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Short communication

Survival of herring after simulated net bursts and conventional storage in net pens

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Abstract

In the herring purse seine fisheries, incidental fishing mortality may occur after net bursts, or during storage of live herring in net pens. We have simulated two net bursts by pulling up net pens until they split by the weight of the herring. In both cases, the experimental group suffered a higher mortality than the control group, and few herring exposed to a simulated net burst survived for more than 120 h. We have also quantified the mortality of herring that were captured by purse seine, transferred to net pens, and towed inshore for storing. Our study indicates that survival is primarily determined by the size of the net pen since the survival percentage was low in small net pens and high in large ones.

Keywords: Clupea harengus; Net bursts; Mortality

1. Introduction

In the Norwegian spring spawning herring fishery the total unaccounted fishing mortality for all categories of gear for the period 1985–1987 has been estimated at 150 000 tons (Anonymous, 1989). Such unaccounted mortality may induce bias in stock assessment based on fisheries statistics. It is assumed that such mortality may occur incidentally after net bursts or during storage of live herring in net pens. During purse seining, net bursts may occur when the gear is torn by the weight and force of fish swimming against the net when hauling the seine, or by the weight of dead, sinking fish in the bunt during pumping onboard. Net bursts occur most frequently during the day when the purse seine is shot on large, dense schools which are formed during migration to the spawning grounds, and they

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tend to occur when the catch in the purse seine exceeds about 300 tons (Beltestad and Misund, 1991). We have conducted small-scale experiments with the aim of investigating whether incidental mortality occurs after net bursts.

The smaller coastal Norwegian purse seiners take most of their catch in autumn when the herring (*Clupea harengus* L.) are found in fjords in northern Norway. These vessels transfer the herring to net pens where they are stored alive for several weeks before delivery to processing plants. Herring that die during the storage are usually discarded, and are therefore not accounted for in catch statistics. We have conducted trials to quantify the survival of herring during storage in net pens of different size, and varied fish density and speed of towing inshore.

2. Net burst experiments

We conducted two small-scale net burst experiments. A 27 m vessel operating a 495 × 120 m purse seine caught herring with a mean length of about 34 cm near Harstad, northern Norway in September 1990. Two groups of fish from the catch were guided over to net pens of similar size mounted on the breast of the seine. One of the net pens was used as a control and handled as during conventional storing by being towed carefully (speed <0.5 m s^{-1}) inshore and moored. The other was moored to R/V 'Fjordfangst' (14 m) from which the net burst experiment took place. In the first experiment we used 1000 m^3 net pens with about 700 kg herring in the experiment group and about 2300 kg herring in the control group. In the second experiment the net pens were about 30 m^3 with 60 kg herring in the experiment group and about 100 kg herring in the control group. All pens were made of knotted net of 31 mm stretched meshes.

Before the experiment, the fishing vessel shot the purse seine around 'Fjordfangst'. When pursing was complete, the net pen was pulled up alongside 'Fjordfangst' by a hydraulic power block until the net was torn by the weight and force of the herring, which then escaped into the purse seine. Thereafter 'Fjordfangst' was manoeuvered out, the purse seine hauled, and the stressed herring transferred to a new net pen of similar size as that used for the respective control group. Then the experiment net pen was towed carefully inshore and moored.

In both net burst experiments, the net sustained the weight and force of the fish for about 3 min before splitting. When the net pen was pulled up, it was observed that the fish lost a lot of scales when wriggling against the net. There was no immediate mortality. However, after 24 h, there was only 5% survival in the 60 kg group held in the 30 m^3 netpen, while 99% of the control group of 100 kg herring held in a netpen of similar size survived. After 120 h, there were no survivors in the experiment group, and only just 2% survivors in the control group. In the 700 kg group held in the 1000 m^3 netpen, 70% survived 48 h, but only 5% were still alive after 9 days. At that time still 88% were alive in the control group of about 2300 kg that was kept in a net pen of similar size.

The reason for the high mortality in both simulations of net bursts was probably a severe loss of scales due to physical contact with the net, followed by lethal osmoregulation difficulties. Examination of 30 dead fish showed that an average of about 75% of the skin on the side of the fish had lost scales in both the 60 kg and 700 kg experiment groups. Severe scale loss and skin damage has been shown to cause similar high mortality in mackerel when confined at high densities in small net pens (Pawson and Lockwood, 1980; Lockwood et al., 1983).

Scale loss was probably also the indirect cause of the mortality in the control groups, which was close to that of the experiment group when using the small net pen. The herring in the control groups, which were handled as during conventional storage, could have lost scales both when swimming against the net in the purse seine, and against the webbing in the pen during towing inshore or during storage. Examination of 30 dead fish showed scale loss from an average of about 25% and 40% of the skin on the side of the fish in the control groups kept in the 1000 m^3 and 30 m^3 pens respectively. Efanov (1981) reported a mortality of 25% for herring that had lost 10% of the scales after passing through meshes in the codend of a trawl.

3. Conventional storage trials

We conducted further trials to quantify the survival of herring during conventional storage. We used net pens of different size, and varied both fish density and speed of towing inshore. Large herring (about 34–35 cm in average) were captured by purse seines when schooling during the day in the Harstad and Lofoten area in northern Norway in September 1990 and 1991. Some of the fish were guided over to a net pen mounted to the breast of the purse seine, and towed inshore and moored. In 1990 we used net pens of 30 m^3 (four cases in addition to the smallest net burst control group) containing up to 460 kg herring, or 1000 m^3 net pens (two cases in addition to the largest net burst control group) containing up to 2500 kg herring. The following autumn net pens of 4000 m^3 (eight cases) filled with up to 40 000 kg herring were used. Further trials were carried out in March 1993, at spawning grounds in the fjords of Rogaland, south-western Norway. Here large herring (about 35 cm on average) were attracted by surface lights at night and captured by a small purse seine. The fish were transferred to net pens of about 1500 m^3 (three cases) or about 7000 m^3 (two cases). Catches of up to 35 000 kg were held in the 1500 m^3 netpens, while up to 71 000 kg of herring were kept in the largest net pens.

The 30 m^3 net pens were cubic (about 3 m in length, width and depth) with a knotted net of 31 mm stretched, rhombic meshes. Those from 1000 m^3 to 4000 m^3 were rectangular, with a length about three times that of their width and depth, and with both knotted and knotless netting of stretched, hexagonal or rhombic meshes from 21 mm to 31 mm. The 7000 m^3 net pens were of octogonal shape, about 40 m long, 16 m wide and 10 m deep, with hexagonal, knotless netting of 31 mm stretched meshes. The net pens were distended by two to four aluminium or wooden bars. Mortality in the net pens was monitored daily by an underwater camera, and the quantity of dead herring was measured accurately when the live fish were delivered to processing plants after storage for 5–18 days.

The conventional storage trials revealed that the size of the net pen is a major determinant of the survival of herring. After 120 h, survival varied from 2% to 30% in the 30 m^3 net pens, from 20% to 90% in the 1000 m^3 net pens, and from 80% to 100% in the larger net pens. On average, survival after 120 h storage in net pens > 1000 m^3 was 92.5% (SD=7.6%, N=13). The survival of the herring was also affected by the towing speed which varied from 0.26 m s^{-1} (0.5 knots) up to 0.77 m s^{-1} (1.5 knots). The overall correlation between towing speed and survival after 120 h was strong ($r=-0.70$, $P<0.05$), but only the smallest net pens were towed at a speed exceeding 0.5 m s^{-1} (1.0 knots). For the larger net pens (> 1000 m^3), survival after 120 h fell from 98–100% for net pens towed at 0.5–0.6 m s^{-1} to 80–90% for net pens towed at 0.8–1.0 m s^{-1}. The fish density in the net pens varied from 0.7 kg m^{-3} to 22.3 kg m^{-3}, but there was no correlation between fish density and survival after 120 h ($r=0.18$, $P=0.45$). The towing time to reach the inshore mooring site varied from 30 min to 180 min, but this was not correlated with the survival after 120 h ($r=-0.02$, $P=0.95$). The influence on survival of the different mesh qualities in the net pens seems to have been rather marginal. In five and three cases with 4000 m^3 net pens of knotless and knotted netting, survival after 96 h averaged 93% (range 90–99%) and 89% (range 85–95%), respectively.

By combining the influence of the size of the net pen and the towing speed in a physical stress index, a relationship which expresses decreasing survival of herring as a function of increasing physical stress when towed and stored in net pens,

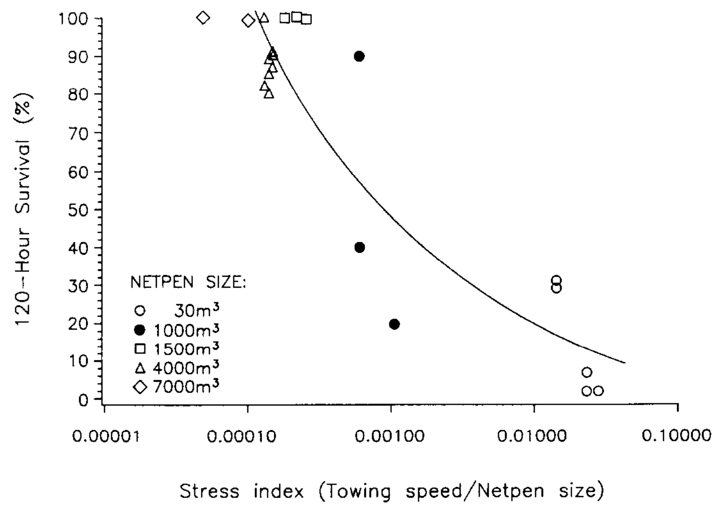

Fig. 1. Relationship between 120 h survival and physical stress index (towing speed in knots per size of net pen in m^3) during trials of conventional storage of large herring in net pens (curve is fitted by hand).

can be established (Fig. 1). As indicated by the net burst experiments, the relevant physical stress during conventional storing trials is probably direct contact with the webbing of the purse seine or the pen, resulting in fatal scale loss and consequent lethal osmoregulation difficulties.

Survival after 120 h in trials with net pens larger than 1000 m^3 averaged 87.9% ($SD=6.1\%, N=8$) and 99.7% ($SD=0.3\%, N=5$) for the trials conducted in autumn at the hibernating areas and in winter at a spawning ground, respectively. There may be several reasons for this significant difference ($P<0.05$, Wilcoxon test) in survival. The herring were caught when schooling during the day in autumn, and when attracted by artificial light at night in winter. The herring may behave more carefully during the night than during daytime schooling, so that physical contact with the net which results in lethal scale loss is reduced. Another possibility is that the lower sea temperature during the winter trials (about 4–6°C) than during the autumn trials (about 9–11°C) made the herring less active and thereby reduced the frequency of physical contact with the net. The herring may also tolerate physical contact with the net better during spawning than when they arrive at the hibernating areas. In the conventional storage trials conducted at the spawning ground, herring were kept in one 1500 m^3 net pen and the two 7000 m^3 net pens for up to 18 days without mortality exceeding 0.5%.

4. Conclusion

Our results indicate that mortality may occur if a purse seine bursts because of the weight and force of live herring. During conventional storage in net pens, the size of the net pen and the towing speed to the inshore mooring site are the main determinants for survival. In the coastal fishery for large herring with conventional storage in net pens in the autumn, a 120 h survival of about 90% seems to be realistic if large net pens (> 1000 m^3) and low towing speed are used, while there may be virtually no mortality in this fishery at inshore spawning grounds in winter.

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