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Proceedings of the Workshop on the Potential use of the Biomass-size Spectrum for Estimating Northern Cod Stocks. Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, March 25-27, 1991

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PROCEEDINGS OF THE WORKSHOP ON THE POTENTIAL USE OF THE BIOMASS-SIZE SPECTRUM FOR ESTIMATING NORTHERN COD STOCKS

Northwest Atlantic Fisheries Centre
St. John's, Newfoundland
March 25-27, 1991

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CONTENTS

Page

ABSTRACT

Paranjape, M. A., and R. W. Sheldon [ed.]. 1991. Proceedings of the workshop on the potential use of the biomass-size spectrum for estimating northern cod stocks. Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, March 25-27, 1991. Can. Tech. Rep. Fish. Aquat. Sci. 1844: iv + 43 p.

An international workshop on the potential use of the biomass size spectrum concept to estimate and predict standing stock levels of northern cod was held on March 25-27, 1991, at the NAFC, St. John's, Newfoundland. This workshop was one of the several held under the auspices of Northern Cod Science Program before new research initiatives were begun. The aim of this workshop was to bring together authorities recognized in the various fields to:

1. review the present state of knowledge;

2. discuss aspects of biomass descriptions and predictions based on contemporary studies of the marine and freshwater ecosystems;

3. assess the feasibility of understanding the dynamics of fish producing ecosystems from a knowledge of food web structure at the lower trophic levels; and

4. attempt a consensus and assess the feasibility of using the biomass size spectrum approach for a study of northern cod.

Over 50 people participated in the workshop. Representatives from Scotia-Fundy, Quebec (DFO), Memorial University, Dalhousie University, University of Toronto, University of Maryland, government research laboratories from U.K., Poland, South Africa, as well as many members of DFO Newfoundland Region were present. The program consisted of a mix of formal presentations and open discussions, followed by deliberation of three panels of experts to produce recommendations for the conduct of future research. Highlights of the workshop are recorded in these proceedings.

RÉSUMÉ

Paranjape, M. A., and R. W. Sheldon [ed.]. 1991. Proceedings of the workshop on the potential use of the biomass-size spectrum for estimating northern cod stocks. Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, March 25-27, 1991. Can. Tech. Rep. Fish. Aquat. Sci. 1844: iv + 43 p.

Un atelier interational sur la possibilité d'utiliser le concept de spectre de taille de la biomasse pour évaleur et prédire les niveaux de stocks actuels de morue du Nord a eu lieu du 25 au 27 mars 1991 au CPANO de St. John's (Terre-Neuve). Cet atelier faisait partie de nombreuses activités menées sous les auspices du Programme scientifique de la morue du Nord, avant la mise en vigueur de nouvelles initiatves de recherche. Le présent atelier visait à réunir des spécialistes reconnus dans divers domaines aux fins suivantes:

1. faire le point sur les connaissances actuelles;

2. à partir de récentes recherches sur les écosystèmes marins et d'eaux douces, aborder divers aspects des descriptions et des prédictions de biomasses;

3. évaluer la possibilité de comprendre la dynamique des systèmes producteurs de poissons en étudiant la structure des réseaux alimentraires du niveau trophique inférieur; et

4. tenter d'arriver à un consensus et évaluer la possibilité d'utiliser l'approche du spectre de taille de la biomasse pour étudier la morue du nord.

Plus de cinquante personnes ont participé à l'atelier. Il s'y trouvait notamment des représentants de Scotia-Fundy, du Québec (MPO), de l'Université Memorial, de l'Université Dalhousie, de l'Université de Toronto, de l'Université du Maryland, des laboratoires gouvernementaux de G.-B., de Pologne, de d'Afrique du Sud, ainsi que des délégués du MPO de la région de Terre-Neuve. L'atelier consistait d'un mélange de conférences et de délibérations par trois groupes de spécialistes qui ont abouti à formuler des recommandations en vue de prochaines recherches. Les points saillants de l'atelier sont décrits dans le présent compte rendu.

PROGRAM SCHEDULE

MONDAY, MARCH 25

09.00-09.10	Welcome by the Regional Director, Science, DFO	L.W. Coady
09.00-09.15	Introduction	R.W. Sheldon

RECENT RESEARCH ON BIOMASS DISTRIBUTIONS
Chair - M. A. Paranjape

09.15-09.35	Towards a theory of the body-size spectrum of in aquatic systems	L. M. Dickie
09.35-09.55	Dynamic simulation modelling of biomass spectra	W. Silvert
09.55-10.15	Biomass spectra as indices of ecosystem production in relation to fisheries yield	P. Boudreau
10.15-10.35	Coffee	
10.35-10.55	Microplankton biomass distributions of three contrasting ecosystems in the southern Bengula Region	C. L. Moloney
10.55-11.15	Size structure of the southern Baltic ecosystem	Z. Witek
11.15-11.35	Particle size and fish larval distributions in the Irish Sea	K. Brander
11.35-11.55	Length abundance and distributions of demersal fishes on the Scotian Shelf	J. de Aracama
11.55-12.15	Effects of fishery exploitation on the size structures of northern cod stocks: a preliminary analysis	S. R. Kerr
12.15-12.35	Biomass size distribution and metabolism in the pelagic zone	R. Quiñones

L U N C H

APPLICATIONS
Chair - M. A. Paranjape

13.30-13.55	Biomass size spectra of the Lake Michigan pelagic food web	W. G. Sprules
13.55-14.20	Size spectra in deep demersal fishes	R. Haedrich
14.20-14.45	Biomass spectra and fish catches in the North Atlantic	R. W. Sheldon, M. A. Paranjape

14.45-15.10	The biomass spectrum in the S.E. Atlantic in relation to historic and potential pelagic fish yields	J. G. Field, C. L. Moloney
15.10-15.35	The allometric determination of pelagic production rates	I. R. Joint
15.35-16.00	Tea	
16.00-	General discussion limited to matter arising from the presentations	

TUESDAY, MARCH 26

BACKGROUND FOR UNDERSTANDING THE NORTHERN COD ECOSYSTEM
Chair - M. A. Paranjape

09.00-09.30	The physical environment of the Northern Cod ecosystem	S. Narayanan
09.30-10.00	Patterns of recruitment variation: influence of life-history and environments	R. Myers
10.00-10.30	Pelagic fish populations of the Grand Banks region	G. H. Winters
10.30-10.50	Coffee	
10.50-11.20	The production system supporting cod in Div. 2J3KL	G. R. Lilly
11.20-11.50	Investigating the effects of the Hudson Strait outflow on the Labrador Shelf using the biomass size spectrum	K. Drinkwater G. Harding L. M. Dickie R. W. Sheldon
11.50-12.20	Quantitative survey data for benthic production estimates	D. Peer, P. Schwinghamer
12.20-12.50	Size- and biomass-distribution of pelagic zooplankton on the SE Shoal of the Grand Bank	C. Taggart, K. Frank J. Carscadden, W. Leggett

LUNCH
STRUCTURED DISCUSSION

14.00- 1) How well can we extrapolate from the size distribution of small organisms to estimate fish stocks?

Discussion Panel: W. G. Sprules (Rapporteur)
S. R. Kerr
L. M. Dickie
J. G. Field

2) How well can we estimate fish stocks from fisheries data?
Discussion Panel: K. Brander (Rapporteur)
B. Atkinson
P. Shelton
J. Carscadden

3) Is either 1) or 2) relevant to fisheries prediction?

Open discussion: All participants

WEDNESDAY, MARCH 27

RECOMMENDATIONS FOR FUTURE RESEARCH

This will consist of a morning session where three committees will address the problem separately and an afteroon session where all the participants will discuss the (widely differing?) recommendations of the committees.

09.00-12.30 Meetings of the working groups.

LUNCH

14.00- Summary and general discussion of research recommendations (All Participants)

PROCEEDINGS OF THE WORKSHOP ON THE POTENTIAL USE OF THE BIOMASS-SIZE SPECTRUM FOR ESTIMATING NORTHERN COD STOCKS

NORTHWEST ATLANTIC FISHERIES CENTRE, ST. JOHN'S, NEWFOUNDLAND MARCH 25-27, 1991

Preamble

To the lover of prescribed routine methods with the certainty of 'safe' results the study of ecology is not to be recommended.

(after Tansley from Elton, 1927, p.4)

This report has been organized so that the recommendations of the ecologists who attended the workshop can be easily appraised. We start with the abstracts of each of the individual presentations. This is followed by the summaries of two "question and answer" sessions, based on the themes 1) how well can we extrapolate from the size distribution of small organisms to estimate fish stocks?, and 2) how well can we estimate fish stocks from fisheries data? We then present the details of the recommendations of each of three specialist working groups. Finally, we present our overall summary of their recommendatons.

INTRODUCTION

The organization of this workshop was a little different from the normal "run of the mill" affair. We did not get together to present the latest hot news of our research, although some of us did this; our prime purpose was to teach each other and to learn from each other. Our ultimate aim was to provide advice on whether it would be worthwhile to spend a large amount of money on biomass spectrum research in an attempt to improve our ability to estimate fish stocks.

We have come a long way since the first presentation of the biomass spectrum hypothesis twenty years ago. Those were the days when Gordon Riley was unconvinced and said that it was nothing more than an Eltonian pyramid. And he was right. The Eltonian pyramid and the biomass spectrum use the same data to describe ecosystem structure. But there are certain advantages to the biomass spectrum approach, particularly to non-mathematicians. The biomass spectrum essentially describes a linear relationship between biomass and size. And as we explain in response to the "it's only an Eltonian pyramid" criticisms, one can extrapolate straight lines fairly easily but pyramids are rather more difficult.

The biomass spectrum hypothesis is now generally accepted by ecologists as a reasonable way to describe aquatic ecosystem structure. But the concern of the workshop was not whether the hypothesis was reasonable or valid. We needed to know if it was useful.

To illustrate this we could profitably draw on a parallel example. Consider the Copernican view of the universe. Most people would agree that this is a valid way to describe the universe. But professional navigators (and members of the flat earth society) would strongly disagree. If one has to navigate a ship from St. John's to Rotterdam using a sextant and a chronometer, the Copernican description of the universe is not going to be very useful. Astronomers, on the other hand, would not doubt the validity of the Copernican system. Their science is entirely based on it. Both views are valid but astronomers and professional navigators just look at the universe from different viewpoints.

We face the same kind of problem with the biomass spectrum. There is little doubt that the hypothesis is valid, but now useful is it beyond academic ecology? This was the question we tried to answer. If it could be shown that useful estimates of fish stocks could be made from observations of the biomass spectrum, then the work of stock assessment scientists could perhaps be made a little easier. If, on the other hand, we found that the stock assessment scientist turns out to be comparable to our navigator, to whom biomass spectrum observations are interesting but not particularly useful, we could save the Canadian Government a considerable amount of research funding. This, ultimately, was the reason for the workshop.

We structured the workshop to address this problem, and we were particularly interested in the application of the biomass spectrum hypothesis to the Northern Cod stocks, although this was not necessarily our only concern. The first day and a half of the workshop was essentially a learning exercise. We tried to organize the talks so we would get the maximum output of useful information. Because of the short time for the organization of the workshop there was some overlap between the talks. But it was better to hear things twice than not at all. The rest of the workshop was devoted to discussion of the points raised by the speakers. This generated a tremendous amount of useful information. The final afternoon was devoted to formulating specific research recommendations. For this we were able to call on a vast body of information that represented the combined experience of the many internationally respected authorities who attended the workshop. We would not go as far as to say that the workshop recommendations are the last word on the subject of the biomass spectrum and fisheries, but we are prepared to state that they represent the present "state of the art" with respect to understanding the interactions between the study of ecology and the practical administration of fisheries, particularly the fishery for the Northern Cod.

Size- and biomass-distribution of pelagic zooplankton on the SE Shoal of the Grand Bank

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Plankton surveys employing a 50 station grid (18.5 km spacing) located between 43.5^0 N and 45.0^0 N, and between 49.0^0 W and 51.0^0 W on the SE Shoal of the Grand Bank were conducted in September of 1987 and 1988. Zooplankton were sized using a calibrated optical particle counter (600-30,000 μm equivalent spherical diameter) mounted on a miniBIONESS 7-net sampler which was towed at ~1.5 m/s in a stepped oblique manner from near-bottom (max 70 m) to near-surface (2.5 m). Temperature and salinity data were collected with a CTD mounted on the miniBIONESS which was employed to collect capelin (*Mallotus villosus*) larvae. Temperature and salinity data showed similar patterns in both years and defined a N-S oriented sub-thermocline front near the eastern side of the grid at the shelf break. This front separated cold (0-2^0 C) Labrador Current water (seaward of the shelfbreak) from a warmer (4-5^0 C) water mass in the 30-60 m depth stratum centred over the shoal. There was evidence of a cold (<3^0 C) water mass intrusion on the western side of the survey grid in both years.

The distribution of size-structured biomass was highly variable in the horizontal (~20 km resolution) and vertical (~5 m resolution) planes, as well as between years. The 1987 depth and station averaged biomass size-distribution showed a maximum of 0.05 g m^{-3} in in the smaller (800-1000 μm ESD) size-class, 0.005 g m^{-3} in the medium (2000-4000 μm ESD) size-class, and 0.025 g m^{-3} in the larger (5000-7000 μm ESD) size-class. The 1988 depth and station averaged biomass-distribution was similar with a maximum of 0.04 g m^{-3} in the smaller size-class and 0.005 g m^{-3} in the medium size-class, but showed a greatly reduced concentration of 0.01 g m^{-3} in the larger size-class. The "normalized" biomass-distribution (600-30,000 μm ESD) had a slope of -0.80 in 1987 and -0.67 in 1988. The standard ("un-normalized") distribution had a slope of -0.164 in 1987 and -0.038 in 1988, and neither were significantly different from zero. However, the distributions in both years showed "wave-like" deviations from the slope predicted from biomass size-distribution theory.

The distribution of particle biomass in the 600-1000 μm ESD size-class (potential prey for 20 mm capelin larvae) was also highly variable in the horizontal and vertival planes. Biomass concentations in the 1000 μm ESD size-class reached 0.06 g m^{-3} in the 30-35 m depth stratum on the western size of the grid, 0.14 g m^{-3} at 30-35 m in the centre of the grid, and 0.37 g m^{-3} at 25-35 m at the sub-thermocline front near the shelf break on the eastern side of the grid. Depth-averaged biomass concentration of the 100 μm ESD size-class ranged from 0.01 to 0.03 g m^{-3} on the western side of the grid, from 0.01 to 0.06 g m^{-3} over the centre of the shoal, and from 0.04 to 0.12 g m^{-3} on the east side of the grid (at the front). Biomass concentrations in the 600-1000 μm ESD size-classes showed a general sub-thermocline west to east gradient from 0.08 g m^{-3} to 0.6 g m^{-3} at the front in 1987, and similarly from 0.08 g m^{-3} to 0.360 g m^{-3} in 1988. The concentration of capelin larvae (20 mm average size) was not correlated with the biomass of the 600-1000 μm ESD particle size-class. However, the spatial disribution of larvae in better-than-average condition (as determined by lipid content) was coincident with regions of high biomass in the 600-1000 μm ESD size-class, which was coincident with the frontal region.

It is concluded that further development of the biomass "spectrum" theory will require quantitative observations directly from the field, and must begin to seriously account for the spatial (vertical and horizontal) and temporal (at least seasonal) variability that is clearly related to variations in water mass characteristics (temperature and salinity). It is further hypothesized that interannual and spatial variations in selected ranges of the biomass size-distribution (e.g. potential prey sizes) are necessary and sufficient to explain variations in the condition and thus survival probability of fish larvae. This approach, and rigorous testing of the hypothesis, may lead to substantial improvements in recruitment and stock-size forecasting.