
**Preliminary evaluation of degradability for natural material ropes
potentially used on fish aggregating devices (FADs) in tuna purse
seine fishery**

Cheng Zhou, Liuxiong Xu, Yucheng Wang, Xuefang Wang, Jie Cao, Jiangfeng Zhu,
Xiaojie Dai, Feng Wu

College of Marine Sciences, Shanghai Ocean University, 999 Hucheng Huan Road,
Shanghai 201306, China;

Key Laboratory of Oceanic Fisheries Exploration, Ministry of Agriculture, 999
Hucheng Huan Road, Shanghai 201306, China;

Fisheries College, Ocean University of China, 238 Songling Road, Qingdao 266003,
China

zhoucheng286@126.com

Abstract

Purse seiners deploy thousands of drifting fish aggregation devices (DFADs) in all tropical oceans to catch tropical tunas. Nowadays these FADs were constructed with synthetic netting, which are explicitly considered responsible for incidental mortality of sea turtles and sharks through entanglement, even causing ghost fish if they are lost and abandoned. The use of natural and/or biodegradable materials to build FADs can effectively mitigate marine pollution and bycatch issues so that they are currently made efforts to promote by fisheries management organizations. This paper presents the degradability of three natural material ropes (3-ply 96-thread cotton, 3-ply 13-thread jute, and 3-ply 8-thread sisal) on the basis of an experiment measurement on breaking strength (N/ktex). These samples were deployed in China's nearshore waters attached to the floating frame of net cage in Dec 2018 and retrieved per month for testing breaking strength in the laboratory. Results showed that jute and sisal experienced rapid reduction of strength in the following months, in particular over the first month soaking in the sea fallen by almost half and lost all strength after three months. Cotton rope appeared to be more preferable component for building Bio-FAD among these congeners which could be durably used, minimally, in seven months, and matches the lifetime of FAD serving fishing for 6 to 12 months.

Introduction

Since the behavioral characteristics of tuna associated with floating objects on the ocean

surface was found, fishermen artificially made more effective and functional tackle, known as fish aggregating devices (FAD), to increase tuna catches in the purse seine fishery. Despite the advantages at increasing the catchability of tunas and reducing the fish-searching time (Dagorn et al., 2012), large deployment of FAD raises the possibility of negative impacts on marine ecosystem including entanglement of sharks and turtles, ghost fishing, accumulation of synthetic marine debris, and damage of vulnerable ecosystems like reefs (Moreno et al., 2017a; Moreno et al., 2017b). So far, all four tuna regional fisheries management organizations (tRFMOs) have adopted resolutions on FAD regulations where contain the specifications or recommendations for FAD design. A solution on the outset proposed by ISSF is using small-sized mesh or tying up netting into bundles for underwater hanging structures. However, observation in practice revealed that those small meshes can split to larger holes, and bundle of netting can untie after a period of time. Follow-up design suggested only FAD structured without netting enables to eliminate entanglements, e.g. using ropes/canvas suspending into the water substituting for netting. Further, to reduce the amount of synthetic marine debris into the oceans, the use of natural or biodegradable materials to build FAD, i.e., so-called Bio-FAD, will become a growing trend.

Materials from natural origin are good alternative for Bio-FAD due to their accessibility and low cost. A competent Bio-FAD should be capable of maintaining enough life span serving for fishing, which is believed to be from 6 to 12 months, and thereafter biodegrades as fast as possible. On the basis of three natural material ropes (3-ply 96-thread cotton, 3-ply 13-thread jute, and 3-ply 8-thread sisal), this paper evaluated their degradability by measuring the breaking strength with the soaking time in natural waters with the purpose of providing reference for the material selection of Bio-FAD.

Material and method

Test material

Three nature material ropes (cotton, jute, and sisal) were selected to implement degradation experiment based on their potential biodegradation UV resistance, abrasion resistance, and availability (Winger et al., 2015). The specifications of structural parameters for three types of samples are showed in Table 1.

At-sea deployment for natural degradation

Due to the difficulties in the real fishing condition that prevent those samples from being tracking by a given vessel over the lifetime, the deployment site was selected to be in nearshore natural waters of the East China Sea (30°48'N, 122°36'E). Those samples were tied on the floating ring of the net cage and the sinkers were attached in the terminal to keep suspension in the water. There are a total of 16 ropes for each material with 5 m long for each rope. Those samples were retrieved per month (ca. 28~31 days) for further measurement since the initial deployment in Dec 2018.

Laboratory measurement

Breaking strength test was conducted using a tensile test machine (HY-5080, made in China)

with the maximum capacity of 50 kN and precision of 0.1 N (Fig. 1). The test environment is under conditions of laboratory temperature 20°C ($\pm 4^\circ\text{C}$) and relative humidity 65% ($\pm 4\%$). The breaking strength (N/ktex) is expressed as the ratio of tension force when the rope breaks under stress to the linear density. The samples were held between two snubbing grips with the initial distance of 263 mm, which moved at a constant stretching speed 100 mm/min until breaking. Before deployment in the sea, we first tested the breaking strength of new samples soaked in fresh water for 24 h as the initial value (Month 0). Degradation of materials was assessed based on the monthly variation of breaking strength with time. Test for each sample was repeated by more than three times to reduce accidental error.

Results and discussion

Breaking points for three material ropes consistently distributed around the center of ropes, within the interval of two snubbing grips, suggesting that these were natural breaking strength aroused by tension stress rather than the attrition with grips (Fig. 2). Three types of ropes presented comparable initial breaking strength (Month 0) around 80 N/ktex. Jute and sisal experienced rapid reduction of strength in the following months, in particular over the first month soaking in the sea fallen by almost half and lost all strength after three months (Fig. 3). There was almost coincident degradation trend between jute and sisal, though at the same soaking time the strength of sisal was higher than jute. Cotton rope exhibited the most inertial degradation behavior, with the reduction ration by the third month at 56% of initial strength. Hereafter, the strength remained stable in the following several months and suddenly declined in the seventh month. Overall, cotton presented more stable physical characteristics between samples at same stage based on low standard deviations compared to jute and sisal.

An eligible FAD was expected to serve fishing for 6 to 12 months. Preliminary results concluded that cotton rope appeared to be more preferable component for building Bio-FAD among these congeners which could be durably used, minimally, in seven months. The results consolidated the assertion by Moreno et al., (2017) who reported 100% cotton rope had useful lifetime around one year, and also showed that mixed cotton and sisal rope was the strongest after one year.

Observation also showed bio-fouling (e.g., algae) for jute and sisal developed as early as the second month, while started to develop at the fourth month for cotton and bloomed in the following months with shellfish attaching. Note that the deployment site was close to the base of mussel farming, where easily allow bio-fouling, compared to mid-ocean. Some fishermen considered a FAD with bio-fouling is more attractive to tunas (personal comm.), while this conclusion needs further confirmation dependent on substantial reliable scientific statistics.

Reference

Dagorn L., Holland K.N., Restrepo V., Moreno G., 2012. Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? *Fish and Fisheries*, 14(3):391-415.

Moreno G., Jauhary R., Adam S.M., Restrepo V., 2017. Moving away from synthetic materials used at fads: evaluating biodegradable ropes' degradation. IOTC-2017-WPEB13-INF12, 1-9 pp.

Moreno G., Orue B., Restrepo V., 2017. Pilot project to test biodegradable ropes at fads in real fishing conditions in western indian ocean. IOTC-2017-WPTT19-51, 1-9 pp.

Winger, P., Legge, G., Batten, C., Bishop, G., 2015. Evaluating potential biodegradable twines for use in the snow crab fishery off Newfoundland and Labrador. *Fisheries Research*, 161: 21-23

Table 1 Specifications of structural parameters for three types of samples

Rope type	Diameter (mm)	Lay length (mm)	Construction	Linear density (ktex)
Cotton	14.5	37.7	3-ply 96-thread Twisted "S"	35.253
Jute	10.5	36.5	3-ply 13-thread Twisted "Z"	46.898
Sisal	11.0	39.5	3-ply 8-thread Twisted "Z"	50.922

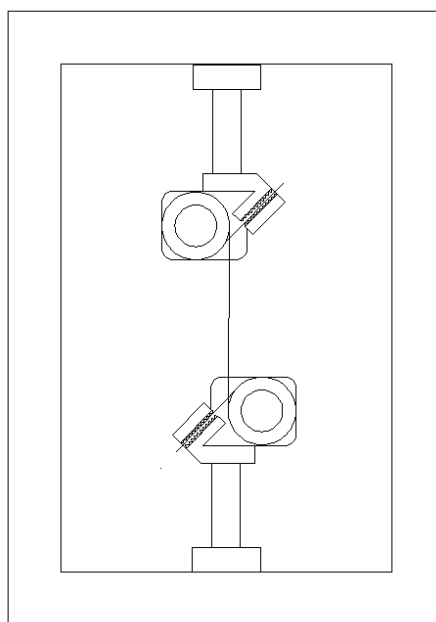


Fig. 2 Schematic drawing of tensile test machine

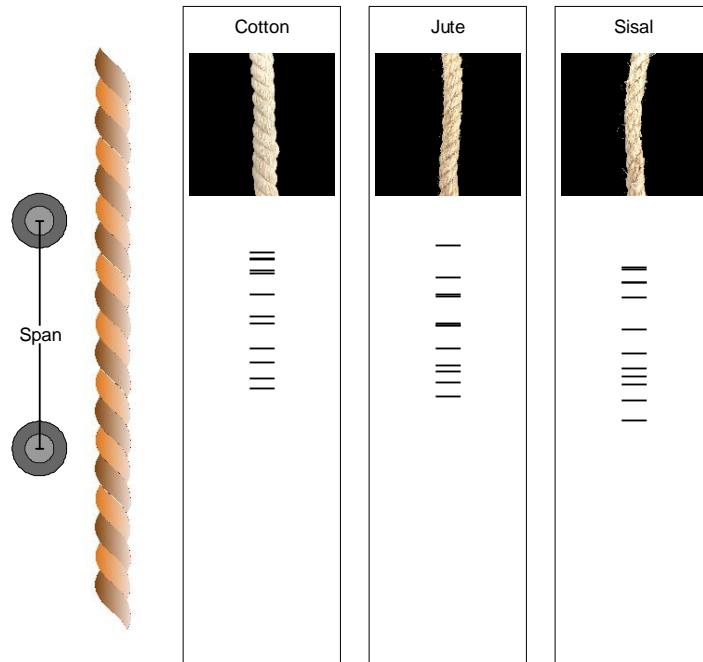


Fig.1 Position of breaking points for three types of ropes (corresponding to the left sketch)

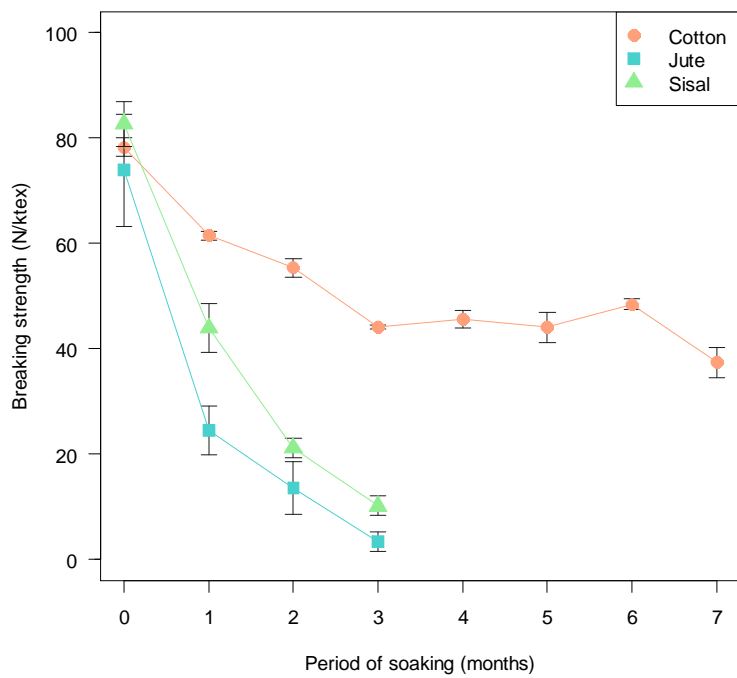


Fig.2 Variation of breaking strength (N/ktex) with soak time (months) for three types of ropes over a total periods of 7 months. Error bars denote standard deviation of the mean