The sea cucumber and its role in the blue economy in Colombia

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In Colombia there is an illegal sea cucumber market that exploits native species and involves artisanal fishermen, indigenous people and poor communities in the Caribbean region (Toral 2008; Agudelo Vergara et al. 2017). Recently, several arrests have been made that show how sea cucumber species have been fished illegally from different regions of the country in various quantities. Records of illegal catches in Colombia have increased in the last three years. Twelve plastic bags with 400 kg were seized in La Guajira (Riohacha city). In San Onofre city (Sucre), 5554 dehydrated sea cucumbers were seized near the international airport; the airport police seized 540 sea cucumbers that were intended to be exported from Bogotá to Hong Kong. In contrast, sea cucumber aquaculture has become viable in in Latin America countries such as Mexico and Colombia; in the case of Colombia, research activities are mainly carried out by the Research and Technological Development Group in Aquaculture, in Santa Marta, Magdalena (Agudelo Vergara et al. 2017).

Artisanal fishermen of the Colombian Caribbean are very poor due to social inequalities, but also because of the decrease in their catches, which is emphasised by the lack of technology in their fishing gear and the lack of other sources of income. Some families are deeply impoverished. The average annual income level in this region was reported (in 2018) to be around USD 1900 for fishers who are involved in small-scale fishing cooperatives (Lavalle and Pretel 2019), with five fishermen, on average, in charge of one boat. These figures indicate that a fisherman earns around USD 5 to 6 daily, depending on whether or not he is part of a cooperative, and that this is his main source of income to support his family. Meanwhile, women barely earn half of what mean earn, clearly showing gender inequality (Viloria-Maestre et al. 2016; Lavalle and Pretel 2019).

In turn, there are no conditions for natural resources to become an opportunity for sustainable local development, with marked overexploitation of fisheries and inadequate resource management (Beltrán and Villaneda 2000). Global warming is an additional factor increasing the region's problems (Lavalle and Pretel 2019; DANE 2020).

A blue economy is based on the principles of the Code of Conduct for Responsible Fisheries (Pauli 2010). It recognises the importance of seas and oceans as engines of the economy because of their potential for innovation and growth. A blue economy attempts to prioritise the balance of sustainable and socioeconomic management of natural aquatic resources, emphasising the efficient use of resources from fisheries and aquaculture, ecosystem services, trade and food systems (Pauli 2010; FAO 2015). Its aim is to reconcile economic growth with better livelihoods and social equity, and to strengthen transparent, reliable and safer food systems. A blue economy also places greater responsibility on national and regional policies for the protection of living aquatic resources, and aims to create an enabling environment whereby fisheries and aquaculture stakeholders are not only resource users, but are also active role in protecting and safeguarding them, for the benefit of future generations (Campbell et al. 2021). In general, developing countries have begun to adopt blue economy strategies, also called blue growth, to promote food security and increase quality of life, and to minimise or mitigate the impacts of these economic sectors on living aquatic resources, biodiversity and ecosystem services (FAO 2015).

Sea cucumber species such as *Isostichopus badionotus*, *Isostichopus* sp. and *Holothuria mexicana* – all of which are grown in aquaculture facilities in Colombia – are included in the blue economy because these species feed on microalgae (e.g. *Isochrysis galbana*, *Chaetoceros calcitrans*, *Nannochloropsis oculata*), sand and organic matter, which do not harm the environment (Agudelo and Rodríguez 2017; Acosta et al. 2020). In outdoor aquaculture facilities, juveniles and adults feed on sand and lime, as well as microorganisms such as bacteria, diatoms and detritus. These foods do not have a significant impact on production costs (which account for anything between 56% and 83%) as compared with foods used in tilapia culture, which is the most popular aquaculture species and is farmed in over 120 countries in the world (Scorvo-Filho et al. 2006; Sabbag et al. 2007; Osamaki et al. 2017). When reared in controlled facilities, sea cucumbers do not need artificial foods, one of the most expensive components of aquaculture activity, and their production incurs low operating costs. The infrastructure investment is also lower than for many other types of aquaculture, such as shrimp or finfish (Osamaki et al. 2017; Barroso et al. 2019). In addition, Caribbean Sea cucumbers have an acceptable nutritional content with a protein content of 6.6% and fat content of 0.35% (Arias et al. 2016; Vergara and Rodríguez 2016).

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The implementation of a blue economy in Colombia can be an option for the legal production of laboratory-reared sea cucumbers and other marine ornamental products, such as fish, crustaceans, mussels and other invertebrates, under controlled conditions. Rearing sea cucumbers will help reduce, for example, the pressure on extractive fisheries. The possibilities of increasing the socioeconomic conditions of fishermen can be carried out by incorporating family aquaculture models that involve sea cucumbers. Ecological benefits should be created, as sea cucumbers are bioremediators that help purify the marine environment through bioturbation (Uthicke 1999; Wolfe and Byrne 2017; Hamel et al. 2001; Uthicke 2001). Sea cucumbers are also organisms that can be cultivated in polyculture, with low operating costs and low infrastructure investments (Inui et al. 1991; Wu 1995; Slater and Carton 2007). This could help reduce pressure on extractive fishing and create additional possibilities for clinical, pharmaceutical and cosmetic applications. Because sea cucumbers have a high collagen content, they are ideal for the manufacture of skin care products (Liu et al. 2002; Li et al. 2020). Colombia, however, has poor environmental legislation, and is facing overexploitation of resources, climate change and environmental pollution among others, so the role of aquaculture in recovering resources has even more pitfalls to be solved. Blue aquaculture could generate tangible work and benefits to change the economies of vulnerable populations like those that inhabit our coastlines.

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