Sec-Sur/4/vrqs-srib/eng/vessel-registrations (Accessed 14 October 2017).

collected for various fisheries through Integrated Fisheries Management Plans (DFO, 2016b-j), financial profiles (GSGislason and Associates Ltd., 2011; Nelson, 2011), and interviews with local fishers.

All financial data including replacement costs, licence costs, quota costs, expenses and gross revenue were taken from Pacific fleet financial profiles as these are believed to be the most recent and complete estimates (GSGislason and Associates Ltd., 2011; Nelson, 2011). It should be noted that these data are not for the 2013 season but they are the most complete set of estimates available. It should also be noted that there is inherent uncertainty in the data used. While uncertainty is not assessed here, it would be considered in further works.

Fuel cost estimates were taken from Nelson (2011), as it contains the most complete estimates of financial profiles for the BC fleets. We converted fuel consumption to litres of fuel per year using fuel unit cost from fuel surveys in real 2016 $CAD[6,7]. These fuel cost estimates only consider 1,472 vessels, which is believed to be conservative as there were an estimated 2,437 licensed and active vessels in 2013 (DFO, 2016a). This estimate does not include the herring fishery because, even though many herring vessels also participate in the salmon fishery, it is impossible to know how many of them are participating in the fishery due to party-based licenses and licence stacking behaviour.

There are many tiers of ownership in the BC fleet (Haas et al., 2016). People, companies and communities can own vessels, quotas and licences throughout the fisheries. This work will investigate the concentration of vessel ownership within the BC fleet both by SSF/LSF and geographically. Ownership is categorized as First Nations/Community, Individual or Company. In this industry, many individuals will incorporate or become limited for legal and tax purposes. This doesn't discount the fact that these individuals could still be owner-operators. An individual is one person who owns one or two boats, as it is feasible for that individual to fish

[6] Active Captain 'Canadian fuel prices in British Columbia' https://activecaptain.com/fuelLists/fuelIndexCA.php?st=BC (accessed 3 November 2016).
[7] Fine Edge 'Fine Edge Fuel Survey' http://fineedge.com/fuelsurvey.html (accessed 14 October 2017).

on both boats. A company is considered to be a business or an individual who owns three or more vessels. Ownership data is found through the DFO vessel[4] and Transport Canada[5] queries but the use of this database slightly skews the results as it only evaluates vessel-based licenses.

4 Results

4.1 Division of the Fleet

4.1.1 Cumulative percent distribution

This approach results in the majority of BC fisheries being designated as small-scale and of the forty-nine fisheries combinations considered for this method, only three are considered large-scale (Figure 2). This means that these three fisheries land about 50% of landings. The fisheries considered large-scale salmon seiners between 65’ and 100’ and trawlers greater than 65’ (Figure 2). Some of the fisheries considered small-scale using this approach do not catch large quantities of fish but they target high value species. For example, geoduck, prawn and sablefish fisheries portray many features of small-scale but they have extreme economic barriers to entry, and rely on foreign markets. Using the cumulative percent distribution by catch results in an unexpectedly large number of fishery combinations considered small-scale.

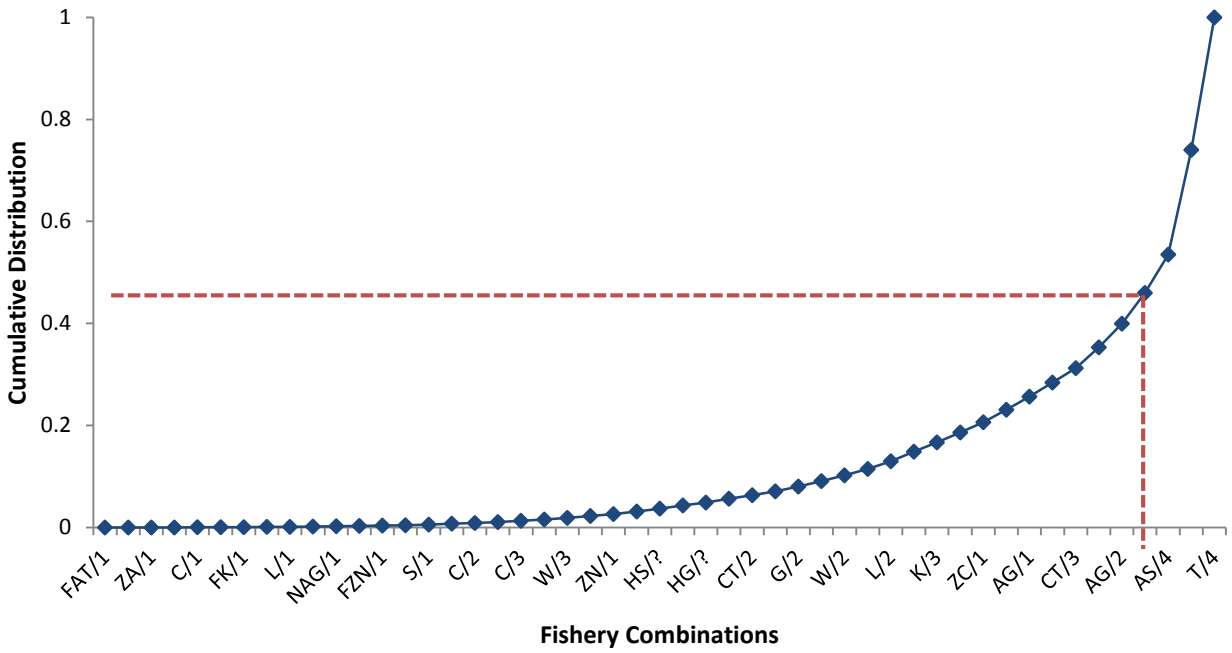

Figure 2 Cumulative percent distribution of BC's fishery by landed weight. Descriptions of licence prefixes can be found in Table 1 and vessel length codes are in Table 2. Note that SSF are to the right of the red dotted line and LSF are to the left.

4.1.2 Vessel length split

Dividing BC's fleet into small- and large-scale in line with Atlantic Canada's PIIFCAF policy classifies five fisheries into the large-scale sector. This method only relies on vessel length to split the fleet. The large-scale sector includes salmon seiners, schedule II tuna hook and liners, sablefish long-liners and trappers, halibut hook and liners and groundfish trawlers over 65 feet in length. This approach has fewer fisheries considered small-scale than the previous approach but makes this distinction based solely on length. As with the cumulative percent distribution approach, this approach places small boat, high value species fisheries into the small-scale category (i.e., geoduck, prawn and sablefish).

4.1.3 Point-based framework

This approach for splitting BC's fleet into small- and large-scale fisheries has the greatest number of fisheries considered large-scale (Table 4). It method uses a number of fishery

features in contrasts to a single feature used in the two previous methods. Therefore, this approach accounts for economic barriers of small boat, high-value species fisheries like geoduck and sablefish (Table 4). It should be noted that this method does not split target fisheries into segments of vessel length and the entire fishery is evaluated as a single entity. This may have an impact on how small- or large-scale a fishery appears.

Table 4 Results of the point-based framework. See Table X for description of fishery licence prefixes. Note, a 'blank' cell = not available data.

Fishery Licence	Overall Length	Type of Gear	Catch (lb.) per Vessel	Crew	Gross Revenue / Harvester	Licence Cost	Vessel Replacement Cost	ITQ Managed	Total	SSF or LSF
FAG	1	2	1	1	1			1	7	SSF
NAG	1	2	1	1	1			1	7	SSF
FAT	1	4	1	1	1			1	9	SSF
FR	1	2	1	2	2			1	9	SSF
FZN	1	2	1	1	3			1	9	SSF
ZA	1	2	1	1	2	1	2	1	10	SSF
FL	1	4	1	3	2			1	10	SSF
FW	1	2	1	3	2			1	10	SSF
ZN	1	2	2	1	3	1	1	1	12	SSF
C	2	2	3	3	2			1	13	SSF
FK	1	2	2	4	3			1	13	SSF
AG	2	2	3	1	3	1	1	1	14	SSF
S	2	4	2	1	2	1	1	1	14	SSF
W	2	2	2	3	4	1	1	1	16	SSF
AT	2	4	2	1	3	1	1	3	17	SSF
FAS	3	4	3	4	2			1	17	SSF
CT	3	4	4	3	4			1	19	SSF
R	1	2	4	2	5	2	2	1	19	SSF
ZC	1	2	5	2	4	1	2	5	22	SSF
AS	3	4	5	4	4	1	3	1	25	LSF
G	2	2	4	2	5	5	1	5	26	LSF
L	3	2	4	3	5	2	2	5	26	LSF
K	3	2	5	4	5	2	4	5	30	LSF
T	4	4	5	2	5	1	5	5	31	LSF

4.1.4 Overlap of approaches

All three methods for splitting fishing fleets into small-scale and large-scale have their pros and cons and there is some overlap between the results they produce. Figure 3 presents the overlap of fisheries found to be small-scale in each of the three methods discussed above and for the

rest of the analysis herein, we will use this as our definition of small-scale fisheries in BC. The cumulative percent distribution found 46 of 49 fisheries to be small-scale (Figure 3). A fishery is considered a combination of target species, gear and vessel length (Tables 1 & 2). The vessel length split approach modelled after Atlantic Canada's PIIFCAF found 40 of 46 fisheries to be small-scale. Finally, the point-based framework approach found 32 of 46 fisheries to be small-scale. Please note that the cumulative percent distribution analysis includes 3 herring fisheries, which could not be analysed using the other two methods with available data.

The cumulative percent distribution was the only approach to find halibut hook and liners and sablefish long liners or trappers between 65 and 100 feet to be small-scale (Figure 3). There are 9 of 46 fisheries considered small-scale by the cumulative percent distribution and vessel length split (Figure 3). Small salmon seiners (45-65 ft.) and groundfish trawlers (under 65 ft.) are considered small under the cumulative percent distribution and the vessel length split. This is a surprising result as these fisheries operate with highly unselective gears and have higher rates of by-catch. The cumulative percent distribution and vessel length split also consider halibut, sablefish and geoduck fisheries with small vessel size to be small. It is not expected for these fisheries to be considered small as they have high replacement and quota costs, which are likely tied to being ITQ, managed fisheries. Only one fishery is considered small-scale by the cumulative percent distribution and the point-based framework (Figure 3).

The overlap approach results in 31 of 46 fisheries being considered small-scale (Figure 3). Salmon gillnet and troll fisheries are found to be small-scale by all three methods as well, which is an expected result (Figure 3). Many of the invertebrate fisheries were found to be small-scale using all three methods as well. The crab trap, shrimp trawl, prawn trap and green and red urchin dive fisheries were all found to be small-scale (Figure 3). These fisheries are typically small in many ways. However, fishers have to incur higher capital investments in order to enter the fishery, which is a feature of LSF.

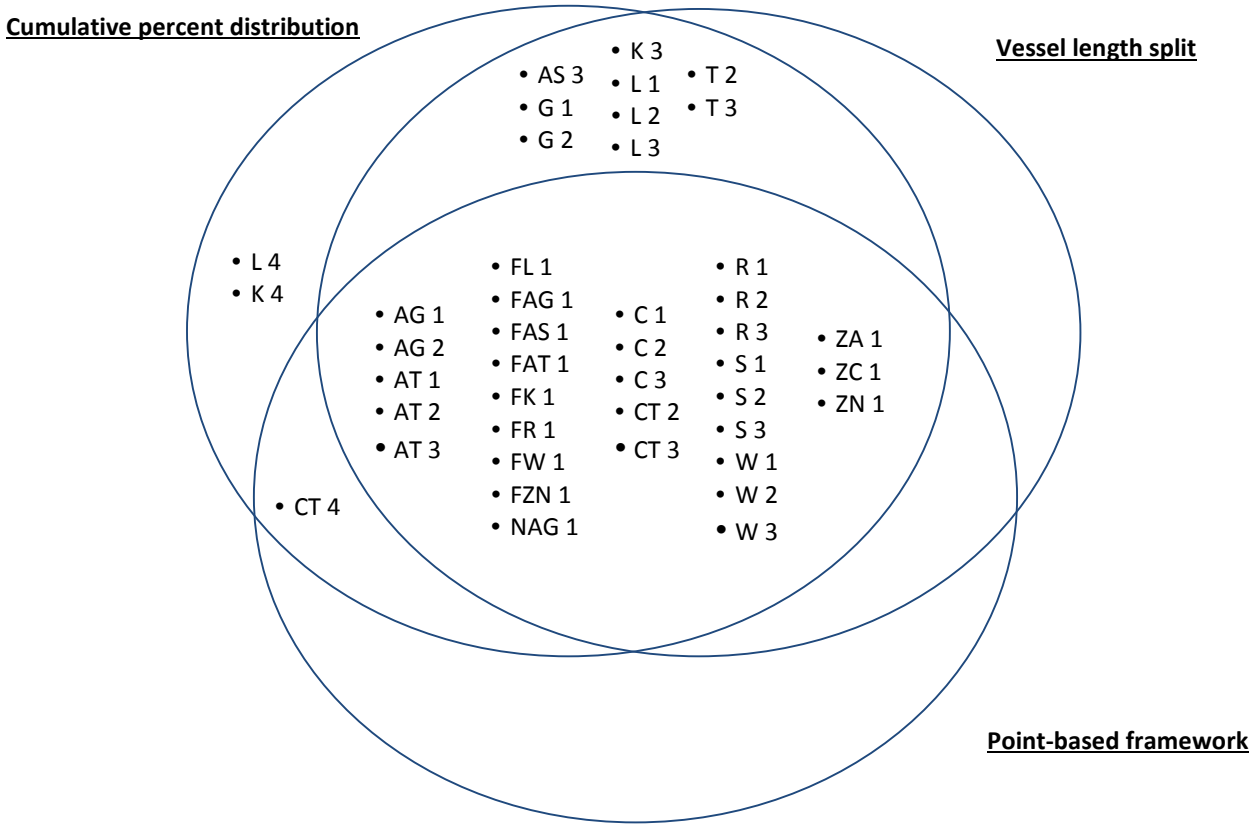

Figure 3 Venn diagram of Fleets considered SSF by all three methods. See Table 1 for licence prefix codes and Table 2 for vessel length codes.

4.2 Socio-Economic Evaluation of Small-Scale and Large-Scale Fisheries

4.2.1 Cumulative Percent Distribution

This approach shows that the small-scale sector catches a smaller proportion of landings, which equates to a majority of the landed value (Appendix A). This result is due to the small boat, high value fisheries mentioned previously. Fisheries such as geoduck catch a small weight but are the highest value species in the province. As expected, the small-scale sector has more active vessels and as a result, there are more primary employment opportunities (Appendix A). The small-scale sector consumes more fuel per tonne landed on average, which is an unexpected result (Appendix A).

A similar relationship may explain the result of BC's small-scale sector consuming more fuel than large-scale. It may also be the case that small-scale vessels in BC are more selective with fishing grounds and having older, less efficient engines, therefore consuming more fuel annually. Analysis of ownership demonstrates the importance of the small-scale sector to individuals and small communities. Individuals own the largest portion of the small-scale sector and only 37% of small-scale owners are located in the Greater Vancouver area (Appendix A). This indicates that 63% of small-scale owners are located throughout the province in areas, which are less urban than Vancouver. Thus, SSF perform a special social role, as they provide employment in smaller communities with fewer opportunities for alternative livelihoods, and are therefore, more dependent upon the fishing industry than residents of Greater Vancouver

4.2.2 Vessel length split

Atlantic Canada's PIIFCAF policy approach for splitting BC's fleet results in the small-scale sector catching less in terms of weight and value (Appendix B). Using this approach, SSF catch less but the sector receives a higher average price per pound than the large-scale sector. Similar to the previously discussed method, the higher average price per pound is a result of the inclusion of small boat, high value fisheries like crab, prawn and geoduck. This approach, like the previous relies on one feature to divide the fleet into sectors. The results of this approach produce similar socio-economic trends to the cumulative percent distribution.

4.2.3 Point-based framework

This approach produces some different results from the previous two approaches as it used a number of fishery features to divide the fleet. Using the point-based framework demonstrates that the large-scale sector catches the majority of catch by weight and value but the small-scale sector achieves a higher average price per pound (Appendix C). This result is due to more fisheries being designated as large-scale than the previous two approaches (Table 4). However, the higher average price per pound is still the result of small boat, high value fisheries like prawn and crab.

Similar to the previous two approaches, this approach also demonstrates that the small-scale sector has more active vessels and a higher number of crew positions (Appendix C). This approach also demonstrates that small-scale vessels consume more fuel per tonne landed. This is likely due to the same reasons discussed previously. However, using this approach, the small-scale sector spends more on fuel per $100,000 landed than the large-scale sector (Appendix C). This result differs from the previous two methods. This occurs because more fisheries are considered large-scale using the point-based framework approach (Table 4). There is proportionally less catch and corresponding landed value in the small-scale sector using this approach and the sector still contains the crab fishery which spends the most money on fuel in BC (Nelson, 2011).

In terms of ownership trends, the results of this approach are similar to the previous two. The largest difference is that more individuals are owners within the large-scale sector (Appendix C). There are more fisheries with predominantly individual ownership, which qualify, as large-scale with this approach. These fisheries primarily include smaller vessels within the salmon seine, groundfish trawl and halibut fisheries (Table 4).

4.2.4 Overlap of the three approaches

Here, the small-scale sector catches a smaller proportion of both catch and landed value (Table 5). However, this smaller catch commands a higher average price per pound (Table 5). This trend is in line with all three of the above methods (Appendices A-C). However, the results are most similar to the point-based framework approach (Appendix C).

The small-scale sector's average price per pound is a result of high value species being caught by fisheries in this sector. These species include Dungeness crab, spot prawn and sockeye salmon (Table 5). Dungeness crab and sockeye salmon are also amongst the top three species landed by weight in the small-scale sector (Table 6). The large-scale sector catches large amounts of lower value species including Pacific hake and pink salmon (Table 5). However, high

value species including Pacific halibut, sablefish and sockeye salmon are also important to this sector (Table 5).

There are nearly five times the licensed and active vessels in the small-scale sector compared to the large-scale (Table 5). The vessels active in the small-scale sector have an average vessel length of 11.25 m and a median vessel length of 10.97 m (Table 5). Both the average and median vessel lengths in the small-scale sector fall below the EU's designation for artisanal, i.e., small-scale sector of 12 m and Atlantic Canada's 'inshore' designation of 19.8 m (Cooper & Clift, 2012; Martín, 2012; Barnett et al., 2016). The large-scale sector's average and median vessel lengths are larger than the EU's designation. However, the large-scale sector's average and median vessel lengths are below Atlantic Canada's 'inshore' vessel length cut-off (Table 5).

The fuel demands of the small- and large-scale sectors are quite different. It is a surprising result that the small-scale sector uses more litres of fuel to land their catch (Table 5). Past comparisons have found that the small-scale sector consumes less fuel than the large-scale faction (Thomson, 1980; Berkes et al., 2001; Jacquet and Pauly, 2008). It should be noted that past assessments are global in scope and include fisheries from developing nations and some of these include non-motorized vessels. However, Therkildsen (2007) found that in New England fisheries, fuel consumption is based on gear and some fisheries within the small-scale sector consume more fuel than their large-scale counterparts.

The small-scale sector provides more employment opportunities as there are more licensed and active vessel in this sector (Table 5). The small-scale sector can also employ more people per $100,000 of catch landed highlighting this sector's economic importance (Table 5). Ownership of the fleet is another important feature while discussing SSF. After combining results from the above methods, the small-scale sector demonstrates that individuals and communities own a majority of the vessels participating in the fisheries (Table 5). Individuals or groups outside of Vancouver and surrounding areas own most of the vessels in the SSF sector. The prevalence of individual ownership in relatively 'rural' communities in the province is an important feature of

SSF (Johson, 2006). Aboriginal commercial fisheries are considered small-scale and have important social implications to aboriginal communities, which again, is a valuable feature of SSF (Johnson, 2006; Schuhbauer & Sumaila, 2016; Sumaila et al., 2016). In contrast, the large-scale sector has mostly company ownership, with many of the owners being located in Vancouver and neighbouring cities (Table 5).

Table 5- Socio-economic features for SSF and LSF using the overlap of all results. Note that values in brackets represent a range of values from the three individual methods.

	SSF	***LSF***
Landings (t)	301,123	882,432
Proportion of catch (%)	25	75
Landed value ($)	1,402,881,358	1,638,146,900
Proportion of landed value (%)	46	54
Average price $/lb.	2.11	0.87
Top 3 species landed by weight	Dungeness crab Sockeye salmon Albacore tuna	Pacific hake Pink salmon Pacific halibut
Top 3 species landed by value	Dungeness crab Spot Prawn Sockeye salmon	Sablefish Pacific halibut Sockeye salmon
Licensed and active vessels (#)	2,005	438
Average vessel length (m)	11.25	18.49
Median vessel length (m)	10.97	18.72
Fuel consumption (L/t landed)	35.94	10.45
Fuel consumption ($/$100,000 landed)	937	676
Crew (#) both part- and full-time	4,855	1,773
Fishers employed per $100,000 landed value (#)	0.35	0.11
Type of ownership (%)	Individual - 52 Company - 36 Community - 12	Individual - 15 Company - 84 Community - 0
Ownership in Greater Vancouver (%)	36	53

5 Discussion

All of the methods explored in this contribution require large swaths of quantitative data. Each approach focuses on different features of fisheries in order to distinguish between SSF and LSF. However, when the results of the three methods are compared, they capture many of the same fisheries under the small-scale designation (Figure 3). Using these methods, all aboriginal commercial fisheries, salmon gillnetters, trollers as well as shellfish fisheries operating in BC are classified as small-scale. Surprisingly, the deeper water fisheries such as halibut, sablefish and other ground fishes are not considered large under all three methods. It should be noted that there is inherent uncertainty associated with data. However, the uncertainty of data sets is not quantitatively assessed for this analysis and would be conducted in future work.

The cumulative percent distribution is founded on the assumption that a small vessel catches small amounts of fish relative to large vessels (Ruttan et al., 2000). This exposes this method to debate, as fisheries that land high value species or a high quantity due to a large number of active vessels may appear to be large scale on the cumulative distribution. When the fisheries combinations are distributed based on cumulative proportion of landed weight, the majority of fisheries combinations for BC's fisheries fall into the SSF category (Figure 2). This is not necessarily an accurate depiction of SSF and LSF in BC. In using this distinction, salmon seiners up to 65', which catch enormous quantities of fish, and sablefish vessels up to 100', which travel far offshore to target this deep-water species would typically be considered large-scale. The cumulative percent distribution can also be carried out using landed value to split the fishery. In BC, the most obvious concern with splitting the fishery based on landed value is that fisheries like geoduck and crab which are highly selective, occur on small boats and don't travel far to fishing grounds are classified as LSF.

The vessel-length split method effectively captures the anticipated features of SSF such as low landed weight, high value, many jobs and more diverse ownership type and location (Appendix B). But, this method doesn't resolve the issue of the small boat, high value fisheries. For example, the landed weight of SSF using a vessel length division captures all of the small vessels

participating in the prawn and crab trap fisheries, along with the dive fisheries for geoduck, urchin and sea cucumber. For example, the geoduck fishery has the highest estimated replacement cost for licence and vessel, which is a feature of LSF but all vessels participating are less than 45' (13.7 m) in overall length, which is a feature of SSF (Nelson, 2011). Implementing Atlantic Canada's fleet separation and owner-operator policies on the West coast of Canada would allow for up to 76% of the landed value to be caught by owner-operators (Appendix B). Many of these owner-operators live along the entire coast of BC and aren't concentrated in Vancouver. Using this method to distinguish between SSF and LSF is a novel approach as it's the current approach used on the Atlantic coast of Canada and United Fishermen and Allied Workers Union (UFAWU) are pursuing it (UFAWU-UNIFOR, 2015; UFAWU-UNIFOR, 2016). This could potentially have incredible social and economic impacts on the industry, especially in the case of aboriginal licensed fisheries and smaller coastal communities.

The point-based framework is a way to include many features of a fishery in decision-making (García-Flórez et al., 2008). This method captures a number of physical vessel features along with more economic features such as crew and replacement costs of the enterprise. However, it is a relatively complicated method of making this distinction and requires a lot of data for each fishery. One concern with this method is that it considers a target fishery as a whole and uses the average of the fishery to determine its corresponding score for the feature. The other methods consider factions of each target fishery according to vessel length. Having factions of target fisheries being included in both SSF and LSF is a more accurate depiction of scale in fisheries. Each target fishery is too broad to lump the entire fishery into small and large categories. The point-based framework is also useful as it considers many socio-economic indicators as part of the assessment as opposed to after as with the other two methods. Unfortunately, this method requires large amounts of data, which aren't available for each fishery, making it hard to evaluate all commercial fisheries on the BC coast. For example, the herring fisheries operate with party-based licenses and fishers will often stack their licenses an quota onto a single boat. This makes it difficult to find information about active vessels and the number of people working on these boats. DFO was not able to provide this information in the

catch statistic request for this analysis. There was also no financial information provided in the Pacific Fleet Financial Profiles (GSGislason and Associates Ltd., 2011; Nelson, 2011).

There is still an element of arbitrary designation in each of these approaches. The cumulative percent distribution has assumed that under 50% of the cumulative distribution of landed value is SSF, vessel length split assumes less than 65 feet to be SSF and the point-based framework assumes less than or equal to 24 points is SSF. There is also limited data, especially in the case of party-based licences for ownership information. The party-based licenses include herring, rockfish and some dive fisheries. Herring fisheries have important implications for the economy and coastal Indigenous communities. Vessel data from these fisheries is therefore not included in the socio-economic analysis of this research. In terms of socio-economic data, there are limited accounts of fixed and variable costs for various fleets.

Even with methodological and data shortcomings these results support past studies of the fishing industry in British Columbia (O'Donnell et al., 2013; Robertson et al., 2015). The majority of the small-scale sector's ownership is located outside of Greater Vancouver (Table 5), which has important economic and social implications. Areas outside of Greater Vancouver like the Pacific North Coast Integrated Management Area experiences higher unemployment rates than the provincial average (SECOA, 2012; Hotte & Sumaila, 2013). The small-scale fishing sector supports primary and secondary employment, distribution of value throughout other economic sectors as well as cultural and community values in more rural areas of the province (O'Donnell et al., 2013; Robertson et al., 2015). The fisheries within the small-scale sector land less, command a higher average price per pound landed and can employ more people (Table 5). These features of the small-scale sector highlight their economic and social importance and the need for their own policy consideration.

6 Conclusions

Canada currently has no nation-wide working definition of SSF, but Atlantic Canadian fisheries have an inshore sector, which is virtually an equivalent to a small-scale sector. These fisheries were determined to have a social and economic importance to coastal communities in Atlantic Canada through the AFPR, and a special designation was made for them. To date, no such policy review has been executed for Canada's Pacific fishing fleet. This does not mean that BC's fisheries policies are perfect or that a small-scale fishing sector does not exist in BC.

In the last four decades, BC has experienced the fleet being reduced by 60% and fishermen numbers reduced by 70% (Robertson et al., 2015). Even with this reduction, there is still a small-scale sector present in the province and there is desire for owner-operator policies (UFAWU-UNIFOR, 2015; UFAWU-UNIFOR, 2016; Gibson & Sumaila, 2017). However, it is unclear why there has not been a similar or the same policy in place for the Pacific fishery. There is no evidence that a similar policy has been explored by DFO for the Pacific region. This may be due to a lack of collective pressure from fishers and/or political pressure from certain stakeholders against such a policy. However, with the closure of the Canfisco's Prince Rupert cannery in November 2015, members of the UFAWU released letters[8] to both Prince Rupert Businesses and the former Fisheries Minister Hunter Tootoo, requesting the application of Atlantic Canada's fleet separation and owner-operator policies to the Pacific fleet (UFAWU-UNIFOR, 2015; UFAWU-UNIFOR, 2016). These requests have not amounted to any policy reform at this point in time but they demonstrate stakeholder interest in policies to protect BC owner-operators.

There is a lot of room for owner-operator and independent fisher policy discussion in BC. However, in doing so, it is important to consider the performance of Atlantic Canada's PIIFCAF, which intends to have an independent owner-operator sector of the fishery. For many years

[8] Northern View 'Fishermen's union takes fights to Minister Tootoo, story and video' http://www.thenorthernview.com/news/366202161.html (Accessed 14 October 2017).

this was not the case and there were loopholes for corporations through Controlling Agreements. There Controlling Agreements allowed for 'an outsider' to influence licence transfer. While there was an overarching concern for the loss of independent control of the resource in smaller communities, the Controlling Agreements allowed for some fishers to stay active in the fishery through financial aide[9] (Anon., 2012; Barnett & Eakin, 2015; Barnett et al., 2016). Major concerns with Controlling Agreements are finally been addressed by DFO. They have been notifying fishers holding independent licenses as fronts for processors to forfeit their licenses across the Atlantic region[10].

A further concern with PIIFCAF, is the exclusion of ITQ fisheries (Barnett et al., 2016). This is regrettable, as ITQ fisheries generally perceived to have the highest numbers of so-called "armchair fishers" and BC has a number of important fisheries that are managed with ITQs (Robertson et al., 2015). Many fisher organizations from Atlantic Canada have expressed the view that they do not want to see their licence and quota in the hands of non-fishers as it could have negative impacts on the interests of coastal communities and their fishers (Anon., 2012). The Pacific fisheries are experiencing similar corporate consolidation and vertical integration to those that the Atlantic experienced and no regulations have been put in place to ensure a reserve of owner-operator vessels in the fishery (Haas et al., 2016).

We would recommend our definition of SSF in BC, which is determined by an overlap of three separate approaches. These results are an excellent start to understanding what small-scale fishing may look like in BC and how we could justify a fleet separation and owner-operator policy such as the PIIFCAF regulation. Fisheries policy reform for BC fisheries would require careful language and enforcement to prevent loopholes prior to implementation.

[9] CBC 'Legal challenge threatening autonomy of inshore fishery opens today' http://www.cbc.ca/news/canada/nova-scotia/inshore-fishery-atlantic-canada-autonomy-1.3999275 (Accessed 14 October 2017).
[10] CBC 'DFO cracks down of fishing licences it says are fronts for corporations' http://www.cbc.ca/news/canada/nova-scotia/dfo-fishing-licence-crackdown-1.4303419 (Accessed 14 October 2017).

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Appendix A

Socio-economic features for SSF and LSF using the cumulative percent distribution

	SSF	***LSF***
Landings (t)	550,408	647,251
Proportion of catch (%)	46	54
Landed value ($)	2,628,469,981	420,004,137
Proportion of landed value (%)	86	14
Average price $/lb.	2.17	0.29
Top 3 species landed by weight	Dungeness crab	Pacific hake
	Sockeye salmon	Pink salmon
	Chum salmon	Arrowtooth flounder
Top 3 species landed by value	Pacific halibut	Pacific hake
	Dungeness crab	Sockeye salmon
	Prawn	Yellowtail rockfish
Licensed and active vessels (#)	2,336	107
Average vessel length (m)	11.34	24.73
Median vessel length (m)	11	22.81
Fuel consumption (L/t landed)	27.56	7.53
Fuel consumption ($/$100,000 landed)	696	1,392
Crew (#) both part- and full-time	6,306	445
Fishers employed per $100,000 landed value (#)	0.24	0.11
Type of ownership (%)	Individual - 49	Individual - 7
	Community - 18	Community - 0
	Company - 33	Company - 93
Ownership in Greater Vancouver (%)	37	70

Appendix B

Socio-economic features for SSF and LSF using the vessel length split.

	SSF	***LSF***
Landings (t)	496,852	686,703
Proportion of catch (%)	42	58
Landed value ($)	2,324,705,282	716,322,975
Proportion of landed value (%)	76	24
Average price $/lb.	2.12	0.47
Top 3 species landed by weight	Dungeness crab	Pacific hake
	Sockeye salmon	Pink salmon
	Chum salmon	Arrowtooth flounder
Top 3 species landed by value	Dungeness crab	Sablefish
	Pacific halibut	Pacific hake
	Prawn	Pacific halibut
Licensed and active vessels (#)	2,293	150
Average vessel length (m)	11.58	24.22
Median vessel length (m)	11.25	22.76
Fuel consumption (L/t landed)	30.13	7.39
Fuel consumption ($/$100,000 landed)	777	850
Crew (#) both part- and full-time	6,129	615
Fishers employed per $100,000 landed value (#)	0.26	0.09
Type of ownership (%)	Individual - 48	Individual - 6
	Community - 19	Community - 7
	Company - 33	Company - 87
Ownership in Greater Vancouver (%)	37	69

Appendix C

Socio-economic features for SSF and LSF using the point-based framework approach

	SSF	***LSF***
Landings (t)	305,857	877,697
Proportion of catch (%)	26	74
Landed value ($)	1,419,091,843	1,621,936,415
Proportion of landed value (%)	47	53
Average price $/lb.	2.10	0.83
Top 3 species landed by weight	Dungeness crab	Pacific hake
	Albacore tuna	Pink salmon
	Sockeye salmon	Pacific halibut
Top 3 species landed by value	Dungeness crab	Pacific halibut
	Prawn	Geoduck
	Sockeye salmon	Sablefish
Licensed and active vessels (#)	2,012	413
Average vessel length (m)	11.25	18.49
Median vessel length (m)	10.97	18.72
Fuel consumption (L/t landed)	37.27	9.85
Fuel consumption ($/$100,000 landed)	975	640
Crew (#) both part- and full-time	4,869	1,759
Fishers employed per $100,000 landed value (#)	0.34	0.11
Type of ownership (%)	Individual - 56	Individual - 12
	Community - 30	Community - 88
	Company - 14	Company - 0
Ownership in Greater Vancouver (%)	35	53