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Short communication

Beam trawlermen take feet off gas in response to oil price hikes

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Average towing speed by Dutch beam trawlermen has fallen substantially between 2002 and 2009. Changes in towing speed are related to changes in oil price. The price of their valuable main target species (sole, *Solea vulgaris*) did not influence towing speed.

Keywords: beam trawling, oil price, towing speed.

Introduction

Fishermen around the world catch fish and shellfish using a bewildering array of ship and gear combinations which can be divided into two broad categories: passive/static and active/mobile. Passive gears, such as gill and trammelnets, are anchored at specific locations, rely on entangling their victims and are relatively economical in terms of fuel usage. Active gears, on the other hand, comprise heavy, drag-resistant trawlnets towed behind powerful ships burning comparatively large quantities of diesel (Ziegler and Hansson, 2003).

In past times, passive gears perforce dominated commercial fisheries (Rijnsdorp and Millner, 1996). Before World War II (WWII), for example, the typical pattern of activity for Scottish fishing fleets was to driftnet in the North Sea for herring in summer and longline for large predatory fish (cod, haddock, turbot, and brill) over winter (Rush, 2011). Since WWII, however, motorized trawlers have dominated the commercial fisheries of developed countries. Currently, for example, trawlers make up ca. 80% of the European Union's fleet capacity (Beare and McKenzie, 2006).

Over the last decade, oil prices have rocketed for a range of economic and geopolitical reasons. According to Abernethy *et al.* (2010), fuel prices doubled between early 2007 and mid-2008 while at the same time prices obtained by fishermen for their landings have remained relatively stable. It has been demonstrated that these fuel price rises have lowered the profitability (Beare and McKenzie, 2006) of European fishing businesses, although little information exists about how the ongoing increases are affecting, either the actual deployment of fishing gears or fishermen's behaviour. In southwestern England, fuel price rises have compelled fishermen to work closer to port, and any potential exploratory fishing activity has been curtailed (Abernethy *et al.*, 2010): phenomena also observed in Danish fisheries (Bastardie *et al.*, 2010). In particular, although it is well known that fishing speed varies substantially with factors such as vessel size, vessel type, and fishing gear, little is known about how it might change over time (either long term or seasonally) within a single gear-categorization.

Since the 1960s, Dutch fishermen have pioneered beam trawling in the North Sea where heavy trawls with tickler chains or chain mats are required to "tickle out" the valuable (>10€ kg^{-1}) target species, Dover sole (*Solea vulgaris*) from the sand. This is particularly true during daylight hours (Woodhead, 1963) when sole are almost totally inactive. These heavy gears are towed at relatively high speeds (4–8 knots) by unusually powerful fishing vessels. Since fuel consumption increases exponentially with towing speed (Ronen, 1982), the Dutch beam trawling fleets are then particularly sensitive to changes in fuel price. The aim of this Short Communication, therefore, is to explore the hypothesis that changes in trawling speeds are directly related to changes in oil price using time-series data.

Material and methods

Analyses on the relationship between fuel price and the auction prices of sole and trawl towing speed were done using a database constructed at weekly intervals covering the period 2002–2009. The towing speed data in knots (1852 m h^{-1}) for the commercial fishing vessels studied originate from the vessel monitoring system (VMS) whereby vessel identities and positions, instantaneous speeds and direction of travel (compass bearing), are monitored by satellite and recorded at 2 h intervals (Mills *et al.*, 2007). In this study, beam trawlers targeting sole (70–99 mm codend mesh) in the southern North Sea with main engine power

>1400 and <1600 kW only are considered. Records from vessels in harbour, on land, and unlikely to be engaged in fishing were eliminated using the VMStools software package (Hintzen *et al.*, 2012). The sole price data used originated from prices paid at daily fish auctions around the Netherlands. Sole was selected because it is a particularly valuable species targeted by Dutch beam trawlermen; and the species most likely, therefore, to motivate their behaviour. In 2011, the Dutch sole catch was around 9000 t (ICES, 2011) which if we assume an average price of 10€ translates into a total revenue of ca. 90€ million. Oil price data for the period were extracted from an US Energy Information Administration database (http://tonto.eia.doe.gov/dnav/pet/pet_pri_wco_K_w.htm), which contains world crude oil prices ($/barrel) on a weekly time interval. (Note: UK, Brent Blend 38° was selected.)

The data were available at weekly resolution (Figure 1), although we quote some of the summary statistics by month. Time-series analyses proceeded using the following three time-series:

(i) average weekly beam trawl towing speed (knots);

(ii) average weekly sole price (€ kg^{-1}); and

(iii) average weekly oil price ($ $barrel^{-1}$).

The main features of the time-series data were explored using "STL: A Seasonal-Trend Decomposition Procedure Based on Loess" by Cleveland *et al.* (1990) which is part of the standard or "base" R installation (R Development Core Team, 2006) and encapsulates the standard approach which "decomposes" the time-series into three separate parts: (i) long-term trend, (ii) seasonality, and (iii) irregular, remaining or residual components. The filtering or smoothing in this particular method exploits the technique of locally weighted regression (Cleveland and Devlin, 1988).

Connections between the series were assessed using the concept of "Granger causality" which tests whether one time-series is useful for forecasting another (Engle and Granger, 1987; Granger *et al.*, 2000). The tests were also done with R using the library "*lmtest*" (Zeileis and Hothorn, 2002), which includes the "function" or program "*grangertest*".

Results

Fishing activity (kW h) by Dutch beam trawlers (>1400 and <1600 kW) targeting sole (70–99 mm codend mesh) is summarized from 2 hourly satellite detected positions data in Figure 2. These vessels clearly avoid the 12-nm limit and also the borders of the Plaice Box (Pastoors *et al.*, 2000) from which they are also prohibited to fish. The most heavily fished areas are in the south-western part of the North Sea and there is also a hot spot in the German Bight along the border of the Plaice Box.

During the period 2003–2009, the overall average price of oil, towing speed by the beam trawlers, and price paid for sole at auctions (weighted across market categories) were $59.4 knots, $6.1 knots, and 10.54€ kg^{-1}, respectively. Long-term (2003–2009) and seasonal changes (weekly) in towing speed, sole price,

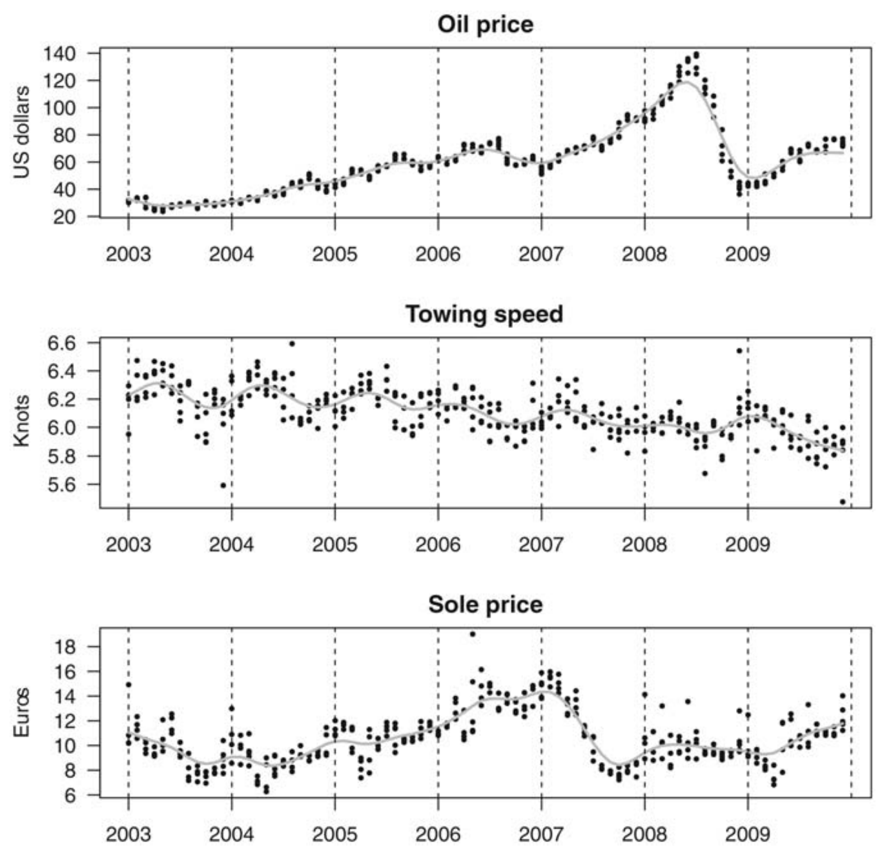

Figure 1. Weekly variations in oil price (US$), trawling speed by Dutch beam trawlers (≥1400 and ≤1600 kW main engine power) and sole price (Euros) between 2003 and 2009.

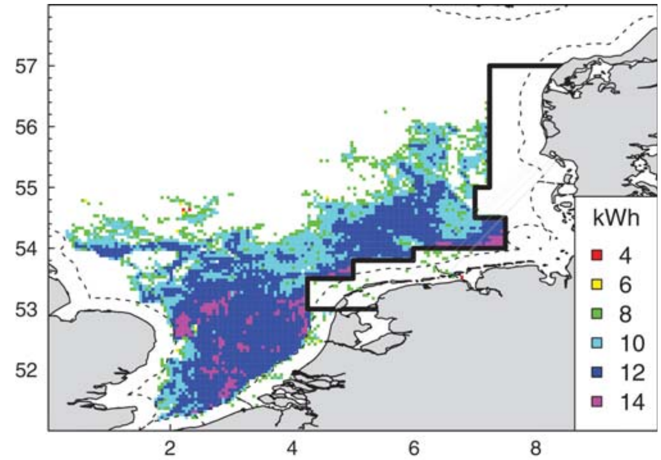

Figure 2. Patterns of fishing effort by Dutch beam trawlers (≥1400 and ≤1600 kW main engine power) in 2009. Borders of the Plaice Box are marked with a solid and those of the 12 nautical mile limit with a thin dashed line.

and oil price from the time-series decomposition are shown in Figure 3. Oil prices rose from around \$30 in 2003 to peak (\$139.3) in July 2008. Beam trawl towing speed has fallen steadily during the entire period 2002–2009; the average speed being 6.22 knots in 2003 and only 5.95 knots in 2009. Sole prices varied between 6.3 and 19€ kg^{-1} over the period studied. The best average prices were paid between mid 2006 and early 2007 (Figure 3). There was a substantial fall during 2007 from 15.9€ kg^{-1} in January to only 7.45€ kg^{-1} in December. The seasonal changes observed in all three time-series were not part of the original remit of this study but they remain a potentially interesting area for future research. The average seasonalities over the 8 years are displayed in Figure 3. The oil price has a clear summer peak, whereas sole prices have a bimodal pattern with peaks in December/January and mid-May. Minima are observed in mid-April and generally in late summer and autumn (Figure 3). Towing speed is also seasonal with pronounced peaks in mid-April and late-December to early January. This April peak is related to a change in targeting behaviour whereby fishermen switch from sole to plaice, working larger mesh gears further north which are towed faster. We do not know why gears are towed faster in late-December and early January, but it might be stimulated by a good sole price (Figure 3). Clearly, the dynamics of these processes are extremely complicated and causative stimuli in season A may not be important in season B.

Simple linear correlation coefficients (Pearson) between the time-series (Table 1) suggest that there might be a negative relationship ($r = -0.5$) between oil price and towing speed, some positive connection between sole and oil prices ($r = +0.14$), and almost no dependence between towing speed and sole price ($r = -0.09$). The presence of a long-term trend, seasonality, and serial correlation make "confirmatory" statistical inferences from these series difficult, but eventually we opted to use pairwise Granger causality tests between all three time-series (at a time-step lag of 1). The results are summarized in Table 2. The hypothesis that "oil price rises cause towing speed reductions" was accepted ($p < 0.05$, Table 2), whereas the idea that "sole price rises cause towing speed increases" had to be rejected ($p > 0.05$, Table 2). Similarly, oil price rises were statistically unconnected ($p > 0.05$, Table 2) to changes in sole prices. (It should also be noted that we experimented with many other lags but the basic pattern remained unchanged.)

Discussion

There is, therefore, a statistically significant negative relationship between average towing speed and fuel price in this component of the Dutch beam trawler fleet. Increases in the oil price lead to decreases in towing speed from one week to the next. Obviously, we see this because the fishermen are trawling at lower speeds to reduce diesel consumption which lowers the costs. If catch rates and prices remain stable then profits will increase. It is questionable, however, that catch rates could have remained stable, because, presumably in the past, the vessels were towing at a higher speed to increase ground covered and maintain catch rates. Our results suggest that there must indeed be a non-linear relationship between towing speed and catch rate, and we believe that this is completely plausible. There are many ways that fishermen can modify vessel and gear combinations to compensate for reductions in catch due to reductions in trawling speed (Rijnsdorp *et al.*, 2008). Further, the Dutch beam trawl fleet has been shrinking in overall size, whereas the size of the sole stock itself has been stable since 2003.

There is also a tantalising hint of a positive connection between oil price and sole price (Table 1). As might be expected, rises in oil price seem to be reflected in the prices fishermen achieve for their sole. Fishermen complain about the prices they get for fish, regularly arguing that they never go up in response to increased costs; but there is evidence here that this may not always be the case. Clearly, further investigations are needed.

The Dutch beam trawl fisheries are currently undergoing rapid development and change stimulated primarily by increased fuel costs, and the conservationist and anti-discard lobbies. Investment in Sumwing trawls (the beam and "shoes" are replaced by a large horizontal wing that glides over the seabed) and electric pulse-trawls (a beam trawl whereby fish are "tickled" out of the seabed by electric pulses having the advantage of requiring neither chain mats nor tickler chains), which are both cheaper to tow, has been substantial (de Vos and Mol, 2010). There is evidence that electric pulse-trawling, in particular, can lead to reductions in the discarding rates of unwanted bycatch, although

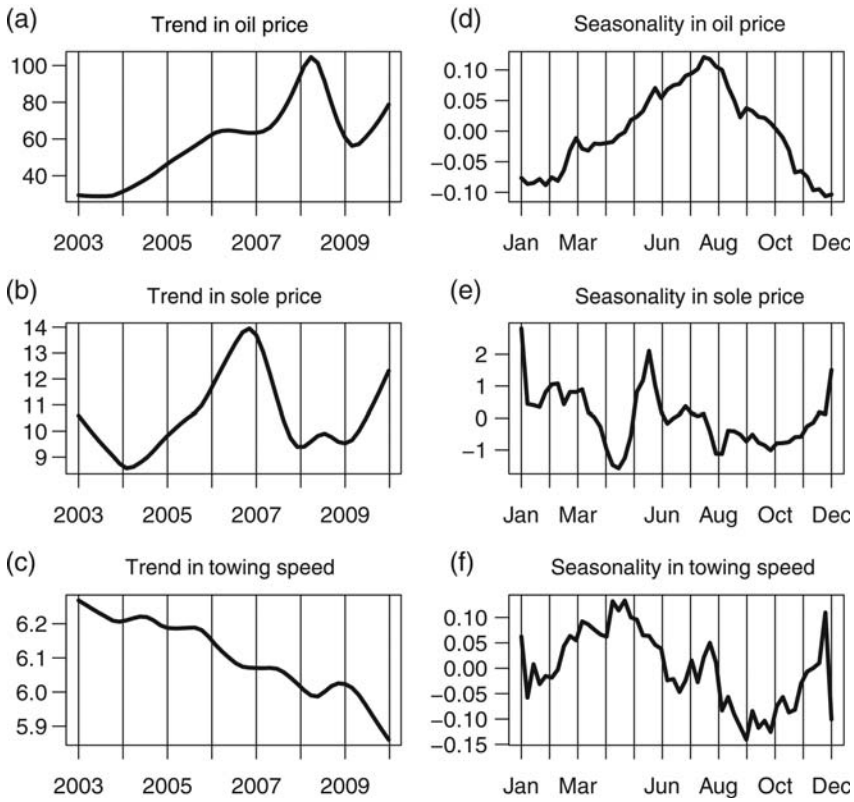

Figure 3. Long-term trend (a–c) and average seasonality (d–f) in oil price, trawling speed, and sole price between 2003 and 2009, estimated using the time-series "decomposition" method due to Cleveland *et al.* (1990).

Table 1. Pearson's correlation coefficients between weekly oil price, towing speed, and sole prices between 2003 and 2009.

	Oil price	Towing speed	Sole price
Oil price	1	–	–
Towing speed	−0.50	1	–
Sole price	0.14	−0.09	1

Table 2. Granger causality tests at lag 1.

Model	Res. d.f.	d.f.	*F*-value	Pr(>*F*)
Oil price rises cause towing speed reductions				
Speed ~ lag(speed) + lag(oil price)	360	–	–	–
Speed ~ lag(speed)	361	−1	30.397	6.73e−08
Sole price rises cause towing speed increases				
Speed ~ lag(speed) + lag(sole price)	360	–	–	–
Speed ~ lag(speed)	361	−1	0.8682	0.3521
Oil price rises cause sole price increases				
Sole price ~ lag(sole price) + lag(oil price)	360	–	–	–
Sole price ~ lag(sole price)	361	−1	2.1389	0.1445

suspicion from some quarters, and a strict licensing system, is slowing more widespread introductions. Information, however, is limiting with respect to these interesting developments (Gascoigne *et al.*, 2009). A particular problem is that no official gear codes yet exist for these métiers in the EU logbook system; so it is impossible to monitor and evaluate the likely impact of these changes across the entire fleet. It is possible (although much of the change has been more recent) that some of the change in towing speed that we have observed here has been due to the gradual introduction of these gears some of which can be towed more slowly.

The reduction in fishing speed may also have implications for the stock assessment process, since commercial catch-per-unit effort series are often used to "tune" stock assessment models (Cotter *et al.*, 2004). The assessment of North Sea sole, for example, is done using an index based on metric tonnes caught per horsepower day. If the average towing speed is steadily declining, as we show here, it follow that, for any given hour trawled, slightly less ground will be covered and this may bias the models and affect their interpretation.

In conclusion, it is known that commercial fishing, although expensive on fuel, is actually more efficient than many other systems of food production, e.g. livestock rearing (Pimentel and Pimentel, 2003; Tyedmers *et al.*, 2005; Powles, 2009), and it is our view that increasing fuel prices will force less efficient vessels out of business, stimulate gear development, leading ultimately to higher profits and more sustainable fisheries (Arnason, 2007).

Supplementary data

Supplementary data are available at *ICESJMS* online.

References

Abernethy, K. E., Trebilcock, P., Kebede, B., Allison, E. H., and Dulvy, N. K. 2010. Fuelling the decline in UK fishing communities? ICES Journal of Marine Science, 67: 1076–1085.

Arnason, R. 2007. The Economics of Rising Fuel Costs and European Fisheries (Les pêcheries européennes confrontées à la croissance du coût des carburants) Die ökonomischen Aspekte steigender Mineralölkosten und europäischer Fischerei. EuroChoices, 6: 22–29.

Bastardie, F., Nielsen, J. R., Andersen, B. S., and Eigaard, O. R. 2010. Effects of fishing effort allocation scenarios on energy efficiency and profitability: an individual-based model applied to Danish fisheries. Fisheries Research, 106: 501–516.

Beare, D.J., and McKenzie, E. (2006). Fuel price change and its affect on fuel costs and the profits of selected European fishing fleets. EU Conference on Energy Efficiency in Fisheries European Commission Directorate-General for Fisheries and Maritime Affairs, Brussels.

Cleveland, R. B., Cleveland, W. S., McRae, J. E., and Terpening, I. 1990. STL: a seasonal-trend decomposition procedure based on loess. Journal of Official Statistics, 6: 3–73.

Cleveland, W. S., and Devlin, S. J. 1988. Locally-weighted regression: an approach to regression analysis by local fitting. Journal of the American Statistical Association, 83: 596–610.

Cotter, A. J. R., Burt, L., Paxton, C. G. M., Fernandez, C., Buckland, S. T., and Pan, J. 2004. Are stock assessment methods too complicated? Fish and Fisheries, 5: 235–254.

de Vos, B. I., and Mol, A. P. J. 2010. Changing trust relations within the Dutch fishing industry: the case of National Study Groups. Marine Policy, 34: 887–895.

Engle, R. F., and Granger, C. W. J. 1987. Co-integration and error correction: representation, estimation, and testing. Econometrica: Journal of the Econometric Society, 55: 251–276.

Gascoigne, J., and Willsteed, E. (2009). Moving towards low impact fisheries in Europe: policy hurdles and actions. Seas at Risk. MacAlister Elliot and Partners Ltd. 103pp.

Granger, C. W., Huangb, B-N., and Yang, C-W. 2000. A bivariate causality between stock prices and exchange rates: evidence from recent Asianflu. The Quarterly Review of Economics and Finance, 40: 337–354.

Hintzen, N. T., Bastardie, F., Beare, D., Piet, G. J., Ulrich, C., Deporte, N., Egekvist, J., *et al.* 2012. VMStools: open-source software for the processing, analysis and visualisation of fisheries logbook and VMS data. Fisheries Research, 115-116: 31–43.

ICES (2011). Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. International Council for the Exploration of the Sea, Copenhagen, Denmark.

Mills, C. M., Townsend, S. E., Jennings, S., Eastwood, P. D., and Houghton, C. A. 2007. Estimating high resolution trawl fishing effort from satellite-based vessel monitoring system data. ICES Journal of Marine Science, 64: 248–255.

Pastoors, M., Rijnsdorp, A., and Van Beek, F. (2000). Effects of a partially closed area in the North Sea ("plaice box") on stock development of plaice. ICES Journal of Marine Science: Journal Du Conseil 57, 1014–1022.

Pimentel, D., and Pimentel, M. (2003). Sustainability of meat-based and plant-based diets and the environment. The American Journal of Clinical Nutrition 78, 660S–663S.

Powles, J. (2009). Commentary: Why diets need to change to avert harm from global warming. International Journal of Epidemiology 38, 1141–1142.

Rijnsdorp, A. D., and Millner, R. S. 1996. Trends in population dynamics and exploitation of North Sea plaice (*Pleuronectes platessa* L.) since the late 1800s. ICES Journal of Marine Science, 53: 1170–1184.

Rijnsdorp, A. D., Poos, J. J., Quirijns, F. J., HilleRisLambers, R., De Wilde, J. W., and Den Heijer, W. M. 2008. The arms race between fishers. Journal of Sea Research, 60: 126–138.

R Development Core Team. 2006. R: A language and environment for statistical computing (Vienna).

Ronen, D. 1982. The effect of oil price on the optimal speed of ships. Journal of the Operational Research Society, 33: 1035–1040.

Rush, C. 2011. Hellfire and Herring: a Childhood Remembered. Profile Books, London. 318 pp.

Tyedmers, P.H., Watson, R., and Pauly, D. (2005). Fueling Global Fishing Fleets. AMBIO: A Journal of the Human Environment, 34, 635–638.

Woodhead, P. M. J. 1963. Diurnal changes in trawl catches of fishes. Rapports et Procès-Verbaux des Réunions du Conseil Permanent International Pour l'Exploration de la Mer, 152: 35–44.

Zeileis, A., and Hothorn, T. 2002. Diagnostic checking in regression relationships. R News, 2: 7–10.

Ziegler, F., and Hansson, P-A. 2003. Emissions from fuel combustion in Swedish cod fishery. Journal of Cleaner Production, 11: 303–314.

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