ICES CM 2006/I:08 - Theme session on quantifying, summarizing, and integrating total uncertainty in fisheries resource surveys

Size and condition of mackerel in research vessel trawl hauls versus commercial purse seine catches: implications for acoustic biomass estimation.

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In September, after the summer feeding has ceased, the Northeast Atlantic mackerel (*Scomber scombrus*) stock tends to aggregate in ICES Area IVa before they start to migrate southwards in December-February towards the spawning grounds. It is during this autumn period that the Norwegian purse seine fleet catch the mackerel in the southern part of the Norwegian Sea and the northern part of the North Sea (IVa). Since 1999 IMR has also carried out annual acoustic surveys to estimate the biomass concurrently with this fishery. During these surveys the mackerel has been sampled with a small pelagic trawl (20 m opening) at a speed of 3-3.5 knots, and the age, length and weight has been measured for use in the biomass estimation. In the present study we demonstrate that the size, both in terms length (mean length and length at age) and condition (weight at length), of mackerel caught in the research vessel trawl hauls is significantly lower than that observed in the purse seine catches from nearby commercial vessels. By using data from purse seine caught mackerel instead of the trawl caught ones, the biomass estimates during 1999-2003 increased by 30% on average. These results also signify the importance of being careful by using research vessel trawl haul samples when estimating abundance and studying variations in growth and condition of high speed swimming species like mackerel.

Keywords: mackerel, trawl, purse seine, acoustic, biomass, estimation.

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1. Introduction

The North East Atlantic (NEA) mackerel stock consists of three spawning components named after their spawning areas, the southern, western and North Sea component. The southern component spawns in Spanish and Portuguese waters, the western component spawns in the Bay of Biscay and northwards along Ireland and UK while the North Sea component spawns centrally in the North Sea and Skagerrak. The fishery of NEA mackerel is commercially important and has during the period 1992-2002 produced catches in the order of 565,000-821,000 tonnes (ICES 2006).

The southern and western spawning areas have been surveyed every third year since 1977 (Lockwood et al 1980, ICES 2002) to measure the egg production, fecundity and thereby the spawning stock biomass (SSB). Surveys have been carried out in the North Sea since 1968. For many years these surveys were carried out once per spawning season, but since 1980 (Iversen 1981, ICES 2003b) the surveys have been extended to cover the spawning area several times per season to estimate the egg production and SSB.

The egg estimates of the spawning stock are the only SSB estimates of mackerel that are fishery independent and are of vital importance when assessing the NEA mackerel stock (ICES, 2003b). However, the fact that mackerel, which does not have a swim bladder, can be distinguished from other fish species and by using echo sounders operating synchronously at different frequencies (Korneliussen and Ona 2003), has implied that also this stock could be estimated acoustically. In this regard, IMR has since 1999 utilised RV G.O.Sars with mulitifrequency equipment on an annual basis to estimate the distribution and abundance of mackerel in October-November as it aggregates in ICES Area IVa, before migrating southwards towards the spawning grounds (Iversen 2002).

Both during the egg surveys and during the acoustic surveys pelagic trawling is carried out with the aim to study biological characteristics like length, weight, age, stage of maturity and fecundity. Such studies are a necessity for both type of estimates and they are based on the assumption that the samples are representative for the real population. However, mackerel is clearly a high-speed swimming fish, schools tracked with sonars have been recorded at speeds up to 6 $ms^{-}1$ (Godø et al. 2004). Hence, the present study is based on the hypothesis that the mackerel to a large degree will tend to avoid the research vessel trawl. Another hypothesis is that this avoidance will increase as the fish grows to be larger; due to increased swimming speed with size (Ware 1975, 1978). Accordingly, the ability to avoid may also decrease if the body condition is reduced and this fish is weaker. In comparison, a purse seine is assumed to be a non-selective gear as it catches whole schools of up to several hundreds of tonnes, although the schools themselves many times may manage to avoid the purse and the seine fishery sometimes may be selective against large and better priced fish by focussing the effort in the areas with largest fish.

The objective of the present study was to test whether the mackerel caught in research vessel trawl hauls, are smaller and in worse condition in comparison with individuals caught in with neighbour purse seine catches, and to what extent this may affect the biomass estimation.

2. Materials and methods

The data used to test for possible size selectivity in research vessel trawl hauls for mackerel was the 1999-2003 data from “RV G.O.Sars” in ICES Area IVa in October-November, and data from commercial purse seine catches from the same area and period (Fig. 1, Table 1). During all these years the same trawl was used, an “Åkra” trawl with 20 m opening, towed at a speed of about 3.5 knots. Note that in 2003 the new G.O.Sars was used, but still towing with the same trawl and speed, i.e. the speed was limited by the trawl construction and not the vessel power. The data used in the present analysis the sampling of research vessels and commercial vessels has occurred side by side on the very same aggregations visual acoustically in the area. Thus, in theory they should catch the same fish.

The biological measures included in the present study were total length (cm), total weight (g) and age (from otoliths). If possible at least 50 fish and up to 100 fish were measured in each sample. The mean sample size given (Table 1) demonstrated that this goal was difficult to achieve in the trawls haul samples in all years, as a result of problems catching the mackerel. In 2003 some of the purse seine samples were small due to storage problems.

The effect of using purse seine samples instead of trawl samples in biomass estimation was investigated. Conversion of the area echo abundance area, i.e. the nautical area backscattering coefficient (NASC), s_A (MacLennan et al., 2002), to numerical fish quantities and biomass was achieved by using the adopted mean target strength, $\langle TS \rangle$ to length, L, relationships for mackerel (Eq. 1), as used in the standard assessment surveys (Foote, 1987).

$$\langle TS \rangle = 20\log L - 84.9 \qquad (1)$$

The number of fish, N, within a particular area (A) was computed in the standard manner:

$$N = \langle s_A \rangle A (4\pi \langle \sigma_{bs} \rangle)^{-1} \quad (2),$$

where $\langle s_A \rangle$ is the mean NASC within the area, A is the size of the area in nmi^2, and $\langle \sigma_{bs} \rangle$ is the mean backscattering cross section of the fish species, as estimated from the target strength equation (MacLennan et al., 2002). The possible effect of gear selectivity on estimates of abundance was carried out using the mean L by gear and year of all samples in the study area, based on the assumption that both gears sampled the same schools (Fig. 1). The estimates of abundance were carried out with the same set NASC value and area A for all years. Based on the applied weight-length relationships the appropriate mean weight of mackerel with mean L was estimated in order to obtain biomass estimates. Finally, the relative difference (%) between the estimates was calculated.

3. Results

A comparison of the overall length distribution of mackerel in ICES Area IVa October-November 1999-2003 between trawl and purse seine samples clearly demonstrated the tendency of the trawl to catch smaller fish (Fig. 2). The length distributions overlapped, but the modal lengths were 4 cm apart at 34 and 38 cm for trawl and purse seine respectively.

When testing for statistical differences in length between the samples from the two gears, a factorial ANOVA was run with year (1999-2003) and gear (purse seine and trawl) as independent factors. The fish length was clearly influenced by both the sampling year and gear ($p<0.001$), trawl caught mackerel was smaller than the purse seine mackerel in all years (Fig. 3).

Similarly, a factorial ANOVA with year, age (2-9 years) and gear as independent factors was used to test for differences in mackerel length at age between mackerel caught with the two gear types. Length at age was influenced by sampling year and gear ($p<0.001$), with trawl caught mackerel being smaller than the purse seine mackerel (Fig. 4).

Finally, a factorial ANOVA with year, length and gear as independent factors was used to test for differences in mackerel condition (weight at length) with gear type. As with length and length at age, the condition varied with by sampling year and gear ($p<0.001$), with trawl caught mackerel being in a worse condition than the purse seine mackerel (Fig. 5).

4. Discussion

The present study have demonstrated that the length, length at age and condition (weight at length) of mackerel caught in the research vessel trawl hauls is significantly lower than that observed in the purse seine catches from nearby commercial vessels. The potential problem with research vessel trawl hauls is also apparent by looking at the sample sizes, which is lower in the trawl samples than in the purse seine samples simply due to small catches.

It is apparent that mackerel is a high-speed swimming fish, schools have tracked been recorded with sonar at speeds up to 6 $ms^{-}1$ (Godø et al. 2004), which to a large degree will avoid the small research vessel trawl being towed at speeds around 3-3.5 knots (1.5-1.8 ms^{-1}). The present study indicates that this avoidance will increase as the fish grows to be larger; probably due to increased swimming speed with size (Ware 1975, 1978). Accordingly the present results indicate the ability to avoid also will decrease if the condition is reduced and this fish is weaker.

These results signify the importance of being careful with using research vessel trawl haul samples in any biological study concerning high speed swimming species like mackerel. First the size and age structure utilised in acoustic estimates will be skewed towards younger fish, which would reduce the biomass estimates significantly. Secondly, the age-length keys from research trawl hauls will also be wrong and cannot be used to convert length-measured fish from commercial catches into age distributions. Finally, due to the reduced condition in the trawl samples, this may influence studies on the maturation and egg production, which in general is influenced by the condition of the fish.

5. References

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Tables

Table 1. Overview of the data (S=number of samples and N=number of individuals) included in the analyses of mackerel length and weight at length related to year and catch gear (RT=research trawl and PS=purse seines). Average sample size (SN) is also given.

Year	Catch gear	S	N	SN
1999	PS	23	1758	76.4
1999	RT	11	416	37.8
2000	PS	23	1359	58.8
2000	RT	22	642	29.2
2001	PS	10	582	58.2
2001	RT	14	282	20.1
2002	PS	15	968	64.5
2002	RT	13	543	41.76
2003	PS	11	371	33.7
2003	RT	24	795	33.3

Figure captions

Fig. 1. Map showing the geographical distribution mackerel samples from commercial purse seine catches (filled symbols) and pelagic trawl catches (open symbols) from the Norwegian RV G.O.Sars during October-November 1999-2003.

Fig. 2. Length distribution of mackerel caught in ICES Area IVa during Octover-November 1999-2003. Comparison between individuals sampled from commercial purse seine catches (filled bars) and pelagic trawl catches (open bars).

Fig. 3. Total length of mackerel in ICES Area IVa during autumn related to year and catch gear; commercial purse seine catches (filled symbols) and pelagic trawl catches (open symbols) from the Norwegian RV G.O.Sars. Mean values ± 95% confidence intervals are given.

Fig. 4. Length at age of mackerel in ICES Area IVa during autumn related to year and catch gear; commercial purse seine catches (filled symbols) and pelagic trawl catches (open symbols) from the Norwegian RV G.O.Sars. Mean values ± 95% confidence intervals are given.

Fig. 5. Weight at length of mackerel in ICES Area IVa during autumn related to year and catch gear; commercial purse seine catches (filled symbols) and pelagic trawl catches (open symbols) from the Norwegian RV G.O.Sars. Mean values ± 95% confidence intervals are given.

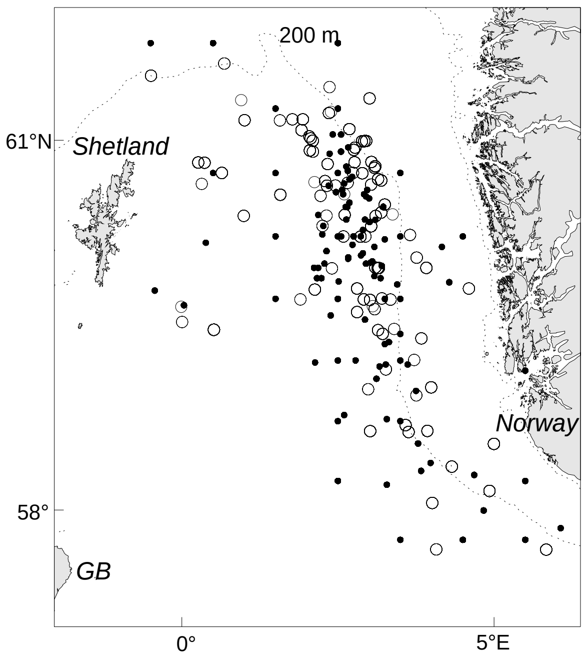


Figure 1

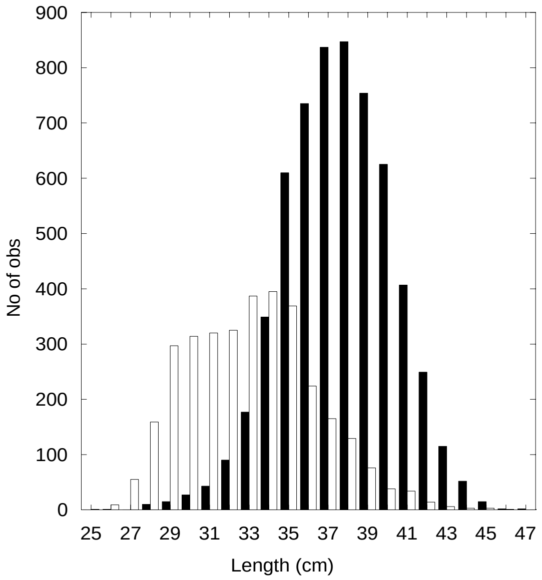

900
800
700
600
500
400
300
200
100
0
No of obs
25
27
29
31
33
35
37
39
41
43
45
47
Length (cm)

Figure 2

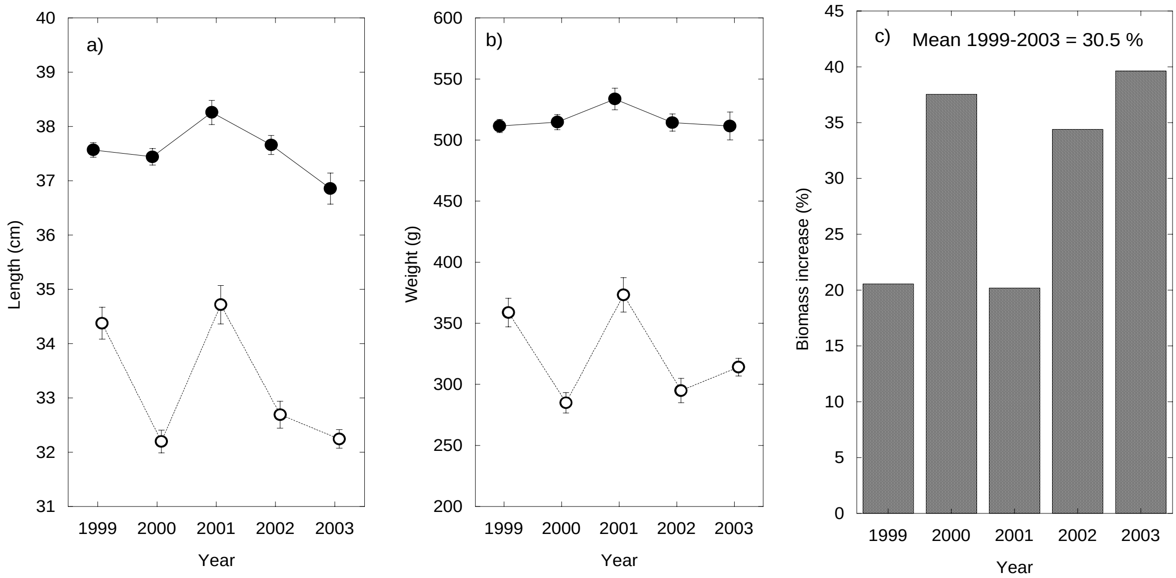

a)
Length (cm)
Year
b)
Weight (g)
Year
c)
Mean 1999-2003 = 30.5 %
Biomass increase (%)
Year

Fig. 3

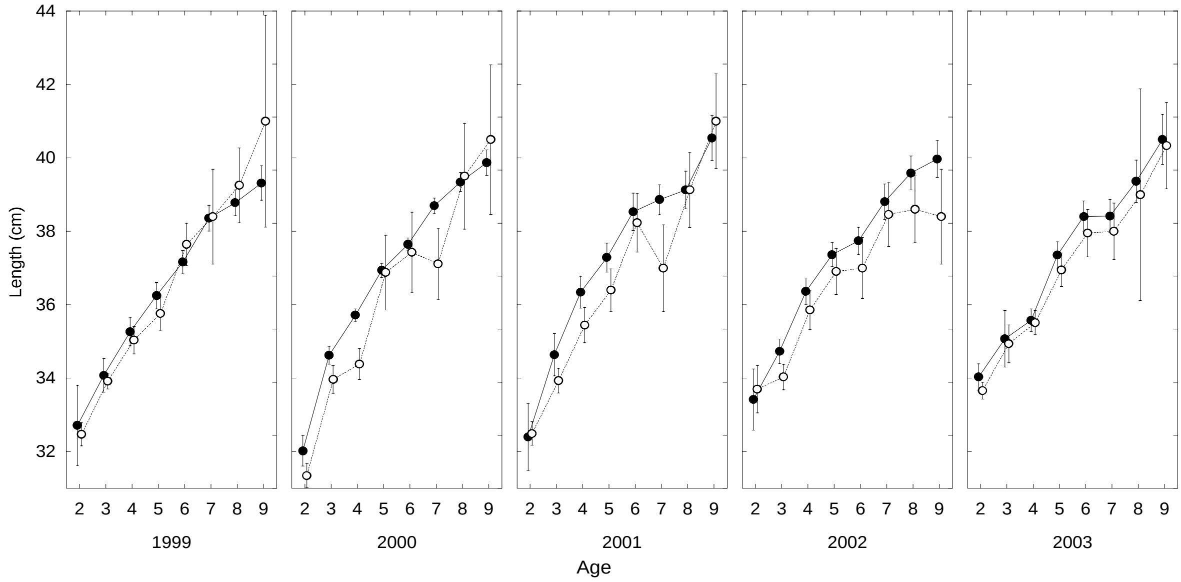
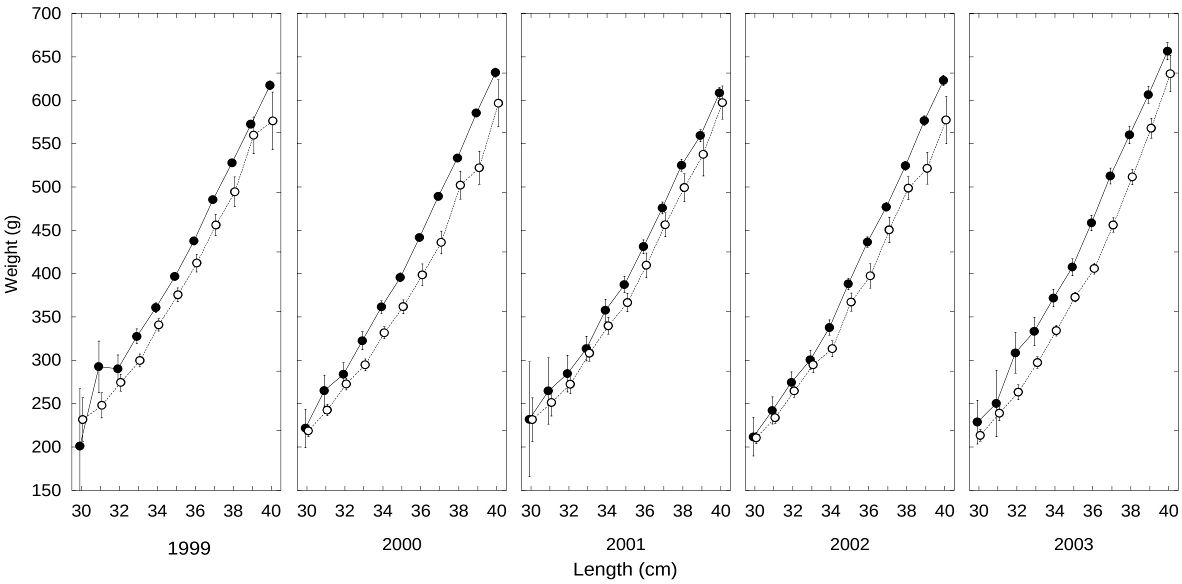

Length (cm)
44
42
40
38
36
34
32
2 3 4 5 6 7 8 9
1999
2000
2001
2002
2003
Age

Fig. 4



Weight (g)
700
650
600
550
500
450
400
350
300
250
200
150
30 32 34 36 38 40
1999
2000
2001
2002
2003
Length (cm)

Fig. 5