Theme Session N
Problems and solutions for the assessment, conservation, and restoration of rare, threatened, and endangered fish species

ICES CM 2008/N:01

Atlantic cod stock: a review of its current status and possible solution for strategic fishery management

Naman Sharma and Dan Lane

This paper presents a review of the Committee on Endangered Wildlife in Canada criteria used to determine the status of species at risk for commercially exploited marine species designated as "special concern", and the approach of the Department of Fisheries and Oceans for stock assessment. Cod stocks in the Northwest Atlantic Canadian zones are examined and species status results are analysed and compared, and updated values for available criteria are provided for some stocks from 2002 through to 2006. The analysis of the updated values suggests that what is needed is a more complete perspective of the fishery system as the context within which the species at risk status is being examined. To this end, a broader set of stock status indicators for the assessment of marine species is proposed that takes into account available information including all fishery stock assessment data. A monitoring programme is presented based on the principles of quality control as a guideline for stock status assessment and risk analysis.

Keywords: species at risk status, fishery stock assessment, reference points, threshold values, process control, risk analysis.

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ICES CM 2008/N:03

A non-invasive automated tagging system using digital pattern recognition

Paul A. Skvorc, II

A non-invasive, fully automated process for identifying threatened and endangered fish and other animals is presented. The system, called the Natural Tag (TNT), identifies individuals from digital images. Preliminary development used rainbow trout (*Onchorynchus mykiss*) and moved to other species, including endangered white sturgeon (*Acipenser transmontanus*). In addition, the sex of out-migrating coho smolt (*O. kisutch*) was readily determined with TNT. TNT's initial study identified individuals from a 400-fish subset of a population of 1200 fish in 13 seconds on a laptop. The average time for individual identification was 32 ms. Using standard hardware, this time is further reduced by at least 100-fold and scaled up for full hatchery and field use. Although fish were the initial focus, individual identifiers for mammals, birds, crustaceans, insects, amphibians, and reptiles are now known. Past pattern recognition challenges (population size, need for human readers, angle of image capture, growth, etc.) have been resolved in TNT. Although some other programmes may work satisfactorily for species with limited numbers (whales), they are problematic for millions of animals, such as the 4 billion hatchery salmon released annually in the Pacific. Physically tagging this many animals is cost prohibitive, and using natural patterns for each individual has heretofore been impossible because of the lack of an automated process. TNT tracks animals throughout their lives non-invasively, provides precise morphometric data automatically and minimizes tag loss. TNT is easily used by professionals and others, and data are collected as in other tag recovery programmes, but with standard camera equipment and web uplinks.

Keywords: non-invasive, tagging, tag, individual identification, threatened, endangered, gender, image, digital pattern recognition, mammalia, aves, crustacea, insecta, amphibia, reptilia, natural tag, hatchery, automated, morphometric, tag loss.

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ICES CM 2008/N:04

Challenges for the assessment of the UK stock of European eel (*Anguilla anguilla*)

Alan Walker, Ted Potter, and Ian Russell

The European eel stock is in a severely depleted state and ICES continues to advise that the stock is outside safe biological limits. The European Commission's Eel Recovery Plan aims to restore the spawning stock, and a management target has been set as 40% of historical, potential escapement. Responsibility for selecting

and effecting management actions has been devolved to Member States. A pseudo-stock/recruitment relationship has been hypothesized for the stock as a whole. However, our present inability to link maturing silver eel escapement with subsequent recruitment at management units relevant to national boundaries (e.g. river basins or districts), and the limited distribution of fisheries around the UK, precludes the use of conventional stock assessment methods. Furthermore, there is a paucity of historical and even recent data on eel populations in nearly all UK rivers, from which we could directly set management targets, assess present-day compliance and, if necessary, select from various management actions to restore silver eel escapement. In light of these challenges, one option being pursued is the development and application of habitat-based life history production models for eels. This paper outlines the challenges associated with this approach and describes recent developments for the proposed management of eels in the UK.

Keywords: European eel, eel recovery plan, life history model, management.

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ICES CM 2008/N:05

The role of stocking in the recovery of the River Tyne salmon fishery

Nigel Milner, Ian Russell, Miran Aprahamian, Roger Inverarity, Jon Shelley, and Phillip Rippon

The River Tyne in northeast England had severely depleted salmon runs in the 1950s as a consequence of estuarine pollution, but now produces the largest rod catch in England and Wales. Water quality improved between the 1960s and 1990s following reduction in industrial activity and improvements to effluent treatment and disposal. Coincidentally, a salmon stocking programme was started in 1979 in mitigation for lost production resulting from the construction of a reservoir. This paper reviews the role that the stocking programme played in the recovery of the Tyne fishery. The investigation incorporated observed patterns of change in rod catches, records of juvenile abundance, estuarine water quality, and returns of stocked fish marked with coded wire microtags. Natural recovery was shown to be the numerically dominant process, but the stocking contribution of first returns, which peaked in 1986, is believed to have accelerated and stabilized stock recovery in its early stages when water quality improvements were still inconsistent. Implications for stocking strategies are discussed.

Keywords: Atlantic salmon, restoration, stocking, coded wire microtagging.

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ICES CM 2008/N:06

Recolonization of North Sea houting after a stocking programme in the Lower Rhine

H. V. Winter, J. J. de Leeuw, A. W. Breukelaar, and J. Borcherding

North Sea houting (*Coregonus oxyrinchus*) became extinct in the Rhine basin around the 1950s. From 1987 to 2006 a stocking programme has been carried out in the German section of the Lower Rhine and the tributary Lippe, aiming to reintroduce a self-sustaining population of this endangered diadromous fish species. Fyke net monitoring programmes during 1992–2007 in the Netherlands were used to assess the population developments in the Lower Rhine. Spatial use and migratory behaviour of adult houting was studied using the NEDAP Trail telemetry system in the Lower Rhine and Rhine Delta (Netherlands, Germany). During 2005–2007, 90 adult North Sea houting (38–56 cm TL) were surgically implanted with passive transponders and released at their catch locations in Lake IJsselmeer. An array of 34 fixed detection stations in the Lower Rhine and Rhine Delta (Netherlands and Germany) allowed passage of individuals to be measured continuously for up to two years after release. Starting at the end of October through December, 40 houting transpondered in Lake IJsselmeer passed Kampen on their upstream migration into the River IJssel, from which five houting were also detected in the Rhine at Xanten in Germany. Only one houting entered the Lippe, one of two locations in Germany where juveniles have been stocked. Spawning sites appear to be located in both the Dutch and the German sections of the Rhine. The recent strong increase in numbers of houting in monitoring programmes and mark–recaptures of juvenile houting further confirmed that a naturally reproducing population has now established in the Lower Rhine.

Keywords: diadromous fish, reintroduction, migratory behaviour, population status, telemetry.

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ICES CM 2008/N:07

The use of GIS-based modelling to establish basin-specific fisheries goals and prioritize restoration efforts in the Penobscot River Basin (Maine, USA)

Tara Trinko, Chad Keith, Rory Saunders, and Tim Sheehan

The Penobscot River Restoration Project (PRRP) is a multimillion-dollar endeavour that aims to restore self-sustaining populations of native sea-run fish through the removal of two mainstem dams and improved fish passage at numerous other dams on the Penobscot River. Although many diadromous species will benefit from the PRRP directly, other species such as endangered Atlantic salmon (*Salmo salar*), alewife (*Alosa pseudoharengus*), and American shad (*Alosa sapidissima*) may require additional habitat improvements (barrier removal, fishways, etc.) or stocking. Thus, additional active restoration measures may be required to realize the full potential of the PRRP. Owing to the high profile and high cost of the project as well as numerous state, federal, and non-governmental organizations involved, there is a need to prioritize restoration efforts in the basin to increase the probability of success. To help facilitate this goal, we have created an ecologically based GIS tool to help set restoration goals and to help identify and prioritize restoration opportunities (stocking options, barrier removal, and fishway improvements). Initial data inputs for the model include spawning habitats for a shortened list of focal species, a habitat weighting variable, and passage barriers (location and passage state). The outputs of the model are ecologically based targets for focal species and prioritized lists of restoration projects based on their biological merits, rather than being selected as opportunities arise. These outputs will help to ensure that restoration efforts and money are targeted appropriately and that achievable goals are set.

Keywords: GIS, modelling, diadromous, restoration.

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ICES CM 2008/N:08

Defining critical habitat and estimating population size of shortnose sturgeon (*Acipenser brevirostrum*) using novel underwater video survey and modelling approaches

Matthew Litvak, Xinhai Li, Sima Usvyatsov, James Watmough, and John Hughes-Clarke

Shortnose sturgeon (*Acipenser brevirostrum*), distributed along the east coast of North America, is listed as a species of special concern in Canada and as endangered in the USA. Like most sturgeons, little is known about their habitat use and there are few precise estimates of their population sizes throughout their distribution. This information is critical to our understanding of ecology and conservation efforts. Recently, we developed a novel underwater video camera system and modelling approach to determine the overwintering habitat of shortnose sturgeon in the upper Kennebecasis River, New Brunswick, Canada. Generalized linear models were used to describe the overwintering habitat of the species; shortnose sturgeon had a significant preference for deeper areas. The total abundance of shortnose sturgeon at the overwintering site was estimated to be 4836 ± 69 (mean ± standard error) using the ordinary kriging method to interpolate sturgeon density at unsampled sites. We now have improved and extended the use of this system and approach by adding a laser system to permit calculation of fish size. This videographic approach is being used this summer with a towed video camera. GPS position, time, and depth will be overlaid on the video to provide precise information on all fish encountered. This information is key to determining habitat use and population size. We suggest that video sampling will be of growing importance in sturgeon research—it provides very fast and accurate sampling, which can be performed in large stretches of the river, providing whole-population data on habitat use and population size.

Keywords: shortnose sturgeon, underwater videography, generalized linear models, krigging, modelling, habitat use, endangered species, mapping.

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ICES CM2008/N:09

Science and monitoring needs for assessing the recovery of Australian orange roughy

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Orange roughy is a commercially exploited deep-water fish that is both long lived and slow growing. In Australian waters it has been commercially fished since the mid-1980s, with most management zones in the southeast region now assessed as overfished based on existing information. Based on this assessment the species was listed as threatened in 2006 under the Australian Environmental Protection and Biodiversity and

Conservation Act (EPBC) and targeted fishing was ceased until the species has recovered. At the same time a fisheries non-trawl spatial closure below 700 m depth was introduced and in 2007 several marine protected areas were placed in traditional high-catch orange roughy regions. Under the 2006 EPBC listing a detailed monitoring strategy is required to determine when, where, and at what level fishing could recommence. Historically, orange roughy are managed within several management zones that have separate total allowable catches with varying degrees of monitoring precision, ranging from fishery-dependent catch per unit of effort (cpue) data to fishery-independent acoustic surveys. In management zones where cpue has been used as the stock status, new indicators are now required to evaluate recovery. Stock structure of the species is also uncertain within and between management zones, so recovery of one zone may imply a recovery in adjacent zones. We outline a strategy to monitor the recovery of selected management zones based on a non-invasive multifrequency acoustic survey method using an assessment model to guide the necessary timing and precision of the surveys. The predicted species recovery rate and population risk based on spatial closures and measurement uncertainty is discussed.

Keywords: orange roughy, recovery, monitoring.

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ICES CM 2008/N:10

Assessing the impacts of commercial fisheries on rare, threatened, and endangered fish species in UK waters

Alice Mackay, Al Kingston, and Simon Northridge

Rare, endangered, and threatened fish species have been variously defined and itemized through several national, international, and intergovernmental bodies. The International Union for Conservation of Nature (IUCN) lists over 1200 fish species as critically endangered, endangered, and vulnerable; the Habitats Directive lists only eight species of fish under Annex IV whereas the UK Wildlife and Countryside Act makes illegal the capture, killing or sale of 12 fish species, including basking sharks, shads, and seahorses. We summarize listings for species of relevance to the UK and northwestern Europe, and highlight key aspects of their biology and ecology that need to be monitored to address conservation goals. We focus on the role of fishery monitoring, especially the use of on-board observer schemes, in assessing certain aspects of the conservation status of such species. We recognize that for some species, typically where conservation threats are the result of habitat loss, there is little that monitoring fisheries can usefully achieve. But for those species for which protection is sought, but which remain numerous enough to be recorded in fishing gear, on-board observer monitoring schemes provide a valuable means of determining vulnerability to fisheries, spatial and seasonal patterns of distribution, and the effectiveness of recovery plans, especially where landings are prohibited. We consider examples including shads, tope, and sturgeon, each illustrating a different set of criteria for which fishery monitoring schemes provide a means of assessing aspects of conservation status, and conclude that more could be done to coordinate conservation efforts through discard and bycatch monitoring schemes.

Keywords: conservation; fish; observer schemes; monitoring.

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ICES CM 2008/N:11

Equilibrium analyses of the recovery feasibility of four Atlantic salmon (*Salmo salar*) in Nova Scotia and Southwest New Brunswick

A. Jamie F. Gibson, Ross A. Jones, and Peter G. Amiro

Abundances of Atlantic salmon in rivers along the Atlantic Coast of Nova Scotia and around the Bay of Fundy, Canada, have declined precipitously during the last two decades. Equilibrium analyses were carried out on four populations in this region in order to evaluate the relationship between threats to these populations, their recovery potential, and the expected population response to recovery actions. Equilibrium models split the life cycle of a species into two or more parts and determine the population size at which the rates in each part of the life cycle are balanced such that the population does not increase or decrease in size. By varying the life history parameters in a way that represents the expected response to a human activity and examining the resulting change in equilibrium population size, the effects of the activity on the population can be evaluated. This approach places the expected population response to alleviating a threat in the context of other threats to the population. The threats and stressors discussed in each case study are representative of those affecting salmon population viability in the Bay of Fundy and Nova Scotia Atlantic coast rivers: acidification, hydroelectric development, low fresh-water habitat productivity, and low at-sea survival. The case studies illustrate the need for population-specific information for recovery planning and show that where

multiple threats exist to a population, multiple actions are likely required to bring about recovery of that population.

Keywords: Atlantic salmon, endangered species, equilibrium models, recovery.

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Minimizing loss of genetic variation and wild fitness in semi-captive populations of endangered inner Bay of Fundy Atlantic salmon

Carolyn Harvie, Manon Cassista, and Patrick O'Reilly

Atlantic salmon inhabiting the rivers that empty into the inner Bay of Fundy are genetically and phenotypically distinct from salmon elsewhere, and have recently been listed as endangered under Canada's Species At Risk Act. In the years 1998–2001, several hundred parr were collected from two of these rivers, and used to initiate a recovery programme for this unique assemblage of Atlantic salmon. Microsatellite genotype information and kinship analyses were then used to recover founder genetic variation from the original collections, and parentage analyses employed to minimize loss of genetic variation in the production of subsequent generations. Adaptation to captive conditions is being minimized by (i) equalizing family size, and (ii) releasing offspring into native river habitat as unfed fry, and recovering wild-exposed individuals as either late stage parr or smolts, prior to their migration to marine waters, where current levels of marine morality are exceptionally high. The efficacy of different strategies in recovering founder diversity, and in minimizing the loss of genetic variation through time, is reported and compared, as is the recovery of families from captive and wild environments.

Keywords: founder diversity, genetic variation, kinship analyses, parentage analyses, microsatellites.

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ICES CM 2008/N:13

Restocking programmes for salmon (*Salmo salar*, L.) in Ireland—how successful have they been?

Niall Ó Maoiléidigh, Philip McGinnity, Denis Doherty, and Jonathon White

Restocking is widely used in Ireland to mitigate against the loss of salmon populations caused by the creation of hydropower dams, river drainage, and pollution. Strategies have included restocking with all stages in rivers supplemented with substantial releases of hatchery-reared smolts. The efficacy of restocking with regard to establishing self-sustaining stocks is examined in light of ongoing problems in fresh water and poor and declining marine survival with reference to returns from coded wire-tagged salmon and recoveries in broodstocks at rearing stations.

Keywords: Atlantic salmon, restoration, stocking, coded wire microtagging.

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ICES CM 2008/N:14

Assessment of endangered shortnose sturgeon in Maine Rivers

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A component of the listing process under the US Endangered Species Act (ESA) is to determine the current status of species throughout their range, including regions where they may have existed historically. For the shortnose sturgeon the Penobscot River represents such a region. Shortnose sturgeon were listed as endangered in 1967 and were last recorded in the Penobscot River as incidental bycatch in 1978. Since 2006 we have been working to assess the distribution, abundance, and movements of adult and subadult shortnose sturgeon in the Penobscot River, the largest watershed in Maine. While working under US ESA Section 7 and 10 permits, we have followed standard protocols established by National Marine Fisheries Service. We have documented critical areas of the Penobscot River that are used for overwintering and foraging. We have employed mark–recapture techniques to estimate population size but have determined that traditionally employed closed population models are not appropriate for Gulf of Maine shortnose sturgeon. Tagged individuals from the Penobscot and Kennebec Rivers have been tracked moving between these rivers. Because of this, we have expanded our use of acoustic receivers to encompass more coastal river systems in

the Gulf of Maine. We are also exploring the use of DIDSON high-frequency hydroacoustics as a non-invasive technique to estimate the number of individuals in the overwintering habitat. Our study provides a case history of a baseline population estimate that will be used to assess effective conservation of this species not only in the Penobscot River but also within the Gulf of Maine.

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ICES CM 2008/N:16 Poster

The rare *Theragra finnmarchica* (Gadidae): endangered or never established?

Svein-Erik Fevolden, Kim Præbel, and Jørgen Schou Christiansen

The Norwegian pollock or berlevågfisk, *Theragra finnmarchica* (Kofoed, 1956), is in many respects a mystery. It was first encountered in 1932 and since then only some 50 adult specimens have been recorded, the majority of them off the coast of Finnmark, northern Norway. The *T. finnmarchica* closely resembles the walleye or Alaska pollock, *Theragra chalcogramma* (Pallas, 1814) in the Pacific, and comparison of the complete mitochondrial DNA nucleotide sequences from both species questions their classification as distinct species. Morphological traits do show some differences between the Pacific and Atlantic variant, acknowledging that this could reflect plasticity and environmental adaptations. Even though *T. finnmarchica* may not be a valid species, the mere existence of a very small but apparently sustainable population of *Theragra* off the coast of Finnmark remains enigmatic. Another question is, of course, how and when were the Norwegian population established? Having dismissed the possibility that they could have been introduced by humans, it would be useful to find out who their closest relatives are. To shed some light on this the available specimens of *T. finnmarchica* were compared with 50 specimens of *T. chalcogramma* from each of the western and eastern North Pacific areas for variation in a number of microsatellite loci. A closer genetic resemblance to either of these would at least indicate possible immigration routes between the Pacific and the Atlantic Ocean.

Keywords: rare species, *Theragra finnmarchica*, pollock, molecular genetics.

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