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OPTIMIZATION OF PURSE SEINES BY LARGE MESHED SECTIONS AND LOW LEAD WEIGHT. THEORETICAL CONSIDERATIONS, SINKING SPEED MEASUREMENTS AND FISHING TRIALS.

by

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Abstract

Theoretical considerations on material requirements and sinking speed by use of different mesh size and lead weight in purse seines are outlined. Measurements confirmed that the sinking speed varied with mesh size and lead weight according to hydrodynamic theory. The sinking speed was slightly influenced by mesh geometry. In fishing trials with white large meshed net in the last part of a purse seine it was never observed that herring or mackerel escaped through the large meshes neither in day nor at night. The results indicates that the construction of herring and mackerel purse seines may be improved with an economic benefit both with regard to building costs and catch success.

Introduction

Purse seining is regarded as one of the most efficient fishing methods on schooling, pelagic species. However, herring and mackerel schools in the North Sea escape capture in about 35 % of the purse seine sets (Misund 1987, 1988).

The catch efficiency of purse seines depends on its length, depth, sinking speed, net type, and the skill by which the purse seine is operated in capture situations. The sinking speed is influenced by the lead weight, mesh size, mesh geometry, material and tickness of the twine, and the hanging ratio. Traditionally, a basic principle in construction of purse seines has been to choose a net type which acts as a fence for particular species. The observations that some species are guided by a mesh size large enough to pass through (Blaxter, Parrish & Dickson 1964), are scarcely tested in purse seines.

The costs of building new purse seines are a heavy economic strain for the fishermen. Construction of more optimal purse seines with regard to building costs and capture efficiency is therefore an important aspect of gear research. On this background, use of varying net parametres and lead weight in purse seine have been considered both theoretically, by sinking speed measurements, and in fishing trials.

Considerations on material requirements and sinking speed

The net in Norwegian purse seines is exclusively made of polyamid, and as illustrated in Fig. 1A, the breaking load of the twine is proportional to its tickness. However, as the tickness of the twine increases, the amount of twine necessary to produce a given piece of net increases lineary (Fig. 1B). But by increasing the mesh size, the amount of twine to produce the given piece of net by a certain twine tickness is reduced (Fig. 1C). As a result of this, the costs of producing a given piece of net is reduced drastically by choosing a larger mesh size in the net even if the tickness of the twine is increased (Fig. 1C). These considerations are outlined on the basis of data supplied by a Norwegian net manufacturer.

According to Stengel & Fridman (1977), the sinking speed (v) of a net is a function of depth (y) and sinking time (t):

$$v = dy/dt$$

A resisting hydrodynamic force (F) will act on the sinking net expressed by:

$$F = k\ y\ (dy/dt)^2$$

The resisting force is proportional to the number of meshes in the net (n), and as the net reaches the hanging depth, the resisting force can approximately be expressed by:

$$F = k\ n\ v^2$$

The constant (k) depends of twine tickness, mesh bar length, and type of material. The number of meshes in the net is a function of its length (L), depth (H), length of the mesh bar (a), the hanging ratio (E), and depth coeffisient (F):

$$n = (L\ H)/(4a^2\ E\ F)$$

The hydrodynamic resisting force is approximatly equal to the load force (q) acting on the net. Consequently, the sinking speed of the net as it reaches the hanging depth may be expressed by:

$$v = ((q\ 4a^2\ E\ F)/(k\ L\ H))^{1/2}$$

Sinking speed measurements and fishing trials

The measurements were conducted by a purse seine built of sections of hexagonal (H-net, Beltestad 1980) or rhombic meshed net (F-net), and with varying mesh size and twine tickness (Fig. 2 A-C). The measurements were conducted by 1, 2 or 4 lead straps pr. 10 m lead line, giving a lead weight of 0.5, 1.0, or 2.0 kg/m lead line.

The measurements were conducted from M/V "Fangst" or M/V "Fjordfangst" in approximatly currentless locations near Bergen. The sinking speed was measured by 3 calibrated Furuno NFZ Mark-III B acoustic depth sensors fixed to purse rings in the middle of each section. The depth recordings in each purse seine set were stored on a data collector, transferred to a computer, and realistic values corrected according to the calibration results.

Fishing trials by the latest version of the purse seine (Fig. 1 C) were conducted on mackerel schools on fjords in South Western Norway, and on herring schools on fjords in North Western Norway, autumn 1987. The twine in the last large meshed section of the seine was white to increase the visibility, and the weight of the lead line 0.5 kg/m. M/V "Fjordfangst" was used for the trials, and the vessel was equipped with a 150 kHz Furuno CH-12 multibeam sonar to locate schools, guide shooting of the purse seine, and record the behaviour of the schools during pursing. In addition, the behaviour of the herring schools was studied more detailed by a 330 kHz Simrad FS 3300 sector scanning sonar.

Results

There were no difference in average sinking speed to 30 m depth between the H-net and F-net, but the H-net sank significantly faster to 40 m depth (Table 1). The mesh size in these experiments was 60 mm, the lead weigth 0.5 kg/m, and the twine tickness R 420 tex.

As expected and apparent from Fig. 3, the sinking speed (v) to 30 m depth increased by larger mesh size (MS) in the net, and followed the relation:

$$v = 8.5\ e^{(0.005\ MS)} \qquad (r^2 = 0.59)$$

There was a relative large variation in the measurements, but the average sinking speed (Table 1) was significantly different for the investigated mesh sizes (Kruskal-Wallis test, $p<0.05$). Both H and F-net with a twine tickness of R 282-420 tex, and a weigth of 0.5 kg/m lead line were used in these measurements.

Table 1. Average sinking speed to different depth (D) for net with different mesh geometry, and average sinking speed for net with varying mesh size and lead weigth to 30 m depth (H: H-net, F: F-net, v: average sink-speed in m/min, n: no. of measurements, p: level of significance for Mann-Withneys test).

	MESH GEOMETRY				MESH SIZE (mm)				LEAD WEIGTH (kg/m)		
	H	F	H	F	15	30	60	150	0.5	1.0	2.0
D	30 m		40 m			30 m				30 m	
v	11.6	11.5	10.2	9.0	8.0	10.1	11.6	17.7	11.6	14.5	17.7
n	12	10	7	5	2	11	23	8	23	20	6
p	>0.05		<0.10								

As illustrated in Fig. 4, the sinking speed (v) to 30 m depth increased by heavier lead weigths (LW) expressed by:

$$v = 4.5 \ln (LW) + 14.6 \qquad (r^2 = 0.48)$$

Despite a relative large variation in the measurements, the average sinking speeds for the investigated lead weights (Table 1) were significantly different (Kruskal-Wallis test, $p<0.05$). As in earlier investigations (Iitaka 1971), the sinking speed was lineary related to the square root of the lead weigth (Fig. 4). 60 mm H and F-net with a twine tickness of R 420 tex were used in these measurements.

The latest version of the experimental seine was used in 20 realistic fishing trials on saithe, sprat, herring and mackerel schools during autumn 1987. Totally, the catch success was 60 %, with a 5 ton catch of 28 - 46 cm long saithe, 2 catches of 28 - 43 cm long mackerel (1.5 and 2 ton), 6 catches from 2 to 25 ton of 22 - 38 cm long herring, and 3 catches of 3 - 5 cm long sprat. Most of the herring and mackerel schools were rather fast swimming, and avoided the vessel distinctly (Fig. 5). The schools escaped capture by avoiding beeing encircled or swimming out under the net in about 50 % of the sets. However, encircled schools never escaped throught the large meshed sections neither in daytime or in darkness at nigth, even if some fatty herring schools performed an "explosion" behaviour when they were enclosed by the purse seine (Fig. 6). The sprat schools escaped through the meshes in the bunt as the seine was hauled onboard.

Discussion

These investigations indicates that the concept of large meshed sections and low lead weight in purse seines is an advantage. The building costs are reduced and the catch properties are maintained as herring and mackerel never escaped through the large meshes. Measurements showed that the sinking speed by use of low lead weights is satisfactory by use of large meshes in the net. The catch success of the experimental seine is about the same as during herring and mackerel fishing by traditional purse seines in the North Sea (Misund 1987, 1988). The concept enables building of larger purse seine to increase the capture efficiency on fast swimming schools (Misund 1988) without creating storing problems as the material requirements are reduced.

Vision is of major importance for the behaviour of fish in relation to netting gear (Blaxter, Parrish & Dickson 1964, Wardle 1985), indicating that use of large meshes may be critical in darkness. However, it was never observed that herring or mackerel escaped through the large meshes in darkness. Schools resolves in looser organized shoals in darkness (Pitcher 1983), and the swimming speed and level of activity of the indivduals are reduced (Class et. al. 1986, Pitcher & Turner 1986). Maybe the fish sences the moving net in darkness by the lateral line system, and avoids the net wall even if the meshes are large enough to swim through.

The paniclike "explosion" behaviour of some herring schools captured in daylight was most critical to the use of large meshed sections, but it was never observed that the schools escaped through the sections. White net which gives best contrast (Tyler 1967) and frightening effect to withstand "explosion" behaviour may therefore be of major importance by use of large meshes in the last part of purse seines. This is supported by the repeated observation of entangled herring in the 60 mm, black selvage and triangle of the purse seine. The "explosion" behaviour resembles a "Flash expansion" for predator evasion (Pitcher 1979), and is also observed during herring purse seining in the North Sea (Misund 1987). Without beeing observed, the front individuals in the schools may have escaped through the large meshes, and "flashing" as they past through, may have frightened the rest of the school. If this behaviour was repeated several times, the whole school would have escaped at last, and this did not occure.

As expected according to the hydrodynamic considerations, the measurements revealed an increasing sinking speed by use of larger mesh size and heavier lead weight. The sinking speed increased lineary by the square of the lead weight which has been an argument to use as much as lead as possible (Iitaka 1971). However, the results revealed that a doubling of the lead weight increased the sinking speed by only about 3 m/min, indicating a limit where an increased lead weight is inconvenient. The results indicates that commercial Norwegian purse seines often carrying a lead weight between 7 to 10 kg/m lead line, are to heavy loaded. The faster sinking speed of the hexagonal meshed net down to 40 m depth was expected as the lateral forces are lower in hexagonal than rombic meshed net when the net reaches the hanging depth (Beltestad 1980). As shown by Hamre (1963), different hanging ratios of the net types may have influenced the results. The relative large variation in the sinking speed measurements are caused by the doppler effect causing errors up to +/- 3 m/min, voltage variation in the depth sensors, and different shooting procedures of the purse seine.

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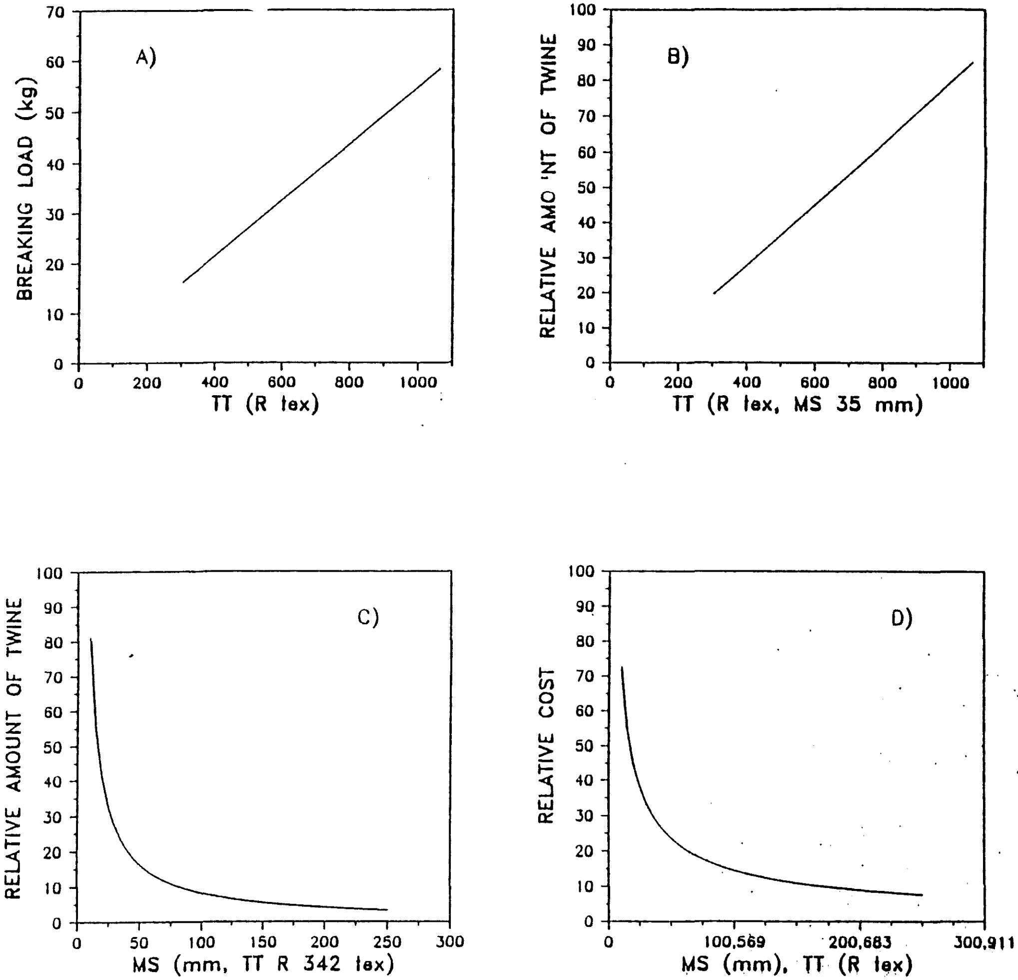


Fig. 1. A) Breaking load for different tickness (TT) of polyamid twine, B) Relative amount of twine to produce a given piece of net of different twine tickness (TT) but by the same mesh size (MS = 35 mm), C) Relative amount of twine to produce a given piece of net of different mesh size (MS) but by constant twine tickness (TT = R 342 tex), D) Relative producing cost of the net by a combination of mesh size and twine tickness relevant for herring seines.

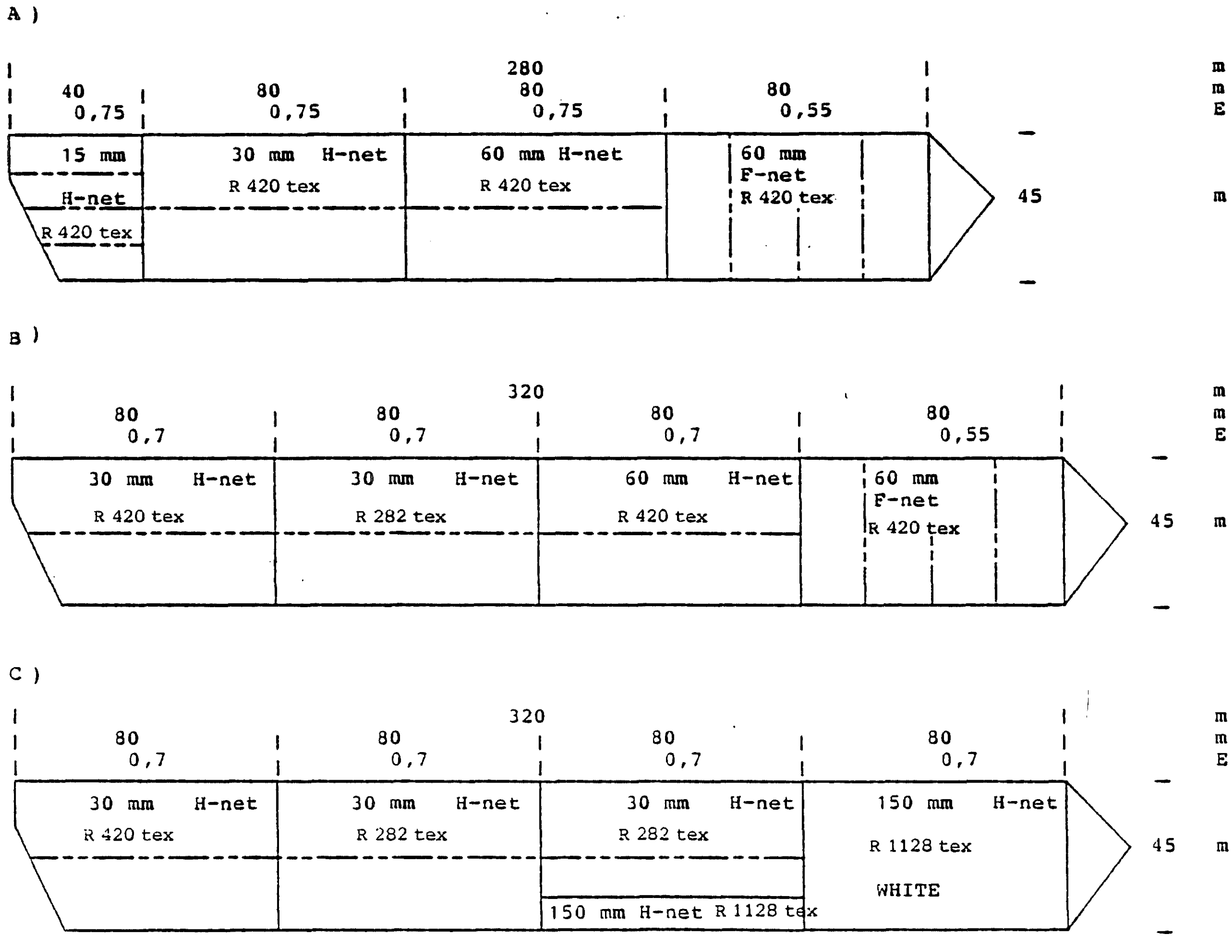
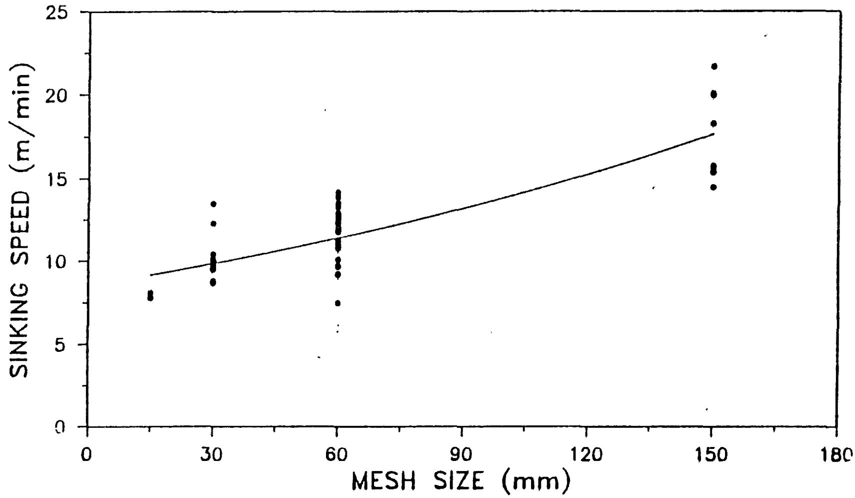
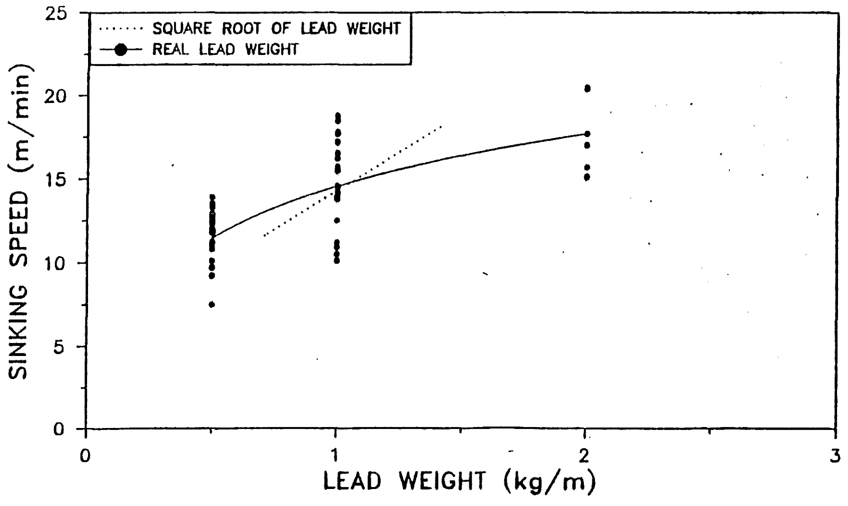


Fig. 2 Design of the purse seine for the sinking speed experiments (A-C), and fishing trials (C).



<u>Fig. 3</u>. Sinking speed to 30 m depht for net of varying mesh size (F&H-net, twine R 282-420 tex, lead weight 0.5 kg/m).



<u>Fig. 4</u>. Sinking speed to 30 m depht by varying lead weight (F&H-net, twine R 420 tex, mesh size 60 mm).

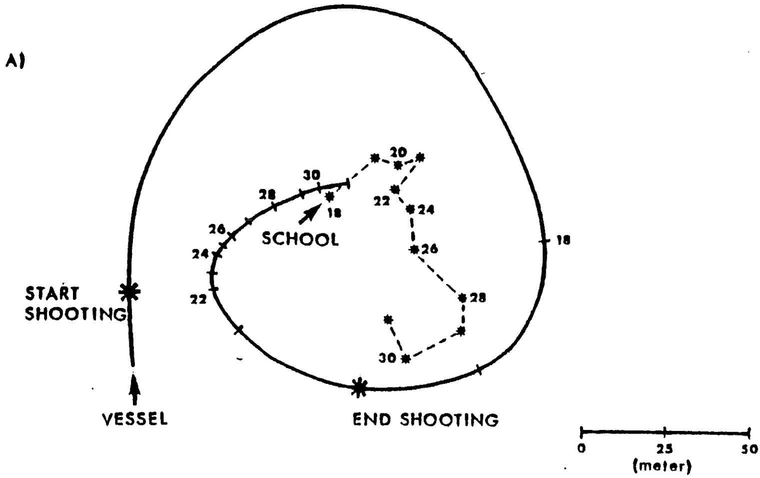


Fig. 5. Horizontal movement of a mackerel school during shooting and pursing of the seine as recorded by Furuno CH-12.

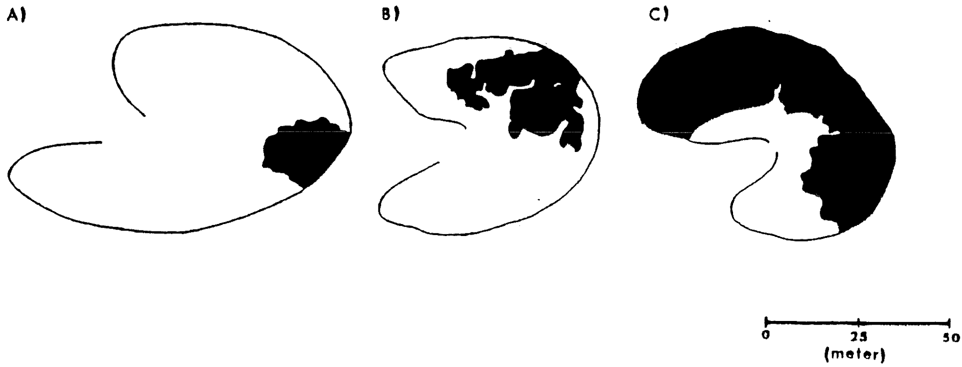


Fig. 6. Situation during and after pursing as recorded by Simrad FS 3300. A) Herring school by the net wall in the latest part of the pursing. B) The school is "exploding" as the pursing is finished. C) The school has extended in the whole net area after the pursing is finished.