Economic incentives to target species and fish size: Prices and fine-scale product attributes in Norwegian fisheries

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Abstract

Improved fisheries management provides fishermen with more opportunities to maximize harvest value by accounting for valuable attributes of the harvest such as species, harvest timing, fish size, product form, and landing location. Harvest values can also vary by vessel and gear type. Moreover, the extent of targeting can influence the ecosystem in which the fishermen operate and provide important management challenges. We utilize a unique data set containing daily vessel-level fish landings in one region of Norway in 2010 to investigate the value of an array of attributes including species, product form, product condition, timing, fish size, vessel type, gear type, and landing location for cod and other whitefish species, as well as king crab. We also investigate to what extent landed value differs across different communities, firms, and plants. The results indicate substantial variation for all attributes, highlighting opportunities for fishermen as well as potential management challenges. For whitefish, the species landed accounts for three quarters of the variation in prices. For cod in particular, the fish size accounts for nearly all variation in prices. In these fisheries, market conditions justify management focus on the biological composition of the catch.

Key words: Margins, product attributes, seafood markets, fish size, fisheries management, cod, whitefish, king crab

Introduction

Fishermen operate in a complex decision environment. Harvesting decisions are influenced by expectations of factors such as fish availability, regulations, and market opportunities (Smith, 2012). Fisheries science primarily considers fishing decisions in the context of how harvests affect fish stock size. Decisions about when to fish, where to fish, what to target, and what gear to use are largely considered in terms of the resulting effects on target stocks, stocks of other species, sub-stocks, or critical habitat. While this emphasis will remain important, it is only a part of the economic environment of fisheries. A separate but important economic dimension of the fishery is how fishing decisions contribute to the economic value of landings. Decisions that influence the catch composition, quality of fish, where fish are landed, and the product forms of landings all contribute critically to fishing revenues and ultimately influence the viability of coastal communities.

In this paper, we explore this essential aspect of economic value with a unique data set containing detailed daily landings information for all whitefish landed by all vessels in the northernmost management region of Norway. The richness of the dataset allows us to highlight fishing incentives on land that likely affect fishing behavior on the water. These behaviors, in turn, affect fish stocks in ways that inform traditional fisheries management but also point toward ways that fishery managers might contribute to generating economic value from scarce ocean resources.

When specific product attributes are more valuable than others, fishermen have incentives to target these attributes in the water. However, a systematic targeting of specific attributes can lead to growth overfishing of some size classes (Diekert, 2012;

Zimmerman, Heino and Steinshamn, 2011), and, theoretically, to a long-run genetic response in the fish stocks through evolutionary changes (Law and Grey 1989). Observational data are consistent with the hypothesis of fishing-induced evolution (Law 2000; Jørgensen et al. 2007), while laboratory experiments provide direct evidence that fishing pressure could induce evolutionary changes (Conover and Munch 2002). Accounting for evolutionary effects of harvesting has important management implications. Fishing-induced evolution can alter biological reference points (Heino et al. 2013) and optimal fishing mortality (Eikeset et al. 2013), and failing to account for the genetic consequences of selective harvest theoretically can lead to the extinction of valuable genes (Guttormsen, Kristofersson, and Naevdal 2008). Despite growing theoretical and empirical literatures in fisheries biology and in bioeconomics, the extent to which gear selectivity and targeting behavior induce actual evolutionary changes in fish populations and the social consequences are still not well understood. Understanding the strength of economic incentives for selection and targeting is one key element of broad policy discussions surrounding growth overfishing and fishing-induced evolution.

Using landings data, we specifically can assess the intensity of economic incentives in at least two categories, fish size and harvest timing. Several species are characterized by size-dependent pricing (Asche and Guttormsen, 2001; Asche et al. 2012; Zimmerman and Heino, 2013; Lee 2014), and the more substantial the price difference is between different size categories, the stronger will the fishermen's incentives be to target specific sizes. Similarly, if prices vary substantially within a season, this provides incentives to target fish at specific times (Larkin and Sylvia, 1999). For short-lived species, timing of the catch is also related to size dependent pricing (Ling and Smith, 2014). Depending on the timing, market incentives can amplify or counter the effects of natural aggregations and result in more or less evenly distributed catches across the season.

Fleet composition and choice of gear type are also important for environmental and societal impacts of a fishery. The “small is beautiful” perspective holds that smaller vessels lead to less environmental impact because they use passive gear types (Hubert, Pope and Dettmers, 2012), supply higher quality and more value due to better handling (Utne, 2007), and provide stronger support to coastal communities because of their more limited range and higher employment (Christy, 1982). Sumaila and Armstrong (2001) show that the Norwegian coastal fleet generates more value than the trawlers per unit of quota and argue that higher average fish size is the main explanation. Guttormsen and Roll (2011) show that while there are differences in harvest efficiency between different vessel groups in the Norwegian whitefish fisheries, the variation in efficiency occurs in all vessel groups. Hence, there are limited systematic cost differences for different vessel groups. By controlling for vessel size or gear type, we can assess whether there is a premium associated with specific vessel groups or gear types, while also controlling for the influence of species, fish size, and other product attributes.

A feature that has received limited attention in the literature is the landing location. A fisher can often choose between communities when landing the fish. Some communities are served by several companies, and some companies have processing plants in several communities. Fish buyers compete for the raw materials with price as the most important factor given their location, and if a company has landing facilities in several communities, distance may be another important factor. Price variation across landings locations can have important implications for the viability of seafood firms and coastal communities.

Methods

Our data set includes all landings in the whitefish and king crab fisheries in Area 3, which is all Norwegian waters east of 26°E (basically the coastline in the county of Finnmark east of the North Cape) for the year 2010. The data are provided by the Norwegian Fishermen's Sales Organization (Norges Råfisklag), one of six legally mandated sales organizations for ex vessel sales of fish in Norway. In 2010, eastern Finnmark accounted for 9.8% of all cod landings in the area covered by the Norwegian Fishermen's Sales Organization, or roughly 7.8% of all Norwegian cod landings. Sales organizations set market rules and a minimum price. We do not explicitly account for the minimum price because it is not perceived to be binding most of the time. Asche et al. (2002) shows that the ex vessel price for cod in Norway is determined by the price on the global market, and Helstad et al. (2005) show that the ex. vessel market for different product forms and sales modes are well integrated. Our results below are also consistent with minimum prices not binding.

A map with pie areas scaled by total landings shows that landings are not uniformly distributed across communities in the region (Figure 1). For each transaction, the data contain transaction date, species, quantity, value, quality grading, vessel length, gear type, and landing spot. If a vessel lands several species at one time, the landing of each species is recorded as a separate transaction. In total, the data set contains information on 579 vessels, 15 communities, 14 companies, and 23 processing plants/landing facilities. Five of these companies have plants in multiple communities. The existence of minimum prices, despite not appearing to bind in most cases, likely discourages oligopsonistic behavior. Moreover, large vessels tend to be mobile and can thus choose to land fish in other regions of Norway. Altogether, the fact that products in our dataset are traded globally in seafood markets that previous studies have found to be highly integrated, and the existence of many sellers (vessels), a reasonably large number of buyers in the region, options to go elsewhere for some of the vessels, and minimum prices to deter anti-competitive behavior, we expect the seafood market in our study to be competitive.

Cod is the most important species in the data set and constitutes 50.86% of the landings by quantity. This share is substantially larger than in the total Norwegian whitefish fisheries , as saithe and haddock in particular, and to some extent redfish, are also important nationally (Asche, 2009; Foley et al., 2010; Guttormsen and Roll, 2011). The prominence of cod is due to the fact that the fishing area covered by our data set it in the northernmost county, Finnmark, which is at the northern extremity of saithe populations. As a result, most fishing trips have cod as the main target, with king crab being the only other primary target species. To a large extent, king crab is a separate fishery from whitefish. By comparing percentage round weight to the natural log of total landings for the seven main species in our dataset – cod, haddock, saithe, tusk, ling, wolf fish, and king crab—we see the dominance of cod and king crab (Figure 2). For each landing that contains a species, we compute the species share of round weight for that landing and then average these shares across all landings that contain the species. High percentages reflect clean targeting where the primary target makes up most of the catch. Low percentages reflect bycatch, i.e. the species is caught largely as incidental catch. The comparison to the natural log of landings highlights the scale of each species within the multi-species fishery. As a whole, this figure suggests that king crab and cod are cleanly targeted, haddock is targeted to some extent but are also bycatch in the cod fishery, and most other species are not directly targeted.

Our main focus is cod, but we also provide separate analyses for king crab and for all whitefish species. For each landing location, we have geographical coordinates (latitude and longitude) as well as company name. These data enable us to identify which plants have the same owners using the Norwegian firm ownership register.

To assess the impact of the different factors on the unit price, we follow the earlier literature (McConnell and Strand, 2000; Carroll, Anderson and Martinez-Garmendia, 2001; Asche and Guillen, 2012; Zimmerman and Heino, 2013; Lee, 2014) and estimate the natural log of price as a function of its attributes where the price is measured per unit of round fish weight:

$$\ln p_i = a + \sum_k \sum_l b_{kl} D_{kl}.$$

Subscript *i* indicate observation *i*, *k* indicate attribute group *k* and *l* indicate the attribute within group *k*. The constant term *a* is the average scaling of price for a base category, while the parameters b_{kl} show how the price premium (in percentage terms) varies with the associated attribute. A maintained assumption in the hedonic price framework above is market equilibrium. As such, price can be decomposed into individual attribute prices, and premiums can be interpreted as marginal incentives to adjust behavior. Quantities sold are not included in a hedonic regression. Whether there are different values for the attributes within a group can be tested with an *F*-test having the null hypothesis $b_{kl}=0$ for all *l* with a given *k*. For instance, whether price varies across different communities will have *k* indicating community, and there will be fourteen *l* categories, one for each community that potentially deviates from the one contained in the base *a*. Failing to reject the null hypothesis in this case would mean that the community in which fish are landed exerts no influence on the price premium; prices are statistically the same across communities after controlling for product attributes.

Results

We first analyze cod prices and have 31,484 observations available. The base category in the cod regression is headed and gutted of regular quality and the smallest of four size groups. Due to a high degree of multicollinearity, we cannot include both gear type and vessel size in the regression. We therefore estimate separate models for all price equations: One that includes dummies for vessel length and another that includes dummies for gear type. In the regressions with length as the vessel characteristic, the smallest vessels are in the base. When gear type is the vessel characteristic, gillnet is the base. We also estimate the equation for three different measures of landing spot: plant, community, and firm. The results are reported in Table A1 in the online supplementary appendix and visualized in Figure 3.

All equations have high explanatory power with an R^2 of about 0.98. Most parameters are statistically significant at a 5% level, indicating a number of product characteristics influence pricing. *F*-tests indicate that all groups of attributes are important. The parameters that are comparable between the models are similar in magnitude, as most variation is in the third decimal, indicating that the estimated differences in the premiums is mostly less than one percent. Thus, estimated premiums are not an artifact of model specification.

In Figure 3, we chart the premiums in different panels for the different categories in the model with gear types and processing plants. The premiums associated with vessel length are from the model excluding gear type dummies but having otherwise similar structure. In the quality category, there is a small discount associated with head on fish, and a substantial discount at 46% associated with damaged fish. The price seasonality is inversely related to the seasonal pattern in the landings. Relative to January, the premium declines by about one percent in February, March, and April before the premium becomes positive. It is over 5% from June, and peaks at 7.1% in November. Hence, there are substantial incentives to spread harvest out in time and away from the main fishing season.

Size of fish is clearly an important factor in pricing. There are four size categories with the smallest, less than 1 kg, as our base. The others are 1-2.5kg, 2.5-6kg and larger than 6kg. The size of the premium increases in fish size. This result is consistent with results in Zimmerman and Heino (2013) who show that size-based pricing for cod is prevalent but in a model that was unable to control for other potentially correlated attributes. The premiums associated with the different sizes are respectively 24.8%, 40.2% and 59.3%. Premiums vary little with vessel length. The mid-sized vessels receive a small discount relatively to the smallest, but it is interesting to note that the larger vessels obtain a statistically significant premium of 3.1%. Gear type seems to be more important. With the exception of pots, all gear types fetch a premium relative to gillnet. For most gear types, this premium is limited to less than 2.5%. However, the premium increases to over 8% for bottom trawl and over 20% for long line. Hence, there is no general premium associated with the passive or selective gears utilized by smaller vessels but a premium associated with the two gears that are only used by larger vessels. Taken together, these results suggest that there is not much of a premium for small-sized vessels or particular gear types as attributes (and as some have argued (Armstrong and Sumaila 2001)), but the premiums are a reflection of what is being caught.

We include different sets of dummies that are associated with the landing sites. In all cases, there is substantial price variation explained by the dummies. There is a 4.1% difference in the average price paid in the highest paying community relative to the lowest paying community. For companies, the difference is 7.29% between the highest and lowest paying company. At the most detailed level, for each plant the premium is 8.63% between highest and lowest paying. However, this difference is only 5.4% if the highest paying plant is excluded. When conducting *F*-tests for whether the price is equal for all plants in each community or for all plants owned by the same company (left panel of Table 1), both of these hypotheses are rejected. Hence, it is clear that prices, and thereby fishermen´s revenues, are substantially influenced by the communities and plants to which they deliver their fish. It is also surprising that there seems to be no coordination in pricing between different plants owned by the same company; prices differ statistically across plants within the same company.

The substantial heterogeneity in premiums for different attributes and strong statistical significance indicate that fishermen have strong incentives with respect to how they fish, what they catch, and where they land the fish. However, it is also of interest to investigate how the variations in the different attributes contribute in percentage terms to the total amount of price variation. To this end, we compute partial effects (η^2) and sum them by variable group (Figure 4). Fish size is by far the most important category in explaining price variation, as it contributes 94% of the explained variation. This result is an indication that the other premiums are associated with a combination of attributes that are less prevalent in the data and smaller in magnitude.

We next turn to the king crab fishery. Here there are significantly fewer observations (7,549), and the models also explain less of the price variation with an R^2 at around 0.33. Still, the parameters that are comparable over categories are very stable. The estimated premiums are reported in online supplementary appendix Table A2. Male crabs fetch twice as high a price as females, and there is a substantial discount for damaged crabs. There is a more pronounced seasonality than for cod; there is a 150% premium associated with crabs landed in December relative to January, and generally the price level is higher during fall. The most striking result for crabs is that, although there is significant variation in premium across plants and communities (middle panel of Table 1), there are not significantly different premiums across companies. Hence, the companies operate a more consistent pricing policy across plants for crab than for cod. In Figure 4, we report the contribution of each variable group to the price variation. Also here, the picture is very different from cod, with more characteristics playing an important part in explaining price variation. Seasonality is the most important source of variation (64%), followed by sex of the crab (20%), and quality categories (15%).

When we include the other whitefish species in a regression together with cod (online supplementary appendix, Table A3), the regressions contain 54,355 observations. In general, the results are similar to those for cod with respect to the common attributes, and there are substantial price differences for the additional attribute species, with cod as the highest priced. The most interesting additional piece of information from this regression is that variation in species is even more important than fish size in explaining price variation (Figure 4). Hence, what is being caught in terms of species and size are the two most important factors in determining price variation and thereby fishermen revenues.

Discussion

Decisions that influence the catch composition, quality of fish, where fish are landed, and the product forms of landings all contribute critically to fishing revenues and ultimately influence the viability of coastal communities. With improving management systems, and particularly with the introduction of individual fishing quotas (IFQs), fishermen are more able to maximize the value of the catch by targeting fish when their values are highest and to land fish in the place with the highest value. As a result, the influence on the economic actions of the fishermen can change both with respect to the impact of the fishing activity on the ecosystem and with respect to the coastal communities that depend on the fishery.

Decisions about when to fish, where to fish, what to target, and what gear to use are important in terms of the resulting effects on target stocks, stocks of other species, sub-stocks, or critical habitat. When the price of fish varies with attributes that can be associated with these factors, this price information is important for management because it influences fisherman behavior and resulting ecosystem impacts. Moreover, to the extent that the management system influences whether fishermen can exploit these values, information about attribute values points toward ways that fishery managers might contribute to generating economic value from scarce ocean resources when the associated targeting does not negatively influence ecosystems and fish stocks.

Globalization of seafood markets has made fisheries increasingly competitive. Real prices for fish products have shown increased only moderately (Tveteras at al, 2012), while costs of key inputs like labor have risen. Increased economic productivity has been documented in a number of fisheries, including the Norwegian whitefish fisheries (Bjørndal and Gordon, 1993; Salvanes and Squires, 1995; Guttormsen and Roll, 2011; Kumbhakar, Asche and Tveteras, 2013). Productivity growth ensures that the fisheries remain competitive but with fewer fishermen. This development challenges the viability of some fisheries-dependent coastal communities. Some communities are likely to thrive because they can process enough raw materials to exploit economies of scale, while other fishing communities will disappear. The communities and the firms offering the best prices over time are most likely to thrive.

With our unique data set, we are able to investigate the margins associated with a number of attributes in the fisheries in the northernmost region of Norway using transaction-level data. The results confirm the findings of Zimmerman and Heino (2013) that fish size is important, and for a given species, size seems to be the most important attribute. This finding indicates that the extent to which the size premium leads to over-targeting of large-sized fish and influences the size composition of stocks and characteristics of individuals is an important topic for future research. To what extent does management facilitate or hinder size-based targeting that generates more revenue for a given total allowable catch, and what are the bioeconomic consequences, including potential genetic impacts?

Despite the primacy of fish size, we find statistically significant premiums associated with all the attributes investigated here: seasonality, species, product form, quality grading, vessel length, gear type, company, and landing location. The importance of different attributes varies substantially across the whitefish and crab fisheries such that the corresponding price incentives for fishermen vary across the fisheries.

The extent to which our findings generalize to other regions in Norway and other seafood markets in other countries is an open question. Because eastern Finnmark accounts for less than 10% of 2010 cod landings in Norway, estimating our models on other years and regions would be useful for future research. Nevertheless, eastern Finnmark it is a sizable region in Norway with large absolute amounts of landings for cod, whitefish, and crab. Our data set contains hundreds of fishing vessels, fourteen companies buying fish, and numerous landings locations. The literature supports the existence of global markets for cod and whitefish and a high degree of market integration in Norway (Asche et al. 2002; Helstad et al. 2005). And our findings are generally consistent with other studies on size-based pricing that use less detailed data in other regions and/or other species (Asche and Guttormsen, 2001; Asche et al. 2012; Zimmerman and Heino, 2013; Lee 2014). As such, our results are likely to have strong external validity.

Although fishermen sales organizations set minimum prices by species and size category, our results suggest that these price minimums are infrequently binding. After controlling for fish size (and species where relevant), other covariates explain variation in prices. A hedonic regression with size categories in which minimum price always binds would explain all variation in prices, and other covariates would not be identified. In a world with mostly binding minimum prices, we would not expect to see statistically significant coefficients on other covariates. Nevertheless, we have not explored the extent to which pre-defined market categories, minimum prices by size, or actual market premiums that exceed minimum prices influence targeting behavior and discarding. And we do not observe weights of individual fish landed. Extremely fine-scale size-based targeting around size category cutoffs seems unlikely, but discarding behavior around size cutoffs would be possible in the absence of perfect monitoring.

The Norwegian management system also includes a fine grid of vessel groups and gear types with portions of the total allowable catch allocated to different groups. To what extent does this management approach allow fishermen to exploit the opportunities provided by the more valuable attributes? Our analysis does not address this question directly. If smaller vessels have higher costs but are more able to exploit higher prices because of size-based targeting or choice of landings location, then the current system may achieve something close to maximizing total economic value. If lower cost vessels can target high-priced attributes equally well, then the current system may be introducing substantial inefficiencies. Lastly, if there are no systematic cost differences across segments of the fleet, as some of the literature suggests (Guttormsen and Roll 2011), then the question becomes whether segmenting the fleet can generate the highest bioeconomically sustainable revenue from the resource.

Our results show that there are a number of attributes that influence the value of a fish. Species, fish size, quality, vessel size, gear used, seasonality, landing location, and sex (for king crab) all explain variation in prices. Species and fish size dominate the others in economic importance for whitefish, a finding that is consistent with other studies that use less detailed data. For future research it would be useful to have more studies with a similarly fine or finer grid of attributes that represent more regions around the globe, other seafood types, and a longer time span. Another important area for future research is to link fine-scale analyses of seafood prices to fishing behavior on the water and bioeconomic models of stock composition. While admittedly ambitious, this research would provide managers new tools to promote desired biological outcomes while helping fisheries generate more economic value from the same resource base.

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Figure Captions

Figure 1. Total seafood landings in each geographical location. Map of Norway with landings locations indicated by bubbles. Bubble sizes reflect magnitudes of seafood landings, measured in metric tons. Inset map is a blow-up of the study region, Finnmark. Landings include cod (*gadus morhua*), king crab (*paralithdodes camtschaticus*), haddock (*melanogrammus aeglefinus*), saithe (*pollachius virens*), tusk (*brosme brosme*), ling (*molva molva*), wolf fish (*anarhichas lupus*).

Figure 2. Species selectivity and quantity landed. The average percent in each landing (horizontal axis) uses the round weight for each species in a landing divided by the round weight of all species in that landing. These percentages are then averaged across all landings that include that species. The higher the percentage, the more cleanly the species is targeted. The natural log of total quantity landed (vertical axis) provides a benchmark for the magnitude of each fishery. The upward slope of the scatter suggests that larger fisheries tend to be more cleanly targeted. The species are cod (*gadus morhua*), king crab (*paralithdodes camtschaticus*), haddock (*melanogrammus aeglefinus*), saithe (*pollachius virens*), tusk (*brosme brosme*), ling (*molva molva*), wolf fish (*anarhichas lupus*).

Figure 3. Price premiums for different attributes of cod (*gadus morhua*) by attribute categories. Panel A is the quality attribute with headed and gutted as the base category. Panel B is monthly price with January as the base. Panel C is fish size with small as the base. Panel D is vessel length with < 10 meters as the base. Panel E is gear type with gillnet as the base. Panel F is processing plant with plant #20 as the base.

Panel G is company with company #11 as the base. Panel H is community with community # 14 as the base.

Figure 4. Price variation attributable to variable groups for cod (*gadus morhua*) (A), king crab (B), and whitefish (C). Percentages are based on summing η^2 (partial effects) of covariates within each group. Whitefish includes cod (*gadus morhua*), haddock (*melanogrammus aeglefinus*), saithe (*pollachius virens*), tusk (*brosme brosme*), ling (*molva molva*), wolf fish (*anarhichas lupus*).

Table Captions

Table 1. Tests of common pricing for communities or companies. F statistics test for joint restrictions with the null hypothesis that all dummy variables in the category are zero. The interpretation of the null hypothesis is, once controlling for community (or company), landing spot provides no additional explanatory power. Tests are run separately for regressions that include vessel length covariates and regressions that include gear covariates. Degrees of freedom for each test are reported in the online supplementary appendix. * indicates significant at a 5% level.

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	Cod	Crab	Whitefish
Landing spot vs Community, Length	415.2*	13.0*	90.8*
Landing spot vs Company, Length	6.3*	1.8	23.6*
Landing spot vs Community, Gear	434.4*	11.3*	125.1*
Landing spot vs Company, Gear	4.4*	1.1	17.7*

Appendix

Figure A1. Price premiums for different attributes of king crab by attribute categories. Panel A is the quality attribute with not damaged as the base category. Panel B is monthly price with January as the base. Panel C is fish sex with female as the base. Panel D is vessel length with < 10 meters as the base. Panel E is gear type with gillnet as the base. Note that nearly all crab is caught with pot gear, and other gear types likely reflect catching crabs as bycatch. Thus, it appears that crab caught as bycatch and then sold is discounted. Panel F is processing plant with plant #20 as the base. Panel G is company with company #11 as the base. Panel H is community with community # 13 as the base.

Figure A2. Price premiums for different attributes of king crab by attribute categories. Panel A is the quality attribute with headed and gutted as the base category. Panel B is monthly price with January as the base. Panel C is fish size with large as the base. Panel D is vessel length with < 10 meters as the base. Panel E is gear type with gillnet as the base. Panel F is species cod as the base. Panel G is company with company #11 as the base. Panel H is community with community # 14 as the base.

Table A1 Regression Results with Cod (with no t-statistics)

Degree of processing – base: gutted and headed; **Quality category – base:** A; **Month – base:** month1; **Size Category – base:** Cod (small); **Vessel Length – base:** length less than 10m; **Gear type – base:** Gillnet (Anchored);

	(1)	(2)	(3)	(4)	(5)	(6)
Gutted	-0.0077*	-0.0015	-0.0061*	-0.0012	-0.0062*	-0.0004
Damaged	-0.4648*	-0.4633*	-0.4641*	-0.4628*	-0.4655*	-0.4643*
Feb.	-0.0083*	-0.0034*	-0.0077*	-0.0044*	-0.0087*	-0.0036*
Mar.	-0.0101*	-0.0043*	-0.0090*	-0.0056*	-0.0108*	-0.0043*
Apr.	-0.0097*	-0.0047*	-0.0082*	-0.0057*	-0.0101*	-0.0047*
May	0.0338*	0.0370*	0.0355*	0.0362*	0.0337*	0.0371*
Jun.	0.0549*	0.0571*	0.0547*	0.0552*	0.0549*	0.0572*
Jul	0.0541*	0.0563*	0.0540*	0.0542*	0.0537*	0.0562*
Aug.	0.0547*	0.0568*	0.0552*	0.0560*	0.0545*	0.0568*
Sep.	0.0608*	0.0633*	0.0630*	0.0641*	0.0608*	0.0634*
Oct.	0.0678*	0.0686*	0.0693*	0.0696*	0.0677*	0.0686*
Nov.	0.0716*	0.0724*	0.0724*	0.0734*	0.0714*	0.0724*
Dec.	0.0659*	0.0663*	0.0663*	0.0672*	0.0657*	0.0662*
Medium	0.2484*	0.2498*	0.2452*	0.2466*	0.2488*	0.2500*
Large	0.4024*	0.4040*	0.3992*	0.4008*	0.4028*	0.4042*
Very large	0.5933*	0.5948*	0.5899*	0.5915*	0.5938*	0.5950*
10-15m	-0.0014*		-0.0013*		-0.0011*	
15-28m	-0.0025*		-0.0017*		-0.0018*	
>28m	0.0311*		0.0317*		0.0325*	
Bottom trawl		0.0827*		0.0816*		0.0833*
Danish seine		0.0080*		0.0097*		0.0070*
Floating line		0.0044*		0.0074*		0.0034*
Long line		0.2066*		0.2054*		0.2065*
Other lines		0.0090*		0.0061*		0.0083*
Troll line		0.0095*		0.0094*		0.0085*
Undefined_net		0.0146*		0.0115*		0.0138*
Other gears		0.0213*		0.0274*		0.0207*
Pots		-0.0010		-0.0014		-0.0023
Processing_Plant	330.24* F(19, 31445)	326.41* F(19,31439)				
Communities			269.72* F(13,31451)	255.45* F(13,31445)		
Companies					620.84* F(10,31454)	615.62* F(10,314
Constant	1.8272*	1.8136*	1.7920*	1.7806*	1.8267*	1.8143*
R^2	0.9804	0.9815	0.9789	0.9799	0.9804	0.9814
N	31484	31484	31484	31484	31484	31484

* indicates significant at a 5% level

Table A2 Regression Results with King Crab

Sex – base: female; **Quality category – base:** A; **Month – base:** month1; **Vessel Length – base:** length less than 10m; **Gear type – base:** gillnet; Note that nearly all crab is caught with pot gear, and other gear types likely reflect catching crabs as bycatch. Thus, it appears that crab caught as bycatch and then sold is discounted.

	(1)	(2)	(3)	(4)	(5)	(6)
Male crab	0.9964*	0.9903*	1.0015*	0.9937*	0.9948*	0.9896*
Damaged	-0.6703*	-0.6644*	-0.6750*	-0.6670*	-0.6720*	-0.6645*
Feb.	0.0835	0.0742	0.0812	0.0732	0.0671	0.0682
Mar.	0.4805*	0.4674*	0.5762*	0.5527*	0.4606*	0.4604*
Apr.	0.9318*	0.9026	1.0920*	1.0574*	0.8970	0.8808
May	-0.1545	-0.1717	0.0187	-0.0377	-0.1863	-0.1930
Jun.	0.8874*	0.8495*	1.0353*	0.9647*	0.8536*	0.8294*
Jul	0.9282*	0.8898*	1.0595*	1.0001*	0.8898*	0.8673*
Aug.	1.2866*	1.2366*	1.3182*	1.2796*	1.2448*	1.2080*
Sep.	1.4418*	1.4088*	1.4791*	1.4683*	1.3967*	1.3784*
Oct.	1.4723*	1.4849*	1.4821*	1.5272*	1.4349*	1.4651*
Nov.	1.4975*	1.5383*	1.4613*	1.5481*	1.4535*	1.5198*
Dec.	1.5311*	1.5722*	1.5037*	1.5872*	1.4941*	1.5562*
10-15m	-0.0167		-0.0357		-0.0220	
15-28m	0.0144		-0.0329		0.0057	
>28m	-0.3931		-0.4762		-0.2237	
Other lines		-0.0771		-0.0929		-0.0920
Pots		0.1121		0.1257		0.0941
Processing_Plant	14.65* F(18,7514)	15.87* F(18,7515)				
Communities			15.31* F(12,7520)	18.03* F(12,7521)		
Companies					24.95* F(10,7522)	27.69* F(10,752
Constant	1.7354*	1.7099*	1.8934*	1.7662*	1.8302*	1.7264*
R^2	0.327	0.329	0.320	0.323	0.326	0.328
N	7549	7549	7549	7549	7549	7549

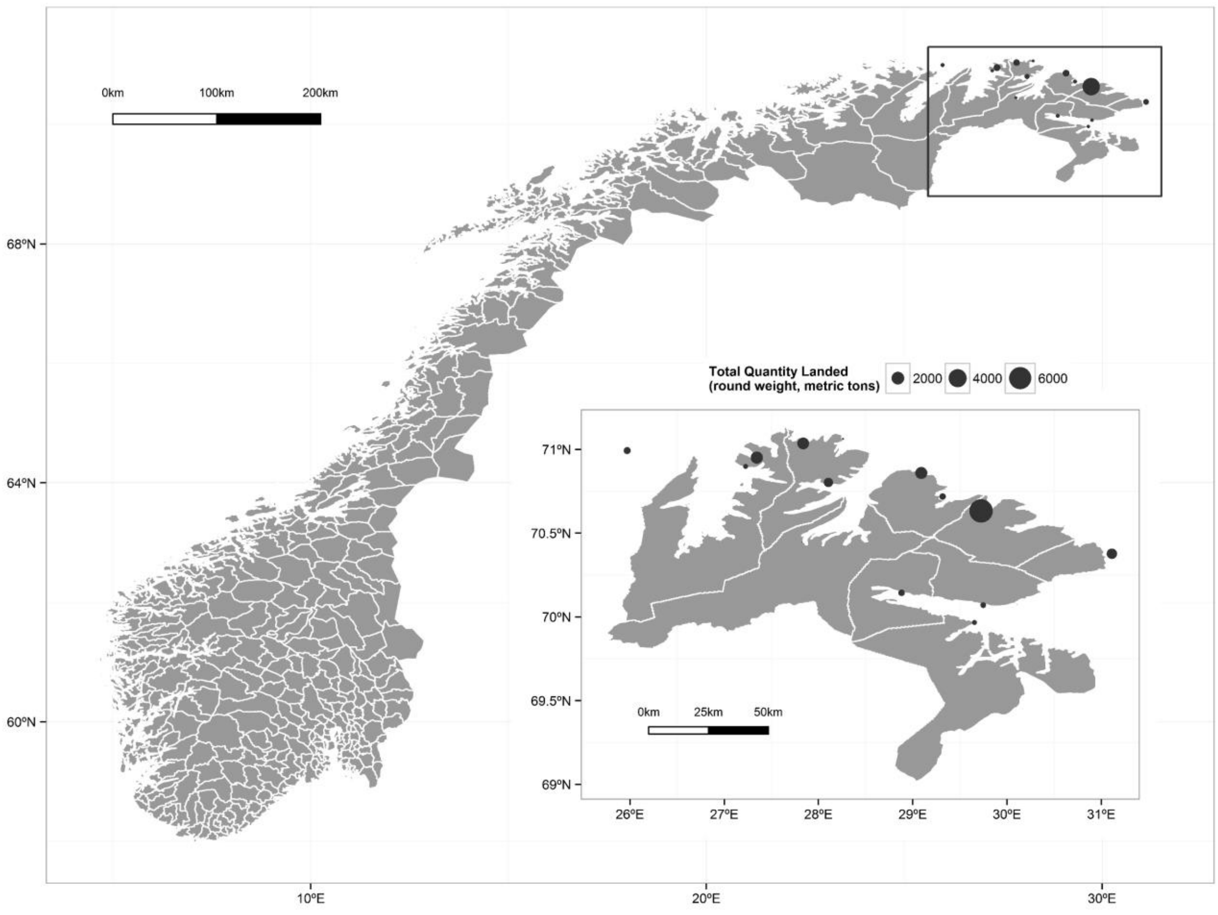
* indicates significant at a 5% level

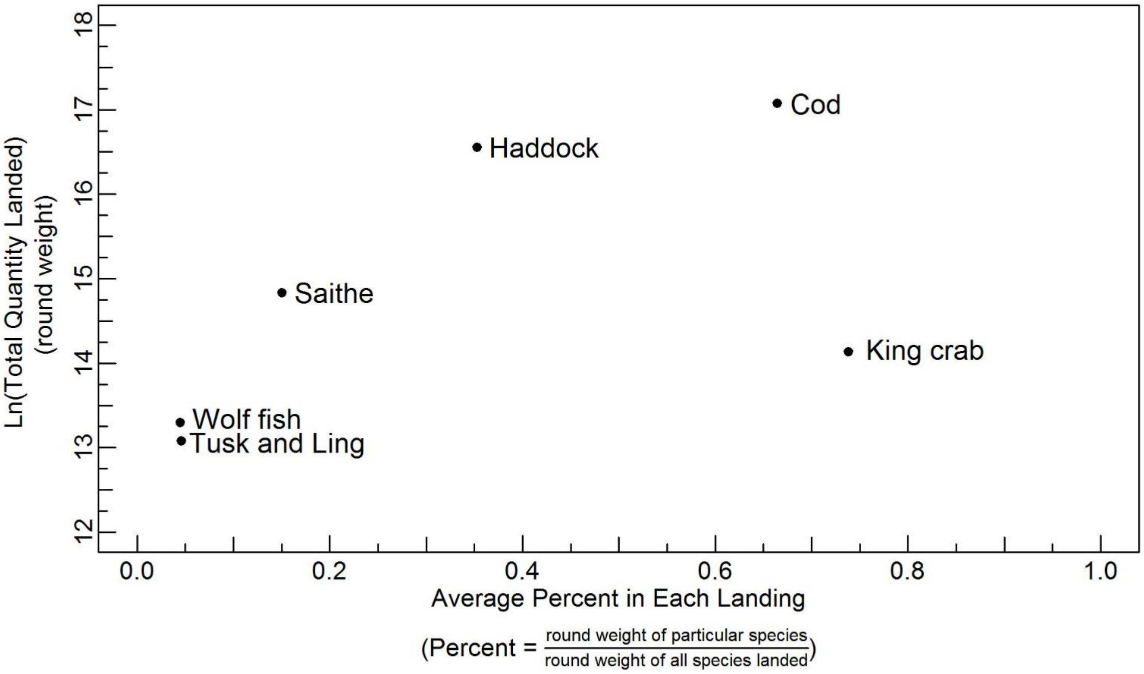
Table A3 Results with Five Species (Cod, Haddock, Saithe, Wolf fish, and Tusk and Ling)

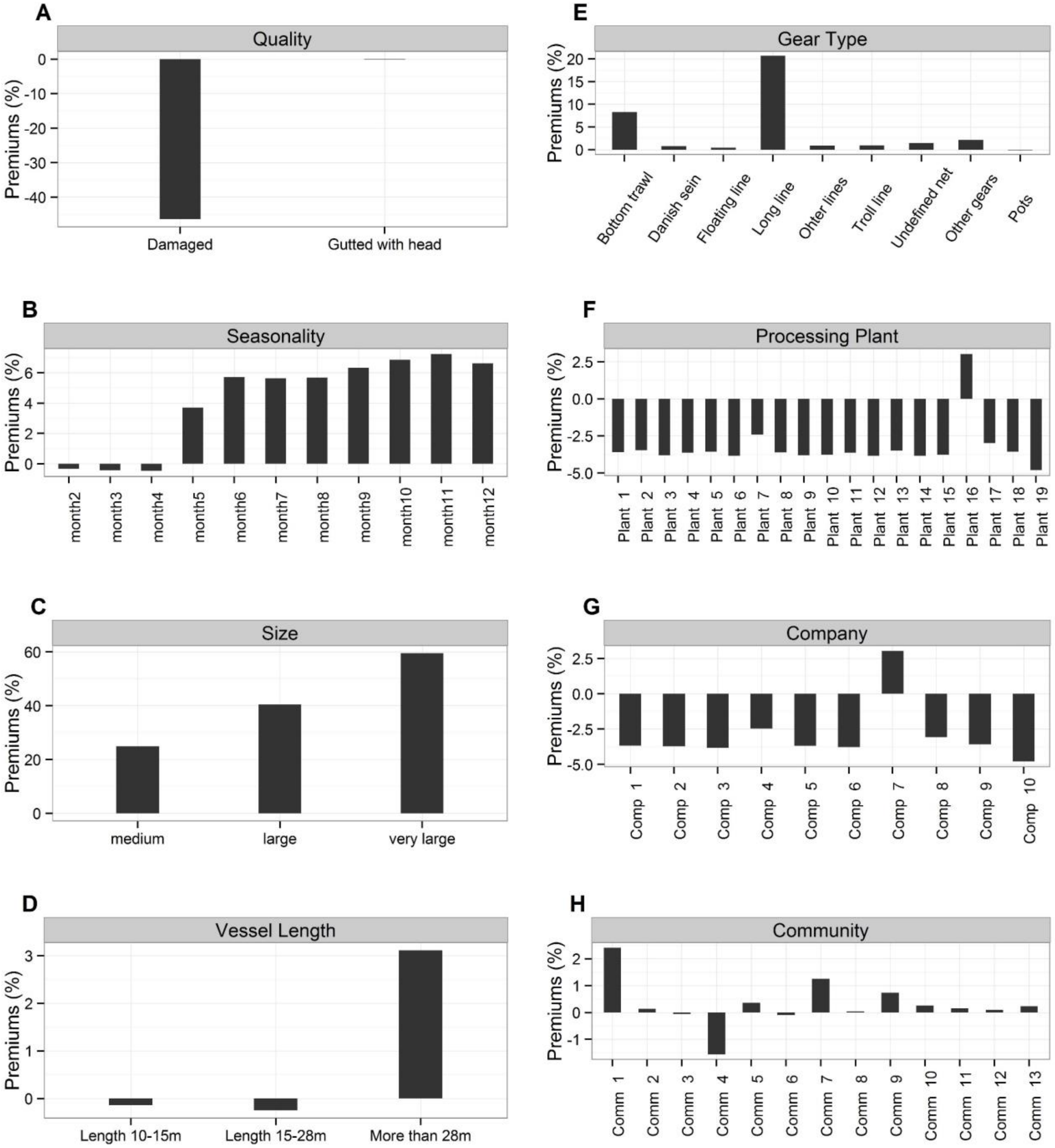
Degree of processing – base: gutted and headed; **Quality category – base:** A; **Month – base:** month1; **Size Category – base:** small; **Vessel Length – base:** length less than 10m; **Gear type – base:** gillent;

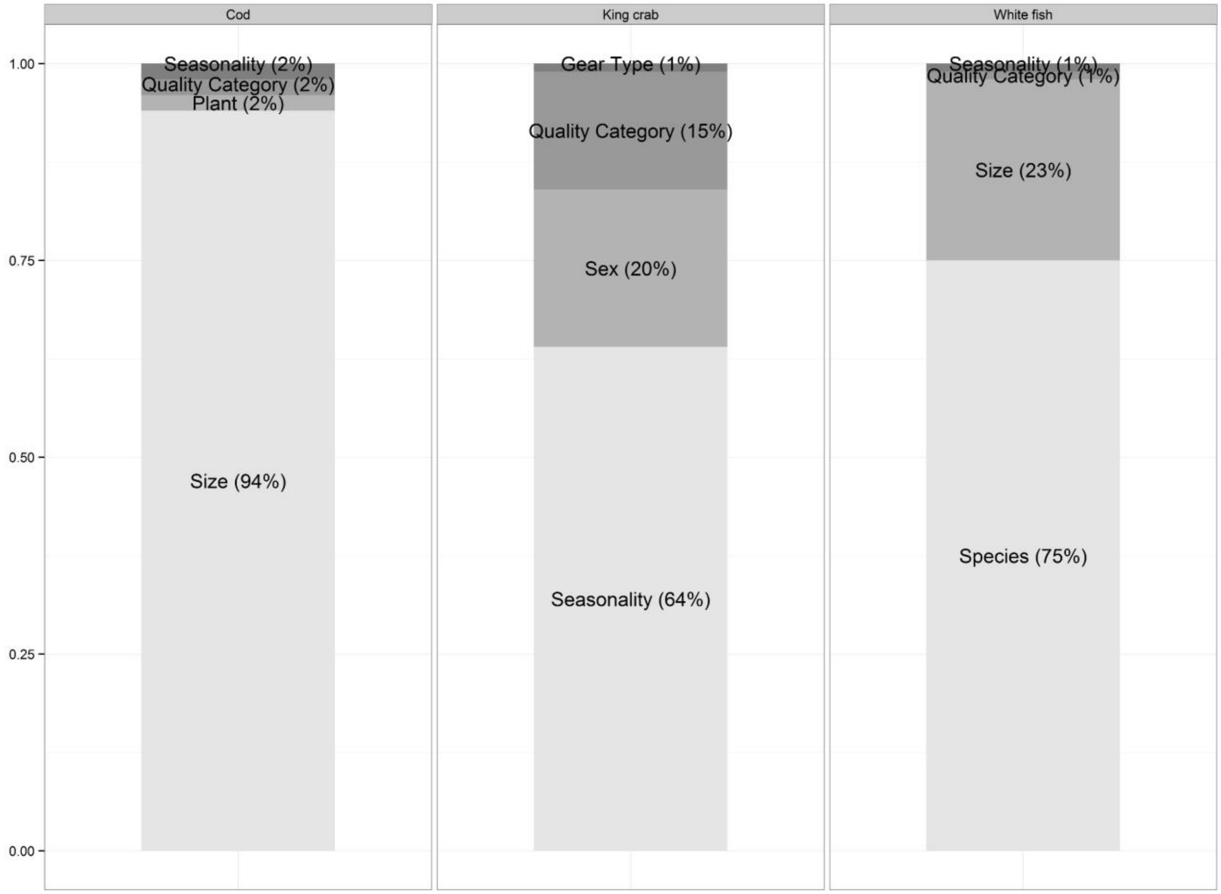
	(1)	(2)	(3)	(4)	(5)	(6)
Gutted	0.0449*	0.0492*	0.0327*	0.0315*	0.0405*	0.0451*
Round	-0.1660*	-0.1583*	-0.1840*	-0.1811*	-0.1707*	-0.1669*
Damaged	-0.4972*	-0.4848*	-0.4979*	-0.4846*	-0.4949*	-0.4861*
Feb.	-0.0260*	-0.0065	-0.0245*	-0.0046	-0.0249*	-0.0040
Mar.	-0.0319*	-0.0027	-0.0308*	-0.0010	-0.0320*	0.0012
Apr.	-0.0289*	-0.0038	-0.0275*	-0.0024	-0.0283*	-0.0005
May	0.0110*	0.0283*	0.0112*	0.0275*	0.0118*	0.0303*
Jun.	0.0427*	0.0439*	0.0437*	0.0443*	0.0438*	0.0457*
Jul	0.0530*	0.0473*	0.0515*	0.0451*	0.0547*	0.0499*
Aug.	0.0606*	0.0649*	0.0624*	0.0666*	0.0612*	0.0661*
Sep.	0.0605*	0.0741*	0.0639*	0.0763*	0.0608*	0.0749*
Oct.	0.0920*	0.1006*	0.0950*	0.1032*	0.0922*	0.1012*
Nov.	0.1036*	0.1083*	0.1065*	0.1112*	0.1046*	0.1092*
Dec.	0.1002*	0.1029*	0.1028*	0.1061*	0.1013*	0.1040*
Small	-0.4503*	-0.3631*	-0.4501*	-0.3628*	-0.4488*	-0.3629*
Medium	-0.2315*	-0.2196*	-0.2308*	-0.2189*	-0.2312*	-0.2194*
Haddock	-0.4129*	-0.5385*	-0.4009*	-0.5227*	-0.4086*	-0.5346*
Saithe	-0.5318*	-0.5454*	-0.5279*	-0.5406*	-0.5317*	-0.5441*
Tusk and Ling	-0.9061*	-0.8895*	-0.9062*	-0.8903*	-0.9059*	-0.8902*
Wolffish	-0.4544*	-0.4462*	-0.4546*	-0.4471*	-0.4533*	-0.4462*
10-15m	-0.0087*		-0.0042*		-0.0059*	
15-28m	-0.0228*		-0.0138*		-0.0191*	
>28m	-0.0134*		-0.0316*		-0.0208*	
Bottom trawl		0.0688*		0.0434*		0.0649*
Danish seine		-0.0058		0.0038		-0.0017
Floating line		0.0271*		0.0304*		0.0291*
Other lines		0.0020		0.0043		0.0061*
Long line		0.2733*		0.2742*		0.2740*
Troll line		0.0080*		0.0038		0.0058*
Undefined net		0.0120		0.0121		0.0150
Other gears		0.0010		0.0040		0.0029
Pots		0.0172		0.0188		0.0194
Processing_Plant	0.21 F(2,54311)	0.01 F(2,54305)				
Communities			22.22* F(13,54318)	31.52* F(13,54312)		
Companies					68.94* F(10,54321)	111.20* F(10,54315)
Constant	2.2859	2.2474	2.2861*	2.2547*	2.3085*	2.2668*
R^2	0.844	0.870	0.842	0.868	0.843	0.870
N	54355	54355	54355	54355	54355	54355

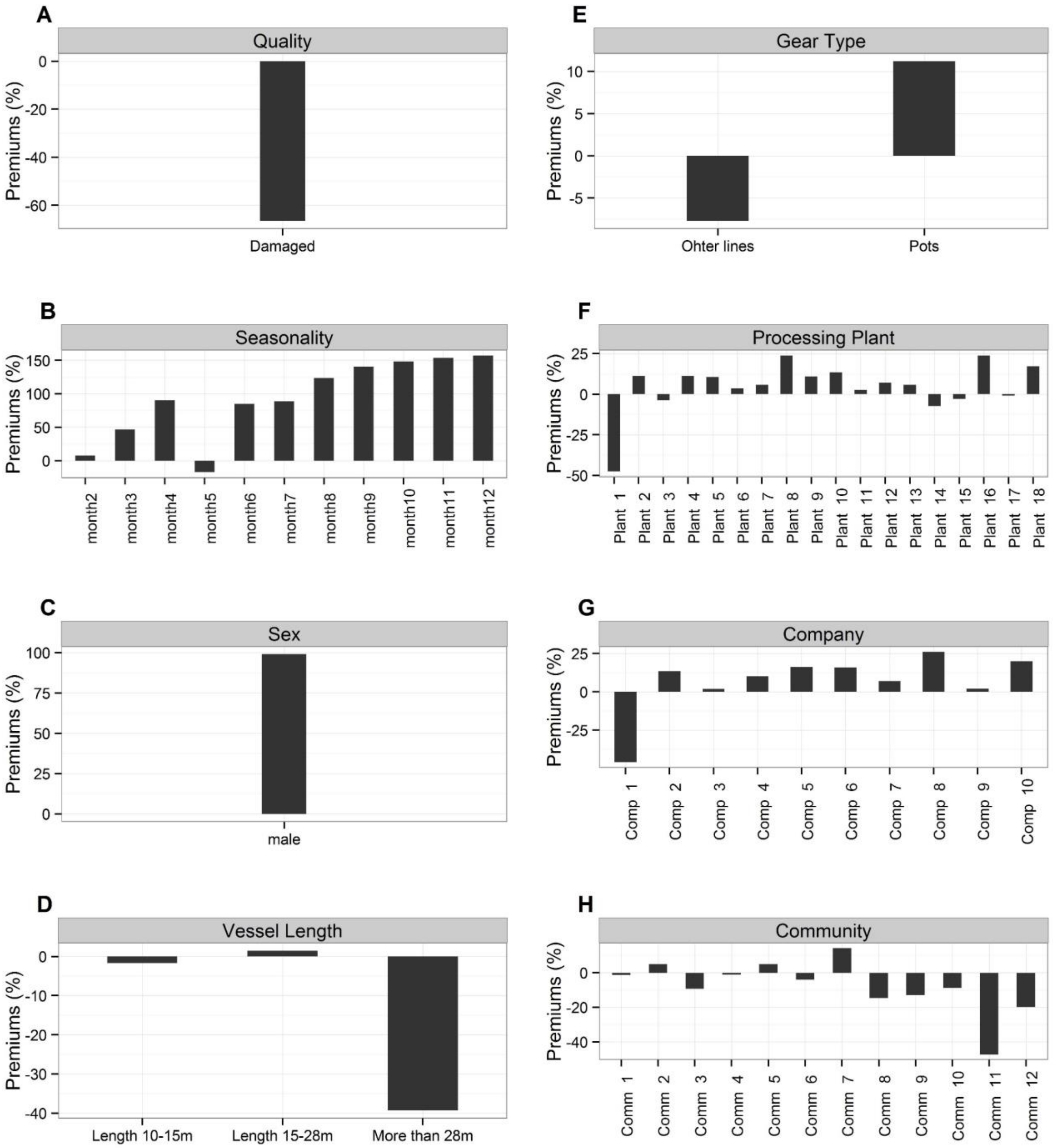
* indicates significant at a 1% level

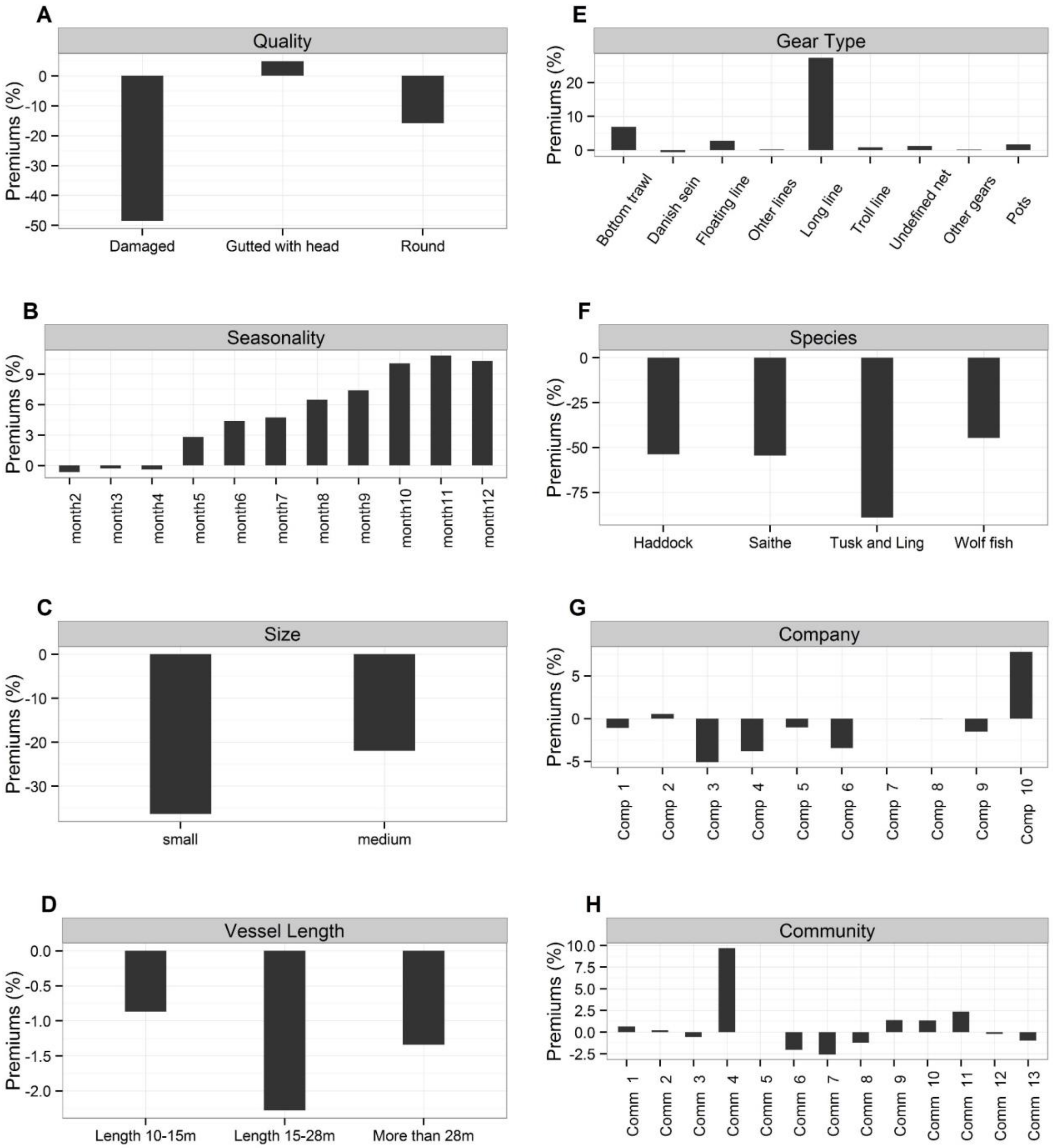

0km
100km
200km
68ºN
64ºN
60ºN
10ºE
20ºE
30ºE
Total Quantity Landed
(round weight, metric tons)
2000
4000
6000
71ºN
70.5ºN
70ºN
69.5ºN
69ºN
0km
25km
50km
26ºE
27ºE
28ºE
29ºE
30ºE
31ºE


Ln(Total Quantity Landed)
(round weight)
18
17
16
15
14
13
12
Cod
Haddock
Saithe
King crab
Wolf fish
Tusk and Ling
0.0
0.2
0.4
0.6
0.8
1.0
Average Percent in Each Landing
(Percent = round weight of particular species / round weight of all species landed)


A
Quality
Premiums (%)
0
-10
-20
-30
-40
Damaged
Gutted with head
B
Seasonality
Premiums (%)
6
4
2
0
month2
month3
month4
month5
month6
month7
month8
month9
month10
month11
month12
C
Size
Premiums (%)
60
40
20
0
medium
large
very large
D
Vessel Length
Premiums (%)
3
2
1
0
Length 10-15m
Length 15-28m
More than 28m
E
Gear Type
Premiums (%)
20
15
10
5
0
Bottom trawl
Danish sein
Floating line
Long line
Ohter lines
Troll line
Undefined net
Other gears
Pots
F
Processing Plant
Premiums (%)
2.5
0.0
-2.5
-5.0
Plant 1
Plant 2
Plant 3
Plant 4
Plant 5
Plant 6
Plant 7
Plant 8
Plant 9
Plant 10
Plant 11
Plant 12
Plant 13
Plant 14
Plant 15
Plant 16
Plant 17
Plant 18
Plant 19
G
Company
Premiums (%)
2.5
0.0
-2.5
-5.0
Comp 1
Comp 2
Comp 3
Comp 4
Comp 5
Comp 6
Comp 7
Comp 8
Comp 9
Comp 10
H
Community
Premiums (%)
2
1
0
-1
Comm 1
Comm 2
Comm 3
Comm 4
Comm 5
Comm 6
Comm 7
Comm 8
Comm 9
Comm 10
Comm 11
Comm 12
Comm 13


Cod
King crab
White fish
1.00
0.75
0.50
0.25
0.00
Seasonality (2%)
Quality Category (2%)
Plant (2%)
Size (94%)
Gear Type (1%)
Quality Category (15%)
Sex (20%)
Seasonality (64%)
Seasonality (1%)
Quality Category (1%)
Size (23%)
Species (75%)


A
Quality
Premiums (%)
0
-20
-40
-60
Damaged
B
Seasonality
Premiums (%)
150
100
50
0
month2
month3
month4
month5
month6
month7
month8
month9
month10
month11
month12
C
Sex
Premiums (%)
100
75
50
25
0
male
D
Vessel Length
Premiums (%)
0
-10
-20
-30
-40
Length 10-15m
Length 15-28m
More than 28m
E
Gear Type
Premiums (%)
10
5
0
-5
Ohter lines
Pots
F
Processing Plant
Premiums (%)
25
0
-25
-50
Plant 1
Plant 2
Plant 3
Plant 4
Plant 5
Plant 6
Plant 7
Plant 8
Plant 9
Plant 10
Plant 11
Plant 12
Plant 13
Plant 14
Plant 15
Plant 16
Plant 17
Plant 18
G
Company
Premiums (%)
25
0
-25
Comp 1
Comp 2
Comp 3
Comp 4
Comp 5
Comp 6
Comp 7
Comp 8
Comp 9
Comp 10
H
Community
Premiums (%)
0
-20
-40
Comm 1
Comm 2
Comm 3
Comm 4
Comm 5
Comm 6
Comm 7
Comm 8
Comm 9
Comm 10
Comm 11
Comm 12


A
Quality
Premiums (%)
0
-10
-20
-30
-40
-50
Damaged
Gutted with head
Round
B
Seasonality
Premiums (%)
9
6
3
0
month2
month3
month4
month5
month6
month7
month8
month9
month10
month11
month12
C
Size
Premiums (%)
0
-10
-20
-30
small
medium
D
Vessel Length
Premiums (%)
0.0
-0.5
-1.0
-1.5
-2.0
Length 10-15m
Length 15-28m
More than 28m
E
Gear Type
Premiums (%)
20
10
0
Bottom trawl
Danish sein
Floating line
Ohter lines
Long line
Troll line
Undefined net
Other gears
Pots
F
Species
Premiums (%)
0
-25
-50
-75
Haddock
Saithe
Tusk and Ling
Wolf fish
G
Company
Premiums (%)
5
0
-5
Comp 1
Comp 2
Comp 3
Comp 4
Comp 5
Comp 6
Comp 7
Comp 8
Comp 9
Comp 10
H
Community
Premiums (%)
10.0
7.5
5.0
2.5
0.0
-2.5
Comm 1
Comm 2
Comm 3
Comm 4
Comm 5
Comm 6
Comm 7
Comm 8
Comm 9
Comm 10
Comm 11
Comm 12
Comm 13