Exfoliation forces of cultured kelp (*Laminaria japonica*) from the braided rope out of gill-net

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SUMMARY : To reuse the garbage fishing gears effectively to the other fisheries production means is the one of rational measures based on the zero-emission concept. This research has aimed to check the ability of regenerated rope with refused gill-net from amyline material to kelp cultivation facilities. By the results of some field tests and stochastic analysis, a large individual kelp grew more abundantly on the regenerated rope of gill-net (GR) than the polyethylene rope (PR), which is widely used for cultivation in Japan. The average force to detach kelp from GR comes up to 6.8 kg in comparison with the case of PR by 4.6 kg. Through the tensile test in a site, the exfoliation probabilities in typical three portions on a kelp have showed the sticking capacity onto GR surpassed PR. Also, kelp on GR has not been easily broken out from a cultivation rope rather than PR.

KEY WORDS : exfoliation, kelp farming, gill net, recycle, breaking force

INTRODUCTION

Thirteen species of kelp has been produced in Japan, and the main production area is limited in the northern part. The average production of kelp has kept on 25 thousand tonnage in a year which is equal to 31 billion yen since ten years ago, so that this fishery is the one of most important fishery. MA-KONBU in Japanese, *Laminaria japonica*, can be produced only in Hokkaido region. Its unit price reaches close to 8,000 yen per kg, contrastively the others species being extent of only 1,000 or 2,000 yen. This fishery has very unique feature against the other domestic fisheries which can be seen broadly so that the artificial kelp farming with hanging method has occupied up to 20% in the whole production of kelp, particularly in MA-KONBU farming. A seed of kelp is normally planted into a cultivation rope with 20 mm in diameter in October. Well cultivated kelp reached over 5 meter in length can be harvested from the next July to September, within only one year cycle.

The kelp cultivation technique is fully developed, but some problems have been still remained in the facilities which always face with rough water condition. One of the issues is how to determine the adequate substrata and structure to larval kelp or algae, which were reported in some articles.¹⁻⁶⁾ The others⁷⁻¹⁰⁾ are related to recapture kelp moved away

from the substrata of cultivation or natural reefs.

By the way, the domestic production of chemical fishing gears would be estimated not less than one thousand tonnage in a year. Although some researchers in fisheries engineering have recommended to reuse the wasted gear and chemical products to the artificial reefs in their articles,¹¹⁻¹²⁾ the used chemical gears have been not so well treated till recently, because the cost coming up.

This study was attempted to check whether the regenerated rope could be applied to a cultivation rope as the appropriate material, which was made out of a refused gill net with certain porosity. If the availability of the reuse could be confirmed, we can get more benefit from not only the well-grown kelp products but also the reduction of recycle cost.

MATERIALS AND METHODS

Settlement of sample

The cotyledon of kelp yielded in Siriuchi reagon faced to the Tsugaru Straits had been planted every 30 cm interval into the regenerated rope (GR) which made out of used gill net with multi-filament (amyline) at 28th on Nov. in '90. At the same time, the polyethylene rope (PR) for the control had been treated with same

way, which is widely used for cultivation in Japan. The diameter of GR was 20mm as same as the PR. The unit length of each cultivation rope was 15m. Both these ropes were brought to the test field Suttu shown in Fig.1.

Fig.1 Location of test field

The kelp in each rope were settled into the two sets of the V shaped facility which is drawn in **Fig.2**. Both end of the cultivation rope has the detachable C clumps. The structure of this cultivation facility has been well developed to stand up to rough water and also widely used for kelp farming in Japan sea area, particularly. The main rope which had 200m total length hanged 15 sets of the unit cultivation rope from itself. The depth to bring up kelp ranged within from 3.0 to 5.0 meter. These ropes for field examination could be exposed to the same sea condition as possible during nursery.

Fig.2 Schematic layout of the V shaped facility

Measurements

The field test had done three times in the next Jun. 5th and in the Jul. 5th and 25th. Well-grown kelp were landed as exactly same condition as it was just hauled up in the cultivation field for the tests. The samples

were maintained on the cultivation rope put into sea near by the wharf during the tests. Without harming the root block of kelp, the sample leaf for tensile test was chosen randomly from the one block on the test plate as shown in **Fig.3**.

Fig.3. Apparatus for tensile test

The segment of a cultivation rope without roots of kelp was nailed on the wooden board as the figure. After the total length and width were measured at first, the test sample was put along elongation distance. For tensile test, leaf on the other end of the nailed rope was wound tightly around a wooden stick.

While the end side of sample was pulled with no impact as possible as the operator can do, the broken force or pull down force of kelp from a cultivation rope was acquired by the pen recorder which connected to the amplifier through the electric load cell (full capacity is 10kgf). Although the broken portion to each rope was recorded simultaneously, the typical portion of kelp had been already categorized to *Blade* as the part of leaf and *Stipe* as the stem and *Holdfast* as the part of roots, which are shown in Fig.4.

Fig.4 Categorized portion

theoretical analysis concerned with the exfoliation probability also was investigated.

RESULTS

Growth condition

41 samples of PR and 38 samples of GR were examined. Fig.5 shows the distribution of total length of the samples. The averaged weight of one set of roots was 5.05 kg(no. 41) and 5.09 kg in GR and PR, respectively. There is no significant difference to the weight and the length of developed kelp on each rope. But, GR seemed to promote the growth of larger kelp than PE.

Fig.5 Distribution of the length of kelp

Exfoliation force

Fig.6 shows the whole results condensed in one. By the graph, the transition trend of date to adhesive force can be compared. Also, the difference of tensile strength among the portions of kelp and the material of ropes can be considerable.

The average exfoliation force, which was actually measured in a site, was 5.0kg in the case of PE and 7.5kg in the GR at Jun. 5th. On the case of Jul. 5th, the force showed 5.7kg and 7.9kg, respectively. The average exfoliation force of GR had taken bigger values than PE regardless of the date.

Broken portion and force

The observed frequency of breaking in the case of GR turned to *Stipe*, *Holdfast* and *Blade* in ascending order. Contrastingly, the case of PR turned to *Blade*, *Stipe* and *Holdfast*.

The calculated frequency and force of the exfoliation, which was conducted from the broken chain model are shown in Fig.6. By the results, the average strength of the exfoliation comes to 6.8kg of GR and 4.6kg of PR. The exfoliation probability was decided to 47% in GR and 56% in PR.

Finally, it is sure that the adhesive capacity of kelp in the regenerated rope has exceeded in the polyethylene rope which is widely used in a site, under 90% significant difference.

Fig.6 Exfoliation force (Broken force) of each portion to the material of rope

DISCUSSION AND CONCLUSION

The regenerated rope which is made out of the multi filament gill net has enough porous space comparatively to the polyethylene rope. This different property of material may become to the one reason of that the harvested kelp on GR comparatively develop larger than PE.

By the other way, the other tensile test revealed that the breaking stress of kelp on each rope was not different under stochastic meanings. In this test, the formed piece of kelp like as to metal material were applied.

There is no difference with the tensile stress of kelp on each rope. Only the size of kelp is different. The kelp on GR seems to be growing more strongly than the normal rope. The adhesive strength of roots is exceeding the other portions, also. Furthermore, the results of growth and this stochastic analysis insists that the kelp on the regenerated rope has higher tolerance to the exfoliation rather than the polyethylene rope.

However, it is almost true that the rope made of polyethylene was the best materials to avoid destroying the facilities by rough sea on the developing facilities. Although the most adaptable materials would have to be designed and applied to the facilities of farming, the historical necessity might allow PR continuously to be used.

But, by the view point of zero-emission, we can conclude as follows. Although the reason why GR promote to develop the growth of kelp is one of the issues in the future research, the merit of reusing wasted fishing gear with least cost and the qualifying of the adequate adhesion capacity as cultivation rope material may provide the new choice to the kelp farming.

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