JRC Scientific and Technical Reports

FP6 CEDER Project Deliverable 1.2.3 "Model Performance"

Report on the performance of the algorithms used to model the fisheries of the CEDER project.

T. Hjörvar (FRI), G. Pétursdóttir (FRI)
N. Bez (IRD), A. J. Cotter (CEFAS), N. Dayagi (Corr.), M. Grønfeldt (Sirius), A. Kideys (JRC), U. Kröner (JRC), J. Neves (NEAFC), G. Pilling (CEFAS), F. Quirijns (IMARES), E. Rosenberg (Corr.), D. Reid (FRS), A. South (CEFAS), K. Sünksen (GINR), E. Walker (IRD)

Catch, Effort and Discard Estimates in Real-Time

EUR 24017 EN - 2009

EUROPEAN COMMISSION
Institute for the Protection and Security of the Citizen

The mission of the JRC-IPSC is to provide research results and to support EU policy-makers in their effort towards global security and towards protection of European citizens from accidents, deliberate attacks, fraud and illegal actions against EU policies.

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

Contact information
Address: TP 051, Joint Research Centre, Via E. Fermi 2749, 21027 Ispra (VA), Italy
E-mail: Ulrich.Kroener@jrc.ec.europa.eu
Tel.: +39 0332 78 6719
Fax: +39 0332 78 9658

http://ipsc.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

JRC 54605

EUR 24017 EN
ISBN 978-92-79-13737-2
ISSN 1018-5593
DOI 10.2788/39926

Luxembourg: Office for Official Publications of the European Communities

Printed in Italy

Contents

1 INTRODUCTION

1.1 Executive Summary

Addressing the uncertainties in fishing activities, the FP6 CEDER project developed a set of algorithms in order to predict vessel activity type, effort, catches, discards, and quota uptake. The algorithms use a variety of input from other variables, namely VMS records, fine-grained vessel GPS positions, target species age and length distribution, logbooks, sales notes, and/or previous quota uptake.

This document (CEDER deliverable 1.2.3) reports on algorithm performance, but also assesses the algorithms' uncertainties.

In conclusion, it can be said that:

- Fine-grained VMS-like position reports, at 15 minute or better resolution, can be used to improve estimates of effort. The estimates are more accurate than the usual measure, "days at sea". This method works for a variety of fisheries.
- For a few fisheries, one can use the 2-hourly VMS messages to predict fishing vessel activity type (fishing or cruising). However, the validity of this approach heavily depends on fishery-specific knowledge, and may not be accurate for individual trips.
- Using a variety of time series models, we attempted to predict future quota uptake from past quota uptake. The performance was mixed. Previous quota uptake is a factor in predicting future quota uptake, but such models tend to be under-parameterised.
- By crossing logbook information, sales notes, and VMS positions, the Greenlandic authorities are able to get a clearer picture on their shrimp quota uptakes, in a timely manner. The Greenlandic skippers' estimates of discards of shrimp proved to be accurate, despite initial assumptions to the contrary.
- For the English and Welsh cod fishery, a model using VMS was successful in predicting vessel behaviour and effort. It was also partly successful in predicting catches and discards, when cod survey data and cod-specific discarding rules were added.
- In the Icelandic redfish fishery, using VMS data and an estimate of the year's CPUE, it is possible to attract attention to vessels that potentially are over- or underreporting their catches. This works only for years where a CPUE estimate is available.

1.2 Introduction

The stated objective of this deliverable is to

> "report on the performance of the models for each of the fisheries in question."

In addition the stated description of the work to be carried out is

> "performance measurement of algorithms on each of the fisheries in the project and assessment of uncertainties"

In line with the above, each of the consortium partners responsible for developing algorithms has delivered a report detailing their design, the methodology of testing, and the results of the tests and assessment of uncertainties.

The partners and fisheries are as follows:

- Correlation Systems, initially only responsible for Black Sea fisheries, but later extended to include data on (Dutch) North Sea flatfish, and the UK fisheries
- Greenland Institute of Natural Resources for the Greenland shrimp fisheries
- L'Instititut de recherche pour le Développement for the Tropical Tuna fisheries
- Centre for Environment Fisheries and Aquaculture Science for the UK fisheries
- The Fisheries Research Institute at the University of Iceland (FRI) for the North Atlantic Redfish fisheries
- The Joint Research Centre, EU

An overview of the partners' findings is presented in the next chapter, while more detailed discussion of the research of each partner is supplied as appendices.

The deliverable is concluded with a summary, bringing together main findings from each of the partner's sections.

2 MODELS AND ALGORITHMS

Following is a summary of the performance testing of each partner's algorithms and models. For more detailed discussion, please refer to a relevant chapter or appendix of the deliverable.

2.1 Development hierarchy

It is helpful to supply a simple overview of where models or algorithms have been developed under the CEDER project. The following diagram gives an idea of the eventual development hierarchy, and the data used by each partner.

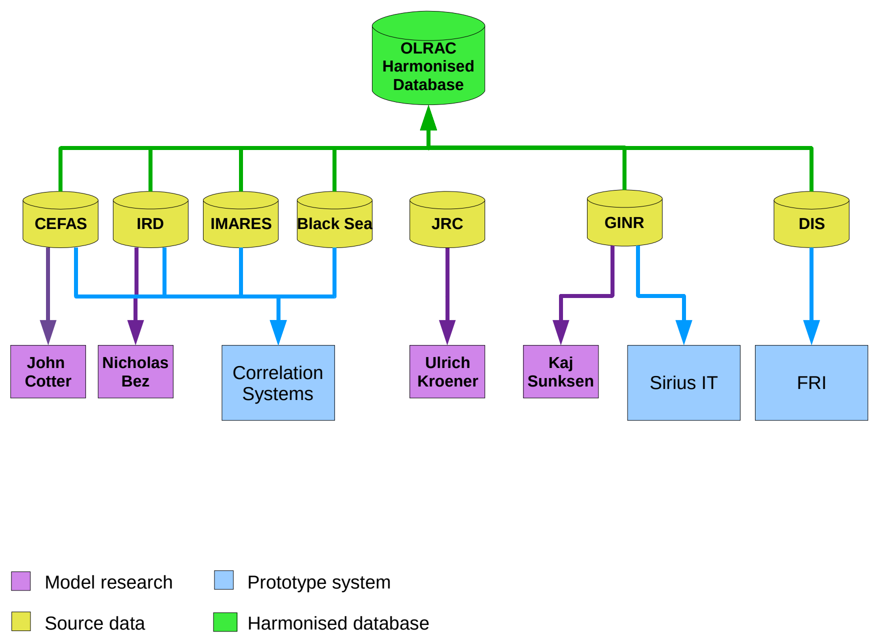


Figure 2.1.1 - Development hierarchy

The figure shows the development hierarchy of the CEDER project, where each box represents algorithms or models developed. The arrows indicate what source data was primarily used for each partner's research. Additionally, the primary data supplied to the harmonised database that was developed is indicated with green arrows. Blue boxes represent algorithms and models developed for use in the three prototype systems.

2.2 Algorithms developed by Correlation systems Ltd

Algorithms developed were used in Correlation Systems' prototype system:

- Effort estimation algorithm
- Calibration algorithm
- Catch and discard estimation algorithm

The effort estimation algorithm (including the self calibration capabilities) has been proven as a good predictor for vessel activities. On average, this algorithm provides a 30% improvement compared to the “naïve” days-in-sea prediction.

The catch algorithm shows promising results as well, however due to the lack of sufficient data (several years of catch data) additional research is required in order to validate the preliminary results.

2.2.1 Effort estimation algorithm

Algorithm description

The Effort Estimation algorithm estimates the activity for each VMS record – fishing, cruising or at harbour. The Effort Estimation analysis is applied to each vessel separately.
The algorithm is divided into three parts: in the first part the VMS records are collected into segments, the segments are collected into tracks, each track representing a single trip of the vessel. In the second part the Effort Estimation algorithm is performed on each track separately. In the third part, the segments are re-separated according to effort estimation of the VMS records, each segment representing a single activity.

There are two types of Effort Estimation algorithms: one is performed on VMS records that are received in a high sampling rate, and the second is performed on VMS records that are received in a low sampling rate. Different parameters are used for each algorithm type: for low sampling rates, the parameter is Instantaneous speed, while for high sampling rates, the parameters are speed mean, density, and instantaneous speed.

Methodology of testing

The algorithm has been tested using observer data that serves as reference data. Effort estimation was calculated based on the VMS data and the results were compared with the observer data.

The following probabilities were defined as follows:

- Probability for Misdetection = all records that were reported "Fishing", and the algorithm estimated as "Cruising"
- Probability for False Detection = all records that were reported "Cruising", and the algorithm estimated as "Fishing"

The total error was defined as:

Misdetection + False Detection

Total records with reported activity

Data was evaluated using two types of sampling rates: a low sampling rate where VMS is received every 2 hours and a high sampling rate where VMS is received every 15 min or less.

Algorithm Performance

The following table summarizes the performance of the Effort Estimation algorithm. The algorithm's results include calibration.

	IMARES	CEFAS	Black Sea
	High sampling rate	Low sampling rate	High sampling rate
Success Rate	86.91 %	73.4 %	81.78 %
Total Error	13.08 %	26.6 %	18.22 %

Algorithm Uncertainties

The effort algorithm includes a hidden assumption regarding the relations between geospatial patterns (speed, distance etc) and the effort activity. As a result, this algorithm does not operate well in fisheries where the activity pattern is different that in the fisheries used in order to train the algorithm (e.g. tuna fisheries).

2.2.2 Calibration algorithm

The Calibration algorithm is used to find the “best parameters” for the Effort Estimation algorithm. The “best parameters” are defined as those which produce the minimal Total Error between the estimated activity and the reported activity.
The Calibration algorithm is performed automatically on the VMS records with the Effort Estimation algorithm. The parameters which are used as the default parameters for the Effort Estimation algorithm are defined for each vessel in the database.

Methodology of testing

The algorithm has been tested using observer data that serves as reference data. Effort estimation was calculated based on the VMS data and the results were compared with the observer data.

The following probabilities were defined as follows:

- Probability for Misdetection = all records that were reported "Fishing", and the algorithm estimated as "Cruising"
- Probability for False Detection = all records that were reported "Cruising", and the algorithm estimated as "Fishing"

The total error was defined as:

$$\frac{\text{Misdetection} + \text{False Detection}}{\text{Total records with reported activity}}$$

Algorithm Performance

The performance improvement of the calibration algorithm varies between 22%-550% at the overall effort performance.

The following table summarize the performance improvements per fleet:

	IMARES	CEFAS	Black Sea
	High sampling rate	Low sampling rate	High sampling rate
Success Rate	86.91 %	73.4 %	81.78 %
Success Rate without calibration	15.82%	60 %	40%
Improvement	549%	22.3%	104%

Algorithm Uncertainties

It is not guarantee that the calibration algorithm will converge. In such a case estimation of “fishing” or “coursing” will be the best predictor.

2.2.3 Catch and discard estimation algorithm

The Catch and Discard algorithm estimates the weight of the catch and discard, for the current month and year, in a specific country, area and for a specific species. The estimation is based on landing reports from previous months and years, logbooks, and observer reports as well as on matching Effort Estimation of relevant vessels.

Methodology of testing

For testing purposes part of the data was used in order to train the algorithm while other parts were used in order to test the prediction of the algorithm.

Algorithm Performance

The algorithm was tested only on IMARES data
The following results had been achieved:

	July	August
2003	Catch – 100.5	Catch – 99.6
	Effort – 26.31	Effort – 26.39
	CPUE – 3.81	**CPUE – 3.77**
2004	Catch – 71	Catch - Unknown
	Effort – 26.57	Effort – 26.3
	CPUE – 2.67	CPUE - Unknown

Estimated catch: 99.15 (August 2004)
Estimated catch after effort correction 69.48
Reported Catch = **67.9**
Estimation Error = 2.2%

Algorithm Uncertainties

Due to the lack of sufficient data, the performance was measured based on a very small dataset and therefore the certainty of the performance is low.
Additional research is required in order to validate these results.

2.3 Algorithms developed by L'Institut de Recherche pour le Développement (IRD)

Algorithms developed were:

- Activity estimation algorithm

for the tropical tuna fisheries.

The higher rates of detection are comprised between 63% and 83%, the detection is considered correct, whereas, for some trips, the detection is quite bad, with rates lower than 30%. The reasons of bad detection are the low frequency of VMS collection for some vessels at some periods.

2.3.1 Activity estimation algorithm

Algorithm description

A first algorithm is applied on only VMS data and aims to detect which points of the trajectory of a purse-seiner correspond to fishing actions. The algorithm is as follows.

A point of the trajectory of a vessel is considered "fishing" if:

- the vessel is in trip,
- the position corresponds to a day time,
- and if the speeds between the two last paths are lower than 1.3 knots.

This first algorithm allows detecting the sets from VMS data, based on the speeds of the vessel during the day.

Methodology of testing

Then, a second algorithm aims to validate the first one, comparing the sets detected by the first algorithm with the sets noted by observers. The objective is to know if the set detected on VMS data happened at the same time and place as the set observed. A non productive set lasts approximately 1h30, it corresponds to the minimal time of a set.

For each set noted by the observer:

- if the set is detected in the VMS data (first algorithm),
- if the distance between the positions of the set from VMS and the set noted by the observer is lower than 3 n.m. (0.05°),
- if the hour of the set from VMS is earlier than the hour of the set noted by the observer,
- and if the difference between the hour of the set from VMS and the hour of the set from the observer is lower than 1h30,

then the detection of the set is validated.

Algorithm Performance

As we can see on the schema below, the observer has noted the positions and the hours of the beginning and the end of the set, and the VMS data are available every hour, but at a random moment compared to the period of the set. This is the main weakness of the system when dealing with automatic detection of sets' locations.

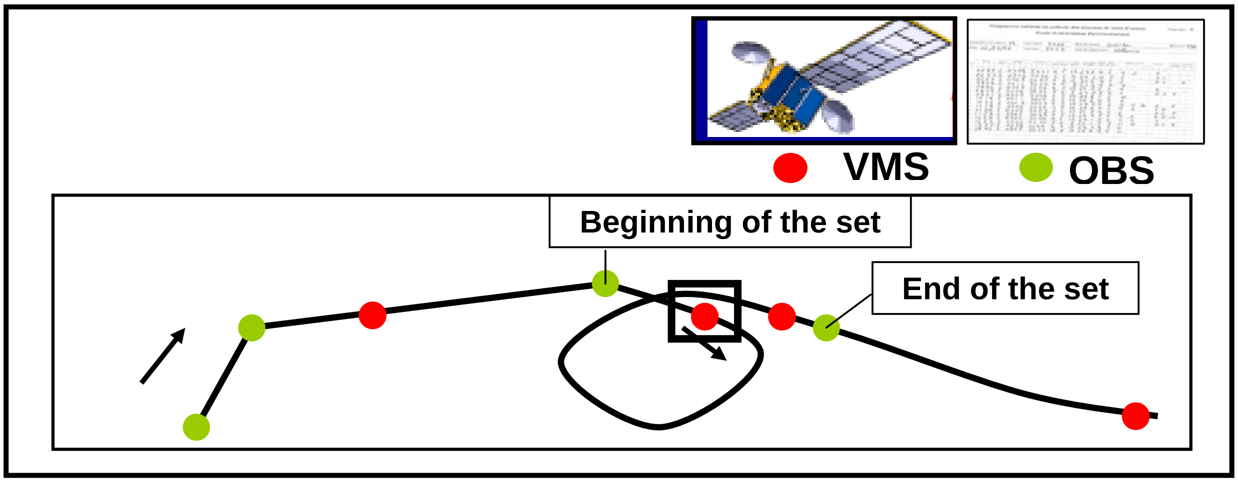


Figure 2.3.1: Weakness of automatic set detection

The table presents the results of the validation for the vessels where there were observers aboard. The higher rates of detection are comprised between 63% and 83%, the detection is considered correct, whereas, for some trips, the detection is quite bad, with rates lower than 30%.

Vessel	Observer	Rate of detection of sets on the VMS data
Vessel 1	Obs 1	63 %
Vessel 1	Obs 1	80 %
Vessel 2	Obs 2	74 %
Vessel 3	Obs 3	0 %
Vessel 4	Obs 4	83 %
Vessel 4	Obs 4	30 %
Vessel 3	Obs 5	7 %

Algorithm Uncertainties

The reasons of bad detection are the low frequency of VMS collection for some vessels at some periods. It is the case for the vessel n°3, for which 30% of the data have a frequency higher than one hour. Moreover, bad meteorological conditions have consequences on the fishing actions: the number of non productive sets is higher than in good conditions and these are sorely detected with hourly VMS data.

2.4 Algorithms developed by Sirius IT and Greenland Institute of Natural Resources (GINR)

Algorithms developed and used in the Sirius IT prototype system:

- Quota uptake prediction algorithm
- Sales notes and logbook joining algorithm

With the use of five years of statistical data it is possible to predict the uptake of each quota in the current year.

In addition, research was undertaken by the GINR in order to produce a discard estimation algorithm. On the basis of a short pilot study in advance of the CEDER-project, we were convinced that the reported discard level was much too low and that some kind of conversion model was needed. After investigating the true levels of discards, we found that the captain's estimate was acceptable as a representation of the true discard.

Thus, we simply use a model stating:

Captains estimate of discarded fish = actual discarded amount of fish

2.4.1 Quota uptake prediction algorithm

Algorithm description

In the Quota Analysis System the prediction of when the quota is exhausted is based on statistical calculations of the previous 5 years pr. Quota.

Methodology of testing

The algorithm was tested by comparing the average catch from 2002-2006 with actual catch from 2007.

Algorithm Performance

Due to the fact that the fishing industry at all time is well aware of how much is left of the quota, the industry adapts the activity accordingly, this means that if we at a given time predicts that only 80 % of a quota will be fished before the end of the year, this might not always be true because industry might increase the activity on the quota in the remaining part of the year.

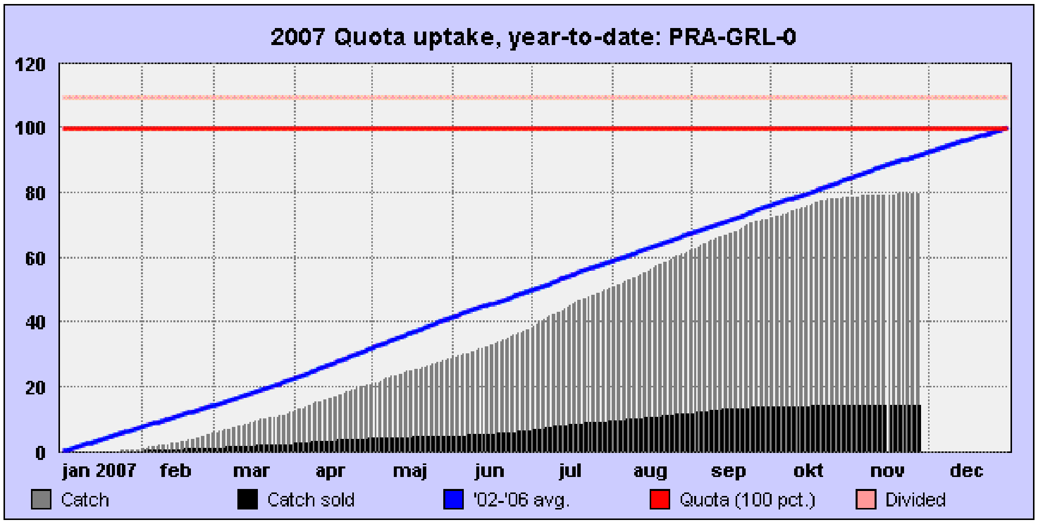


Figure 2.4.1: Quota uptake

As can be seen on the figure above, the fishing on the quota normally starts in January (blue line), but in 2007 the fishing on this quota first started in February, (gray bars) which caused the quota uptake to be lower that the 2002-2006 average in the first 6 month of 2007 but in July and August the catch levels increases.

In June the calculation showed that only 66% of the quota would be caught, but in December the calculation showed that 88% of the quota would be caught.

Algorithm Uncertainties

Does this mean that the calculation in June was wrong? No, because the calculation was based on the assumption that the catch levels for 2007 be like the average for 2002-2006, but the industry knows that they have started on this quota later than usual, so in July-August the industry increases the effort on the quota in order to be able to catch as much of the quota as possible.

We have no way of predicting how much effort the fishing industry will put into a certain fishery in e.g. 3-6 month in the future, but the visual information that the Quota Analysis System gives the inspector, combined with the inspectors experience, will give the inspector an idea whether an effort in a certain fishery will increase or decrease in the months ahead.

2.4.2 Sales notes and logbook joining algorithm

Sirius IT has developed algorithms in order to join sales notes data with logbook data.

First, the system restricts the scope for matches, by pre-matching information on Vessel ID and Species. If a trip number is available both in the logbook and sales note, the algorithm ends by finding an exact match, and exits.

If no matching trip number is found, the algorithm continues by using a weighted scoring system. Higher scores signify higher probability of a match.

The logbook has catch dates, and the sales notes landing dates. The system calculates the sales notes landing date minus logbook catch date, and attributes a first score.

Difference in days	Score
-1	75
0	100
0	95
1	90
2	85
3	80
4-9	10
Other	0 (No match)

Let this first score be the "difference in days score".

Next, the system divides the weight in the logbook by the weight of the sales notes. Commonly, skippers have a slight tendency to under-declare weights in their logbooks, so the ratio tends to be less than 100%[1].

A score is attributed according to the following table:

Sales note in relation to logbook	Score
> 120%	1
100% - 120%	60
80% - 100%	100
70% - 80%	90
0 – 70%	80

Let this second score be the "weight ratio score".

The final score of each possible match is given by the formula

Final score = "difference in days score" * 60% + "weight ratio score" * 40%

This formula is based on empirical research in the Greenland Shrimp fishery.

[1] Ratios of up to 0.92 are commonly tolerated by inspectors. But the matching algorithm continues regardless of this enforcement-related tolerance.

The possible combinations between sales notes and logbooks are given by a matrix. The matrix is then reduced by successive iterations. In each step, the entries into the matrix with highest final scores are “paired off” and removed from the matrix.

A possible borderline case is that a logbook achieves the same “high score” with 2 or more different sales notes (or conversely, a sales note has the same “high score” with 2 or more logbooks, or possibly both apply). This is unlikely, as it would mean that the same vessel sold catches of the same species at dates so close to each other, that the algorithm would be confused. Such oddities would require operator intervention to manually pair off the equally likely sales note to logbook combination.

If there are any residues in the matrix (i.e. unmatched sales notes or logbooks), then these are mostly due to the newest or oldest entries in terms of catch or sales date. An unmatched logbook entry or sales note with a date of more than 9 days in the past warrants an investigation; most likely the matching sales note or logbook was not entered into the system.

Information on unmatchable sales notes is available to the users which then are able force the link between a certain logbook and sales notes.

2.5 Algorithms developed by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS)

Algorithms developed were:

- Effort estimation algorithm
- A model for forecasting trawler trip catches of North Sea cod-at-length and –at-age based on observer data.

Note: Effort estimation algorithms developed prior to CEDER by Mills et al. were tested and further developed in other fleets and areas as a part of CEDER.

Using the effort estimation algorithm, trawling effort can be accurately represented at a grid cell resolution of 3-km or less.

The model of observer data predicts next year's landings and discards of cod. It also allows investigations of the effects of vessel and seasonal factors on discarding and catch rate.

2.5.1 Effort estimation algorithm

Algorithm description

Mills et al. (2007) developed high resolution estimates of trawling effort for North Sea UK beam trawlers using VMS data received at 2 hourly intervals. The optimal estimation method to differentiate between trawling and steaming behaviour combined speed and directionality rules.

Methodology of testing

The UK VMS database records the geographic position, date, time, and identification number of UK fishing vessels in all areas, along with the same information for other EC vessels fishing within or transiting UK waters. Here, we analyse UK beam trawling data in the North Sea, and within this region almost all beam trawling is in ICES divisions IVb and IVc (Figure 1a). VMS data for UK-registered beam trawlers from June 2000 to December 2003 inclusive were used in the analyses, because VMS coverage of the trawling fleet remained relatively constant for the period.
Although transmission of vessel speed was not mandatory then, 65% of UK beam trawlers provided speed information (recorded as an integer) voluntarily. Vessel course was estimated from the relative positions of successive positions every 2 h. During a 7-month period from November 2000 to May 2001, nine UK beam trawlers reported their position at an increased frequency of 15 min (Dann et al., 2002). These more frequent position reports were used in two ways: first, to validate the rules for assessing trawling behaviour developed from the 2-h data on position; second, to support development of a "best" estimate of the spatial extent of trawling.
Between 2000 and 2003, discard observers on board UK beam trawlers fitted with VMS recorded the time and position of 332 individual trawls during 10 fishing trips. Position reports for 2-h
VMS data were linked to fishing trips to identify VMS records that corresponded with observed trawling events. Relationships between vessel speeds and directional movements from the VMS

database and known trawling could then be established. Steaming events from the observer reports were determined as the time of leaving port to the time when the first trawl was shot away, the time between hauling and shooting subsequent trawls, and the time between hauling the last trawl and returning to port.

Algorithm Performance

The combined speed and directionality rule was based on the assumption that high speeds (.8 knots) were steaming activity and that all other speeds were trawling. The directionality rule was then applied to the entire data set to distinguish trawling from steaming. Combining speed and directionality resulted in a marginally better overall rule, trawling and steaming being identified successfully in 99% and 95% of cases, respectively.

Algorithm Uncertainties

Data filtered with both speed and direction rules, processed with the “best” estimate method and summarized in 3-km grid cells, provided an accurate representation of the spatial distribution of trawling effort by the UK North Sea beam trawl fleet in 2003. The adoption of a consistent method for analysing VMS data will help to ensure that calculations of trawling effort are repeatable and comparable among studies. We recommend a reporting scale of 3 km as a compromise between the perfect description of all patchiness, the level of information on true trawling tracks provided by 2-hourly positional data, and the need to select grid cell sizes that can sensibly be applied at very large spatial scales. Based on previous experience of assessing trawling impacts, trawling effort data summarized on a 3-km grid would support most studies of trawling impacts (Jennings et al., 2001; Duplisea et al., 2002; Kaiser et al., 2002). Notwithstanding, data filtered with both speed and direction rules and processed with the “best” estimate method can readily be summarized at different grid cell scales, as required.

The speed rule (i.e. 2–8 knots taken to reflect trawling activity) provides a simple method for identifying trawling activity in the North Sea beam trawl fishery, but a speed rule alone is not recommended to support accurate quantification of trawling effort. The primary reason is the absence of speed records for 17% of the VMS positions. The speed rule also fails to detect times when beam trawlers steam at speeds < 8 knots, relying on the assumption that the transmitted speeds are accurate and relatively constant between successive position reports. When speed records are absent, the direction rule can identify those vessels in transit to and from port, but more importantly, those vessels steaming slowly between fishing grounds and close to port.
Whereas the speed rule underestimated steaming, the use of deviation angle or mean vector length independently tended to overestimate steaming. By combining the directionality methods,
prediction accuracy increased, although there remained some inaccurate predictions for fast-moving vessels. Using the highest speeds to identify steaming was, therefore, a logical step towards developing the optimum method. However, the optimum method still overestimated steaming. This may arise if the seabed allows vessels to trawl in straight lines for extended periods, or when vessels are trawling along closed area boundaries such as the Plaice Box (Pastoors et al., 2000).

2.5.2 Model for forecasting trawler trip catches of North Sea cod-at-length and –at-age based on observer data

Algorithm description

The algorithm consists of an age structured model of the cod population assuming variable annual recruitments and, for each estimation period, a constant *M*, *F*, and a simplified fleet-average selectivity function over age which serves to simulate variable *F* at age. A length frequency distribution (LFD) is then applied to each age class so that numbers at length can be added over the most significant age classes present in the fishery to estimate an LFD for the stock. LFDs for trip catches are estimated from the stock LFD at the time of the trip together with a logistic selectivity function having a common slope but a different location over length for each type of trawl. The variable catching powers for cod of three different types of trawl in the NE coast fishery are accounted for with two additional parameters. The design of the model was intended to capture the main factors affecting catches of cod with the minimum of parameters to be estimated.

The model was fitted using the Winbugs software (http://www.mrc-bsu.cam.ac.uk/bugs). A Poisson likelihood function was written in Winbugs notation as

$$O_{t,i,L} \sim \mathrm{dpois}\left(n_{t,i,L}\right)$$

where $O_{t,i,L}$ is the observed CPUE-at-length recorded for the *i*'th trip. This likelihood does not allow for correlated occurrences and non-occurrences of fish of similar lengths on the same trip. A random trip factor was found to ease this problem but also to disturb the stability of the MCMC chains, requiring longer, less definite estimation. A random factor did not appear to be necessary for obtaining credible estimates of parameters, would not have assisted the predictive powers of the model and, for these reasons, was abandoned. The consequence of serial correlation is that statistical weight is given to observations even though they are dependent on other, adjacent observations. Estimated parameters may therefore be biased to fit best those trips finding clumped LFDs, and the standard errors output by Winbugs are likely to over-estimate precision somewhat. The fit of the model mainly depends on the distinctness of the LFD for 1-year olds in each year, on the assumption of constant average catchabilities, q_v, for the observed sample of trawler trips, on the priors chosen for fitting an initial block of trips, and on the policy for updating the priors for the next block using the posteriors from the preceding fit. The primary criteria chosen to indicate a successful policy for updating the priors were that it should be uninfluenced by the analyst following the initial setting of priors, and that the model should track relative annual recruitments in reasonable agreement with the abundance indices from 1994 onwards obtained by the International Bottom Trawl Survey (IBTS) quarter 1 results. Additionally, the MCMC chains should be consistently straight and well mixed for all years of data.

Methodology of testing

Predicted catch rates for year y were prepared with a preferred run of the model using the posterior mean estimates of parameters in year $y-1$, except for the four required year class strengths (ages 1 to 4). Those aged 2 to 4 were each taken as the posterior mean found from analysis of years $y-1$ back to $y-3$. That aged 1 was not available directly from previous analyses. It was taken as the geometric mean of all the previous year-class estimates, i.e. from 1990 to $y-2$, the first four (1990 to 1993) being the initial supplied values of recruitment scaled by $\bar{k}$. Since this does not allow for variations in year class, another set of predictions was formed using the IBTS quarter 1 abundance index for the year class aged 1 in year *y* scaled by the geometric means (GM) of model estimates divided by the GM of IBTS estimates, both running from the start of the series up to $y-1$. Using the GMs provided a scaling factor which did not vary greatly from year to year. Mean NPH predicted for *y* using only the results available in $y-1$ were compared, firstly, with mean NPH (trip NPH weighted by trawling hours) as observed during *y*, and secondly, with NPH estimated for *y* using observations made in *y*.

Algorithm Performance

Figure 1 shows examples of observed and estimated LFDs from run 2 for the 1 to 4 year-old year classes, for each of the three gear types and for an arbitrary selection of years. The heights of the estimated LFDs for 1- and 2-year olds are generally somewhat reduced by size selectivity from those expected in the population. The selectivity curve itself is shown dotted in figure 1; the slope is unvarying within each year but the fitted location over the length axis is determined by the estimate of L50 for that trawl type and year. Observed points to the left of the selectivity curves imply that the gear on that trip had lower than average selectivity, or perhaps that exceptionally large numbers of small fish were encountered. Older year classes (3+) were estimated to have grown to a length experiencing asymptotic selectivity, i.e. unity. LFDs of the 3 and 4 year old year classes display gradual reduction of height due to loss of numbers, growth along the length axis, and increasing spread as date within the year increases.

The observed LFDs varied markedly from trip to trip, with zero values, and positive values often clumped, i.e. serially correlated, over a narrow range of lengths. This represents the serendipitous nature of trawling off the English NE coast, as well as the selectivity of the gear in use on each trip. Despite these problems, the model produced credible average length and age compositions for the catches of the three types of gear. Results for pair trawls are shown for 1995 in figure 1a. It implies that the pair trawlers were predominantly catching cod from the 1993- and, to a lesser extent, the 1994- and 1992-year classes.

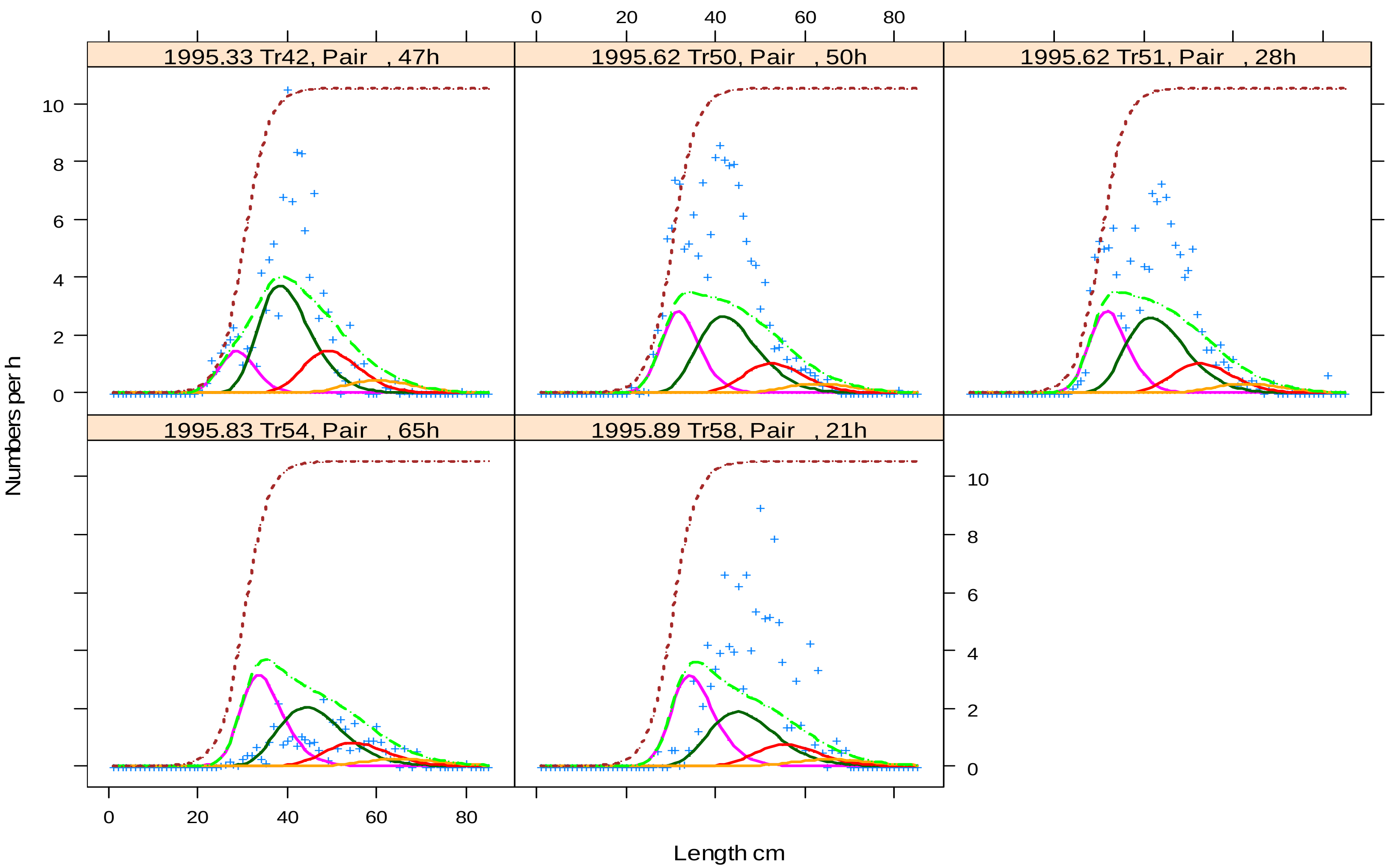
Results for otter trawls are shown for 1996 in figure 1b. Several trips showed high positive residuals over most of the length range, while others showed particular success at catching larger cod. Peaks of observed CPUE coincided with inferred 1-year olds in trips 64, 65, 85, 94, 95, and 98. Relatively poor correspondence for some other trips may be a consequence of larger than average L50s on those individual trips since 1-year old cod were presumably well dispersed in the region. The observed peaks of CPUE for inferred 2-year olds tended to be to the right of the estimated LFDs for 2-year olds. This may indicate that growth was somewhat under-estimated in 1996 or that the selectivity curve was too shallow, such that more of the LFD for 2-year olds was revealed by growth as time passed.

Results for Nephrops trawls are shown for 2003 in figure 5c. Two trips, 285 and 286, showed exceptionally high catch rates for young fish, many of which would have been discarded, as well as for older fish of 3 or 4 years old. Otherwise, prevailing catch rates were much lower than for otter and pair trawlers, as expected because Nephrops trawlers do not target cod. The L50 for Nephrops trawls is seen to be substantially lower than for the other two types.

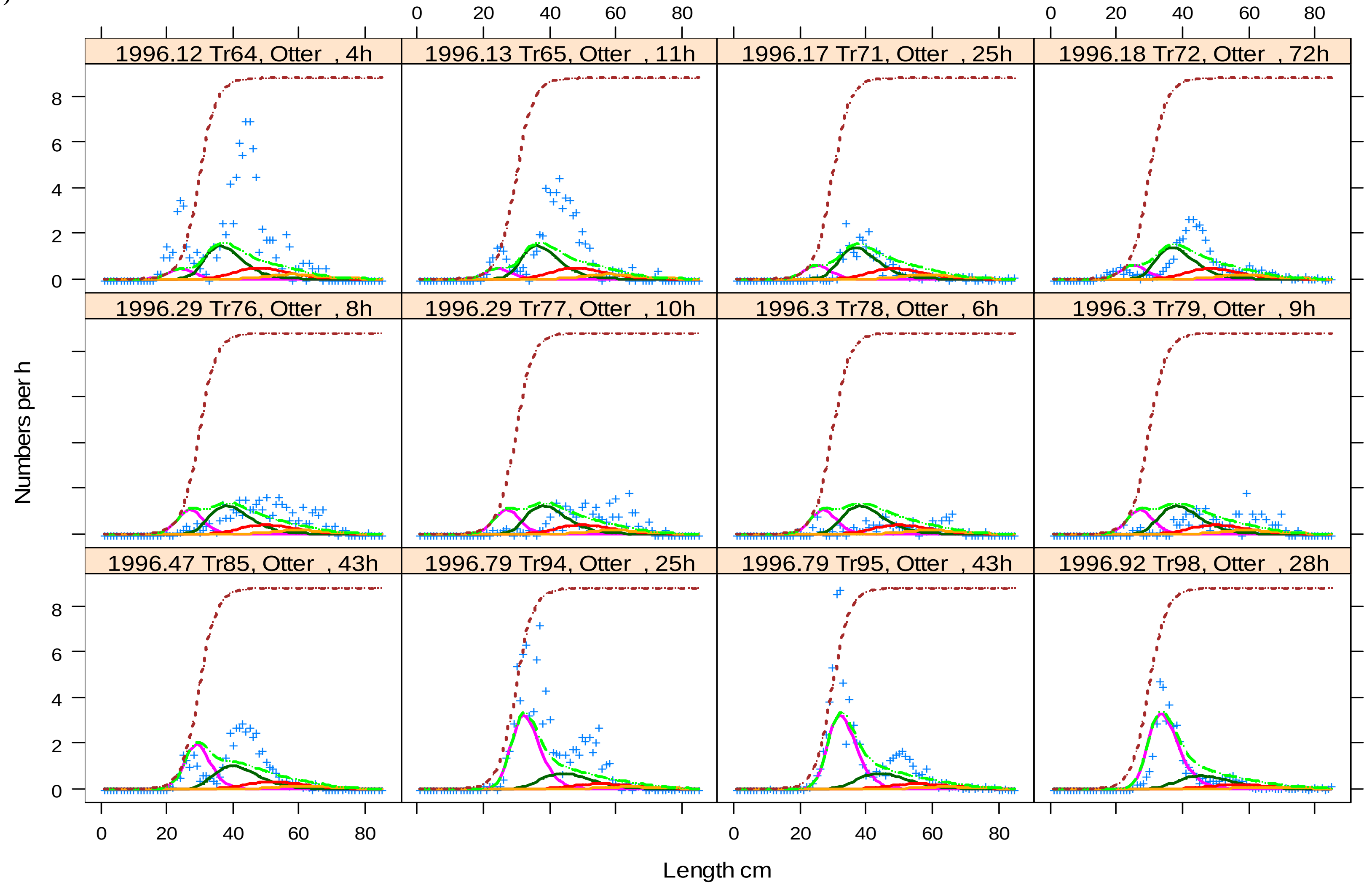
Figure 2 compares numbers per hour (NPH) discarded and retained for the three types of trawler as observed, estimated, and predicted for years $y = 1995...2005$. For pair trawlers, shown in the upper panel of figure 2a, estimated average annual NPH discarded fitted the observed averages quite closely even though fits were often poor for individual trips as seen in figure 1a. Predicted NPH were generally at similar levels but did not closely follow the detailed ups and downs in the other two series. Predicted NPH made with foreknowledge of the 1-year old year class (IBTS estimates) were somewhat better in that the expected peak of discarding in 1997 following the large year class of 1996 was successfully identified. The lower panel of figure 2a, for cod retained by pair trawlers, also shows a reasonable coincidence of predictions with the observed and estimated series. In this case, the peak retention rates occurred in 1998 when the 1996 year class had grown beyond the MLS; they exceeded the observed levels. Including IBTS estimates of the 1-year old year class did not improve predictions (because few 1 year olds are longer than the MLS).

The illustrations for otter trawlers, figure 2b, suggest comparable precision of predictions but most predictions and estimates of retention rates lie above the observed series from 1999 onwards. Predictions for the lower discarding and retention rates observed on Nephrops trawlers, figure 2c, were not close to the observed and estimated series but note that the high observed results for 2002 were based on a sample of only 3 observed trips on this type of trawler in that year, all of which showed exceptionally high catch rates compared to the same trawler type in other years.

Figure 1. Model of cod observed on English NE coast trawler trips: Example LFDs for observed (+) and estimated (solid lines) numbers caught per hour for ages 1 to 4 years in sequence (mauve, black, red, orange); overlying dashed green line is estimated sum for all ages. Dotted sigmoidal curve is fitted selectivity, S, arbitrarily scaled. Banners show trip date (year and decimal), trip (Tr) number, trawl type, and hours (h) of trawling observed. a) Pair trawlers, 1995. b) Otter trawlers, 1996. c) Nephrops trawlers, 2003.



b)


1996.12 Tr64, Otter , 4h
1996.13 Tr65, Otter , 11h
1996.17 Tr71, Otter , 25h
1996.18 Tr72, Otter , 72h
1996.29 Tr76, Otter , 8h
1996.29 Tr77, Otter , 10h
1996.3 Tr78, Otter , 6h
1996.3 Tr79, Otter , 9h
1996.47 Tr85, Otter , 43h
1996.79 Tr94, Otter , 25h
1996.79 Tr95, Otter , 43h
1996.92 Tr98, Otter , 28h
Numbers per h
Length cm
0
20
40
60
80
0
2
4
6
8

c)

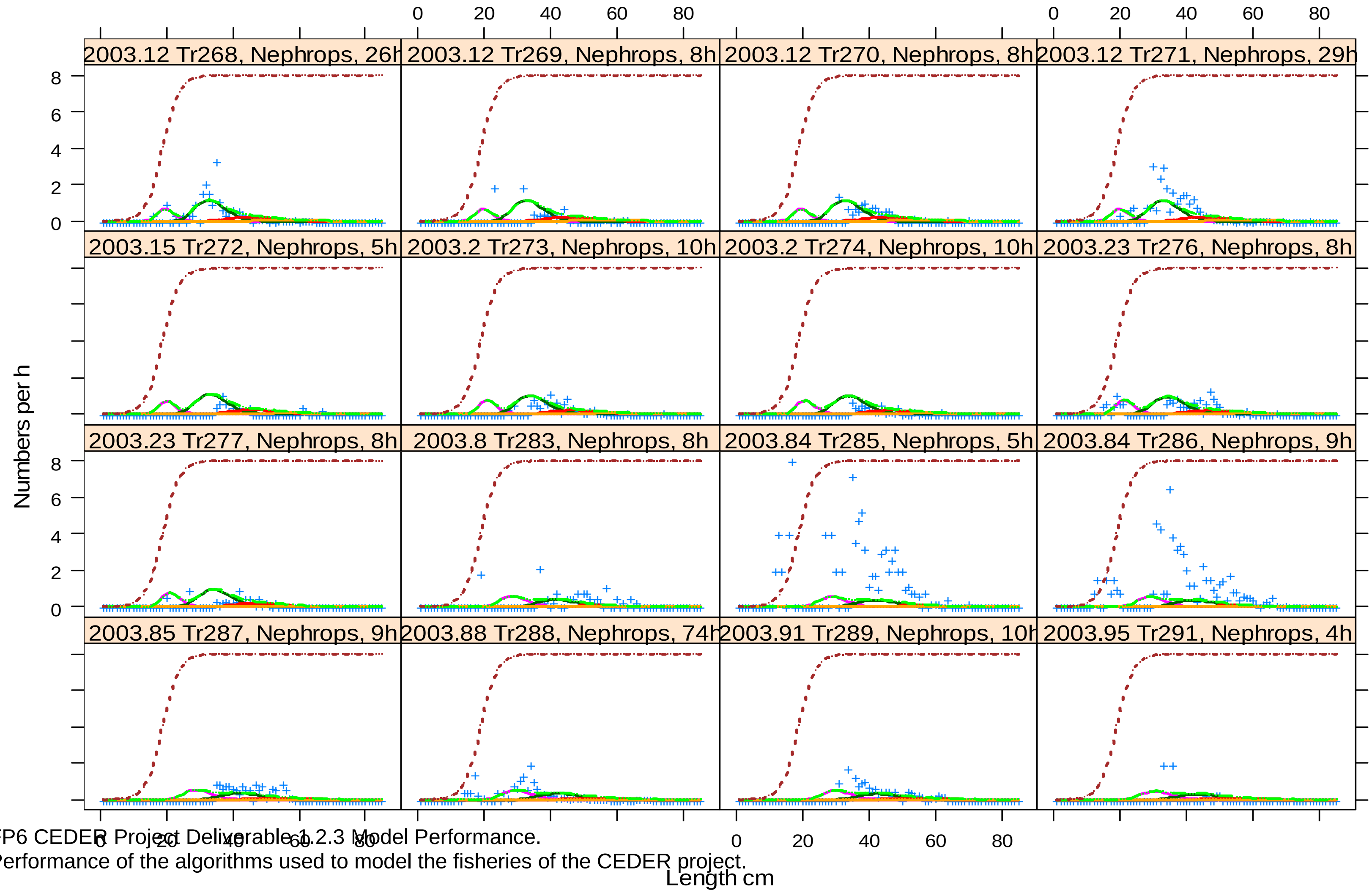
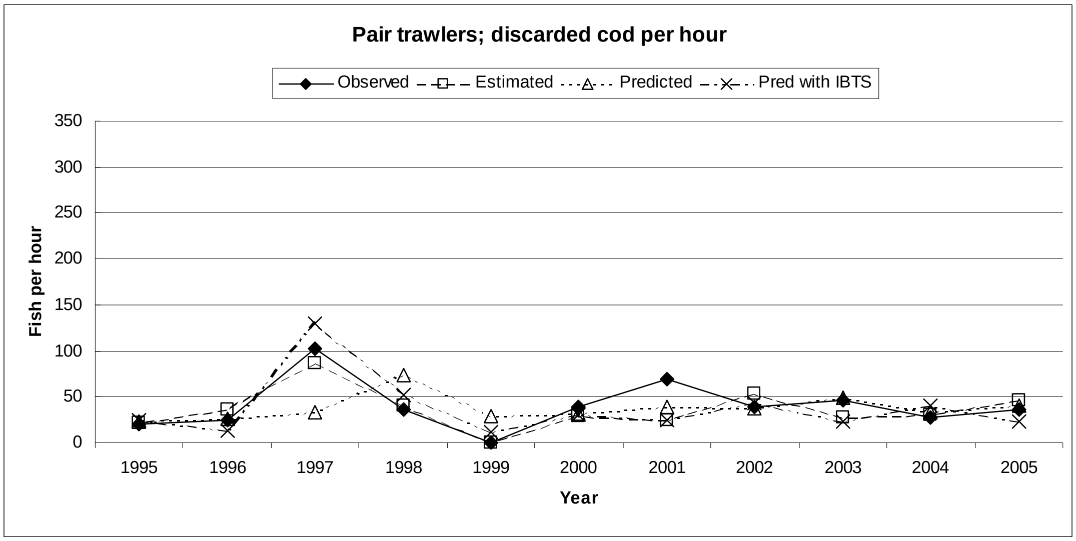

2003.12 Tr268, Nephrops, 26h
2003.12 Tr269, Nephrops, 8h
2003.12 Tr270, Nephrops, 8h
2003.12 Tr271, Nephrops, 29h
2003.15 Tr272, Nephrops, 5h
2003.2 Tr273, Nephrops, 10h
2003.2 Tr274, Nephrops, 10h
2003.23 Tr276, Nephrops, 8h
2003.23 Tr277, Nephrops, 8h
2003.8 Tr283, Nephrops, 8h
2003.84 Tr285, Nephrops, 5h
2003.84 Tr286, Nephrops, 9h
2003.85 Tr287, Nephrops, 9h
2003.88 Tr288, Nephrops, 74h
2003.91 Tr289, Nephrops, 10h
2003.95 Tr291, Nephrops, 4h
Numbers per h
Length cm

Figure 2. Model of cod observed on English NE coast trawler trips: numbers of fish nominally 'discarded' (i.e. < 35 cm) and 'retained' (i.e. ≥ 35 cm) per hour of trawling by three types of trawlers as averaged for each year, *y*. 'Observed' = sample means for *y*; 'Estimated' = model estimates from fitting from 1994 to *y*; 'Predicted' = model prediction for *y* from fitting from 1994 to $y-1$. a) Pair trawlers, b) Otter trawlers. c) Nephrops trawlers.

a)

< 35 cm



≥ 35 cm

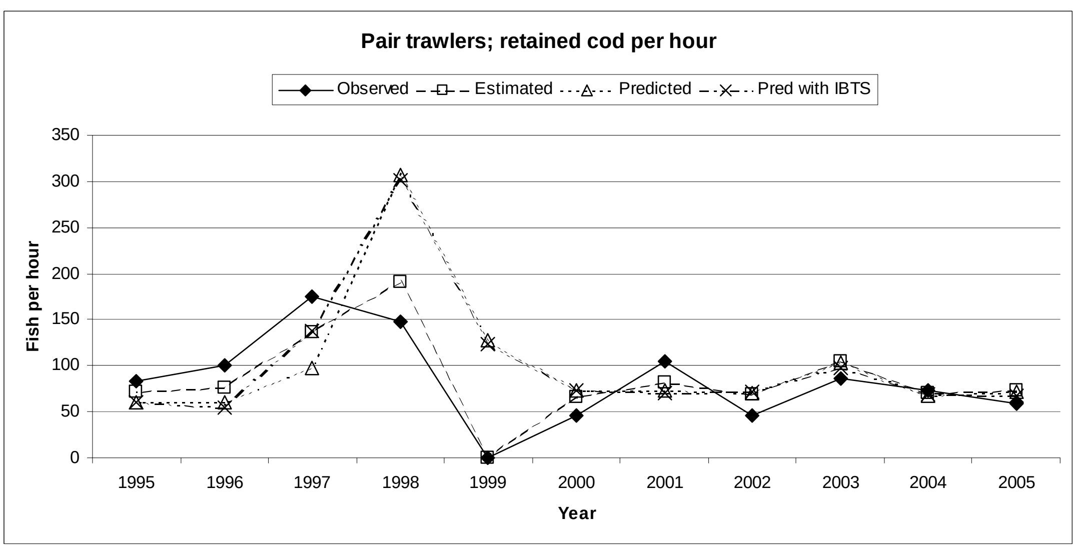
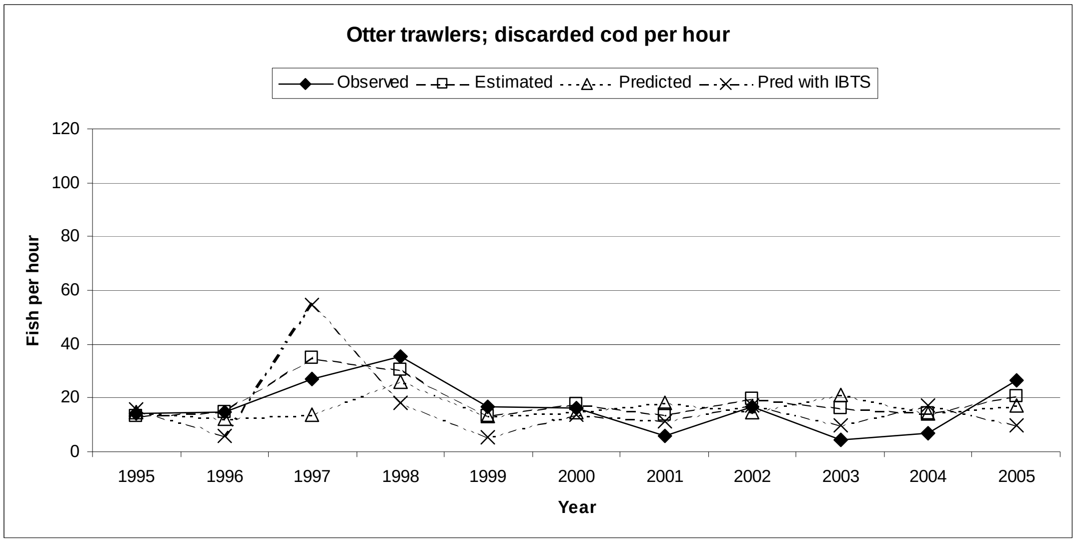


Figure 2 continued

b)

< 35 cm



≥ 35 cm

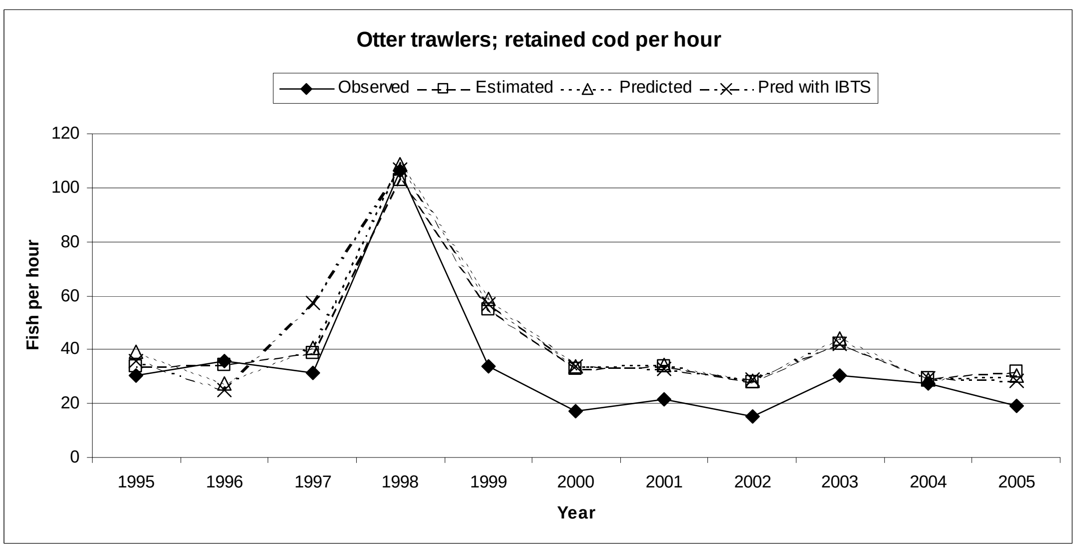
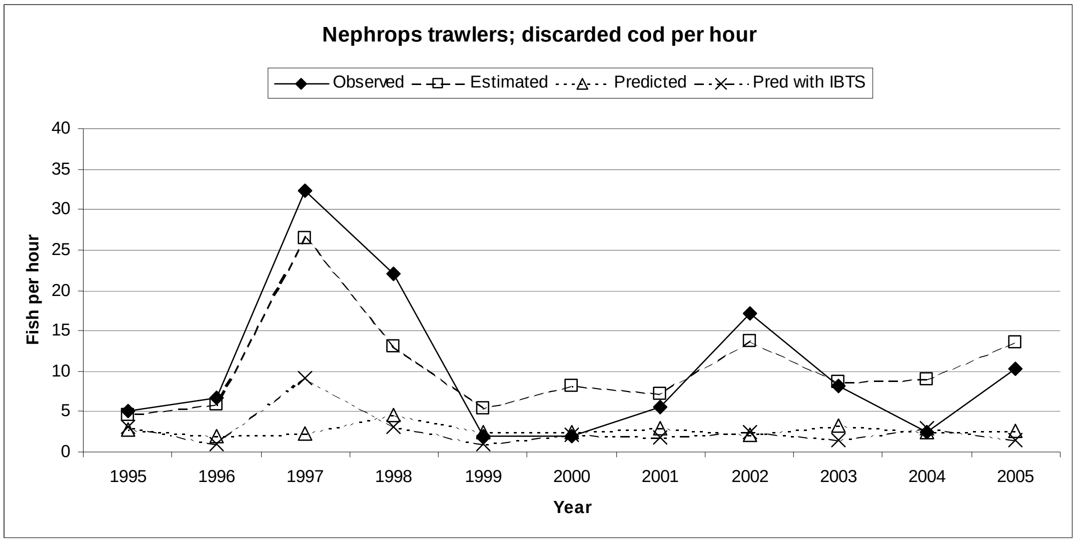


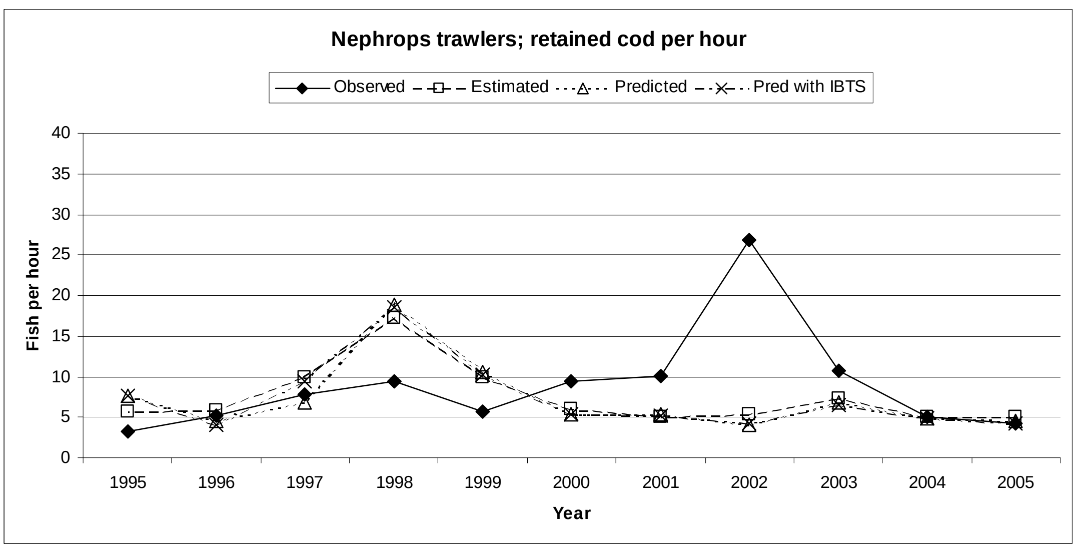
Figure 2 continued

c)

< 35 cm



≥ 35 cm



Algorithm Uncertainties

The present modelling achieved estimation of the relative average catchabilities of the three types of trawler, relative estimates of year-class strengths, fishing mortality, and selectivity parameters, and absolute estimates of the average von Bertalanffy growth coefficient and the standard deviation for the LFDs. Estimates were not noticeably impaired when no external information on relative strengths of the 1990 to 1993 year classes was used to start the fitting process. The estimated parameters are not claimed to have high precision. Much depends on the degree to which the trips observed in each year represent a random sample of the trips made by each type of trawler. If bias is low as a result of successful randomisation, the presumption of constant average catchability coefficients for the fleet from year to year for modelling purposes is not unreasonably optimistic, despite the known diversity of trawl design and rigging from vessel to vessel in the fleets.

The precision of estimation depends not only on the sampling but also on the formulation and fitting of the model. The Bayesian method used here proved convenient in that poor formulations could be readily detected from the behaviour of the MCMC chains, and the precision of estimation could be seen to improve as the number of years of observations analysed increased. The danger with the Bayesian method for a sequential analysis is that biased or wrong estimates can become frozen in the sequence of annual analyses by making poor choices for the initial priors or for the policy of updating priors from one year to the next. The policies and model used here successfully simulated the pattern of year class strengths obtained independently by the IBTS quarter 1 survey. There is one significant conflict, however, because the IBTS shows a decreasing trend of recruitment in recent years while the model found an increasing trend. This might be a result of modelling bias. On the other hand, it is easy to believe that more young and middle-aged cod are found close in to the NE coast of England - where there has been a cod fishery for many years probably for just that reason - than are found further out in the North Sea where the majority of the IBTS fishing stations are situated. A similar point is often made by local fishers (e.g. Fishing News, 14 September 2007). It is not claimed that the research described here can resolve the issue.

The model was partly successful for predicting trawler catches and discarding. Prediction of average annual rates of discarding without using information external to the model was poor. Discarded cod (< 35 cm) in this fishery are primarily 1-year olds, the strength of whose year class is not estimable by the model as currently formulated. Attempts to extend it to include 0-group cod proved unsuccessful because the observed catches were too variable, depending not just on year-class strength but also on the size selectivities of the few trawlers that happened to be sampled towards the end of each calendar year. We therefore used the geometric mean of previous recruitments as the best internal estimate of the prior mean for the strength of the current 1-year old year class when predicting discards. Using external information, here the IBTS quarter 1 index for the 1-year old year class appropriately scaled, appeared to improve predictions, mostly in line with expectations though, without knowledge of the true quantities in each year, the extent of the improvements cannot be gauged.

Prediction of average annual retention rates of retained cod (>35 cm) was more closely in tune with subsequently observed results than for discards. Better prediction is expected for older fish because the relevant year class strengths have been estimated from preceding years. Such a result may be applicable to prediction of the uptake of landings quota from current records of trawling effort, as originally envisaged by the Ceder project. The cod fishery investigated here had one advantage for modelling, namely the occasional very large year class which provides a clear signal for the model to estimate. It also had two big disadvantages, e.g. the presence of only one visibly distinct year class, the 1-year olds, and low and rather sporadic catch rates. A feasible project for cod in the North Sea would be to model the several regional fisheries separately to see whether coherent year class signals were found and, if so whether precision of estimation could be improved by the larger total sample of observations. Other useful information might be obtainable on growth, migrations, selectivities and catchabilities for different fisheries.

2.6 Algorithms developed by the Joint Research Centre (JRC)

Algorithms developed were:

- Quota uptake and/or landing prediction algorithm

This algorithm performs with mixed results. If the quota uptake exhibits some form of regularity, then the predictions prove accurate (quota consumption prediction errs by 0-2%). If there are big irregularities in the time series, such as a broken trend, then the predictions were quite inaccurate (quota consumption prediction errs by 8-20%).

2.6.1 Landing prediction algorithm

Algorithm description

Our algorithm is an attempt to predict the next few months for the current year of cumulative quota uptake, using time series analysis with the past cumulative quota uptake as input. Alternatively to cumulative quota uptake, the system can predict landings using the same approach. Most of our models take some form of seasonality and long-term trend into account. (Some do not. This is a healthy approach since models will compete with each other, so the ones unsuitable to the data will simply perform poorly, and will not perform any forecasts.)

Methodology of testing

We have set up a process whereby time series models compete with each other. The models, fed with partial data, will be examined on their ability to predict the numbers in the known data set. A few “winners” of that ranking will then be used to predict the future.

In the JRC’s algorithm, validation is performed by answering the following basic question: “If the data would be generated by a given statistical model, would that given model then be a winning model?” We then asked that question for all models for which such a test makes sense.

For the purpose of testing the algorithm’s performance, we tested the predictions using the following fisheries (country, area, and species):

- North Sea Flatfish: NLD, PLE, 2AC4., and GBR, SOL, 07D.
- Northern Shelf Anglerfish: GBR, ANF, 07.
- Scottish Pelagic: GBR, HER, 5B6ANB
- North Sea Roundfish: GBR, COD, 2AC4. and NLD, WHG, 2AC4.

All these fisheries had the following prediction parameters

- Predict cumulative quota uptake from cumulative quota uptake only
- Use linear, spline, GAM, and ARIMA models
- When evaluating model fitness, ignore first 2 months of predicted quota uptake

We varied the following parameters:

- The number of months predicted ahead: between 1 and 4 months were predicted
- The number of years that the models received for training: The models had between 4 and 19 years of data at their disposal

We then compared the predicted values to the actual values.

Algorithm Performance

North Sea Flatfish

Country, species, area		NLD, PLE, 2AC4.	
Data from - to		01/1995 – 03/2004	
Number of months to predict ahead		3	
Winning model used for predicting		lm(cumul_final_uptake ~ as.factor(month))	
Month/year	Predicted	Actual	Difference
04/2004	36%	36%	0%
05/2004	42%	43%	1%
06/2004	48%	49%	0%

The good performance of this prediction is due to 2 factors:

- A seasonal component of medium importance. About ¾ of Plaice is fished in September to March; quota consumption continues at a lower level during Spring and Summer.
- The relatively regular quota consumption of this particular fishery. (Note: Even though the absolute kgs caught are in historical decline, quota consumption is quite regular.)

Country, species, area		GBR, SOL, 07D.	
Data from - to		01/1999 – 05/2005	
Number of months to predict ahead		1	
Winning model used for predicting		ARIMA(1,0,1) 12 (0,1,1)	
Month/year	Predicted	Actual	Difference
06/2005	29%	22%	8%

This relatively bad performance of the prediction reflects a change in the way in which quota was taken up.

- From 1999 to 2004, about 90% of the quota for sole was routinely exploited at the end of each year.
- From 2005 to 2007, on average about 50% of sole was fished at the end of each year. From 2004 to 2005, the actual kgs fished are pointing in the same direction. The kgs fished, but not the quota, show a relative recovery in 2006 and 2007.

Northern Shelf Angler (Scottish)

Country, species, area		GBR, ANF, 07.	
Data from - to		01/1999 – 05/2005	
Number of months to predict ahead		4	
Winning model used for predicting		ARIMA(1,1,1) 12 (0,1,1)	
Month/year	Predicted	Actual	Difference
06/2005	42%	39%	3%
07/2005	49%	44%	5%
08/2005	57%	51%	6%
09/2005	63%	57%	6%

This run represents an acceptable performance. This fishery is characterized by

- Year-round fishing with little seasonality
- High variability in the quota uptake, with 65% of quota being fished in 2000, and 92% being fished in 2003 (Note: The actual kgs fished per year are pretty stable, only the quotas vary from year to year)

Scottish Pelagic

Country, species, area		GBR, HER, 5B6ANB	
Data from – to		01/1990 – 06/2005	
Number of months to predict ahead		3	
Winning model used for predicting		ARIMA(2,0,0) 12 (1,1,0)	
Month/year	Predicted	Actual	Difference
06/2005	29%	35%	6%
07/2005	74%	72%	2%
08/2005	96%	92%	4%

The prediction performs acceptably. This fishery can be characterized as follows:

- This is a very seasonal fishery that makes most of its catches from June to August of each year.
- There is a low variability in the final uptake of quota, as every year, the quota is exhausted at 95-105%.

North Sea Roundfish

Country, species, area		GBR, COD, 2AC4.	
Data from - to		01/1987 – 05/2007	
Number of months to predict ahead		3	
Winning model used for predicting		ARIMA(1,1,1) 12 (0,1,1))	
Month/year	Predicted	Actual	Difference
06/2007	53%	54%	1%
07/2007	61%	63%	2%
08/2007	71%	70%	1%

The good performance of this prediction is due to 2 factors:

- The relatively low seasonal component, as cod seems to be fished year-round.
- The relatively regular quota consumption of this particular cod fishery. (Note: Even though the absolute kgs caught are in historical decline, quota consumption is quite regular.)

Country, species, area		NLD, WHG, 2AC4.	
Data from - to		01/1989 – 09/2004	
Number of months to predict ahead		3	
Winning model used for predicting		lm(cumul_final_uptake ~ as.factor(month)*trend)	
Month/year	Predicted	Actual	Difference
10/2004	61%	52%	11%
11/2004	72%	58%	14%
12/2004	83%	63%	20%

The performance in this run is particularly poor, but we expected as much.

- In this trial, we actively looked for a time period where quota uptake (from 10/2004 to 12/2004) did not continue as in previous years. Therefore, we expected that the software would perform poorly. The software did not know the 10/2004 – 12/2004 data, indeed predicted data as in previous years, therefore performed as was to be expected.

Algorithm Uncertainties

As noted in the result, the algorithm's performance is mixed. Why is this so?

The prediction algorithm makes use of a set of mathematical models, to predict quota uptake from itself, exploiting any seasonality and/or trend it can find. The algorithm performs forecasts with those models that performed the best forecasts in the past.

Such forecasting yields promising results if the time series has statistical properties that vary cyclically with time. For instance, this is the case for seasonal fisheries (with non-seasonal fisheries being a mathematically degenerate case). It would also be the case for seasonal fisheries with some form of trend, like a declining fishery.

These models however break down when the quota uptake exhibit an arbitrarily large variance. The models also have issues with abrupt changes in seasonality, where for example, a fishery would suddenly occur in the summer months rather than in the spring months, or if a fishery experiences a stock collapse.

Algorithms developed by the Fisheries Institute of the University of Iceland (FRI)

Two algorithms were developed as part of the model:

- activity classification / effort estimation
- catch prediction

Overall, the activity classification was severely hampered by coarse resolution in the VMS data, resulting in as low as 48% correct classification.

In spite of this, the catch prediction model does not suffer too much from this inaccuracy, since it is very much more sensitive to the large variations in individual catches and annual CPUE changes. The catch prediction for individual years ranges from 19% to 39% accurate on average, or 38% when applied to a previously unknown year.

The model shows clear signs of bias from stock numbers, in that the CPUE varies somewhat between years. It may be thus be used for monitoring purposes within each year, proving useful in flagging vessels that over or under report their catch compared to their effort as indicated from VMS data, but should not be relied upon for catch prediction for unknown years without modifications.

To correct for the error between years, it may be worthwhile to incorporate a measure of the expected CPUE into the model, for example from stock assessment or fleet or vessel TAC-figures.

We will discuss the design and testing of each of these algorithms in the following chapters.

2.6.2 Activity classification / Effort estimation algorithm

Algorithm description

The algorithm is based on the assumption that a cruising vessel will travel faster than a trawling vessel. For the North Atlantic Redfish fisheries, the trawling speed has been found to be around 4 knots, while cruising speeds are generally above 8 knots. Adding up the total time spent in each speed interval gives us the *effort estimate*.

Methodology of testing

The algorithm was tested by running the classification on data for the year 2006, which had not been used previously when developing it.

A leg-by-leg[2] approach was used to gauge the classification accuracy.

The leg-by-leg approach involves comparing the result of the activity classification algorithm to a reported activity for that leg. Using this approach, a leg is deemed correctly classified if the two match. A false positive (type I) error can occur when the leg is classified as "trawling", when in fact it was reported as "cruising". Conversely, a false negative (type II) error occurs when the leg is classified as "cruising" when it was reported as "trawling".

Algorithm Performance

Classification based on vessel speed as a calculated mean-speed between VMS-positions proved to deliver disappointing accuracy as the following table shows.

Table 2.7.1: Classification results

Actual activity	Classified activity	Result	Percentage

[2] A "leg" is defined as a track segment between two consecutive VMS-positions.

Cruising	cruising	Correct	27%
Cruising	stopped	False	33%
Cruising	trawling	False	40%
Stopped	cruising	False	1%
Stopped	stopped	Correct	99%
Stopped	trawling	False	0%
Trawling	cruising	False	7%
Trawling	stopped	False	45%
Trawling	trawling	Correct	48%

Whereas the classification algorithm was very successful at identifying when a vessel was stopped, it had serious problems in distinguishing between ”trawling” and ”stopped” activities (45% false), and ”cruising” and ”trawling” (40% false). Surprisingly, the algorithm also had trouble with ”cruising” and ”stopped”, falsely classifying 33% of the legs as stopped. This may be an indicator of a problem with the ”actual” activity classification, as discussed below.

An explanation for the classification results may be found in Figure 2.7.1 which shows that with a VMS-resolution of 2 hours, an algorithm based on speed will clearly overestimate the effort. All legs under 4 knots as classified as trawling, while small spikes can sometimes be seen between reported catch-activities. It is our belief that with a higher resolution, and/or using reported speed from VMS-records (which was not included in the dataset studied) rather than calculated mean-speed, these spikes would resolve to give a clearer trawling/cruising separation.

Algorithm Uncertainties

Vessels are not spending the entire time fishing, even when at low speeds as Figure 2.7.1 shows. Significant gaps between fishing activities occur, when the vessel may be processing the catch or doing other activities that should not be calculated into an effort estimate.

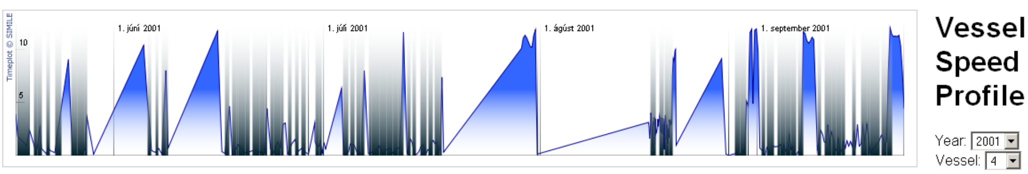


Figure 2.7.1: Vessel speed profile

The figure shows vessel speed over the course of one year, with reported fishing activity marked as gray areas.

Additionally, the VMS data did not in fact include activity reports for each leg. Therefore, the activity during each leg had to be provided by the catch logbook, where the position of catches (recorded as the starting position of trawling) and the trawling time were recorded.

An added complication was that the catch logbook only records the dates and not the times of the catches. This called for the logbook entries to be connected to legs with rules-based logic, potentially contributing to classification errors.

2.6.3 Catch prediction algorithm

Algorithm description

Having obtained the effort estimate from the previous algorithm, we now turn to the question of predicting the catch. A simple linear model was used, correlating the estimated effort with reported catch.

This very simple approach allows us to examine how individual vessels are expected to perform in context of the fleet as a whole, and can be used to monitor vessels for unexpectedly high or low reported catch. When annual cycles and trends are minimal, this type of model may also be used to predict catches in unknown years.

Methodology of testing

For the simple linear model, we again use 2006 data for validation. A comparison of several statistics, such as the Mean-Squared-Error (MSE) and the Mean-Proportional-Error (MPI) were used to validate the model.

To examine the model performance free from interference of the activity classification, we built two sets; one based on the estimated effort from the classifier, and one based on the reported actual effort from vessel logbooks.

Algorithm Performance

The catch prediction model performed reasonably well, when the large variance of each haul is considered.

Using data on actual reported effort and modelling for individual years with data from other vessels in the fleet, a mean proportional error ranging from 9% to 26% is achieved in catch predictions.

When using effort estimates from the classification algorithm, this precision is reduced to between 19% and 38%.

When the model is applied to a previously unknown year, the precision is reduced to 37%, and shows clear signs of a bias because of a different CPUE from previous years.

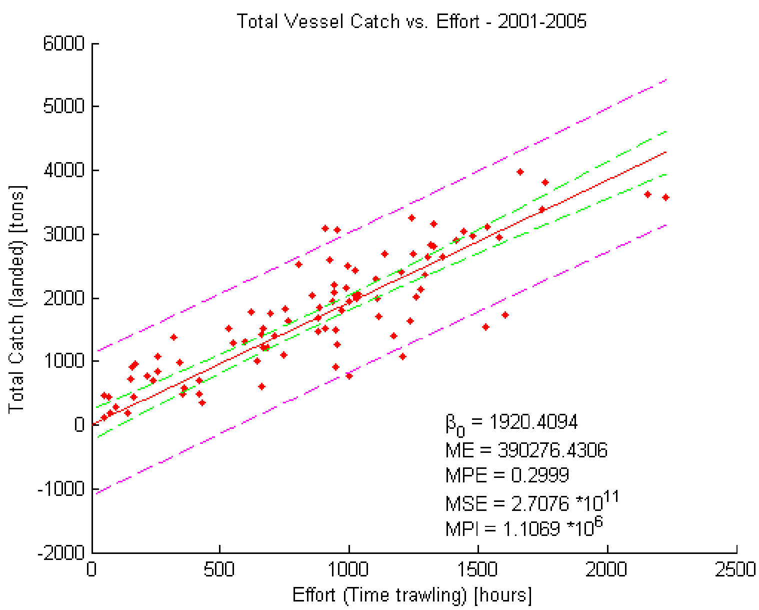


Figure 2.7.2: Catch prediction model based on data from 2001-2005

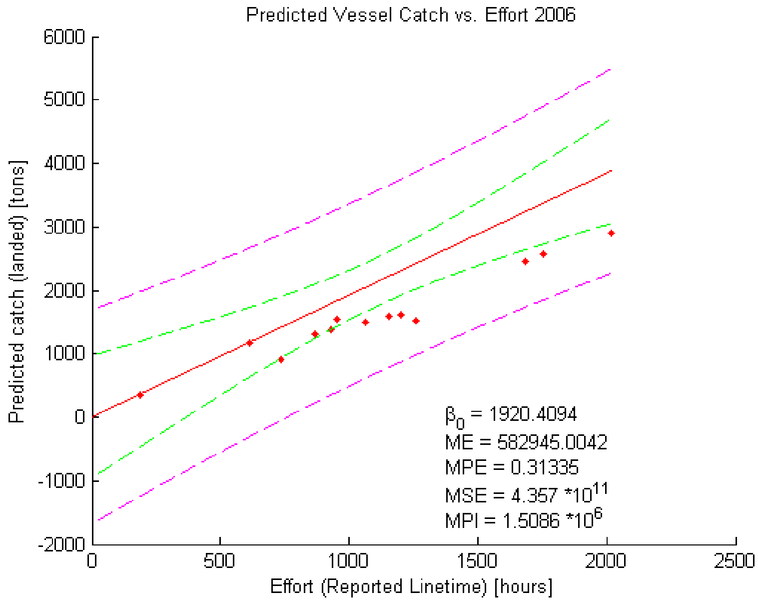


Figure 2.7.3: Catch prediction for a previously unknown year

Algorithm Uncertainties

As Figure 4 shows, the variance in the catch size is significant, with an average around 30 tons, tapering off sharply at 40 tons.

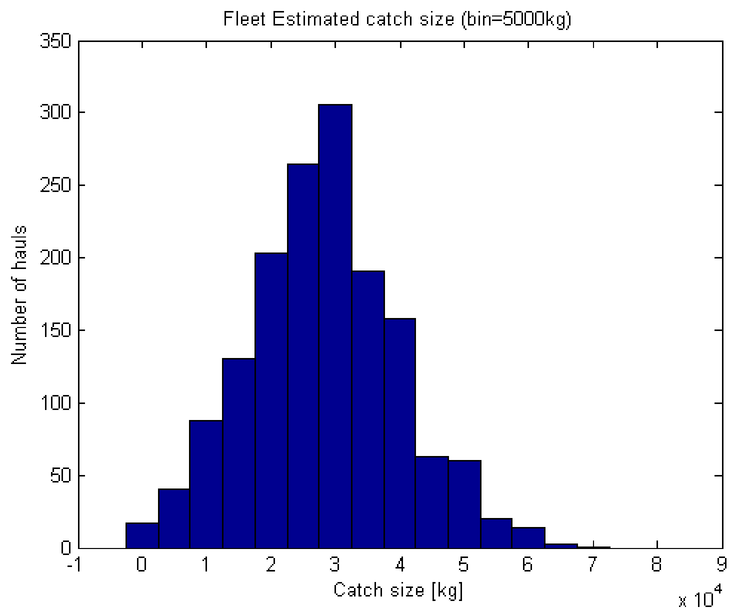


Figure 2.7.4: Catch size

This corresponds to the captains' preference to have between 30 and 40 tons in each haul.

This variation in catch is what contributes most strongly to prediction errors, much more so than variations in the effort estimate.

This model is not responsive to effects from each vessel or seasonal or annual trends in the fisheries, and thus cannot be used reliably to predict catches for a year where no reference data from other vessels is available. A possible improvement might be achieved by including stock assessment figures for the upcoming fishing year in the model.

One aspect of the study was to examine if there was any significant difference between the catch as reported by vessel logbooks, and landing reports. As Figure 2.7.5 shows, there is practically no difference in the predicted catch weather we use logbook or landing report data. This is reflective of the fact that there is virtually no discard in the North-Atlantic Redfish fisheries and the logbook data gives a good picture of the actual catch.

It is maybe worth mentioning that the main reason there is negligible discard in these fisheries is simply that there is no incentive for the fishermen to throw away other than clearly diseased or damaged fish. There is no real by-catch, and the vessels have not been able to fill their annual quotas due to declining stock levels.

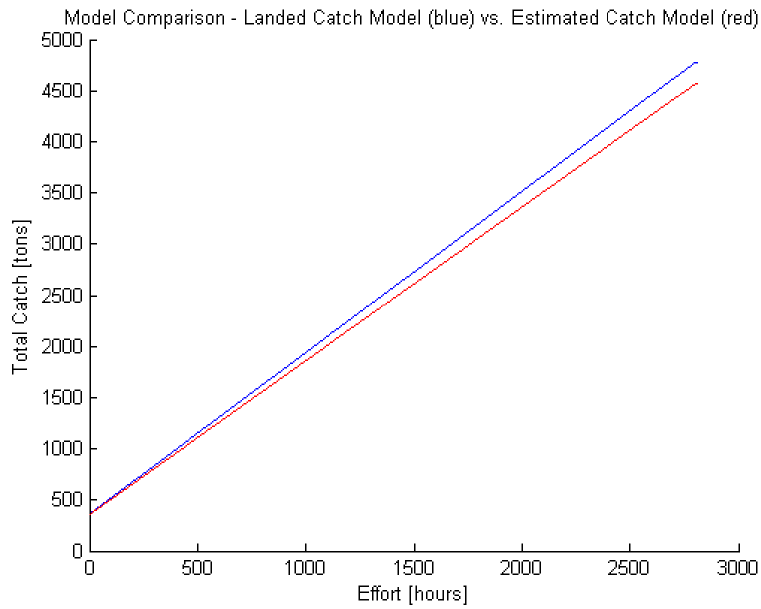


Figure 2.7.5: Logbooks vs. Landing reports

3 SUMMARY

The algorithms developed generally fall into three categories:

- Activity classification
- Effort /catch estimation
- Discard estimation

and depend on such parameters as time between VMS-records, reported speed, calculated speed, time of day, and density of VMS-records in the vicinity.

In estimating the accuracy of the algorithms, their predictions were compared with actual data where possible, e.g. observer data, landing reports, reported activity, etc., giving an estimate of error rates.

4 Conclusions of individual consortium partners

4.1 Correlation systems:

The tests show that for the UK fisheries, the North Sea fisheries and the Black Sea vessels the effort algorithms improved the estimates considerably, often by about 30% compared with a “naïve” (days at sea) algorithm.

4.2 Joint Research Centre (JRC):

This algorithm performs with mixed results. If the quota uptake exhibits some form of regularity, then the predictions prove accurate (quota consumption prediction errs by 0-2%). If there are big irregularities in the time series, such as a broken trend, then the predictions were quite inaccurate (quota consumption prediction errs by 8-20%).

4.3 L’Institut de Recherche pour le Développement (IRD):

The higher rates of detection are comprised between 63% and 83%, the detection is considered correct, whereas, for some trips, the detection is quite bad, with rates lower than 30%. The reasons of bad detection are the low frequency of VMS collection for some vessels at some periods. Moreover, bad meteorological conditions have consequences on the fishing actions: the number of non productive sets is higher than in good conditions and these are sorely detected with hourly VMS data.

4.4 Sirius IT and the Greenland Institute of Natural Resources (GINR):

We have no way of predicting how much effort the fishing industry will put into a certain fishery in e.g. 3-6 month in the future, but the visual information that the Quota Analysis System gives the inspector, combined with the inspectors experience, will give the inspector an idea whether an effort in a certain fishery will increase or decrease in the months ahead.

A small difference in discard levels was found between the average of GFLK observer and captain and the true levels found by the scientific assistant. However both levels are considered very low as the discarded amount of fish in average for all 332 hauls were 2.2 % of the total shrimp catch. In shrimp fisheries in warmer waters often only 10% to 40% of the total catch is shrimps and the rest is discarded.

Due to these low levels, it is not in the interest of Greenland Institute of Natural Resources to incorporate any conversion factors in a future online quota uptake system maintained by Greenland Fisheries License Control (GFLK). Instead it is recommended that GFLK continue using the values given by their observers and captains of the vessels.

4.5 Centre for Environment, Fisheries and Aquaculture Science (CEFAS):

Using the effort estimation algorithm, trawling effort can be accurately represented at a grid cell resolution of 3-km or less.

The model of observer data predicts next year’s landings and discards of cod. It also allows investigations of the effects of vessel and seasonal factors on discarding and catch rate.

Data filtered with both speed and direction rules, processed with the “best” estimate method and summarized in 3-km grid cells, provided an accurate representation of the spatial distribution of trawling effort by the UK North Sea beam trawl fleet in 2003. The adoption of a consistent method for analysing VMS data will help to ensure that calculations of trawling effort are repeatable and comparable among studies. We recommend a reporting scale of 3 km as a compromise between the perfect description of all patchiness, the level of information on true trawling tracks provided by 2-hourly positional data, and the need to select grid cell sizes that can sensibly be applied at very large spatial scales.

The speed rule (i.e. 2–8 knots taken to reflect trawling activity) provides a simple method for identifying trawling activity in the North Sea beam trawl fishery, but a speed rule alone is not recommended to support accurate quantification of trawling effort.

By combining the directionality methods, prediction accuracy increased, although there remained some inaccurate predictions for fast-moving vessels. Using the highest speeds to identify steaming was, therefore, a logical step towards developing the optimum method. However, the optimum method still overestimated steaming.

The model was partly successful for predicting trawler catches and discarding. Prediction of average annual rates of discarding without using information external to the model was poor.

Prediction of average annual retention rates of retained cod (>35 cm) was more closely in tune with subsequently observed results than for discards. Better prediction is expected for older fish because the relevant year class strengths have been estimated from preceding years. Such a result may be applicable to prediction of the uptake of landings quota from current records of trawling effort, as originally envisaged by the CEDER project.

A feasible project for cod in the North Sea would be to model the several regional fisheries separately to see whether coherent year class signals were found and, if so whether precision of estimation could be improved by the larger total sample of observations. Other useful information might be obtainable on growth, migrations, selectivities and catchabilities for different fisheries.

4.6 Fisheries Institute of the University of Iceland (FRI):

Overall, the activity classification was severely hampered by coarse resolution in the VMS data, resulting in as low as 48% correct classification.

In spite of this, the catch prediction model does not suffer too much from this inaccuracy, since it is very much more sensitive to the large variations in individual catches and annual CPUE changes. The catch prediction for individual years ranges from 19% to 39% accurate on average, or 38% when applied to a previously unknown year.

The model shows clear signs of bias from stock numbers, in that the CPUE varies somewhat between years. It may be thus be used for monitoring purposes within each year, proving useful in flagging vessels that over or under report their catch compared to their effort as indicated from VMS data, but should not be relied upon for catch prediction for unknown years without modifications.

To correct for the error between years, it may be worthwhile to incorporate a measure of the expected CPUE into the model, for example from stock assessment or fleet or vessel TAC-figures.

(end of document)

European Commission

EUR 24017 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen
Title: FP6 CEDER Project Deliverable 1.2.3: “Model Performance”
Authors: T. Hjörvar (FRI), G. Pétursdóttir (FRI)
N. Bez (IRD), A. J. Cotter (CEFAS), N. Dayagi (Corr.), M. Grønfeldt (Sirius),
A. Kideys (JRC), U. Kröner (JRC), J. Neves (NEAFC), G. Pilling (CEFAS),
F. Quirijns (IMARES), E. Rosenberg (Corr.), D. Reid (FRS),
A. South (CEFAS), K. Sünksen (GINR), E. Walker (IRD)
Luxembourg: Office for Official Publications of the European Communities
2009 – 45 pp. – 21 x 29,7 cm
EUR – Scientific and Technical Research series – ISSN 1018-5593
ISBN 978-92-79-13737-2
DOI 10.2788/39926

Abstract
Addressing the uncertainties in fishing activities, the FP6 CEDER project developed a set of algorithms in order to predict catches vessel activity type, effort, catches, discards, and quota uptake, from other variables. This document reports on algorithms’ performance.

How to obtain EU publications

Our priced publications are available from EU Bookshop (http://bookshop.europa.eu), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

LB NA- 24017- EN- C

EUROPEAN COMMISSION

ISBN 978-92-79-13737-2

Publications Office
Publications.europa.eu