EXPLAINING SHORT-TERM CHOICE THROUGH RANDOM UTILITY MODELS

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ABSTRACT

Fisher behavior can be divided into choices made in the short term (i.e. tactics) and choices made in the long-mid term (i.e. strategies). Random utility modeling (RUM) is well suited for the empirical analysis of these issues. In this paper, RUM is applied to a number of EU fisheries in order to assess the key factors affecting short-term discrete choices with regard to choice of fishing location in European fisheries. In the analyses presented, components of the choice relating to gear, species targeted and the fishing area/ground selected are explored. Four differently structured case studies are considered to develop the discussion: Basque trawlers, English beam trawlers, French trawlers and Danish gillnetters. In the case of the Basque trawlers, a multinomial logit formulation proved suitable to analyze the fishing area (including gear used and target species). For the English beam trawl fleet and French trawlers conditional logit is used, and for the Danish gillnetters a nested logit formulation is developed. Specific attention is given to the identification of explanatory variables incorporated in these analyses. Overall results show that short term behavior models (RUM) are highly capable of predicting the spatial effort distribution of fishing fleets.

Keywords: Random utility model; logit regression, tactics, effort location choice

INTRODUCTION

The aim of this paper is to identify the approaches of the short term dynamics of a fleet given by the literature and to review some applications made within some of the case studies studied during the project TECTAC.

Roughly speaking two levels of fleet dynamics can be found, short and long term: Long term dynamic is normally seen as the behaviour of fleets between the years with the aid of a significant positive or negative investment (financial investment, not necessarily capacity investment). These dynamics are covering topics as the level of the investment, the entry-exit behaviour of the vessels to the fisheries, metier, or even fleet, the technical development and the effort allocation. Those decisions are also referred to strategies.

On the other hand short term behaviour is defined the behaviour of fleets within the year, without (presumed) financial investment. It takes into account, effort level (discarding including highgrading) and its allocation (among others, marine protected areas –MPA- and pollution of sea areas).

It is important to remark that the definition of short term does not come from the qualitative action analyzed (area, gear or fishery selection), but with the timing of it. From the economic point of view time is just the possibility of investment (see Figure 1) so, short term decision are those purely tactic, that is, without investment. It implies that a gear selection can be seen as a short or long term decision. For example, multipurpose vessels change often their fishing gear (even from day to day). It has a cost, but it is not an investment since the decision of having more than one gear has been taken before.

This paper deals with the tactical fishing area choice. Short term effort allocation lies on the fact that effort does no evaporate it just re-distributes, normally to the next-best performance area. It has several consequences such as that, for example, the effect of protecting a fishing area can be diluted due to an increase of the effort in surrounding areas.

The paper will only deal with this short term behavior. Furthermore, it will analyze only the application of a certain model to selected case studies. Even if some other approaches are explained before. It will explain how this analyze

has been performed for four case studies. The English beam trawlers, the Danish gillnetters the Basque trawlers and the French trawlers are the case studies selected.
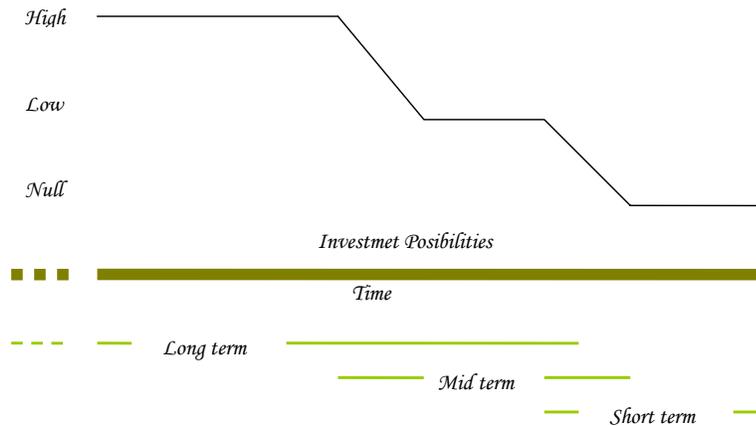

Figure 1. Investment possibilities and time.

The paper is structured as follows: Firstly a brief review of the existing models for analyzing the short term behavior is made. In that sense, "world" has been divided in bioeconomic and Random Utility Models (RUM). Third section will describe the main challenges affecting the short term behavior analysis, (assumptions, resolution, variables and model) and how the case studies presented here have deal with them. Finally the case studies are presented and the results and conclusions obtained from them are presented. The paper ends with the general conclusions obtained.

MODELS

Many different approaches have been attended in the literature for modeling short term behavior. For example the distribution of fishing effort could be assumed to move towards areas of highest catches (i.e. reflecting differences in revenues assuming constant costs [1]), highest catch rates modified for distance to port or greatest profit ([2]; [3]).

Further, descriptive techniques can be used to characterize fishing tactics on a spatial scale, using location choice as a key variable [4]. However, such methods do not provide an indication of the underlying choices. The significance of explanatory variables that can explain the patterns of distribution observed is typically not assessed. Fishing is an economic activity, so spatial patterns of fishing effort are largely driven by expected economic returns [5]. However, Gordon's model assumes that profit rates would equalize over areas fished, thus not taking account of differences in fish density or cost structures of vessels.

Allen and McGlade [6] proposed a model based on the probability of selecting alternative fishing grounds, which in turn was based on the utility (expected net rate of return) of each fishing ground. Alternatively, vessels could redistribute their effort over open areas (assuming that some areas were closed), based on the assumption that they would fish on a fishing ground where other similarly powered vessels operated. In a different approach, "gravity" models predicts the share of effort to each ground based on expected economic variables, i.e. how profitable a fishing ground is going to be, based on a function that includes fish availability and cost factors. Furthermore, the assumption could be made that vessels will allocate effort according to Ideal Free Distribution theory, which predicts that vessel density is proportional to resource abundance (see references in [7]). If it is assumed that catch per unit effort (CPUE) is proportional to abundance, then vessels would gravitate towards areas where the catch rate is highest. Rijnsdorp et al. [8] showed that this is indeed the case, vessels depleting areas until the catch rates dropped.

Broadly speaking two types of approaches can be used for this decision analysis. The wide world of the bioeconomic models, and the random utility models (RUM) world. The main characteristics of each approach are described below.

Bioeconomic Models

Bioeconomic models satisfy the dynamic pool assumption and thus homogeneity in the spatial distribution of the stock and fishing effort is assumed (e.g. pelagic species). In sedentary resources (e.g., selfish), the above assumption is not always valid for the following reasons [9].

1. Populations are patchily distributed.
2. The low or null mobility precludes species redistribution over a fishing ground, by filling gaps in patches resulting from a sequential distribution pattern produced by the heterogeneous allocation of fishing effort [9]. Thus, CPUE cannot be used as an unbiased index of abundance.
3. Growth, mortality and recruitment parameters are extremely dependent on environmental conditions even between small distances [10].

Two alternative approaches seem to be appropriate:

1 To relax the assumption of spatial homogeneity of stock distribution. Thus, extensive fishing grounds with variability in environmental conditions and related abundance heterogeneity, growth and mortality patterns, can be divided into smaller areas that can be considered as independent units [11]. Hence, for a stock showing a continuous geographic range of population characteristics, a useful approach is to consider it as composed of several discrete subpopulations which can be studied independently and the predictions integrated afterwards [12].
2. To develop a comprehensive approach, integrating effects of different environmental regimes on the spatial structure of the population, spatial heterogeneity of fishing effort, biological interactions, and the implications of economic factors and human attitudes (behaviour of resource managers and users) [12].

Studies on fishing effort dynamics have been focused on long-term decisions of fishers, emphasizing the estimation of rates of entry and exit to the fishery and the characterization of general patterns of allocation of fishing intensity [13]. However, it is in the short-term that fishers make their spatial decisions: after deciding to go fishing and selecting the target species they decide where to fish [2]. The latter decisions are of utmost importance, because, in contrast with traditional views which focus on excess of fleet capitalization, dissipation of economic rent can arise primarily as a result of today's excess of fishermen's movements in response to yesterday's spatial catch rate variations.

When spatial considerations in modelling fisheries are introduced, notably, the distance from ports to fishing grounds becomes relevant, in order to further understand short-run decision making of fishers in their allocation of fishing intensity.

This literature takes a different view when the fishery is regulated by individual transferable quotas, individual vessels harvests are fixed. In this case each vessel minimizes the cost of harvesting the given quota. The short run cost function is estimated and with the estimated parameters we investigate whether vessels harvest at optimal level.

Random Utility Models

Heterogeneity of fishermen is a difficulty. Different cost structures, derived from different base ports or different landing ports, imply divergences in revenue for similar level of catches.

Random Utility Models (RUM) do not assume homogeneity. The basic idea is that the benefit that an individual receives is observable with some degree of uncertainty. Hence, they are based on utility (satisfaction), which level, is assumed to be maximized. It is, in essence, probabilistic. The effort applied by an individual fisherman to a certain area is just the product of the total effort expended and the probability that this effort is applied to that area.

Current models a turning again to the discrete choice literature as in the case of effort location (see [14] for details of it), thus, this is what is going to be used in the next sections.

Although the RUM approach has proved successful in estimating fishermen response to area closures, few attempts have been made to integrate these models into bioeconomic models for a more broad based assessment of fisheries management changes. Smith and Wilen ([15], [16]) incorporated the probabilities of fishing in each area into a

bioeconomic model. Most of the other analyses cited above were extremely short run in nature, and considered the immediate impact on profitability and catch of effort relocation following a management change.

Most attempts at incorporating spatial behaviour into bioeconomic models have adopted approaches based on the set of economic incentives facing fishers. An early approach to modelling spatial movement of fishing effort was proposed by [17]. In their model, effort was originally allocated spatially, and movement of effort was based on an iterative approach where the expected profitability (measured in terms of value per unit of effort less an area-specific cost per unit of effort) in alternative areas was considered. The catch rate estimates (and hence value and profitability per unit of effort) were endogenous in the model based on total effort allocated to an area.[18] takes a similar approach.

Several studies (e.g. [19]; [20]) have applied the concept of optimal foraging theory to model location choice. The concept of an optimal foraging model is, in essence, a model of rational economic behaviour. In the fisheries context, "energy" is replaced by economic variables in the objective function. That is, the fishers are assumed to try to maximise economic returns (energy in) while minimising the costs of obtaining the returns (energy out). A fisher is assumed to leave the patch (fishing area) when the marginal rate of return of the patch is equal to the mean return (including the travel cost) for the entire set of patches [19].

The Hilborn and Walters model [17]and the optimal foraging studies considered above assumed that effort moves from one area to the next based on economic incentives, but do not provide information on the initial allocation of effort. An alternative approach has been employed by [21] and [22] that allows both initial allocation and effort movement to be determined endogenously. These models used optimisation procedures to determine the spatial allocation of effort across the fishery based on the relative profitability in each patch, with movement between the patches based on changes in the stock status. This model was extended by [23], who developed a dynamic form of the model to consider changes in effort allocation, stocks and profitability over time following a pollution event in one of the areas. Using an agent-based simulation framework, Soulié and Thébaud [24] show that effort reallocation processes may have strong implications in terms of the overall bio-economic impacts of a temporary and partial fishery closure.

A major difficulty facing the development of spatial bioeconomic models is limited information on economic performance measures and their relationship with area fished. A more generic difficulty facing the estimation of location choice models of fishers is lack of detailed spatially disaggregated data in general. The (annual) process of stock assessments does not generally include the spatial detail required for inclusion in fisher choice models. Also, logbooks that fishers complete may also suffer from similar problems of spatial definition. In Europe, where location is recorded, it is generally done at the ICES rectangle level. Hence, more often than not in bioeconomic models of fisheries, spatiality is either not included or included for large areas defining a fishery. The increasing interest in spatial management of fisheries, however, will lead to greater activity in collecting spatial information. This is also being observed in other areas of marine resources management, including aquaculture [25].

These developments, along with the growing recognition that short-term firm response acts as a major determinant of the consequences, both biological and economic, of management measures, lead to increasing demand for impact assessment tools which explicitly take this into account. For example, the recent closure of the anchovy fishery in the Bay of Biscay led to studies of the effects of this closure, taking into account the likely responses of affected fleets [26].

IMPLEMENTING RUM FOR SHORT TERM CHOICE.

Before explaining the case studies and their RUM implementations, it is important to remark the main challenges for this short tem, area location choice:

Independence of Irrelevant alternatives

One of the major restrictive assumptions for the standard logit model is the independences of irrelevant alternatives (IIA) [14], which means that a change in the attributes of one choice requires proportional changes in the probability associated with alternative choices. Wilen et al. [27] pointed out that the assumption of IIA is quite often violated in the context of fishery management, as some alternatives share the same unobserved characteristics. To avoid this

problem more generalized logit models can be applied to take account for heterogeneity correlation structure among choices and decision makers [14]. In the fisheries literature nested logit models have mainly been used to relax the assumption of IIA for correlation among choices in modeling spatial location choice.

Spatial Resolution

It must be kept in mind that data and decision variables in the observed utility function should be compatible with the available data. Information on costs of individual vessels and variations in profitability due to spatial activity is often difficult to obtain, as fishers are not required to report costs on a trip-by-trip basis. Nevertheless, it should be ensured that the decision variables can be computed on available input and output data in the same spatial resolution.
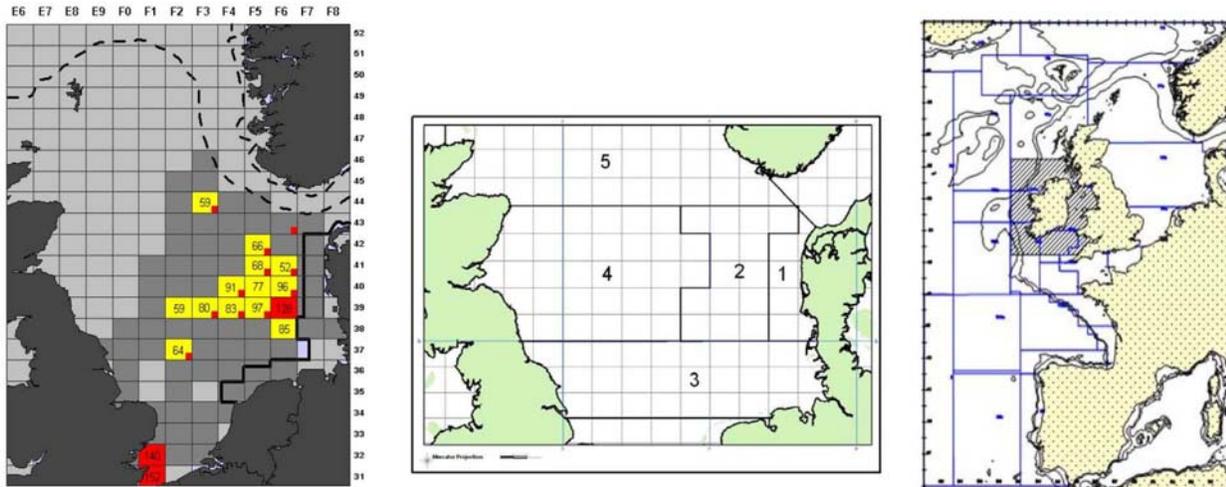

Figure 2. Spatial resolution for UK beam, trawlers, Danish gillneters and Basque trawlers

The approach to model areas fished that has been taken generally has been to consider larger areas, so that a discrete choice is definable. For fleets that operate in European waters, an area aggregation may not be clear. For example, in the trip level data, in whichever way these areas are defined, a vessel may fish in two or three areas on a given trip. However, the bulk of a trip's activity may relate more to one of these areas, either in volume or in value of catch. A similar approach to that of [28] could then be taken to handle distance from port.

The four case studies presented in this paper also face different spatial resolution levels (Figure 2). ICES rectangles for English beam trawlers[1] and French trawlers, aggregation of these rectangles defining "ad hoc" areas for Danish gillnetters, and ICES Sub-area for the case of Basque trawlers.

There is some natural choice that fishers make on where to fish with a given boat on their initial capital investment. For example, a fisher may invest in a specific sized vessel with specific gear, because that is what it is thought is required to fish profitably in a given area. There are clearly physical restrictions as larger vessels are generally used further from shore. It could be expected that greater returns are available for fishing a greater distance from port. As the resolution is decreased these problems become higher, and it should be noted that short term has been defined as tactical (not investment based strategic) time schedule.

In any case, as pointed out in [29], aggregation of choices (unless very restrictive conditions hold, will lead to biased results. Among some other conditions, it has to deal with the existing correlation between alternatives, even if the extend of the bias can be considered as circumstantial. If the data exists, but the alternatives are too many, estimating random draws of alternatives is a non biased aggregation way of solving the problem

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[1] In this case study also an aggregation of these rectangles has also been analyzed.

Identification of the explanatory variables

The four case studies have estimated the probability that an individual (fishing vessel) will choose to fish a given site, according to the characteristics of the site and its substitutes (choice specific –CS-) and the characteristics of the individual (individual specific –IS-). Selection of variables, choice and individual specific, also will determine the model to be used as it can be seen in the next sub-section:

The typical IS characteristic explaining a location choice is vessel's physical characteristics. Used explicitly in the Basque trawlers case study, have probed that bigger the vessel, higher the probability of choosing a longer trip (even if its marginal probability changes are small). English Beam trawlers also have it as a significant variable, but not in the utility function specification, but in the production function (which will be included in the utility formulation). Danish gillnetters and French trawlers did not consider these variables, given the size homogeneity between their vessels.

Management variables (IS or CS) probed to be also important. It is obvious that a closure of a fishing area will determine effort spatial distribution. But in some cases this regulation can be altered form trip to trip. For example the fishing days limits by area of the Basque trawlers, and its possibility of transferring have probed to be significant, especially these fishing rights that are relatively scarce.

Trip characteristics (CS) especially distance to the fishing area has probed to be one of the main characteristics defining the utility functions of three case studies (not for the French trawlers). In the case of English case study a proxy for it has been used (average trip length) while in the Basque case study this proxy has probed to be more significant than the distance measured in miles.

The last two more important factors are the production function (IS or CS) and the behavioral (habit) characteristics. (IS) Production function has been used in all the case studies with some differences. UK bean trawlers have estimate a pure production function, while Danish case study, French case study and the Basque trawlers case study have used simply VPUE with some lag (expecting that the value obtained it will be the more or less the same as the one obtained in the same trip last year/month).

Finally it has been tried to incorporate behavioral characteristics to the utility function. Using variables like, effort last year/month/trip (English beam trawlers, French trawlers and Danish gillnetters) and inertia (a dummy variable that stands for they do what they did in the last trip) for Basque trawlers. All of them have probed to be significative.

Selection of the Model

Selection of the model comes from two different facts. The sequence of choices (if there are) and the variables presumed to be determining the utility function. This last determination can be obtained using previously made questionnaires as in these case studies.

As commented before, a change in the attributes of one choice requires proportional changes in the probability associated with alternative choices. Sometimes using a non nested model this is not the case (violation of the IIA), simply because a sequential choice is taken (there is a feeding from the lower nest to the upper one) or as simultaneous choice where "full information" from the lower nest affects the nesting parameter to the upper nest. In this case nested logit has to be implemented. An example of this will be seen in the case study of the North Sea gillnetters where it has been observed that fisherman first chooses a target species and afterwards the fishing area.

The other decision to be taken in terms of the model to be used depends on the specification of the variables used to determine the utility function. According to that two types of logit model can be used:

In the multinomial logit model, the independent variables contain characteristics of individuals, and are the same for all choices. In other words, estimates how individual-specific variables affect the likelihood of observing a given outcome [14]. This is what has been used in the Basque trawlers case study.

In the conditional logit model, the independent variables contain the attributes of the choices In other words, it estimates how alternative-specific, variables affect the likelihood of observing a given outcome. Therefore, data need to be appropriately arranged in advance. This is what has been used in the English beam trawlers case study.

CASE STUDIES

English Beam Trawlers

Individual trip data for beam trawlers (English registered vessels only) were collated for 1999 and 2000 from the log-book fishing activity database. The year 2000 was taken as the base year. The previous year, 1999, was used to obtain estimates for past activity to take account of the fact that past activity may have an influence on future decisions. The spatial coverage includes ICES sub-divisions IVa, IVb and IVc with the spatial resolution of an ICES statistical rectangle used. In 2000, 81 such rectangles were visited in the North Sea by this fleet. Vessel characteristics such as engine power, length of vessel and 'home' port (assumed to be the port of registration of the vessel) were included. Also, trip (i.e. choice) attributes such as effort (hours fished), catch (weight and revenue) and landing port. However, due to the discrete nature of RUM, the number of potential choices (i.e. rectangles) was limited by the constraint that more than 10 trips to (viable) choices were made during 2000. In total, 52 rectangles were included in the analysis instead of the 81 visited in 2000. The fishing hours covered by this subset comprised approximately 80% of the total activity. The data for individual trips included the catch and value for the following species (or species groups): cod, haddock, whiting, nephrops, lemon sole, saithe, plaice, sole, skates, redfish, anglerfish and turbot.

Aggregated log-book data by vessel and month for the year 2000 was compiled for a choice-specific variable model. The model was found to be highly significant at the 1% level [30]. Several alternative measures of expected gains were considered, both revenue and catch rate per unit effort (i.e. VPUE and CPUE) as well as a mixed species measure of a weighted index (i.e. catch weight weighted by value, similar to a Divisia index). However, a simple expected catch value based on average catch value from a given area gave best results.

Although distance was not explicitly incorporated into this model, average trip length was included as an explanatory variable. Even though this is not an explicit measure of distance, it is evident in the data that the further a vessel travels then the longer the fishing trip (i.e. a higher effort in that rectangle). This makes good sense as in order to cover increased variable costs (particularly fuel costs), which would occur from a more distant trip, then trip length would increase to enable a larger catch. Other explanatory variables that were found to be significant in the location choice problem were average effort expended in a given rectangle for the previous month, as well as average effort in that rectangle at that time last year. Also, average catch value achieved in a given rectangle in a given month was included. All other choice parameters tested were found not to be significant. It is clear in the results that past fishing effort in a particular rectangle at a particular time of year gives a good explanation of where a fisher fishes.

When including explanatory variables for distance explicitly in the rectangle model, using the above ideas, they are not found to be significant. This is perhaps due to the complications caused by trips that are in fact made up of visits to several rectangles. Therefore, the 'choice' associated with a single rectangle is not being uncovered. In order to try to overcome this, the 'larger' area model, using the five areas described was developed. A simple production function was used to calculate expected revenue (Y_{it}) for a given vessel in a given month[2], specified as:

$$Y_{it} = \alpha^K KW_i + \alpha^E EFFORT_{it} + \sum_{a=1,4} \alpha_a^A A_{at} + \sum_{m=1,11} \alpha_m^M M_{mt} + u_{it} \tag{1}$$

where Y_{it} is the landing value for vessel i in month t, KW is engine power, $EFFORT$ is aggregated fishing effort in hours fished, A is a set of dummy variables for area fished, M is a set of dummy variables for month and u is the error term. The production function is highly significant ($R^2=0.80$). For the most part, variables are significant at the 1% level. The results show a fleet that is seasonal in nature as well as location dependent. Effort is significant which may suggest a degree of heterogeneity within the sample to area fished, i.e. that effort consistently differs by area.

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[2] Dummy variables were used for the spatial and temporal components of this production function.

Results of the location choice by 'large' area, show the same trends as the previous 'rectangle visit' model, with all distance measures used. Seasonal choices were not evident in the choice model, but as before choice of location is highly significant to variables describing past history of fishing in a particular area, whether it is in recent months or recent years.

The results for all 'distance' indicators show that little explanatory power is added to the model by their inclusion for describing fishing location choice of the English beam trawl fleet operating in the North Sea in 2000. This is indeed the case for trip length, distance to area fished, total variable cost (analogous to profit) of the fishing trip and a calculated 'marginal' profit for the trip. This is perhaps contrary to a priori expectations. The problem associated with the fact that a vessel typically visits more than one (and often up to seven) rectangles on a trip seems at first glance the main issue behind this. However, even a model with significantly larger areas does not overcome the lack of explanation of distance to fishing location choice for this fleet.

Danish Gillnetters

The Danish human consumption fishery in the North Sea is characterized by exploiting a wide range of fish stocks (such as cod, haddock, saithe, hake, plaice, sole, turbot and Nephrops) with several different types of gears and riggings. One of the larger fleet components in this mixed fishery is the Danish North Sea Gillnet fleet, which, during the last decades, have landed over 50% of the Danish cod quota yearly and contributed to around 30% of the total annual Danish landings (in value) of demersal species. Data for the quantitative analysis of fishermen's behaviour were derived from the Danish national fishery database which was based on commercial fishermen logbooks, sale slips and vessel register data.

The database contained information per vessel at trip level, including landing weights and values per species, gear, mesh size, fishing location at a resolution of ICES rectangles and vessel characteristics such as length and tonnages. The final data contained 40492 fishing trips, undertaken by 117 vessels. The Danish demersal fishery in the North Sea is subject to common pool (open access) quota regulation. Based on ad hoc knowledge from historical catch information five areas were defined. In addition, the defined areas were designed to fit the closure of are large fishing area in the North Sea in 2001. That gave a total of 25 choices (5 target species and 5 areas), however, choices with <100 trips for the entire study period were grouped with nearby fishing area. The final number combination of fishing area and target species was 16.The simplest way to structure a fisherman's short term decision processes is by assuming a single level decision structure (or tree). In the first test hypothesis we expect a single level decision making structure by assuming that a fisherman before he goes fishing chooses among the 16 choices which are defined as a combination of target species and fishing ground. To estimate the parameters in the utility function, a standard conditional logit model is applied and it takes the following forms:

$$U_{ni} = \beta_1 \%EFF_{(m-1)} + \beta_2 \%EFF_{(m-12)} \beta_3 VPUE_{(m-1)} + \beta_4 TOT\_EFF_{(m-1)} + \beta_5 DISTANCE \quad (m{=}month) \quad (2)$$

The observed utility function for nested logit model was divided into two levels. The utility in the first level is the percentage of effort that a given fisherman had made in each choice in the previous year in the same quarter (%EFF(q-4)). This explanatory variable is a proxy for the attractiveness of a fisherman choosing the same target species as last year at the same time of the season. The standard logit model was tested for assumption of IIA. It was probed that this assumption failed.

The second model test: a log-likelihood ratio test was used to test for any model reduction in the nested logit model with the test hypothesis for equal inclusive value ($H_{02}{=}\tau_1{=}\tau_2{=}\tau_3{=}\tau_4{=}\tau_5$) and afterwards the inclusive value was set to 1. Both tests were rejected (H_{01}: $c_2(5){=}408$, $p{<}0.01$; H_{02}: $c_2(5){=}445$, $p{<}0.01$) and no model reductions were carried out.

All the estimated coefficients within the conditional and nested logit model were tested significantly from zero at the level of 1% and no further reduction of the full model was done. Except DISTANCE, all the explanatory variables had a positive sign.

Basque Trawlers

Spain, and particularly the Basque Country, has an important fleet operating in ICES Sub-areas VI and VII and Divisions VIIIa,b,d. According to the gear used this fleet can be split in to two sub-fleets: Firstly the "Baka" otter trawl catches main commercial species like hake, megrim and anglerfish. In the case of the Very High Vertical Opening (VHVO) bottom pair trawlers, most of the vessels are adaptations of other fishing units, namely, "Bou" and "Baka" trawls and a few longliners. This sub-fleet began to work in 1993 and their main target species is hake. The Basque trawl fleet is managed through TAC and TAE, apart from some other technical and physical measures.

Basque offshore trawl fleet has three different main choices. The first one is Sub-area VIII; It includes the Bay of Biscay, except its southern part (Division VIIIc). The second one is Sub-area VII. Finally, the last possible choice is Sub-area VI, which includes West of Scotland (Division VIa) and Rockall (Divisions VIb).

The data set used contains trip level information for the period 1996- 2002, obtained from logbooks and sale forms of trawl vessels, operating in ICES Division VIIIa,b,d, and Sub-areas VI and VII, which base port is in the region of the Basque Country (Spain).

According to the variables used in the analysis, even if some of them can be seen as choice specific, i.e, the distance to the fishing ground, the way it has been computed (see previous section) makes them individual specific. Furthermore, all the trip and behavioral characteristics of the fleet are individual (trip) specific[3], hence, the model that have been used is the multinomial (unordered) logit.
Approaches of these models applied to similar investigations can be found in, among others, in [31], [18] and [28]. Nevertheless a main difference can be found from the approaches given by the literature. The regulation that these vessels have, combining fishing rights by Sub-area and TAC by Sub-area, makes this investigation a good example of how two kinds of regulations can interact.

The deterministic component of the indirect utility function in the multinomial (unordered) logit model has empirically been specified as:

$$V_j = \alpha + \beta \ Vessel \ Length + \gamma \ Duration + \delta_1 F\_Rights\text{-}VI + \delta_2 F\_Rights\text{-}VII + \delta_3 F\_Rights\text{-}VIII + \delta_4 \ TAC \ Hake + \theta_1 Fuel\_Cost + \theta_2 Production \ Function + \eta_1 \ Risk + \eta_2 \ Inertia \qquad (3)$$

The utility function is estimated iteratively using a multinomial logit model, converging to the maximum likelihood result. The model makes the assumption explained above of the independence of irrelevant alternatives (IIA).
Estimated model from the multinomial model (3) is not presented. But it can be said that the pseudo-ρ^2 indicates that the model explains about 68% of the variation in area selection behaviour. The loglikelihood ratio and chi-square value were also significant. Finally, residuals were tested in order to confirm that they follow a Weibull distribution. It has to beaded that estimates do not show the utility function for each of the alternatives, since one of these alternatives (Divisions VIIIa,b,d) has been normalized, all the results are relative to it.

Trip characteristics, managerial characteristic, TAC applied to hake, economic characteristic and behavioral characteristics are significant for determining the area choice.

The existing difficulties for the interpretation of the parameter estimates of the model, conduces to the necessity of the computation of the marginal effects on the probability of an outcome (dP_j/dx_K). The probability of fishing area selection has been simulated under different scenarios of changes in the expected turnover

In the case of changes in the expected turnover, it could increase by, technological, natural or fishing strategic changes, but also the other way around, that is, it could decrease by technological or natural reasons[4]. In any case, the probability of selecting the Bay of Biscay as the fishing ground will decrease, increasing the probability of selecting Sub-area VII, while the probability selecting Sub-area VI does not change.

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[3] The only variable
[4] The reader could think that the expected turnover can change due to many other reasons, but in this case, we only include those that have not been taken into consideration when defining the utility function of each fishing area alternative.

South-Brittany trawler fleets

The trawler fleet based in ports of Southern Brittany (administrative districts from Camaret to the North, to Vannes to the South) operates mainly in the bay of Biscay (ICES area VIII) and in the Celtic Sea (ICES area VIIh-k) . Key species targeted include anglerfish, nephrops, hake, megrim, cod, sole and seabass.

5417 trips were analyzed, while the choices facing these trips were reduced to eight based on ICES Statistical rectangle (highest resolution).

To estimate the parameters in the utility function, a standard conditional logit model is applied and it takes the following forms:

$$U_{ni} = \beta_1 \%EFF_{(m-1)} + \beta_2 \%EFF_{(m-12)} \ \beta_3 VPUE_{(m-1)} \ \ (m=month) \tag{4}$$

All the estimated coefficients within the conditional logit model were tested significantly from zero at the level of 1%.. Except $VPUE_{(m-1)}$, all the explanatory variables had a positive sign. The DISTANCE factor was not found as significant for explaining the utility function. Again a simple production function and the past history (effort lagged one month and one year) were enough for obtaining and R^2 of 40%.

CONCLUSIONS

Random utility modeling is the state-of-the-art empirical analysis tool for the measurement of short term discrete choices. It does not assume that individuals display homogeneous behavior, and ultimately provides the probability that an individual or group of individuals will make a particular choice.

In the case studies presented, depending on the type of fleet selected, similar choice decision but in different resolution were modeled. For example, location choice by, ICES rectangle, ICES sub-area or fishery (area), are considered. Through simple comparisons, there is clearly a similar structure across case studies, including similar data. Particularly, the issue of definition and use of parameters must be considered.

Important parameters for the modeling of location choice behavior, from the literature review and from the surveys undertaken, were identified to be: habit (experience); expected returns (revenue); variability of returns; cost data (travel or fuel) or a proxy for distance; catch rate; vessel characteristics (e.g. length and engine power of vessel); and effort (lagged). In the studies presented, these and other parameters were included. It is interesting to note past history has a clear affect on the short-term decision making process of fishers regarding where they choose to fish.

In the case of the Basque trawlers, a multinomial logit was undertaken where three distinct choices were modeled based on area fished and implicitly the type of activity that is associated in that area (i.e. gear used and species targeted). Firstly, all categories of parameter (vessel, trip, managerial, economic and behavioral characteristics) provided at least one statistically significant variable. This gives an immediate indication of the complexity involved in reasoning the choice of fishing area made. Key characteristics were shown to be vessel length, fishing rights, inertia, fuel costs and the 'risk' of each area (i.e. the standard deviation of the average turnover of each area).

In the case of the English North Sea beam trawlers, the choices of the fleet to fishing in 81 ICES rectangles were investigated. Average trip length and lagged effort were shown to be the variables most describing the choice made. Average trip length was correlated with distance to grounds (i.e. longer trips the further traveled) and grounds were indicated to be preferred that were in fact relatively closer to port. Lagged effort (i.e. historic activity/experience) was also shown to have a positive impact on the choices made. Other indicators of distance to fishing grounds were also considered in this analysis.

However, the results for other 'distance' indicators showed that little explanatory power is added to the model. The problem associated with the fact that a vessel typically visits more than one (and often up to seven) rectangles on a trip seems at first glance the main issue behind this. However, even a model with significantly larger areas does not overcome the lack of explanation of distance to fishing location choice for this fleet. A reason for the lack of

10

effectiveness of the large area model is that perhaps much of the heterogeneity in locations fished is lost resulting in a lack of variation across trips. Perhaps also, there is some natural choice that fishers make on where to fish with a given boat on their initial capital investment. There are clearly physical restrictions as larger vessels are generally used further from shore. It could be expected that greater returns are available for fishing a greater distance from port.

In the Danish and French case studies, the "own experience" proxy was modified from a simple dummy variable to include the level of recent activity during the previous month and year. This has contributed to a more flexible and dynamic description and interpretation of this decision factor. Gillnetters were positive to alternatives with higher expected revenue rates that may imply a profit maximizing behavior among the Danish gillnetters. Distance traveled to fishing grounds was again shown to be 'minimized', as grounds closer to homeports were indicated to be preferred. On the other way around, French trawlers expected VPUE probed to be negative (if small) while the "own experience" took the main explaining power.

The applied short-term behavioral models are capable of predicting the spatial effort distribution in a mixed fishery under the closure of large areas [30]. Overall the model can (to some degree) predict the redistribution of effort among the defined fishing areas and target species before and after the closure. But the findings illustrate that the level of prediction also depend on both the temporal and spatial accuracy of interest. Modeling spatial choice behavior in terms of effort allocation is based on catch and effort information from fishermen logbooks (such as in the case studies developed here) and are therefore restricted to the spatial resolution of the ICES statistical rectangle. As short term closures (e.g. seasonal closure, protections of aggregation of juvenile and spawning fish) are getting more frequently used as a management instrument, the demand for this type of analysis is important.

Overall, results of the short-term RUM studies validate the assumption that past history is followed for locations fished. This is in line with results achieved by other empirical analyses ([18] and [32]). It is clearly shown that past history can explain where vessels fish, but distance is not always well-defined enough to be shown to be a significant factor. Catch rate (whether modeled by CPUE or VPUE) is shown to be a highly relevant indicator of where vessels fish, although this may be judged from immediate past activity and past activity for up to several years previously. In the case studies developed, this has been a key issue under investigation.

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