AN ANALYSIS OF CHANGING FISHING UNITS USING FIELD SURVEYS: CASE STUDIES FROM THE EU

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ABSTRACT

Three case studies were included in a study on fishing vessels, most of which use trawl gear in demersal fisheries. The case studies include the French Bay of Biscay bottom-trawlers, the English beam trawlers fishing in the English Channel, Celtic Sea and North Sea, and the Basque trawlers fishing in ICES areas VI, VII and VIII. The characteristics surveyed were based on operator, crew and boat information. Information included changes made to equipment on deck for handling and processing catch, engine changes and changes made to onboard electronics. Information on gear used and species targeted was also collected in order to describe various tactics and strategies. Investment decisions, in terms of acquiring a new vessel were mainly based on economic factors such as opportunity costs. Changes to deck equipment are regularly made to increase efficiency and there is a tendency in each fishery to reduce the number of crew, as this reduces costs. The replacement of an engine was linked to the engine breaking down or to reduce the risk of breakdown. The vast majority of vessels surveyed have installed state of the art onboard electronic equipment after it has become available. The rate of uptake averages about 9 years for GPS-PC linked devices (in terms of average time of the majority of the uptake). This new electronic equipment is used to locate productive areas. Modifications made to gear primarily appear to be to increase efficiency and in some cases may be in response to changing fishing opportunities. External factors constrain fishing operations and in order to remain competitive fishermen require changes in technology to achieve greater efficiency. Output-based fisheries management strategies do not necessarily take into account these changes in efficiency leading to situations where effective fishing effort is greater than the reported nominal effort.

Keywords: fishing units, vessels, field surveys, demersal trawlers, efficiency

INTRODUCTION

External factors (management, perceived stock abundance on fishing grounds, market conditions) impact on the dynamics of fishing fleets. Any impact on a fishing operation provides incentives for technological change to achieve greater efficiency. The rationale is based on the assumption that skippers are profit or utility maximisers. The key questions are: are skippers influenced by prices (the market and changing revenues), increasing costs (e.g. fuel), safety of the vessel and crew, regulations, and/or other skippers and their decisions (i.e. imitation)? Thus the objective of this investigation was to quantify the reaction of fishermen to external factors and describe how they adapt their tactics (in the short-term), their gear and vessels (in the medium-term) and their investment strategy (in the long-term). Longer-term decisions such as entering (investment) or exiting the fishery (decommission) are highly relevant and in this paper we evaluate the reasons for the decision to invest or not. The methodology available to undertake these investigations is surveys, questionnaires and/or in-depth interviews. The overall aims of this research is to enhance the understanding of the mechanisms influencing the decisions made by individual fishers, and in particular their adaptation to changes in regulations. A secondary objective was to relate the findings with complimentary empirical studies on the same fleets that considered either short-term choices (Prellezo *et al*. 2006) or long-term choices (Mardle *et al.* 2006). Both studies mentioned apply discrete choice models to the same case studies as those presented in this study. This field study provides a way of validating or a way to "ground-truth" the results of the research that apply discrete choice models to the same case studies.

CASE STUDIES

The case studies considered in the analysis were carried out as part of the "TECTAC" European research project. Within the project there were originally five case studies in total (the three in this comparative review as well as a case study on the Danish Demersal fleets and a case study on the Galician trawlers and longliners operating in the Celtic Sea). Christensen and Raakjær Nielsen (2004) in addition, undertook a more in-depth study on the Danish fisheries providing a typology of strategies. For comparative reasons, the focus in this paper centres on the three following fleets:

- the French fleet of trawlers operating in the bay of Biscay (ICES areas VIIIa,b,d,e) and the Celtic sea (ICES areas VIIc,f,g,h,j,k);
- the Spanish fleet of trawlers based in the Basque region, composed of 'Baka' (otter) trawlers and pair trawlers using Very High Vertical Opening which operate in ICES areas VI, VII and VIIIa,b,d; and
- the English Beam Trawlers (over 10 metres) that operate in the North Sea (ICES areas IVa,b,c) and a separate fleet fishing out of ports in the South West of England that operate in the English Channel and Celtic Sea (VIIe,f,g,h)(see Mardle *et al.* (2006) for a map of the ICES areas in Europe).

The key information available for the three fleets, with respect to the average physical characteristics of vessels, and their average landings in year 2003 is summarized in Mardle *et al.* (2006). Additional metrics are available in Thébaud *et al.* (2006). In terms of survey coverage, Table 1 shows the sampling rate (% of the number of vessels surveyed versus number of active vessels) and the time period that the survey related to.

Table 1. Coverage of survey for each case study (number of vessels, % of fleet and period covered)

	English Beam trawlers	French (Bay of Biscay) trawlers	Basque trawlers
Vessels surveyed	16	80	27
Percentage of fleet	26%	25%	60%
Period of coverage	2005 (or most recent since 1990)	1985-2003	1995-2003

METHODOLOGY – THE SURVEY

The aim of this study is to characterise the technological changes and strategies of fishermen and to explain the reasons for this. Changes on an inter-annual scale may occur due to investments and renewal of material, modifications in the metiers undertaken in terms of target species, of gears used or fishing zones frequented. A questionnaire was designed to identifying the changes in the vessels but also the technological evolutions (over the last twenty years) and fishing strategies on the fishing unit/vessels. The structure of the approach was: (i) to undertake preliminary interviews with fishers to produce a general understanding of fishers' behaviour; (ii) then select from these a relatively small number of fishers for a series of in-depth interviews to identify important factors both in relation to decisions made at the trip level and from a long-term perspective; and (iii) to test through questionnaires a larger population to compare the results with the statistical analysis. The survey covered the following factors: (A) Personal information or boat information (skipper focus or vessel focus); (B) vessel characteristics; and (C) gear used (fishing method, and effort per gear) and species targeted. That is, part A considered the history of owned/operated vessels and the reasons for changing boat or not changing boat (long-term, strategic decisions). In addition, part B considered vessel characteristics and changes and reasons for change (medium-term, strategic decisions) (with evolution over time if data available) with regard to:

· equipment on deck for handling and processing catch onboard and reasons for change
· activity of fishing units and crew size and reasons for change
· engine changes and reasons for change
· on-board electronics and reasons for change

Furthermore, part C considered gear used and species targeted (short-term, tactical decisions), that is:

· Fishing method(s) used and gear – and reasons for change
· Principal species - and reasons for change

The category concerning fishing tactics (short-term) covered three main topics: questions about fishing location and how skippers decide where to fish; questions on gear used and species targeted (as specified above) and questions on fishing activity and the routine of fishing trips.

RESULTS

Due to the fact that the full results from the field surveys are extensive a sub-set of the findings are presented in this paper as illustrative results. Correspondingly, the associated explanations of the background information relating to each result, is a summary. For example, with regard to electronics, this paper focuses on changes made to PCs and GPS systems (and associated mapping software) with a brief summary of the changes made. Changes made to sounders, sonar or radar are not presented. Furthermore, only a brief summary is presented of the changes made to engines. Space does not permit for the presentation of changes to equipment on deck (such as winches) and handling and processing machinery (and the reasons forthwith). The results are presented first for short-term (tactical) decisions, then medium-term and longer-term (strategic) decisions.

Short-term decisions (tactics)

English beam trawlers

During the survey of English beam trawlers, all skippers were asked about how they make decisions relating to where they go to fish. Several multiple-choice questions were presented to them in order to establish some of the basic responses to areas fished. A general question was first asked: do you fish in the same areas on a weekly/monthly/seasonal/yearly basis? The responses are given in Figure 1, which shows no real trend in visiting areas other than there is a high chance that vessels will go back to the same areas all through the year.

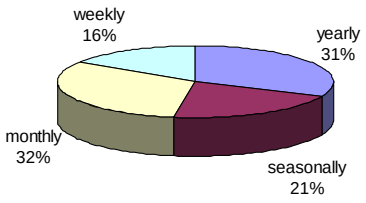

Figure 1. Responses to: Do you fish in the same areas …?

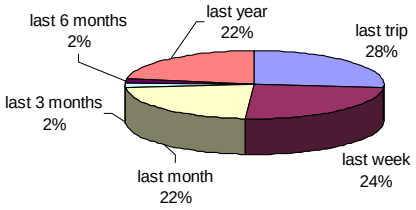

Figure 2. Was the area you visited last an area you visited in the…?

The following question attempted to clarify the activity of returning to areas fished, asking was the area you visited last an area that you have also visited in the last trip / week / month / 3 months / 6 months / year? The responses are given in Figure 2. Patterns of activity are more clear for this question. That is at specific times of the year (in monthly periods), a fisher will go back to the same areas. There is also an apparent consistency over years as well as individual months. For example, based on these results, a skipper can be expected to fish in the same area as last year in April and will return to that area in April next year (if regulations permit).

To the question, how do you choose which area to fish? Or how do you remember the best areas at specific times of year? The predominant answer was catch rates by haul (Figure 3). This is directly linked to the fact that the majority of skippers surveyed keep a personal logbook of catches by haul (or at least by day/trip). In questioning it was uncovered that value of the catch is implicit in the decision-making process based on the knowledge of past catch rates. Similarly for quantity caught and profit made. Furthermore, it was uncovered that skippers will use their personal logbooks to find the next best alternative should the chosen area result in

poor catches or be unavailable for fishing (due to regulation or some other restriction). One skipper noted that he recently went back 8 years in his personal records to find better options.

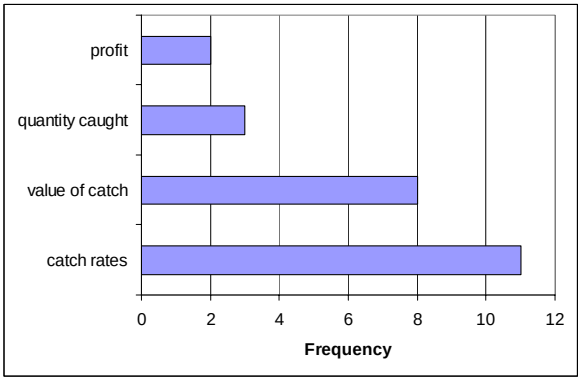

Figure 3. Response frequency to: How do you choose which area to fish, based on past…?

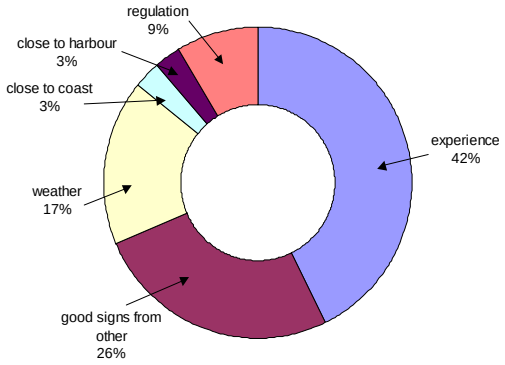

Figure 4. Responses to: How do you determine which areas to fish, based on …?

Related to the previous question is that of the importance of experience / regulation / weather etc in determining where to fish. The responses to this question are given in Figure 4. It is not surprising that a skipper's personal experience is the most common response. However, the weather and receiving good signs from others have a significant part to play in the decision-making process of choosing where to fish. The majority of skippers reported that they have up to 5 other skippers who they share information with honestly in order to make the best decision.

Regulation, specifically that relating to days at sea restriction in the North Sea, is reported to be starting to have an impact on where and when fishers fish. For example, if a force 9 wind is blowing then it is better to save the days at sea than go fishing immediately. The average number of days fished on a given trip is given in Figure 5. There is a significant difference by region. Vessels fishing in the North Sea (the East Coast, in Figure 5) will generally fish for 4 or 5 days whereas vessels fishing from ports in the South-West (Brixham and Newlyn) will undertake 7 or 8 day trips. It appears that this is mainly due to the structure of the markets in each region where in Dutch ports vessels land on a Friday or Saturday for the auction, where in the South-West it is organised more by the company.

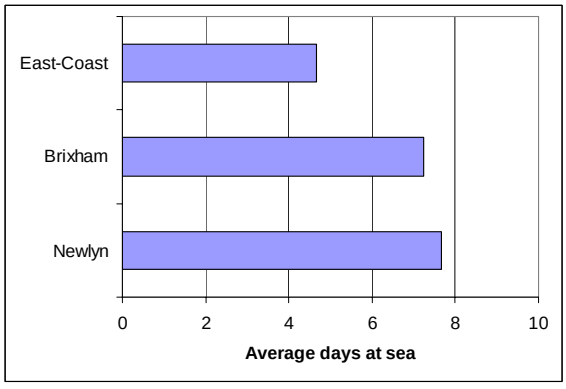

Figure 5. Average number of days fished per vessel by region

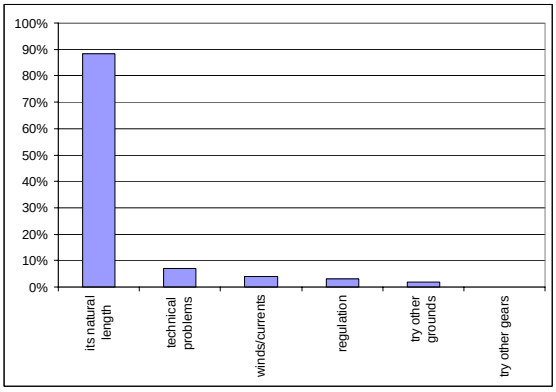

Figure 6. Responses to: How often do you terminate your trip due to …?

The final trip related question was based on how often skippers have to terminate a trip for reasons other than the natural length of the trip. On average, 88.4% of trips were reported to be of 'natural length' (i.e. the length of trip decided before leaving port)(Figure 6). Technical problems account for the termination of 1 trip in 14,

and winds for 1 trip in 25 on average. Based on surveyed values, vessels in the sample are expected to make between 30 and 40 trips per year.

Basque trawlers

In terms of the choice of the fishing ground, Figure 7 summarizes the main reasons for the choice of the fishing area. As it can be seen there are non-classified reasons ("others") that account for most answers. Nevertheless, regulations in Sub-area VIII and VII, expected harvest and external communications (external people have communicated that there were good catches in this area) in Sub-area VI and fuel consumption and experience in VIII are also significant reasons for the choice of the fishing ground. Thus, the "others" category combines all these different answers but it has not been possible to distinguish them.

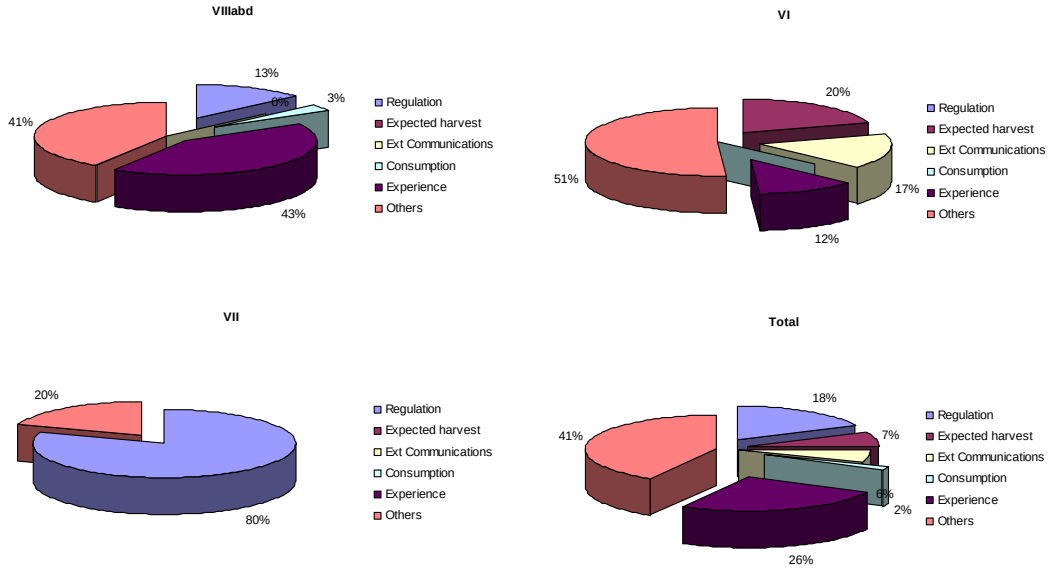

Figure 7. Reason for the selection of the fishing ground

Another important result obtained is that in 25% of the hauls, experience and expected catch have been simultaneously chosen as the main reasons for selecting the fishing ground. These reasons have also been characterized by quarter and fishing gear. For example, regulation is only relevant in the third and fourth quarters of the years and especially for Otter "Baka" trawlers, as quotas are being exhausted. The results of the choice of the fishing trip onset indicate that variance in the responses obtained is low. Regarding the fishing trip onset only two skippers (7% of the total hauls) selected regulation as the reason for the trip to start.

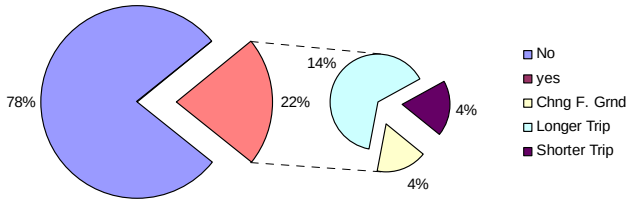

Figure 8. Changes in the initial planning of the fishing trip

For the remaining trip onsets, i.e. the time when the trip starts, are based more on historical reasons, again tradition. Thus, things are done in that way simply because they have been always done in that manner.

Following on, the results from the choice of the fishing trip ending also indicate that variance in responses obtained is low. The main reason for the trip ending is to maintain the historical duration of the trips established, in the majority of the cases, as the time in which the amount of catch can be maximised and the fish freshness or quality is high and optimum for marketing. In some cases the high level of prices (5%) and technical reasons (less than 1 %) have been the main reason given for trip ending. Lastly, the results for changes in the initial planning of the fishing trip show that twenty-eight percent of the fishing trips have changed from what it was initially planned. Sixty five percent of these changes are due to a trip being made longer, with 18% on shorter trips and 17% of the trips have changed the initial fishing ground (Figure 8).

Medium-term decisions (strategies)

Gear, species and crew changes

English beam trawlers

For the beam trawl vessels surveyed, in all cases bar one, beam trawling accounted for 100% of their fishing activity. Each beam trawler will have a beam trawl rig with a 'standard' design in terms of net-configuration on each outrigger boom, on each side of the vessel. In the early 1990s, the maximum width of a single beam was set to 12 metres for offshore fishing. According to surveys, before this time 15 metres was typically used by the larger vessels. This is more recently legislated in EC Regulation 850/98: Article 30. The average single beam width of vessels was sampled. North Sea beamers have an average single beam width of 12m whereas the average beam width of SW beamers is lower (about 9 metres) as some vessels surveyed fish in inshore waters (i.e. within the UK 12 mile limit), and in this environment (according to regulation) they are limited to an aggregate beam width of 9 metres (EC Regulation 850/98: Article 34).

In terms of target species, North Sea vessels concentrate on plaice and sole. However, there appears to be two strategies in the South-West: fishing for sole, megrim and anglerfish; and fishing for sole and cuttlefish (with other flatfish, e.g. plaice and lemon sole being an important component). As a result of fuel price increases, it was indicated that crew on-board several of the vessels surveyed were reduced from 6 to 5 hands in 2000 (the first major rise in fuel price), and from 5 to 4 hands in 2005 (the second major rise in fuel price).

French (Bay of Biscay) trawlers

A certain type of capital-labour substitution appeared in the case of the Bay of Biscay trawlers. Changing from the single otter trawl to the twin trawl is the main change observed in fishing gear used by the 12-16 and 16-20 meters trawlers from the Bay of Biscay (Figure 9). Almost 90% of the vessels used the twin trawl in 2003, compared to less than 10% in 1991. With a surface swept by the twin trawls theoretically 40% greater than a single rig, this technique was introduced in the mid-1980's, in particular to target the Norway lobster and other species living on the sea-bottom (anglerfish, megrims).

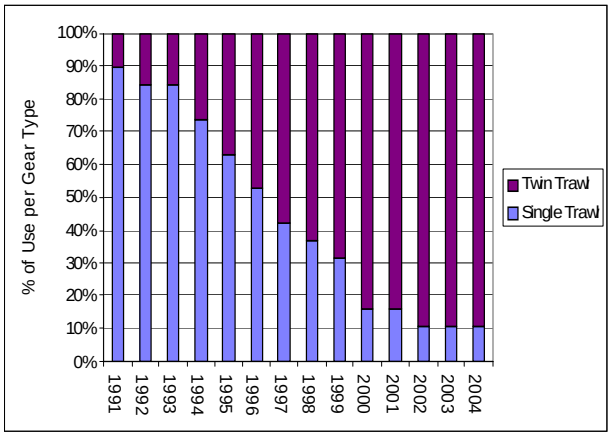

Figure 9. Use of gear type

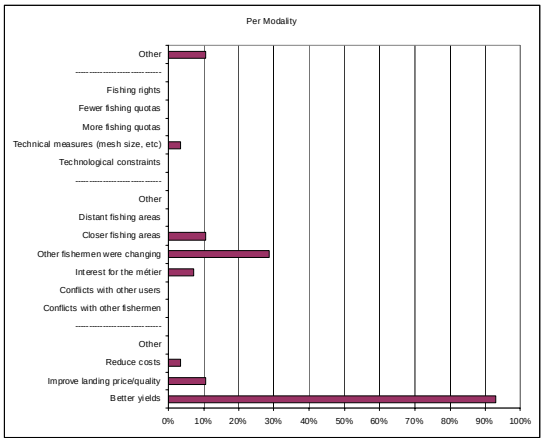

Figure 10. Reasons for change in gear type

The main reasons for changes in gears appear very clearly and are motivated by the growth in productivity (92% positive replies for this modality) given that the imitative or follower behavior (30% of the replies) explain or reinforce these changes in gears (Figure 10). It should be stressed that the activity of Norway lobster trawling is often undertaken in fleets, which may help explain these behaviors. The proximity of the fishing zones and the improvement in the quality or in the price of the products landed represents a less significant percentage of replies, with 10% of replies per modality. These changes indicate changes in fishing zone with a transfer of the fishing effort of some vessels from the Celtic Sea to the Bay of Biscay, given that the living Norway lobster fished in the Bay of Biscay (ICES Area VIIIab) is better valued than the frozen Norway lobster mainly fished in the Celtic Sea (VIIfghj).

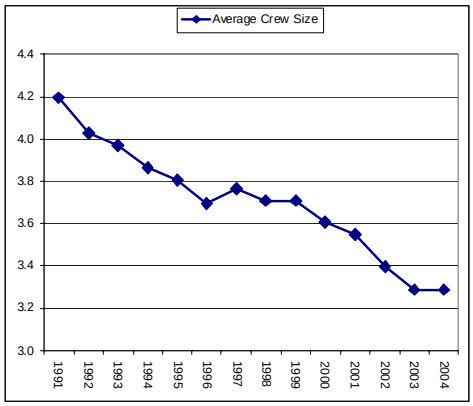

Figure 11. Average crew size

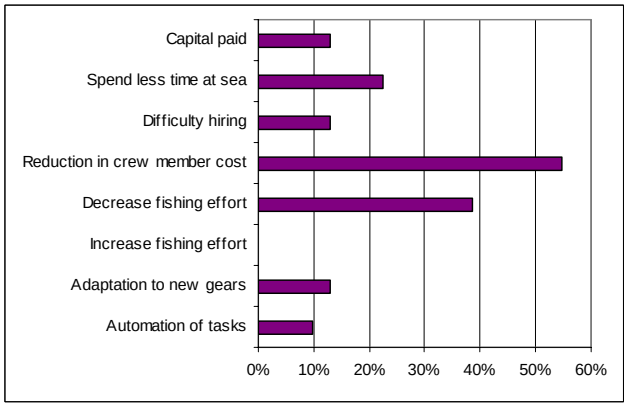

Figure 12. Reasons for change in crew size

The results in Figure 11, present a downward trend of crew numbers, from an average size of 4.2 to 3.3 crew members per vessel. The main reason (see Figure 12) is the desire to reduce salary costs (55% of those replying) followed by the reduction in the fishing effort (39%) and the reduction in the time spent at sea (23%) or the fact that the loans are reimbursed and therefore that the levels of expenses no longer require the same intensity of exploitation. Technical innovations, in particular the use of reels in a certain number of cases, lead to a reduction in crew size. Even if the motivations of those replying may be multiple, in particular the reduction in fishing time and work costs, there is no significant statistical correlation between these two variables, nor between the others either. However, the qualitative indications collected enable changes resulting from a modification in fishing strategies (working in more coastal zones, reductions in trip duration) that require less work, to be differentiated from changes whose only motivation is the reduction in costs for a given fishing strategy.

Basque trawlers

There have been no significant changes in crew numbers on these vessels. Each vessel is designed for a set number of crew, in terms of tasks to perform, room and safety commitments. The crew number normally, equals this maximum. The only change has occurred on those vessels incorporating drums, which have resulted in a reduction of 1-2 member (s) of the crew.

Engine changes

English beam trawlers

The main reasons cited for engine change are presented in Figure 13. The main reason given for engine change was breakdown (50%) except for one where the change was made due to an expected breakdown in the near future. When replacing the engine, some skippers did appear to make use of the change for adapting to a new strategy as well as adding a degree of safety/comfort to the crew. The descriptive benefits all related to expected reductions in costs, that specifically included reduced maintenance costs and reduced fuel consumption (64% of the responses for both reasons). In addition, the new engine was expected to bring about greater reliability to the fishing operation.

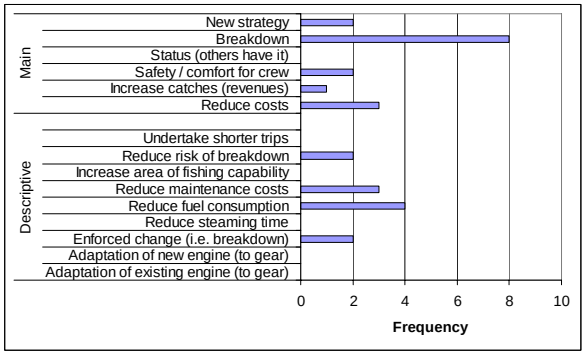

Figure 13. The reason and benefits reported for vessels surveyed with an engine change.

French (Bay of Biscay) trawlers

Analysis of the main reasons for change in engine shows unsurprising results (Figure 14). In 50% of the situations, the change is linked to the engine breaking down, so almost 40% of the people surveyed install a new engine in order avoid the risk of breakdown. Related to the previous problems, the reduction in maintenance costs is mentioned by 10% of those surveyed while adaptation to new gears concerns 17% of changes in engine.

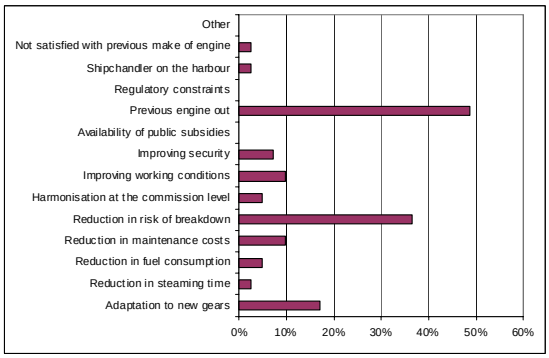

Figure 14. Reasons for change in engine

Basque trawlers

In general, in the period analysed there has not been many changes to engines. Engines usually have a life of 30-35 years and the Basque fleet has a lower age than these years. However, from 1995 to 2002, there have been 3 vessels, where an engine change has been detected. One of them is a relatively new vessel built in 1997 (the engine broke down) and the other two are older vessels.

Onboard electronics

English beam trawlers

The reasons and benefits for using and updating computer systems are presented in Figure 15. In the categories of main reasons for change, few vessels reported to expect increased catches with new computer equipment. However, more suggested that new computers would have an impact on the safety/comfort of the crew. Of the more descriptive reasons noted, the two clear benefits of such updates were to make use of the systems to reduce the risk of losing nets (i.e. through hitting rocks or wrecks)(40% of the responses under main reasons) and to better locate productive fishing areas (35% of the responses under descriptive reasons). In all cases, these computers were linked up to the GPS systems installed on the vessel. In most cases, vessels have one 'older' computer and one 'newer' computer. The year of last change of a computer on each vessel is presented in Figure 16. Most vessels reported that they look to change the 'older' computer at least once every two years but most likely once every year.

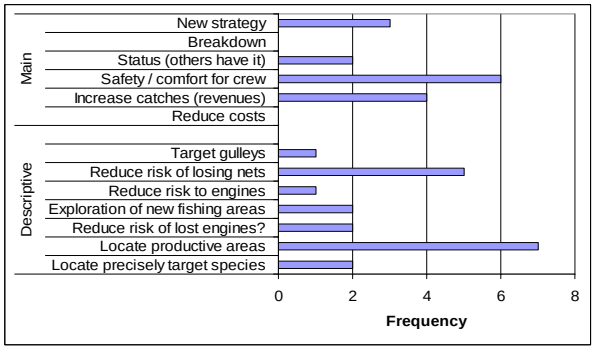

Figure 15. Reasons for using and updating computer systems on-board vessels surveyed (incl. GPS and tracking maps)

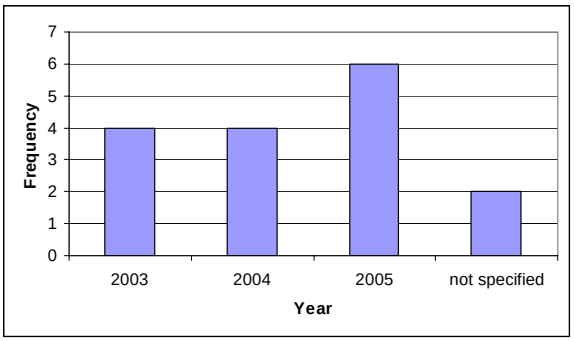

Figure 16. The last year that at least one on-board computer was changed (by vessel)

French (Bay of Biscay) trawlers

Figures 17-18 illustrate the evolution in the rates of equipping vessels with computers, mapping tables, GPS and GPS connected to computers. They show a generalisation of this electronic equipment on almost all vessels in 2004. The adoption of mapping tables in the 1980's and the other systems in the 1990's did not happen instantly but during a transition phase lasting around ten years.

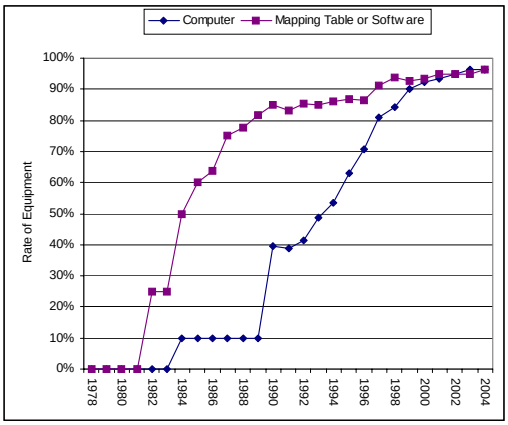

Figure 17. Computer and charting systems: equipping rate

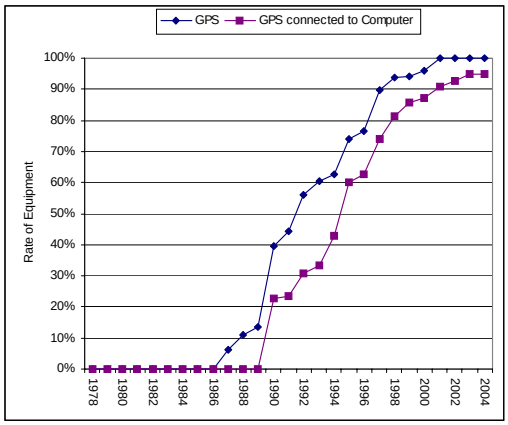

Figure 18. GPS and Connection: equipping rate

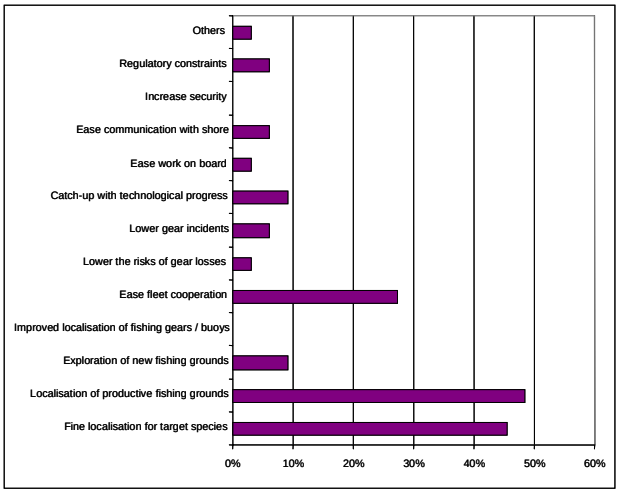

Figure 19. Reasons for change in electronics

Like changes in gear, the technological evolutions related to onboard electronics are mainly motivated by the increase in vessels' fishing efficiency. To be more precise, these are improvements in locating species and the most productive fishing zones, with 44 and 48% of replies, respectively (Figure 19). In addition, this equipment has perceptibly enabled new fishing zones to be explored (10% of replies). Other changes in equipment were justified by the improvement in communication between vessels, by almost 30% of those surveyed.

Basque trawlers

The evolution of change of GPS uptake is shown in Figure 20. The maximum rate of uptake occurred over a six-year period (1995-2000) and now all the vessels have GPS. Another important change in the equipment on board has been the inclusion of the MaxSea software with plotter. This software can ease the workload on a skipper, as it allows the tracking and storing of all fishing routes carried out as well as qualitative comments.

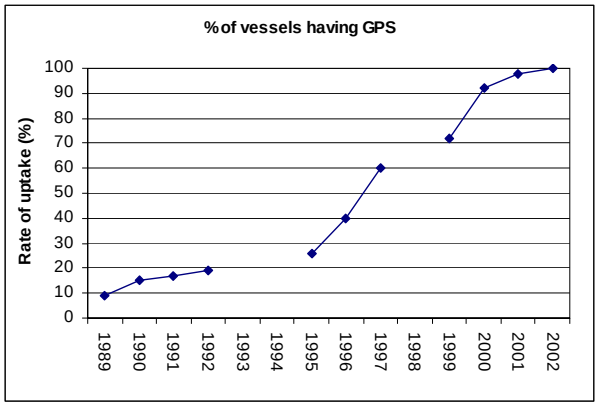

Figure 20. The percentage of vessels with GPS over time

Long-term decisions (investment in purchasing or not purchasing fishing vessels)

English beam trawlers

In the sample, five of the 16 vessels surveyed, had been bought by their current owners in the last ten years. Of those five vessels, the responses given regarding the reason for change are presented in Figure 21.

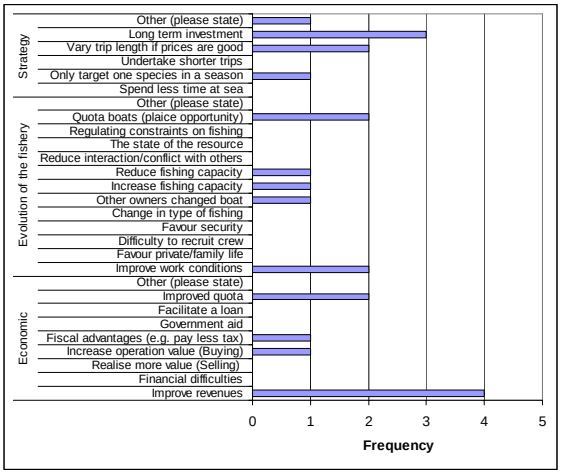

Figure 21. The reasons reported for owners purchasing vessels in the last 10 years

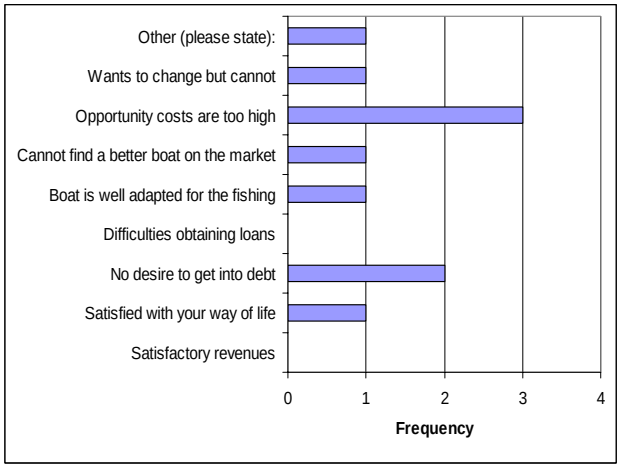

Figure 22. The reasons for owners not changing their vessels in the last 5 years

The two key reasons are that it is a long-term investment and that the expectation is to improve revenues with a newer vessel. Two of the vessels that have recently been purchased noted that the main reason was the amount of quota attached to the vessel (specifically for plaice). Skippers were also asked why their vessel had not been changed in the last five years. For skippers who played an active role in the investment of their fishing operation responses were given (Figure 22). Clearly, the two main reasons given were that the opportunity costs are too high (i.e. that it is too costly to change), and that they have no desire to get into debt (together totally 50% of the responses).

French (Bay of Biscay) trawlers

This rationing of entries in the context of MAGP led potential vessel purchasers to operate mainly in the second-hand market, which meant a rise in the frequency of transactions in this market for the fleet studied. The transaction rate increased from to around 5% at the beginning of the 90's to around 9% after 1996. This evolution is important for a better understanding of the behaviour of buying or selling fishing units.

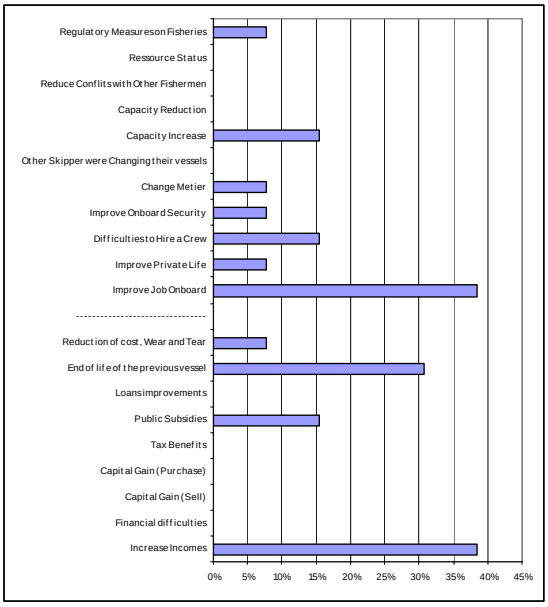

Figure 23. The reasons for changing vessel

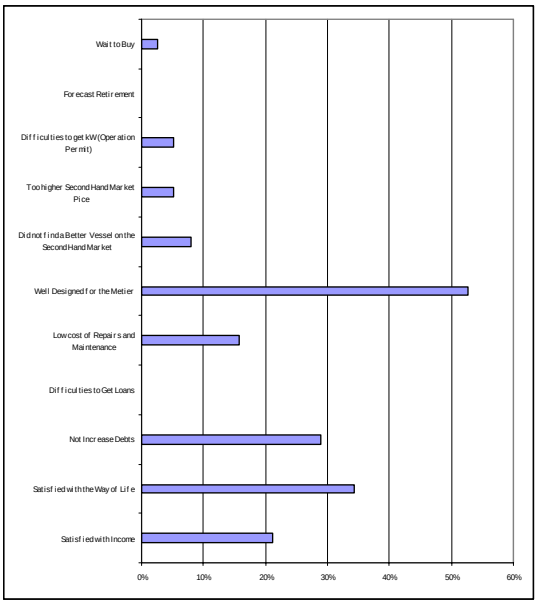

Figure 24. The reasons for not changing vessel

The main motivations for changes in vessel are, on the one hand, a growth in revenue (40% of replies) and, on the other hand, improvements in working conditions on board (40%)(Figure 23). Buying a vessel with a covered deck, compared with a traditional trawler, considerably changes the work on board. The end of the life of the fishing unit is the third reason given (30%), while increased capacity, public subsidies, or difficulties in recruiting crew-members represent 15% of the replies respectively. One should note the low influence of regulatory measures on the fisheries on the scale of this fleet. Concerning owners who had never changed their vessel (Figure 24), this behaviour can be mainly explained by the fact that users are satisfied with their fishing unit, which is both adapted to their metier (50% of those replying), which allows a satisfactory professional/private way of life - (35% of those replying) and provides them with sufficient incomes (20% of those replying). Finally, some owners do not change vessel, anticipating changes in their professional environment, in particular taking retirement, or an evolution in the economic and institutional environment and who wait before changing their vessel. The difficulty in obtaining loans is not a factor that explains this type of behaviour. Note, that in the case of the third case study (Basque trawlers), information on the reasons for purchasing or not purchasing fishing vessels was not collected.

DISCUSSION AND CONCLUSIONS

The strategic decisions are mostly directly related to the economic viability of a fishing unit. That is, investment decisions are made on the basis of wanting to increase revenues through the acquisition of a new (or newer) fishing vessel(s). In the case of English beam trawlers (operating in the North Sea with plaice quota) as quotas often limit income, the purchasing of a fishing vessel and the vessels associated quota is also an investment. However, if the opportunity costs are too high and operators do not wish to get into debt then new (or newer) fishing vessels (with associated new machinery onboard) will not be purchased. Generally, the age of a vessel determines the overall effectiveness and reliability of all its main components (the engine, equipment on board, handling and processing machinery, electronics). New fishing vessels have new, more fuel efficient engines, new winches and new processing machinery. Equipment that is new breaks down less often and has lower maintenance costs. Unreliability of equipment can result in loss of time for fishing with an associated loss of revenue. Electronic devices (e.g. PCs linked to GPS with associated mapping software) used for recording spatially each fishing trip or each haul can be fitted to vessels of all ages, however these devices can represent (if updated each year or every two years) a considerable investment. These are used to locate productive areas (previously visited and logged) and avoid obstacles reducing gear entanglement. The tactical decisions associated with the choice of fishing location (time and space) and trip length are influenced by experience and constrained by (a) the nature of the operation (size of vessel, distance to grounds) and (b) regulations such as days-at-sea restrictions and/or quota restrictions per area. Generally, any investment in the fishing unit results in a more efficient operation which results in greater profit that can in turn be used for further investments, a series of strategic decisions (where the opposite can be true). Other factors can also influence investment, such as the availability of capital, the status of the resources, the market, rising fuel and labour costs. However, further investment is critically important in such a competitive environment and it is essential to recognise the consequences of fishing units investing in technology that results in efficiency changes. Output-based fisheries management strategies (TAC restricted) do not necessarily take into account these changes in efficiency leading to situations where effective fishing effort will increase significantly over time whereas the reported nominal effort may remain constant or decrease due to effort reduction programs that only focus on nominal effort.

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