

## Theme Session I

### Fishing capacity, effort, and fishing mortality—the understanding of fishery dynamics and their links to management

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#### ICES CM 2008/I:01

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##### **Managing fishing methods: the structure and dynamics of the New Zealand set-net fishery**

David A. J. Middleton

Since the establishment of the Quota Management System in 1986, the focus of the majority of fishery science and management in New Zealand has been setting total allowable catches for individual fish stocks (administrative units relating to a species in a particular management area), and the allocation of these quotas to commercial rights holders while making allowances for recreational and customary harvests. The characterization of fisheries has been primarily stock-centric: describing the temporal and spatial patterns of fishing effort that target the species of interest or take it as bycatch, as a part of the stock assessment process. However, many current fishery management problems require a different focus. Management of protected species bycatch, for example, typically requires an understanding of the structure and dynamics of fisheries from the perspective of a particular fishing method. Although the current New Zealand fishery data system focuses primarily on the collection of data required for the assessment of stocks and administration of quotas, it provides a rich source of information relevant to other fishery management issues. This paper investigates the use of statistical clustering techniques to describe the structure of the New Zealand set gillnet fisheries, and their dynamics from 1990 to 2006.

Keywords: New Zealand gillnet fishery dynamics cluster analysis.

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#### ICES CM 2008/I:02

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##### **Projecting mixed-species yield of New England groundfish**

Nikki Jacobson and Steven Cadrin

New England groundfish are harvested in multispecies fisheries and are managed under a single fishery management plan. Current practice is to determine fishing limits through single-species projection models that allow for stock rebuilding or sustainable yield. Effectiveness of alternative harvest scenarios for achieving management targets is then evaluated using multispecies patterns of catch per effort, by season and location. However, the current mixed-species analyses are static, in that they do not project population dynamics. Our approach incorporates the dynamic aspects of single-species projections with technological interactions for multispecies evaluations. The computational approach extends a traditional (but seldom applied) mixed-species yield-per-recruit model by incorporating stock-recruitment relationships. Multispecies catchability coefficients (derived from study fleet, observer, and logbook data) are disaggregated by season, area, gear, and target species. This multispecies projection approach provides short-term evaluation of alternative management scenarios, including optimal days-at-sea and time-area closures that achieve stock rebuilding and sustainable yield targets.

Keywords: multispecies, catchability.

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#### ICES CM 2008/I:03

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##### **The use of Fcube (Fishery and Fleet Forecasts) method for mixed-fishery management: Western Waters case study**

Ane Iriondoa, Dorleta García, Marina Santurtún, Iñaki Quincoces, Leyre Goti, Jose Castro, Stephanie Maevas, and Alex Tidd

Fisheries management is moving towards a fleet-based approach. Nowadays the total allowable catch (TAC) fixed for different species is not always coherent among different species harvested in the same fleet. The quotas for all the species are not exhausted simultaneously, and the fleets continue fishing until all quotas are exhausted. Thus in a mixed fishery, when the quota of the most restrictive species is exhausted, the catch is discarded. The aim of the Fcube method is to give a coherent TAC for mixed fisheries using fleet-based data. The implementation of this method is the main task to be deployed in the AFRAME European project. The basic principle of Fcube is to predict the future level of effort by fleet, known catchability, and effort

distribution by métier and TAC forecast by stock. This method was initially developed within the multifleet, multispecies simulation framework TEMAS. Three input data are needed: single-species assessments (fishing mortality estimates) and catch forecasts (TACs), observed effort and landings by fleet, métier, and stock. In this method the vessel is considered to be the manageable unit and all its trips within a year are considered. Those trips are aggregated into métiers in terms of catch profiles and catchability. The Fcube method has been implemented on the Bay of Biscay and Celtic Sea fleets. Different scenarios have been deployed based on economic or TAC-based management objectives. After implementation, the strengths and weaknesses of the model have been pointed out and some other alternative options have been analysed.

Keywords: Fcube, multispecies, mixed-fisheries, effort.

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## ICES CM 2008/I:04

### Application of observations and modelling data to support fishery management options: fishing intensity and fishing effort

S. Kasatkina and V. Ivanova

The methods for analysing the operation of individual fishing vessels in term of catching, distribution, and behaviour of target species are shown based on the application of probability statistical models of the fishery systems. The authors discuss applications of these analytical methods to support fishery management options. First, we estimate fishing intensity deployed by fleets relating to geographic areas/subareas/localities based on the observed fishing effort and investigating the impact of fish removal on their resources here. Haul-by-haul data from the commercial fleets are used. The available fish biomass at the start of a considered period is derived from the estimated fishing intensity and total catch. This approach is demonstrated using haul-by-haul data from two commercial fisheries: the krill fishery in the Scotia Sea and Peruvian horse mackerel fishery in the southeastern Pacific Ocean. Fishery dynamics in terms of standardized catch per unit effort (cpue), fishing intensity, and available commercial biomass are traced by month, season, and annual assessment under changing environment. Second, we show the approach to model a predictive fishing effort for achieving allowable TAC, taking into account gears and technological equipment capacity deployed by specific fleets. Fish distribution data from acoustic survey and former haul-by-haul data are used in this case. This approach is illustrated by the developed scenario for predicting Russian fleet operation under examples of the Peruvian horse mackerel fishery. Modelling fishing effort including daily catch, cpue, number of trawlers, and fishing days relating to environmental and resource situations observed from surveys in the study area is shown.

Keywords: fishing intensity, fishing effort, modelling, observation.

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## ICES CM 2008/I:05

### Identifying fishing trip behavioural mode and fishing effort using Bayesian Hidden Markov Models

Youen Vermard and Etienne Rivot

Data from satellite-based vessel monitoring systems (VMS) have been used for fishery control and enforcement. But they also offer the opportunity to estimate fishing effort at a high spatio-temporal resolution, which is useful to analyse a fleet's distribution pattern, fishing area, or the fishing trajectory and research behaviour. We propose a Bayesian Hidden Markov Modelling (HMM) framework to analyse VMS data. Classical analysis of VMS data usually uses the vessel's speed and sometimes directionality rules to identify trawling and steaming behaviour. Bayesian HMM provide a more general and flexible framework to fit different behavioural models to tracking data. This approach was applied to analyse the behaviour of pelagic trawlers in the Bay of Biscay. At each time-step, the state (e.g. fishing, streaming, standby) of each trawler is modelled by a hidden state variable, and a Markov chain is used to model transitions between successive states. Bayesian methods are used to integrate the available data (typically position and time) to draw inferences on the variables and parameters associated with each state, such as movement, speed, and turning rates. The method allows us to distinguish several behaviours during the fishing trip, such as fishing, streaming, standby, or at port, and to estimate different characteristics of the movements, such as trawling speed, ratio research/fishing time, and mean turning angles. The results are compared with a speed-based approach to illustrate how the HMM framework greatly enhances the analysis of the trawler's behaviour.

Keywords: fishing trip behavioural mode, Bayesian Hidden Markov Models..

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**ICES CM 2008/I:06****Quantifying the impact of the almost complete cessation of commercial fishing on the haddock population of the northern North Sea during World War II**

Doug Beare, Georg H. Engelhard, Franz Hölker, Eddie McKenzie, and David Reid

Understanding the mechanisms by which commercial fishing pressures, management regimes, and environmental changes interact with the ecology of wild fish populations is a key question for fishery management science. Such questions are difficult to address, however, using recent time-series datasets from 1950 to the present, because fishing pressure was sustained and ubiquitous during that period. The only reliable way to separate the effect of fishing from that of the environment would be to set up huge “designed experiments” in which different marine regions are subjected to different “treatments”, but manipulation of such large ecosystems is probably impossible. An “experiment” did, however, occur in the North Sea during World War II (WWII) when commercial fishing almost ceased. We begin our study, therefore, by describing the construction of a fishery database (scientific and commercial trawl catches) spanning the period 1928–1958, which allows us to scrutinize the impact of WWII. By using a “statistical” method to span the 1939–1945 period we estimate how WWII affected haddock survival and mortality using age-structured models. We reveal a dramatic reduction in mortality ( $Z$ ) between 1939 and 1945 and show how the survival rates of each age class were differentially affected by zero fishing effort and changes in sea temperature and salinity. The study concludes by discussing the results in the context of topical issues such as the instigation of marine protected areas and fishery-induced change in the genetic composition of fish stocks.

Keywords: North Sea, haddock, World War II, mortality, survival.

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**ICES CM 2008/I:07****The impacts of effort standardization procedures (GLM, GLMM, and integrated estimations) and error distributions assumptions (normal, lognormal,  $t$ -Student robust) on the depletion model biomass estimations of *Loligo gahi* off the Falkland Islands**

Ignacio Payá

Historically, *Loligo gahi* biomass estimations had been made by DeLury depletion models assuming an arbitrary fleet stratification and lognormal error distribution. In the last two years the model has been fitted assuming equal fishing powers between vessels and normal error distribution. The aim of this study is to analyse the impact of these assumptions and different methods of effort standardization on biomass estimations. Fishing powers were estimated using generalized linear models (GLM) with different error assumptions (gamma, Gaussian, and inverse Gaussian), GLM with mixed effects, and a depletion model that integrates fishing power estimations. Standardized catch per unit effort (cpue) was used to fit depletion models with normal, lognormal, and  $t$ -Student robust error assumptions. The relation between fishing powers and morphological variables and captain experience were analysed. The high correlations between these variables were reduced by principal component analysis. The biomasses estimated with the assumptions of equal fishing powers underestimated the biomass. The depletion models fitted with  $t$ -Student robust and lognormal errors had better performance than the one with normal errors: the model that integrates fishing powers produced similar biomasses than the models with standardized data only when the  $t$ -Student robust and lognormal error distributions were used. Fishing powers estimated by the different methods were similar and the small differences between them did not affect the biomass estimations. Fishing powers were correlated with all the morphological variables and master experience. The use of the first principal component produced similar results to the models with only GRT. The impacts on effort allocation and total allowable effort are discussed.

Keywords: fishing powers, GLM, GLMM, robust estimations, vessel variables, captain experience, depletion models, effort management.

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**ICES CM 2008/l:08**

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**Capacity and effort metrics of the Scottish pelagic fleet: utility in testing management plans for pelagic fish stocks in the waters around Scotland**

Neil Campbell, Alastair Pout, Doug Beare, Richard Hillary, Dave Reid, and Franz Hoelker

There is increasing interest in Europe and further afield in moving beyond traditional TAC-based approaches to fishery management, towards effort- and/or capacity-based management regimes. This study presents the results of a case study on effort and capacity metrics in the Scottish pelagic fleet, and their links to underlying stock dynamics. The annual activity of this fleet has been modelled with emphasis on seasonality as a series of linked statistical process models. Modelling fleet activity over such a time-scale was considered to be most appropriate owing to the seasonal availability of the mackerel, herring, and blue whiting stocks, the closed-season restrictions in force, and the annual operation of the quota system. These factors combine to impose temporal constraints on the vessels that are considered to be far more significant in limiting the fleet behaviour than the spatial distribution of the stock or the activity patterns of vessels themselves. Simulations were carried out using this model to investigate likely responses across the fleet to changes in closed seasons and the work rate of vessels. Surplus production models of herring, mackerel, and blue whiting stocks were built into the models to provide a realistic biological background to fleet activity. Finally, functional models of fleet activity were applied to short-term projections of stock dynamics to investigate the utility of our linked stock-fleet models in exploring currently established management plans.

Keywords: fleet capacity, effort, simulation study, pelagic fisheries, Scotland.

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**ICES CM 2008/l:09**

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**The relative weight of traditions, economics, and catch portfolios in New Zealand fleets dynamics**

Paul Marchal, Philippe Lallemand, and Kevin Stokes

We investigate the relative weights of catch portfolios, expected profit, and traditions in fishers' decision-making for six contrasted New Zealand fleets regulated by individual transferable quotas. Several métiers were defined for these fleets, using two different typologies. A nested logit RUM (random utility model) was used to model the métier allocation of fishing effort in relation to catch plans, expected profit, and past fishing allocations. This study showed that traditions and catch plans, which appeared to be determined to a large extent by an annual strategy, were the most important determinants of fishers' behaviour in the case of the New Zealand fleets being investigated. The model developed in this study fitted the data generally well, and was also able to predict in most cases future effort allocation both one month and one year ahead.

Keywords: random utility models, catch portfolios, métiers, fleet dynamics, New Zealand fisheries.

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**ICES CM 2008/l:10**

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**Individual transferable quotas and mixed fisheries: a bioeconomic modelling investigation applied to the New Zealand hoki fishery**

Paul Marchal

In theory, ITQs (individual transferable quotas) create incentives for fishers to maximize the value of their catch and minimize harvest costs. They also create, in principle, economic incentives to avoid catch of species the fisher does not have quota for. In mixed-species ITQ fisheries, fishers have a portfolio of catch rights, the catch plan. They are expected to operate their fishing operations in such a way that their resulting catch mix matches their catch plan as much as possible. Experiences from all around the world, however, have shown that fishers' species mixes of catch do not exactly match their portfolio of catch rights. Different systems have been implemented to compensate for this discrepancy, including discarding and/or charging over-quota fish landed, but such systems may have contributed to compromise fishery sustainability. We evaluate, using a bioeconomic modelling approach building on the ISIS-Fish software, the impact of ITQ on fleet dynamics and harvested resources in the case of the New Zealand hoki fishery.

Keywords: individual transferable quotas, deemed value, New Zealand hoki fishery.

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**ICES CM 2008/l:11**

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**Dynamics of small-scale patch use in fishers targeting several fish species**

Adiaan D. Rijnsdorp, Jan Jaap Poos, Floor J. Quirijns, and Reinier HilleRisLambers

The dynamics of the Dutch flatfish fishery targeting sole and plaice is analysed using logbook data on individual tows in combination with VMS position records. It is shown that flatfish occur in patches on a scale of ~100 km<sup>2</sup> that persist for 1–3 weeks. Fishers find these local patches by sampling the environment. Tows can be classified as either searching, sampling, or exploitation, based on the inter-tow distance. The catch rate during exploitation is well above the catch rate while searching. The sampling catch rate is slightly above the searching rate. Once a patch is found, fishers stay put and until the catch rate drops below a threshold level. Residence time on a ground matches the theoretical expectation based on the decline in catch rate and the searching time. Fishers respond to quota restriction by reallocating their effort to grounds with a high catch rate of other, less constrained species. The implications of fisher behaviour for management are discussed.

Keywords: fleet dynamics, flatfish, beam trawl, North Sea, VMS.

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**ICES CM 2008/l:12**

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**Performance of XSA with two separate tuning indices vs. one integrated index when exploitation varies spatially**

Sarah Kraak, B. M., Niels Daan, and Martin A. Pastoors

Fisheries effort distributions are subject to change for autonomous reasons and in response to management regulations. Ignoring such changes in the stock assessment procedure may lead to a biased perception. For example, the Dutch fishing industry has criticized the plaice assessments of ICES, because of a marked decrease in fishing for plaice in the northern North Sea and the introduction of the plaice box. Such gradual or abrupt regional changes might not be captured by the eXtended Survival Analysis (XSA) applied routinely in these assessments. The commercial catch data mainly reflect the intensively fished region, whereas the stock status in the less heavily fished region may only be reflected by the tuning series. We simulated a stock distributed over two regions with interregional migration and with different trends in exploitation. XSA estimated the true developments in the stock only if a single tuning index reflected the total abundance of the stock over the entire area. If the tuning index did not cover both regions or if two tuning indices each covered one region, estimates of fishing mortality and spawning–stock biomass were biased. The latter is likely to be the result of the automatic weighting procedure that is inherent in XSA. For the North Sea plaice example, this means that the three indices routinely used should be integrated into one before being applied in the XSA in order to provide an unbiased assessment.

Keywords: XSA performance, tuning indices, simulation study, North Sea plaice, spatial effort variation.

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**ICES CM 2008/l:13:**

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**Changes in the dynamics of the Norwegian mackerel purse-seine fishery—does it influence the representativeness of the reference fleet data?**

Irene Huse and Cecilie Kvamme

In the last three years, the peak period and the fishing area of the Norwegian mackerel purse-seine fishery has changed considerably as a result of the market situation. The Norwegian reference fleet was established to get better and continuous sampling from all the Norwegian fisheries. In all, 34 vessels are contracted and the crew trained to conduct sampling of the catches. The fleet includes both offshore and coastal vessels and since 2003 the number of purse-seine vessels has increased from one to five. In order to investigate whether the changes in the mackerel fishery will affect the representativeness of the data from the reference fleet we use data from the vessel monitoring system, landing statistics, and sampled data from the reference fleet. We compare the catch per unit effort (cpue) of the total fleet with the reference fleet, and look at the spatial and temporal overlap for the period 2005–2007.

Keywords: fisheries dynamics, mackerel, purse-seine fishery, reference fleet, representativeness.

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**ICES CM 2008/l:14**

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**A study of the economic drivers of investment in capacity applied to Basque fleets in the Western Waters (ICES Subareas VII and VIII)**

Leyre Goti, Raúl Prellezo, and Ane Iriondo

One of the main reasons for the endemic problem of overfishing in most of the world's fisheries is the overcapacity of the fleets. Various regulations have focused on capacity investment but its economic drivers, such as those of economic investment in general, are still not well known. At present, even if decommissioning schemes have decreased, there is nevertheless a considerable variability in fishing capacity that is left unexplained. The aim of this study is to identify economic drivers of investment/disinvestment in order to better understand the behaviour of the fishing firms and thus provide useful information for management. To pursue this, a variety of statistical and economic methods have been tested on the Basque fleets in the Western Waters area. Different methodologies are employed using firm and vessel level data. The inputs have been taken from a variety of sources such as survey and logbook data as well as some qualitative knowledge from ship owners and local credit institutions. Based on both revenue and cost data as well as characteristics of the vessels, an analysis has been made on the number of vessels bought/sold, considering also the type of vessel when possible. The methodologies have been evaluated on their capacity to explain the investment decisions with reference to changes in regulation and economic parameters.

Keywords: capacity, investment, economic drivers, Western Waters.

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**ICES CM 2008/l:15**

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**Modelling fishers' behaviour in the Mediterranean Sea using random utility models**

J. Haralabous, E. V. Tsitsika, and C. D. Maravelias

Knowledge of how fishers allocate their fishing effort in space and time is essential to understand how a fishery develops, and the relationship between catch rate and abundance. Understanding fishing strategies is also vital in predicting how a fishery might respond to proposed management changes such as effort or area restrictions, and in the formulation of management policy. Random utility models (RUMs) were used to examine the factors affecting fishers' choice behaviour in the northeastern Mediterranean Sea. The probability of selecting a specific fishing rectangle was estimated using monthly purse-seine fishery data. The RUM results revealed that the onset of the fishing trip, the fishers' previous experience, and temporal factors significantly affected the choice of fishing ground. The present study provided, for the first time in the Mediterranean Sea, direct evidence of the role that the fishers' behaviour could play in understanding the way the industry will respond to changes in the resource, market conditions, and management measures. As purse-seining constitutes one of the most important fishing methods in the eastern Mediterranean, the findings of the present study are discussed in the light of the need to incorporate additional quantitative information if improved fishery management scenarios are to be advanced.

Keywords: fishery dynamics, Mediterranean, purse seiners, RUM.

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**ICES CM 2008/l:16**

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**Fishing capacity assessment in the eastern Mediterranean purse-seine fisheries**

E. V. Tsitsika, C. D. Maravelias, and J. Haralabous

Excessive fishing capacity being responsible for the degradation of fishery resources and for significant economic waste is also globally recognized by resource managers as a major problem for fisheries. In the absence of total allowable catches (TACs) or quotas in the Mediterranean, the fishery management system depends heavily on technical measures and effort control programmes, including limited entry and decommissioning schemes. Estimates of fishing capacity and capacity utilization may provide helpful tools in designing an effective capacity management plan for the Mediterranean fisheries. Data envelopment analysis (DEA) was implemented to estimate capacity utilization and efficiency of the eastern Mediterranean purse-seiners. The two fleet segments were found to be operating below their capacity output level, indicating the existence of overcapacity. The 24- to 40-m segment was found to be more efficient than the 12- to 24-m fleet segment. Results suggested that purse-seiners could have increased their catch during the study period through increasing the variable inputs, for example days fished. An assessment of additional factors that might affect the capacity utilization in the fishery was performed using Tobit analysis. It was found that the crew size, the monthly average price of fish, and temporal factors significantly affected the capacity

utilization. In data-poor environments, such as the Mediterranean Sea, the DEA and Tobit models applied in this study provided useful insights into fleet capacity and efficiency assessment.

Keywords: capacity utilisation, Data Envelopment Analysis, efficiency, pelagic fishery, Tobit analysis.

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#### ICES CM 2008/l:17

##### **Estimation of nominal fishing effort of tropical tuna purse-seiners, with a Bayesian approach**

E. Walker, D. Gaertner, Ph. Gaspar, F. Mortier, R. Pianet, and N. Bez

The tropical tuna purse-seine fishery is characterized by two fishing modes: (i) free-swimming tuna schools and (ii) schools associated with floating objects, either natural or artificial fish-aggregating devices (FADs). The catch on FADs is composed of various tuna species (yellowfin, skipjack, and bigeye tuna) and of several associated species, such as sharks, small pelagic fish, etc. In contrast, the catch from free-swimming schools is mainly mono-specific (e.g. large yellowfin). The distinction between the two fishing modes is thus fundamental in the calculation of the fishing effort of tuna purse-seiners and should be taken into account when assessing the impact of fishing practices on the ecosystem. The aim of this study was (i) to identify each set and its corresponding fishing mode (i.e. free or FADs school) from individual trajectories of purse-seiners operating in the Indian Ocean with the aid of vessel monitoring system (VMS) data and (ii) to calculate the fishing effort associated with each fishing mode. Apart from vessels with observers aboard from which the model has been calibrated, the real activity of a vessel is not known (latent variable), leading to the use of a hidden Markov chains approach. To account for historical information on fishing behaviour (e.g. spatio-temporal strata with frequent FAD fishing operations), the model was developed in a Bayesian framework, allowing prior distributions of the parameters of the trajectory (step lengths, turning angles) and on the switching matrix. The performance of the model on fine-scale data (one position per 15 min) is analysed and compared with the actual VMS data (one position per hour).

Keywords: fishing effort, vessel monitoring system (VMS), hidden Markov chains, Bayesian approach, individual trajectory, tuna purse-seiners.

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#### ICES CM 2008/l:18

##### **The Spanish fishery on anchovy in the Bay of Biscay: analysis of the relationship between fishing capacity, effort, and mortality**

Andrés Uriarte, Raúl Prellezo, Antonio Punzón, Martín Aranda, and Begoña Villamor

The Spanish purse-seine fishery targeting anchovy has suffered a strong decline throughout the second half of the twentieth century. The relationship between fishing capacity, effort, and fishing mortality is suspected to be weak for purse-seines, given the catchability problems associated with these types of gear on small pelagic fisheries in other parts of the world. In this work we review this relationship for the Spanish purse-seines operating on anchovy in the Bay of Biscay since 1987. This is done by reviewing the dataserie of fishing vessels operating each year on anchovy, with their fishing characteristics defining their fishing capacity and the actual fishing calendar defining the effort, taking into account the standardization performed by generalized linear models (GLMs) in a former presentation. This series is coupled with a seasonal integrated catch-at-age analysis applied to the different fleets in the Bay of Biscay, in order to fit the best catchability model to this purse-seine fleet. The variability between fishing effort and actual catches and fishing mortality is high. The implications for the management of this fishery are discussed. This work was carried out as part of the CAFE project (EU project no. 022644).

Keywords: anchovy, purse-seiners, effort, capacity, catchability, fishing mortality.

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#### ICES CM 2008/l:19

##### **Direct estimation of catchability in a combined acoustic-trawl survey, with reference to fish spatial distribution**

M. Doray, S. Mahévas, and V. M. Trenkel

Few analyses have estimated catchability using the ratio between catches and acoustic densities. In summer 2006, acoustic and fishing data were collected simultaneously over three days by three fishing vessels equipped with identical semi-pelagic trawls during a scientific survey (CHAPAUV'06) in the Bay of Biscay. These data were used to compute direct diel catchability estimates for selected demersal species and to relate them to the fish assemblage spatial structure. Trawl hauls were first classified based on their species composition by correspondence analysis and *K*-means clustering. For this study, we focused on hauls consisting mainly of hake, mixed with horse mackerel and whiting. Acoustic backscattering densities expressed as nautical areal scattering coefficients (NASC) recorded in the trawled layer were compared with equivalent NASC (ENASC) calculated from the species composition in the trawl, their length structure, and available target strength-length relationships. Significant linear relationships were found between ENASC and NASC during daytime ( $ENASC = 0.003 * NASC$ ,  $R^2 = 0.82$ ) and night-time ( $ENASC = 0.016 * NASC$ ,  $R^2 = 0.73$ ), respectively. The absence of significant horizontal spatial autocorrelation in the acoustic data suggests that estimated catchability coefficients probably reflect fish vulnerability to the trawl rather than availability, as the individuals were more or less randomly distributed in space.

Keywords: catchability, availability, spatial distribution, acoustics, pelagic trawl, hake, Bay of Biscay.

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## ICES CM 2008/l:20

### Small-scale estimates of the biological and technical components of catchability

Stéphanie Mahévas, Verena Trenkel, and Mathieu Doray

Trawl catchability is thought to be affected by two processes: those linked to the technical characteristics of the fishing gear/vessel and human factors such as experience or strategy and those linked to the biology of the exploited resources, such as variations in fish distribution or vulnerability to the gear. The objectives of this study were to assess the respective contributions of human and technical aspects of the exploitation process on one hand, and factors linked to the biology of the exploited population on the other hand. Using generalized linear models, we first estimated the technical and human factors affecting catchability by exploring the links between these factors and the landings per unit of effort (LPUE from logbooks) of French trawlers catching hake (*Merluccius merluccius*) in ICES Subdivision VIIIa. The amount of remaining variations in catchability explainable by biological traits was subsequently estimated. We were particularly interested in assessing to what extent the catchability was affected by variations in the fish spatio-temporal distribution when technical and human factors were controlled. To focus on the biology, we carried out a survey using three nearly identical fishing trawlers in parallel ('CHAPAUV-Trawlers'06'). We conducted this survey in a small homogeneous area in the northern part of the Bay of Biscay during July 2006. The three commercial vessels belonged to the fleet studied previously. Generalized linear mixed models were used to relate catch rates to spatio-temporal variations in the targeted fish community. We explored the influence of fish diel behaviour (small-scale spatio-temporal variations, e.g. position in the water column, temporary aggregations), as well as effects of broader scale process (e.g. between-day variations).

Keywords: catchability, accessibility, fishing power, spatial distribution, beam trawl, GLMM.

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## ICES CM 2008/l:21

### Standardizing fishing effort according to technical characteristics requires an assessment of the fisher's skill contribution in catchability estimates

Stéphanie Mahévas, Youen Vermard, Trevor Hutton, Ane Iriondo, Angélique Jadaud, Christos Maravelias, Antonio Punzón, Jacques Sachi, Alex Tidd, and Effie Tsitsik

The impact of fishing effort exerted by a vessel on a population depends not only on the vessel's fishing power (efficiency) and the gear's selectivity but also on population accessibility. The coefficient linking fishing effort and fishing mortality is called catchability. In this study we focused on fishing power and we investigated whether the variation in fishing power could be linked to technical characteristics of the vessel and the gear (such as vessel's tonnage, vessel's length, electronics, etc.), or were a reflection of inter-vessel differences not accounted for by the technical information. In this case, variation in fishing power could indicate the presence of a crew-skipper effect. A crew-skipper effect can be detected when the experience of the skipper and the crew (their fishing methods and short-term harvesting strategies) are likely to contribute significantly to the overall catchability of the vessel. First, we tested the hypothesis that the variations in fishing power were linked to spatial and temporal strata, possibly corresponding to common fleet fishing tactics. Then, we assessed the relative contributions of the crew-skipper vs. technical characteristics effects in fishing power. To do so, we related landings per unit of effort (LPUE) from logbooks to technical

information on vessels and gears collected during interviews of fishers using generalized linear models (GLM). We conducted this analysis on several European fleets for one of their targeted species. We derived some specific and generic conclusions on the robustness of fishing effort standardization based on GLM, comparing the magnitudes of crew–skipper effects and purely technical effects.

Keywords: catchability, fishing power, technical characteristics, skipper skill, GLM.

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#### ICES CM 2008/I:22

### **Integrating Random Utility Model fit in ISIS-Fish to simulate the dynamics of the Anchovy fishery of the Bay of Biscay**

Youen Vermard, Sigrid Lehuta, Stéphanie Mahévas, Olivier Thébaud, Paul Marchal, and Didier Gascuel

Fisheries in the European Union (EU) are mostly managed using single-species total allowable catch (TAC) and technical measures derived from single-species assessment models. This management system has repeatedly been criticized for not reaching the objectives of resource conservation. These criticisms have led managers to provide alternative management schemes regulating inputs rather than outputs, such as fishing effort and/or capacity. Whatever the management regime, the success or failure of actions with regard to objectives are conditioned both by the dynamics of the population and by the exploitation dynamics, particularly the response of the fleet to management measures. ISIS-Fish is a spatially and seasonally explicit simulation tool designed to explore how management measures affect mixed fisheries, including fishers' reactions to management. ISIS-Fish has already been used to simulate the pelagic fishery in the Bay of Biscay. The model describes the dynamic of the anchovy (*Engraulis encrasicolus*) population and its exploitation but the effort allocation was static (corresponding to the average historical pattern). To fill this gap, we developed a fleet dynamic model simulating métier choice using random utility modelling (RUM), including trip components (a lagged value of the main species caught, lagged percentage of effort spent in the different métiers, inertia to change from one métier to another). We present here the integration of this fleet dynamics model of the French pelagic fishery into ISIS-Fish and assess the contribution of this more realistic fleet dynamic model in the analysis of TACs, marine protected areas, and effort regulation on the pelagic fishery.

Keywords: ????

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#### ICES CM 2008/I :23

### **Modelling spatio-temporal effort allocation and size-dependent discarding in a mixed fishery with individual catch and effort quotas**

Jan Jaap Poos, J. A. Bogaards, Darren M. Gillis, and Adriaan D. Rijnsdorp

Management of European fisheries aims to safeguard the fish stocks under exploitation by reducing fishing mortality. Such a reduction in fishing mortality is attempted by putting constraints on the total landings of species or the fishing effort of fishing fleets. Owing to the mixed nature of the fisheries, the effects of such constraints may be reduced by the response of the fleet through changes in the effort distribution in space and time or discarding. Viewing the response of a fishing fleet as the sum of the decisions of all individuals, aiming to maximize profit, helps to understand the effects of the constraints. In this study, we analyse effects of landings and effort quota on the fishing behaviour of the Dutch beam trawl fleet, targeting sole and plaice using simulation models. In these models, the size structure of the fish population and the migration patterns are taken into account. Both stocks are managed by annual TACs, divided in quotas for individual vessels. In this system, a vessel has to take into account meeting the quotas for both species, given the realized landings in a sequence of decisions on effort allocation and discarding. Dynamic state variable models are a way of modelling this situation. We study whether discarding and effort reallocation disrupts the linkage between effort and landings, which may bias our perception of the fish stocks and negatively affect the quality of the management advice.

Keywords: bottom trawl, quota regulations, catch/effort, discarding.

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**ICES CM 2008/l:24**

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**Appropriate effort metrics for bycatch estimation**

Simon Northridge, Al Kingston, and Alice Mackay

Measures of fishing effort may be poorly recorded in logbook data, as detailed effort statistics are often not legally required. Increasingly, detailed effort statistics are becoming key factors in improving the accuracy of estimates of bycatch as well as for regular stock management purposes. We have collected detailed effort data among several UK fleets for over ten years, notably static gear and pelagic trawls. We use these data to explore how more accurate estimates of fishing effort can be obtained rather than relying solely on logbook data. We assume that logbook data can be used to estimate the number of days spent at sea by any fleet sector, and we provide measures of the variability of fishing effort among static gear and pelagic trawl sectors with respect to days at sea. In each case we examine the suitability of several different effort metrics as potential denominators for raising observed bycatch rates to fleet estimates. These metrics include days at sea, number of hauls, net length, and soak or tow duration time. We have also tracked trends in fishing effort among static net fleets that may be obscured by a reliance on just logbook data. We propose standard metrics for cetacean bycatch estimation in each of the fisheries that we have observed and suggest ways in which these data might usefully be recorded in future.

Keywords: bycatch; quantifying fishing effort; observer schemes.

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**ICES CM 2008/l:25**

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**Small-scale pattern in the allocation of fishing effort in the Scottish pelagic fishery: a view from different landscapes**

D. G. Reid, P. J. Copland, F. Armstrong, and M. J. Stewart

Fishing effort is generally seen in terms of hours or days fished by a vessel or group of vessels within a given métier. The spatial allocation of that effort is usually at the level of the ICES rectangle and based on landings declarations. In the present study we have made use of acoustic logging systems installed on a number of vessels in the Scottish pelagic fleet operating in the summer herring fishery. The loggers provide information on date, time, and position from GPS at a 1- to 2-second resolution. Most importantly, they also collect echogram information from the vessel's echosounder. This shows what fish aggregations are being seen by the vessel during its operations. We present an analysis of the fine-scale (minute-to-minute) pattern of the vessel's activity, partitioned into fishing, pumping, steaming, and scouting. The research also includes analysis of the fish schools seen by the vessels echosounder. The echograms were analysed and herring school information extracted (e.g. school height, width, and echo integral). The movements and fishing operations are then analysed in the context of the landscape of the overall herring distribution seen during the acoustic survey conducted by Fisheries Research Services at the same time as the fishery. They were also analysed in the context of a landscape based on the type of schools the vessels actually prosecuted, rather than the total stock distribution. The findings will be discussed in relation to the vessel's choice of location and typology of target schools, together with inferences on the choices made in the spatial allocation of commercial fishing effort in the Scottish herring fishery.

Keywords: herring, commercial vessels, acoustics, effort allocation.

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**ICES CM 2008/l:26**

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**Vessel characteristics, fishing power, and the development of fishing effort in the Wash (UK) brown shrimp fleet from 1989 to 2004**

A. R. Lawler and M. T. Smith

Brown shrimp fisheries in the southern North Sea are important for a number of countries, but rapid growth, high mortality rates, and short lifespan make assessment difficult. The ICES Working Group on Crangon Life History and Fisheries has used landings per unit effort (lpue) series as abundance indices and assembled a time-series of total international fishing effort adjusted by vessel engine power (ICES, 2004). However, little work on fishing power for brown shrimp vessels has been published. We investigated relationships between vessel characteristics and fishing power for UK Wash shrimp vessels using linear models and described fleet capacity and fishing effort trends. Many vessel characteristics were highly correlated with each other and generally indicative of vessel size, which was strongly related to fishing power. Vessel breadth featured most strongly in the best fitting models, although engine power was usually less significant. In recent years, fishing

power adjusted effort was higher than unadjusted effort, but changing time units to hours fished, rather than days, was a major factor in this, as well as the adjustment for fishing power. The latter reflected some increasing vessel size, with larger vessels tending to fish more days and more hours per day. An investigation of fishing power should be considered integral to the use of effort and lpue time-series, although for pragmatic reasons it may not always be possible to apply the “best” fishing power adjustments, particularly when combining effort series from different sources.

Keywords: Crangon, brown shrimp, fishing power, fishing effort.

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ICES CM 2008/l:27

Poster

### Cod-end selectivity of diamond (40 mm) and square mesh panel (36 mm and 40 mm) bottom trawl for whiting (*Merlangius merlangus euxinus*, N.) off the western Black Sea coast of Turkey

Süleyman Özdemir and Yakup Erdem

This study investigates effect of square mesh escape window installation on selectivity of bottom-trawl codends for whiting (*Merlangius merlangus euxinus*, N. 1840) in the Western Black Sea. Codend mesh selectivity experiments were carried out using 40 mm nominal diamond mesh PE codend with 36 mm and 40 mm mesh size square mesh panel inserted in the forward part of the top panel. The experiments were carried out in the Western Black Sea between February and March 2005 on a traditional fishing boat. In all, six valid hauls were made using a hooped covered codend method. Mean  $L_{50\%}$  and selection ranges of whiting were found as 12.56 cm (se 0.31) and 3.46 for 40 mm nominal diamond mesh, 12.73 cm (se. 0.35) and 3.12 for 36 mm square mesh panel and 13.54 cm (se 0.34) and 3.70 for 40 mm square mesh panel, respectively. Comparison of the results with those obtained in other studies carried out in the same area using conventional codends show that the use of square mesh panel (40 mm) in the forward part of the top panel increases the escape of juvenile whiting.

Keywords: Black Sea, whiting, codend selectivity, square mesh panel, bottom trawl.

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ICES CM 2008/l:28

Poster

### Incorporating uncertainty into management—an INEXFISH approach

Catherine L. Scott and Sture Hansson

Scientific advice is provided to try to ensure that fish spawning–stock biomass (SSB) is maintained at a sufficiently high level, such that recruitment is not impaired. This biomass constitutes a management reference point called  $B_{lim}$ —the minimum SSB. A complementary reference point could be  $R_{lim}$ —the expected recruitment produced at  $B_{lim}$  at average environmental conditions. By and large, current scientific advice does not take into account the effects of environmental variability in setting reference points. Where recruitment can be predicted from SSB and environmental data using objective-criteria selected metrics, the biomass of spawners required to produce  $R_{lim}$  under different environmental conditions can be derived. New management reference points allow more sustainable exploitation of the ecosystem and potentially better knowledge of required effort levels. To ensure that  $R_{lim}$  is achieved, uncertainty—both in data and in the understanding of the relationships—should be considered. The use of prediction intervals allows the consideration of this uncertainty in order to provide honed advice.

Keywords: metrics, uncertainty, management, methodology.

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ICES CM 2008/l:29

Poster

### A bioeconomic evaluation of quota for the management of the Peruvian Hake fishery

Humberto Olivera, Elsa Galarza, Edward Barriga, Carlos Salazar, Jaqueline Palacios, and Rashid Sumaila

The focus of this paper is examine the trade-offs between variable and fixed quota in terms of the economic benefits and biological risks in such a variable fishery. The Peruvian hake (*Merluccius gayi peruanus* Guilchenot, 1848) fishery is Peru’s most valuable commercial demersal fishery, but it was overexploited in the 2000s and, despite reduction of catches, it has not yet recovered. Since 2004, free access to the fishery has been restricted by an individual non-transferable quota system. A total allowable catch is established annually

by the Fisheries Ministry, based on recommendations from the Peruvian Marine Research Institute, and distributed to the individual ship owners. In the last four years, around 40 trawl vessels have caught about 25 000 t of hake per annum, valued at about US\$10 million. This paper reports the results from a bioeconomic model developed to allow evaluation of a range of possible future management regimes, including individual transferable quotas. The biological and economic reference points determined by the Gordon–Schaefer model using maximum likelihood showed that the commercial coastal fleet has harvested more fish than the maximum economic yield during 1995–1997 and 2000–2001. Their catches have also exceeded the maximum sustainable yield during 1995–1997 and 2001. By integrating the known biological data with cost and revenue information, and applying non-linear optimization, we have produced ten-year steady state solutions for alternative management options. Although the analysis indicates significant economic benefits to a move to quota, it also shows the need to assess trade-offs between maximizing net economic returns and biological risks carefully.

Keywords: bioeconomic modelling, fishery management, Peruvian hake.

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ICES CM 2008/l:30

Poster

### **The anchovy fishery in the Bay of Biscay I: description and analysis of the Spanish fleet (2000–2005)**

Begoña Villamor, Martín Aranda, Antonio Punzón, Andrés Uriarte, and José Carlos Báez

The anchovy fishery in the Bay of Biscay has historically been one of the main economic resources for fishing communities along the shores of the Cantabrian Sea, supporting a significant associated canning industry. The resource is subject to active assessment and development of management plans in international scientific forums such as ICES. The nature of anchovy itself, a short-lived species with high natural mortality, often makes its management difficult owing to considerable interannual fluctuations in recruitment. Recent ICES assessments have classified the Bay of Biscay anchovy stock as a stock at biological risk of having a reduced reproductive capacity and very low levels of abundance, and has therefore recommended the closure of its fishery (2005–2007). In this context, precise identification of the components of the fleet involved in the fishery, its behaviour, and its relationship with the abundance of the resource is urgently required. To provide this information, a description of the Spanish fleet targeting anchovy in the Bay of Biscay is presented. The objective is to supply information useful for more robust management in accordance with the criteria of sustainability. This work was carried out as part of the CAFE project (EU project no. 022644) and is based on the CAFE EFLALO database (effort and landings based on combined logbooks and sale slips), which covers all purse-seiners based in the Cantabrian and Basque harbours that have had activity for at least a year during the spring seasons 2000–2005. The database contains information per vessel at a trip level, including landing weights and values by species, technical characteristics of the vessels, and fishing location (ICES rectangle).

Keywords: anchovy, fisheries, Bay of Biscay.

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ICES CM 2008/l:31

Poster

### **A transparent precautionary approach to harvest control rules**

Alberto G. Murta and William Silvert

A problem with the precautionary approach is that stakeholders often disagree on how much precaution is necessary. It may help to separate the technical aspects of stock assessment from more controversial issues of health and resilience of stocks, especially in the light of the growing uncertainty associated with climate change and other environmental issues. We therefore developed a two-step approach to setting harvest control rules based on fuzzy logic. Step one is to set a maximum acceptable total allowable catch (TAC) based on standard statistical methods. Step two represents the health of the stock by an index between 0 and 1, indicating how much the catch should be reduced from the maximum acceptable TAC to maintain viability of the stock. This index is zero for a stock in danger of collapse, one for a healthy stock that can support full exploitation, and takes intermediate values for stocks somewhat at risk. Calculation of the index includes all relevant factors, whether they are measurable environmental variables or qualitative expert opinions. Although this approach will not resolve all of the fundamental issues over which managers and stakeholders disagree, it can focus the assessment process on a single factor that is intuitively meaningful to all participants, including the fishing industry, NGOs, and consumers. It may therefore help to reduce some of

the tension and conflict which have long been obstacles to good fishery management and which appear to be increasingly evident as the general population becomes more familiar with the concept of ecosystem health.

**Keywords:** fisheries stock assessment, fuzzy logic, harvest control rules, precautionary approach, uncertainty.

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