Basic Studies on the Shrimp Drag-II

Field Experiments Using a 15-Meter Shrimp Drag with a Cover-net^{*1}

Akio FUJISHI^{*2} and Toshiaki ISHIZUKA^{*3}

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Field experiments were carried out using a polyethylene shrimp drag in order to make clear the differences in the towing resistance between the gear with a cover-net for mesh selection and one without the covernet. The experiments were conducted in the waters with a muddy bottom under calm sea conditions. We measured the warp tension at its foremost end in relation to the towing speed under drag trawling condition and also when keeping the gear in the layer close to the surface. The results indicate that in the case of the gear with the cover-net the towing resistance increased by about 20% in comparing with the resistance when the cover-net was detached from the gear, and also the frictional resistance amounted to about 35% of the whole towing resistance.

For many years small-scale trawl nets for coastal fishery have been used on a fleet of small draggers along the shores in Japan. The shrimp drag, a small beam trawl, is of the type widely used in the coast of Shimonoseki city, Yamaguchi prefecture. The size of this net is mainly governed by the power of engine, and by the species to be caught, but there is no great difference in the design. Each trawlers were equipped with the original type trawl having a about 15 meters headrope. The wings and square of the nets were constructed of 23 mm mesh 6 ply polyethylene, 27 mm mesh 6 ply polyethylene and cod-end from 20 to 23 mm mesh 9 ply polyethylene. Fig. 1 shows the general arrangement of a typical type of shrimp drag, which the design is most popular among the coastal fishermen in this part of the country for its easy construction. In this fishery one usually catches more ground fishes than shrimps, however, the ratio between shrimps and fishes varies chiefly in accordance with fishing ground, fishing seasons and day-time trawling or night-time trawling. There are eight species of shrimps and many fishes caught by the experiments on the mesh selection of shrimp drag with 23 mm mesh cod-end, on October, 1970.¹⁾

Fig. 1. General arrangement of shrimp drag with cover-net.

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^{*2} Shimonoseki University of Fisheries, Yoshimi, Shimonoseki. (藤石昭生: 水産大学校)

^{*3} Trawl Gear Technical Laboratory, Hirata Spinning Co. Ltd., Amagasuka, Yokkaichi, Mie. (石塚敏明: 平田紡績トロール技術研究室)

Among eight species two of them are most important than others, because they are caught in great quantities than the other six species. Those are of tiger shrimp (*Metapenaeopsis acclivis*) and monkey shrimp (*Trachypenaeus curivirostris*). Approximately 1,700 metric tons of these shrimp have been taken each year in Shimonoseki district.²⁻⁴⁾ At the peak of shrimp seasons (June to October) fishermen go out to fishing grounds after sunset and return to their base in early morning.

The personnel aboard these trawlers have shown a tendency to decrease with every passing year and consequently member per a trawler is generally only one skipper, and also trawlers are mostly rigged for dragging one net. Accordingly, the fishermen tend to use much more light, durable and handy materials for the netting of this gear such as polyethylene, nylon and other synthetics than the natural textiles. At present time polyethylene netting is used more commonly among the fishermen. On the one hand, for the protection of resources of the coastal shrimps and fishes, the total number of trawlers engaged in this fishery have been restricted under the provisions of the Yamaguchi Prefectural Fisheries Regulations, e. g. there are ninety nine licenced trawlers in all, in the Shimonoseki region. Furthermore, the maximum tonnage of a trawler and maximum power of engine equipped shall be less than 5 gross tons and 15 horsepower, respectively, under the above provisions.

We feel that there is some problem remaining unsolved as to the mechanical characters of this gear since the polyethylene netting has increased rapidly in place of the natural materials. Our purpose in conducting the field experiments was to get some gear technological clues needed to:

- 1) study the more effective design of net under the restrictions regarding the fishing vessel and its engine-power.
- 2) investigate what degree of differences in the towing resistance were found out between the gear with cover-net for examining the mesh selection of shrimp and that without cover-net.

Therefore, the gear employed was a polyethylene trawl rigged to conform as same as possible to the standard characteristics of the type used in this fishery. The experiments were conducted aboard a dorry wooden boat that was given several improvements for shrimp fishery, in the northwest coast of Yoshimi, Shimonoseki city, during 3 to 9, October, 1970.

Materials and Methods

In this series of experiments, the gear constructed on a full scale of the standard size by a local fisherman was used. The dimension and construction characteristics of this gear, and also the method of attaching small meshed covernet for examining the mesh selection of shrimps, are described in detail by one of the authors in previous paper.¹⁾ The experiments were conducted by the fishing boat, in the waters of about 30 meters deep

with a muddy bottom, under the very smooth sea conditions. This boat is 10.8 meters in total length, 4.32 gross tons, and is powered by a 18 horsepower diesel engine.

In order to find out the increments of towing resistance caused by attaching the cover-net to the cod-end and the changes in the frictional resistance of the gear in operation relating to the changes in either towing speed, the tension in warp at its foremost end quite near the bridle chain was measured by the waterproof self-recording tension meter (sensitivity: 10 kg), towing speed by the electric current meter (sensitivity: 0.1 m/sec), in the following two series. During the first series, the tension in warp of the gear with cover-net was measured in relation to the towing speed of 0.5–1.0 m/sec, under the towing conditions of drag trawling and of mid-water trawling. The next series was made under the same trawling methods as the first series in respect to the gear without cover-net, in relation to the towing speed of 0.5–1.3 m/sec. In the mid-water trawling it was paid special attention to keep the gear in a certain limited depths. Practically the gear was towed in the layer close to the surface by means of paying out 20 meter's warp from the working deck. The long and the short of it was that the gear was towed at the condition under which the floats attached to the headrope disappeared immediately below the sea surface. And in the common trawling the warp was paid out 3.5 times as long as the depths in accordance with the commonest method used by the local fishermen in the waters where the present experiments were conducted.

Results and Discussion

Towing resistance The tension in warp of the gear with cover-net and without cover-net were plotted against the towing speed in log-log papers by the two trawling conditions in Fig. 2. Each tension (T) and the towing speed (V) were expressed in the following regressions by the method of least squares, respectively:

In the case of the gear with cover-net.

$$T_{M-1} = 249.6 V^{1.11} \dots\dots\dots (\text{at mid-water trawling}),$$

$$T_{D-1} = 350.3 V^{0.94} \dots\dots\dots (\text{at drag trawling}).$$

In the case of the gear without cover-net.

$$T_{M-2} = 190.6 V^{0.97} \dots\dots\dots (\text{at mid-water trawling}),$$

$$T_{D-2} = 293.8 V^{0.95} \dots\dots\dots (\text{at drag trawling}).$$

There are no great difference in the value of the adjustable parameter, the exponent of V . Those values almost agree with the experimental result of the larger net for use at greater depths.⁵¹ The tension obtained can be almost equal to the resistance of the gear under the respective trawling conditions, because the vertical component of tension in warp was negligibly small for the reason of which the warp nearby bridle chain was considered to be parallel to the sea bed. After calculating from the above equations, at the common trawling, the resistance is estimated to be 293 kg for the gear without cover-net and 350 kg for

Fig. 2. Relation between the tension in warp at its foremost end and the towing speed.

for the gear with cover-net in the normal towing speed (1.0 m/sec) in contrast with 152 kg and 182 kg in the case of low towing speed (0.5 m/sec). Namely, the rate of increase of the towing resistance caused by attaching the cover-net to cod-end is held about 20% corresponding to the value of T_{D-1} in either towing speed even if the towing speed varied from 0.5 to 1.0 m/sec. On the other hand, in the mid-water trawling, this rate increases from 20 to 30% as the towing speed increases, when the towing speed is within the range of from 0.5 to 1.0 m/sec.

Frictional resistance It is not easy to directly measure the frictional resistance in field experiment. In this report, accordingly, we estimated the frictional resistance by subtracting the towing resistance of the gear at midwater trawling from that of the gear at drag trawling. That is to say, when the towing speed is within the range of from 0.5 to 1.0 m/sec the frictional resistance is 67 to 100 kg for the gear with cover-net, while 55 to 103 kg for the gear without cover-net. The frictional resistance which was obtained in the way described above and the rate of frictional resistance corresponding to T_{D-1} or T_{D-2} are shown in Fig. 3. From this figure, there is not very much changes of the rate in the case of the gear without cover-net even though the towing speed increases. But, for the gear with cover-net, this rate decreases slightly according as the towing speed increases. These rates in normal towing speed amount to 35% for the gear without cover-net, whereas 29% for the gear with cover-net. It is clear that the obtained rates 35 and 29% are considerably great compared to the estimated rate from the model experiment of pelagic trawler's net.⁶⁾ As regards such a cause increasing of this rate, it can be readily imagined

Fig. 3. Relation between the estimated frictional resistance and the towing speed.

that the bridle chain probably was too heavy for the gear size. The most suitable weight of the bridle chain and the changes of the net mouth in either towing speed, which are left unsolved, will be reported at a later date. Especially in regard to the height of net mouth, we will discuss in detail by a model experiment because the accuracy of the measured height of net mouth was not satisfactory in this experiments.

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