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A Descriptive Characterization of the Norwegian Purse Seine Fishery

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with summary correlations of major industry variables

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A Descriptive Characterization of the Norwegian Purse Seine Fishery,
with summary correlations of major industry variables*

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Abstract: The purpose of this report is to provide a detailed description of data available from annual cost and earnings surveys collected by the Norwegian Directorate of Fisheries. The cost and earnings surveys are the principal data source characterizing the structure and economics of the Norwegian fishing fleet. Here we focus on the purse seine fleet. The data are set up in a panel framework and provide a detailed economic picture of vessels reporting information on value and quantity of catch by species, inputs used in operation, and characteristics of the vessel. The data set is enriched by linking individual vessels in the profitability survey with information on fishing license holdings and quota size. The survey includes a description of the regulatory structure of the Norwegian purse seine fleet and summary correlations of the major industry variables.

Keywords: Norwegian Purse Seine Fleet, Cost and Earnings Survey, Quota Regulations

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1.0 Introduction

Data are the fundamental building blocks for guiding research and economic policy. Data identifies both market parameters and the behavioral response of economic agents. In support of research and policy analysis, descriptive papers on important data sets are useful. The purpose here is to provide a detailed description of data available from annual cost and earnings surveys collected by the Norwegian Directorate of Fisheries. Norway is an important fishing nation, and the cost and earnings surveys are the principal data source characterizing the structure and economics of the Norwegian fishing fleet.[1] The focus here is the Purse Seine fleet, an important but somewhat understudied segment of the Norwegian fishery.[2] The data are set up in a longitudinal/panel (unbalanced) framework and provide a detailed economic picture of vessels reporting information on value and quantity of catch by species, inputs used in operation, and characteristics of the vessel. The data set is enriched by linking individual vessels in the profitability survey with information on vessel ownership, fishing license holdings and quota size. Combining this information, we are able to provide an overall data picture of the purse seine fleet with changes in the major economic and biological variables describing the fishery.

The next section will describe the origin, purpose and basic design of the profitability survey. This is followed by a description of the regulatory structure used in managing the purse seine fishery and the major policy initiatives and changes. Next, in numerous tables and figures the data describing the fishery are presented. This is followed by some reduced form regression

[1] A number of studies have used the survey data for empirical research see, e.g. Asche et al. (2007), Asche et al. (2009), Bernt et al. (2020), Greaker et al. (2017), Bertheussen et al. (2019), Diekert and Schewder (2017), Ekerhovd and Gordon (2020), Isaksen et al. (2015), Nøstbakken (2012), Sandberg (2006), Zhang et al. (2018).

[2] Data on individual vessels 1994-2019 were made available to us in 2021. Information passed on in this manuscript is not at a level that enables the identification of certain entities or persons.

results of key variables describing the economics of the fishery**.** The final section offers suggestions for future research.

2.0 The Profitability Survey

The Profitability Survey[3] for fishing vessels in Norway has a long history going back to 1950. The surveys in the early years covered all vessels larger than 40 feet, with additional information gathered for trawlers greater than 300 BRT. For the period 1958-76, the Directorate of Fisheries would occasionally conduct profitability surveys for vessels less than 40 feet. From 1977 to 2004, the task of collecting data was assumed by the Budget Committee for the Fish Industry. After 2004, all survey duties are carried out by the Directorate of Fisheries.

For statistical purposes, the population of vessels is defined as 'year-round operated fishing vessels 8 meters and above' with some minimum revenue restrictions. The observation unit is at the vessel level. The population of vessels is identified from a number of Directorate of Fisheries Registers: Fishing Vessel Register, providing an overview of registered fishing vessels with owner; Fishing License and Participant Register, providing an overview of fishing permits linked to fishing vessels and owners; and Landing and Finishing Register, providing an overview of catch quantity and value. For surveys prior to 1997 participation was not compulsory, relying on vessels to voluntarily submit the requested information. To improve data recovery and following methods prepared by Statistics Norway, new selection and methods were introduced for the 1998 survey year. Since 1998, if selected, it is mandatory for purse seine vessels to complete the survey.

[3] See, https://www.fiskeridir.no/Yrkesfiske/Tall-og-analyse/Loennsomhet and https://www.fiskeridirektoratet.no/Yrkesfiske/Tall-og-analyse/Loennsomhet/Om-statistikken-Loennsomhet-fiskeflaaten

Selecting vessels for the survey consists of three steps; stratification, size of sample and trekking. Stratification is a classification of vessels by group, size and geographical location. The sample is top heavy in vessels from the high catch revenue strata. A random draw of vessels is taken from this classification (i.e., ETU trekking). In the period 1998-2008, the sample was set at 750 vessels per year. As of the 2009 survey, the sample had been reduced to about 375 vessels per year.

2.1 Regulatory Structure of the Purse Seine Fleet

The Norwegian purse seine fleet is comprised of vessels using seine or (mid-water) trawl gear harvesting pelagic fish species. Norwegian purse seine vessels larger than 90 feet in length or 1,500 hectoliters of cargo capacity must operate with a purse seine concession[4]. In the early 1970s, licenses were introduced as means to limit entry to the fishery. Licenses were offered to fishermen gratis but non-transferable. In the early years of the merger schemes, the acquired license capacity was assigned in perpetuity but with the introduction of the unit quota system in 1996, acquired quota was restricted to a maximum ownership of 13 years. Prior to the 1996-reform, the size and cargo holding capacity of purse seine vessels are tied to the vessels' license capacity. A vessel holding a license (concession) capacity of say, 5,000 hectoliters (hl) was restricted to a cargo volume no larger than 500 cubic meters. With the introduction of the unit quota system, the vessels' capacity was no longer directly tied to its license holdings and purchases in the vessel market were no longer as encumbered, allowing owners to buy vessels less restricted of size and cargo capacity. However, for the purse seine pelagic trawl fishery, the trawl license capacity remained an upper limit to vessel size, leaving the combined purse seine-pelagic trawl vessels size restricted until a unit quota system was introduced in the pelagic trawl fishery from 2003 onwards.

[4]Here after, the common word 'licence' is used in place of the official 'concession'.

In 2005, with the introduction of the Structural quotas scheme, ownership was extended to 18 years. By regulation, acquired license capacity reaching its expiry date is to be clawed back by the Fisheries Directorate for re-distribution across all participates in the fishery. The license capacity of a vessel is based on historical cargo capacity.[5] Individual vessel quotas (IVQ) where introduced for the capelin fisheries in the late 1970s and for the herring and mackerel fisheries in the 1980s. The blue whiting fishery has been regulated by IVQs since 2006. Licensed vessels are allocated a unit share of the TAC (i.e., a quota unit), this value is multiplied by license capacity and defines the individual vessel quota for a specific fishery (see, Ekerhovd & Gordon (2020, p. 569-70)). A quota unit is set for each fish species covered under a purse seine license.

Various forms of vessel merger schemes are allowed in the purse seine fishery. The basic idea is that a licenced vessel owner can purchase rights from another vessel in the fleet and thus capture the license capacity of the purchased vessel. The purchased vessel must be removed from the fishery. The fishery has seen a 22% decline in the number of licenced purse seine vessels over the period 2001-2020. Currently, there are 74 licenced purse seine vessels in the fleet. In addition, a given percentage of the newly acquired license capacity is clawed back by the Fisheries Directorate for re-distribution across all participants in the fishery.[6] The fish quota clawed back is re-distributed among the remaining vessels according to a vessels' percentage of the sum of total Base quota holdings remaining in the fishery.[7]

[5] Initially measured in hectoliters, later in tonnes, see Årland and Bjørndal 2002.

[6] The claw back is either 5% or 40% depending on county of vessel registration. The largest claw back is when the decommissioned vessel is registered in the counties of Finnmark, Troms, Nordland, Nord-Trøndelag or Sør-Trøndelag and the acquiring vessel registered elsewhere. Over the period 2001-2020, about 6% of the total purchased structural quota has been re-distributed across licenced purse seine vessels.

[7] For example, if a vessel is decommissioned from the fleet and the license is merged and structured on another vessel, the resulting clawback is re-distributed as follows; the sum of the total base quota units in the purse seine fleet are reduced by the clawed back amount, while the base quota holdings of the remaining active vessels remains unchanged except for, of course, the receiving vessels' holdings that increase by the un-clawed amount of the decommissioned license. This means that all individual vessel's share, as a fraction of the fleets' TACs has increased. In sum, the clawback policy, *ceteris paribus* increases individual vessel harvest quota.

Regulations do allow acquired license capacity from a decommissioned vessel to be divided amongst several (purse seine licensed) receiving vessels. The converse is also allowed, where license capacity from a number of decommissioned vessels can be consolidated. However, there is a maximum license capacity limit of 650 tonnes; raised to 850 tonnes in 2015.[8] At the same time, the upper-limit quota for pelagic trawlers was raised from 630 tonnes to 1000 tonnes.

Interestingly, the introduction of unit quotas in 1996 and transformed to structural quotas in 2005 introduced a transferable component to IVQ management in the purse seine fishery.[9] To be clear, unit/structural quota are generated by a licensed purse seine vessel buying the base quota from another licensed purse seine vessel, and that vessel removed from the fishery.[10] As noted, some of this quota is clawed back by the Fisheries Directorate with the purchasing purse seine licensee allowed to transfer the new quota (now defined as unit/structural quota) to own vessel. The transfer is subject to the 850t total vessel quota constraint, and the licensee can sell part (or all) of the quota to other licensed purse seine owners. The actual market for transferable quota is not public information but third-party brokers are used to arrange the price and sale of quota (Hannesson 2017).

Purse seine vessels participating in the blue whiting trawl fishery require a special permit. While most licenses acquired by purse seine concessions regulate vessel harvest through total allowable catch, licenses and individual vessel quotas to limit and regulate catch, the blue whiting fishery was for some time an exception with no strict vessel regulations on harvest (Standal 2005). A TAC has been in place for this fishery since 1994 but Norway, as for many costal nations, set the TAC without adherence to recommendations from the International Council for the

[8] The total license capacity is the sum of the basic license capacity plus acquired unit and structural quota.
[9] Economists argue that transferability allows improved efficiency and profitability in a quota regulated fishery.
[10] The vessel selling the base quota must be removed from the fishery.

Exploration of the Seas (ICES) and catches far exceeded best practice guidelines (Bjørndal 2009). For example, in 2003, catches of blue whiting reached a record high of almost 2.4 million tonnes, whereas the advised ICES catch limit was around 600,000 tonnes. Purse seine vessels operating in the Norwegian blue whiting fishery saw the unrestricted harvest and large TAC as an opportunity to better utilize existing vessel capacity (short run), as well as, an incentive to increase capacity to take advantage of the booming blue whiting stock and resulting revenue gains (long run).[11] Overall, blue whiting trawlers faced fewer limitations and restrictions on expansion than pelagic trawlers prior to 2006 and pure purse seiners operating exclusively in the more tightly regulated purse seine fisheries. In 2006, an agreement amongst EU, Faroe Islands, Iceland, and Norway set TAC and country shares (Bjørndal 2009, Ekerhovd 2010). The Norwegian share of the blue whiting TAC is allocated to licensed vessels based on a simple equal share measure and not a function of licensed capacity.

A third subgroup of licensed purse seiners hold additional permits for pelagic trawling with main target species sandeel, Norway pout, and blue whiting. As standard purse seine vessels and purse seiners with additional blue whiting trawl license had less vessel capacity restrictions imposed on them after 1995, however purse seine vessels with pelagic trawl license, *de* facto, operated under capacity restriction until 2003. The supplementary licensing scheme allows a division of the purse seine fleet into three subgroups: standard purse seiners (PSs), blue whiting trawlers (PSbw), and pelagic trawlers (PSt). The three subgroups will allow a useful focus for describing and reporting the data available.

[11] In most purse seine fisheries, strict vessel and total harvest regulations are enforced, in the blue whiting fishery, purse seine vessels with a trawl license had the opportunity to expand vessel size to take advantage of the unrestricted harvest opportunity.

3.0 Data Description of the Purse Seine Fleet

In this section, a detailed data description of the purse seine fleet will be presented. All financial values are in real terms. Aggregate statistics describing the fleet will be shown followed by more detailed numbers for the three different segments[12] of the fleet. The data are summarized over time periods consistent with regulatory changes affecting the fleet. During the period of study (1994-2019), four changes/modifications to regulations important to merging and acquiring licenses for the purse seine fleet can be identified. Unit quotas were introduced to the fleet in 1996 and extended to the pelagic trawl fishery in 2003. Additional changes were introduced with structural quotas in 2005, which included vessel quotas for the blue whiting fishery from 2006. As well, the changes allowed the possibility of multiple blue whiting licenses per vessel. In 2011, vessels were allowed to combine purse seine, blue whiting license and pelagic trawl license on a single vessel.

For the time periods defined, Table 1 reports summary statistics for some important aggregate economic indicators in the fishery. Average vessel profits (and revenues) increase over the periods falling off somewhat in the last period but showing an impressive 3.9-fold increase. On the other hand, the measure of cost reported shows only a 2.0-fold increase. Clearly, this is a profitable fishery. Landings reported in the table show a strong uptick in the early periods of the data averaging almost 16,000kg per vessel in the 2003-04 period. By the mid-2000s landings have declined but profits are still strong. Over time landings are associated with fewer operating days to harvest the allocated quota.

[12] Standard purse seiners, Blue whiting trawlers, and Pelagic trawlers.

Table 1: Purse Seine: Average Vessel Output Input Statistics, Various Years

	Obs.	Profit[a]	Revenue[b]	Cost[b]	Landings[c]	Days[d]
1994-95	70	7,163.9	19,600	12,500	7,832.8	275.8
1996-02	458	15,859.7	36,000	20,200	13,586.4	276.6
2003-04	139	18,429.6	39,100	20,700	15,975.6	265.9
2005-10	397	23,174.3	47,200	24,000	13,804.0	204.1
2011-13	180	27,961.7	53,400	25,500	10,067.5	167.9
2014-19	341	26,342.2	51,000	24,600	11,349.9	167.3

[a] Real profit, total revenue minus cost expenditures for fuel, ice, crew share, gear & vessel maintenance (,000 NOK).
[b] ,000 NOK
[c] kg.
[d] Operating Days

Table 2 shows profitability and structural characteristics for the three different segments of the fleet. In the early period, a purse seine vessel with blue whiting license was much more profitable than either standard or pelagic trawl purse seine vessels and this ranking is maintained over the periods. Purse seine vessels with blue whiting license are substantially larger compared to other segments of the fleet, but all vessel groups show a doubling in tonnage size (GT), over the data periods. Notice that quota allocations are in favour of blue whiting vessels and show a modest increase over time. Early on, vessels are on average about 30 years old but with new investment over time, average vessel age drops in half.

Crew remuneration and numbers are reported in Table 3. On average total crew salary more than doubled over the periods but crew expenditure as percentage of revenue[13] actually declined from about a 35% share to 30% for standard and industrial trawl vessels, and from a 30% share to 26% for blue whiting vessels. Notice that on average individual crew member salaries doubled over the periods and that the number of crew members per vessel is very stable albeit vessel size has increased substantially (Table 2).

[13] Crew share as a percentage of revenue, is negotiated by the fishermen's union.

Table 2: Purse Seine: Average Vessel Structural Statistics, Various Years

	Profit[a]	GT[b]	LT[c]	Quota[d]	Age[e]
1994-95					
PSs[f]	5,650.3	601.7	49.3	365.7	32.4
PSt[g]	4,429.1	406.2	41.9	279.4	28.1
PSbw[h]	10,328.1	1,042.3	60.5	447.7	30.8
1996-02					
PSs	12,627.5	794.1	52.6	383.1	30.1
PSt	9,853.7	486.8	43.7	304.9	21.9
PSbw	20,484.5	1,585.3	65.8	463.7	15.3
2003-04					
PSs	12,791.5	1,036.9	56.1	390.0	22.9
PSt	9,306.3	721.2	48.4	330.6	13.3
PSbw	23,791.1	1,757.0	67.5	459.1	10.6
2005-10					
PSs	15,370.1	1,066.5	56.6	390.1	21.8
PSt	16,861.5	1,034.7	55.4	347.6	13.0
PSbw	28,461.1	1,923.2	68.5	461.9	10.7
2011-13					
PSs	19,416.5	1,065.1	55.8	386.3	24.0
PSt	24,328.1	1,541.6	62.4	370.0	13.1
PSbw	32,827.7	1,968.2	68.9	460.9	13.8
2014-19					
PSs	16,197.8	1,182.2	58.1	389.7	23.9
PSt	25,671.9	1,572.0	62.5	351.7	12.2
PSbw	32,353.5	2,256.9	70.3	458.1	13.8

[a] Real profit, total revenue minus cost expenditures for fuel, ice, crew share, gear & vessel maintenance (,000 NOK).
[b] Gross tonnage
[c] Total length in feet
[d] Base Quota (tonnes)
[e] Age of vessel
[f] Purse Seine, Standard, [g] Pelagic Trawl, [h] Blue Whiting

Table 4 provides a summary of inputs used in harvest for the different categories of purse seine vessels. Inputs are separated into three categories, Fuel, Inputs and Other, where Fuel is by far the largest single input expenditure after crew. We observe a doubling of fuel costs over time for all vessel categories. The category Inputs includes the cost of ice, salt, and gear and vessel maintenance. This group shows a modest increase over time for standard and pelagic trawl vessels and a somewhat larger increase in costs for the blue whiting group. All remaining costs are grouped in the Other category and includes all additional operating expenditures (e.g., social costs, product

fee, food, insurance, etc.) not directly related to harvest but must be covered by revenue generated. Here we observe substantial increase in these supplementary costs over time and for all vessel groups.

Table 3: Purse Seine: Crew Share, Various Years

Purse Seine		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Crew Exp[d]	5,834.7	5,101.5	7,564.1
	Member[e]	604.8	657.5	767.5
	%Revenue[f]	34.9	35.3	30.1
	Crew[g]	9.7	7.9	10.0
1996-02				
	Crew Exp	9,191.8	7,344.3	12,913.5
	Member	954.7	890.3	1,284.6
	%Revenue	32.3	31.8	28.3
	Crew	9.7	8.5	10.2
2003-04				
	Crew Exp	8,302.1	6,193.1	13,079.4
	Member	841.8	757.8	1,326.6
	%Revenue	31.7	30.6	26.3
	Crew	9.9	8.5	10.0
2005-10				
	Crew Exp	10,206.7	10,375.8	15,005.6
	Member	1,099.7	1,226.5	1,545.8
	%Revenue	31.1	29.7	26.6
	Crew	9.4	8.6	9.7
2011-2013				
	Crew Exp	11,328.3	13,374.9	16,108.7
	Member	1,222.5	1,496.8	1,616.7
	%Revenue	29.7	28.8	26.4
	Crew	9.4	9.0	10.1
2014-2019				
	Crew Exp	9,438.3	13,408.9	16,148.9
	Member	1,027.5	1,588.6	1,705.3
	%Revenue	30.4	28.3	26.5
	Crew	9.3	8.5	9.5

[a] Purse Seine, Standard, [b] Pelagic Trawl, [c] Blue Whiting
[d] Per Vessel Crew Expenditure ,000NOK
[e] Average Expenditure per Worker ,000NOK
[f] Average Crew share as % of Vessel Revenue
[g] Average crew members per vessel

Table 4: Purse Seine: Average Inputs Statistics, Various Years

	PSs[a]	PSt[b]	PSbw[c]
1994-95			
Fuel[d]	1,278.9	1,033.0	2,374.1
Inputs[e]	4,117.5	4,071.2	4,070.2
Other[f]	2,052.9	1,357.0	2,942.7
1996-02			
Fuel	1,864.9	1,584.7	4,413.4
Inputs	5,178.7	4,526.2	8,305.6
Other	3,176.8	2,288.4	4,784.7
2003-04			
Fuel	2,044.5	2,311.8	6,264.7
Inputs	3,725.8	2,999.5	7,358.9
Other	3,980.7	2,896.9	5,857.6
2005-10			
Fuel	3,229.0	4,264.6	6,519.2
Inputs	4,423.8	4,714.2	6,634.0
Other	4,380.5	4,202.8	6,791.8
2011-13			
Fuel	3,174.5	5,408.1	6,016.3
Inputs	4,703.7	5,896.5	6,567.4
Other	4,917.7	6,768.7	8,036.9
2014-19			
Fuel	2,591.8	5,230.8	5,924.5
Inputs	3,865.6	7,173.4	7,139.3
Other	5,373.3	7,321.1	8,654.3

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting
[d] Fuel expenditure ,000NOK
[e] Input expenditures include, ice, salt, gear maintenance, vessel maintenance ,000NOK
[f] Other expenditures Product fee, Control fee, Food, Pension, Insurance, other ,000NOK.

In the purse seine fishery, the main technical advantage in recent years is the ability of vessels to refrigerate landings soon after harvest. This allows for improved quality of catch and thus higher prices and provides some additional flexibility allowing the vessel to stay longer on the fishing grounds without losing quality of the refrigerated catch. Unfortunately, the profitability survey does not contain information on carrying capacity other than gross tonnage and vessel

length, however, information is available from 'Illustrert Norsk skipliste'[14], which reports refrigerated sea water capacity of purse seine vessels for the period 1993 to 2019. These values are reported in Table 5 and shows a strong positive trend over the period. This is a particularly useful variable and can be considered a proxy for technical change in the purse seine fleet and perhaps one of the main drivers of price and profit in the fishery.

Table 5: Average Refrigerated Sea Water Capacity Purse Seine Vessels, 1993-2019

Year	Obs.[a]	Refrigerated Capacity[b]	Year	Obs.	Refrigerated Capacity
1993	97	570.6	2007	82	1,326.0
1994	95	598.0	2008	82	1,314.5
1995	99	614.9	2009	80	1,332.6
1996	100	630.9	2010	80	1,316.4
1997	101	647.7	2011	80	1,314.8
1998	101	695.0	2012	81	1,371.9
1999	101	722.7	2013	77	1,451.3
2000	98	827.3	2014	76	1,473.5
2001	99	878.1	2015	74	1,631.1
2002	95	974.4	2016	71	1,611.3
2003	89	1015.9	2017	72	1,616.6
2004	87	1,101.6	2018	67	1,621.0
2005	86	1,292.2	2019	66	1,650.7
2006	85	1,291.3			

[a] Observations
[b] Cubic meters

For the different time periods evaluated, Table 6 offers interesting information on changes in Base and Structural quota allocation. Notice, Base quota allocations to vessels in the purse seine fleet increases somewhat over the periods. This is to be expected as claw back and redistribution occurs overtime. For Unit quota, although active since 1996, data on actual allocations are only available for the 2001-05 period. This is an important variable and represents the start of transferable quota separate from the physical vessel. Unit quota was transformed to Structural

[14] Illustrert Norsk skipliste, del 2. (1984-2014), Krohn Johansen Forlag AS, Larvik, Norway

quota in 2006 and shows an increase in tonnage over the last three periods. For the total purse seine fleet, the share of Structural quota relative to Base quota increased from 10.3% to 24.1% over the period 2012-2020.

Table 6: Purse Seine: Ownership Various Years

	Base Quota	Unit Quota	Structural Quota
1994-95	383.9[a]	-	-
1996-02	411.2	17.2[b]	-
2003-04	421.4	66.8	-
2005-10	427.7	-	74.3[c]
2011-13	428.8	-	97.9
2014-19	423.6	-	116.1

[a] Average sample Base quota (t)
[b] Average sample Unit quota (t)
[c] Average sample Structural quota (t)

Figure 1 shows fish stocks development for six major species over the period 1994-2019, harvested by the purse seine fleet. All stocks, except sandeel show a positive trend over the period but with substantial fluctuations in levels. Spring spawning herring and mackerel show the strongest sustained growth, whereas blue whiting stock triples in size during the mid-nineties and early 2000s but all gains are lost by the end of the 2000s. The stocks of sandeel are virtually flat over the full period.

Tables 7a-7g list average vessel statistics for revenue, landings, and price (real) for each fish species harvested by the different segments of the purse seine fleet for the different time periods studied. For spring spawning herring (Table 7a), we do observe an increase in landings over the first four time periods but falling off considerably in the last period. What is interesting is that price has more than doubled over the periods and revenue has more than tripled in value up to 2013 but declining in the last period. The story is somewhat different for North Sea herring (Table 7b) and Mackerel (Table 7c) where average landings have steadily declined up to and

including the 2013 period, but price and revenue both showing strong gains. Landings have improved for both species in the last period.

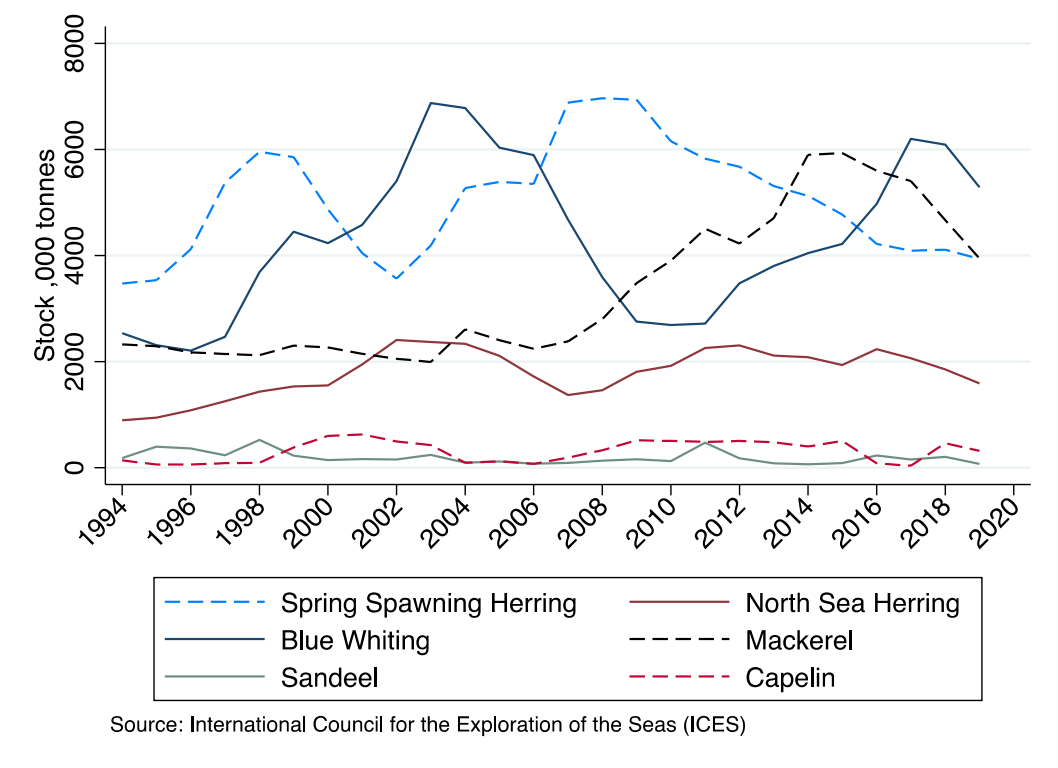

Figure 1: Stock Abundance of the six Major Purse Seine Fish Species, 1994-2019

Table 7a: Spring Spawning Herring; Average Revenue, Landings and Price

		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Revenue[d]	5,181.1	3,457.4	6,425.3
	Landings[e]	2,206.2	1,767.8	2,757.6
	Price[f]	2.33	1.97	2.35
1996-02				
	Revenue	10,546.52	8,177.7	13,196.8
	Landings	3,486.4	2,639.7	3,913.1
	Price	3.27	3.44	3.64
2003-04				
	Revenue	9,688.1	7,073.4	12,364.4
	Landings	2,348.0	1,717.1	2,752.9
	Price	4.06	4.06	4.44
2005-10				
	Revenue	15,691.7	15,193.0	21,357.6
	Landings	4,162.5	4,295.2	5,748.4
	Price	3.93	3.73	3.84
2011-13				
	Revenue	14,791.9	15,801.1	21,964.3
	Landings	2,394.6	2,594.9	3,428.7
	Price	6.13	6.07	6.33
2014-19				
	Revenue	7,222.0	8,029.9	10,700.3
	Landings	1,438.4	1,531.1	2,091.9
	Price	5.4	5.7	5.7

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting
[d] ,000NOK
[e] tonnes
[f] NOK/kg

Table 7b: North Sea Herring; Average Revenue, Landings and Price

		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Revenue	2,485.7	1,424.4	3,486.3
	Landings	1,126.1	792.9	1512.8
	Price	2.20	1.65	2.30
1996-02				
	Revenue	2,037.1	1,240.2	2,679.9
	Landings	593.4	371.2	779.8
	Price	3.47	3.25	3.54
2003-04				
	Revenue	2,743.3	1,977.3	3,426.0
	Landings	1,061.8	775.7	1,274.9
	Price	2.57	2.55	2.63
2005-10				
	Revenue	3,013.1	2,249.1	3,575.6
	Landings	847.9	627.1	966.4
	Price	3.69	3.75	3.89
2011-2013				
	Revenue	4,049.9	3,939.5	6,119.5
	Landings	857.6	820.9	1,193.1
	Price	4.97	5.02	5.43
2014-19				
	Revenue	5,147.1	5,988.9	7,996.9
	Landings	1,179.2	1,388.4	1,749.9
	Price	4.34	4.39	4.61

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting

Table 7c: Mackerel; Average Revenue, Landings and Price

		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Revenue	7,391.3	6,282.6	9,266.0
	Landings	1,640.4	1,470.0	2,080.1
	Price	4.61	4.39	4.56
1996-02				
	Revenue	10,460.9	8,205.8	12,814.6
	Landings	1,112.9	871.9	1,375.0
	Price	9.48	9.46	9.35
2003-04				
	Revenue	11,421.3	8,243.8	13,675.2
	Landings	1,187.9	872.6	1,415.2
	Price	9.65	9.47	9.70
2005-10				
	Revenue	10,468.2	10,131.1	14,868.5
	Landings	972.4	986.6	1,394.9
	Price	11.1	10.83	11.19
2011-13				
	Revenue	13,758.3	13,019.9	19,900.3
	Landings	1,288.3	1,183.3	1,832.4
	Price	10.46	10.68	10.68
2014-19				
	Revenue	16,512.2	19,316.9	24,185.8
	Landings	1,595.1	1,944.4	2,356.6
	Price	10.67	10.28	10.72

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting

Blue whiting statistics reported in Table 7d, show that blue whiting purse seine vessels are the major harvesters of this species with industrial trawl vessels reporting a more modest fishery. Blue whiting licensed purse seine vessels show increased landings for the first three periods but then very serious declines in catch in both the 2005-10 and 2011-13 periods. In fact, landings in the 2005-10 period where only 47% from the previous period with a further decline in the 2011-2013 period. This is consistent with the decline in blue whiting stock levels shown in Figure 1. Notice that with the decline in catch levels prices

have increased but revenue has shown serious losses. The final period 2014-19 shows improved landings and revenue.

Table 7d: Blue Whiting; Average Revenue, Landings and Price

		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Revenue	-	-	6,241.7
	Landings	-	-	7,068.6
	Price	-	-	0.87
1996-02				
	Revenue	-	1,426.4	11,269.1
	Landings	-	1,295.5	11,438.5
	Price	-	0.78	0.99
2003-04				
	Revenue	-	2,303.9	16,548.1
	Landings	-	2,341.6	16,108.6
	Price	-	0.76	1.00
2005-10				
	Revenue	-	3,886.9	10,247.3
	Landings	-	2,732.1	7,579.0
	Price	-	1.25	1.45
2011-2013				
	Revenue	-	1,887.4	5,404.5
	Landings	-	808.9	2,263.7
	Price	-	2.23	2.44
2014-19				
	Revenue	-	6,607.0	13,885.7
	Landings	-	3,603.6	7,299.5
	Price	-	1.85	1.94

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting

The Capelin fishery reported in Table 7e stands out showing strong growth through to the mid 2000s in landings for all segments of the fleet. And what is more, both prices and revenue show substantial gains. This fishery suffered serious decline in revenue and landings in the last period of the data. Sandeel (Table 7f) is landed only by purse seine industrial trawl and shows a serious collapse in revenue and landings in the 2003-04 period but recovering very well in the last period. Interestingly, with declining

landings prices have increased over time resulting in a strong revenue outcome. Finally, to complete the review, other fish species taken by the purse seine fleet are reported in Table 7g. Here we observe relatively small quantities landed over the periods, but this fishery does allow for a steady, albeit minor, revenue flow.

Table 7e: Caplin; Average Revenue, Landings and Price

		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Revenue	859.6	505.4	998.1
	Landings	1,144.4	809.4	1,256.3
	Price	0.75	0.62	0.92
1996-02				
	Revenue	3,696.5	2,925.6	4,810.2
	Landings	2,291.4	1,723.9	3,526.6
	Price	1.87	1.84	1.49
2003-04				
	Revenue	2,795.1	1,429.2	3,014.9
	Landings	2,037.6	1,180.6	2,350.3
	Price	1.34	1.18	1.26
2005-10				
	Revenue	2,993.6	2,508.2	3,556.0
	Landings	1,221.7	1,328.7	1,720.5
	Price	2.44	1.84	2.03
2011-13				
	Revenue	4,502.4	4,049.2	7,296.5
	Landings	2,008.2	1,823.3	3,347.3
	Price	2.20	2.24	2.19
2014-19				
	Revenue	2,359.1	2,863.5	3,423.7
	Landings	816.8	1,049.9	1,182.1
	Price	2.15	2.32	2.52

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting

Table 7f: Sandeel; Average Revenue, Landings and Price

		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Revenue	-	3,635.3	-
	Landings	-	3,656.8	-
	Price	-	1.00	-
1996-02				
	Revenue	-	3,690.6	-
	Landings	-	3,474.1	-
	Price	-	1.02	-
2003-04				
	Revenue	-	849.8	-
	Landings	-	759.6	-
	Price	-	1.11	-
2005-10				
	Revenue	-	2,493.1	-
	Landings	-	1,545.6	-
	Price	-	1.58	-
2011-13				
	Revenue	-	3,760.1	-
	Landings	-	1,799.4	-
	Price	-	2.16	-
2014-19				
	Revenue	-	6,243.7	-
	Landings	-	3,128.3	-
	Price	-	2.06	-

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting

Table 7g: Other; Average Revenue, Landings and Price

		PSs[a]	PSt[b]	PSbw[c]
1994-95				
	Revenue	1,663.0	660.2	3,219.4
	Landings	711.8	289.8	1,825.9
	Price	3.37	2.01	1.98
1996-02				
	Revenue	1,845.9	809.0	2,064.8
	Landings	501.7	236.1	726.5
	Price	3.88	3.04	3.09
2003-04				
	Revenue	1,246.6	939.7	1,362.4
	Landings	370.9	328.7	433.4
	Price	2.71	2.63	2.95
2005-10				
	Revenue	2,321.5	2,252.9	2,786.3
	Landings	561.6	570.6	640.7
	Price	3.96	3.73	4.44
2011-13				
	Revenue	2,949.0	2,124.6	2,088.9
	Landings	547.7	505.1	370.2
	Price	4.39	4.85	6.06
2014-19				
	Revenue	739.3	2,434.9	1,301.1
	Landings	191.1	736.5	335.5
	Price	2.26	3.27	3.39

[a] Purse Seine, Standard
[b] Purse Seine, Pelagic Trawl
[c] Purse Seine, Blue Whiting

4.0 Some Reduced Form Statistics

For the purse seine fleet, the data set available is extensive and important for economists studying the structure and operations of the fishery. The purpose is to provide a strong economic framework for proper policy analysis allowing for both financial and biological sustainability. This section provides some basic reduced form regression results that are useful in showing statistical correlation for some main economic variables and important industry drivers.[15] Using regression statistics allows recovery of standardized beta coefficients that are useful to compare and rank the importance of explanatory variables explaining variation in the dependent variable.

The first exercise is to investigate real vessel profit (π) regressed on a number of important exogenous factors in the fishery; aggregate fish price index (*P*), aggregate fish stock index (*Stock*), vessel size measured by gross tonnage (*Vessel*), and dummy variables to sort out the introduction of transferable quota (*Transq*), and the three vessel categories purse seine standard (PSs), pelagic trawl (PSt) and blue whiting (PSbw) with standard purse seine as the base group. A Cobb-Douglas aggregator function weighted using harvest shares, defines the price index. The aggregate stock index is a geometric mean over individual stock levels defined in Figure 1. The transferable quota index is a dummy variable defined as one after the introduction of unit quotas in 1996. Results are reported in Equation (1).

$$\pi = -13427.7 + \underset{[0.323]}{2523.2 * P} + \underset{[0.119]}{5.86 * Stock} + \underset{[0.299]}{4.86 * Vessel} + \underset{[0.035]}{1946.0 * Transq} \quad (1)$$

$$+4331.1 * PSt + 10762.9 * PSbw$$

$$R - square = 0.535, Obs. = 1{,}585,\ F(5{,}1578) = 345.1$$
$$All\ individual\ p - values < 0.01,\ \ Standardized\ Beta\ coefficients\ in\ squarebrackets$$

[15] Such regressions have no causal interpretation.

The dummy variables for vessel category show the changes in profitability for the different vessels consistent with data reported in Table 2. A blue whiting licenced vessel is more profitable than a trawl licenced vessel and both more profitable compared to a standard purse seine. The remaining variables are correctly signed showing a positive and statistically significant effect on profitability. Regression coefficients do not allow for direct comparison as units of measurement differ. However, a simple standardization where each regression coefficient is transformed by the ratio of its standard error to the standard error the dependent variable generates so-called Beta coefficients that allow direct comparison. From these results, price, vessel size and stock seem to be the important drivers of profitability in rank order. The transferability of quota as measured by the *Transq* variable is positive but considerably less important as a predictor of profitability.

Interestingly, Table 1 shows a 40% decline in days at sea over the period of study yet average landings were maintained at around 12 thousand kg. This is likely explained by the very large increase in size of vessels, gross tonnage and vessel length, in the purse seine fleet over this period A simple regression model can separate out the statistical importance of individual drivers impacting days at sea *Days*. In this regression, we define the explanatory regressors as the index of vessel size (*Vessel*), the level of base quota for each vessel (*Quota*), stock size (*Stock*) and control for the three vessel categories. Results reported in Equation (2).

$$Days = 247.5 - \underset{[-0.356]}{0.033} * Vessel + \underset{[0.097]}{0.101} * Quota - \underset{[-0.142]}{0.039} * Stock \quad (2)$$
$$+29.3 * PSt + 54.8 * PSbw$$

$R - square = 0.142,\ Obs. = 1{,}585, F(5{,}1579) = 51.15$
$All\ individual\ p - values < 0.01,\ \ Standardized\ Beta\ coefficients\ in\ squarebrackets$

In this equation, all variables are statistically important with both vessel size and stock level predicting a negative response to days at sea. On the other hand, the size of base quota has a

positive effect. Notice that both blue whiting and trawl licensed vessels spend more time at sea compared to standard purse seine. The standardized best coefficients show a strong ranking of vessel size on profits followed by stock size and a relatively weak impact of base quota on profits. This equation has the potential for building an instrumental variable for fishing effort that could be used as a regressor in production function modeling.

Refrigerated sea water data are available but not included in the profitability survey, however, data have been recovered for the purse seine fleet for the period 1993-2014 and a simple regression model adds some insight into the importance of aggregate effects predicting refrigerated sea water capacity. For this model refrigerated sea water (*RSW*) is regressed against size of vessel (*Vessel*), aggregate price index (*P*) and a dummy variable defining the introduction of transferable quota (*Transq*). The results reported in Equation (3).

$$RSW = -120.2 + \underset{[0.777]}{0.684} * Vessel + \underset{[0.079]}{42.65} * P + \underset{[0.067]}{112.15} * Transq \qquad (3)$$

$R - square = 0.677, Obs. = 1{,}585,\ F(5{,}1966) = 673.2$
$All\ individual\ p - values < 0.00, \qquad Standardized\ Beta\ coefficient\ in\ squarebrackets$

The equation indicates that almost 70% of the variation in refrigerated sea water can be explained by the right-hand-side regressors. This is picking up the trend in vessel size and sea water capacity. Here again we see all regressors positive and statistically significant. The standardized Beta coefficients show convincingly that size of vessel is the main driver in predicting refrigerated sea water capacity. This equation is particularly important for starting a serious investigation into the importance of technical change affecting price and profitability in the purse seine fleet.

5.0 Future Research

The reduced form equations reported in the previous section lead naturally to important research topics based on the data sets described. The first issue of interest is to properly model the multi-output multi-input characteristics of the fishery. This requires a structural model of the fishery with careful identification of the importance of output prices, quota regulations and changes in stocks (Gordon 2013). This can be extended to an examination of output/input changes in efficiency, using perhaps Stochastic frontier modeling, to predict the importance of fishery regulation causing changes in efficiency and supporting/increasing profit levels.

Fishing effort is an important predictor in standard Gordon-Shafer models but suffers from endogeneity problems that make statistically consistent estimates impossible to recover. The problem is that fishers can decide of the level of fishing effort as a function of prices or stock level and thus correlated with the endogenous variable of interest, say harvest or profitability. The fact that fishing effort is a choice variable is the cause of the correlation and inconsistency in estimates. Equation (2) offers the potential of building an instrumental variable to overcome the inconsistency problem. The challenge here is to find exogenous variation that allows for identifying changes in fishing effort from changes in harvest/stock level.

Finally, a very important question in fisheries is the role of technical change in impacting efficiency and profitability (Squires and Vestergaard 2013 and Gordon and Hannesson 2015). Equation (3) hints at the importance of vessel size and variations in stock impacting a proxy for technical change but the interesting question is the role of technical change in reducing risk and improving profitability.

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The purpose of this report is to provide a detailed description of data available from annual cost and earnings surveys collected by the Norwegian Directorate of Fisheries. The cost and earnings surveys are the principal data source characterizing the structure and economics of the Norwegian fishing fleet. Here we focus on the purse seine fleet. The data are set up in a panel framework and provide a detailed economic picture of vessels reporting information on value and quantity of catch by species, inputs used in operation, and characteristics of the vessel. The data set is enriched by linking individual vessels in the profitability survey with information on fishing license holdings and quota size. The survey includes a description of the regulatory structure of the Norwegian purse seine fleet and summary correlations of the major industry variables.

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