Fisheries Research 176 (2016) 65–75

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Pumping of mackerel (*Scomber scombrus*) onboard purse seiners, the effect on mortality, catch damage and fillet quality

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ARTICLE INFO

Article history:
Received 15 July 2015
Received in revised form
21 December 2015
Accepted 22 December 2015
Available online 5 January 2016

Keywords:
Mackerel
Pumping
Purse seine
Mortality
Injuries
Fillet quality

ABSTRACT

Differences in the mortality, catch damage, and fillet quality of mackerel pumped either from the seine directly onboard the catching vessel or transferred at sea to a secondary vessel were explored. Three studies were performed on commercial vessels, both purse seiners and coastal seiners, during the catching season in September and October 2012–2014. Most of the fish died after 20 to 60 min due to the duration of the crowding time. There was a significantly higher survival rate for the fish that were pumped to the main vessel due to shorter crowding time compared to the fish that were pumped to the secondary vessel, with an average survival rate of 53.4% versus 23.9% The mackerel caught with the secondary vessel in 2014 had a significantly higher proportion of catch damage and discolorations compared to the fish caught with the main purse seine in 2014, and coastal vessels in 2012 and 2013. For the experiment in 2014, a sensor fish was developed with the purpose of registering acceleration forces (g-forces) during pumping. The results from the sensor fish revealed that more strain/g-forces (29%) were exerted on the fish pumped to the secondary vessel as compared with the main vessel. This is likely to be the result of several factors: (a) the pump speed was higher (30%), (b) more fish were processed, and (c) the tubing system extension of 50 m created a "rollercoaster" course for the fish. The quality of the fillets was good overall, but with some differences in gaping scores between the main and secondary vessels after storage onboard.

1. Introduction

Catch adjustment by slipping of either the whole or parts of the catch has traditionally been used in pelagic fisheries if the catch is too large, or if the size and/or quality of the fish is unsatisfactory (Borges et al., 2008; Stratoudakis and Marçalo, 2002). Due to Norwegian fisheries regulations, fishermen are obliged to bring the whole catch on shore if more than 7/8 of the net is taken onboard. Therefore, pumping catches directly from the purse seine of the catching vessel onboard a neighboring/secondary vessel often occurs. In Norwegian mackerel fisheries, catches are mainly delivered for human consumption and often to a highly quality-conscious market, e.g. the Japanese market, where prices are strongly influenced by fish size and quality (Gezelius, 2006). The experience of both fishermen and buyers related to mackerel that has been transferred to a secondary vessel and the subsequent price discussion has contributed to its negative reputation, without any documented studies on how this process impacts the quality of the mackerel. Consequently, it might lead to the dumping of mackerel (Gezelius, 2006). In recent years there has been an increased focus on fish quality on Norwegian fishing vessels, with improvements in their cooling technology, and increased capacity, which has reduced the need for fish to be transferred to a secondary vessel.

In purse seining, which is a common method of catching pelagic fish species in Norway, a long net is set around a school of fish, the top of the net usually being at the water's surface. Controlling the catch size may be very difficult, and skippers may end up with more fish in the net than planned. Unless the excess catch can be pumped to a nearby vessel they have no choice other than to release parts of the catch.

The slipping of fish often occurs after the fish have been subjected to a variety of capture stressors and possible damage due to contact with other fish, debris, or the fishing gear itself. It is known that species such as mackerel are highly vulnerable to gear-inflicted injuries, and thus the amount of contact with fishing gears is of importance (Misund and Beltestad, 2000). Lockwood et al. (1983) studied the effects of the crowding of mackerel at various densities and for different durations, where they observed severe mortalities

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http://dx.doi.org/10.1016/j.fishres.2015.12.011
0165-7836/

where the fish were held at densities similar to those in pursing before slipping. Mackerel are extremely delicate fish and are subject to very high mortality rates following the stress of capture, handling, and retention in nets. Compared to, for example, cod and plaice, mackerel are much more sensitive to physical stress (Pawson and Lockwood, 1980), and even moderate handling may produce high mortality. Huse and Vold (2010) studied the effect of crowding and subsequent slipping from a purse seine on the mortality of Atlantic mackerel and found that the mortality was higher among crowded fish (80–100% mortality) compared to the control group (0.1–46% mortality). They concluded, despite the number of replicates being low, that the process of pursing and slipping mackerel has a substantial impact on the survival of the fish after release. In relation to other species, Marçalo et al. (2010) studied the impact of purse seining on deliberately released sardine and found that survival rates decreased significantly with increasing periods in the net.

Fishing gear has an impact on fish quality and may result in catch damage and quality degradation of the fish products, as has been shown for trawling, gill nets, Danish seiners, and long lining (Botta et al., 1987; Esaiassen et al., 2004; Margeirsson et al., 2006; Digre et al., 2010; Rotabakk et al., 2011; Olsen et al., 2012). Both weather conditions and the duration and size of the haul may affect the quality of catches by trawl or Danish seiners (Margeirsson et al., 2006). However, in seine fishing the towing speeds are slower and so seine-caught fish often have less skin and scale damage, as well as a higher survival rate, than trawled fish (Sorensen and Mjelde, 1992; Gregory, 1998). Bruising and mechanical damage often occurs when the fish are pumped automatically from seine nets. Fish pumps are typically used in the Norwegian purse seine fleet, and these pumps often cause more broken dorsal and pectoral fins than lift nets (Gregory, 1998).

The main objective of the present work was to study any differences in the mortality, catch damage, and fillet quality of mackerel pumped from the seine directly onboard the catching vessel or transferred at sea to a secondary vessel. Three studies were performed on commercial vessels, both purse seiners and coastal seiners, during the catching season in September and October 2012–2014.

2. Methods

2.1. Vessels, fishing gear, and pumping equipment

Purse seining was conducted on mackerel (*Scomber scombrus*) with six different vessels in September and October 2012–2014. Two purse seiners were charted for each of the experiments. The experiments during 2012 and 2013 were conducted using coastal purse seiners, while ocean going purse seiners were used in 2014. M/S Svebas, M/S Hovden Viking, and M/S Liafjord served as the main vessels in 2012–2014, respectively, while M/S Frøybas, M/S Storegg, and M/S Ligrunn served as the secondary vessels. The main characteristics of the vessels are given in Table 1. A purse seine was utilized for each of the experiments in 2012 (length = 470 m, depth = 99 m), 2013 (length = 627 m, depth = 165 m), and 2014 (length = 800 m, depth = 250 m).

Pumps were utilized to transfer fish from the seine to the RSW-storage tanks traditional fish. A rubber pumping hose with a diameter of 12–18 in. and a length of 7–30 m was used for pumping the fish onboard the vessels (lifting height 4–9.5 m). On the rim of the secondary vessels, the hose was coupled with a bend of 45° or 90° before continuing into the drainage zone separating the water and the fish (Fig. 1). There the fish were distributed through aluminium tubes to storage tanks. Table 1 shows the specifications for the transportation of the fish from the net to the storage tanks for all three experiments.

The vessels employed in 2012 and 2013 were smaller than those used in 2014, and the secondary vessel in 2013 lacked a stabilization tank, making the vessel less stable in rough seas than the other vessels, which all had a stabilization tank onboard.

2.2. Fish capture

The fishing experiments were conducted at different positions in an area between Norway, Great Britain, and the Faroe Islands in 2012 (59°05 N 01°32W), 2013 (59°54 N 2°26W), and 2014 (63°58 N 0°40W) (Table 2). During the two first experiments the seine was set in ICES (International Council for the Exploration of the Sea) area IVa between Norway, Scotland, and the Faroe Islands. During the last experiment, the seine was set farther north in area IIa, on the border with EU-waters, the Norwegian economic zone (NEZ) and The Faroe Islands. Before departure, temperature loggers were installed in one of the tanks onboard each vessel. The temperature loggers covered the tank height at 0.5 m intervals. Seawater was taken onboard immediately after departure and cooling started. The vessels started to search for fish when they arrived at the fishing area. The wind conditions during fishing were 8–11 m/s for the study in 2012 and 2013, and 11–14 m/s in 2014. Two vessels were employed for each experiment; a main vessel where the fish were pumped directly onboard, and a secondary vessel pumping the remaining catch onboard. About half the catch was loaded onboard the main vessel and half onboard the secondary vessel. A specific research fishing quota was proposed for each of the trials. The seine was dragged towards the main vessel when the fish were caught and pumping started when the seine was at the vessel. The total catch volumes for each vessels are shown in Table 2, with an average catch of 140 ton in 2012, 68 ton in 2013, and 225 ton in 2014. The average weight of the fish ranged from 315 to 370 g, and the largest fish were caught at the trial conducted in 2014. The pumping time ranged from 27 to 85 min depending on the capacity of the pumps onboard. The loading capacities of the vessels in 2014 were about six times higher than those of the vessels in 2012 and 2013 (the pumping velocity ranged from 1.2 to 1.7 for the smaller vessels, and 7.4 and 8.6 for the vessels used in 2014, Table 2).

The temperature was logged in the RSW-tank on every vessel. A wire with temperature loggers were stretched from center to bottom to the top of the tank, where it was attached to a ladder. The loggers were placed with 0.5 m intervals from top to bottom (on the vessels in 2012 and 2014), while the distance between the loggers were 1 m in 2013. This was done to see if there were any possible temperature differences between the separate layers in the storage tanks. The cooling capacity differs between the vessels. The main vessel in 2012 was equipped with three RSW tanks (45–62 m^3) with a cooling capacity of 260 000 kcal, while the secondary vessel had six RSW tanks (41–55 m^3) with a cooling capacity of 300 000 kcal. In 2013, the main vessel had six RSW tanks with a capacity of 380 000 kcal and the secondary vessel four tanks of 230 000 kcal. Similarly, each of the vessels in 2014 had nine RSW tanks with a cooling capacity of 1000 KW (860 000 kcal). The ratio of fish/water in the recirculated seawater (RSW) tanks varied between 40 and 91% (Table 2). The total storage time for the fish in the RSW-tanks was about 38 h in 2012, 55 h in 2013, and ranged from 22 to 39 h in 2014. The reason for the differences in the storage time in 2014 was the unloading procedure at the processing plant. Some of the fish were unloaded in the evening and the rest were unloaded the next morning. The fish were delivered to different processing plants in Norway due to auction sale.