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Opinion

Ocean Acidification: Positive and Negative Impacts on Seaweeds

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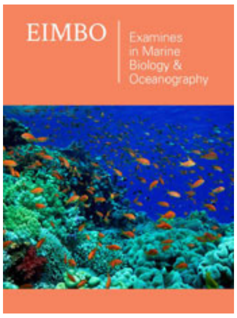
ISSN: 2578-031X



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Submission: August 04, 2023
Published: August 09, 2023

Volume 6 - Issue 2

How to cite this article: Gour Gopal Satpati*. Ocean Acidification: Positive and Negative Impacts on Seaweeds. Examines Mar Biol Oceanogr. 6(2). EIMBO. 000631. 2023. DOI: 10.31031/EIMBO.2023.06.000631

Opinion

Due to industrial revolution and anthropogenic activities carbon-di-oxide (CO_2) in the atmosphere has increased day by day. Deforestation, burning of fossil fuels, forest fires resulting in the enhancement of CO_2 in the ocean ecosystem. About 30% of the atmospheric CO_2 is absorbed by the ocean surface water which results in carbonic acids. The carbonic acids formed cause harmful effects to marine aquatic lives including sea animals and seaweeds. A series of chemical reactions results in the formation of carbonic acids and bicarbonates which has a bad impact on the living creatures. Marine organisms, especially hard shell containing species like corals and oysters become more effective as their skeleton is formed by the dissolved carbonate and calcium. On the other hand, clownfish have decreased in the additional acidic waters than normal marine water. Around 14-17 billion years ago, at the age of the middle Miocene, the pH of the ocean was less than 8 which resembles the present day environment (https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification).

Seaweed are the marine photosynthetic macrophytes that can absorb CO_2 for basic growth and synthesis of metabolic compounds [1,2]. Fluctuations of CO_2 on the surface water causes noteworthy influences in the metabolism of seaweeds in early stages of growth and development [3]. Study revealed that the brown (*Phaeophyceae*) and red (*Rhodophyceae*) seaweeds are dominant in marine ecosystems and play an important role in the food web of the ocean. Seaweeds sometimes become sensitive to Ocean Acidification (OA). On the other hand, OA promotes the growth and other physiological activities of seaweeds. The Atlantic Kelp, *Saccharina latissima* protected blue mussels, juvenile hard clams and eastern oysters from OA [4]. Biological activities like polysaccharides, fucoidan and alginate were highly synthesized in acidic sites than non-acidic sites [5]. Fluctuating pH in the culture of *Ecklonia radiata* resulted in sufficient growth and photosynthetic activity at juvenile stage [6]. The positive and negative impacts of seaweeds on OA has been highlighted in (Table 1).

Table 1: Effects of seaweeds to ocean acidification.

Seaweeds	Class	Effects to Ocean Acidification	References
Macrocystis pyrifera	*Phaeophyceae*	Sensitive	Roleda et al. [7]
Padina pavonica	*Phaeophyceae*	Resistant	Celis-Plá et al. [8]
Cystoseira compressa	*Phaeophyceae*	Resistant	
Ulva lactuca	*Chlorophyceae*	Neutralization	Ginneken [9]
Sargassum vulgare	*Phaeophyceae*	Resistant	Kumar et al. [5]
Fucus vesiculosus	*Phaeophyceae*	Sensitive	Kinnby et al. [10]
Ulva fasciata	*Chlorophyceae*	Resistant	Barakat et al. [3]
Saccharina latissima	*Phaeophyceae*	Sensitive	Young et al. [4]
Ecklonia radiata	*Phaeophyceae*	No effect	Paine et al. [11]
Lenormandia marginata	*Rhodophyceae*	No effect	
Plocamium cirrhosum	*Rhodophyceae*	No effect	

Modern technologies have also been suggested to control OA in an eco-friendly way. Integrated algal bioreactors with H^+ absorbance capacity can control OA and are suggested to protect coral reefs and seaweeds [9]. Three dimensional kelp forests are very influential to OA and help to increase the growth of bivalves of North Atlantic origin [4]. It has also been suggested that the co-culture of kelp and marine bivalves can reduce OA in the present day and near future.

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