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The ecological potential of beach-cast seaweed

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Abstract. The characteristic of the beach-cast seaweed concept is given. The approximate composition of beach-cast seaweed and their typical location on the coastline are described. It is described the ecological impact on the environment depending on the stage of the life cycle on the shore or seaweed return to the marine environment, including the effect of seaweed on the formation of the coastline and food chain, as well as the use of seaweed by animals and birds for nesting. The article presents the consequences of cleaning the beaches from beach-cast seaweed, including the negative effect of cleaning, and also offers options for processing beach-cast seaweed into fertilizers or other useful products instead of disposing them in landfills.

Keywords: storm-cast seaweeds, beach-cast seaweed, wracks, macrophytes, environmental impact, seaweed, fucus, kelp, anfeltia.

The terms "storm-cast seaweed" or "beach-cast seaweed" and connected term “beach wrack” refer to macrophyte seaweed washed ashore by a storm as a result of natural death, as well as seaweed released to the littoral by any tidal process, regardless of weather conditions [1, 17]. The most of incoming seaweed are formed due to the detachment of part of the thalli from the rhizoids by wind waves. At the same time, most of the torn off thalli end up on the shore, and only an insignificant fraction of them forms freely drifting seaweed accumulations [2].

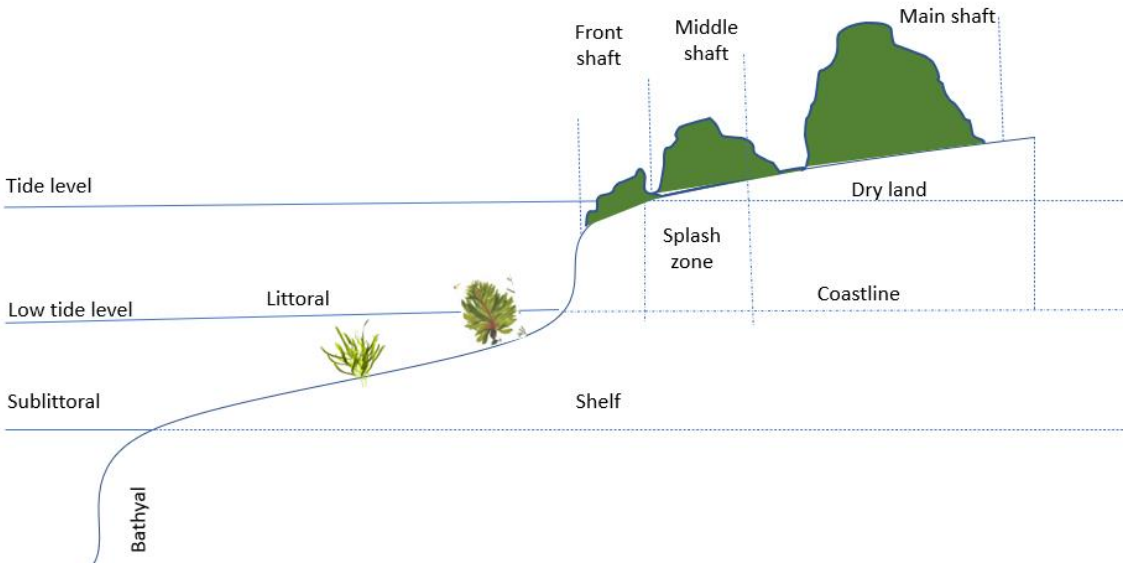

Figure 1. Location of beach-cast seaweed on the coastline (made by the authors).

The beach-cast seaweed wracks are usually located in several (usually three) rows along the coast, with an increase in row width with distance from the coast. The nearest rows are washed away and applied back by constant tides (twice a day in calm weather, the first row of beach-cast seaweed is formed and destroyed by a tidal wave), while the main upper shaft can be destroyed only during severe storms [3].

The shafts of beach-cast seaweed can reach 10 m in width with a height of up to 2 m. It's mass varies widely: from 1.5 to 5 kg/m^2 [4, 5]. Both lower shafts are usually represented by relatively fresh seaweed, while the plant material of the upper shaft is most often at various stages of decay, up to a semi-liquid mass that is absorbed into the sand to a greater or lesser depth. [3, 16].

During the roughness of the sea, not only seaweeds are thrown onto the shore, but also other objects, such as logs, chips, household waste, plastic, metal, glass. In the northern regions of Russia in beach-cast seaweed one can find both marine and terrestrial fauna, the average biomass of which is about 1300 g/m^2. The biomass includes mollusks, arachnids, crustaceans, small bristle worms, millipedes [1].

In the cold seas of Russia, the main beach-cast seaweed can be divided into two types: the first type is fucus, the second type is anfeltia and kelp. The quality of beach-cast seaweed depends on the degree of infestation with other seaweed and algae, sea grasses, and fauna.

Currently, beach-cast seaweed volume is not prognosed in time, space and magnitude and is not included in the recommended catch [6, 7].

The amount of seaweed discarded is mainly determined by the ruggedness of the coast, as well as by the strength and direction of the prevailing winds. The largest amount of beach-cast seaweed discards occurs on open sandy beaches that adjoin rocky reefs or forests [8, 9].

Environmental Impact of Beach-Cast Seaweed

After being washed ashore, seaweeds are either return to the marine environment during subsequent tidal cycles or remain in the coastal area / onshore. Accordingly, there are two options for their impact on the environment:

1) Seaweeds remaining on the shore are involved in physical processes (such as the formation of dunes, the formation of detritus, become the basis for succession), in food chains (become food for animals, reptiles, birds [10, 28], become a habitat for innovative dune vegetation if it is released to land too far and in general for terrestrial fauna (reptiles live in wracks, birds make nests [11]). Decaying seaweeds are a source of nitrogen for coastal waters due to the relatively rapid release of nutrients during decomposition, which affects primary productivity (phytoplankton) and participates in the food chain [21]. And, of course, it should not be forgotten the significant effect on aesthetic and amenity values [13].

2) When the seaweeds are washed back into the sea, they can:

- float on the surface,
- float in the water column,
- or float near the seabed.

These seaweeds are habitat and food for juvenile fish and herbivores [14], can spread the invertebrates over long distances, they undergo further decomposition, and are used by detrital animals [15].

But only opportunists and species tolerant to hypoxia can remain under the drifting macroalgal mats and it is accompanied by high particulate organic C/N ratios in the sediment under algal plots [22] because of inhibiting photosynthesis through shading. And it should be mentioned that seaweed blooms presence can increase the turbidity [13].

So, the balance between negative (on species richness, eutrophication, turbidity) and positive impacts (food for faunal communities) can be observed.

The consequences of cleaning beaches from seaweeds

The ecological effects of removing coastal seaweeds are poorly described in the literature and can vary greatly from one source to another [10].

Beach-cast seaweed wracks play an important role in both terrestrial and marine ecosystems. Some beaches where storm seaweeds accumulate are regularly cleaned by hand or

mechanically [29], but the impact of human removal of these seaweed on these ecosystems is not well understood.

Beach cleaning can have very significant adverse effects on marine and coastal processes and biodiversity.

The consequences of removing seaweeds can be:

1) threat to sandy coastlines (erosion)

2) the disappearance of macrofauna and birds that hunt macrofauna [18].

3) depriving beach ecosystems of valuable nutrients

4) the impact on the morphology of the beach, since together with the seaweeds, sand is removed from 25-30 m^3/t of seaweed [19].

5) a decrease in the density of epifauna and fish (however, these values are able to recover within two months) [20].

6) Even short-term beaches cleaning results in changes in species composition, and although these beaches recovered within two months, this could affect other species depending on the time of cleaning; for example, if it occurs during a nesting or breeding time for birds or during the time of settlement for fishes. [21].

7) Removing of beach-cast seaweed leads to removal of nutrients contained in the biomass, which would otherwise return to the water environment during decay and realize in eutrophication [26, 27].

Prospects for beach-cast seaweed processing

There are 2 points of view on removing seaweeds from beaches:

1) Criterion 4 of the Blue Flag environmental label states that “seaweeds or other vegetation should be left to decompose on the beach, unless it causes inconvenience” and “Only if it becomes absolutely necessary should seaweeds or other vegetation be removed and then dispose of by composting or use as fertilizer” [23].

The EHS (Environment & Heritage Service) position on beach clean-up recommends leaving algae to decompose on beaches, zone beaches that are regularly cleaned, leaving space for the natural decomposition of algae [24].

2) It is proposed to leave the farthest coastline on the beaches untouched, and to limit beach cleaning in summer or, if necessary, to remove excess material. For example, after the mass fishing [25].

Conclusions

The beach-cast seaweeds using potential is practically not revealed, with the exception of a number of countries where they are mined for personal use as food or raw materials for cosmetology or fertilizers. And the swells of seaweeds rotting in huge quantities on the coasts cause at least aesthetic harm, they are collected, depending on the territory, either by hand or by harvesters and disposed of in the nearest landfills or moved back into the sea by machinery. At the same time, beach-cast seaweeds have a certain potential for use as a raw material for the production of biofuel, since due to the decay processes [12] that have begun in them, it becomes possible to eliminate several stages of preparation.

It is necessary to study in depth the prospects for the collection and use of storm seaweeds emissions in industry without harming the environment. To do this, it is worth assessing the amount of biomass formed depending on the geographical and climatic characteristics of the emissions, determining the amount of possible removal without damage to the ecosystem and / or the time of collection, as well as the possibilities of processing storm emissions into useful products, for example, into fertilizers or biofuels.

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