Novel flotation model for the experimental culture of macroalgae *Kappaphycus alvarezii* in Florianópolis, Brazil

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Abstract - A new flotation model for the experimental culture of macroalgae *Kappaphycus alvarezii* (Doty) Doty ex P.C. Silva is described and illustrated. The ellipsis-shaped 90L apparatus is made of medium density virgin polyethylene, measuring 2000mm long x 300mm wide x 200mm high, and weighing 9kg. The device has been successfully tested in the littoral region of the state of Santa Catarina, Brazil, throughout the experimental period. Contrastingly to traditional models available on the market, with their instability in strong sea currents, current model is an alternative to enhance algae-mollusks integrated culture, by providing stability to culture structures. It may also serve as a spacer and support for mooring of double long lines.

Index terms: sea culture; flotation devices; *algae;* mollusks; culture technology.

Novo modelo de flutuador para o cultivo experimental da macroalga *Kappaphycus alvarezii* em Florianópolis, Brasil

Resumo - Um novo modelo de flutuador para o cultivo experimental da macroalga *Kappaphycus alvarezii* (Doty) Doty ex P.C. Silva é descrito e ilustrado. Confeccionado em polietileno virgem de média densidade, possui formato elíptico e dimensões de 2000 mm de comprimento x 300 mm de largura x 200 mm de altura, com volume de 90 litros e peso de 9kg. O aparato foi testado na região costeira catarinense e obteve grande êxito durante todo o período experimental. Diferentemente dos modelos tradicionalmente disponíveis no mercado, cujo principal entrave diz respeito a sua instabilidade ante as fortes correntes marinhas litorâneas, o presente modelo emerge como uma alternativa para viabilizar o cultivo integrado de algas e moluscos, oferecer estabilidade às estruturas de cultivo e servir, ao mesmo tempo, como espaçador e suporte para amarração de *long lines* duplos.

Termos para indexação: maricultura; flutuadores; alga; moluscos; tecnologia de cultivo.

Macroalgae *Kappaphycus alvarezii* (Doty) Doty ex P.C. Silva is a world-acknowledged sea commodity. It is the main source for the extraction of carrageenan, the mucilaginous substance on the cell wall, with high economic value due to its vast application as thickener and stabilizer used in the food, cosmetic and pharmaceutical industries (BIXLER & PORSE, 2011; FAO, 2014).

During the last decades, several countries have developed its commercial culture, whilst others, Brazil in particular, have focused on experiments. Due to its exotic status, the introduction of the macroalgae occurred experimentally in Ubatuba, in the state of São Paulo, Brazil, in 1995, warranted by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) (OLIVEIRA et al., 2009). In 2008, IBAMA also authorized the introduction of the species in the Sambaqui beach, Florianópolis, Santa Catarina (HAYASHI et al., 2011) and, more recently, further warrants have been provided to other municipalities, such as Penha and Governador Celso Ramos, in the state of Santa Catarina, in 2017.

These activities have triggered the production of data on the capacity of the culture and its adaptation to local environmental conditions such as environmental safety of sea culture (HAYASHI et al., 2011; CASTELAR et al., 2015; CARVALHO et al., 2015) and the seasonality of production (culture occurs between September and May exclusively, due to high temperatures; low water temperature kills the tropical species) (HAYASHI et al., 2011).

However, great progress occurred in culture technologies. At first, 100mm-PVC tube cylindrical rafts were employed for the culture of *K. alvarezii* (Figure 1A). However, they proved to be unsatisfactorily throughout the culture cycle since the device could not resist the strong maritime currents of the Santa Catarina littoral (HAYASHI & SANTOS, 2010; HAYASHI et al., 2011).

PVC-tube rafts were than replaced by ▶

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other flotation devices, round-shaped, 20cm diameter, and manufactured of recyclable polyethylene material (3mm thick injectable plastic) (Figure 1B).

Its field performance was equally unsatisfactorily since it did not provide proper stability to culture structures, with excessive mobility due to the waves´ hydrodynamic force, rupture of cables and moorings and an increase in maintenance and managements events.

Further, wooden spacers coupled to a round-shaped flotation device were also tested (Figure 2A) to keep distance between the two culture cables. The latter were heavily colonized by *Teredo* sp., popularly known as "shipworms", and replaced every six months, with more liabilities (Figure 2B).

Since 2012, several studies were conducted for the development of a flotation device adapted to sea conditions on the littoral of the state of Santa Catarina, Brazil. Current study described a novel flotation model for the integrated culture of mollusks and *K. alvarezii*, featuring three functions: spacer and support of double long line increase in productivity, greater stability to culture structures on the surface to cope with local environmental conditions.

The flotation device was manufactured in medium density virgin polyethylene, with a 5mm-thick wall, with a 2.000mm long x 300mm wide x 200mm high, at a cost of US$ 73. It was treated with UVA/UVB to increase durability, estimated between 8 and 10 years. The prototype had an elliptical shape to reduce attrition against sea waves and to accommodate 5 culture cables fixed to grooves placed 370mm one from another to prevent the lateral drag of the cables (Figure 3).

The prototype counter-mold, made of wood and fiber, was then cast in aluminum. The device later received holes for cables and moorings. Parts were manufactured by auto-molding employing micronized polyethylene powder of medium linear density. Linear molecule structure provided the required malleability and resistance against breakage. It may crumple in certain cases but it would not crack or break. The mold was then placed in an oven at approximately 200ºC, rotated in two directions on axis X (12rpm) and axis Y (3rpm). During rotation, the powder polyethylene melted and adhered to the mold. After 30 min in the oven, the structure was removed and cool rotation started for 15 min until the solidification of the material. After cooling, the structure was smoothed and breather sealed with a PVC buffer, screwed and glued with silicone (Figure 4).

First field tests with the prototype were performed between April and May 2017 in the sea of Sambaqui beach, featuring monoculture system,

Figure 1. Flotation devices: (A) cylindrical shaped, made of PVC; (B) spherical shaped, made of recyclable polyethylene.

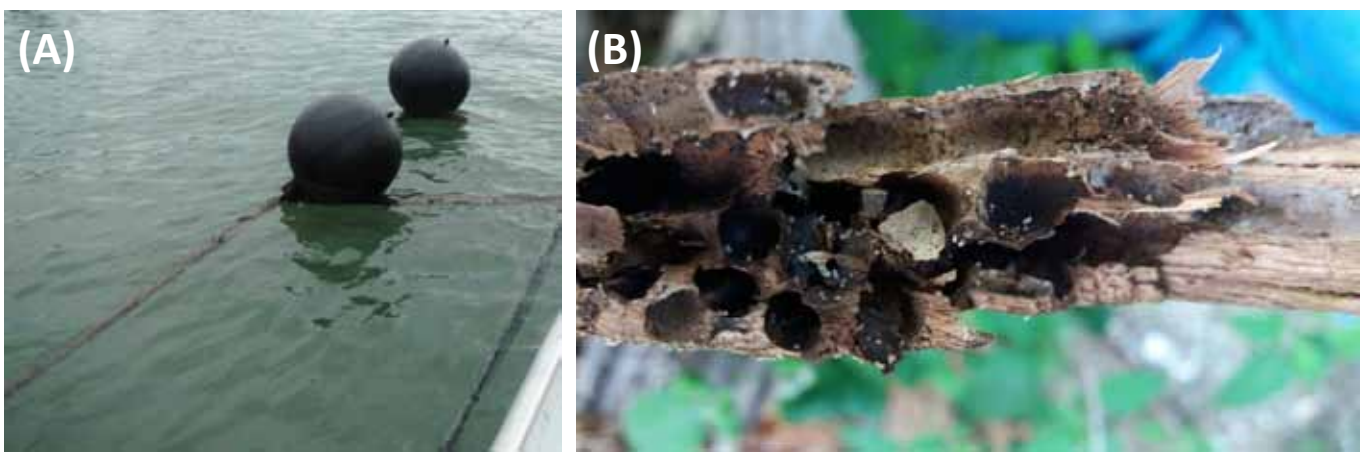

Figure 2. (A) wooden spacers (arrows) coupled to oval flotation device; (B) cross-section of a structure infested with Teredo sp.

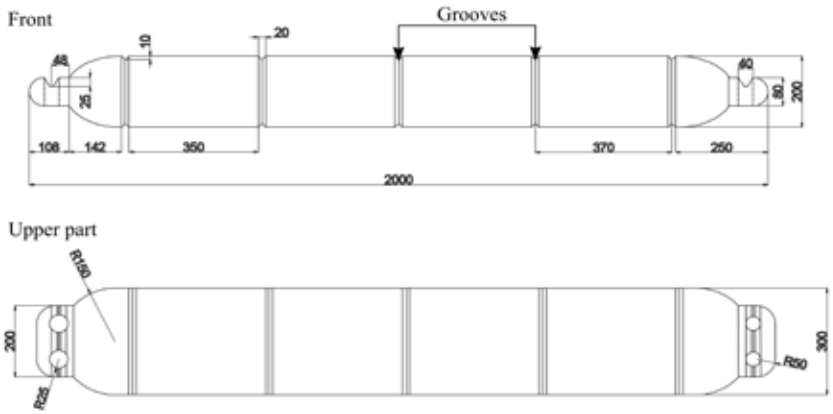

Figure 3. Sketch of the prototype, in mm.

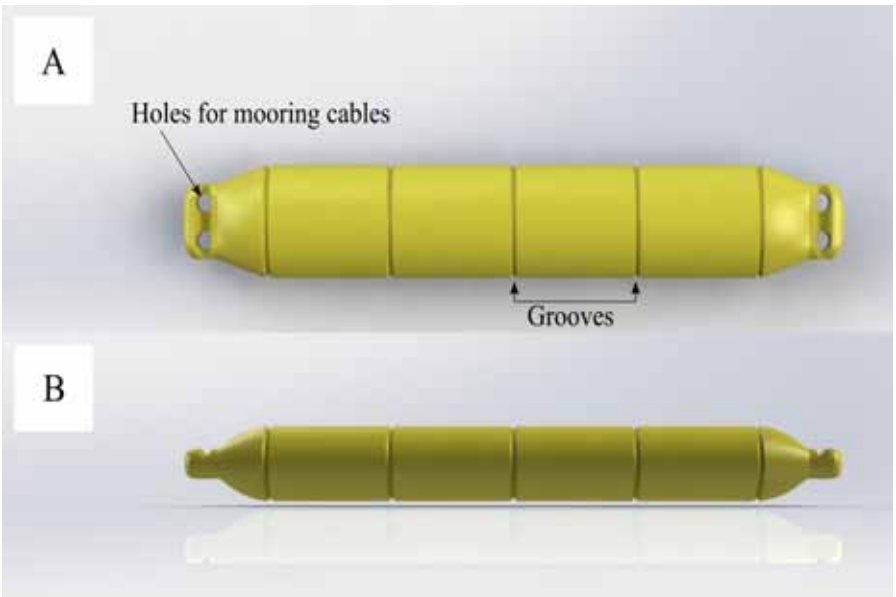

Figure 4. Prototype of flotation device in wood and fiber, with grooves for mooring cables for the cultivation of algae and holes for moorings to the long line.

with great success throughout the assay period. The apparatus´s elliptical device was less affected by waves since they passed over it, with a reduction of hydrodynamic force (Figure 5).

Current studies on the novel flotation elliptical device developed by EPAGRI in joint partnership with the Federal University of Santa Catarina (UFSC) have so far only focused on the algae monoculture in Sambaqui beach, Brazil (Figure 5A). It is believed, however, that it may be a useful tool for integrated culture with *K. alvarezii*, oyster and mussel.

The pre-experimental phase of the project "Assessment of commercial cultivation of *Kappaphycus alvarezii* in the littoral of Santa Catarina" occurred in October 2017, identifying the best technology in product mechanization for algae culture and evaluating the integration of such technology with mollusk cultivation (ranging between oyster *Crassostrea gigas* and mussel *Perna perna*). The pre-experimental phase comprises the formation of biomass (Figure 5B) to obtain approximately 100 kg of algae for experiments at sites Ribeirão da Ilha (Florianópolis, Aquaculture Area 384, Aquaculture Park 05), Canto dos Ganchos (Governador Celso Ramos, Aquaculture Area 552, Aquaculture Park 1), Paciência beach (Penha, Aquaculture Area 44, Aquaculture Park 01), and Sambaqui (a district of Florianópolis, Experimental Unit of UFSC). The results ▶

Figure 5. Field tests with the new elliptical flotation model. (A) Culture rafts spaced 5 m, with double long lines; (B) Planting of *Kappaphycus alvarezii* for biomass formation.

of the technical, environmental and financial performance will be assessed for its commercial viability.

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O Laboratório de Fitossanidade do Centro de Pesquisa para Agricultura Familiar (CEPAF) conduz pesquisas relacionadas a pragas e doenças de diversas culturas, como feijão, milho, citros e pastagem. Conta com estrutura para práticas de microbiologia, biologia molecular e bioquímica, uma coleção e criação de insetos e casas de vegetação.

O laboratório também recebe amostras vegetais para a diagnose de problemas fitossanitários.

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