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# Fish and Trips in the Baltic Sea

Prices, Management and Labor Supply

Cecilia Hammarlund



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DOCTORAL DISSERTATION

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<b>Title and subtitle</b> Fish and Trips in the Baltic Sea – Prices, Management and Labor Supply		
<b>Abstract</b> <p>The essay discusses different aspects of the market for fish from the Baltic sea. The first chapter introduces the subject and discusses how the how the essay relates to fishery economics and gives a background of the development of the fisheries in the Baltic Sea.</p> <p>Prices of different attributes of Baltic cod is the topic of the second chapter. The results show that larger sized and better quality cod have higher prices and that these prices have increased over time. The chapter also shows that quantities have some effect on prices.</p> <p>The third chapter is about the effects on bargaining power when the management system was changed in the Swedish Baltic cod fishery in 2011. The results show that ex-vessel prices have increased due to increased bargaining power of fishers after the reform.</p> <p>The fourth chapter discusses a small-scale herring fishery in the western Baltic sea that was exempted from a system of tradable fishing concessions (TFC-system). The main conclusion is that it is important to build other institutions dealing with the problem of access to quota when exempting a fishery from a TFC-system.</p> <p>Finally, the fifth chapter investigates short run labor supply and the occurrence of revenue targets in the Swedish Baltic cod trawler fishery. The results suggest that there is not much support for fishermen aiming for revenue targets in this fishery.</p>		
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# Fish and Trips in the Baltic Sea

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Cecilia Hammarlund



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**KLIMATKOMPENSERAT  
PAPPER**



*Overhead the albatross  
hangs motionless upon the air*

*And deep beneath the rolling waves  
in labyrinths of coral caves*

*The echo of a distant tide  
comes willowing across the sand*

*And everything is green and submarine*

Pink Floyd



# Acknowledgments

Writing the final sentences in this essay I feel a bit like when you are getting pretty good at a new language, so good that you can hear that your accent is flawed as you speak. I have learnt a few things, definitely, but I know more about what I do not know than of what I know. I suppose that this is a good thing and just like it should be.

First of all, I would like to thank my supervisors Joakim Gullstrand and Staffan Waldo. Let us not get sentimental but these two are probably among the most enthusiastic people on earth. Joakim and I started working together a long time ago, long before there was any talk about PhD studies, when econometrics was mysterious stuff that Joakim did and my mathematical knowledge was limited to that of division.

Not that there is anything wrong with division, but Joakim never doubted that I could do more fancy stuff. But it was Staffan who came up with the idea that I should take a Licentiate degree. He came into my room one day and said that it was time for me to grow up, comb my hair and get an education. But I was hesitant, in fact, I was stiff scared of the mathematics I did not know, of having to spend time with bright young people looking down on me for not knowing what an integral was or sitting in a lecture not understanding a word of what was being said. But after some time I realized that it could be fun to speak to the young and bright, that it was actually possible to learn something about integrals, and as time went, I sometimes understood what was going on in the lectures. So I thank Staffan for letting me take one step out of the Alpha-building and a giant step into the world of Economics.

Support from the Swedish Research Council Formas is gratefully acknowledged. This essay is part of the project *Multidimensional co-management of coastal fisheries*, a multi-disciplinary project with

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I thank Cecilia for letting me know about the readability tests, and for sharing ideas on the Swedish language in general. And Johan, who is my co-writer and an honorable member of the fisheries group, thanks for lending me your mobile charger and also for guidance on econometric issues. Helena, thanks for letting me relax from thinking too hard by letting me order chairs and shelves, pay the bills, and work with the AgriFood homepage.

One of the best people to annoy at AgriFood is Sören. All the stupidity I come up with is just like water off a duck's back. Recently, I have come up with this great new invention: Friday music sessions, where Sören introduces me to all the hits of the 70s that I missed. One day we might even get two speakers that work.

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I almost forgot to mention, but I was spending a lot of time at the Department of Economics during my PhD studies. The best thing about that was that I got to know a lot of new people. It started off in a big room with Anna and Jens, and in these days I truly thought that either I or Jens would end up in a nut-house before long. Anna would just stay there in the room and continue her PhD studies until done without noticing anything. But there was also Kasia and Ding in the dark room together with Graeme and “the other Chinese”. Sometimes if I worked late “the other Chinese” was singing while an old man, that I actually never saw, was coughing in the room next door.

After a year or so, Jens moved in with the other Alpha males and I and Anna got a new room to share in the noisy part of the corridor and we were listening to students asking stuff (rather loud), students talking about parties (loud) and students talking about Stockholm (very loud). This was lively and nice for a change and the administrative staff having their fikas seemed to have a lot of fun. And Anna was a great roommate, she knew how to build houses, where to find mechanics and who to contact in every possible imaginable situation.

Then I had my 40 years crisis. I started doing yoga, singing in a choir (crazy stuff about Jesus) and taking drama classes. And all this you could do at work (fantastic!) so I never had to leave the premises, never too far away from data on fisheries. I thank Guying, Anna and Daniel especially for inspiring me to do these activities. And I like to thank Jens and Albin for two water-related adventures: One was canoeing on Rönne å and the other sailing from Limhamn to Lomma, probably as close as being on a fishing vessel I will ever get. And while I am at it, I thank Kasia, Ding and Graham for Friday lunches and for letting me win my own games. And I thank all the people at the department of Economics. I would especially like to mention Mahtem, Anton, Karin, Maria, Claes, Karl, Hassan, Alexander, Anna, Azra, Jenny, Mariana, Nathalie and Rikke.

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and Emma, thanks for listening to dreary talk about exams, papers and fisheries.

My three daughters, Clara, Olivia and Emily, you are big girls now and could look after yourselves. But if you wonder why I am working late, or why there is no food on the table, or why the house is full of cardboard boxes and plastic, you should know that it is just temporary. Better times will come.

Lund, Norra Fäladen, April 2015

*Cecilia Hammarlund*

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# Chapter 1

## Introduction

The core of fishery economics is concerned with the workings of resource economics, and much emphasis has been on how to solve problems with an open-access resource: that is, one with no owner. This thesis recognizes that the resource perspective is important, but it also regards fisheries as an interesting case for testing economic theories from other fields. The current thesis explores demand theory, bargaining theory and prospect theory in the context of the fishery. By contributing empirical examples from the fisheries on the Swedish Baltic coast, it aims to provide a contribution to the wide and challenging subject of fishery economics.

## Managing the Seas

In a famous statement in the inaugural address of the London Exhibition of Fisheries in 1883, Thomas Huxley declared that, "... the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea fisheries, are inexhaustible; that is to say, that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case, to be useless" (Huxley 1883, p.6).

Huxley was one of the first scientists to investigate overfishing, and to discuss how fisheries should be managed (Hubbard 2014). Although he believed that most sea fisheries were inexhaustible considering the modes of fishing of the time, he did not rule out exhaustion or opposed

management measures in other fisheries. This is demonstrated by his entirely different conclusions when it came to the salmon fishery. He claimed that salmon rivers could be netted, " ... in such a manner, as to catch every salmon that tries to go up and every smolt that tries to go down" (Huxley 1883, p.5). This called for regulation. As Huxley put it, "... man is the chief enemy, and we can deal with him by force of law" (Huxley 1883, p.5). His suggestions for the salmon fishery included management solutions that would be rather familiar to a modern-day fishery regulator: annual closing times, hunting for predators, removal of pollution, construction of fish passes, restrictions on the character and size of the meshes of nets, and license duties on nets and rods.

Fishery resources are difficult to manage for a number of reasons: several countries are often involved in their exploitation, species migrate, and there are ecological changes that are difficult to predict. In addition, fish are often not visible prior to capture, making planning more difficult for fishermen than is common in other industries. It might be seen as a purely biological concern to estimate the amount of fish in the ocean, and to make recommendations as to how much fish can be harvested in different time periods, and if fishermen are following the biological advice, there should be no problems with overfishing. But the constant problem of actual quotas being set at higher levels than those based on the maximum sustainable yield (Aps and Lassen 2010) calls for different solutions.

Seen from an economist's perspective, the fundamental issue of ownership of resources is at the heart of the problem of overfishing. Fishery resources are often not owned by anyone, but still exploited in a competitive market. This is the underlying reason for the overexploitation of many of the world's fisheries from an economic point of view (Bjorndahl and Munro 2012). The difficulties in establishing property rights have motivated the analysis of the economics of open-access resources, those that have no owner, and is the reason why this type of analysis has been a major part of fishery economics (Scott 2011). Understanding the problem of open access has paved the way for suggesting remedies, and thus, another important part of fishery economics has been to propose effective management systems.

Fishery economics is part of a topic that is referred to as “resource economics”. Fish is seen as a natural resource, just like oil, forests or soil carbon. Fishery resources are renewable, meaning that when some of the resource is used it is compensated by natural growth and reproduction. Thus, the starting point for any economic resource model is a biological one. The biological fishery model assumes that if a resource is at a natural equilibrium there will be no growth of the resource, and if there is no resource there will be no growth (obviously, nothing will come out of nothing). But in all states between these two extremes there will be some kind of growth of the resource, and at some point this growth will be at its maximum: the maximum sustainable yield (MSY). This is often used as a reference point when constructing advice on how much fish can be extracted from a particular fish stock (ICES 2012).

The models of fishery economics were formulated in the 1950s, when Gordon (1954) and Scott (1955) made major contributions. In 1911, Warming had already published a paper on the open access problem and its solutions, but it never reached a wider audience since it was in Danish (Eggert 2012). Gordon (1954) concluded that, despite the fisherman being a profit-maximizer just like any other worker, the utilization of fishery resources would not be optimal in an open-access fishery. The optimal use of a fishery resource was the one that maximized the net economic yield, i.e. the difference between total costs and total revenues. At this point, fishing effort would in many cases be lower than the MSY, since the maximum profit would be reached before the MSY point. But in an open-access fishery fishermen would earn no profit, since the effort of the fishing vessels would increase as long as there were any profits at all to be earned. With no ownership of the resource, there would be no common strategy, and each fisherman would act in isolation. Scott (1955) introduced the economic theories of capital and investment to fisheries economics. A decision has to be made on how much should be consumed today and how much should be left for consumption tomorrow. There is an inter-temporal allocation problem. The idea is that natural resources should be regarded as natural capital, and the decision maker must decide on the optimal rate of investment. Scott (1955) concluded that, without regulation, the fishing industry would also

employ more effort than was needed to maximize economic rent in the long run.

Huxley's mistake was that he did not foresee the advances in technology that would also increase the depletion of fish stocks in the great sea fisheries in the century to come. Steam-powered trawling was already around in the 1880s, but the improvement of trawling methods and the building of faster, safer and bigger vessels came to increase the pressure on sea fisheries at an unprecedented level. Marine biologists noticed that fishery resources increased in the North Sea after the two world wars, and related this to the reduction in fishing activity during the wars. They made the conclusion that man was affecting the size of fish stocks, and that it was possible to reduce fishing activities to let stocks grow (Gordon 1954).

After the Second World War, coastal states attempted to increase their jurisdiction over the sea. At the time, two types of marine areas had been recognized: the coastal state territorial sea, and the high seas. The territorial sea, which traditionally extended to only three nautical miles (5.5 km), was considered to be under the jurisdiction of the nation state, whereas the high seas were common property. As a response to nation states trying to increase their territorial claims, the first Conference of the Law of the Sea was held by the United Nations in 1958. This Conference was followed by yet another one, but it was not until the third UN Conference on the Law of the Sea, 1973-82, that an important agreement was made. The 1982 Convention granted coastal states the right to establish Exclusive Economic Zones (EEZs) up to 200 nautical miles (370.4 km) from shore. This granted the nation states the right to manage fishery resources in wide areas (Bjorndahl and Munro 2012). In 1978, Sweden became the first country in the Baltic Sea region to claim a 200-nautical-mile EEZ, but because such a wide area overlapped with other countries' claims, a mid-line principle was used.

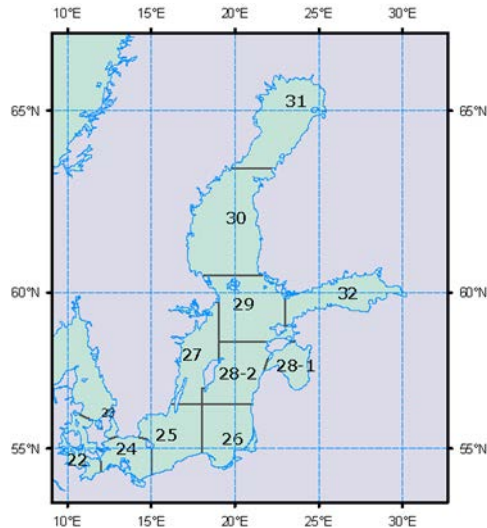
Since many fish stocks are trans-boundary (crossing the borders of several EEZs) or straddling (crossing EEZs and the high seas) it became more urgent in the 1990s to come to multilateral agreements on how to manage these fish stocks. In 1993-1995 the United Nations Fish Stocks Conference was held, resulting in the UN Fish Stocks Agreement, which

encouraged the establishment of Regional Fisheries Management Organizations (Bjorndahl and Munro 2012).

## **Fish and Fishing in the Baltic Sea**

The study object of this thesis is the fisheries of the Baltic Sea. In the following paragraphs, I will give a brief description of the area covered and how the catches of the main species have developed, and provide some information on how these fisheries have been managed over the years. This will explain why the Swedish Baltic Sea fisheries make an interesting topic for the investigation of economic issues.

Figure 1 shows the Baltic Sea and its subdivisions. The subdivisions are used by the International Council for the Exploration of the Seas (ICES), a scientific advisor that estimates stock sizes and gives recommendations on the extent of fishing pressure that is suitable for different stocks. The Baltic Sea consists of brackish water with inputs of fresh water from rivers in the north-east and inputs of saline water from the Atlantic Ocean entering through the Kattegatt. The dominant species are cod, herring and sprat. Commercially, these species account for over 90% of landings. Cod is found under more saline conditions in the southern and eastern parts of the Baltic Sea, whereas herring and sprat are found in the central and northern parts (Zeller et al. 2010; Nieminen, Lindroos, and Heikinheimo 2012; Blenckner et al. 2015).

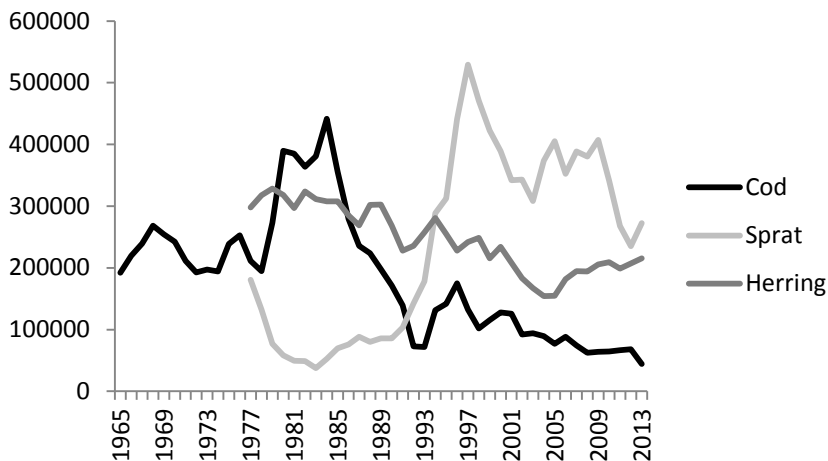


**Figure 1:**  
The Subdivisions of the Baltic Sea.

Baltic cod is separated into two different stocks, where the western is found in subdivisions 22 (the Belt Sea), 23 (the Sound) and 24 (the Arkona Basin) and the eastern is mainly concentrated in the south-east part of the Baltic in subdivisions 25 and 26. Four separate herring stocks can be found in the following areas of the Baltic Sea: the Central Baltic Sea excluding the the Gulf of Riga (areas 25-29 and 32, hereafter called the central herring stock), the Gulf of Riga (area 28.1), the Bothnian Sea (area 30) and the Bothnian Bay (area 31). Finally, the sprat stock is considered to be one and the same in the whole of the Baltic Sea.

ICES provides statistics on landings of fish from the stocks of the Baltic Sea. Figure 2 sums up the statistics on the weight of landings from the different stocks for the three major species: cod, sprat and herring. It is evident that there have been major changes in the composition of landings since the 1980s. Cod and herring were the most important species until the mid-1990s, when sprat came to dominate. The changes in catches reflect changes in the ecosystem of the Baltic Sea in the late 1980s. High fishing pressure, combined with climate changes (higher

spring temperatures and lower salinity levels), contributed to the reduction of the cod stock that had previously kept the sprat stock at a low level. As the sprat stock that lived near the surface of the sea increased, the cod stock at the bottom decreased. And since sprat fed on cod eggs, and competition for zooplankton increased between sprat and cod larvae at the surface, it became increasingly difficult for cod to reproduce. Furthermore, eutrophication led to an excess of nutrients in the sea, which increased the availability of food for herring and sprat. There was also a reduction in the oxygen levels in the deep bottoms that reduced the amount of food for cod. Thus, the replacement of a cod-dominated ecosystem by a sprat-dominated system in the beginning of the 1990s was the result of several combined factors (Ojaveer and Lehtonen 2001; Blenckner et al. 2015).



**Figure 2:**

The Development of Landings (tonnes) of the Three Major Species (Cod, Sprat and Herring) in the Baltic Sea (Excluding the Gulf of Riga Herring).

Source: Own calculations based on ICES Advice, 2014. Book 8.

The most recent concern considering the Baltic cod stocks is the decline in the number of larger individuals in the Eastern Baltic. The amount of cod available for fishing (i.e. cod that is above the minimum landing size

of 38 cm<sup>1</sup>) has decreased, whereas the amount of cod below the minimum landing size has increased. It is currently unclear what has caused this problem, and different theories have been put forward. One is that the geographical overlap between cod stocks on the one hand and herring and sprat stocks on the other, has been reduced since the 1980s. This is related to a decrease in oxygen levels in the Gotland and Gdansk basins, which has led to these areas no longer functioning as spawning areas for cod. The only spawning area left for eastern Baltic cod is the Bornholm basin, which is situated in the southern part of the Baltic Sea. Since cod is a major predator on sprat and herring, which are geographically concentrated in the central and northern Baltic Sea, this means that there has been less food available in the areas where cod is currently spawning and thus the cod is slow-growing (ICES 2014).

However, there are other factors that could explain the lack of growth. One hypothesis is that size selective gear has favored slow-growing individuals in the population. These individuals reproduce and an increasingly greater number of fish are slow-growing. This is demonstrated by the fact that age groups that were previously above the minimum landing size are now below it (ICES 2014). Svedäng and Hornborg (2014) argue that increases in mesh size over the last 15 years have made non-fishable size groups increasingly dense since they have experienced less fishing pressure and less cannibalism from larger individuals that have been reduced by fishing. In addition, the increased competition for food for smaller sized fish has reinforced the negative relationship between the size of the stock and the size of fish (Svedäng and Hornborg 2014). Other explanations are that parasites induced by seals are preventing cod growth, that there is a growing number of seals that feed on cod, and that increased fishing pressure for herring and sprat has reduced the availability of food (ICES 2014).

Nine countries are currently fishing for sprat in the Baltic Sea. Poland (29% of the catch), Sweden (18%), Latvia (12%) and Estonia (11%)

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<sup>1</sup> The minimum landing size has recently (2015-01-01) been changed to 35cm (European Commission 2014). A minimum landing size of 38cm was applied between 2005-2014 (European Commission 2005).

were the major fishing nations in 2013. In 2013 the smallest cod catch since 1965 was harvested: around 13,000 tonnes of cod were caught in the Western Baltic sea and 44,000 tonnes in the Eastern Baltic sea (ICES 2014). Denmark (55%), Germany (25%) and Sweden (13%) dominated the fishing for cod in the Western Baltic in 2013, as they had during the two preceding decades. In the Eastern Baltic, fishing for cod was dominated by Poland (38% of catches in 2013), Denmark (19%) and Sweden (17%) (ICES 2014).

While the deterioration of the cod stocks is clearly affecting landings negatively, the patterns of the landings of herring and sprat are different. There is a steady decrease in landings of herring from 1978 until 2005 when landings start to slowly increase again. This is mainly due to increased landings from the herring stock in the Bothnian Sea. The landings from the central herring stock have decreased steadily and by more than 50% since the late 1970s. Since herring and sprat compete for the same food, the increase in the sprat stock has affected the herring stock and the herring have also become smaller (there has been a reduction of mean weights-at-age). Nine countries are fishing for herring from the herring stocks, with Sweden, Poland and Finland as the main fishing nations (ICES 2014).

## **Managing the Baltic Sea**

Nine coastal states are involved in managing the fisheries in the Baltic Sea. In 1974 the International Baltic Sea Fishery Commission (IBSFC) was established, and was responsible for the management of fishery resources in the Baltic Sea up until the accession of the new EU members in 2004. This commission resulted in several action plans and long-term strategies for the concerned species. But the main task was to agree on the yearly quotas, the Total Allowable Catch (TAC) for each species, using scientific advice from the ICES. The scientific advice was collected, and then TACs were negotiated.

The national quotas were shared among the vessels of each country according to rules that depended on the national management system in

place. In Sweden, for example, national quotas for herring and cod were given to vessels bi-weekly. Each vessel was given a quota that was based on the size of the vessel (gross tonnage), and these quotas had to be fished or they would be lost. Regulating by TACs was complemented by more detailed rules that, for example, restricted fishing during certain times of the year in certain areas, required fishermen to apply for licenses and kept technical regulations on the gear and the size of the fish. The common fisheries policy of the EG was established in 1983, and successively made it possible for vessels from Baltic countries to fish in each other's waters as new members entered. Denmark and Germany were original members, Sweden and Finland joined in 1995 and in 2004 Poland, Estonia, Latvia and Lithuania joined the union, leaving only Russia outside (Zeller et al. 2010). Since 2005, TACs are negotiated between the EU and Russia.

Since the early 1990s it was evident that many stocks were in a poor state and that the control of the fisheries was not satisfactory. The IBSFC, and later the EU, were unable to limit fishing pressure to levels recommended by ICES in the decade that followed, and for all Baltic stocks that were evaluated, TACs were systematically set higher than had been recommended by scientists. In addition, the scientific advice was unreliable since it was based on incomplete and missing data. For example, ICES estimated that total catches of cod could have been 30-40% higher than officially reported during 2000-2006 (Aps and Lassen 2010).

Lately, there have been substantial changes in the management systems of many Baltic countries, as more and more fisheries are introducing systems in which quotas are held for longer time periods. In particular, individual transferable quotas (ITQs) have become popular. In Denmark, the first ITQ system was introduced in the pelagic (herring and sprat) sea fisheries in 2003, and by 2009 all Danish fisheries were under ITQ systems (TemaNord 2009). Estonia implemented ITQs in all offshore fisheries as early as 2003, whereas Sweden introduced ITQs in the pelagic fishery in 2009. Poland has so far opposed the introduction of transferable fishing concessions such as ITQs, but the trend towards new management systems in the Baltic is clear (Figus 2013).

A new reform of the Common Fisheries Policy was finalized in 2013. Emphasis was put on ecosystem-based management, and management plans for fish stocks were encouraged. In particular, plans that covered several species and years were seen as important for getting closer to taking entire ecosystems into consideration in fishery management. An obligation to land all species that were covered by EU quotas (with some exceptions) was also decided on, and further integration of fishery policies and environmental policies was called for. The new regulations are meant to serve as a basis for measures that are decided on a regional level with concerned member states and advice councils. In line with the reform, the EU commission has recently suggested that the three main stocks of the Baltic – cod, sprat and herring – should be regulated together in the same management plan (Swedish Board of Agriculture 2014, European Commission 2014).

## **The Swedish Fishery Sector**

The fishery sector is a small part of the Swedish economy. The value of landed fish has been around one billion Swedish kronor per year since 2004 and the number of employees in the sea fisheries sector was 1,679 in 2011. In addition, there were around 300 firms involved in the processing of fish products in 2012 (STECF 2014; Swedish Board of Agriculture 2014).

In December 2013 there were 1,362 vessels registered for commercial fishing in Sweden. The number of vessels has decreased during the last decade, reduced by 232 between 2004 and 2013. After 2009 the reduction of vessels stabilized, although the introduction of the pelagic ITQ system resulted in a further reduction of the number of vessels fishing for herring and sprat. When the system was introduced there were 82 vessels with a permit to fish for pelagic species. By 2013 there were 47 vessels left. That is to say, the number of vessels was reduced to 34 vessels in 2013 (Swedish Agency of Marine and Water Management 2014).

Table 1 shows the value of landings of the most important species in Swedish fisheries in 2013 in three coastal districts. It is clear that the most important species is herring, and that this species is important in all coastal areas as well as for Swedish landings abroad. Most of the fish landed abroad is landed in Denmark, and this is where most of the fish for reduction is landed. Fish for reduction mainly consists of sand eel, sprat and herring (Swedish Agency of Marine and Water Management 2014).

**Table 1:**

Values of Landings by Swedish Vessels of Different Species, Millions of SEK, 2013.

	West Coast	South Coast	East Coast	Abroad	Total
Herring ( <i>Clupea Harengus</i> )	84.0	30.3	27.1	89.4	230.8
Fish for Reduction	0.6	14.4	5.0	177.4	197.4
Norway Lobster ( <i>Nephrops Norvegicus</i> )	105.4	0.2	0.1	0.6	106.2
Northern Shrimp ( <i>Pandalus Borealis</i> )	99.0	-	-	0.3	99.2
Cod ( <i>Gadus Morhua</i> )	16.8	61.1	0.6	13.0	91.6
Sprat ( <i>Sprattus Sprattus</i> )	5.2	7.7	38.6	26.6	78.1
Other Species	45.6	13.2	18.2	24.7	101.8
Total	356.6	126.8	89.6	332.1	905.1

Source: Adapted from JO 55 SM 1401, Table 4: Landings of Sea Fisheries by Coastal District in 2013, Value.

On the west coast, the Norway lobster and northern shrimp fisheries are important. These species are valuable and contribute to around 23% of the value of total landings. Although cod is also a relatively valuable species, the reduction of landings from the Eastern Baltic has recently reduced the economic importance of cod in Swedish fisheries. In 2013 the landings from cod fishing consisted of only 10% of the total landings from Swedish vessels.

## **Prices, Management and Labor Supply**

This thesis discusses prices, management and labor supply in Swedish Baltic Sea fisheries using empirical methods to explore the economic behavior in the sector. The formation of prices takes a central place in the thesis. Prices are important for fishermen and processors, and lower prices can force processing firms to exit the industry as well as making fishermen look for work elsewhere. I will discuss prices of different attributes, the effect of prices on demand, and how prices and management issues are related. The second, third and fourth chapters deal with issues that are related to price formation, whereas the fifth chapter takes a look at the incomes of fishermen.

In the second chapter I will look at the prices of different sizes and qualities of cod, and how changes in prices will respond to changes in the supply. The case of landings of cod made by Swedish vessels in Swedish Baltic ports is used. Here, it is clear that ecosystem changes are closely related to prices, since the quality of the product is a result of an ecological process. In light of the recent concerns about cod being small and of low quality, it is evident that there is a direct link between the status of the ecosystem and the prices of fish, and that the survival and development of the fisheries and the processing industry is dependent on the development of the Baltic sea's ecosystem.

Rather than studying the prices of different types of a product, it is possible to isolate the attributes of that product and study the prices of these attributes. This can be done in a hedonic demand model. In Chapter 2, the attributes that are studied are four different sizes and three different quality ratings of cod. It is clear that prices have decreased since the end of the 1990s, and that prices are substantially lower if cod is of the smallest size (0.3-1 kilo.). And although there is a price premium on cod that is of better quality than average, this attribute is unusual.

As the composition of landings changes, the prices of different attributes will also change, and hence revenues could be affected. The results are important when modeling the effects of new management proposals on revenues, since changing quantities could result in new prices. I show

that prices depend on landed quantities, and that quantity effects are greater for prices of small cod than for large cod. It is also shown that different sizes of cod are substitutes, i.e. when cod of a particular size gets more expensive, buyers turn to cod of another size. Finally, over the time period studied, there is an increased demand for larger sizes of fish and fish with a higher quality rating.

It was noted above that the management systems used for different fishery resources have changed dramatically over the years. Turning attention to management, the third chapter, co-authored with Johan Blomquist and Staffan Waldo, discusses the effects of a management reform in the Swedish Baltic cod fishery. In April 2011, as part of a reform process aimed at preventing fishers from throwing fish overboard, trawlers were given annual quotas rather than the previously applied quarterly ones. The chapter investigates whether the bargaining power of trawler fishermen has improved since the reform. Since fishermen gain more freedom in choosing when to fish while processors are keen to have regular landings (in order not to have unused capital), we suggest that prices are likely to increase following the reform.

The results indicate that prices have increased due to the increased bargaining power of trawler fishermen after the reform. The effects of fish size, fish quality, landing port and landing date are left out of the analysis; if any of these factors changed due to the regulatory change, it did not affect the results. We also investigate whether the price change that we have found is driven by changes in reservation prices (i.e. the lowest price a fisher would accept and the highest price a buyer would accept), and find that this is not the case. Thus, we conclude that introducing yearly quotas is likely to have changed bargaining power between fishers and buyers in the Swedish Baltic cod fishery.

However, it is important to realize that the market for Swedish Baltic cod is not isolated from the rest of the world. Frozen and processed cod are highly traded products on the international market and even markets for fresh cod have been shown to be internationally integrated (Nielsen 2005). Prices of cod on the local market will thus be affected by world market prices. This is the reason why the price effects found in Chapter 2 and Chapter 3 are small.

As discussed above, Sweden introduced an ITQ system in pelagic fisheries in 2009. One of the major concerns when introducing these systems is the effect on small-scale fisheries. Chapter 4 is co-authored with Staffan Waldo, Kim Berndt, Martin Lindegren, Anders Persson and Anders Nilsson, and provides insights into the management design for a Swedish small-scale herring fishery in the western Baltic Sea. This fishery was exempted from the ITQ system that was introduced for the large-scale Swedish herring fishery in 2009.

The migratory pattern of the herring implies high densities in the southern parts of fishing areas during the spring, and in the northern parts during the autumn. This forms the basis for two fisheries in the area competing for a shared quota, as well as for the management proposal to divide the quota into spring and autumn parts. Since prices are higher in the autumn it is more profitable to fish at this time of the year, provided there is quota left. Different management proposals are discussed in the paper. The main conclusion from the case study is that, when exempting a fishery from an ITQ system, it is important to build other institutions dealing with the fundamental problem of access to the quota.

The final chapter (Chapter 5) discusses how fishermen are thinking about their incomes using ideas from prospect theory (Kahneman and Tversky 1979). Again, the case of Swedish cod fishermen is used, this time limited to trawlers above 12m. Since there is a lot of uncertainty in fishing, and the catch can vary on different trips and on different hauls, there must be strategies for handling this uncertainty. One solution might be to set specific revenue targets, i.e. to stop fishing when a certain revenue level has been reached in a certain time period. This period could be the time of the fishing trip or perhaps a more strict time period like a week. In Chapter 5, trip-specific revenue targets as well as weekly revenue targets are investigated.

The results indicate that cod fishermen choose to continue a fishing trip if revenues are higher than expected on a specific trip and hence there is no evidence of trip-specific revenue targets. If revenue targets are instead assumed to be weekly, the results are slightly different, as higher revenues later on in the week (and particularly higher revenues on a Friday) make fishermen end their fishing activities earlier. Although this

result points toward revenue-targeting behavior, most fishing trips end before Friday and thus the general conclusion is that fishermen do not have weekly revenue targets.

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# Chapter 2

## The Big, the Bad and the Average: Hedonic Prices and Inverse Demand for Baltic Cod

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### Introduction

Much focus in fishery economics has been on the total biomass of harvested fish stock without any consideration of the size or quality of the fish. In order to maximize the economic value of a fishery, it is not just the weight in tons that matters, since attributes such as size and freshness can change the value of the catch substantially. The prices of different sizes and qualities<sup>2</sup> are closely related to the management of fishery resources. Fisheries, such as the Baltic cod fishery, are often regulated by quota restrictions set in tons of fish, with fish size regulated by restrictions on mesh sizes and minimum legal landing sizes. As discussed below, a fish stock that is efficiently managed economically

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<sup>2</sup> Although it is possible to refer to size as a quality, herein, size is regarded as separate from quality, which is considered to be a quality aspect related to freshness and appearance of the product as set forth in EU regulation *No 2406/96 of 26 November 1996*.

often has a larger amount of large-sized fish as well as a high amount of undamaged and fresh fish.

The pricing of size attributes is especially interesting since price has been the focus of a large number of studies relating fishery management to the size (or age) structure of the biomass (Döring and Egelkraut 2008; Froese et al. 2008; Quaas et al. 2010; Diekert 2011; Ravn-Jonsen 2011; Cardinale and Hjelm 2012). Numerous benefits of delaying harvesting until fish have reached a certain size have been pointed out. Firstly, the most obvious point is that larger fish increase the value of the total catch. Secondly, larger fish can also decrease uncertainties about the future stock, since the spawning success will be less likely to be dependent on a single age group (Döring and Egelkraut 2008). Finally, societal values, like a good sea ecosystem status and higher values of recreational fisheries can be achieved in a fishery with larger fish (Cardinale and Hjelm 2012).

Quality attributes not related to size may also be related to the status of the biomass stock but will also depend on how the fish are handled after they have been caught. The incentives for fishermen to produce high-quality fish are expected to increase in an economically efficient fishery, and fishermen will, therefore, deliver a larger amount of fresh, undamaged fish (Squires, Kirkley, and Tisdell 1995; Larkin and Sylvia 1999; Grafton, Squires, and Fox 2000; Carroll, Anderson, and Martinez-Garmendía 2001). The price paid by fish processors to fishers is likely to depend on these quality aspects. Fish that have been handled more carefully and have not been stored too long are expected to receive a higher price on the market. Hence, the pricing of quality attributes, other than size, is interesting from a fishery management perspective.

Since Rosen (1974), the estimation of supply and demand of attributes has been discussed in the literature (Brown and Rosen 1982; Bartik 1987; Epple 1987; Ekeland, Heckman, and Nesheim 2004), and a number of studies have empirically estimated the demand and supply of attributes (Palmquist 1984; Bowman and Ethridge 1992; Stewart and Jones 1998; Wang 2003; Kristofersson and Rickertsen 2004, 2007). This study contributes to the literature on hedonic prices and

inverse demand by using the Brown and Rosen model with random coefficients as presented in Kristofersson and Rickertsen (2004).

Using a unique and detailed dataset, the study takes a closer look at prices related to the size and quality ratings of cod in the Swedish Baltic Cod fishery. Lately, the size and quality composition of Swedish Baltic cod have become an important issue, as the problems of a diminishing fish stock, especially for Eastern Baltic cod, have become less severe (Romare 2011; Cardinale and Hjelm 2012; Eero, Köster, and Vinther 2012). Despite the recovery in the stock biomass, the size of harvested cod is still small (Cardinale and Hjelm 2012). Fishermen, as well as society, could benefit from larger higher-quality cod. The price premiums of different attributes, five size classes, and two quality ratings are investigated using the hedonic method. In addition, the effects of increasing the quantities of cod with different attributes are analyzed in an inverse demand system. Increasing the quantities of attributes is expected to result in decreasing attribute prices. If these price increases are not considered, the benefits of sustainable management might be overestimated. The ambition of this study is to give guidance on the economic value of different size and quality compositions of cod landings.

The article proceeds with a short description of the Swedish Baltic cod fishery and the regulations surrounding it. This is followed by a description of the estimation of the hedonic model and the inverse demand model in the literature and herein. Next, the database of the Swedish cod fishery and some statistics based on it are presented, as are the results from the hedonic inverse demand model. A discussion on how the results relate to fishery management issues brings the paper to a close.

## **The Swedish Baltic Cod Fishery**

The Baltic Cod Fishery is one of the most important fisheries in Sweden. In 2011 around 17 % of the value of all fish and seafood landings in Sweden consisted of cod, mostly landed along the south coast of Sweden

(Swedish Agency of Marine and Water Management 2012). The fishing areas include the Western Baltic (the Belt Sea, the Sound, and the Arcona basin) and the Eastern Baltic (including the Bornholm basin, the Gdansk basin, the Gotland basin, the Bothnian Sea, the Bothnian Bay, and the Gulf of Finland). In 2011, nine countries were fishing for cod in these two areas in the Baltic. Poland, Denmark, and Sweden were the major fishing nations fishing for cod in the Eastern Baltic, while Denmark, Germany, and Sweden fished in the Western Baltic. In total, 50,368 tons of cod were landed from the Eastern Baltic in 2011, of which 20 % was landed by Swedish vessels, and 16,332 tons of cod from the Western Baltic stock were landed, of which Swedish vessels landed 16 % (ICES (International Council for the Exploration of the Sea). 2012).

The Swedish cod fishery is regulated by EU legislation and national legislation that, in some cases, goes further than the EU regulations. The regulations consist of setting quotas, limiting the number of days out of port, fishing bans, and closed areas. A multiannual plan for cod stocks in the Baltic Sea was established in 2007, the motivation being a decline in the stock to levels of reduced reproductive capacity and unsustainable harvesting (European Commission 2007). The purpose was to gradually reduce and maintain fishing mortality rates at levels no lower than 0.6 on ages 3 to 6 years for the Western Baltic cod stock and 0.3 on ages 4 to 7 for the Eastern Baltic cod stock. This regulation also stipulated prohibited periods and closed areas for the two Baltic cod stocks. Fishing with most types of fishing gear is prohibited from the April 1st until the April 30th in the Western Baltic Sea (the April closure) and from July 1st until August 31st in the Eastern Baltic Sea (the summer closure). Most types of fishing activities in the Gdansk deep, the Bornholm deep, and the Gotland deep are prohibited from May 1st to October 31st (European Commission 2007). The number of days at sea is regulated from year to year under different EU regulations. For example, in 2011 vessels were limited to 163 days absence from port in the Western Baltic Sea and 160 days absence from port in the Eastern Baltic Sea (European Commission 2010). In addition, regulations require fishers to have licenses and vessel permits, and stipulate the allocation rules for fishing quotas. Special rules also apply to cod fishing, which requires a special

permit in the Baltic Sea, and the number of ports with the right to receive more than 750 kilos of cod has been limited to 29 since 2005 (Swedish Board of Fisheries 2004; European Commission 2007).

Regulations related to cod size are mainly requirements on mesh sizes and minimum legal landing sizes found in Council regulation no 2187/2005, which also determines the technical measures for the conservation of fishery resources in the Baltic Sea. The regulations on mesh sizes for vessels using active gear are part of the detailed requirements for Bacoma and T90 trawls; the mesh size is set at 105 mm on the Bacoma trawl, except for the exit window, which should have a minimum mesh opening of 110 cm. For the T90 trawl, the mesh size should be at least 110 mm. For vessels using passive gear, mesh sizes should be larger than 157 cm when vessels target cod only and between 110 and 157 cm when more than 90 % of the target species consists of cod (European Commission 2005). Regarding minimum landing sizes, the EU regulation on technical measures, issued in 2005, establishes that the minimum length of cod taken from the Baltic Sea is 38 cm (European Commission 2005).

The attributes of cod taken from the Baltic are the result of biological conditions as well as management decisions. The regulations discussed above influence the size and quality composition of landings, these are discussed in the following sections. In the next section, a suitable model for estimating attribute prices is discussed.

## **The Hedonic Model and Inverse Demand**

The analysis of attribute prices in a competitive setting was formalized by Rosen (1974) in the hedonic model. The general form of this model is written as:

$$p = f(z), \tag{1}$$

where  $p$  is the price of a product and  $z$  is a vector of different attributes of that product. Hedonic price analysis is often used to explore revealed preferences of quality attributes where no market prices exist. In relation

to fish markets, McConnell and Strand (2000) use a hedonic function of different fish species to investigate the qualities of Hawaiian tuna sold at fish auctions. Hedonic prices have also been estimated with a hedonic pricing model by Roheim, Gardiner, and Asche (2007) to determine the relative value of the attributes of frozen, processed seafood in the UK. The effects of different fishing methods on prices have been investigated by Asche and Guillen (2012), who compare the prices of hake caught by longline, trawl, and gillnets in the Spanish wholesale market. The results show that fish caught by longline receive a higher price than fish caught by trawl or gillnets. However, hake caught by gillnets have smaller price premiums than hake caught by trawlers, which suggests that trawling does not reduce quality as much as gillnetting. The value of line-caught haddock and cod in British supermarkets is investigated by Sogn-Grundvåg, Larsen, and Young (2013), and the results suggest that consumers pay more for line-caught fish compared to fish caught by other methods. This study also finds a price premium for fish labeled by the Marine Stewardship Council (MSC).<sup>3</sup> A recent study by Lee (2014) discusses hedonic pricing of Atlantic cod and finds price premiums for large and fresh cod.

All of the above studies focus on the hedonic price function, without considering how changing quantities of attributes affect hedonic prices. Rosen (1974) pointed out that this type of hedonic price function can only reveal something about attribute prices at prevailing quantities, since prices normally are determined by demand as well as the supply of attributes. Hence, in order to identify the demand and supply of attributes, a system of demand and supply equations should be estimated (Rosen 1974). However, it is possible that in markets like housing markets (Palmquist 1984) and natural resources (Wang 2003), or fresh produce like fish (Barten and Bettendorf 1989; Kristofersson and Rickertsen 2004, 2007), the supply of attributes can be assumed to be exogenous. In this case, the estimation of an inverse attribute demand equation for an attribute is possible:

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<sup>3</sup> The Marine Stewardship Council is a non-profit organization with a certification program that recognizes and rewards sustainable fishing.

$$\beta_t = \delta'q + u_t, \quad (2)$$

where  $\beta_t$  are observations of marginal prices of the attribute;  $q$  is a vector of variables explaining demand, including quantities supplied of different attributes; and  $u_t$  are unobserved factors influencing the marginal price of the attribute.

In order to estimate an inverse demand equation, it is necessary for attribute prices to vary. One way to find variation is to use a non-linear hedonic model where hedonic prices differ among buyers who prefer different quantities of these attributes. A functional form of the hedonic model must be assumed, then the attribute prices for different buyers are used in a second step demand model (Ekeland, Heckman, and Nesheim 2004). Another way to find price variations is to use information from multiple markets assuming that consumers in each market share a common preference structure. This method was first suggested by Brown and Rosen (1982) and has been used by Palmquist (1984); Bartik (1987); Zabel and Kiel (2000); Kristofersson and Rickertsen (2004, 2007).

For fish markets, Kristofersson and Rickertsen (2004) use the Brown and Rosen model to estimate hedonic inverse input demand for Icelandic cod. In the first stage, 881 trading days in the Icelandic fish auctions are used to estimate hedonic prices for different sizes of cod, non-gutted cod, and storage time. In the second stage, input demands for these attributes are estimated. The results show that price changes are small in response to increased quantities of size attributes. The price changes are larger when the quantities of the attributes non-gutted and storage increase. The study also shows that the attribute prices of larger sizes have increased more over time than those of smaller sizes.

Another problem that has caused much debate concerning the hedonic demand function is that unobserved demander characteristics can affect the choice of product attributes (Bartik 1987; Epple 1987). In a fish market context, this translates into processor characteristics affecting the choices of quantities of fish with different attributes. For example, it might be that processors with fillet machines have a demand for fish of a

certain size that fit in the machine, or there could be buyers of fish who sell to luxury restaurants that demand higher quality fish.

One way to find variation of prices and solve the problem of unobserved demander characteristics is to use daily observations of the hedonic price function under the assumption that this function varies from day-to-day, but that unobserved characteristics of the processors do not. This allows the estimation of hedonic price functions that are unaffected by processor characteristics.

## **Estimation**

In this study, fishers are assumed to be price takers in the short run. The assumption seems especially motivated for daily supplies. After fishers have landed the catch, the fish attributes cannot be changed. It is also assumed that unobserved processor characteristics do not vary from day-to-day. Thus, on a daily basis, the prices of fish attributes are determined by the demands of fish processors. Furthermore, the demand for cod from processors is assumed to be separate from demand for other types of fish. The assumption can be motivated since results from previous studies have shown that the market for whitefish is separated from other fish markets and that cod is a price leader on the whitefish market (Asche, Gordon, and Hannesson 2004; Nielsen 2005; Nielsen, Smit, and Guillen 2008). The details of the theoretical framework underlying the model used in this study is described in Kristofersson and Rickertsen (2004) and Kolstad and Turnovsky (1998).

The estimation follows the approach of Kristofersson and Rickertsen (2004), where the hedonic inverse demand equation is estimated using a random coefficient model. The motivation for using this model is that there is a need to take the importance of each landing day into account. For comparison, as in Kristofersson and Rickertsen (2004), the Brown and Rosen (1982) model, which relies on an underlying assumption that estimates from each landing day have the same level of accuracy, is used. The Brown and Rosen model is estimated in two steps whereas the random coefficient (RC) model is estimated in one step.

Starting with the Brown and Rosen model, the hedonic equation is estimated for each trading day in a first step. Then the inverse demand equations of the attributes are estimated in the second step using the estimated hedonic prices from the first step. That is, for each landing day,  $t$ , we have:

$$p_{nt} = z'_{nt}\beta_t + \varepsilon_{nt}, \quad (3)$$

where real prices<sup>4</sup> on each trading day ( $t$ ) are regressed on the attributes  $z$ . The first-stage equation gives the attribute prices on each trading day. The second-stage inverse demand functions for each attribute are then estimated as:

$$\beta_t = \gamma + \delta'q_t + \theta't + u_t, \quad (4)$$

where the coefficients from the first-stage models are used as dependent variables,  $\delta$  are price effects in Swedish krona (SEKs) of increasing the quantity of fish with different attributes, and  $q_t$  is a vector of variables explaining demand on trading day,  $t$ , divided by monthly imports. Monthly imports<sup>5</sup> are used as a numeraire in order to impose homogeneity, and  $t$  is a time trend. The second stage coefficients, are interpreted as own-quantity and cross-quantity effects. The own-quantity effects show how much a certain attribute price is affected by a change in the quantity supplied of that attribute, whereas cross-quantity effects show the effects of changing quantities of other attributes on the price of a certain attribute. Symmetry is imposed a priori on the system, which reduces the number of cross-quantity effects to be estimated. Imposing homogeneity and symmetry is motivated by the theoretical model (Kristofersson and Rickertsen 2004), which assumes that rational producers are not affected by units of measurement and that choices of inputs are consistent. This approach is followed in several other studies of seafood demand; Barten and Bettendorf (1989), Eales, Durham, and Wessells (1997), Park, Thurman, and Easley (2004), and Xie, Kinnucan,

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<sup>4</sup> Prices are deflated by 1997 consumer prices in order to account for macroeconomic fluctuations.

<sup>5</sup> Imports are important to Swedish processors since the supply from Swedish fishers is inconsistent.

and Myrland (2008). Furthermore, following Kristofersson and Rickertsen (2004) quantity effects are normalized to mean to facilitate interpretation; the coefficients can then be interpreted as the price reduction in SEK if the quantity of an attribute increases by 100 %. Finally, the trend variables are adjusted so that the coefficients accompanying them can be interpreted as yearly effects.<sup>6</sup>

Using the Brown and Rosen two-stage method, the two steps are estimated separately. As mentioned above, the problem with this model is that it gives equal weight to the estimates from each trading day. Hence, the main focus in this study is on the RC model; i.e. the two steps are estimated simultaneously by inserting the second equation into the first (as in Kristofersson and Rickertsen (2004)):

$$p_{nt} = z'_{nt}\gamma + z'_{nt}\delta'q_t + z'_{nt}\theta't + z'_{nt}u_t + \varepsilon_{nt}, \quad (5)$$

The first part of the equation,  $z'_{nt}\gamma + z'_{nt}\delta'q_t + z'_{nt}\theta't$ , is the fixed part, and the second part, that is,  $z'_{nt}u_t + \varepsilon_{nt}$ , is random. The estimation will contain main effects,  $z'_{nt}\gamma$ , as well as cross-level interaction effects; i.e.,  $z'_{nt}q_t$ . The coefficients of the interaction terms involving  $q_t$  will be the quantity effects of the model. Assuming that the time effects are attribute specific results in them being specified as interactions in the model. The same restrictions regarding homogeneity and symmetry as in the Brown and Rosen model is used, as is the normalization of the  $q$ -variables. Additionally, variance and covariances of the  $u_t$ :s are distinctly modeled, which results in a variance-covariance matrix with 21 unique parameters in the preferred model.<sup>7</sup>

More specifically, the RC model assumes that each landing day has different slope coefficients, and that the variation of these coefficients can be explained by the  $q$ -variables (and a time trend). This means that the relationship between the kilo price of cod and the attributes of cod depend on the quantities of different attributes that are traded. The

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<sup>6</sup> In practice, the trend variable is divided by 365.

<sup>7</sup> A log-ratio test of the model with covariance terms (unconstrained model) versus the model with only variance terms (constrained model) indicates that the model with covariance terms is the preferred model.

quantity variables thus act as moderator variables for the relationship between price and attributes, where the relationship varies according to the value of the moderator variables (i.e., the quantities variable for a certain day). The coefficients,  $\gamma$ ,  $\delta$  and  $\theta$  are fixed coefficients since they apply to all landing days. All between-days variation that is left in the  $\beta$ -coefficients, after predicting using these coefficients, is residual error variation indicated by  $u_t$ .

## Data

Data on values and quantities of cod landings by Swedish vessels in the Swedish Baltic ports for the period 1997-2011 is available from the Swedish Agency for Marine and Water Management. The data is collected from sales notes sent from fish receivers to the Swedish Agency for Marine and Water Management. All primary receivers of fish are required to register and report to the Agency, and the database thus includes all cod that is reported as sold in Swedish Baltic ports (European Commission 2009).

Fish from a specific vessel is split into different observations depending on the size and quality of the fish. For each observation the following is reported: the amount landed, the price paid, the size class of the observation (E, A, or B), the quality class of the observation (1-5), the port where the fish was registered, and the date when the fish arrived at port. Price per unit of cod can thus be calculated for each observation. There is a total of 731,540 observations in the database used in this study. Some summary statistics, together with data on Swedish quotas, are presented in table 1.

**Table 1.**

Summary Statistics: Baltic Cod Catches from Swedish Vessels, 1997-2011

	Number of Observations	Number of Vessels	Quantity Landed (tons)	Swedish Quota (tons)	Price per Kilo (real SEK)
1997	65,848	612	22,093	38,860	9.6
1998	58,599	563	14,024	29,246	13.2
1999	64,356	536	14,134	25,870	13.8
2000	68,005	546	16,154	21,303	13.9
2001	69,218	517	16,286	22,083	14.9
2002	55,043	476	12,378	15,203	14.9
2003	58,297	440	12,332	15,438	12.5
2004	53,852	408	12,697	12,323	12.2
2005	46,567	391	8,892	12,918	13.8
2006	42,168	350	10,243	14,969	14.2
2007	33,090	323	10,427	13,649	14.5
2008	35,933	320	9,311	12,011	13.9
2009	32,399	276	9,892	12,916	10.6
2010	24,760	237	9,564	14,685	11.1
2011	23,467	228	10,258	16,645	11.1

Note: Quotas as set by the original EU regulations each year; i.e., amendments are disregarded. Prices are deflated by 1997 consumer prices.

Over the time period the number of observations has decreased substantially. The total number of observations in 2011 was only 36 % of the total number of observations in 1997. This decrease is accompanied by a decrease in the number of vessels and the quantity of cod landed, which, in turn, is related to the decrease in quotas for the Swedish cod fishery. For example, the national quota for Sweden, which was 38,860 tons in 1997, had decreased to 12,011 tons in 2011 (European Commission 1996a, 2010). In 2011 the number of vessels landing cod was less than half (38 %) of the number of vessels in 1997. A further look at the data reveals that this decrease is due to a decrease in the number of vessels using passive gear. The share of the total quantity landed by vessels using active gear was around 60 % in 1997, which had

increased to more than 80 % by the end of the time period (own calculations). Table 1 also displays the average cod price over the time period and shows that it is negatively correlated with landed quantities. The highest average prices were recorded in 2006-2008 when Swedish fishers received around 16 SEK (around 14 SEK in 1997 prices) per kilo of cod.<sup>8</sup> The average price has since declined.

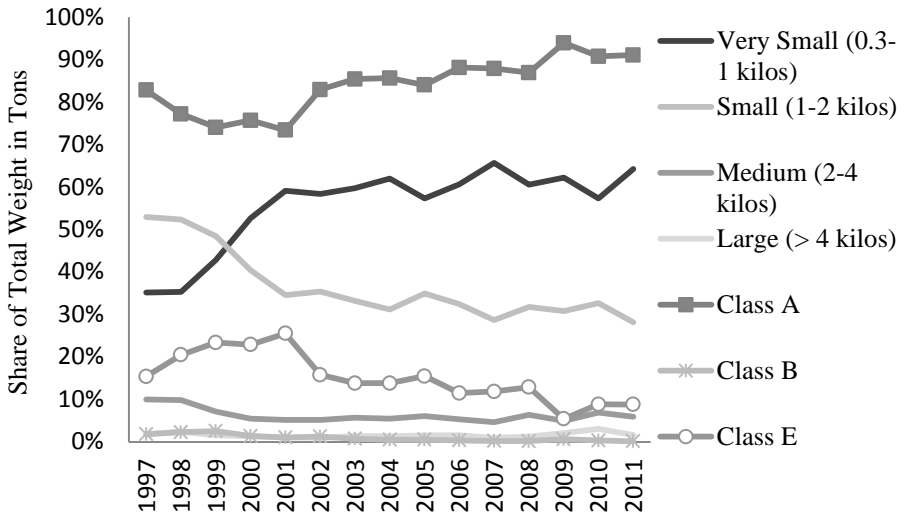
Prices are related to size and quality and, therefore, a change in the composition of landings could hide the effect that different characteristics have on average prices. Size classes and quality ratings are regulated by the European Commission in a regulation that determine common marketing standards for certain fishery products (European Commission 1996b). There are five size classes for cod: 0.3-1 kilo, 1 to 2 kilos, 2 to 4 kilos, 4 to 7 kilos, and more than 7 kilos. The quality classes are determined on the basis of freshness and are the same for all whitefish. To be classified in category E, the fish must be free of pressure marks, injuries, blemishes, and bad discoloration. For category A, the fish must be free of blemishes and bad discoloration; a very small proportion with slight pressure marks and superficial injuries can be tolerated. Finally, for category B, blemishes and bad discolorations are not tolerated, but a small proportion with more serious pressure marks and superficial injuries is accepted. Further definitions of the categories are specified in the regulation, where special ratings are based on the skin, skin mucus, eyes, gills, peritoneum (in gutted fish), and smell of gills, abdominal cavity, and flesh. For ease of presentation the quality classes are referred to as Class A, B and E in the following.

Figure 1 presents shares of cod with different attributes in total landings. The two largest size classes (>4 kilos) have been added together since they represent small shares of the total quantity landed. Only around 1-3 % of the cod weigh more than 4 kilos. Between 5 and 10 % of the landings of cod weigh between 2 and 4 kilos, whereas most of the cod landed are smaller than 2 kilos, since more than 90 % are classified into one of the smaller size classes. The most notable change during the time

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<sup>8</sup> A Swedish krona was equivalent to 0.14 USD as of 2011-12-31.

period is the increase of landings of very small fish. Cod weighing between 1-2 kilos become more unusual, and cod weighing 0.3-1 kilos constitute almost 60 % of landings by the end of the time period.

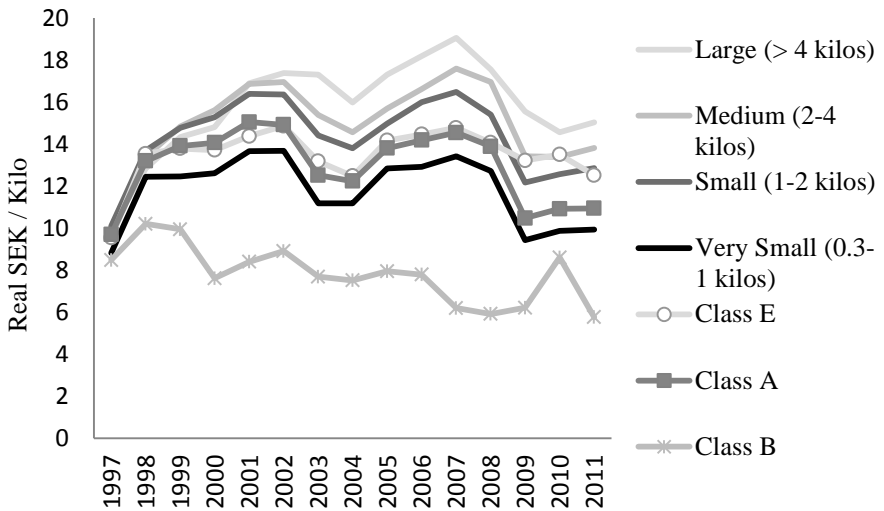


**Figure 1.**  
Quantity Shares (tons) of Cod with Different Characteristics, 1997-2011

The quality ratings outlined in the EU regulation result in most fish being classified as of average quality; i.e., Class A. A varying amount of fish is classified as Class E; that is, the finest quality available in the EU classification. Over the years, this share ranges between 5 and 25 %. A very small share of the fish is classified as Class B; i.e., below average quality. The trend is towards more fish being classified as Class A. In summary, the data show that cod landed in Baltic Swedish ports have decreased in quality as well as size.

Figure 2 presents real prices of cod with different characteristics. Real prices increase for almost all types of cod, except for cod in Class B, until 2007. Since then, real, as well as nominal, prices have decreased. Comparing cod of different characteristics, it appears that Class B

receives considerably lower prices than the other classes and that the price of cod in this class decreases over time. Most of the cod landings in Swedish Baltic ports are classified as Class A cod, and the price of this class is, therefore, close to the average price during the time period. The price of Class E cod follows the price of Class A cod closely until 2008, when a price premium for Class E cod appears.

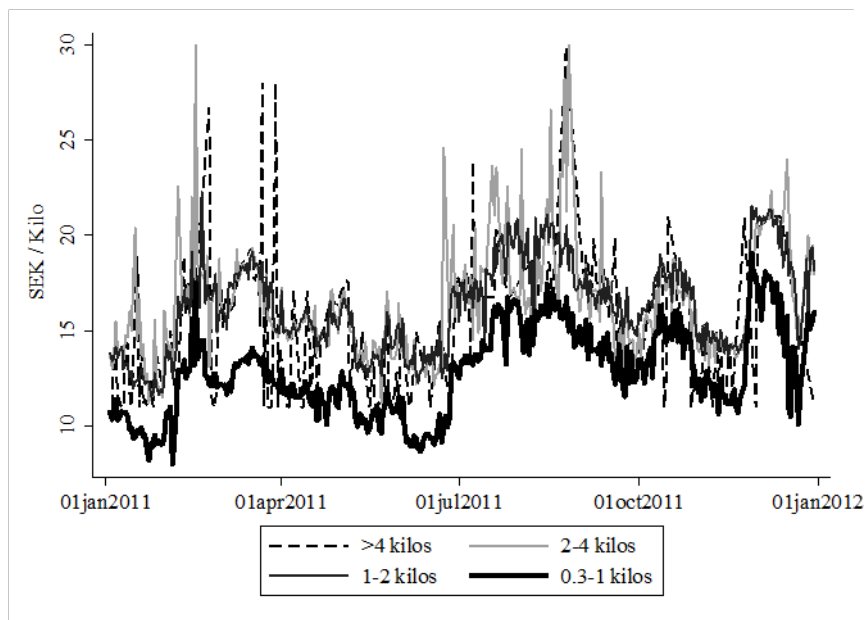


**Figure 2.**  
Prices of Cod with Different Characteristics (1997-2011), SEK/Kilo

Note: Prices are deflated by 1997 consumer prices from Statistics Sweden.

Looking at the prices of cod of different sizes, it is apparent that larger sizes receive higher prices. However, it appears that the smallest size category (Very Small) receive substantially lower prices than the other size categories. Another interesting observation is that the prices of different categories of cod appear to be more similar in the beginning of the time period and diverge more towards the end of the time period. This is an indication that different attributes of cod have become more important over time.

The inverse demand model uses information on daily attribute prices and landed quantities to estimate the effect of quantity changes on attribute prices. Hence, it is important that prices vary from day to day. An example of the price variations is shown in figure 3 where prices (in SEK per kilo) vary considerably between days in 2011. The diagram shows that prices, as before, are lower for very small cod (0.3 to 1 kilo). The price difference between the other sizes is more difficult to observe in the diagram, although it is clear that smaller cod (1-2 kilos) vary less in price than cod in the two largest size categories.



**Figure 3.**  
Day-to-day Variation of Average Prices of Class A Cod Landed in Swedish Baltic Ports in 2011

Note: Price observations that are larger than 30 SEK or smaller than 1 SEK have been omitted in order to get a clearer picture. A total of 1,394 observations are lost, which is only 0.002 % of the total number of observations in the dataset.

The diagram also reveals seasonal patterns; the price is higher in late summer and lower in the beginning of the year. Running a regression of monthly dummies in a simple hedonic model shows that a similar pattern occurs during the entire time period. This regression also shows that the price is highest in October and lowest in May.<sup>9</sup>

Table 2 summarizes the variables used in the regressions. In the first stage of the Brown and Rosen model,  $p_{nt}$  is regressed on six dummy variables (z-variables). In the second stage, the estimated marginal prices of the first stage are used to estimate the inverse demand functions using the quantity variables defined in table 2. Imports of fresh and chilled cod<sup>10</sup> to Sweden are used as a numeraire. In the RC model all variables are estimated in one step.

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<sup>9</sup> The results are available upon request.

<sup>10</sup> Fresh and chilled cod has CN-number 030250 according to the Combined Nomenclature of tariff lines used in the European Union.

**Table 2.**  
Definition of Variables

Variable	Definition	Mean
p	Real price per kilo of each observation in SEK	14.26
z_L	Dummy variable, 1 for Large (>4 kilos)	0.05
z_M	Dummy variable, 1 for Medium (2-4 kilos)	0.18
z_S	Dummy variable, 1 for Small (1-2 kilos)	0.41
z_VS	Dummy variable, 1 for Very Small (0.3-1 kilos)	0.36
z_B	Dummy variable, 1 for Class B	0.04
z_E	Dummy variable, 1 for Class E	0.2
qL	Total quantity of Large cod, tons per day	0.56
qM	Total quantity of Medium cod, tons per day	2.25
qS	Total quantity of Small cod, tons per day	13.48
qVS	Total quantity of Very Small cod, tons per day	19.36
qB	Total quantity of Class B cod, tons per day	0.4
qE	Total quantity of Class E cod, tons per day	5.1
qIM	Total quantity of imports of fresh and chilled cod, tons per month	521
tr	Trend	
Constant	Constant	

## Results

Hedonic real prices are presented in table 3, which shows the results of an ordinary least squares (OLS) regression using all observations, the average of the coefficients from the first stage of the Brown and Rosen (BR) model and the average coefficients of the dummy variables of attributes ( $\mathbf{z}'_{nt}\boldsymbol{\gamma}$ ) in the RC model.<sup>11</sup> Since the model is run without a constant and all the size variables are included, the coefficients of the size variables show the average prices of cod of each size in quality

<sup>11</sup> Here the RC model is estimated without a time trend in order to get average values comparable with the OLS and Brown and Rosen models.

Class A. The coefficients of the quality attributes (Classes E and B) show the price premia of supplying a product of better or worse quality.

**Table 3.**  
Attribute Prices

	OLS	BR Model, Average of Coefficients	RC Model Coefficients
z_L	14.9746***	15.6926	16.3007***
z_M	14.2180***	14.8874	15.1857***
z_S	14.2184***	14.64	14.8504***
z_VS	11.6026***	11.954	12.0628***
z_B	-5.8873***	-6.4069	-6.7406***
z_E	1.2571***	1.2686	1.3624***

Note: The number of observations in the OLS and RCmodel is 731,540. The number of regressions in the first stage of the BRmodel is 5,307. Significant levels are: \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ .

All models show the same pattern and have similar coefficients. Since the number of observations is much larger in the beginning of the time period, the price differences in the OLS model reflect the situation in the beginning of the time period to a larger extent than the other models (compare figure 2). The Brown and Rosen model shows the average of the coefficients from 5,307 landing-day regressions and hence accords each landing day equal importance. Since price differences increase over the time period (figure 2), the higher prices of Medium and Large cod as compared to OLS is not surprising. Finally, the RC model, which includes all the interaction terms (except the trend interactions) and random error terms in equation 5 (not presented in table 3), show slightly larger average prices over the time period.

Although the three models show a similar pattern, the RC model is preferred, mainly because it takes differences in landing days into account. A log-ratio test comparing the RC model to a model without the interaction terms, and the variance-covariance components (i.e., a model corresponding to the OLS model) confirms that the unconstrained RC model is preferred. Furthermore, by adding the second level explanatory variables the remaining error variance decreases from 7.85 to 1.44,

indicating that the second level is important in explaining price differences. Since the Brown and Rosen model is run in two steps, it is not nested in the other models and comparisons are somewhat more difficult. However, the coefficients on the quantity variables are less significant than in the RC model, which also suggests that the RC model is preferred.

Using the results from the RC model, the real price difference between Very Small cod and Small cod is 2.79 SEK. The difference between the real prices of other size classes is smaller; the difference between Small and Medium cod is only 0.33 SEK, on average, over the time period using the RC model results. Large cod has a somewhat higher price premium; the price of Large cod is 1.12 SEK higher than the price of Medium cod according to the RC model. Interestingly, the results on the size variables are similar to the findings of Lee (2014) who also finds that the size premium is non-monotone; i.e., price differences are larger for smaller sizes of cod. The effect of increased quality on price, i.e.; the change from Class A to Class E, increases the price of cod by 1.36 SEK using the RC model. Class B cod, on the other hand, generates significantly lower prices than Class A or Class E cod in all models. This suggests that Class B cod is of significantly lower quality than Class A.<sup>12</sup>

The results of inverse demand from the RC model; i.e., the coefficients of the interaction variables in equation 5, above, are presented in table 4.<sup>13</sup> As with the hedonic prices, the size coefficients have to be interpreted as changes in prices of Class A cod. The reason for choosing this category is that it is the most common (80 to 90 % of the landings). The coefficients are interpreted as the effect on price of a 100 % increase in quantities of different attributes as compared to the mean quantities (table 2). To facilitate comparison with other studies, flexibilities are presented in the Appendix (A1).

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<sup>12</sup> Testing the coefficients on the  $\mathbf{z}'_{nt}$  – variables of the size attributes show that these coefficients are significantly different from each other in the RCmodel.

<sup>13</sup> Estimated using the xtmixed command in STATA.

**Table 4.**

Results of Inverse Demand from the RC Model: Marginal Effects of Quantity Changes

	z_L	z_M	z_S	z_VS	z_E	z_B
qL	-0.1872***	-0.1189***	-0.1055***	-0.0987***	0.0133	0.0675***
qM	-0.1189***	-0.1708***	-0.1477***	-0.01	-0.0006	0.0709***
qS	-0.1055***	-0.1477***	-0.1758***	-0.0805***	0.0211	0.0708***
qVS	-0.0987***	-0.01	-0.0805***	-0.2923***	0.0027	0.0508***
qE	0.0133	-0.0006	0.0211	0.0027	-0.1055***	-0.0144
qB	0.0675***	0.0709***	0.0708***	0.0508***	-0.0144	-0.0184
tr	0.1943***	0.0703***	0.0003	-0.0670***	0.1385***	-0.1452***

Note: The number of observations is 731,540. Significant levels are: \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ .

Most coefficients are significant and have the expected sign.<sup>14</sup> The own-quantity effects are expected; increasing the amount of Large, Medium, Small, Very Small, and Class E cod gives lower prices of these attributes. The effect on the price premia of increasing the amount of cod in Class B is not significant. Class B cod has a substantially lower price than other types of cod and the landed quantity is small (figures 1 and 2). The own-quantity effect is largest for the Very Small cod (0.3-1 kilo); when the quantity of Very Small cod doubles, the price decreases by 0.29 SEK. The own-quantity effects of the other size attributes are very similar, and the results indicate that price decreases by 0.17-0.18 SEK, on average, when quantities increase by 100 %. This suggests that increasing the weight of cod to more than 2 kilos would not affect prices substantially. However, the relatively small price premia on larger sizes of cod might discourage fishers from aiming for cod larger than 2 kilos. One possibility is that this is a short-term effect due to processors being restrained by current technology. If the supply of larger-sized cod were to increase substantially, technology could also change and prices would increase for larger sizes of cod. An increase in the amount of Class E cod in the market does not affect price as much as increases in size

<sup>14</sup> The regression was also run using robust standard errors: however, this did not change the significance of the coefficients in any significant way.

attributes, indicating that demand for Class E cod is relatively insensitive to quantity changes.

Cross-quantity effects are negative between the size attributes, indicating that different sizes are substitutes. Cross-quantity effects are significant in all cases except between Very Small and Medium cod. There is also some indication that when cod are closer in size, the effect of quantity changes on price is larger. For example, if the quantity of Medium and Small cod increases by the same amount, the price of Large cod will be affected more by the increase in Medium cod. The price of Medium cod also seems to be more affected by quantity changes in Large and Small cod than by quantity changes of Very Small cod. In fact, Very Small cod does not seem to be affected much by quantity changes in substitute attributes.

The cross-quantity effects of Class E and Class B cod are positive in most cases although insignificant for Class E cod. Increasing the amount of Class E cod does not seem to affect the prices of other attributes except for the price of Class E cod itself. However, increasing amounts of Class B cod increase the price of all the size attributes, indicating that larger amounts of low-quality cod increase the value of average quality cod.

The coefficients for the trend variables shows that, over time, Class B cod and Very Small cod are less preferred, while Class E cod and Large cod are more preferred. On average, the price of Class E cod increases by 0.14 SEK per year, and the price of Large cod increases by 0.19 SEK per year. Also, the price of Medium-sized cod is increasing, although a bit less, over time. The pattern is similar to that of Kristofersson and Rickertsen (2004), who find a trend in demand away from bad and towards better-quality cod over time. Thus, there is an indication that markets give an increased value to larger, higher-quality cod over time.

The variance and covariance components of the RC model are shown in the Appendix (table A3). All variance components are significant and all covariance components, except one, are significant. The estimates show that attribute prices variability is greater the larger the cod and also greater for cod in quality Class B. The variability of the size attributes

confirms the pattern in figure 3. The results from the second stage of the Brown and Rosen model are also shown in the appendix (table A2). These results are similar to those presented above: own-quantity effects are negative, cross-quantity effects are smaller and give an indication of whether attributes are substitutes or complements. As in the RC model, time trends indicate that larger, better-quality cod is valued more over time. However, the coefficients are smaller in magnitude and the number of coefficients significant at the 0.1 percent level is smaller. As mentioned above, the results from the RC model seem to be more robust.

The theoretical model in Kristofersson and Rickertsen (2004) suggests that demand also depends on the production of the fish processors. Since it is not possible to get a reliable measure of cod production, this variable has been omitted from the regression above. However, a sensitivity check is run, where the quantity of monthly exports of cod products from Sweden are used as a proxy for production. When using the proxy, the results show that most hedonic price coefficients become slightly smaller, whereas the coefficients on the quantity variables become somewhat larger.<sup>15</sup> The marginal hedonic price of Class E fish becomes insignificant, while the own-quantity effect of Class B fish becomes significant. Also, four coefficients on cross-quantity effects that were insignificant in the original model now become significant. In general, the ranking of coefficients seems stable between the original and the new model. Although the model with the production proxy seems to result in more significant coefficients, it is not entirely clear that exports are a good proxy for production.<sup>16</sup> The main conclusion from this exercise is that the coefficients might be somewhat downward biased in the original specification because of the omitted production variable.

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<sup>15</sup> The results are available upon request.

<sup>16</sup> Exports constitute around 20 % of the production of fish processors. The correlation of yearly real returns and real exports from 1997-2010 is 0.23, so there is possibly some correlation between the proxy and the variable of interest, although it is rather weak. The composition of cod products in exports may also have changed over time, something that is not possible to account for.

## Discussion and Policy Implications

An interesting aspect of the Swedish Baltic cod fishery is that both fishermen and researchers are looking for methods to increase the size of Baltic cod. For example, the Swedish Association of Cod Producers is aiming at increasing the minimum size of landed cod to above 40 cm (STPO (Svenska Torskfiskares Producent Organisation). 2012). In addition, as mentioned above, increasing the size of Baltic cod has also been suggested as desirable by a number of biological studies. One of the most important expectations of increasing cod size is that it will generate higher revenues for fishermen.<sup>17</sup> Thus, the effects of quantity changes on attribute prices could be used to indicate how revenues change as the composition of landings change.

Cardinale and Hjelm (2012) estimate revenues from changing the size range of Eastern Baltic cod by introducing methods for size selectivity (i.e., regulating gear mesh size). The optimal scenario is to harvest cod that has reached a length of 70-77 cm and is 5-6 years of age. This cod would be of Medium size, weighing between 2 and 4 kilos, according to the definition used above.<sup>18</sup> Two different price scenarios are used in Cardinale and Hjelm (2012), where prices are assumed to be either the same for all sizes or vary between sizes such that the largest cod is 65 % more expensive than the smallest cod. These prices are based on Swedish cod prices in 2010. Initially size selective harvesting will result in a loss, since there are currently few large cod in the population. However, the authors conclude that revenues would increase in the long run and would be higher than under the current management plan within five years. Prices in the study are unrelated to other quality attributes or changes in quantities.

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<sup>17</sup> Although it could theoretically be possible that costs per unit increase when catching larger fish, it is not a realistic assumption since the inputs of fishermen (boats, nets, fuel consumption) are likely to be the same for small and large fish.

<sup>18</sup> The length-weight relationship is approximate and based on personal information given by the Swedish Institute of Marine Research 2013-04-22, Hans Nilsson.

Froese et al. (2008) investigate how size selective fishing in the Western Baltic can increase the biomass more than under the management regime proposed by the European Commission, which aims for the maximum sustainable yield. An age structure that is similar to an unfished stock could give the same yield as in the EU management regime. The optimal size of cod is then 80 cm, which would be equivalent to cod in the largest size category, Large, in the dataset used above.

Considering that only 10 % of the cod catch consisted of cod that is larger than 2 kilos, on average, during 1997-2011 the optimal scenarios in the biological studies, above, are far from today's situation. One challenge when using the coefficients from the RC model is that it is difficult to extrapolate to compositions of landings that differ from those observed during the time period studied. However, by experimenting with the quantities caught of different size attributes we can move in the direction of the optimal scenario. An attempt to do so is presented below, but the results must be interpreted with caution.

To simplify, we assume that the total quantity does not change and that all cod is Class A. Then, assuming that cod weighing less than 1 kilo is no longer fished, perhaps because of a mesh size regulation, the revenues from Very Small cod will disappear. Initially, as discussed by Cardinale and Hjelm (2012), total revenues will decrease. But eventually the Very Small cod that are left will grow. Assuming that all cod caught have grown into the next size category the quantities of Large, Medium, and Small cod will increase and attribute prices will decrease. The effects of this experiment on revenue are shown in table 5, where the new revenue is also compared to the old revenue and the expected revenue without taking into consideration quantity effects.

**Table 5.**

Changes in Prices and Revenues using the Parameters from the RC Model

	p_L	p_M	p_S	p_VS	
Price at average quantities	18.511	15.733	14.341	10.653	
Price change because of change in qVS	0.099	0	0.081	0.292	
Price change because of change in qS	-0.046	-0.065	-0.077	-0.035	
Price change because of change in qM	-0.592	-0.85	-0.735	0	
Price change because of change in qL	-0.757	-0.481	-0.427	-0.399	
Total price change	-1.296	-1.395	-1.158	-0.142	
Price at new quantities	17.215	14.337	13.183	10.511	Total revenue (SEK)
Revenue in SEK	48,413	193,211	255,243	0	496,868
Initial revenue in SEK	10,323	35,471	193,261	206,265	445,320
Unadjusted revenue in SEK	52,058	212,014	277,662	0	541,734

Note: Assuming all fish has grown into the next size category and initial prices are at 2011 prices given by the model (see text for details).

Using the calculated attribute prices from the RC model for 2011 as the initial prices, the price changes from quantity changes of different attributes are calculated. The new attribute prices are lower for Large, Medium, and Small cod. In this case, the price of Large and Medium cod is affected more than the price of Small cod. This is because the percentage quantity changes are much larger for Medium and Large cod. However, despite lower prices, the last column to the right shows that average revenues per day increase in the new situation. This is due to the shift away from Very Small cod that have lower prices. The last column also shows that total revenue is lower when using the coefficients from the inverse demand model than if unadjusted prices are used, as in Cardinale and Hjelm (2012). Using unadjusted prices results in an overestimation of approximately 47,000 SEK, or a 10 % increase of the initial revenue.

Several studies (Quaas et al. 2010; Diekert 2011; Ravn-Jonsen 2011) conclude that TACs and tradable quotas, measured in terms of biomass, will fail to solve the problem of growth overfishing; i.e., the situation when fish are caught at an inefficiently low age and weight class. The solution would be to measure the TACs and tradable quotas in terms of number of fish.<sup>19</sup> An underlying assumption in studies on growth overfishing is that the revenues of fishers increase when larger-sized fish are landed. Here, we have shown that prices are higher for larger-sized cod than for the very smallest cod and that prices will not decrease substantially when the amount of larger cod increases on the market. Hence, there will be incentives for fishermen to aim for larger sizes of cod if quotas are set in numbers of fish rather than quantities. Furthermore, the time trend quantity changes in this study show that larger, better quality fish have become more valuable over time, suggesting that larger, higher-quality cod is part of the demand for the future.

Despite the fact that increasing quantities of Swedish Baltic cod seem to have a downward effect on prices, these effects are small. This is not surprising; market integration studies (Gordon and Hannesson 1996; Asche, Gordon, and Hannesson 2002; Nielsen 2005) have found that the European markets for fresh cod are integrated. A large quantity change on the Swedish market is thus only a small quantity change in a European context and will have a small effect on the prices of cod. For example, Nielsen, Smit, and Guillen (2012) estimate the own-price flexibility of fresh cod at -1.26 on the European market, and according to the same study 570,000 tons of cod were landed on average, in European ports from 1995-2005. Landings of cod in southern Sweden were only 12,500 tons per year (average from 1997-2005), which corresponds to 0.02% of the total European landings. Using the Nielsen, Smit, and Guillen (2012) price flexibility, an increase of Swedish landings by 0.01% is expected to result in a 0.0126% price reduction, on average.

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<sup>19</sup> The same effect could arise if mesh size were increased by regulation, but the cost of monitoring would perhaps be higher for society.

This can, for example, be compared to the price flexibility of 0.0118% for small cod estimated with the hedonic model above.

The fact that price changes are small will have implications for local management, since any local measures will have small effects on prices. This might be advantageous from a management point of view, since there will be no disincentives for better management by fishers from falling prices. A main point of this study is to check the differences of price effects between different attributes, since management can affect the supply of attributes (i.e., the composition of the fish stock). If an increased supply of large cod results in a greater price reduction than a corresponding supply of small fish, stock management might be less beneficial to fishers than expected. This does not seem to be the case for Swedish Baltic cod.

## **Conclusions**

This study uses a RC model to estimate the attribute prices and inverse demand of Baltic cod landed in Swedish ports in the period 1997-2011. A detailed dataset makes it possible to use daily observations of cod landings of different size and quality rating classes. The results show that there is a price difference of 2.79 SEK between cod weighing 0.3-1 kilos and 1-2 kilos. Looking at larger sizes of cod, price premiums are increasing less per kilo added. The price difference between cod weighing 1-2 kilos and 2-4 kilo is only 0.33 SEK. The largest cod in this study, defined as weighing more than 4 kilos, are, 1.12 SEK more expensive than the 2-4 kilo cod, on average.

Looking at the quality ratings, there is a clear indication that cod classified as Class B is of inferior quality. Prices are much lower than for the most common quality rating, Class A. However, the highest quality class, Class E, generates only somewhat higher prices (a price premium of 1.36 SEK in the RC model) than Class A cod.

The results of inverse demand show that own-quantity effects are negative for all attributes, and cross-quantity effects are negative between size attributes indicating that size attributes are substitutes. This

means that when the quantity of cod with a certain attribute increases, attribute prices of that particular attribute decrease, as do prices of other size attributes. The largest own-quantity effect is for the smallest cod in the sample; when the quantity of small cod increases by 100 %, the price decreases by 0.29 SEK. The own-quantity effects of the other size attributes range between 0.17 and 0.18 SEK. Over time, the results suggest that the prices of larger cod and cod with the highest quality rating are increasing.

The fact that price effects are small is not surprising considering that studies of market integration often find that cod is traded on an international market of whitefish. However, the management system chosen for a particular fishery will affect the size and quality composition of fish landed. A management system that increases the size and the quality of landed fish will, to some extent, face the law of demand; as the quantity of attributes increases, prices will decrease. This study has shown that the price effects of increasing quantities of attributes are moderate, but nevertheless too important to ignore. Thus, when the revenues of future management systems are modeled, the price effects of attributes should be considered.

## Appendix

Flexibilities are calculated using the inverse demand model that is estimated with random coefficients. The results are presented in table A1 below.

**Table A1.**  
Flexibilities of the Second-level Parameters of the RC Model

	z_L	z_M	z_S	z_VS	z_E	z_B
qL	-0.0127***	-0.0081***	-0.0071***	-0.0078***	0.0618	-0.0117***
qM	-0.0081***	-0.0117***	-0.0099***	-0.0008	-0.0027	-0.0123***
qS	-0.0072***	-0.0101***	-0.0118***	-0.0064***	0.0983	-0.0123***
qVS	-0.0067***	-0.0007	-0.0054***	-0.0231***	0.0125	-0.0088***
qE	0.0009	0.0000	0.0014	0.0002	-0.4923***	0.0025
qB	0.0046***	0.0048***	0.0047***	0.0040***	-0.0673	0.0032
tr	0.0132***	0.0048***	0.0000	-0.0053***	0.6462***	0.0252***

Note: Significant levels are: \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ .

The results from the second stage inverse demand functions of the Brown and Rosen model are presented in table A2. The price premiums of each attribute from the first-stage models are used as dependent variables in the regressions together with a time trend. The equations are estimated as a system,<sup>20</sup> which is reasonable since error terms might be correlated across the equations. For example, what influences prices of large fish on a certain day will also influence prices of small fish on that day. The system is also estimated with the same homogeneity and symmetry restrictions used in the RC model.

<sup>20</sup> Using the `surreg` command in STATA.

**Table A2.**

Results from the Second-stage Inverse Demand Brown and Rosen model, System Estimation

	z_L	z_M	z_S	z_VS	z_E	z_B
qL	-0.0659***	-0.0343**	-0.0345***	-0.0303**	0.0072	0.0105
qM	-0.0343**	-0.0694***	-0.0566***	0.003	-0.0021	0.0159*
qS	-0.0345***	-0.0566***	-0.0830***	-0.0199*	0.0186**	0.0180**
qVS	-0.0303**	0.003	-0.0199*	-0.1229***	-0.0016	0.0101
qE	0.0072	-0.0021	0.0186**	-0.0016	-0.0342**	-0.0032
qB	0.0105	0.0159*	0.0180**	0.0101	-0.0032	0.0038
tr	0.3541***	0.1553***	0.0531***	-0.0349**	0.1432***	-0.1922***
Constant	13.7495***	14.0660***	14.4054***	12.2432***	0.0736	-5.2652***

Note: The number of regressions in the first stage of the BR model is 5,307. Significant levels are: \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ .

The results, when significant, are of the expected sign. Similar to the RC model, the own-quantity effects are negative for the prices of Large, Medium, Small, Very Small, and Class E fish and looking at the size prices, the largest effect of increasing the quantity is on the very smallest fish. Additionally, similar to the RC model, the own-quantity effect of Class E cod is smaller than the own-quantity effects of the size attributes.

The variance and covariance components of the RC model are shown in table A3. All variance components are significant and all except one, of the covariance components are significant. The estimates show that the attribute price variability is greater the larger the cod and greater for cod in quality Class B. The variability of the size attributes is confirmed in figure 3.

**Table A3.**

Variance and Covariance Component Estimates of the RC Model

	z_L	z_M	z_S	z_VS	z_E	z_B
z_L	12.86	9.47	8.41	7.24	-0.94	-5.96
z_M	9.47	8.27	7.68	6.65	-0.66	-5.63
z_S	8.41	7.68	7.43	6.52	-0.53	-5.61
z_VS	7.24	6.65	6.52	6	-0.45	-4.86
z_E	-0.94	-0.66	-0.53	-0.45	1.63	-0.07 <sup>a</sup>
z_B	-5.96	-5.63	-5.61	-4.86	-0.07 <sup>a</sup>	6.74

<sup>a</sup> indicates that the result is not significant at the 5% level. All the other results are significant at the 0.1 %level.

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# Chapter 3

## Time for Fishing: Bargaining Power in the Swedish Baltic Cod Fishery

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### **Introduction**

Property rights, such as Individual Transferable Quotas (ITQs), have the potential to reduce capacity and increase profitability in the fishery sector (Andersen, Andersen, and Frost 2010; Arnason 2008; Gómez-Lobo, Peña-Torres, and Barría 2011; Suitinen 1999; Waldo and Paulrud 2013). However, the introduction of property rights and the way these are designed might have effects not only on fleet size and the cost structure of the fleet, but also on the distribution of rents between fishers and processors in the ex-vessel market for fish (Hackett et al. 2005; Matulich, Mittelhammer, and Reberte 1996; McEvoy et al. 2009). By studying reform-related price changes it is possible to understand how rent distribution is affected, and why there might be resistance to reforms.

In this paper, we contribute to the literature by analyzing price formation in the Swedish Baltic Sea cod fishery when the management system changed from quarterly to annual quotas. The new management system introduced more flexibility for fishers since the obligation to land on a quarterly basis was removed. This could result in landings becoming

more irregular if, for example, costs are lower during certain time periods (Costello and Deacon 2007 and Fell 2009) or if alternative fishing possibilities generate higher rents during certain periods (Sheld, Anderson, and Uchida 2014). Processors, on the other hand, are reliant on regular landings, since processing capacity is fixed in the short run and hence capital and labor resources might be wasted with more irregular landings. In addition, down-stream markets (i.e. wholesalers and retailers) might be willing to pay more for fish that is regularly delivered. Thus, in the short run, processors might be negatively affected, and concerns about supplies for processors were accordingly raised in the proposal for the new management system (Swedish Board of Fisheries 2010a).<sup>1</sup>

The purpose of this paper is to examine whether the new management system has altered the price formation process in the ex-vessel market. There is considerable dependency between fishers and processors on the Baltic Sea coast of Sweden, and both groups operate on markets with limited entry, which implies that there is a bargaining situation on the market. More specifically, as the fishers' flexibility to allocate landings within the harvest season has increased, we hypothesize that the bargaining power of the fishers should improve. To test the hypothesis of increased bargaining power of fishers empirically, we use detailed price data from landing tickets submitted to the Swedish Agency for Marine and Water Management. To identify the bargaining power effect, we utilize the fact that the regulatory change only applied to vessels using active gear (i.e. bottom trawlers). Thus, the segment of passive gear (i.e. vessels using nets and hooks) is used as a control group, and the effects are operationalized as changes between the two groups.

The method of using control groups for estimating effects of regulatory change in fisheries have been used in previous studies. For example, Wakamatsu (2014) uses a control group for assessing the impact of a MSC certification in Japan. More closely related to our study, Scheld,

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<sup>1</sup> Of course, other effects than price effects are likely when introducing a new management system. For example, Hutniczak (2014) notes that decreasing quotas of Baltic cod may lead to increased catches of other species.

Anderson and Uchida (2012) analyse the economic effects of a catch share management pilot program. Vessels taking part in the program are matched to vessels not taking part by using a number of vessel-specific covariates and two vessel groups are thus formed. Landed quantities of the vessel groups after implementation of the reform are then compared. This strategy might be useful if the *observed* matching variables are successful in controlling for all differences between groups that are unrelated to the regulatory change. In this paper, we apply a similar identification strategy, but instead of using matching we employ a difference-in-differences (DID) methodology. The benefit of the DID approach is that it is able to control for *unobserved* time-invariant differences between the “treatment” and “control” groups. To the best of our knowledge, the quasi-experimental approach used in our study is a novelty in the literature on the relative bargaining power of fishers and processors.

Earlier studies have analyzed price effects when introducing new management system in fisheries, for example Herrmann (1996), Herrmann (2000), Grafton, Squires, and Fox (2000), Alsaharif and Miller (2012) and Dupont and Grafton (2001). Although the full price effect of a new management system might be interesting as such, it is difficult to determine exactly what factors contribute to such price changes. For example, reform-related price changes can occur if the quality of fish changes, or if fish is landed in certain ports on certain dates when fishing costs are low. Our study investigates the effects of the reform on bargaining power, and focuses on the idea that the reform made it possible to fish at times more suitable for fishers, but perhaps more unsuitable for processors. By looking at this one aspect, i.e., the bargaining power of fishers, the effect of other reform-related price changes can be left out of the analysis.

The quotas for the Baltic cod stocks (the eastern and the western) are set by the EU each year, but within the system member states have great flexibility to allocate national quotas among their vessels. The Swedish Baltic cod fishery is regulated by non-transferable individual quotas and traditionally, the fishery was regulated by weekly catch rations, i.e. each vessel was allocated a short-term quota lasting for one week and the

quota could not be saved for later periods. The aim of the system was to prevent the overcapitalized fishery from landing the entire quota at the beginning of the year. To protect the small scale fishery the Swedish quota has further been divided into one part for the small scale fishery (passive gear) and one part for vessels using active gear since 2007. The weekly catch rations were abandoned on 5 April 2010. From this date, vessels using passive gear have been able to operate without catch restrictions (FIFS, 2010). For vessels using active gear, however, the weekly catch rations were replaced by quarterly catch rations. About a year later, 1 April 2011, yearly quotas were introduced for vessels using active gear (FIFS, 2011).

## Data

The database used in this study is provided by the Swedish Agency for Marine and Water Management, and includes information about prices, landed quantities, size classes and quality classes. All fish receivers in Sweden are compelled to send this information to the Swedish Agency for Marine and Water Management. The dataset used in this study includes cod that was commercially traded in Swedish Baltic harbors between 1 April 2010 and 31 December 2011, i.e. the period after the latest regulatory change that affected both vessel types (active and passive). Some summary statistics from the database are presented in Table 1.

**Table 1.**  
Summary Statistics

Segment	No. Landings	No. vessels	Quantity (tons)	Av. price (SEK)	Important ports
Passive	32 416	197	3 542	13.8	Skillinge, Nordersund, Simrishamn
Active	9 799	49	12 297	13.3	Simrishamn, Karlskrona-Saltö
<b>Total</b>	42 215	244 <sup>1</sup>	15 838	13.4	

Source: the Swedish Agency for Marine and Water Management.

Note: Av. is shorthand for Average. Quantity landed (in tons) live weight. The prices are expressed in Swedish crowns (SEK). 1 SEK  $\approx$  0.11 €.

<sup>1</sup> The total number of vessels is not the sum of active and passive vessels since two vessels changed their status during the time period.

Table 1 shows the number of landings (i.e. the number of observations) for vessels using active and passive gear. For each landing the following is reported: the amount landed, the price paid for the landing, the id-number of the vessel, the size class of the landing, the quality class of the landing, the port where the landing was registered, the id-number of the buyer and the date when the landing arrived. Vessels using passive gear have more than three times as many landings as vessels using active gear. This is to be expected since vessels using passive gear are generally smaller and thus have smaller storage capacities. There are 197 vessels using passive gear and 49 vessels using active gear included in the dataset. Vessels using active gear also land considerably more cod than vessels using passive gear (12 297 tons compared to 3 542 tons). The average price of cod (all sizes and quality classes) is 13.44 SEK during the time period and passive vessels receive slightly more than active vessels.

The dataset also reveals that the landings of cod are geographically concentrated. The most important ports for landing cod fished in the Baltic are Simrishamn (40 percent of the landed quantity) and Karlskrona-Saltö (25 percent). Vessels using active gear land 79 percent of their cod in these two harbors. The landings by vessels using passive gear are somewhat less concentrated with 50 percent in three ports (Skillinge, Nordersund and Simrishamn).

Taking a closer look at the prices of cod of different size and quality classes, Table 2 reveals that there are price premiums for larger cod and for cod of better quality. Cod in Class E is defined as fish that must be free of pressure marks, injuries, blemishes and bad discoloration. Cod in Class A and B have similar but slightly lower demands on the quality of the product (European Commission 1996).

**Table 2.**  
Average Prices of Cod

Size Classes	Class A	Class B	Class E
>7 kilos	17.1	13.8	20.1
4-7 kilos	16.0	12.4	19.4
2-4 kilos	15.5	10.4	18.4
1-2 kilos	15.3	9.9	16.6
0.3-1 kilos	11.9	7.8	12.5

Source: the Swedish Agency for Marine and Water Management.

Most of the landed quantity (86 percent) is Class A and categorized in one of the smaller size classes, i.e. between 0.3 and 2 kilos. The price discount when cod is classified as Class B is substantial, although only a small proportion of the landings is classified in this category (0.2 percent of the landed quantity). On the other hand, the price premium of landings of cod in Class E is not that large, especially not for the smallest size category. Around 9 percent of the landings are in Class E.

The data show that there are differences between segments, and that different qualities and sizes of cod have different prices. The latter is consistent with recent studies using hedonic price models to estimate the price premium of size and quality (e.g. Lee 2014; Hammarlund 2015). Thus, it is important to take these differences into account when estimating bargaining power. This issue will be further discussed below.

## Imperfect Market Competition

There are good reasons to expect most regulated fisheries and ex-vessel markets to be imperfectly competitive. Fishers are restricted by limited entry programs, TAC restrictions, season length restrictions and technical regulations on equipment, and ex-vessel markets are often restricted by inaccessibility because of geographical remoteness and entry costs of the processing industry. These characteristics of the primary fish market are also relevant for the Swedish cod fishery and are discussed below.

Two regulations are especially important in limiting entry into the fishery. First, all vessels above 8 meters engaged in the Swedish Baltic Sea cod fishery need a special permit. In 2012 permits were given to 249 vessels (Swedish Agency for Marine and Water Management 2012). Second, because of overcapacity problems the fishery was closed to new entrants between 2008 and 2011 (it was not until 2011 that small scale fishers could seek new permits, (FIFS 2011)).<sup>2</sup> This ban on entry is perhaps the most important regulation limiting competition among fishers.

Rules and regulations can incur fixed costs of entering the processing sector. For example, strict hygienic requirements make it difficult for fishers to sell their catch directly to consumers without making costly investments (Swedish Board of Fisheries 2010b). Looking at the data, there is clear evidence that the processing industry is characterized by an oligopsonistic structure. The majority of the landed volume is bought by a handful of large agents, indicating that the Swedish cod processing sector has economies of scale. To convey an idea of the concentration of the cod processing industry analyzed in this paper, Table 3 displays the volume and percentage of cod sold to the five largest buyers in the ex-vessel market in 2010-2011 (there was a total of 55 buyers in the market).<sup>3</sup>

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<sup>2</sup> Although new vessels were allowed to enter in 2011 the number of passive vessels continued to decrease after the reform (from 181 before the reform to 173 after the reform). Thus, the relaxed entry regulation did not seem to affect competition among vessels.

<sup>3</sup> Buyers are assumed to be processors or deliver to processors. We make no particular distinction between them.

**Table 3.**

Concentration of the Cod Processing Industry 2010-2011

<b>Processor</b>	<b>Volume (tons)</b>	<b>Percent of total harvest</b>	<b>Cum. percent of total harvest</b>
<b>1</b>	5006	25.3	25.3
<b>2</b>	4084	20.6	45.9
<b>3</b>	2351	11.9	57.7
<b>4</b>	2193	11.1	68.8
<b>5</b>	2127	10.7	79.5

Source: Authors calculations based on data from the Swedish Agency for Marine and Water Management.

Note: Total volume (in tons) live weight and percentage of total harvest sold to the five largest buyers (from 1 April 2010 to 31 December 2011). Cum. is shorthand for Cumulative.

As evident from the table, the majority of cod landed is sold to five large buyers that purchased almost 80% of the total landings. In the extreme case when fishers can only deliver to a single processing firm, we would expect the processor to offer a low ex-vessel price close to fishers' average cost and thereby extract all the rents generated in the fishery. In fact, the data used in this study shows that it is not unusual for one buyer to dominate the purchases in many of the smaller ports.

It is also evident from the data that fishers are highly dependent on specific ports and buyers. From 1 April 2010 until 31 December 2011 244 vessels landed cod in 58 Swedish Baltic harbors. Table 4 presents some statistics that show this dependency.

**Table 4.**

Fisher Dependency on Buyers and Ports

<b>Number of buyers (x)</b>	<b>Share of vessels that sold their landings to x number of buyers (%)</b>	<b>Number of ports (y)</b>	<b>Share of vessels that visited y ports over the time period (%)</b>
1	65	1	61.50
2	20	2	25.40
3	12	3	9.40
4	2	4	2.90
5	0	5	0.40
6	1	6	0.00
		7	0.40

Source: Authors calculations based on data from the Swedish Agency for Marine and Water Management.

Most vessels limited their landings to one particular buyer (65 percent) and one particular port (62 percent), indicating that there is a strong dependency between sellers and buyers. Only 20 percent of the vessels turned to 2 different buyers during the time period and 12 percent of the vessels turned to 3 different buyers. Turning to more than three different buyers is unusual; only 3 percent of the vessels turned to more than three buyers during the time period. The same pattern is revealed looking at the number of ports visited by the vessels: 25 percent of the vessels visited two ports, 9 percent visited three ports and only 3.7 percent of the vessels visited more than three ports during the time period.

As processors are highly dependent on a continuous supply of raw fish to make efficient use of their processing capacity and fulfill their commitments in the downstream market, they would like to prevent irregular landings. Irregular landings and seasonal closures force processors to import cod from abroad in order to guarantee a stable delivery of processed fish to food markets and other retailers (Swedish Board of Fisheries 2010b; County Administrative Board of Skåne 2005). The weekly catch rations were intended to mitigate this problem. In the new management system with annual individual quotas, fishers can

afford to be more patient in waiting for more profitable fishing periods. In this situation, an individual processor may need to offer higher ex-vessel prices to ensure a continuous supply of fish. If there is competition among processors, this price-raising action may induce other processors to raise their prices in order not to lose future contracts in the downstream market. Thus, we expect the new management system to increase ex-vessel prices through the increased bargaining power of fishers, especially since the fishery is more or less closed to new entrants.

## The Bilateral Bargaining Model

Some researchers have considered fisheries as consisting of an oligopsonistic processing sector buying fish from oligopolistic fishers (see Matulich, Mittelhammer, and Greenberg 1995 and the references therein). As noted by Fell and Haynie (2011) and Matulich, Mittelhammer, and Greenberg (1995), most of the relevant aspects discussed above can be captured in the bilateral bargaining model suggested by Blair and Kaserman (1987) and Blair, Kaserman, and Romano (1989). In this framework, an upstream firm (oligopolist) sells its products to a downstream firm (oligopsonist) and the firms bargain over how to split the profit resulting from their joint activities. The intermediate good price (in our case the ex-vessel price) reflects the bargaining outcome, and can be modeled as a linear combination of the price that would emerge from complete domination by the fisher and complete domination by the processor. We can illustrate the general idea by the following equation for the ex-vessel price:

$$p = \alpha(p^d - p^u) + p^u, \quad (1)$$

where  $p^d$  is the downstream firm's (processor's) reservation price and  $p^u$  is the upstream firm's (fisher's) reservation price. That is, the fisher would prefer not to fish if he is offered a price below  $p^u$ . Similarly, a processor would not accept a price above  $p^d$ . For a transaction to occur, it is required that  $p^d \geq p^u$ . While the second part of (1) constitutes the lower bound of  $p$ , the first part is subject to negotiation between the

fisher and processor. The coefficient  $\alpha$ , which lies between 0 and 1, signifies the level of fishers' strength in determining the ex-vessel price. For example, if  $\alpha = 0$ , processors will capture all of the profits generated by the fishery as the ex-vessel price is equal to the fishers' reservation price (if there is no outside option for the fisher, the reservation price equals the average cost of catching a unit of fish). On the other hand, if a large number of processors compete for raw fish, we expect  $\alpha > 0$  so that the price of cod is above  $p^u$ . The next section describes our approach to analyzing the effects of the new management system on the first part of (1).

## Estimating the Price Effects of a Change in Bargaining Power

Equation (1) above suggests that the bargaining power could be estimated given observations on  $p^d$  and  $p^u$ . However, the reservation prices are typically not observed. Moreover,  $\alpha$  may not be constant over time. To overcome these difficulties, Fell and Haynie (2011) propose an unobserved-component model to decompose the observed ex-vessel price into its unobservable components  $(\alpha, p^d, p^u)$ . Estimation of the model is carried out by the use of nonlinear filtering techniques and requires the authors to specify the two functions determining the reservation prices, and a time series model for the bargaining coefficient. Although promising, a precise estimate of the bargaining power requires an adequate specification of the functions determining the reservation prices, and data on relevant explanatory variables. Failing this, we may obtain spurious estimates of the bargaining power coefficient.

In this paper we follow Fell and Haynie (2011) in that we allow the bargaining power to be time-varying. However, in contrast to them, we make use of a quasi-natural experiment to explore the changes over time. The idea is very simple: to measure the effect of the increased flexibility, we are interested in the price difference before and after the new management system,  $p^a - p^b$ . Here,  $p^a$  denotes the realized ex-vessel price if the fisher benefits from increased flexibility, and  $p^b$  is the ex post counterfactual outcome. If, on the other hand, the fisher is not

affected by the regulatory change,  $p^b$  will be realized and  $p^a$  will be the ex post counterfactual. Of course, we cannot observe both  $p^a$  and  $p^b$  because a fisher cannot be in both states. Instead, we use ex-vessel prices for fishers observed in one of the two groups (fishers using active and passive gear) in one of the two time periods (before and after the new management system). That is, while we are primarily interested in the group of fishers who benefit from the new management system (fisher using active gear), the segment of passive gear is used as a control group and the bargaining power effects are operationalized as changes between the two groups. More specifically, let  $p_{tlsq}$  be the average cod price at date  $t$ , in landing port  $l$ , for a particular size,  $s$ , and quality,  $q$ . We calculate the price difference between the groups as,  $\tilde{p}_i = \tilde{p}_{tlsq} = p_{tlsq}^a - p_{tlsq}^b$  where the superscripts  $a$  and  $b$ , indicate the group (active gear and passive gear, respectively) and  $i = 1, \dots, N$ . We consider two time periods,  $M \in \{0,1\}$ , which correspond to the two management periods (before and after the regulatory change). The so-called difference-in-differences (DID) estimator is given by

$$\hat{\pi}_{DID} = (\overline{p_1} - \overline{p_0}), \quad (2)$$

where  $\overline{p_m} = \sum_{(i|M=m)} \tilde{p}_i / N_m$  is the average price difference in management period  $m$ . By taking differences between groups we remove potential biases that could be a result of time trends (demand and supply fluctuations etc.) unrelated to the regulatory change. Similarly, the differencing over time removes any biases, which could be the result from permanent differences not related to the new management, in second period comparisons between the groups. To illustrate the benefit of the DID approach, we use a slight modification of equation (1),

$$p = p^u + \epsilon, \quad \text{where} \quad 0 \leq \epsilon \leq p^d - p^u, \quad (3)$$

where  $\epsilon$  reflects the markup over the fisher's reservation price. Combining equation (2) and (3) we obtain

$$\hat{\pi}_{DID} = ((\overline{p_1^u} + \overline{\epsilon_1}) - (\overline{p_0^u} + \overline{\epsilon_0})), \quad (4)$$

where  $\overline{p}_0^u = \sum_{(i|M=0)} \tilde{p}_i^u / N_0$ , with  $\tilde{p}_i^u$  being the difference in reservation prices between fishers using active and passive gear, and similar definitions of  $\overline{p}_1^u$ ,  $\bar{\epsilon}_1$  and  $\bar{\epsilon}_0$ . Assume for the moment that there is no systematic difference in reservation prices between fishers using active and passive gear, or that the difference in reservation prices is constant over time. In this case,  $E(\tilde{p}_i^u) = 0$ , which implies that  $E(\hat{\pi}_{DID}) = E(\bar{\epsilon}_1 - \bar{\epsilon}_0)$ . In other words, using the DID approach we can test whether fishers gain a higher markup in the new management period, controlling for a variety of confounding factors such as the quality and size of fish, port-specific characteristics that change over time and aggregate time trends such as supply and demand fluctuations. In practice, of course, it is not known if the reservation prices vary systematically between the groups, making it difficult to attribute an increase in price differences to increased bargaining power. We elaborate on this issue in the next section.

An estimate of  $\hat{\pi}_{DID}$  can be obtained from the dummy variable regression

$$\tilde{p}_i = \beta + \pi_{DID} \cdot W_i + u_i, \quad (5)$$

where  $u_i$  is the error term and  $W_i$  is an indicator variable, taking the value 1 in the new management period (after 1 April 2011) and 0 otherwise. That is, we are primarily interested in the quantity  $E(\tilde{p}_i|W_i = 1) - E(\tilde{p}_i|W_i = 0) = \pi_{DID}$ . The overall intercept  $\beta$ , reflects the difference in price between the groups prior to the new management system.

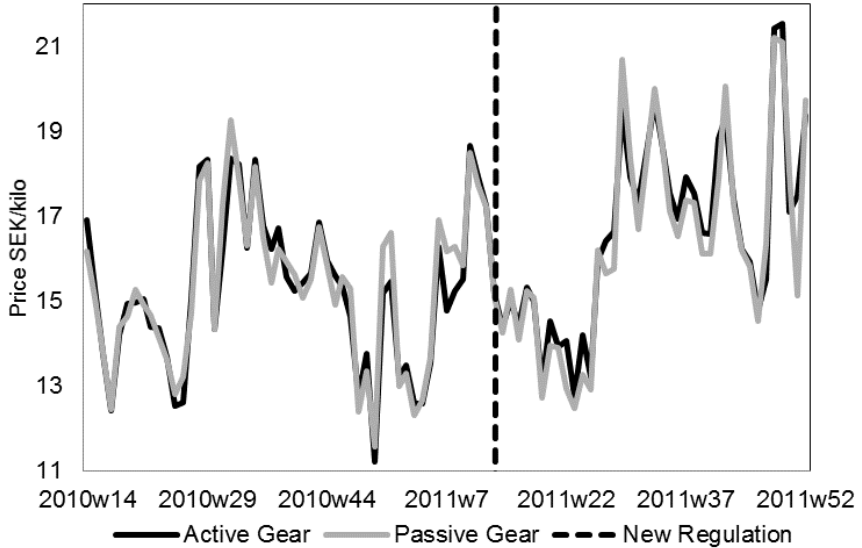
When using the DID methodology to examine treatment effects of a new management policy, it important that the treatment is exogenous. In our case it is required that, conditional on observed variables (quality, size, landing port), there are no unobserved factors that are associated both with the price difference between fishers using active and passive gear, and with the introduction of the new regulation. Although this assumption is not testable, it should not be too controversial to argue that there is no unobserved driver of price differences that also influenced

fishers with active gear to push for a new management system, or the other way around.

Another key assumption of the DID methodology is the so-called “common trend” assumption, which posits that the price for the two groups would follow the same time trend in the absence of the new management system. If this assumption is violated, the DID leads to biased estimates of the bargaining power effect, and it is therefore important to assess its plausibility. One way to do so is to compare trends before the regulatory change (see e.g. Angrist and Krueger 1999). In our case, if price trends are not similar, it suggests that passive gear vessels may not serve as a credible control group. Figure 1 plots the weekly average cod price for the two groups of vessels. The dashed line signifies the introduction of the new management system. As can be seen from the figure, the two price series follow each other closely and there is no evidence of divergent price trends before (or after) the regulatory change. This provides some confidence that the group of passive vessels is indeed an appropriate control group.<sup>4</sup>

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<sup>4</sup> It should be noted, however, that Figure 1 does not directly test the common trend assumption; by construction it is untestable.



**Figure 1:**  
Weekly Average Prices

We note that instead of analyzing price differences as in (5), it is common in the literature to model the price level directly using a multiple regression framework (see e.g. Imbens and Wooldridge 2009). In this case, observed factors such as the size and quality of the fish, as well as time and landing port dummies, are included in the regression as control variables. The benefit of the latter approach is that all observations are used, as opposed to the difference operation in (2), which implies more precise estimates. In contrast, in the approach taken in (2) to (5), only landings of fish of the same size, with the same quality rating, landed in the same ports, and on the same day are used in the analysis. On the other hand, this may also be seen as an advantage since the difference approach does not rely on potentially imprecise estimates of time and landing port coefficients. Although the choice is not obvious we favor the model laid out in (2) to (5) for its simplicity and its reliance on comparable price observations. For comparison purposes we show the results from a multiple regression approach in Appendix 1.

## Results

The results from regression (5), presented in Table 5, show that there are price differences between the two groups after the reform when controlling for size, quality, port and landing day. The interpretation of the coefficient is that vessels using active gear received 0.24 SEK more on average than vessels using passive gear during the time period following the reform, and that this price increase was unrelated to the size or the quality of the fish, or where and when it was landed. The constant shows the average price difference before the reform and since it is not significant it suggests that there were no price differences between segments prior to the reform.

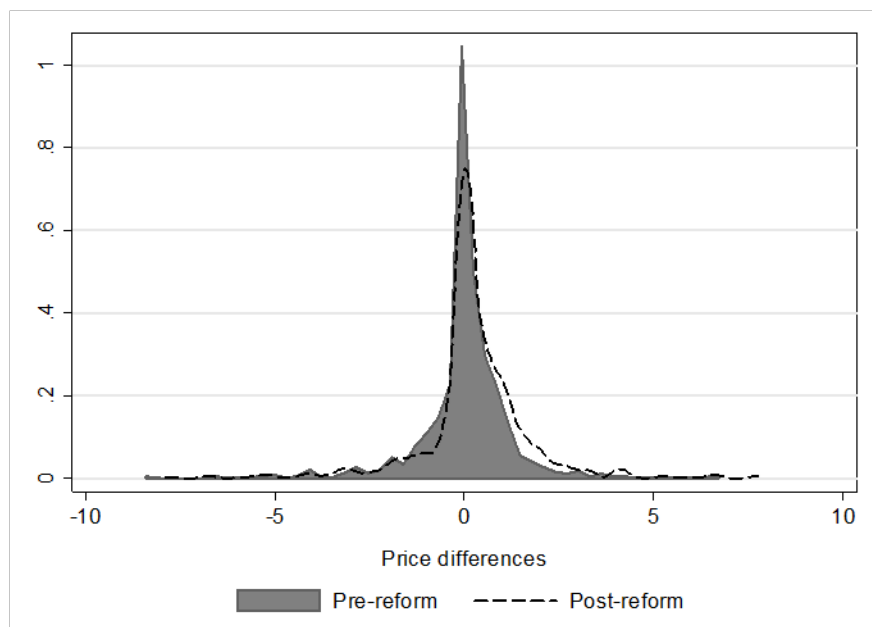
**Table 5.**  
Price Differences Before and After the Reform

Coefficient	Point estimate	P-value
Constant	0.027	0.454
Difference-in-differences coefficient	0.239	0.000

Note: Estimation results of equation (5). The number of observations is 1973.

Another way to envisage the difference between the two groups is to estimate the distribution of  $\tilde{p}_i$ . Figure 2 shows two density functions estimated using the Epanechnikov kernel density estimator.<sup>5</sup> The shaded area shows the estimated density of  $\tilde{p}_i$  before the reform and the dashed line shows the estimated density after the reform.

<sup>5</sup> The bandwidth is estimated using Silverman's (1992) optimal bandwidth estimator.



**Figure 2.**  
Kernel Density Estimates

Figure 2 shows that the remaining price differences are slightly larger post-reform, which confirms the results of the regression. The post-reform density curve is to the right of the pre-reform density curve, indicating price differences are larger post-reform.<sup>6</sup> The pre-reform estimates are closer to zero, and most observations show no differences between vessels using passive gear and vessels using active gear when other factors (size, quality, landing-day and port) are controlled for in the analysis. The figure also shows that there are no extreme observations driving the results.

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<sup>6</sup> The hypothesis that price differences are equal before and after the reform is tested using the Kolmogorov-Smirnov test. The hypothesis is rejected at the 1 percent level.

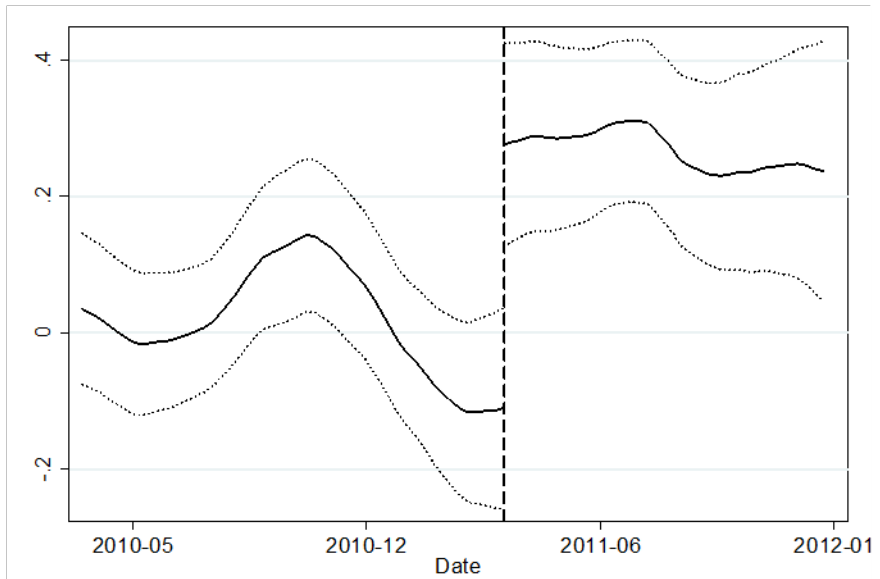
While the results in Table 5 and Figure 2 indicate higher ex-vessel prices for fishers who profited from the new management system, they are not indicative of whether the price difference changed abruptly or gradually over the year. Nonparametric regression methods can be used to analyze the behavior of the conditional mean around a particular point in time. Let  $x$  be a time-variable representing date and consider  $m(x) = E(\tilde{p}_i | x_i = x)$ , where  $m(\cdot)$  is some unknown mean function. Instead of using equation (5), we want to estimate the conditional mean directly, without making any assumptions about the functional form of  $m(\cdot)$ . In this case, we can use the Nadaraya-Watson estimator (see for example Racine 2008),

$$\hat{m}(x) = \sum_{i=1}^N \tilde{p}_i \cdot \lambda_i, \quad (6)$$

where  $\lambda_i$  is a kernel weight function.<sup>7</sup> As the Nadaraya-Watson estimator is a smoothing estimator, it may mask an abrupt shift in the conditional mean around the date of the new management system. To allow for a discontinuity point, Figure 3 displays the results from the Nadaraya-Watson estimator when the mean function and the 95 percent confidence bands are estimated separately for the two management periods.

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<sup>7</sup> As above, we use the Epanechnikov kernel. However, when it comes to bandwidth selection, there is no commonly used rule of thumb like the one used above. Instead, we experimented with several different choices for the bandwidth (30, 40, 50, 60, 70, and 80). Fortunately, the qualitative results were not sensitive to this choice, and Figure 3 presents the result when the bandwidth is set to 50.



**Figure 3.**  
Estimated Mean Functions Before and After the Reform

The estimated mean function shows that price differences vary somewhat before the reform, but is close to zero and mostly insignificant. In accordance with Figure 1, this indicates that the two groups followed similar price trends before the regulatory change. The figure also shows that price differences become larger immediately after the reform, and that they stay at a higher level during the rest of the time period studied.

The results above suggest that the new management system results in higher ex-vessel prices for fishers using active gear. However, in terms of equation (1), the results are not indicative of whether the higher prices are due to improved bargaining power or a shift in fishers' or processors' reservation prices. For example, the processors' reservation price is likely to be a function of the average variable costs of processing. Since the quantity landed is much larger for fishers using active gear, the costs of processing may be lower for this group. To investigate this issue, we

follow Fell and Haynie (2011) and assume that processing costs are dependent upon the quantity processed. More specifically, we define the variable  $\tilde{q}_i = q_{tlsq}^a - q_{tlsq}^b$ , where  $q_{tlsq}^a$  and  $q_{tlsq}^b$  denote the average quantity landed at date  $t$ , in landing port  $l$ , for a particular size,  $s$ , and quality,  $q$ , where the superscripts  $a$  and  $b$  indicate group membership (active gear and passive gear, respectively). The variable  $\tilde{q}_i$  can then be included as an explanatory variable in regression (5). If processor reservation prices for the two groups of vessels change disproportionately, this might affect price differences. Similarly, the fishers' reservation price is likely to be determined by their fishing costs. To control for fishing costs, we include the daily changes in diesel price. Usually, vessels using active gear are more fuel intensive than vessels using passive gear, and if diesel prices change, the reservation price of active vessels might change more than the reservation price of passive vessels. Table 6 shows the results when these variables are included in regression (5).

**Table 6.**  
Price Differences Before and After the Reform (Additional Controls)

Variable	Point estimate	P-value
Constant	-0.011	0.812
Difference-in-differences	0.233	0.000
Diesel price	-0.004	0.993
Difference in quantity	0.017	0.257

Note: Estimation results of equation (5) with additional control variables. The number of observations is 1973.

The results indicate that reservation prices for processors or fishers have not changed disproportionately between vessel groups. The coefficients of diesel prices and quantity changes are very small and insignificant.

## Summary and Conclusions

In this paper we contribute to the literature on how the distribution of rents between fishers and processors changes when a regulatory change is introduced in a fishery. More specifically, we focus on how the bargaining power of fishers and processors is altered when we move from a system of quarterly to annual quotas in the Swedish Baltic cod fishery.

The fishery is characterized by limited entry restrictions and a limited number of processors. Vessels have close-knit relations with their processors and are also closely connected to specific ports. Because of the imperfect market structure, a bargaining situation is likely to occur where fishers and processors bargain over the price of fish. The study of bargaining power is, however, complicated by the fact that it cannot be directly observed. To identify the bargaining power effect, we utilize the fact that the regulatory change only applied to vessels using active gear. Thus, the segment of passive gear is used as a control group, and the effect is operationalized as changes between the two groups.

Using a detailed dataset and a difference-in-differences approach, we are also able to control for other factors that could have affected the prices during the time period. Prices of fish of the same size, with the same quality rating, landed in the same ports, and on the same day are compared for the two segments. Thus, any price changes related to these factors are controlled for in the analysis. Furthermore, the difference-in-differences approach ensures that all factors which affected prices in a similar manner for the two segments during the time period are left out of the analysis. Such price changes could for example be changes in the demand for cod, macro-economic fluctuations or changes in input prices.

The results indicate that bargaining power increases for fishers, since price differences between vessels affected by the reform and vessels not affected by the reform are larger after the reform holding other factors fixed. On 1 April 2011 vessels using active gear were no longer restricted by the quarterly quota that had been in effect during the previous year. The price increase due to increased bargaining power is estimated to 0.24 SEK, which is equivalent to 1.8 percent of the pre-

reform price received by vessels using active gear. Thus, while statistically significant, the price effect is fairly small. This is to be expected since Sweden is a small supplier of cod and the high degree of market integration between ex-vessel markets for cod in Europe restricts price formation on the Swedish market (Nielsen 2005).

The discussion on making fishing quotas transferable is an on-going issue in Sweden as well as in the EU, and an introduction of transferable quotas in the Swedish Baltic cod fishery could be realistic in the future, at least for active vessels. The bargaining power of fishers could then raise ex-vessel prices further, since rationalization in the fishery sector could result in the exit of the most inefficient fishers and increased market power of the remaining fishers. The potential bargaining effects of an introduction of transferable quotas and the discussion about compensation to processors are interesting questions for the future. This paper suggests that the bargaining situation between fishers and buyers is affected by a regulatory change, and thus policy makers should consider market distortions when introducing new management systems.

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## Appendix 1

Instead of analyzing price differences as in (5), it is possible to test whether fishers gain a higher markup in the new management period using a regression model of the price level. In this case, we may specify the following model

$$p_{igt} = \alpha + x'_{igt}\beta + \delta d_{gt} + \gamma_g + \lambda_t + u_{igt}, \quad (\text{A.1})$$

where  $p_{igt}$  is the ex-vessel price for vessel  $i$ , belonging to segment  $g$ , at date  $t$ . The vector  $x_{igt}$  contains dummy variables controlling for landing port as well as size and quality of the fish,  $\lambda_t$  is a common time effect, and  $u_{igt}$  is the error term. The coefficient  $\gamma_g$  is included to capture segment-specific effects, which is necessary as only the segment of active gear was affected by the new regulation. Thus, this coefficient ensures that we remove permanent price differences between vessels with different gears that have nothing to do with the new regulation. The dummy variable  $d_{gt}$  is the treatment dummy, taking the value 1 in the period after the regulatory change (for vessels using active gear). The coefficient  $\delta$  measures whether fishers gain a higher markup in the new management period.

The results from regression (A.1) are shown in Table A1. As can be seen, the DID estimate is around 0.2 SEK, which is close to the estimate in Table 5 (0.24 SEK). We conclude that the two modelling approaches produce similar result. Regarding the other coefficients, since we include intercepts in (A.1), the estimated  $\beta$ -coefficients should be interpreted as the price deviations (in SEK) from a baseline product with a given set of attributes. In our model, the baseline is cod of large size (over 7 kilos) and medium quality (quality A), and caught by a vessel using passive gear. We can see from the table that quality and size of the fish are important attributes. For example, compared to the price of large cod (over 7 kilos) of medium quality (quality A), the price is 3.5 SEK (around 30 percent) higher for large cod with high quality (quality E).

**Table A1.**  
Results from the Regression Model

Variable	Point estimate	P- value
Difference-in-differences	0.198	0.000
Active gear	0.240	0.000
Quality ratings:		
Class E	3.467	0.000
Class B	-7.408	0.000
Size classes:		
4-7 kilos	-0.167	0.183
2-4 kilos	-0.446	0.000
1-2 kilos	-0.748	0.000
0.3-1 kilos	-4.102	0.000
No.Obs	42872	



# Chapter 4

## Swedish Coastal Herring Fisheries in the Wake of an ITQ System

With Staffan Waldo, Kim Berndt, Martin Lindegren, Anders Nilsson and Anders Persson

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### Introduction

The European common fisheries policy (CFP) advocates measures to sustain and promote small-scale coastal fisheries in order to enable them to prevail and thrive alongside larger-scale fisheries. This is highlighted in the EU commission's proposal for introducing a mandatory system with individual transferable fishing concessions [1]. The proposal is limited to vessels above 12 m and/or vessels using active gear, and the inclusion of smaller vessels is a national decision for each member state. A reason for not including them is to protect the small-scale fisheries from being bought out by larger vessels. However, exempting a small-scale fishery from a management system is fundamentally different from successfully managing it.

Exempting a fishery from a system with individual transferable quotas (ITQ) implies that part of the quota is set aside for the fishery. Theory predicts that with open access to the quota the system will generate a

biologically sustainable fishery (as long as the quota is set according to biological recommendations) with low profitability. The latter because as long as the fishery is profitable it will attract new entrants, which in turn implies increased competition for the quota and decreased catch per vessel. New entrants will be in line with political employment objectives for small-scale fisheries, but if the quota is limited, the process might generate over-capacity.

Following the increasing number of ITQs and other systems with tradable fishing concessions, the development of biological [2,3], economic [4–6], and socioeconomic [7] values for these systems has become publicly available in the literature. The development of segments fishing on the same stocks but exempted from the system are less studied although commonly occurring.<sup>1</sup>

In this paper a Swedish small scale herring fishery in the western Baltic is used to show the development and management issues of a fishery that is excluded from a large scale ITQ system.

Sweden is part of the CFP, and Swedish political objectives regarding the small-scale fleet include employment opportunities, economic viability, rural development, etc. [9]. Profitability in general is low in the Swedish Baltic Sea small-scale fishery [10] and recruitment to the sector is low. With this in mind, a major objective of exempting the small-scale fishery from ITQs is to use the quota to attract new fishermen. However, the current issue in the herring fishery is that the fishery has expanded rapidly, leading to competition for the quota. Incumbent fishermen are part of the traditional fishery which was protected from being bought out by large scale fisheries through the ITQ-exemption, but they now face the risk of the quota being fished by others since they fish later in the season than new entrants.

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<sup>1</sup> An exception is [8], who describes a system where Icelandic vessels could leave the ITQ system for an effort-based management option and then re-enter ITQs again. This led to increased fishing effort, at least partly motivated by the possibility of re-entering with an improved catch record.

Although coastal fisheries have high political priority and the studied herring fishery has a separate quota that can be managed with targeted measures, the Swedish fisheries authority has not yet presented a long-run sustainable management plan for the fishery. Situations like this, with national authorities being responsible for managing a small fishery, will emerge in the proposed reform of the CFP. Central management of a small-scale fishery is expensive in terms of the economic contribution of the fishery, and efficient management systems are necessary to deal with the topics. In this paper, proposed management options for the coastal Swedish herring fishery are presented and discussed from both a theoretical and a management perspective.

The paper continues with a presentation of the herring stock (“The biology of the western Baltic herring” section) and the Swedish ITQ system (“The Swedish pelagic ITQ system” section). In “The coastal fishery” section the coastal fishery and the problems arising due to the expansion are discussed. The “Management proposals” section contains the management options proposed for the fishery, and the “Discussion” section concludes the paper with a discussion.

## **The Biology of the Western Baltic Herring**

The herring stock in the western Baltic Sea and the Sound between Sweden and Denmark (Öresund, ICES subdivision 23) is mainly composed of a migrating and seasonally occurring population [11]. Although local (coastal) sub-populations are present in the area, the considerably larger Western Baltic Spring Spawners (WBSS) provide the main resource for the commercial herring fishery in the area. After spawning in the western Baltic Sea from March to May, the adult part of the population (i.e., age 2+) undertake a northward feeding migration, entering the Kattegat, Skagerrak and eastern North Sea through the narrow Belt Sea and the Sound [12]. Towards the end of summer the adults migrate southwards to the main overwintering areas in the southern part of the Kattegat and the western Baltic Sea [13], with peak aggregations (i.e., 45–165,000 t) in the Sound from September to February [14]. During overwintering, the highest densities are found

primarily in the northern Sound, while high concentrations in the southern part are restricted to spring just before the onset of the spawning migration [14]. Given the high densities seasonally occurring within the narrow confinement of the Sound, conditions for a small-scale local gillnet fishery are particularly suitable, especially given the local trawl-fishing ban [15] limiting competition from large-scale trawlers in the area.

## **The Swedish Pelagic ITQ System**

Before the ITQ system was introduced in 2009, the Swedish pelagic fleet consisted of approximately 80 large-scale vessel fishing for herring, sprat, mackerel, blue whiting and sand eel. The fishing takes place in the Baltic, Kattegat, Skagerrak, and North Sea. Excess capacity had been prevalent in the segment for years and the economic performance had been poor [16], and the idea of introducing an ITQ system was provided by the industry itself. Individual non-transferable quotas were introduced in 2007, and an ITQ system was put in place in autumn 2009 [17]. In 2011 the large-scale pelagic fishery consisted of 17 vessels. The system includes elements of both regional and small-scale considerations. An important feature in this is that part of the quota for each stock is set aside for small-scale fisheries using passive gear, the so-called coastal quota. Fishermen using the coastal quota cannot be part of the ITQ system.

## **The Coastal Fishery**

The development of the total Swedish and the coastal quota is presented in Table 1. Initially the coastal herring fishery was small, but expanded rapidly and the coastal catches exceed the allocated quota in 2009 and 2010. The idea of the coastal quota is to enable the coastal fishery to continue “without limitations” [18], and extra allocations have been made. However, additional allocations are made at the expense of quotas

for the ITQ-system, and in practical policies there will be an upper limit of the coastal catches.

**Table 1.**

Swedish Herring Quotas in ICES Area 22-24 (Western Baltic Sea), Ton.

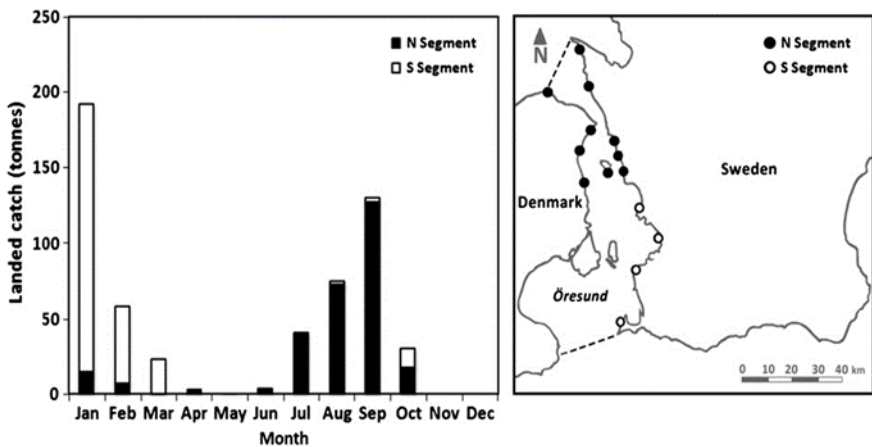
Year	Swedish Quota	Coastal Quota	Coastal catch	Coastal quota (%)
2008	7926	400	284	5.05
2009	4835	400	817	8.27
2010	4037	800	952	19.82
2011	2826	565	554	19.99

Source: The Swedish Agency for Marine and Water Management

A first observation is that the total Swedish quota has declined continuously since 2008 (due to a general reduction of Total Allowable Catch agreed in the EU) from almost 8000 to 2800 t. The western Baltic herring quota is a small part of the total ITQ system, but is important for coastal fisheries. The coastal quota has increased from 400 t in 2008 to 565 in 2011 with a maximum of 800 t in 2010. The development of the coastal quota is due to a larger share of the total quota allocated to coastal fisheries each year.

In total about 40 Swedish fishermen have their primary fishing area in the Öresund where the western Baltic herring is caught. The main targeted species are Atlantic cod (*Gadus morhua*), Atlantic herring (*Clupea harengus*) and European eel (*Anguilla anguilla*). In 2011 approximately 20 fishermen were active in the herring fishery, although some of them only had marginal catches. The herring fishery in the Öresund has been profitable in recent years, but, at the same time, the important cod fishery has declined. This may explain the increase in the coastal catch presented in Table 1. The increase is due not only to existing fishermen increasing their herring fisheries, but also to newcomers discovering the herring in the Sound. Increasing fishing pressure has previously been solved by increasing the coastal quota, but this is not an option in the long run. Further, fishing in the Öresund has a North-South dimension, where the fishermen in the northern part of the Sound are largely ‘traditional’ fishermen focusing on autumn when the price for

herring is high and the herring is overwintering in high densities in the North. The fishery in the southern part of the Sound has been described as ‘bulk fisheries’ focusing on larger quantities in the spring when the herring is gathering in the southern parts of the Sound. The prices are in general lower in this fishery. In 2011 the average price was SEK 4 in January and SEK 5.4 in September (€ ~ SEK 9), i.e., an increase of about 35%. At present the fishery is characterized by open access for vessels using passive gear as long as the total coastal quota is not exceeded. The problem, as described by the regional fisheries management, is that the coastal quota will not last for the entire year and the autumn fishery in the North will face a quota deficit if additional quota allocations cannot be made. The seasonal pattern of the landings in the northern and southern parts of the Öresund is presented in Fig. 1 (Swedish landings in both Swedish and Danish harbors).



**Fig. 1.**  
Swedish Landings of Atlantic Herring (*Clupea Harengus*) in the Öresund, 2011.

Source: the Swedish agency for marine and water management.

## Management Proposals

The regional fisheries management has brought the problems facing the local herring fishermen in the Öresund to the attention of both the fishery and the central authority (the Swedish Agency for Marine and Water Management). Three ideas have been informally discussed, but only the third has been formally proposed as a management solution.

The first idea for solving the situation was to form a co- management organization where the fishery is closed for new entrants. In this approach, the quota will be allocated to the fishery and the fishermen can solve the quota issues internally. The approach has been rejected since the very idea of the coastal quota is to allow new entrants into herring fisheries.

The second idea is to introduce rationing where each fisherman is to be allowed a fixed catch per week (or other limited time period). This is a traditional Swedish management option that has been used on a large scale for both cod and herring fisheries. It is still used for small-scale fishing for mackerel. However, several drawbacks have been put forward: It is not possible for the fishermen to allocate their fishing activities to the optimal time period when prices are high or herring fishing for other reasons is profitable for the company. Further, a rationing system will be expensive to administer since authorities will have to keep continuous track of the weekly catches for each vessel.

The third idea is to divide the quota to a spring and an autumn part (formally the division is into four periods). This has been proposed by the fishermen themselves, but the proposal is problematic due to different ideas among fishermen regarding the size of the spring and autumn shares. Separate spring and autumn quotas are still the main options, and the county administrative board has made a formal proposal to the Swedish Agency for Marine and Water Management to split the quota.

## Discussion

The management system for the Swedish coastal herring may be described as regulated open access under a catch quota. A fishery that is characterized by 'race to fish' will lead to excess capacity and low profitability, and large vessels fishing early in the season are expected to get a higher share of the quota. The Swedish coastal herring fishery might be viewed as a micro-example of this situation. New entrants and 'bulk' fisheries in the southern part of the Sound fishing a large share of the quota during the spring causes problems for the fishermen active in the autumn when prices are high. As long as the fishery is profitable and one of the main purposes of the coastal quota is to allow the entry of new fishermen, competition for quotas is expected to be an important characteristic of the fishery.

It could be argued that the quota should be fished in the autumn when prices are high, but this is only one dimension of the situation. The high coastal quota is due to the new entrants and the larger fisheries in the South, and the quota would probably not be utilized if only caught in the autumn. Further, the fishermen in the South are heavily dependent on the spring fishing due to the bad cod catches in recent years. The idea of the coastal quota is to allow new fishermen to establish themselves, and if entering the herring fishery is a way for these small-scale fishermen to stay in business, it has served its purpose. The problem is whether it is at the expense of others.

When a fishery is put under pressure, it is important to have strong institutions to deal with the problem, and this is not the case in the situation presented above. The individual quotas work as such an institution in the ITQ-part of the herring fishery, but other institutions are politically preferred in the coastal fishery. The co-management alternative for the coastal quota was rejected due to possibilities of generous access to the fishery, but is still interesting to mention as a possible solution in the future. The fishermen constitute a small homogeneous group that is dependent on the resource, and has the common goal of utilizing the stock for commercial purposes. These are important characteristics for the possible success of a co-management

body [19]. Under the right conditions, local management of a small fishery might be a cost-effective strategy with strong support among fishermen. The current strategy of dividing the quota to a spring and an autumn part might solve the problem in the short run, but has obvious drawbacks as a long-run solution since it does not deal with the fundamental issue of access to the quota: New entrants might still join the fishery, thereby reducing catch possibilities per vessel, and there are no legal sanctions against fishermen conducting spring fishing and then choosing to participate in the autumn fishing as well.

Taking the lessons learned from the Swedish example into the framework of the CFP reform, the exemption of the small-scale fishery from the system with tradable fishing concessions did not solve the problems facing the small-scale fleet. If a fishery becomes profitable, it will attract new capacity and there is need for a management system to solve the same over-capacity issues as have been present in the EU for decades, but on a micro-scale. It is important to have an institutional setting and a management plan to deal with the topics arising in these fisheries. The topics are not fundamentally different from those in larger scale fisheries. However, managing a small fishery might be expensive in terms of the economic gains from the fishery. Still, this cost might be motivated, since, in many cases, the reason for the fleet being exempted from tradable concessions is to protect values other than the strictly economic.

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# Chapter 5

## A Trip to Reach the Target? – The Labor Supply of Swedish Baltic Cod Fishermen<sup>1</sup>

### Introduction

Revenues from fishing are uncertain and vary on different trips, and even at different times on the same trip. Also, working hours for fishermen are irregular since a fishing trip can take many hours and often last for several days. Furthermore, the decision-making process can be characterized as relatively short-term since many decisions on board a vessel have to be made continuously through the trip, i.e. choice of fishing place, time of setting of trawls and decisions on how many hauls to make. This makes the fishing trip an ideal setting for investigating the idea of revenue targeting, i.e. investigating whether fishermen are aiming for specific short-term revenues rather than maximizing expected utility over a longer time period. The issue of revenue targeting in fisheries has been investigated previously, with the evidence being mainly in support of revenue target behavior (Giné, Martínez-Bravo, and Vidal-Fernández 2010; Eggert and Kahui 2012; Nguyen and Leung 2013; Ran, Keithly, and Yue 2014), but there is also recent evidence that fishermen substitute labor for leisure intertemporally (Stafford 2015).

Traditional labor market theory suggests that the amount of labor supplied in the long run is determined by substitution and income

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<sup>1</sup> I would like to thank Kaveh Majlesi for comments on an earlier version of this paper.

effects. Higher incomes will make workers substitute labor for leisure but they will also make workers richer and increase their demand for leisure, which in turn decreases the amount of time spent working. The effect of increasing incomes is thus indecisive in the traditional model. The traditional model can be contrasted with the revenue target hypothesis. The idea is that workers adapt their level of labor supply depending on whether they have reached a predetermined target level for their incomes in a specified, often very short time period.

The idea of target revenues derives from prospect theory, which was introduced as an alternative to traditional expected utility theory by Kahneman and Tversky (1979). Prospect theory proposes that it is changes in income that matter rather than final wealth during a lifetime. Changes in welfare around a reference point are measured using a value function that is concave for gains and convex for losses, and is often steeper for losses than for gains. This implies that individuals are risk-averse for gains, risk-seeking for losses and that losing a sum of money is often worse than gaining the same amount (Kahneman and Tversky 1979). The point at which losses are replaced by gains is the reference point, and in the context of revenue targeting this is a point that serves as a desirable short-term target for the individual (Camerer et al. 1997). Köszegi and Rabin (2006) build on the ideas of Kahneman and Tversky and develop a theory that implies that targets are defined by probabilistic beliefs held by a person in the recent past. This allows targets to vary considerably between individuals and over time.

The issue of how changes in revenues affect the amount of labor supplied is of interest for fishery policy analysis. The idea that the behavior of fishermen might not be based on expected utility theory can improve our understanding of fishermen's behavior and allow us to make better predictions of how fishermen react to changes in environmental conditions and policies. If profits in fisheries are not maximized in the long run the results from traditional economic fishery models might be unreliable. Recently, new regulations in many countries have given increased flexibility to fishermen through the introduction of individual quotas and transferable quotas. Fishermen have increased opportunities to decide on when and where to fish and how much time to

spend on individual fishing trips. For example, when the system of yearly individual quotas was introduced for Swedish cod trawlers in 2011 there were concerns that supplies might become irregular for processors (Blomquist, Hammarlund, and Waldo 2015). If fishermen choose to spend more time fishing for cod when revenues are high the concern might be warranted. But if fishermen are target earners on a trip basis, landings are more likely to remain regular over the year.

The purpose of this article is to empirically investigate the labor supply of fishermen and relate labor supply to changes in short-term revenues using the example of fishermen working on Swedish Baltic Sea cod trawlers. More specifically, the effect of unexpected changes in revenues on the probability of stopping at the time of different hauls is investigated using the estimation method suggested by Farber (2005, 2008). To my knowledge, this approach has not been tested outside the realm of taxi drivers before. By using controls at a detailed level I attempt to avoid the problem that expected revenues (that are used to form potential target levels) cannot be separated from unexpected ones. This also enables me to interpret the results in line with the model of reference-dependent preferences suggested by Kőszegi and Rabin (2006) where a reference point is determined endogenously by the economic environment. I also consider potential constraints that could affect the decision to return to port. Since fisheries might be constrained by government regulations (such as quotas) and the physical capacity of the vessels I will also discuss how these constraints might influence the labor supply of fishermen.

Most studies investigating revenue targeting look at small businesses, often comprising one self-employed individual (e.g. a taxi driver, a stadium vendor or a bicycle messenger). The question of whether reference-dependent behavior is also prevalent when work is organized in a more collective manner, as is the case on a fishing vessel, is of interest, as is the effect on behavior of the size of the workforce. For this reason I investigate whether there are differences in behavior between small, medium and large vessels.

Since it is not clear how long the decision-making horizon might be for individuals exhibiting revenue target behavior I suggest two different

time horizons over which I test the revenue target hypothesis. First, I assume that it is the fishing trip that matters for the fishermen since it seems natural that leaving port and arriving back at port should constitute the time limits over which decision making is made. But fishing is also conducted with a weekly pattern where many vessels make several trips in a week but stop fishing as the weekend approaches. For this reason I also test the revenue hypothesis for weekly targets.

## **Previous Applications**

There are a large number of studies investigating wage elasticity (a survey is found in Blundell and Macurdy (1999)). In general, the wage elasticities that are found are small, implying that labor supply is not very responsive to wage changes (Blundell and Macurdy 1999). In empirical studies with short-term wage changes the long-term income effect from the traditional model is normally ignored since fluctuations in wages can be viewed as transitory. The substitution effect can in this case be viewed as temporal; it is beneficial to substitute labor for leisure when wages are high since lower wages are expected in the future. Thus, in the traditional model where there are no target revenues the expectation is that temporary increases in wages increase the supply of labor.

An example of a study on labor supply in fisheries is Gautam, Strand, and Kirkley (1996) who investigate leisure and labor trade-offs in the mid-Atlantic sea scallop fishery. The results suggest that there is a short-run backward-bending supply of fishing labor, i.e. when profits per day are low or average captains will increase their time offshore, but as profits per day reach sufficiently high levels, captains will increase their time onshore and reduce their time at sea. Furthermore, the authors find that anticipation of future profits influences the current labor supply in line with the intertemporal model. Fishermen decrease their labor supply if they expect profits to be higher later on in the season. Although the revenue target hypothesis was never mentioned in Gautam, Strand, and Kirkley (1996) the results could be interpreted as support for the

hypothesis since high unexpected daily revenues seem to reduce work hours.

An empirical study that has received much attention is Camerer et al. (1997) studying reference targets of New York taxi drivers. The authors found that daily working hours for taxi drivers were negatively correlated with average hourly earnings, i.e. on average, taxi drivers worked shorter hours when wages were high. Together with the result that wages were correlated within days (so that drivers could expect more or less the same hourly wage during the day) and uncorrelated across days (to make sure wages were transitory across days) this was interpreted as evidence of a daily income target and as support for the ideas of prospect theory.

Some weaknesses of the Camerer et al. (1997) study have been pointed out by Farber (2005). One concern is that the correlation within days may not be applicable to other settings, which makes it difficult to use average income per hour as a dependent variable. Farber (2005) does not find any correlation within days in his study of New York taxi drivers in the period June 1999 through May 2001. Rather than using the wage equation, Farber (2005) suggests using an optimal stopping model where the probability of stopping on a day is estimated as a function of accumulated hours, accumulated revenues and other factors. Using accumulated variables makes it unlikely that a shift for the taxi driver would end because of a time-specific slowdown of traffic during the day. It also avoids the need for strong within-day wage correlation and downward-biased estimates caused by potential measurement problems when using hours worked on both sides of the equation. Farber (2005) finds that the probability of stopping daily work after a particular trip is strongly related to the number of hours worked so far and not significantly related to cumulative income earned so far and concludes that these findings are not supportive of the target income hypothesis.

Transitory wage changes were further investigated by Fehr and Goette (2007) in an experiment involving bicycle messengers. As an experiment, the commission rate for bicycle messengers was temporarily increased by 25 percent for a four-week period. The results show that bicycle messengers work more hours with the higher wages in line with

the traditional theory of intertemporal labor supply. But although the main effect is an increase of total hours supplied, Fehr and Goette also show that bicycle messengers decrease their effort per shift worked, where effort can be affected by riding at higher speed, listening to the radio more carefully or finding shortcuts along the way. Two alternative explanations for the reduction in effort were suggested and a second experiment was carried out. First, it is possible that messengers that work longer hours experience increasing disutility of effort during the day; hence they have an incentive to decrease effort even if wages are higher. Second, there is a possibility that messengers have a reference income level and if they exceed this level their marginal utility of income will decrease and hence they will decrease effort. The second experiment tests whether bicycle messengers are loss-averse when using a lottery (Do they prefer to prevent a loss in one lottery rather than to gain the same amount in another lottery?) and whether there is correlation between being loss-averse and decreasing effort. The authors find such a relationship and interpret this as evidence of the income target hypothesis, or that the hypothesis is valid for at least some individuals.

Since fishermen experience transitory changes in revenues and often have considerable flexibility regarding work hours there have been a number of studies using the approach of Camerer et al. (1997) to estimate labor supply. Nguyen and Leung (2013) investigate revenue targeting in the Hawaii-based long-line fishery and estimate the effect of daily average revenue on the number of fishing days on a trip. The key finding is that daily fishing revenue has a negative and significant impact on the number of fishing days and these results are interpreted as support for the idea that Hawaiian fishermen have revenue targets. A similar study is that of Eggert and Kahui (2012) who discuss reference-dependent behavior of paua<sup>2</sup> divers in New Zealand and estimate the relationship between the number of hours that divers choose to work each day and the average daily wage. A negative relationship is again found here.

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<sup>2</sup> Paua is Maori for three types of edible sea snail.

In contrast to the above studies, Stafford (2015) does not find that fishermen work less when earnings are high in her study on the daily labor supply of Florida lobster fishermen. She looks at the wage elasticity as well as the participation elasticity, i.e. the effect of wage on the probability of taking part in the fishery on a certain day, and takes econometric problems such as endogeneity of wages, self-selection into participation and measurement error in hours into consideration. Rather than finding a negative wage elasticity like Camerer et al. (1997) she finds that the wage elasticity of hours worked is significantly positive, although small. Furthermore, she also finds that the participation elasticity is large and positive. Thus, higher wages are primarily associated with a higher likelihood of participating in the fishery on a certain day rather than working longer hours on that day. The results are also compared to results received when using the method in Camerer et al. (1997) and show that the wage elasticity becomes negative. Stafford concludes that the behavior of the lobster fishermen is consistent with a neoclassical model of labor supply and that the estimation strategy may explain the negative wage elasticities found in previous studies.

In 2008, Farber developed the stopping model further and assumed that revenue targets can vary across days for different taxi drivers (Farber 2008). The results show that drivers are more likely to continue driving before the reference income level has been reached. But still Farber does not think that he had found any substantial evidence of the target income hypothesis since most taxi drivers would stop before they reached their income target level and because the reference income level for a given driver varies unpredictably from day to day. In addition, a large unexplained within-driver variation in income is not believed to be in line with drivers having income targets. Using Farber's model, Doran (2014) analyzes the labor supply of taxi drivers in response to short-term and long-term wage increases. He finds that taxi drivers decrease hours in response to short-term wage increases but not to long-term wage increases. Thus, contrary to the conclusions of Farber (2005); Farber (2008) he believes that he has found support for the reference-dependent behavior of taxi drivers.

The issue of how to determine reference points was not considered to any substantial extent in the early studies on reference dependence, but has been increasingly discussed in the last decade. Kőszegi and Rabin (2006) suggest that reference points are determined endogenously by the economic environment. For this reason the authors suggest a model where a reference point is formed by rational expectations held in the recent past. In an application they show that in a labor supply decision a worker is less likely to continue work if income earned so far is unexpectedly high, but more likely to show up as well as continue to work if expected income is high. Similar results are found in the empirical studies of Abeler et al. (2011) and Chang and Gross (2014). Kőszegi and Rabin (2006) also believe that the variation of targets found in Farber's work can be explained by their model of expectations.

Crawford and Meng (2011) follow the approach in Kőszegi and Rabin (2006) and develop the empirical analysis made by Farber (2005, 2008) further. More specifically, targets for hours and income that are determined by proxied rational expectations are included in the Farber model. In a first analysis the authors split the sample into good and bad days by using the earnings from the first hour of driving. A good day is when the first hour's earnings are larger than expected and a bad day is when this relationship is the reverse. The expected hours and revenues are proxied by the sample averages up to but not including the day in question. Crawford and Meng also use a dummy for above and below the proxied target for both hours and income in a second analysis.

The results show that on a day when earnings are higher than expected, the probability of stopping increases with the number of hours spent driving. There is no effect of increasing cumulative revenues. The authors suggest that the reason for this pattern is that the revenue target is reached before the hours target and the former will, for this reason, not affect the stopping probability. For a day when earnings are worse than expected, the effect is the opposite: There is no effect of an increase in cumulative hours but there is an effect of cumulative revenues, i.e. the revenue target is affecting the stopping probability but the hours target is not. Using the dummy for the above targets the authors find that there are larger positive effects above the targets than below on the stopping

probability. This is in line with the reference-dependent model with rational expectations according to the authors.

Giné, Martínez-Bravo, and Vidal-Fernández (2010) investigate how boat owners' labor participation in a South Indian fishery is related to expected earnings and recent earnings. Expected earnings are calculated as the predicted values from a regression of log earnings per day on a number of explanatory variables. Recent earnings are the sum of earnings during the last seven days and if these earnings have a negative effect on labor supply it is assumed that it is more likely that the reference income has been achieved. The findings of a positive effect on participation of expected earnings together with a negative effect of recent earnings are thus interpreted as evidence of revenue targeting.

In summary, the evidence of target revenues is still mixed; different models and settings give different results. In addition, it is clear that it is difficult to make assumptions of what the expected target might be. In the following chapter, the data that are used in this study are presented and some preliminary statistics suggesting that the Swedish Baltic cod fishery is an interesting case for investigating the revenue target hypothesis are presented.

## **The Case of the Swedish Baltic Cod Fishery**

The Baltic cod fishery is historically one of the most important fisheries in Sweden; in 2013, around 10 percent of the value of all landings of fish and seafood in Sweden consisted of cod. The fishing areas mainly include the Western and Eastern Baltic and the majority of the cod from these areas is landed on the south coast (Swedish Agency of Marine and Water Management 2013c). The fishery is regulated by EU legislation and national legislation and includes the setting of quotas, fishing bans, limitations on the number of days out of port, a requirement for a special permit for cod fishing, and technical regulations for the equipment (Swedish Board of Fisheries 2004; European Commission 2005, 2007). In 2013, the cod landings were considerably smaller than in previous years; the value of landings from the south coast of Sweden had

decreased from ca 140 million SEK (Swedish krona) in 2011 to 61 million SEK in 2013.

Using the case of Swedish Baltic cod trawlers for investigating the revenue target hypothesis has a number of advantages. Since markets for cod are international, with some local variations, prices can be regarded as exogenous, i.e. they will not be affected by the behavior of individual fishermen (Hammarlund 2015). The problem encountered in taxi studies, where the number of taxi drivers out on the street affects the wage, is thus not an important problem in the current setting. Also, the quantities caught on different hauls by the same vessel on the same trip are highly variable, since it is difficult for fishermen to control the size of the catch, which in turn depends on uncontrollable biological conditions (e.g. the density of shoals and the size and quality of the fish). This variability can be exploited to investigate the effect on the labor supply of fishermen of revenue changes that are largely unexpected.

Work hours of Swedish fishermen are normally not regulated since fishermen are self-employed. The operating profits are shared between vessel owners and crew according to a share system. A fisherman could have owner shares as well as crew shares and normally crew shares are equal for fishermen that have participated on trips in the period before the revenues are counted. The shares are split among the vessel owners and fishermen on a regular basis and at least once a month. The operating profit is calculated as the value of fish sold minus variable costs of ice, boxes, diesel, provisions, vessel fees etc. Decision making regarding the fishing activities of the crew is conducted in consultation with the members of the team, although in cases of dispute the view of the captain should prevail according to the statutes of the standard crew cooperation agreement (SFR 2011). In practice, the captain is the main decision maker.<sup>3</sup>

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<sup>3</sup> Personal information from Staffan Larsson 2014-06-09.

Although fishermen (or the captains)<sup>4</sup> are free to set their work hours in a way that is considerably more flexible than that of an ordinary worker, it can be argued that fisheries are regulated by government agencies in numerous ways and that these regulations to some extent limit the trip revenues and flexibility of work hours. In this paper I will argue that the revenues and work hours are largely unaffected by regulating restrictions in the short run during the period that is investigated.

In 2011, yearly catch quotas were introduced in the Swedish Baltic Sea cod fishery. Previously, quarterly catch quotas had been used and a year earlier quotas had been given to fishermen on a biweekly basis. Short-term quotas are more likely to affect the length of the fishing trip and constitute a capacity constraint and for this reason the time period investigated is restricted to the time period after the yearly quotas were introduced. The yearly quota is given to each vessel based on the gross tonnage of the vessel (Swedish Board of Fisheries 2004) and it is possible for a vessel to reach its quota level before the year ends. However, every year since 2011, further quotas have been issued as fishermen are not filling their quotas. Already in May 2011, the year when the annual quotas were introduced, the quotas were increased in the Eastern Baltic and in September that year the quota restriction was abandoned completely in the Western Baltic whereas quotas were further increased in the Eastern Baltic (Swedish Agency of Marine and Water Management 2011b; Swedish Board of Fisheries 2011a, b). Later that year, in October 2011, quotas were abandoned completely in the Baltic Sea (Swedish Agency of Marine and Water Management 2011a). Although the quotas increased, the fishermen did not manage to catch more than 76% of the original quota (Table 1).

**Table 1:**

Quotas, Catches and Values of Landed Cod in 2011, 2012 and 2013

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<sup>4</sup> There will be no distinction between the captain and other members of the crew in the following. The term “fishermen” will refer to the group of fishermen that makes decisions on the vessel or the captain of the vessel.

	Quota (tons)	Actual catches in live weight (tons)	Catch as a share of the quota	Value of landings (Million SEK)
2011	16,645	12,644	0.76	140
2012	19,103	12,460	0.65	115
2013	17,445	7,002	0.40	61

Note: The Swedish quota is as defined in the EU regulations of the previous year and is calculated as the sum of the quotas for the Western and Eastern Baltic.

Sources: (European Commission 2010, 2011, 2012; Swedish Agency of Marine and Water Management 2012d, 2013c, 2014b).

Similarly, in 2012, quotas were increased during the year. On three occasions, in September, October and November, quotas were increased for fishing in the Eastern Baltic (Swedish Agency of Marine and Water Management 2012a, b, c). The share of cod landed of the total quota decreased to 65% that year (Table 1). The new quotas issued in 2013 were left untouched until July 18th when the quota for the Western Baltic was increased (Swedish Agency of Marine and Water Management 2013b). However, in the autumn of that year, fishing in the Western Baltic was left without quota restrictions (Swedish Agency of Marine and Water Management 2013a). Increasing the quotas did not, however, result in the Swedish cod fishery becoming closer to filling the original quota: In 2013, only 40% of the original quota was filled (Table 1). The fact that the availability of fish deteriorated during the period studied (ICES 2014) thus made it increasingly difficult for vessels to reach their quota limits. The evidence suggests that fishermen can anticipate quota increases since this is what has happened in recent years and that quota limits did not constitute an important constraint to the Swedish cod fishery in the Baltic Sea between April 1st 2011 and December 31st 2013.

Other regulations that could potentially affect the work hours of cod fishermen are regulations concerning closed areas and limitations on the number of days absent from port. There are two closure periods in the Baltic Sea: From April 1st until April 30th the Western Baltic Sea (the April closure) is closed and from July 1st until August 31st fishing is prohibited in the Eastern Baltic Sea (the summer closure). In addition, the Gdansk deep, the Bornholm deep and the Gotland deep are closed

from May 1st to 31st October (European Commission 2007). For example, a fishing trip could potentially finish because the summer closure period has started. The regulations of closed areas could perhaps limit the length of a fishing trip and on certain trips any estimation method will have to take these limitations into consideration.

Finally, the number of days at sea is regulated in the EU regulations. Vessels with a cod fishing permit are limited to 163 days' absence from port in the Western Baltic Sea and 160 days' absence from port in the Eastern Baltic Sea (European Commission 2010, 2011, 2012). In total, a maximum of 163 days' absence from port in both areas together is allowed. In 2012, it became possible to trade days between vessels under certain conditions (HVFMS 2012:39). The decision to continue a trip or not could potentially be affected by the days-at-sea limitations, but it is unlikely that these limitations would affect decisions on trips in the investigated setting. Checking the data reveals that vessels seldom reach the limit of 163 days. In fact, the average number of days at sea was 81 per year in 2011–2013. On only four occasions, in 2013, did the number of days exceed 150 for any vessel and on one of these occasions the number of days exceeded 163, which was possible since fishing days could be traded between vessels. In conclusion, the number of days at sea allowed cannot be considered as an important factor in deciding the length of a fishing trip in my example.

## **Data and Preliminary Statistics**

The data used in this study is logbook data from Swedish Baltic cod trawlers limited to vessels that caught at least 85 percent<sup>5</sup> cod per year from April 1st 2011 until December 31st 2013, i.e. the main activity of these vessels is cod fishing and the period of interest is after the yearly quota system was introduced. For each vessel I have data on the date and time when the vessel left port, the date when the fishing activity took

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<sup>5</sup> The figure of 85% is of course arbitrary; however, a sensitivity check where the main model of the paper was run with vessels that caught at least 90 percent cod per year did not reveal any important differences in results.

place, the time of setting of each trawl, the number of hours' fishing before each haul and the date and time when the vessel arrived back in port. This allows me to calculate the time spent out at sea, the time from leaving port until setting the first trawl, the time from setting of the first trawl until hauling of the first trawl, the time from hauling of the first trawl until setting of the second trawl, and so on. In addition, I have data on the quantity of cod caught on each haul and average prices of cod given to trawlers in the area<sup>6</sup> at the time the vessel left port that have been used to calculate revenues from each haul. If the price on the leaving date is missing, the price on the nearest previous available date is used. Prices are for gutted cod whereas the quantities reported in the logbooks are for whole cod, thus a conversion factor of 1.15 has been used (Swedish Agency of Marine and Water Management 2013c) to calculate revenues. To take weather changes into account the average temperature in an area to the northeast of the island of Bornholm is used.<sup>7</sup> Four different daily temperatures at 00:00, 06:00, 12:00 and 18:00 are used.

The data thus consists of 16,111 observations of hauls on 4432 trips made by 43 vessels between April 1st 2011 and December 30th 2013. There are 12 small vessels (12–18 m), 22 medium vessels (18–24 m) and 9 large vessels (24–40 m) in the data set. A fishing trip typically starts on a Monday (35% of the trips) and ends on a Tuesday, Wednesday or Thursday (64% of the trips). Looking at how the number of observations is spread over the years it is evident that cod fishing is more intense during the spring months, and that there is a slowdown during the Easter holiday and a peak in May before a slowdown during the summer. The slowdown starts around mid June and continues until the end of August. This is related to the summer closure of the Eastern Baltic fishery that starts on July 1st and ends on August 31st. In September, fishing activity increases again and fishermen are very active until the beginning of December, when there is a sharp decline in activity, especially around

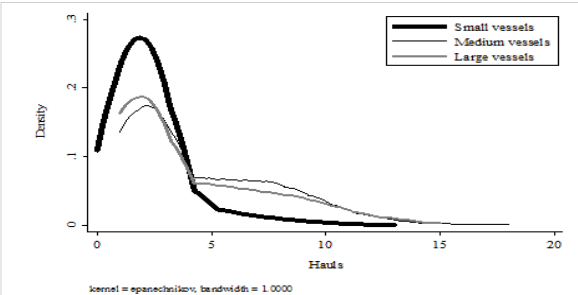
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<sup>6</sup> The relevant area consists of 24 ports in southern Sweden where cod can be legally landed.

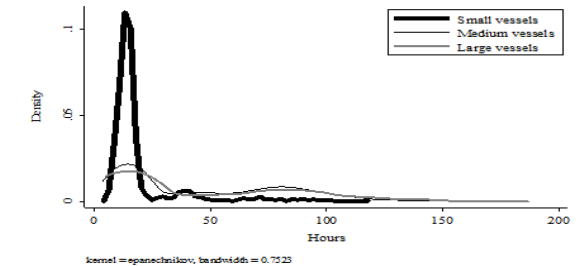
<sup>7</sup> The temperature is measured at longitude 16.25 and latitude 56.25, which is situated between the Bornholm and Öland Islands in the Baltic Sea.

the week of the Christmas holidays. The seasonal patterns are rather similar across years, although there is a significant slowdown in fishing activity in the autumn of 2013. This is related to the state of the cod stock, in particular to the sharp decline in fishable biomass, i.e. the availability of cod that was above the minimum landing size (38 cm) (ICES 2014).

Below are kernel densities of the number of hauls, revenues, quantity caught and hours spent out at sea presented on a trip level (Figure 1).

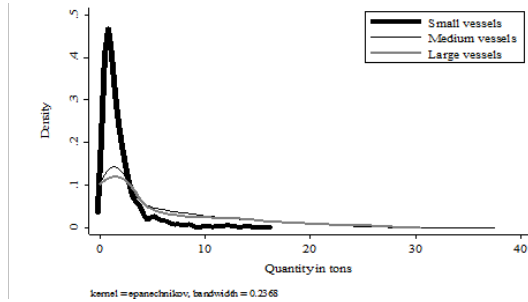


A. Number of hauls per trip.

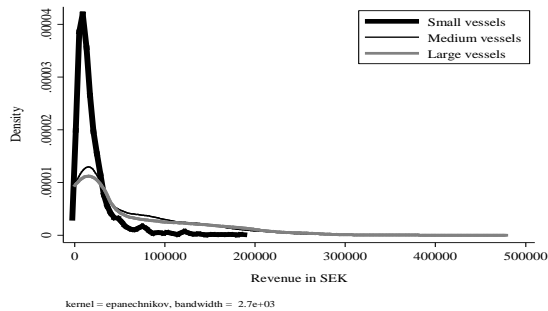


B. Hours spent out at sea per trip.

**Figure 1:**  
Distributions of the Number of Hauls, Hours Spent out at Sea, Quantity Caught and Revenue Received per Trip



C. Quantity in tons per trip.



D. Revenues per trip, revenues above 500,000 SEK are excluded (six trips).

**Figure 1 continued:**

Distributions of the Number of Hauls, Hours Spent out at Sea, Quantity Caught and Revenue Received per Trip

Figure 1A shows the kernel density estimate of the number of hauls per trip. Although the number of hauls varies considerably between trips it is relatively common for a trip to contain two hauls. In fact, 38 percent of the trips end after the second haul. This is related to the fact that small vessels make a larger number of trips that are relatively short. Small vessels on average haul 3.31 times whereas the corresponding figures for medium and large vessels are 6.64 and 6.59. Looking at individual vessels, the number of hauls made on a trip varies considerably. Although small vessels make fewer hauls than large vessels there is a lot

of variation in the data: There are cases when small vessels make more than 10 hauls on a trip.

On average, a fishing trip lasts for 38 hours but there are differences between vessel sizes as shown in Figure 1B. Small vessels stay out at sea for 20 hours on average whereas medium and large vessels both stay out for 47 hours on average. Over time there is a tendency for smaller vessels to spend less time out at sea on each trip and for medium vessels to spend more time out at sea. Large vessels do not show any such pattern.

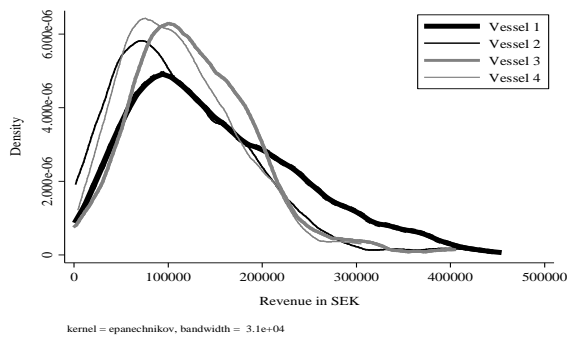
Looking at the quantity of cod caught and the revenue on each trip a similar pattern is revealed (Figure 1C and Figure 1D). This is not surprising since prices do not change much compared to quantities caught. Small vessels catch 1.90 tons of cod on average on a trip, medium vessels 5.66 and large vessels 5.68 tons. On average, small vessels earn 20,600 SEK on a fishing trip, medium vessels 61,200 SEK and large vessels 61,600 SEK.<sup>8</sup> As indicated in Figure 1C, catches can vary considerably between trips and at times they can be very large (the right-hand tail of the distribution is very long). This is not surprising, given that fishing is an unpredictable business. If there is a common revenue target present in any of the vessel groups, peaks can be expected in the kernel densities. This seems to be clearest in the case of small vessels but there are also quantity and revenue bumps for medium and large vessels.

Rather than a common revenue target for all vessels in a size class it is possible that different revenue targets exist for individual vessels, since the skills and expectations of the vessel crew might differ between vessels and vessels might have different types of equipment. Looking at revenue densities for individual vessels could reveal whether there are peaks in these distributions. As an example, vessels that made more than 100 trips during the time period are selected to check for revenue peaks. Excluding one vessel with extremely large revenues, the revenue

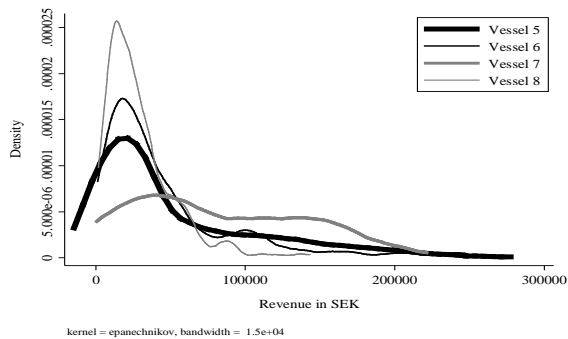
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<sup>8</sup> 1000 Swedish krona was equal to 123 USD as of 2014-01-16.

distributions of 16 vessels making 100 trips or more are shown in Figure 2.

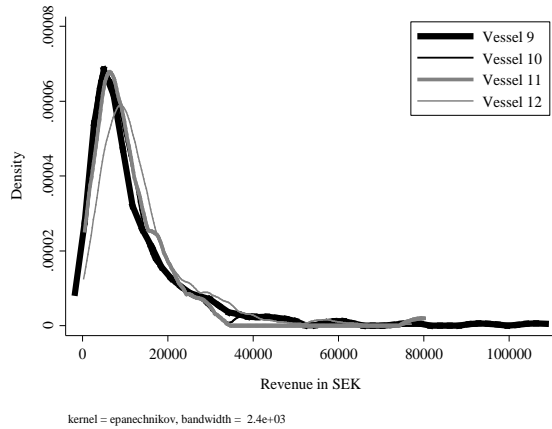


A: Trip revenues of four medium vessels.

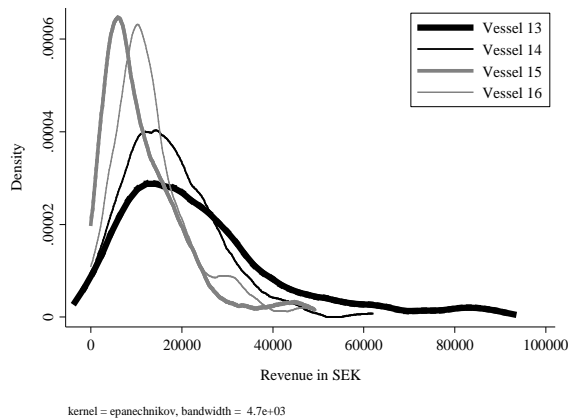


B. Trip revenues of two medium (5,6) and two small vessels (7,8).

**Figure 2:**  
Distributions of Revenue Received per Trip for 16 Different Vessels.



C. Trip revenues of two medium vessels (9,12), one small (11) and one large (10) vessel



D. Trip revenues of four small vessels.

**Figure 2 continued:**

Distributions of Revenue Received per Trip for 16 Different Vessels.

Vessels 1–6, 9 and 12 are medium vessels, vessel 10 is large and the remaining vessels are small vessels. All vessels have clear peaks at the beginning of their distributions and right-hand tails that are rather long, with the exception of vessel 7, which has a flatter distribution of trip revenues. The pattern is similar to the overall pattern but it is also evident that different vessels have different peaks (note that the length of the x-axis varies between figures). Vessels 1–4 are all medium vessels with revenue peaks around 100,000 SEK per trip, vessels 5–8 have revenue peaks around 20,000 SEK and the remaining vessels in Figures 2C and 2D have peaks around 10,000 SEK.<sup>9</sup>

In conclusion, the summary statistics reveal that smaller vessels make a smaller number of hauls, stay out at sea for a shorter time, catch less per trip and earn less revenue per trip. Medium and large vessels show very similar patterns. It is not evident from the summary statistics whether there are revenue targets for the cod fishers in the sample, although “peak” revenues seem to exist. Peak revenues also seem to differ between vessels and revenue distributions have long right-hand tails, i.e. most vessels seem to experience some trips with unusually high revenues.

## Estimation Strategy

As a starting point, this study assumes that fishermen consider one trip at a time and make decisions on trip length based on trip-specific conditions. The idea is that fishermen simplify decisions by “bracketing” the decision-making horizon between the time they leave port and the time they arrive back in port. This can be motivated by the fact that fishing is uncertain, implying that decisions are made with a short-run perspective. The choice of location, the time spent trawling in each

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<sup>9</sup> Staffan Larsson, representative of the Swedish Producer Organization of cod fishermen, mentions that a good trip might make the fishing trip shorter and that the largest vessels that are out for several days aim for a catch of 10 to 15 tons. He also confirms that it is not unlikely to catch 10 tons in one haul, but it is unusual (personal information from Staffan Larsson 2014-06-09).

location and the decision on whether to set another trawl are all decisions that are made with a short-run perspective. The fishing trip has also been used as the relevant decision-making horizon in previous studies where days at sea have been used to measure trip length (Giné, Martínez-Bravo, and Vidal-Fernández 2010; Nguyen and Leung 2013; Ran, Keithly, and Yue 2014). But, since many vessels make day trips and because there is a weekly pattern of fishing, it is also possible that the “bracket” is wider than the trip. For this reason decision making with a weekly horizon will also be considered in this study.

A common approach to test the income target hypothesis is to use the wage elasticity function where the average wage is regressed on the number of hours worked. This approach has been used in several previous studies with temporary wage increases (Camerer et al. 1997; Eggert and Kahui 2012; Nguyen and Leung 2013; Stafford 2015). One precondition for the average wage to work as a measure of the wage is that this wage does not change much during the time horizon that is investigated. In the context of fishermen it would be necessary that high early revenues on the trip are followed by equally good revenues later on the trip. If trips end because smaller revenues are expected later on, this is in line with the intertemporal model of labor supply rather than the model of reference dependence. The degree of revenue dependence during the trip is thus interesting for the choice of model.

Checking the data on cod trawlers reveals that the standard deviation of revenues from different hauls is large. The average revenue from a haul is 13,500 SEK for the entire sample and the standard deviation is 16,100 SEK. Checking the variation within trips using a fixed-effects regression reveals that there is also a lot of variation left when controlling for trip effects: within-trip variation is still 12,900 SEK. Since revenues can be expected to vary because of the time of the day, the geographical position and the hour of the day, these variables were also added to the regression, reducing within-trip variation only slightly to 12,800 SEK. Hence, high within-trip variation does not suggest that fishermen can expect constant revenues from different hauls on a trip even if they

adjust their expectations because of knowledge of the area or time-specific conditions.

The correlation between adjacent hauls might also matter for the fishermen. If the previous haul was successful it might be expected that the next haul will be so as well. The correlation between the current and the next haul within trips is estimated using a regression with the current haul as a dependent variable. The results show that the relationship is insignificant (Table 2, Model 1). In a second specification day-of-the-week effects, hour-of-the-day effects and dummies for geographical position are added, the motivation being, as above, that fishermen could expect revenues to depend on these variables. However, the dependence of the current haul on the previous haul is even smaller given these aspects. This suggests that it is unlikely that fishermen expect good hauls to be followed by equally good hauls and vice versa.<sup>10</sup>

**Table 2:**

Revenues from Hauls Regressed on Lagged Revenues from Hauls within Trips

	(1)	(2)
Coefficient of lagged revenue	324.79	196.01
Standard error	212.27	214.04
t-value	1.53	0.92
p-value	0.126	0.360
R2	0	0.017

Note: Regression (1) is  $y_{ht} = \alpha + \beta y_{h-1,t} + \mu_t + \varepsilon_{ht}$ , where  $y_{ht}$  and  $y_{t,h-1}$  are current and previous revenues from hauls,  $t$  indexes the trip and  $h$  indexes the particular haul and  $\mu_t$  are trip fixed effects. Regression (2) is the same model with day-of-the-week effects, hour-of-the-day effects and dummies for geographical position added. The number of observations is 11,660.

Although it might be the case that fishermen consider the entire revenue from a haul when deciding whether to continue fishing it is also possible

<sup>10</sup> It is possible that revenues from hauls earlier on during a trip ( $\text{lag} > 1$ ) have an effect on the revenues from the current haul. However, the number of observations would decrease significantly using more than one lag, and this kind of specification is therefore avoided.

that the time spent trawling matters and that what matters for fishermen is the revenue earned per hour. Since fishermen spend time on board their vessel for several days and have very irregular working hours on board it is difficult to distinguish between time spent traveling, time for breaks and sleeping hours. One way is to consider all hours spent on board as work hours since being on a fishing trip prevents the fisher from taking part in family activities or other land-based recreational activities. Another view is that only time spent trawling is considered as working hours and that traveling, having a break or sleeping is spare time.

Calculating revenues per hour for each haul using the entire time spent on board shows that revenues per hour is 1944 SEK/hour for the entire sample with a standard deviation of 7547 SEK/hour. Also, within-trip variation is very large, 8074 SEK/hour, suggesting that there is more variation within trips than between trips. However, it is possible that sleeping hours gives low revenues per hour when using the entire time spent on board. Using only time spent fishing when calculating revenue per hour gives a higher revenue per hour: 3194 SEK/hour with a standard deviation of 4889 SEK/hour. Checking within-trip variation reveals that this variation is 4229 SEK/hour without additional controls and 4198 SEK/hour with additional controls. Thus, it seems as though the conclusion when using only revenues from hauls is confirmed by using revenues per hour, whether hours from the entire trip is used or only hours spent fishing, i.e. revenues during a fishing trip vary to a large extent.

Regressing the lag of revenues per hour on revenue per hour using the two different time measures shows that there is little dependence between revenue per hour from different hauls (Table 3). Using all time spent on board does not reveal any dependency between hourly revenues (Models 1 and 2), and using only time spent fishing shows some positive dependency between hourly revenues. However, this latter dependency becomes insignificant when more controls are added to the regression.

**Table 3:**

Revenues per Hour from Hauls Regressed on Lagged Revenues per Hour from Hauls within Trips

	(1)	(2)	(3)	(4)
Coefficient of revenue per <u>hour spent on board</u>	-241.764	-81.841		
Standard error	126.781	137.181		
t-value	-1.91	-0.6		
p-value	0.057	0.551		
Coefficient of lagged revenue per <u>hour spent fishing</u>			145.488*	131.947
Standard error			70.749	71.304
t-value			2.06	1.85
p-value			0.04	0.064
R2 of regression	0	0.01	0.001	0.021

Note: Regression (1) and (3) is  $y_{ht} = \alpha + \beta y_{h-1,t} + \mu_t + \varepsilon_{ht}$ , where  $y_{ht}$  and  $y_{t,h-1}$  are current and previous revenues per hour using two different measures of hours as described in the text,  $t$  indexes the trip and  $h$  indexes the particular haul and  $\mu_t$  are trip fixed effects. Regression (2) and (4) are the same models with day-of-the-week effects, hour-of-the-day effects and dummies for geographical position added. The number of observations is 11,660.

The conclusion from this exercise is that there is not much support for dependence between adjacent revenues on a trip. I therefore conclude that a fisherman cannot expect good revenues to be followed by equally good revenues or that bad revenues will persist during the day. Thus, using the average revenue from a trip would not make sense in this case. I will use a version of the stopping model with cumulative revenues suggested by Farber (2005, 2008). In this model, fishermen are assumed to make decisions based on all revenues collected previously on the trip.

From a decision-making point of view, the most important time points during a fishing trip are the times of the hauls since I assume that the fisherman must decide whether to continue fishing or return to port at these points in time. For a decision point to be relevant it is necessary that the vessels are able to set at least a second trawl; if a vessel has no

such capacity it would return to port after hauling for the first time and there would be no relevant decision point. Calculating the maximum number of hauls of each vessel reveals that each vessel made two or more hauls on at least one of their trips. Thus, there should exist at least one decision point for every vessel in the sample.

Assuming that the time of the haul is a decision point for the fisherman the stopping point is modeled as a function of the log of the number of hours worked so far (*cumh*) and the log of the revenue collected so far (*cumr*).<sup>11</sup> The number of hours worked are calculated as the total number of hours spent on board until the time of the haul assuming that all hours spent on board are work hours. The basic linear probability model will look as follows:

$$P(\text{Stop} = 1|x_i) = \beta_0 + \beta_1 \text{cum}h_i + \beta_2 \text{cum}r_i + \varepsilon_i. \quad (1)$$

At each decision point the fisherman will decide whether to continue to fish, i.e. to place another trawl in to the water, or whether to return to port.<sup>12</sup> The revenue target model predicts that the likelihood of quitting is related to the income earned so far during the trip. Conditional on the number of hours worked so far, the income reached so far should be positively related to the probability of going home, i.e. if two trips have lasted the same amount of hours it is more likely that a vessel with higher revenues returns to port.

Since it is unlikely that there is one common revenue target for every vessel or even for the same vessel on different trips it makes sense to assume that potential targets are based on expectations formed in the recent past as suggested by the rational expectations model developed by Kőszegi and Rabin (2006). Thus, assuming that the trip is the relevant decision horizon, expected revenues are assumed to be formed by beliefs that the captain and crew hold when starting the trip and will differ

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<sup>11</sup> Using logged variables is motivated by the skewed distribution and facilitates the interpretation of the coefficients.

<sup>12</sup> It is possible to decide to haul at any time and the weight of the trawl gives some indication of the quantity of the catch, so the decision whether to stop could in practice occur just before the haul.

depending on the season, fishermen characteristics and other trip-specific conditions. High expected revenues are assumed to result in longer working hours in line with the intertemporal model and in order to look for potential revenue targets of unexpected revenue changes it is important to control for factors that are important in determining expected revenues.

Assuming that the trip is the relevant decision-making horizon motivates the use of trip fixed effects, assuming that factors that are unchanged during a trip correlate with the time spent at sea and the revenues collected. Using trip-specific effects controls for factors such as seasonal differences, vessel characteristics (such as size, gear and engine power), crew and captain characteristics and skills, effects of what happened on previous trips and fixed costs of the trip. Also, the effect of prices is kept constant, since the price used is the price given at the beginning of each trip. It can also be argued that trip-specific effects control for weather conditions since the decision to make the trip might be based on weather prognoses available when starting the trip.

Additional factors that affect the trip length and revenues are also used in the model. These are the geographical position of the fishing place (*geopos*), the day of the week (*dow*) and the time of the day (*tod*). The geographical position is added since it might change during the trip and because biological conditions could differ between different positions. The positions are areas used by the International Council for the Exploration of the Seas (ICES) that divide the Baltic Sea into rectangles with a longitude of 1 degree and a latitude of 0.5 degrees (ICES 2011). Day-of-the-week effects are motivated by noticing that fishermen have different preferences for working on different days of the week. For example, fishermen are more likely to finish earlier or not fish at all on weekends. Using day-of-the-week effects also controls for seasonal closures and limited periods that prevailed during the time of the trip. Time of the day also accounts for time preferences since fishermen are more likely to return to port in the evening than in the morning. Thus the extended fixed-effects model is:

$$P(Stop = 1|x_{it}) = \beta_0 + \beta_1 cumh_{it} + \beta_2 cumr_{it} + geopos\delta_{it} + dow\gamma_{it} + tod\theta_{it} + \gamma_i + \varepsilon_{it}, \quad (2)$$

where the variables for haul  $t$  on trip  $i$  are defined as described above.

The literature on revenue targeting is often concerned with the heterogeneity of subjects; for example, the degree of loss aversion might differ between subjects (Fehr and Goette 2007) or experienced individuals might use different strategies than inexperienced individuals (Camerer et al. 1997; Nguyen and Leung 2013). In this study I will use the differences in vessel length to explore potential differences in revenue targeting for smaller vessels (12–18 m), medium vessels (18–24 m) and large vessels (24–40 m).<sup>13</sup> It is possible that the decision-making horizon differs between fishermen on smaller and larger vessels and that this will reflect the tendency to reach for revenue targets. It is, for example, often argued that fishermen on smaller vessels have utilities from fishing that are not in the form of pure profit as fishing is often considered to be a lifestyle choice (Swedish Agency of Marine and Water Management 2014a).

One potential problem when estimating the effect of increasing revenues on stopping probability is that vessels might have reached a physical capacity limit, i.e. there is no more room for fish on board, and thus vessels have to return to port. If high revenues are correlated with reaching such a capacity limit it might be that high revenues are associated with a high probability of returning without there being a revenue target for the trips. Previous studies have handled the capacity problem by adding dummy variables for vessel length or the existence of an ice breaker on board (Nguyen and Leung 2013) or by noting that maximum capacity is hardly ever reached (Eggert and Kahui 2012). It is, however, difficult to measure the influence of capacity constraints using dummy variables since such variables will only control for differences in capacities between vessels. Given that vessels have different physical capacities, they might still reach their vessel-specific capacities and return to port for this reason.

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<sup>13</sup> The number of full-time equivalents in 2010 was 1.53 on average on smaller vessels and on larger vessels it was 2.54 (TemaNord 2014).

Returning to Figures 1c and 1d and Figure 2 it is evident that the distributions of catches and revenues on a trip level are highly skewed to the right, i.e. catches can sometimes be considerably larger than the average catch. This suggests that reaching or even getting close to a capacity limit is not very common. Using the maximum catch of a vessel during the time period as the capacity limit and counting the number of trips that reached 75% or more of this maximum reveals that only 6% of the trips (264 trips) were close to or at the maximum catch. The maximum catch of the vessel might, however, be a strict definition of the maximum catch since many vessels in the sample make only a few trips during the time period. Using the maximum catch of vessels in the same size category as the capacity limit (i.e. small, medium or large) shows that a vessel reaches 75% of the maximum on 47 trips, which corresponds to 1% of the trips in the sample. Although it is unusual that a vessel gets close to a capacity limit, a version of the model where trips that reached 75% of their vessel-specific revenue maximum is omitted in the main specifications of this study.<sup>14</sup>

Three additional variables that might affect the stopping probability are also added to the model. These are temperature changes during the trip, by-catches per haul and the average revenues from previous hauls made by all fishermen in the same fishing area. Temperature changes during the trip might affect how pleasant it is to fish at different stages of the trip, higher temperatures are expected to make it less likely for fishermen to return. The effects of by-catches, i.e. catches of species other than cod, are expected to increase stopping probability since it can be argued that catching species other than the desired one will contribute to smaller profits because of increased handling and distribution costs. Finally, the average revenues from the previous 20 hauls (alternatively 10 previous hauls) is a proxy variable for information exchange from other fishermen in the area. If fishermen receive information about increased earnings

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<sup>14</sup> Including a variable that measures capacity (cumulative or as a dummy variable) in the original model is difficult since there is high correlation between reaching a potential capacity level and accumulating revenues.

opportunities they expect to receive higher revenues and the prediction is that they will stay out fishing longer.

By controlling for factors that can be observed by the fishermen (e.g. trip-specific effects, day of the week, time of the day and previous catches) an increase in revenue can be interpreted as a proxy for an increase in revenue that is unexpected, or not possible to control or observe for the fisherman.<sup>15</sup> Since revenues are highly volatile it is difficult for fishermen to control exactly what is caught in a trawl; often, the density of shoals and the quality and size of the fish vary and are not observed until the fish are on board. Also, sudden weather changes (winds) can change the amount of fish that is caught. Thus, it is the effect of unexpected revenue changes on the likelihood of returning to port in line with the theory of Kőszegi and Rabin (2006) that is measured.

In summary, the predictions of my model are:

The likelihood of returning to port is positively related to the number of hours worked so far on a fishing trip.

If the revenue target hypothesis is relevant the effect of revenue earned so far should be positively related to the likelihood of returning to port.

If the intertemporal hypothesis is relevant the effect of revenue earned so far should be negative or insignificant, the effect of previous catches should be negative and the effect of by-catches should be positive.

The coefficient on hours worked will necessarily be positive since I am looking at within-trip variation. The longer a trip has lasted the more likely it is that the vessel will return to port since the length of a trip will decrease with fatigue and the ability to keep fish fresh. This variable is mainly used as a control variable for making comparisons between vessels that have been out at sea for the same amount of time. If the revenue target hypothesis is the correct hypothesis a trip with higher revenue than expected should be more likely to end when two trips have

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<sup>15</sup> In reality, it might be that the fishermen can observe factors that the researcher cannot; for this reason the variable is a proxy.

lasted for the same length of time. If the intertemporal model is the correct hypothesis the coefficient on the revenue variable will be insignificant or negative, the effect of previous revenues negative and the effect of by-catch positive. If cumulative revenue has a negative effect on the probability of returning to port, fishermen want to continue fishing when revenues are high. This could be because they believe that revenues will also be higher than usual on the rest of the trip, substituting leisure for labor when they believe revenues will be high.<sup>16</sup>

In this paper, the linear probability model will be used rather than a nonlinear model such as the probit or logit model. A number of problems with the linear probability model are often mentioned in the literature. Standard errors are heteroskedastic, parameters close to zero or one are difficult to interpret and sometimes the interpretation of parameters is not representative of the relationship between the independent and dependent variables (Wooldridge 2006). To deal with binary choices it might make sense to use different kinds of distribution functions. However, any nonlinear function is problematic when fixed effects are present since the number of observations within panels is often small. Adding fixed-effects parameters results in inconsistent estimation of these parameters and because of the nonlinearity these parameters will also affect other parameters of the regression, resulting in inconsistency for all the parameters of the model (the incidental parameters problem) (Cameron and Trivedi 2010). In this paper, the linear probability model has been chosen, given that the numbers of hauls are small, and that there are many panels with only a few observations. However, it is not necessary to assume that the effect of revenues is linearly related to the stopping probability, even when using a model that is linear in parameters. Increasing revenues might have different effects as the trip proceeds; in particular, if there is a target revenue level, we might expect a higher probability of returning when such a target has been reached. Interacting revenue earned with hours worked, haul number and day of

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<sup>16</sup> As noted earlier, there is no statistically significant relationship between revenues within trips, but high cumulative revenues could still be perceived as an indication of how revenues will develop on the rest of the trip.

the week is therefore used in different specifications to investigate whether the effect of higher revenues is nonlinear.

## **Results**

Table 4 shows the results from the stopping probability model. Hours worked have a negative coefficient and revenue earned so far has a positive coefficient in the first model (a cross section model). This model does not take the heterogeneity of different vessels and time periods into consideration and is only presented for reference. Model 2, where trip fixed effects are added, controls for everything that is unchanged during a trip. The coefficient on hours worked shows that the longer a trip has lasted, the greater the probability that the vessel returns to port. Interpreting this coefficient indicates that the probability of returning to port increases by 0.44 on average for a 1% increase in trip length. Model 2 does not suggest that the level of revenue earned has any effect on stopping probability given that a vessel has been out for a certain length of time. However, when revenue earned is interacted with hours worked there is an additional negative effect on stopping probability, indicating that the longer the trip has lasted the more important high revenues are for the likelihood of continuing.

**Table 4:**

Hazard of Stopping After a Haul: Estimates from a Linear Probability Model

	(1)	(2)	(3)	(4)
Hours worked	-0.044*	0.435***	0.429***	0.439***
Revenue earned	0.041**	-0.036	-0.076***	-0.094***
Revenue*Hours	0.029	-0.066*	-0.028	-0.047**
Temperature	-0.007***	-0.036***	-0.002	-0.003
Previous catches	-0.111***	-0.060***	0.006	-0.004
By-catch	0.054***	0.067***	0.049***	0.048***
Constant	3.088***	9.556***	-1.082	-0.472
Trip fixed effects	No	Yes	Yes	Yes
Geographical position effects	No	No	Yes	Yes
Day-of-the-week effects	No	No	Yes	Yes
Hour-of-the-day effects	No	No	Yes	Yes
N	15916	15916	15916	14949
R2	0.088	0.353	0.474	0.489

Note: Standard errors are clustered on vessels in all models. Hours worked, Revenue earned and By-catch are in logs. Revenue and Hours are centered around their means for the calculation of the interaction. Significant levels are \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ .

Model 3 refines Model 2 by adding more variables. Since fishermen are more likely to return to port in the evening or on specific days in the week, variables indicating the hour of the day and the day of the week are added to the model. Since a certain geographical position could also be related to the decision of a fisherman, dummy variables for different areas in the Baltic Sea are added. The added variables seem to strengthen the idea that high revenues increase the willingness to continue fishing since the main effect of revenues is also significant and negative now. Finally, when trips where the proxy for a capacity limit is reached or is about to be reached are removed from the sample (Model 4), the estimates suggest that the physical capacity limit is not very important on average; the coefficients on revenue earned are similar in Model 3 and Model 4. But Model 4 indicates that there is a combined effect of revenues and hours since the interaction variable now becomes

significant. Using the 95% confidence interval from Model 4 shows that a revenue increase of 1% is associated with a decrease in the probability of returning to port by 6–13 percentage points on average. The interaction effect suggests that the likelihood of continuing is more affected by higher revenues if the fishing trip has lasted for a longer time. In summary, these results do not lend support to the revenue target hypothesis since higher revenues than expected do not result in shorter working hours for fishermen.

The temperature and information variables (average revenues from previous hauls) are only significant in Models 1 and 2. This suggests that the dummy variables for geographic position, day of the week and hour of the day control for temperature and information exchange. Interestingly, the information variable in Model 2 is negative, which indicates that when previous catches (catches from the vessel of interest as well as catches from other vessels are included) are good the probability that a fishing trip will continue increases. This is in line with the intertemporal model with expected revenues; expecting revenues to be high in the future will make it more likely to continue fishing.<sup>17</sup> The temperature variable in Model 2 has the expected sign, since warmer weather increases the trip length somewhat.

The coefficient of the by-catch variable is positive and significant in all models, suggesting that an increase in catches other than cod increases the probability that fishermen will stop fishing. One interpretation could be that, for these fishermen, catching species other than cod gives lower total revenues than if only cod had been caught, and that this decrease in revenues also decreases the probability of continuing the trip. This result is in line with the idea that fishermen substitute leisure for labor when unexpected revenues are low.

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<sup>17</sup> Two alternative measures of revenues from previous hauls were used, one with the average revenue per hour spent trawling from 20 previous hauls and one with the average revenue per hour from 10 previous hauls. Both variables have negative and significant coefficients in Model 1 and Model 2 and insignificant coefficients in Models 3 and 4.

Since the captain and crew on different types of vessels may exhibit different behavior, the revenue and hours' variables have been interacted with large, medium and small vessels respectively using the model with the capacity limit (equivalent to Model 4 in Table 4). The results are presented in Table 5.

**Table 5:**

Hazard of Stopping after a Haul: Estimates for Different Vessel Types (Small, Medium and Large) from a Linear Probability Model

Variable	Coefficient
<b><u>Hours worked</u></b>	
Large vessels	0.329**
Medium vessels	0.440***
Small vessels	0.551***
<b><u>Revenue earned</u></b>	
Large vessels	-0.046*
Medium vessels	-0.110***
Small vessels	-0.063
<b><u>Revenue*Hours</u></b>	
Large vessels	-0.003
Medium vessels	-0.028
Small vessels	-0.090**
By-catch	0.049***
Constant	-1.466***
Trip fixed effects	Yes
Geographical-position effects	Yes
Day-of-the-week effects	Yes
Hour-of-the-day effects	Yes
N	15,121
R2	0.496

Note: The regression is based on Equation 2. Standard errors are clustered on vessels in all models. Hours worked, Revenue earned and By-catch are in logs. Revenue and Hours are centered around their means for the calculation of the interaction. Significant levels are \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ .

Increasing the number of hours worked by 1 percent has different effects on stopping probability on average for small, medium and large vessels. On average, an increase in time spent on board has a larger effect the smaller the vessel, which is related to the fact that smaller vessels spend less time out at sea. Turning to the variable of interest, the revenue

variable, the results indicate that the decrease in stopping probability related to higher revenues is more important for medium vessels than for small or large vessels. The coefficient on small vessels is in fact insignificant. However, the interaction variables between revenue earned and hours worked show that the number of hours spent out at sea does not matter for medium and large vessels but is increasingly important for small vessels. This suggests that small vessels behave more like medium vessels when spending more time out at sea.

Another approach that allows for nonlinear effects of cumulative revenues is to estimate the effect of revenue increases at the time of different hauls. The motivation is that the times of the hauls are decision points for the fishermen and thus constitute interesting points for the decision whether to continue fishing or return to port. The hauls are labeled haul 1, haul 2, haul 3 etc. and are also added as main effects to the regression. Table 6 shows the results of the coefficient of the revenue variable interacted with different haul numbers, for large, medium and small vessels using the model of Equation (2) using the sample where trips that are reaching a potential capacity constraint have been removed (compare Model 4 Table 4). Coefficients of other variables are not shown and nor are coefficients of the interaction variables after haul 10. The number of observations decreases dramatically after 10 hauls, producing insignificant coefficients in most cases.

**Table 6:**

Coefficients on Revenue Earned Interacted with Different Haul Numbers for Large, Medium and Small Vessels

Haul number	Number of trips/observations	Percent-age share	Coefficient on revenue earned, large vessels	Coefficient on revenue earned, medium vessels	Coefficient on revenue earned, small vessels
1	4434	28%	0.002	-0.048**	0.016
2	3607	22%	-0.102**	-0.160***	-0.032
3	1913	12%	-0.03	-0.123**	0.086
4	1502	9%	-0.011	-0.089*	-0.036
5	1253	8%	0.016	-0.072	-0.016
6	1038	6%	0.06	-0.033	-0.007
7	794	5%	0.074	-0.008	0.03
8	598	4%	0.1	0.002	0.022
9	416	3%	0.136	0.073	0.097
10	233	1%	0.168	0.047	0.062

Note: All models are based on Equation 2, results from other coefficients are not presented for reasons of space. Standard errors are clustered on vessels. Significant levels are \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ .

In general, the results suggest that higher revenues conditional on the number of hours spent out at sea do not affect the probability of returning to port. This is especially true for smaller vessels; the effect of increasing unexpected revenues does not affect the decision whether to return to port at any stage of the trip. For large vessels there seems to be an effect of higher revenues at the time of the second haul. Having a good second haul is perhaps interpreted as an indication of a good trip and thus the trip tends to be longer. A similar effect is seen at the beginning of the trip for medium vessels; in fact, having higher revenues than usual on the first, second, third and fourth haul makes the fishermen more reluctant to stop fishing.

Using the trip as the relevant decision-making horizon is somewhat ad hoc and it might be that some vessels use a longer decision-making horizon, especially vessels that go on day trips several times a week. On average, a vessel makes 1.74 trips a week, but smaller vessels make

more trips (2.39) than medium and large vessels (1.55 and 1.54). Thirty-one percent of the hauls in the data set are made by vessels that make at least one day trip on a particular week. Assuming that the week is the relevant decision horizon the hypothesis that fishermen have weekly income targets is tested. Using the week necessitates the use of a breaking point where weeks are defined in a way that is logical from the fishermen's perspective. Turning to the data, it is evident that there are relatively few trips starting at the weekend (11% of the trips) and that most trips start on a Monday (35% of the trips). For this reason, the break point of the week is assumed to be the night between Saturday and Sunday and the hypothesis that is tested is that a vessel has a weekly income target that is reached at the latest on Saturday at 11.59 p.m.

The fixed effects used in the analysis of weekly targets are vessel-week specific, i.e. all factors that are unchanged for a certain vessel during a certain week are kept constant. The interpretation is therefore similar to the interpretation of the trip-specific model, although the number of fixed effects reduces to 2495 as compared to 4355 in the trip-specific models. Dummy variables for the day of the week, the hour of the day and geographical position will be added as before and with the same motivation. Also, as before, to account for physical capacity constraints, trips that are about to reach maximum physical capacity are excluded from the analysis.

To account for nonlinearities in revenue targeting, revenue is interacted with hours but also with different days of the week. The idea is that it is more likely for the fishermen to reach a target later on in the week. The results are presented in Table 7.

**Table 7:**  
Assuming Weekly Targets and Nonlinear Revenue Effects

	(1)	(2)
Hours worked	0.085**	0.054*
Revenue earned	0.014	
Revenue*Hours	0.047***	
Monday		-0.067***
Tuesday		-0.049***
Wednesday		-0.026*
Thursday		0.023
Friday		0.065*
Saturday		0.005
Sunday		0.054
Temperature	0.002	0.002
Previous revenues	-0.029*	-0.025*
By-catch	0.029***	0.029***
Constant	-3.112***	-2.528***
Vessel-week effects	Yes	Yes
Geographical-position effects	Yes	Yes
Day-of-the-week effects	Yes	Yes
Hour-of-the-day effects	Yes	Yes
N	14,961	14,961
R2	0.347	0.348

Note: Standard errors are clustered on vessels. Significant levels are \* for  $p < 0.05$ , \*\* for  $p < 0.01$ , and \*\*\* for  $p < 0.001$ . Revenue and Hours are centered around their means for the calculation of the interaction in Model 1 and Model 2.

Model 1 shows that the main effect of revenue earned so far in the week is not significant but the interaction between revenue earned and hours worked is significant. This suggests that higher revenues increase the probability that the fishermen will stop fishing only when the fishermen have spent a certain amount of hours out at sea. Interacting revenues earned with the day of the week to account for nonlinearities in revenue

effects gives the results of Model 2. High revenues at the beginning of the week make it less likely that the fishing week will end whereas high revenues on a Friday make it more likely that the fishermen will stop fishing for the week. This somehow supports the results of Model 1 since the longer the week has lasted, the more likely it is that the fishermen care about high revenues when making the decision to stop fishing.

The results of the remaining variables are similar to the trip-specific models with one exception: the coefficient on the variable of previous revenues is significant even when controlling for geographical position, day-of-the-week effects and hour-of-the-day effects. Compared to the models using trip effects it might be more important to control for information exchange between fishermen when assuming weekly targets. But the conclusions are similar to the conclusions of the trip-specific model: if fishermen expect good revenues they will continue fishing and if by-catches (that are unexpected) are large fishermen will be more likely to return to port. These findings are in line with the intertemporal model where labor is substituted for leisure when incomes are high and vice versa.

What can we make of these results? It is important to keep in mind that most vessels have stopped fishing before Friday. Using the number of vessel-week-specific observations shows that, on average, only 25% of the vessels are left when Thursday ends and Friday begins. There is no particular difference between vessels making at least one day trip and other vessels in this respect. Obviously, to end the week of fishing on a Friday if unexpected revenues are high is thus only a possibility if the vessel is still fishing on Friday. Fishermen on most vessels (those making day trips as well as those making longer trips) end their week of fishing on a Wednesday or a Thursday (56% of the vessels). The effect of an increase in cumulative revenues on the probability of stopping fishing activities for the week is insignificant on those days.

Since many factors that fishermen are aware of are controlled for (i.e. trip-specific conditions, day of the week, geographical position etc.) it is assumed that fishermen expect certain revenues based on those factors. Assuming that expected revenues can be controlled for might, however, be a strong assumption. Fishermen on board a vessel might clearly have

information, correct or incorrect, that cannot be measured in any way using available logbook data. This could explain that, despite the finding that there is no within-trip correlation between revenues from different hauls, there is still a negative coefficient on the probability of returning to port for early hauls. If you cannot draw conclusions from previous hauls, why then continue fishing when revenues are higher than usual? Perhaps fishermen believe wrongly that good times will be followed by equally good times (the inverse of the gambler's fallacy), or it might be that fishermen tend to forget all the miserable hauls and remember only the good ones and make their decisions based on this (availability heuristic). These explanations, or others, could perhaps be used in the future to better explain what constitutes an expected target.

It might also be possible that fishermen have other targets in addition to revenue targets. In that case, if the revenue target is only one of the targets to be reached and if it is not the last reached target, there will not be any correlation between ending a fishing trip and reaching the revenue target. Crawford and Meng (2011) assume that taxi drivers have revenue targets as well as hours targets and that both have to be reached before the taxi driver ends his shift. Controlling for time-specific effects (such as day of the week and time of the day) picks up some time-related differences in preferences but the issue could be further investigated. On the other hand, if it is the relationship between working hours and revenues that is of interest it is implicitly assumed that hours are a function of revenues and not an independent goal as such.

So far, most of the evidence of revenue targeting has been limited to workers that are independent in their decision-making process, i.e. taxi drivers who decide themselves when and where to work. If revenue targeting is an important aspect of economic life and if it is important to consider targets when forming policies it is necessary to prove that they exist outside the realm of certain independent self-employed workers. A fisherman working on a trawler, although self-employed, is more dependent on cooperation and the decisions of the captain. The evidence provided here does not suggest that revenue targeting is an important aspect for this kind of worker. On the other hand, it is more difficult to determine whose preferences are actually measured, and although there

is no collective revenue target for the entire crew of the vessel, might it still be possible that individual fishermen have their own specific revenue targets?

## **Conclusions**

This paper investigates the relationship between short-term revenues of fishermen and the time spent out at sea, i.e. the working hours of fishermen. More specifically, the revenue target hypothesis is tested. So far, the empirical literature has not found substantial evidence supporting the hypothesis, neither for fishermen nor for other workers.

The main results indicate that a fishing trip is more likely to continue if revenues are unexpectedly high. It thus seems that the revenue target hypothesis is not very relevant for explaining the behavior of Swedish Baltic Sea fishermen. Constraints (i.e. the physical capacity of the vessel, quota limitations or other regulations) do not seem to influence the results. Also, there is no evidence of revenue targeting differing between vessel types (small, medium or large). On the other hand, assuming that revenue targets are weekly rather than trip-specific gives slightly different results. The main conclusion is still that most fishermen are not very likely to have revenue targets but there is some indication that there is a Friday effect. If the cumulative incomes of the week are higher than expected on a Friday, it is more likely that the fishermen will return to port.

There are also some indications that fishermen substitute labor and leisure intertemporally, both for expected and unexpected revenue changes. If revenues from previous hauls are high, fishermen are more likely to continue fishing, thus substituting leisure for labor when incomes are high. If unexpected catches of species other than cod (by-catch) are high fishermen are more likely to return to port, and assuming that handling costs increase and incomes decrease with more by-catch, this is in line with an intertemporal model where leisure is substituted for labor when incomes decrease.

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