Theme Session Y

Reference Point Approaches to Management within the Precautionary Approach

ICES CM 2003/Y:01

Reference point approaches for precautionary management of fishing to avoid impacts on top predators

Robert W. Furness

Harvesting reduces fish stock size. One biomass limit reference point may be set by the need to maintain satisfactory recruitment. However, where an exploited fish stock is also a key food for wildlife, another limit reference point might be set based on the food needs of dependent predators. One approach may be to consider through bioenergetics models the quantity of food required to sustain wildlife populations. Another may be to consider the density of food required by top predators in order to permit profitable foraging. By examining empirical data, I conclude that considering bioenergetics estimates of the quantities of food required by top predators is inadequate to set reference points. Top predators such as marine mammals and seabirds generally consume only a very small fraction of food stocks, but show population declines or breeding failures when food stocks remain far above the minimum amount predators need to eat. Much more importantly, the density of the prey field for foraging predators is a crucial factor affecting their foraging performance. Such effects on foraging can be measured to determine reference points that could be used in fishery management to avoid fishery impacts on dependent wildlife. It is possible to identify aspects of predator ecology most likely to require high densities of food to permit economically profitable foraging. Identification of 'sensitive' species of seabirds and marine mammals permits development from empirical studies of reference points that would act in a precautionary way to protect the broad community of dependent wildlife.

Keywords: fishery management, conservation, *Ammodytes marinus*, industrial fishing, predator-prey interactions, functional response, seabirds, marine mammals, black-legged kittiwake.

R. W. Furness: Graham Kerr Building, University of Glasgow, Glasgow G12 8QQ, UK [tel: +44 141 3303560, fax: +44 141 3305971, e-mail: r.furness@bio.gla.ac.uk]

ICES CM 2003/Y:02

Environmental variability and the precautionary approach: the Baltic cod case

Stuart Reeves

The processes affecting recruitment to the Eastern Baltic cod stock are arguably amongst the most closely studied and well understood of any major commercial fish stock, and it would seem desirable that this information should be used in specifying precautionary reference points for the stock. However, PA reference points are typically defined with reference to avoiding recruitment overfishing, whereas the results of recruitment process studies often demonstrate that the effects of environmental influences, can be at least as important as the stock size in determining recruitment. This makes it difficult to define reference points associated with recruitment overfishing as there is no single stock size below which recruitment is depleted.

This paper develop a model of stock and environmental influences on the recruitment of Baltic cod then uses this model in stochastic projections to explore approaches to establishing precautionary reference points for this stock. These approaches may also have application for other stocks where environmental effects have a major influence on recruitment.

S. A. Reeves: Danish Institute for Fishery Research, Department of Marine Fisheries, Charlottenlund Slot, DK-2920 Charlottenlund, Denmark [e-mail: sar@dfu.min.dk]

ICES CM 2003/Y:03

Evaluation of candidate management plans, with reference to North-East Arctic Cod

Dankert W. Skagen, Bjarte Bogstad, Per Sandberg, and Ingolf Røttingen

We here discuss the scope, nature and quality standards of simulation models that may be used in order to evaluate proposed or candidate management plans, including their parameters (reference points). A recently proposed management plan for North-East Arctic cod is used as a working example.

We discuss some generic designs of management plans, in particular with respect to performance in relation to different kinds of objectives, including adherence to the precautionary approach. We further discuss simulation tools to evaluate the performance of management plans and to select appropriate values for their key parameters, and suggest some quality criteria for such tools. In particular, we stress the need to have unbiased stochastic parameters and to have realistic levels of errors in the basis for future decisions according to the plan.

A new management plan for North-East Arctic cod (*Gadus morhua*) was agreed by the management agency (Joint Norwegian/Russian Fishery Commission) in 2002. The main elements in this plan are:

- Estimate the average TAC-level for the 3 following years based on F_{pa}. TAC for the following year is set on the basis of this average TAC level.
- The following year the estimation of the TAC-level for the next 3 years is repeated based on updated information on stock development. However, the change of TAC from one year to the next cannot be more than +/-10%.

This relatively complex plan is used as an example, and aspects that need to be considered in order to evaluate how it can be expected to perform, are discussed.

D. W. Skagen, B. Bogstad, P. Sandberg, and I. Røttingen: Institute of Marine Research, P. O. Box 1870, N – 5817 Bergen Nordnes, Norway [tel: +47 55 23 84 19, fax: +47 55 23 86 87, e-mail: dankert.skagen@imr.no]

ICES CM 2003/Y:04

The language of fishery management advice offered by ICES

Per Sandberg, Ingolf Røttingen, and Harald Gjøsæter

Since the establishment of the Exclusive Economic Zones in the mid-1970s, several exploited fish stocks in the Northeast Atlantic have been managed by total allowable catch (TAC). The advice on annual levels of TAC, as offered by ICES, has been given on certain assumptions as to what the objectives of the fishery management agencies might be. These objectives have seldom been stated explicitly by fishery management agencies, and the language of the advice has been subject to alternative interpretations. In this paper, we discuss the language of ICES' advice, and offer some suggestions on how to improve communication between ICES and relevant fishery management bodies, NGOs, and the general public.

Keywords: Fishery management, precautionary reference points, language of advice.

P. Sandberg: Directorate of Fisheries, Box 185, 5804 Bergen, Norway [tel: + 47 55 23 69 86, fax: + 47 55 23 86 87, e-mail: per.sandberg@imr.no]. I. Røttingen and H. Gjøsæter: Institute of Marine Research, Box 1870, 5817 Bergen, Norway [tel: +47 55 23 84 04, fax: +47 55 23 86 87, e-mail: ingolf.rottingen@imr.no and harald.gjosaeter@imr.no]

ICES CM 2003/Y:05

A framework for communicating qualities of indicators

Kjellrun Hiis Hauge, Hilde Elise Heldal, Erik Olsen, and Hein Rune Skjoldal

There is a growing focus on ecosystem-based indicators and what qualities they need to satisfy. However, the qualities and the characteristics of the already existing indicators vary substantially. Due to both scientific and societal aspects, so will the future indicators. With a growing interest for participatory decision processes it is crucial that scientific advice or knowledge based on these indicators is transparent. Advice should therefore be presented in such a way that a

manager or a citizen is able to judge the rigidity and the relevance of the scientific information. This will also improve the communication of uncertainty. A common framework for presenting indicators could clarify such aspects by addressing qualities associated with the scientific knowledge and societal concerns. Some relevant qualities are how well an indicator is able to detect a man-made change, the rigidity of the scientific knowledge, how well an indicator threshold reflects a danger, how useful an indicator is for decision-making and the characteristics of the uncertainty. In this paper we discuss what features should be addressed in the communication of scientific knowledge and how this can be communicated through a general framework. The framework and the discussion of its content will be illustrated by case studies on measured technetium-99 levels in lobster and on Ecological Quality Objectives (EcoQOs) for commercial fish stocks and harbour porpoise by-catch.

Keywords: Characteristics, indicators, qualities, uncertainty.

K. H. Hauge, H. E. Heldal, E. Olsen, and H. R. Skjoldal: Institute of Marine Research, P.O. 1870 Nordnes, N-5817 Bergen, Norway [tel: +47 55 23 85 90, fax: + 47 55 23 86 87, e-mail: kjellrun@imr.no, erik.olsen@imr.no, hein.rune.skjoldal@imr.no]

ICES CM 2003/Y:06

The fragility of precautionary reference points

Kjellrun Hiis Hauge

A basic idea in fisheries management is that a fishery should be managed so that there is sufficient spawning stock biomass left to reproduce after the following year's fishing. An essential task for the scientists has thus been to predict spawning stock one to two years ahead. The focus on precautionary approach in fisheries management is an expression of a will to be careful with the marine resources by taking into account the uncertainty in science. The fisheries science community has responded by designing precautionary reference points to reflect the state of the stock and the uncertainty in the predicted spawning stock biomass and fishing mortality rate. However, experience has shown that this has not become the intended success. In this paper I argue that the precautionary reference points do not communicate uncertainty adequately. The system of reference points is static regarding the communication of uncertainty, it is an inefficient way of communicating uncertainty, it only reflects part of the total uncertainty in advice and it is value-laden as it is not transparent regarding underlying assumptions. In addition, the ACFM advice on catch options communicates an incorrect precision level and contradicts the precision level reflected by the reference points. ICES should therefore rethink the concept on how to communicate fisheries-related advice that is more robust and more in accordance with the precautionary approach. The solution to the mismatch between quantified uncertainty and the total uncertainty could be to partly move the focus from quantified uncertainty to qualitative perspectives of the uncertainty. I include some suggestions that should be further explored.

Keywords: Precautionary reference points, uncertainty, uncertainty characteristics.

K. H. Hauge: Institute of Marine Research, P.O. 1870 Nordnes, N-5817 Bergen, Norway [tel: +47 55 23 85 90, fax: + 47 55 23 86 87, e-mail: kjellrun@imr.no]

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ICES CM 2003/Y:08

A model of aggregate biomass tradeoffs

Jason S. Link

Multi-species and ecosystem-based approaches to fisheries management provide alternate and complimentary views of fishery ecosystems. This work provides an example of the need to consider species interactions when evaluating and establishing management goals. Given the caveats of scale and variability, there is a finite amount of biological production within ecosystems. These carrying capacity limits to all levels of biomass production can lead to difficult choices about the allocation of production and biomass among commercially valuable finfish. I present a model based upon the functional guild approach to explore various scenarios for a hypothetical food web, roughly analogous to the finfish community of the U.S. northwest Atlantic. The model, an extension of simpler production models, has both ecological and abiotic constraints and accounts explicitly for predation, competition, and harvest. Model simulations show greater stability of biomass at the guild level when compared to the species level, irrespective of species

composition within a guild. Individual species biomasses within a guild are typically much more dynamic. Fishing and abiotic conditions are the more dominant factors changing total guild biomass when compared to internal ecological dynamics. Scenarios with excessive fishing demonstrate a tendency to forego biomass relative to the potential carrying capacity in an ecosystem. These simulations mimic observations of the U.S. northwest Atlantic finfish community from the past 40 years. Using aggregate models such as the one presented here will generally provide more conservative harvest reference points and are likely to be valuable tools for further implementation of the precautionary approach.

Keywords: trophic dynamics, production models, multi-species, reference points, fishery management.

J. S. Link: National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543, USA [tel: +1–508–495–2340, fax: +1–508–495–2258, e-mail: jason.link@noaa.gov]

ICES CM 2003/Y:09

Ranging year-class strength and survival rates during early life history of the Barents Sea food fishes to establish biological reference points and evaluate environmental effects

M. V. Bondarenko, A. S. Krovnin, and V. P. Serebryakov

Survival index (SI) of a year class in early life history is defined as the ratio of abundance of fish at age 3 to population fecundity (PF), or to the spawning stock biomass (SSB). SI is considered here to be an integrated indicator of survival conditions during early life, i.e., periods of egg, larval and fry development.

Ranking of SI by means of cluster analysis revealed three types of survival conditions – favourable, moderate and unfavourable. The corresponding values of SI (*10–6) to these three types of conditions were estimated in spring spawning Norwegian herring as 152.49, 28.27, 4.97; in Northeast Arctic cod – 16.94, 6.40, 3.05; in Northeast Arctic haddock – 24.18, 8.55, 2.00; and in Greenland halibut of the Barents Sea – 219.29, 101.24, 45.60. Regression equations were obtained describing dependence of recruitment on spawning stock size in three types of survival conditions for each of the stocks considered. Three levels of PF and SSB - safe, minimal required acceptable and critical were calculated correspondingly to the types of survival conditions in the food fish populations studied.

An attempt was made to collate long term changes in survival conditions (logarithm of SI) with the same of some indicators (three main components) of ambient conditions in the ocean (IO). There is a good correspondence between shifts in the state of climatic characteristics and SI of most North Atlantic fish stocks on decadal and interdecadal time scales. However, the significant relationships between SI of spring spawning Norwegian herring, Northeast Arctic cod and haddock ranged into three groups of years corresponding to favourable, moderate and unfavourable survival conditions and basin-scale and regional climatic indices were not found. The local oceanographic conditions (wind mixing, local eddy structure, vertical fluxes, etc.) should be also taken into account.

Keywords: Abundance of fish, ambient conditions, Barents Sea, fecundity, spawning, survival index, decadal and interdecadal time scale, North Atlantic Oscillation.

M. V. Bondarenko, A. S. Krovnin, and V. P. Serebryakov: All-Russian Federal Research Institute of Fisheries and Oceanography, V. Krasnoselskaya, 17, Moscow 107140, Russia [tel: +7 (095) 264 90 43,264 84 01, fax: +7 (095) 264 91 87, e-mail: ontogeny@vniro.ru, akrovnin@vniro.ru, vserebryakov@yahoo.com.au]

ICES CM 2003/Y:10

Evaluation of the use of segmented regression through simulation for a characterisation of the North Sea cod (*Gadus morhua* L.) stock, in order to determine the properties of B_{lim} (the biomass at which recruitment is impaired)

C. M. O'Brien, L. T. Kell, and M. T. Smith

A new objective technique to determine the level of biomass (B_{lim}) at which recruitment is impaired based upon a segmented (or piecewise linear) regression has previously been proposed and developed by O'Brien and Maxwell. The formal statistical details of the approach are presented; together with hypothesis tests and goodness-of-fit statistics, and the approach evaluated for a characterisation of the North Sea cod (*Gadus morhua* L.) stock. This paper computes the values of B_{lim} obtained by segmented regression for a simulated stock based upon North Sea cod. The properties of the estimates are explored for a variety of hypotheses about stock dynamics (e.g., stock-recruitment) and data quality (e.g., discarding and mis-reporting). In particular, the robustness of the method to underlying assumptions is evaluated.

Keywords: Uncertainty, precautionary approach, evaluation, reference points, cod, segmented regression.

C. M. O'Brien, L. T. Kell, and M. T. Smith: The Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, UK [tel: +44 (0) 1502 524257, fax: + 44 (0) 1502 513865, e-mail: l.t.kell@cefas.co.uk]

ICES CM 2003/Y:11

Performance of management advice on North Sea fish stocks using a precautionary approach

G. J. Piet and J. C. Rice

For seventeen stocks in the greater North Sea (ICES Area IV, IIIa and IIIb, VIId and e, and part of VIa) the performance and effectiveness of management advice using a precautionary approach was evaluated. Three criteria were used to identify whether a stock was within safe biological limits: respectively SSB < B_{pa}, F > F_{pa} or SSB < B_{pa} and F > F_{pa}. Four scenarios were considered using the 2002 assessment output: (1) stock outside safe biological limits, advice to reduce fishing (2) stock outside safe biological limits, advice for status quo harvesting (3) stock within safe biological limits, advice to reduce fishing (4) stock within safe biological limits, advice for status quo (or increased) harvesting. Signal detection theory was applied to these scenarios and proportion of Hits (1 and 4), Misses (2) and False Alarms (3) were determined per year as the proportion of the stocks for which the respective scenarios applied.

Using both B_{pa} and F_{pa} was deemed the most precautionary approach and resulted in the about same proportion "Hits" in management advice as when using B_{pa} alone (62%) but the proportion "Misses" was slightly lower (24% instead of 26%). Therefore the suggested EcoQ element would be the "proportion of commercial fish stocks within safe biological limits (i.e., SSB > B_{pa}, and F < F_{pa})" and the objective (EcoQO) should be that this EcoQ should be at or above a desired level. This desired level is a societal/political decision relative to the EcoQ reference level (i.e., where the anthropogenic influence on the ecological system is minimal), which by definition is 100%. At present probably less than 10% of the North Sea stocks is within safe biological limits in spite of the relatively high "Hit" rate of over 60%. A possible explanation is that most of these stocks (e.g., flatfish and roundfish) are caught in a mixed fishery for which TAC management is less effective.

Keywords: Stock assessment, EcoQO framework, TAC management.

G. J. Piet: Animal Sciences Group, Wageningen UR, Netherlands Institute for Fisheries Research (RIVO) P.O. Box 68, 1970 AB IJmuiden, The Netherlands.[e-mail: gerjan.piet@wur.nl]. J. C. Rice: Canadian Science Advisory, Fisheries and Oceans, 200 Kent Street, Stn. 12S015, Ottawa, Ontario K1A OE6, Canada [e-mail: ricej@dfo-mpo.gc.ca]

ICES CM 2003/Y:12

Some ideas on how to translate the Precautionary Approach (PA) in a better way in the management advice

Jan Birger Jørgensen

Since ICES in 1999 implemented the Precautionary Approach (PA) in its management advice for fish stocks, a fish stock has been characterized to be outside safe biological limits in case the spawning stock biomass (SSB) is assumed to be below B_{pa}. Correspondingly, the stock is characterized to be harvested outside safe biological limits if the fishing mortality is assumed to be above F_{pa}. The Norwegian Fishermen's Association find that it is a strong weakness connected to the use of the terminology "harvested outside safe biological limits" in situations when the spawning stock biomass for a specific stock, is in a good condition. On that basis we disagree using the terminology "outside safe biological limits" for stocks where the SSB is well above the precautionary reference point, and a good recruitment for the stock is confirmed. The new reference points for several fish stocks developed by ICES are not flexible enough for the management authorities. In some situations it may also, from a biological point of view, be correct to accept a fishery which implies a fishing mortality above the adopted F_{pa}. The Norwegian Fishermen's Association is of the opinion that the terminology "outside safe biological limits" exclusively should be used to describe situations when the spawning stock biomass is below some critical reference points. We further disagree that ACFM today uses a static limit for F_{pa}, without looking at the level of the spawning stock biomass. The level of the F_{pa} should be a function of the level of the SSB. The Norwegian Fishermen's Association also finds it important to develop more specific management strategies.

Keywords: fish stock, reference points, outside biological limits.

J. B. Jørgensen: The Norwegian Fishermen's Association, Pirsenteret, 7462 Trondheim, Norway [tel: +47 73545850, fax: +47 73545890, e-mail: jan.birger.jorgensen@fiskarlaget.no]

ICES CM 2003/Y:13

Optimization of a Structure of the Spawning Stock of the Northeast Arctic Cod is a Key to its Rational Exploitation

V. L. Tretyak

A model of recruitment of a commercial cod stock has been worked out for two sufficiently long historical periods of fishery: 1952–1967 and a period after 1978. The basis of the model is an idea on the non-stationary process of recruitment as an random function along the entire discussed times series (1952–2000) and on the elementary components of a spawning population, as well as an idea on existence in it of structures with different qualitative composition of spawners and their different contribution into the recruitment, as well as a Ricker's model "stock-recruitment". The model takes into account the water temperature in the period of a change of a biotope, i.e., the transition of 0-group to the bottom mode of life. In each of two historical periods, three additive abundance components of the mature part of the population were revealed with different contribution into the recruitment, which are used as indices of a reproduction potential. The contribution of each component, as well as of temperature factor into the recruitment of a commercial stock was estimated. Estimations of components at which maximal contributions are reached were called optimal ones. It was concluded that the rational exploitation of cod stock suggests such planning of a catch composition, which would ensure an optimal structure of the mature part of the population.

V. L. Tretyak: Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6, Knipovich Street, 183763 Murmansk, Russia [tel/fax: +47 789 10 518, e-mail: inter@pinro.ru]

ICES CM 2003/Y:14

Theory of optimal control based adaptive fishery management

Robert Aps, Jake C. Rice, R. Tamsalu, and V. Zalesny

The overarching strategic objective in fishery management is the sustained exploitation of the fishery resources. As a prerequisite for adaptive fishery management, such broadly-stated strategic objective must be translated into specific operational objectives, expectations, desired future trajectories and behaviour. Precautionary approach is to be used to formulate both the strategic and operational objectives for adaptive fisheries management. Furthermore, these operational objectives should be stated in terms that can be measured and monitored. Such operational objectives are closely related to precautionary reference points and are used as benchmarks for evaluation of the status of fishery resources and the efficiency of the management measures taken. Attempt is made to present the concept of coupled cycle of economic system and marine ecosystem as a tool to evaluate the strategic and operational management objectives. Adjoint equations technique based steering of the adaptive management processes of reducing or eliminating discrepancies between the assessed state of the fishery resources and the precautionary operational objectives is discussed.

Keywords: fishery management, precautionary approach, theory of adjoint equations.

R. Aps: Estonian Marine Institute, University of Tartu, 10a Maealuse, 12618 Tallinn, Estonia [tel: +372 6267 407, fax: +372 6267 417, e-mail: robert.aps@ness.sea.ee]. J. C. Rice: Canadian Science Advisory, Fisheries and Oceans, 200 Kent Street, Stn. 12S015, Ottawa, Ontario K1A OE6, Canada [e-mail: ricej@dfo-mpo.gc.ca]. R. Tamsalu: Estonian Marine Institute, University of Tartu, 10a Maealuse, 12618 Tallinn, Estonia [tel: +372 6267 407, fax: +372 6267 417, e-mail: bill@sea.ee]. V. Zalesny: Institute of Numerical Mathematics, Gubkin str., 8, 119991 Moscow, Russia, [tel: +007 938 3907, fax +007 938 1821, e-mail: zalesny@inm.ras.ru]

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Recent progress on the implementation of the precautionary approach on Canadian cod stocks leading to the re-introduction of the moratorium

Peter A. Shelton, Jake C. Rice, Denis Rivard, Ghislain A. Chouinard, and Alain Fréchet

Seven out of ten cod stocks in Atlantic have undergone collapses of 90% or more as a result of overfishing, most of them in the late 1980s – early 1990s. By 1994 eight of the ten stocks were under a moratorium on directed fishing. The Canadian portion of the Georges Bank was reduced to a bycatch fishery in 1995, leaving only one cod stock, supporting a directed fishery. In 1997/98 the directed commercial fishery reopened on four stocks, only one of which had shown any signs of recovery. Although these fisheries were small relative to previous levels, scientific evidence rapidly accumulated to show that they were unsustainable given the recent productivity of these resources. Recognising that unsustainable fisheries on collapsed, non-recovered resources was inconsistent with a conservation-minded approach, Canadian Department of Fisheries and Oceans scientists, with input from fisheries managers, developed a precautionary approach framework which defined spawner biomass limits associated with serious harm to stock productivity. This framework was implemented in the February 2003 assessments for the three stocks of most concern. Medium-term deterministic projections of spawner biomass relative to these limits were sufficiently pessimistic to convince decision makers of the need to place the fisheries back under moratorium despite pressing social and economic considerations. We describe the process leading to the development of the framework, in particular the spawner biomass limit reference points, and the implementation in the most recent assessments. We give consideration to further developments required to develop a fully articulated framework for Canadian cod stocks.

Keywords: precautionary approach, cod, spawner biomass limit reference point, framework, deterministic projections.

P. Shelton: Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, PO Box 5667, St John's, Newfoundland, Canada, A1C 5X1 [tel: +1 709 772–2341, fax: +1 709 772–4105, e-mail: sheltonp@dfo-mpo.gc.ca]. J. Rice: Canadian Science Advisory Secretariat, Department of Fisheries and Oceans, 200 Kent Street, Ottawa, Canada, K1A OE6 [e-mail: ricej@dfo-mpo.gc.ca]. D. Rivard: Fisheries Research Branch, Department of Fisheries and Oceans, 200 Kent Street, Ottawa, Canada, K1A OE6 [e-mail: rivardd@dfo-mpo.gc.ca]. G. A. Chouinard: Gulf Fisheries Centre, Department of Fisheries and Oceans, PO Box 5030, Moncton, New Brunswick, E1C 9B6, Canada [e-mail: chouinardg@dfo-mpo.gc.ca]. A. Fréchet: Institut Maurice-Lamontagne, Department of Fisheries and Oceans, P.O. Box 1000, Mont-Joli, Quebec, G5H 3Z4, Canada [e-mail: frecheta@dfo-mpo.gc.ca]

ICES CM 2003/Y:16

The integration of stakeholder opinion into the management of marine habitats

O. A. L. Paramor, J. L. Hatchard, K. H. Mikalsen, T. S. Gray, C. L. Scott, and C. L. J. Frid

Measures to protect the marine ecosystem have been incorporated into several pieces of international legislation. The introduction of stakeholder opinion and demands into these ecosystem-based management plans has been researched by the European Fisheries Ecosystem Plan which aims to assess the impact of these demands on the ecosystem of the North Sea.

One of the components of the ecosystem which needs to be addressed within the management plans of the fisheries is habitat. The effect of fishing activities on habitat will differ according to variables such as substrate and physical complexity. Scientists need to evaluate the importance of particular habitats to ecosystem functioning and allow managers to determine the level of protection required. However, the opinions of fishers, conservationists and other concerned citizens is essential as it will determine the effectiveness of these management measures.

Presented here is an overview of stakeholder opinion from four European countries and the science required to address these views. A scientific assessment of the impact of stakeholder management preferences on habitats and the functioning of the North Sea ecosystem is made.

Keywords: ecosystem, management, habitats, benthos, stakeholders.

O. A. L. Paramor and K. H. Mikalsen: Department of Political Sciences, University of Tromsø, 9037 Tromsø, Norway [e-mail: Corresponding author: O.A.L.Paramor@newcastle.ac.uk]. C. L. Scott and C. L. J. Frid: Dove Marine Laboratory, School of Marine Science and Technology, University of Newcastle, Cullercoats, North Shields, NE30 4PZ,

UK [tel: +44 191 252 4850, fax: +44 191 252 1054]. T. S. Gray and J. L. Hatchard: School of Geography, Politics and Sociology, University of Newcastle, 40–42 Great North Road, Newcastle upon Tyne, NE1 7RU, UK

ICES CM 2003/Y:17

Stakeholders and the ecosystem approach to management

C. L. Scott, C. L. J. Frid, T. S. Gray, J. L. Hatchard, and O. A. L. Paramor

The European Community has adopted the precautionary principle and is in the process of developing an ecosystem approach to management into the Common Fisheries Policy (CFP). The question is how likely are stakeholders to accept and implement such approaches? The EC-funded "European Fisheries Ecosystem Plan" (EFEP) project incorporates stakeholders' views and ideas into the development of a framework for implementing FEPs in European seas.

Stakeholders consulted in the EFEP acknowledge that several North Sea fish stocks are in poor shape, for which over-fishing is at least partly responsible. Nevertheless, stakeholders consider that the long-term prospects for the fisheries in the North Sea are optimistic, provided that a variety of technical and effort-related measures are undertaken. Incorporating stakeholders' preferences into an effective management plan requires that such measures need to be acceptable to all stakeholders and it is necessary to take into account fishers' knowledge alongside fisheries science. However, scientists have an essential role in the provision and interpretation of information from many sources when structuring management scenarios. Thus there is a need to rationalise management decision-making processes and make them available in an explicit format to stakeholders.

Keywords: ecosystem, management, stakeholders.

C. L. Scott, C. L. J. Frid, and O. A. L. Paramor: Dove Marine Laboratory, School of Marine Science and Technology, University of Newcastle, Cullercoats, North Shields, NE30 4PZ, UK [e-mail: c.l.scott@newcastle.ac.uk]. T. S. Gray and J. L. Hatchard: School of Geography, Politics and Sociology, University of Newcastle, 40–42 Great North Road, Newcastle-upon-Tyne, NE1 7RU, UK

ICES CM 2003/Y:18

Improvements in the management of Bay of Biscay anchovy by incorporating environmental indices as recruitment predictors

José A. A. de Oliveira, Andres Uriarte, and Beatriz A. Roel

A short-lived species such as anchovy is particularly difficult to manage in the context of the ICES advisory system because the population and the fishery in the prediction year depend largely on incoming recruitment. In the absence of pre-recruit surveys, environmental indices can be used as predictors of recruitment and to provide management advice. Environment/recruitment relationships (ERR) have been established for the Bay of Biscay anchovy population, but their performance is still being tested. The purpose of this paper is to investigate under what circumstances incorporating environmental indices would lead to improvements in managing this anchovy stock in terms of reducing the risk of falling below B_{lim} and increasing yields. The assessment is made by stochastic simulation of the anchovy population and its management. Management actions resulting from advice based on geometric mean recruitment or on precautionary low levels of recruitment are compared with those resulting from recruitment forecasts based on precise levels of use and knowledge of real environment/recruitment relationships. The uses considered were direct use (R estimated from the ERR) or indirect (expected R as a trigger of a precautionary approach). Linear models for ERR with a coefficient of determination (r^2) of 0, 0.25, 0.5 and 1 are considered in the simulations for cases when such relationships are known perfectly or when the parameters are estimated and selected with measurement error. Results illustrate circumstances when the use of environmental indices to predict recruitment result in an improvement in TAC advice under the Precautionary Approach.

Keywords: anchovy, environment, management, recruitment forecast.

J. A. A. de Oliveira and B. A. Roel: CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK [tel: +44 (0) 1502 524358, fax: +44 (0) 1502 513865, e-mail: J.DeOliveira@cefas.co.uk, b.a.roel@cefas.co.uk]. A. Uriarte: Fisheries and Food Technological Institute (AZTI), Fisheries Resources Department. Herrera Kaia, z.g., Portualdea, 20110 Pasaia (Gipuzkoa), Spain [tel: +34 943 00 4800, e-mail: auriarte@pas.azti.es]

ICES CM 2003/Y:19

Reflections on the biological reference points in use in ICES, and their application in management

R. C. A. Bannister and Laurence Kell

This paper reviews the biological reference points currently in operation in ICES, compares them to other possible reference point values, and evaluates them for consistency within and among species. The paper uses scenario modelling to evaluate how reference points behave in relation to assessment uncertainty.

R. C. A. Bannister and L. Kell: Centre for Environment, Fisheries and Aquaculture Science Lowestoft, Suffolk, NR 33 0HT, UK

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Diversity of perceptions about status and productivity of fish stocks. Northern hake: a case example of PA management advice

Enrique de Cárdenas, Lorenzo Motos, Carmela Porteiro, José Ramón Fuertes, Víctor Badiola, and Y. Jean Jaques Maguire

Precautionary reference points (PRP) have been defined to maintain or restore the historically observed productivity of the stocks by attempting to prevent recruitment over-fishing. In the case of Northern hake, PRP were established by ACFM in 1998. The biomass limit (B_{lim}) was fixed at the lowest observed spawning biomass which led to a later recovery (B_{loss}). However, the assessment of Northern hake suffered from instability making the definition of PA points uncertain. The main problems came from measurement (actual catches and discards, input data revisions,…), model misspecification (structural model uncertainty, plus group,….) and implementation errors (Official TACs overshooting ICES recommendations and real catches overshooting official TACs). Variability in natural processes (for example, geographical shifts related to climatic influence on CPUE indices) that could have influenced the perception of the status of the stock and its productivity also played a role.

In addition, ICES' perception of the status of the stocks differed from that of the Industry which was experiencing increasing catch rates at that time. The disagreement was public and a scientific review supported by the Industry challenged the official ICES advice. Furthermore, in addition to the drastic reduction in TACs, the European Commission put in place an urgent Regulation establishing technical measures for the recovery of Northern hake and the conditions for the control of fishing activities. Both TACs and technical measures were intensely disputed by a substantial part of the fishing industry, arguing that the rational was based on bad science and political interests and set through opaque procedures.

The present paper reviews the basis for setting PA BRP for Northern hake, describe the facts around its implementation and presents the various perceptions on this from scientists and fisherman representatives. The common agreed aspects are highlighted and contrasted against the disagreements and the arguments behind them.

A way forward is proposed for minimizing risks of stock collapse while allowing for economically viable fisheries with reasonable exploitation rates. This is based on co-operation between scientists and fishing industry through the whole process of generating scientific advice for fisheries management.

Keywords: reference points, acceptance, precautionary framework, hake.

E. de Cárdenas: Instituto Español de Oceanografía, Avda. de Brasil 31, 28020 Madrid, Spain [tel: +34 91 597 08 41, fax: +34 91 597 37 70, e-mail: E.decardenasr@md.ieo.es]. L. Motos: Department of Fisheries Resources, AZTI Foundation, Herrera kaia, Portualde z/g, 20110 Pasaia, Gipuzkoa-Basque Country, Spain [tel: +34 943004800, fax: +34943004801, e-mail: lmotos@pas.azti.es]. C. Porteiro: Instituto Español de Oceanografía, Centro Oceanográfico de Vigo, Apdo. 1552, 36200 Vigo, Spain [tel: +34 986492111, fax: +34 986492351, e-mail: carmela.porteiro@vi.ieo.es]. J. R. Fuertes: ANASOL, Association of Grand Sole Fishing Boat Owners, Puerto Pesquero Edificio de Vendedores Ofc. 1, 36202 Vigo (Pontevedra), Spain [tel: +34 986433844, fax: +34 986439218, e-mail: anasol@arvi.org]. V. Badiola, OPPAO, Ondarroa Organisation of Deep Sea Fish Producers, Egidazu Kaia s/n, Ondarroa, Bizkaia, Spain [tel: +34 946830223, fax: +34 946134144, e-mail: oppao@nexo.es]. J.-J. Maguire: 1450 Godefroy, Sillery, Québec, Canada, G1T2E4 [tel: +1 418 688 5501, fax: +1 418 688 7924, e-mail: jjmaguire@sympatico.ca]