



Socioeconomic impacts of beach wrack management

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Large beach wrack landing on German Baltic Sea beach (© J. Hofmann)

About the author

This report has been produced by EUCC – The Coastal Union Germany (EUCC-D) as an output of the CONTRA project. EUCC-D supports Integrated Coastal Zone Management (ICZM) by bridging the communication gap between research, policy and practice, and by facilitating stakeholder engagement. We offer advice, training, and development support to local authorities, as well as public

outreach and awareness raising on socio-economic issues affecting the coast, sea and catchment areas of European waters. Within our profile area, the triangle of coastal tourism, environment, and sustainable development, EUCC-D works with coastal communities and creates partnerships and projects at the regional, national and international level.

EUCC-D's role in the CONTRA project

The CONTRA project was structured into four main work packages, each covering the beach wrack challenge from separate perspectives. EUCC-D's main task was to lead the work on socio-economics within the field of beach wrack management, with special attention on the tourism sector and the demand for beach wrack removal. During the project, EUCC-D led an international public survey, the establishment of beach wrack working groups in each partner country and open interviews with

beach managers and local experts. The aim of the working groups was to share knowledge and synchronise efforts towards improved understanding and management of beach wrack at the CONTRA case study sites. Local research activities were done in a collaborative fashion with help from designated national Working Group Coordinators. The results of these activities are a fundamental part of the research which this report builds on.

How to read this report

The aim of this baseline report is to offer insights, and knowledge about the socio-economic components relating to beach wrack and its management. It targets policy makers, municipalities, tourism service providers, and researchers who wish to explore ways of balancing the environmental, social and economic impacts of beach wrack practices. Besides the introduction and conclusion, this report's body is divided into 7 sections. Approximating the driver-pressure-state change-impact-response (DPSIR) framework, the main body discusses each of the DPSIR elements relevant for

socioeconomics of beach wrack management in the BSR in a sequential fashion. The framework is described in more detail in Section 2. As this is a baseline report, it consists of roughly an even mix of two sources of data. On one hand, it summarizes existing data available in previously published scientific literature on the topic. On the other hand, it introduces own data from several of CONTRA's own questionnaires, including a survey of the general public and a questionnaire issued to relevant beach managers.

Summary

This baseline report tackles the previously unexplored topic of the socioeconomic aspects of beach wrack management in the Baltic Sea Region. While it serves as a general overview and synthesizes the findings of multiple relevant academic works, it also introduces new information from the project CONTRA (2019–2021) and its seven case studies in the region, both those specifically relevant to the locales and generalized findings. The report focuses on managed tourist resort beaches. It starts with the history of beach wrack and beach wrack management before moving on to the main drivers of beach cleaning and beach wrack removal: tourism and recreation. It then looks at various aspects of concern expressed by relevant stakeholders, including public opinion, health and safety, coastal landscape and conservation, knowledge and development. It finally provides an overview of findings to be applied at each stage of beach wrack management and ends with a short conclusion.

The main takeaway of the report is that both management considerations and research work regarding beach wrack management in the region are in their infancy. While multiple socioeconomic and environmental factors are at play at every case site, they rarely appear as a consideration. In contrast, financial aspects are commonly measured or approximated using indicators and factored in to the decision making that goes into beach management. The sheer complexity of the factors at play makes balancing stakeholder interests very difficult even in the short- and mid-term. In the long-term, structural considerations such as the impact of climate change and shifting tourism flows make providing recommendations a Sisyphean task. While the report is an important first step in establishing and increasing awareness of these factors, further research is required to develop concrete and streamlined guidelines on a local level that beach managers can refer to while considering all relevant specificities of their beaches.



1 Introduction

In the Baltic Sea Region (BSR), many communities have an intricate social and economic connection to their coasts. The coasts and beaches have a strong social, historical, and economic value to local residents (HELCOM 2017). While thriving Hanseatic League trade boosted the growth of vibrant commercial port cities, the forces of nature sculpted beautiful and sometimes dramatic landscapes, offering themselves forward as prime tourist destinations. Over the years, the prime locations gifted with natural coastal beauty emerged as best examples of what Baltic Sea tourism has to offer. Tourism revenue has become a primary source of income for most of these communities (Haller et al. 2011).

For such communities, one every challenging issue can be the organic material that gets washed up with wind and waves, namely beach wrack. Some beach wrack 'hotspot' areas, like the Island of Poel in Germany, experience landings of up to 1000 metric tons of beach wrack per month (CONTRA – Management Summary Report 2021) along main tourist beaches. Since competition between beach tourism destina-

tions is strong and there is a real threat of income loss if beaches fail to meet public expectations, local authorities are under great pressure to remove beach wrack. However, this comes at a great financial cost. Recent estimates to collect, remove and dispose of beach wrack put the cost for municipalities at between 20 €–40 € per meter of beach length (CONTRA – Management Summary Report 2021). According to unstructured interviews we had with beach managers in 2019, municipalities generally treat beach wrack as an organic waste. Thus, they almost never generate any money back from processing and use. The main driving factor behind beach wrack removal is thus the economic value of cleaned sandy beaches for the tourism sector and the local economies (CONTRA – Beach wrack in a business environment 2021). The explanation beach managers provided for this is that the general public associates beach-wrack-free beaches with high-quality tourist facilities and services.

Beach cleaning operations can, however, inadvertently alter the coastal landscape and the beach

Figure 1 Birds feeding amongst rotting beach wrack on tourist beach (© EUCC-D)



ecosystem, with long-term social and economic consequences (CONTRA-report Möller et al. 2021 about ecological aspects). Altering the provision of ecosystem services, including biodiversity and coastal protection, may over the long-term result in decreased attractiveness for the beach and, in turn, negatively affect tourism and recreational activities. Financial impacts of beach wrack removal include the direct cleaning costs and the loss of tourist revenue in affected coastal areas (CONTRA-report Almqvist et al. 2021 about beach wrack in a business environment). Negative social impacts, such as reduced benefits from access to coastal environments and well-being losses from living in a perceived degraded environment, may also be present. These may affect the sense of identity and community, reduce opportunities for recreational activities, and potentially pose health risks to coastal visitors.

The role of beach wrack in the interplay of society, environment, and the economy in the BSR has thus far been scarcely researched. Existing studies have analysed various ecological aspects of beach wrack, but have rarely specifically linked them to society. The few attempts rarely relied on own social and economic data (see Hammann and Zimmer 2014; Filipkowska et al. 2008; Mossbauer et al. 2012). When assessing socio-economic impacts of beach wrack, it is important to recognise that each

site is unique and that factors to consider include beach type, morphology, public infrastructure and services, cultural identity, coastal landscape, and local flora. While the impacts of beach wrack and its management are complex, we could not find studies that have specifically addressed them. This is true not only for the BSR, but for Europe and the rest of the world as well.

This report aims to identify and describe the key socio-economic components of beach wrack management in the BSR and to highlight the human dimension of beach wrack management on managed tourist resort beaches. It introduces own data in the form of several questionnaires put out to relevant stakeholders, including the general public, beach managers, and beach wrack experts from the region. Working groups based in each participating country organized unstructured interviews with these relevant stakeholders as well. At the start, the history of beach wrack and beach wrack management is briefly presented. Next, the main drivers of beach cleaning and beach wrack removal, tourism and recreation, are analysed. We then look at various aspects of concern expressed by relevant stakeholders, including public opinion, health and safety, coastal landscape and conservation, and knowledge and development. Lastly, this report provides an overview of findings, best practices and lessons learned at each stage of beach wrack management.

2 Beach Wrack of the Baltic Sea Region: The Basics

Why does beach wrack deserve to be considered when managing a tourist resort beach? A common public view is that it is a conglomerate of natural and manmade material that washes up on the beach every now and then. It is thought to have little or no use to society, essentially being a waste product and a nuisance that should be removed. In practice, beach wrack is a complex organic material generating a number of eco-system services (CONTRA-report Möller et al. 2021 about ecological aspects). In the BSR, it is primarily made up of torn off seagrass, macro-algae (brown, green and red species), shells and even dead animals. Its content varies depending on the location, time of year, and other environmental factors (Chubarenko et al. 2020). On one hand, beach wrack is a key part of the beach ecosystem. On the other hand, the public survey (Hofmann et al. in preparation) has shown that its presence can be problematic and have

undesired effects for beach users. What it consists of and how it is collected determines its usability as a resource, which can be very high or even none (CONTRA-report Chubarenko et al. 2021 – Case studies for innovative solutions 2021). Determining if it is problematic and how to remove and process it comes down to decisions made by beach managers and the local public authority or landowner. In the long term, every beach wrack management policy has an impact on how a given beach's ecosystem evolves. To set the scene, let us first look at the history of beach wrack perception and treatment in the BSR.

2.1 A Centuries-old Traditional Resource

Beach wrack has featured in the daily lives of Baltic Sea coastal communities for generations. Prior to 19th century industrialization, it was largely seen as a versatile resource. Various traditional uses



Figure 2 Fresh seagrass covering the foreshore (© J.Hofmann)

for beach wrack include: mattress filling, livestock fodder and bedding, souvenirs, fertilizer, soil improvement, insulation material in construction and bedding, tobacco supplement, food, and medicine (Heywood 1996; Heimatmuseum Warnemünde 2020). There is no evidence of a systematic treatment or management practice beyond removing what was needed for the specific application. The randomness of the location, time and composition of beach wrack likely prevented a more systematic exploitation of the material. Despite its unpredictability, its unique properties made pure seagrass that was washed ashore a valued resource. Its qualities include durability, mould and fire resistance, effective insulative properties, and non-attractiveness to vermin and pests (Posidonia-Dämmstoffe 2011). At least since the early 18th century up until around 1930, BSR coastal communities saw great value in beach wrack as a resource. Unfortunately, seagrass meadows were decimated by a wasting disease that emerged in the 1930s and peaked in the 1970s and 80s (de los Santos et al. 2019). At around the same time, in the Baltic Sea, the level of nutrients, including nitrogen and phosphorus (Larsson et al. 1985), as well as heavy metals, progressively increased (Bernes 2005). We could thus infer that



Figure 3 Historic Danish seagrass roof (© Læsø Museum, Denmark)

water quality in the Baltic deteriorated. During this time, societies moved to synthetic and man-made building and filling materials and beach wrack use declined. In turn, this contributed to a wide-scale loss of the skills and know-how of sustainably utilizing beach wrack.

2.2 Becoming an Undesirable Object

At some point in the late 19th century, the centuries-old tradition of coexisting with beach wrack

Traditional applications of beach wrack across the BSR

Denmark (Læsø Museum n.d.)

Evidence of the strong Danish culture around seagrass use can still be found there today. On the island of Læsø, the tradition of seagrass roofing can be traced back about 800 years. There are still about 20 houses, with traditional seagrass roofs dating back over 300 years, standing as monuments to a time when communities relied on local resources. In the 1930s, eelgrass near Læsø died out due to a fungal infection (Læsø Museum n. d). Recently Læsø roofs have been restored and an effort has been made to re-educate roofers in the roofing technique.

There are also remnants of old seagrass boundary walls on the Danish islands. In the early 18th century, eelgrass was used in Denmark and Sweden, to build dikes and dams to protect low-lying coastal areas against storm floods.

Germany

Fishermen working in the Wismar area of northern Germany, supplemented their daily income by selling seagrass to local residents and it was also here where a number of seagrass processing and upholstery companies emerged. Records show that the use of seagrass even extended to the filling of cushions in ships and trains.

Sweden

Due to the availability of nutritious beach wrack that they could easily collect, farmers established agricultural “beach” fields near the coastline and fertilized them with beach wrack. Beach wrack was also used to stabilize sand on the beach and prevent sandstorms.



Figure 4 Mechanical beach wrack collection (© Hanseatische Umwelt CAM GmbH)

and treating it as a resource to be used in everyday life slowly broke down. Industrialization, the advent of railways and the increasing popularity of tourism likely helped influence a shift in the perception of beach wrack (Bal and Czalczyńska-Podolska, 2020). New marketing vehicles that relayed an image of the newly hip beach destinations, such as postcards, did not market beaches full of beach wrack, but “pristine” ones free of it. City dwellers now visiting these destinations were less likely to be as aware of the value of beach wrack as the local residents. The composition of beach wrack itself also likely started to shift. around that time (Chubarenko et al. 2020). It is not clear how far back organized beach cleaning goes, but it is highly unlikely that it began before tourists generated the demand and funding for it.

In the BSR, the beginnings of beach tourism can be traced to the early 1800s. The large-scale demand for beaches free from litter and other items washed ashore, including beach wrack, probably only appeared once the advent of railways in the mid-19th century brought large numbers of far-flung visitors to beach resorts for the first time (Bal and Czalczyńska-Podolska, 2020; Heimatmuseum Warnemünde 2020). Of course, not all beach tourist sites in the BSR will have enjoyed a direct rail link with the large cities. Less accessible locations only got more tourists with the advent of the automobile in the 20th century (ibid). The increasingly negative perception of beach wrack will have been accompanied by the development of ever larger and more sophisticated machinery used to remove it. At first, beach wrack was only collected by hand,

possibly with the help of simple tools like rakes and pitchforks. Sometime in the 20th century, agricultural tractors with dedicated attachments started becoming more common, including among our respondents. However, the large-scale mechanical beach cleaning taking place today only goes back a few decades. For example, a notable early adopter of purpose made beach cleaning vehicles was the 1996 Atlanta Summer Olympics (Sack 1996).

2.3 Newfound Beach Management Consideration

Describing how beach wrack serves the local environment, society and the economy can be done by assessing its contribution to ecosystem services. Ecosystem services can be broadly defined as “the benefits people obtain from ecosystems” (MEA 2006). Some services provided to people by sandy beaches will be direct and easily perceptible, such as beaches being an aesthetically pleasing recreation space with good air quality. In contrast, they are also likely to be less obvious and have more indirect benefits. An example of this is the services provided by beach wrack. One service is that it is used by endemic birds for nesting, shelter and food (McCulloch 1996), helping to keep the local food chain in balance. Other benefits of beach wrack include mitigating climate change effects and reducing sand erosion (GSA 2017). While these ecosystem services have an economic impact, especially in the long-term, they are notoriously difficult to quantify and thus to incorporate in policy (Gómez-Baggethun and Ruiz-Pérez 2011). More information about ecosystem services can be found in CONTRA-report by Möller et al. 2021.

On tourist resort beaches, beach cleaning, which includes the removal of beach wrack (sometimes called “beach grooming”), alters the ecosystem services of the beach. The relative importance of the various ecosystem services provided by sandy beaches in the BSR changes depending on whether the beach is managed or not. We define managed beaches as beaches where the following criteria is met: 1) they are used for recreational purposes, 2) there is a dominance of sandy sediments, and 3) beach wrack is removed from them on a regular basis. An illustration of the shifting relative importance can be found in CONTRA-report Möller et al. 2021. On unmanaged beaches with beach wrack, the relative importance of biodiversity and habitats, natural heritage, and knowledge systems is higher, with the overall picture being more balanced. In contrast, on managed beaches, there is

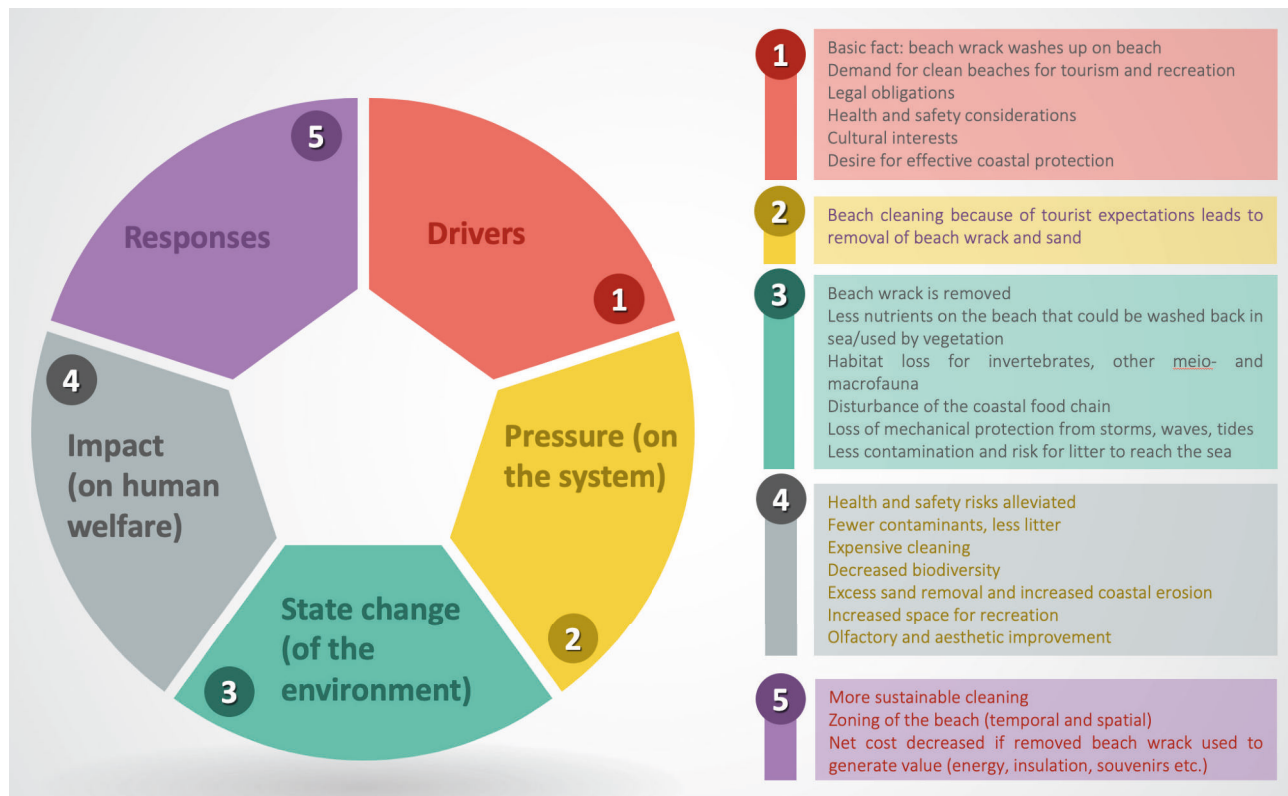


Figure 5 Illustration of beach wrack management dynamics using the DPSIR framework (© EUCC-D)

a strong bias towards a single ecosystem service: tourism-oriented recreational services (CONTRA-report Möller et al. 2021).

The following sections describe how this dynamic takes place and how it impacts the individual socioeconomic sectors and their various stakeholders. In this report, we will loosely follow the driver-pressure-state change-impact-response (DPSIR) framework to describe beach wrack management in the BSR (Elliott 2014). We illustrate the various directions managed beaches can take depending on local priorities, as well as the impact that the individual drivers of beach land use may have on the local society, economy and the environment in the short, mid- and long-term. We also present historical case studies of beaches that have adopted specific policies and the observed effect such policies have had on the beach environment. Our own data comes from a series of questionnaires with the public, local beach managers, and experts working in the field of conservation, open-ended discussions with local experts, and local meetings with working groups from each studied site. The intended outcome is that, by the end of the report, readers will have a better idea of the impact beach wrack management policies have on the beach and coastal communities and how these policies could be adjusted. But first: what is already being done

to shift the public perception and political attitude towards beach wrack?

The shifting narrative surrounding beach wrack contributed into making it an example of how society gradually abandoned a naturally occurring, mostly organic raw material and moved to synthetic alternatives. The former natural materials play a key role in trying to reinvent BSR economies to become more sustainable in line with political goals set out by HELCOM (2017) and the European Commission (2014a). Beach wrack specifically offers a plethora of options in developing the blue economy, circular economy and bioeconomy. A holistic approach to beach management implying a balancing of environmental protection, social considerations, and economic development would help achieve this in the long term. If the local authorities wish to comply, they would have to employ a sustainable long-term strategy in managing their beaches – including their beach wrack. Plenty of opportunities exist to readjust the treatment of beach wrack with greater sustainability in mind. While historical use cases of beach wrack present potential for rediscovery, there are fresh possibilities for beach wrack use abound in cosmetics, pharmaceuticals, soil improvement, biogas, and coastal protection, among others. Some of these use cases are also presented in the report.

3 Tourism and Recreation

The main sources of economic value on managed beaches are tourism, recreation and associated activities (CONTRA-report Almqvist et al. 2021 about beach wrack in a business environment). The EU Commission's Blue Economy report states that coastal and maritime tourism is the largest sector in the blue economy, accounting for over 50% of the job opportunities and 36% of the GVA (Gross Value Added) (EC, 2019). A fact of nature is that beach wrack regularly washes up on most of managed BSR beaches surveyed in our management questionnaire. On these beaches, it is often considered as a potential nuisance to value generation (CONTRA – Management Summary Report 2021). This drives beach managers to remove it. This section analyses this economic value in more detail.

3.1 World and European Tourism: Trends and Figures

Tourism is one of the world's largest economic sectors, consistently increasing in value. UN data shows that global tourist arrivals continued to increase in 2018, maintaining a positive pattern seen since 2009. Over 9.25 trillion USD is contributed by tourism and travel to the world economy. A total of 1.46 billion arrivals were recorded in 2019; over 4.7 billion USD alone was spent on leisure travel. Europe is one of the world's most popular vacation destinations. In 2018, the wealth of European cultures, the variety of its landscapes and the quality



Figure 6 Busy tourist beach in Poland (© D. Szponder)

of its tourist infrastructure have, among other reasons, attracted over a third of the world's international tourists to holiday in the EU-27 (EC 2020a). Tourism is a key economic component in many EU regions, especially in peripheral ones like the BSR. Coastal and maritime tourism typical for BSR has been identified as one of the five sectors of Blue Growth (EC 2014b). On one hand, tourist infrastructure "contributes to local and regional development, while jobs that are created or maintained can help counteract industrial or rural decline" (EC 2020a). On the other, tourism can have negative consequences. Excess demand can strain local infrastructure and hinder daily lives within local communities. Tourists harm the environment locally through noise, pollution, waste, and habitat loss; and globally through transport-related Greenhouse gas emissions (EC 2020a).

3.2 Socioeconomic Development in the Baltic Sea Region

Many BSR locations benefit from ecosystems that feature endemic marine flora, fauna, and, perhaps most importantly, wide sandy beaches. For developers and politicians, the most alluring financial prospects for their coasts lie in the tourism revenue. Unlike some other forms of tourism that require significant capital investment early on, e.g. cultural tourism, the tourist attractions of an area with sandy beaches, which "represent the primary natural capital on which seaside tourism is based", already exist (Flayou et al. 2021). Such tourism brings a strong influx of revenue spread over a wide variety of service industries such as catering, accommodation, transport, and recreational activities such as swimming, diving, sailing, and surfing. There are even purpose-built coastal resorts creating and catering to such tourist demands for sandy beaches in every BSR country. Examples include Prora (Germany), Sopot (Poland), Liepaja (Latvia), and Haapsalu (Estonia). A correspondingly high number of hotels, restaurants, cafes, night clubs and other businesses reliant on tourist revenue operate in the resort areas. In addition, unlike some types of social and cultural tourism, beach tourism appeals to international tourists. The latter contributes to the tax revenues of host country

governments through various taxes paid on their trip. Yet, as they are short-term visitors, the government does not have to spend any of their tax revenue on them through welfare, as they do with their own citizens (Orams 2003). This makes international tourists a particularly appealing source of income.

In the BSR, the beaches along the Baltic coast help their surrounding communities generate economic revenue from tourism and recreation. Beach tourism and reliant types of tourism, such as meeting, incentive, conference, or exhibition tourists, as well as recreational, medical, wildlife and eco-tourists, are a natural fit for a region rich in attractive sandy beaches but with relatively few major cities (Jędrzejczak 2004; Flayou et al. 2021). Germany, Poland and Russia were named in the UNWTO list of top 10 destination countries globally (EC 2020a). While these countries have diversified tourist industries, their share of coastal and maritime tourism was important for the structure of their tourism industry and tourism revenue, especially in Germany and Poland. In Germany, 17% of all overnight stays are recorded in the coastal provinces of Hamburg, Mecklenburg-Western Pomerania and Schleswig-Holstein, while in Poland, 43% of such stays are generated in the coastal regions of Północno-Zachodni and Północny (BSTC 2018).

Unlike most large European tourist markets, the BSR region has a very high share of domestic and intra-BSR tourists. For example, in Germany, where beach holidays are the preferred holiday type, the Baltic coasts in Mecklenburg-Western Pomerania and Schleswig-Holstein are especially popular among domestic tourists. In 2018, 96.1% of nights spent in tourist accommodation in Mecklenburg-Western Pomerania came from domestic German tourists, which was the highest share of domestic tourists in any region in the EU (Eurostat 2018). The destinations benefit from the fact that around 30% of German tourists vacation domestically and that 45% of them drive to their destination (ADAC 2018). Between 2014 and 2016, the direct employment of the BSR tourism industry increased by 6.5% to a total of more than 650,000 jobs directly provided. The major labour markets are the German Baltic coast with over 180,000 employees, closely followed by Sweden with 173,000. In terms of GDP contributions generated by the BSR tourism industry, tourism generated between 1.8% (Lithuania) to 4.3% (Finland, Latvia) of each BSR country's overall national GDP in 2016 (BSTC).

However, this significant economic contribution



Managing beach wrack with tourists in mind – Yantarny, Kaliningrad District, Russia (Photo: © J. Gorbunova)

How does one best go about managing beach wrack while catering primarily to tourists? According to the Russian local working group coordinator, we can look at Yantarny in Russia. The beach used to be primarily used by local residents, mostly fishermen and farmers. A gradual expansion of the zone devoted for tourism and recreation has led to the development of a prime four kilometres long stretch of managed sandy beach, which has been awarded the Blue Flag (2020) and highlighted as a destination in tourist catalogues. Steady investments in the beach's tourist infrastructure and marketing have been bringing increasing levels of revenue for its owners, the local municipality, as well as the local hospitality sector. The area is world famous for its amber ("yantar" in Russian), with around 90% of the world's reserves estimated to be located here. Amber collection is also a major tourist activity during the season, when tourists collect it from the beach wrack. Even so, the entire beach and the wider area are cleaned regularly. This has led to concerns about biodiversity and sand erosion in the area. Like with many others, the beach's ability to withstand climate change and extreme weather events is likely to be reduced over the medium and long term.

comes with several socioeconomic challenges attached. To mention just a few, they can unknowingly harm local endemic flora and fauna or introduce foreign species, which can reproduce rapidly with

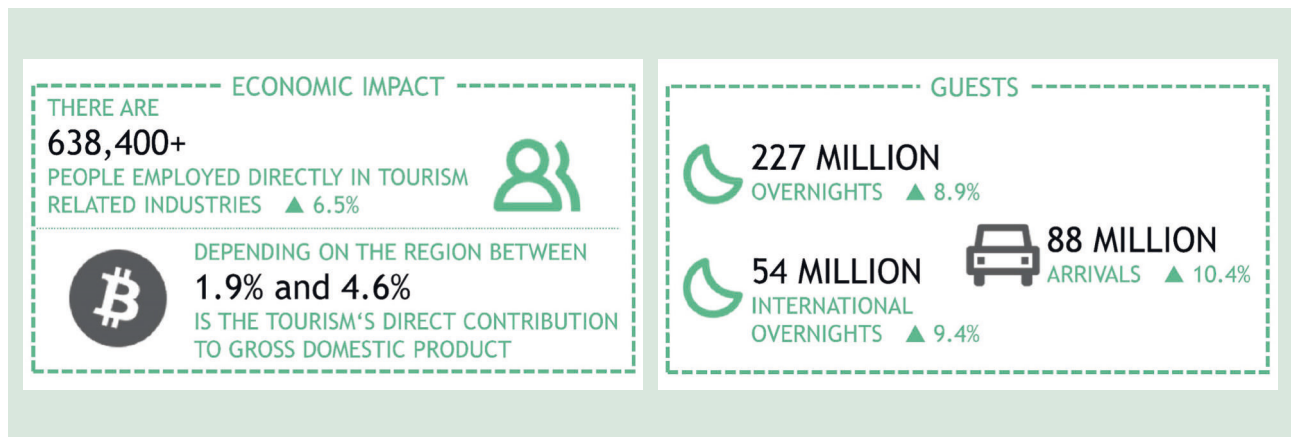


Figure 7 Economic figures and impact of tourism in the BSR, 2014–2016 (© BSTC 2018)

no natural predators and become a pest. Other relevant problems include higher levels of sunscreen oil in the water near the beach and formerly public beach sites limiting access to paying customers only to increase revenue. It also increases the demand for beach grooming and beach wrack removal (Orams 2003).

Land and Beach Use Patterns and Trends

Beach tourist resorts follow fairly similar land use patterns. A large amount of land near the beach is used for real estate development (Smith 1991; Bal and Czalczyńska-Podolska 2020), mostly short-term rentals like hotels, apartment buildings, and campsites. The side effects of this can include local traffic congestion, removal of trees, and (over) construction leading to the loss of traditional cultural identity (Bal and Czalczyńska-Podolska 2020; Jankauskaitė and Grecevičius 2018). In some tourist resorts, attempts are made to limit or prohibit manmade interference, including zoning to limit building height and density, monumental protection for older and historic buildings, mandatory green space quotas, ecologically protected zones near the beach, and sustainable transport infrastructure like bike lanes (Kropinova 2020). If executed successfully, these measures can alleviate the negative environmental and social side effects of tourism on the local community and help present a more premium image of the resort, as was traditional of BSR resorts in the late 19th and early 20th century (Bal and Czalczyńska-Podolska 2020).

Meeting Tourism Sector Demands in the Long Term

Tourism is thus a proven profitable economic activity in the short- to mid-term. However, over time, if the tourism activity destroys the attraction upon

which it is based, the entire investment in accompanying tourism infrastructure and businesses is lost. Environmental sustainability is therefore a critical component of the long-term economic success of any nature-based tourism venture such as those based around sandy beaches. Balancing the social and especially economic benefits with the environmental and social downsides of tourism requires a complex and holistic approach. This includes the reconsideration of beach wrack management.

3.3 Impacts of Beach Wrack Management on Tourism (and Vice Versa)

Socioeconomic pressure to promote tourism and recreation activities alters the beach ecosystems of tourist beaches. This also concerns beach wrack management (CONTRA-report Möller et al. 2021). Due to its prevailing culturally conditioned perception as unclean, beach wrack is commonly removed from managed beaches. A key source of socioeconomic pressure is modern social media, where posts are written in minutes or seconds and publicly visible instantly. According to an anonymous BSR municipality representative responsible for beach cleaning and tourism services, this makes it harder for beach managers to have a traditional discussion with tourists who see beach-wrack-laden beaches as a letdown. In turn, it increases the pressure for beach managers to remove beach wrack. While trying to preserve their beach's reputation, they may even begin removing it "preventively", in anticipation of negative reviews (CONTRA – Management Summary Report 2021).

The extent and regularity of beach wrack deposits is affected by weather and the coastal landform. In general, research shows that protected beaches (e.g. behind an island, dam or spit, or with a back-shore forest) can accumulate large amounts of



Figure 8 Beach wrack pile on tourist beach (© EUCC-D)

beach wrack that can persist over time. In contrast, unprotected beaches are more exposed to environmental conditions. Larger deposits on such beaches are linked to highest wave heights and stronger winds. Beach wrack deposits at unprotected beaches are more often irregular and can be very large.

his unpredictability on unprotected beaches, which most BSR tourist beaches are, clashes with the predictable behaviour of beach tourists. The latter generally start filling the beaches during the tourist season at the same time every morning. Several beach managers thus indicated in interviews that they must grapple with a difficult dilemma. If extreme weather events result in abnormally large accumulations of beach wrack, the space for tourism and recreation activities can be entirely obstructed, particularly on smaller beaches, for as long as the beach wrack stays in place. For these situations, managers ideally have as much capacity for material removal as possible. The decision regarding removal also has to be taken very early in the morning under time pressure, before the tourists begin to arrive. However, they also have an incentive to avoid costs linked to unused capacities. Most managers we interviewed managed smaller resorts. Correspondingly, the majority of them reported to have a policy of removing beach wrack on demand rather than periodically.

3.4. Summary

To summarize, managed tourist beaches face a complex balancing act between economics, social interests and the environment. These interests can be further broken down. For example, the residents' social interests can often clash with tourist visitors' or small business owners with short-term oriented business models may not see eye-to-eye



Generating economic revenue through large events – Tälletstranden, Åhus, Kristianstad, Sweden

(Photo: © Kristianstads kommun)

Information gathered by the local CONTRA working group coordinator indicates Åhus is a vibrant summer resort with a lot of visitors, mainly from Sweden, Denmark and Germany. The beaches have a high value for the municipality. The coast is an attractive area for housing, tourism, business and recreation. There is a handful of hotels and a campsite in the village, as well as a lot of summerhouses in the vicinity. The town gets around 2 million visitors every year. Exact numbers on the total economic value are lacking, as it is a complex question. However, the total tourist economic revenue for the municipality is around 900 million Swedish kronor, and the municipality estimates that the Tälletstranden beach in Åhus accounts for at least 20%. On Tälletstranden, beach wrack is removed just once per month between March and August. It is spatially zoned, meaning not all parts of the beach get cleaned. The beach also hosts some of the largest events in Åhus. In 2018, eight major sporting and cultural events, including a melody festival and a beach handball tournament, attracted over 100,000 visitors and generated sales of over SEK 210 million (20.7 million EUR).

with beach managers worried about the integrity of their beach. We analyse these various interests in the following sections.

4 Public Interests and Behaviour

The best interests of tourist visitors are regularly cited by beach managers as the reasoning behind beach wrack removal. But what are the public's views of beach wrack exactly? How much pressure in favour of beach wrack removal does the public exert? And how do their views affect their tolerance levels regarding beach wrack quantities? These questions are explored in this section.

4.1 Public Perception of Beach Wrack

While millions of visitors are drawn to Baltic Sea tourist resorts every year, the reasons for a specific beach visit and activity choices vary depending on location, infrastructure, beach services provided and several natural conditions.



Figure 9 Large amounts of dried seagrass washed ashore after a storm in Warnemünde, Germany (© J. Hofmann, above); Local residents searching for litter amongst the beach wrack (© J. Hofmann, below)

Tourist Expectations regarding Beach Quality

Results from the Hofmann et al. (in preparation) public survey of around 700 people around the BSR found that the public's first choice of activity is bathing/swimming (→ Fig. 10). This leads us to the assumption that the public's measure of beach quality will largely be related to the beach form, water quality and water access, all of which are impacted by beach wrack management practices.

In practice, public preferences are not homogeneous across beach user profiles. They are most likely to vary between tourists and local residents. Roca et al. (2009) researched this in the Costa Brava area of Catalonia (Spain). They found that, on natural or semi-natural beaches, one more often came across local residents or regional visitors, who were more likely to value peace and quiet. In contrast, at urban beaches, more visitors were tourists, who found manmade beach facilities more important. Furthermore, the findings from an Estonian study of beach wrack socioeconomics point out that Estonian beach resorts tended to develop in locations with low to moderate beach wrack landings, implying a general correlation between managed beach sites and the visitors' preference for less beach wrack (Consulare ÖU, 2021).

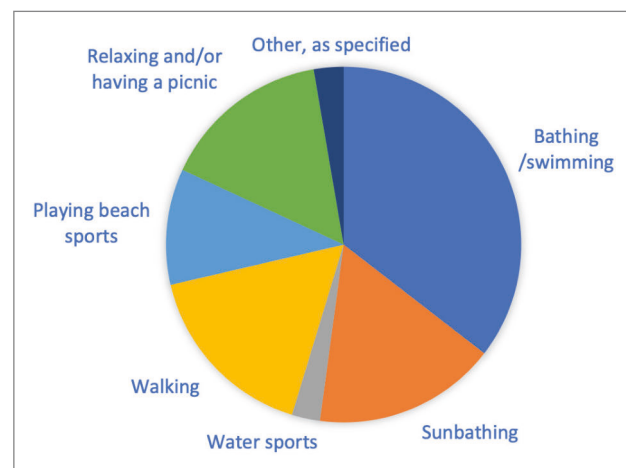


Figure 10 Most important beach activities of the public in the BSR (© Hofmann et al. forthcoming)



Figure 11 Large amounts of marine litter washed ashore (© EUCC-D; above); Decomposing algae on sandy tourist beach, Rügen, Germany, 2019 (© J. Hofmann; below)

Knowledge and Experience

The findings from Hofmann et al. (in preparation) indicate that the ecosystem services of beach wrack are currently not well understood by the general public. On one hand, public experience is high, with nearly all beach goers having come across beach wrack in one form or another at some point. On the other hand, knowledge levels vary per country. Whereas Danish beach visitors were on average relatively well aware of beach wrack's importance to the coastal ecosystem, this was rarely observed by the beach goers in the Kaliningrad Region of Russia.

Awareness of environmental issues and their importance for people and the planet is steadily increasing. However, this is much more often the case for highly publicised issues, such as climate change, rising sea levels, oil spills, and nuclear accidents. On beach wrack, the distribution of official public information from the responsible authorities is virtually non-existent (CONTRA – Management Summary Report 2021).

Examples of public complaints about large amounts of beach wrack

- It reduces beach area available for recreation;
- It impairs the bathing experience with unpleasant odours;
- It obstructs access to the water;
- When dry, it's hard and uncomfortable under bare feet
- It can be populated with sand fleas and other small creatures

Figure 12 Some public complaints about large amounts of beach wrack from CONTRA anonymous public interviews

Public Perception of Beach Wrack Hazards

In 2019, a man died at a beach in the French coastal region of Brittany (Chrisafis, 2019). The beach was inundated by green algae due to nutrient dumping by local agricultural undertakings (especially nitrates from fertilizers). The man stepped on decomposing beach wrack with a high green algae content, which had trapped pockets of toxic gases created during decomposition. These gases later fatally intoxicated him. Such events grab media headlines and have a potentially major impact on the public perception of beach wrack. It is worth noting though that in most cases, beach wrack will not release enough toxic gases during decomposition to physically harm humans. Interestingly, the respondents of an Australian study express an even bigger concern about beach wrack's impact on marine biota than on their own health (Campbell et al. 2016). Thus, other, relatively minor concerns for tourists' health and safety, can take up more attention than potentially deadly rotting algae.

Information and guidance for local authorities on the hazards associated with beach wrack is scarce. It is thus perhaps understandable that beach managers act with an air of caution and that the public is uncertain about potential risk factors. According to Hofmann et al. (in preparation), many interviewed BSR beach goers said that beach wrack is dirty and that they didn't know whether beach wrack can be hazardous. However, the study also indicated that direct experience, impact on activities, and (to some extent) knowledge play a role in public perception. Indirectly, experience also helps shape the public's tolerance levels.



Figure 13 Litter contamination of beach wrack (© J. Hofmann; above); Land sourced litter trapped in drying beach wrack (© J. Hofmann; below)

Unlike municipal beach cleaning operations, the public makes a clear distinction between anthropogenic litter and natural beach wrack. Hofmann

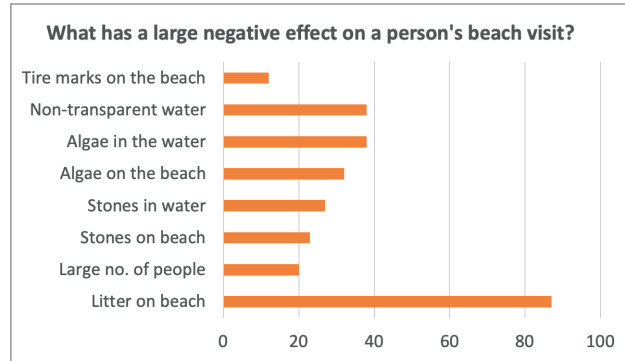


Figure 14 Percentage of respondents who say that certain occurrences have a notable negative effect on their beach visit (© Hofmann et al. forthcoming)

et al. (in preparation) indicate that litter and beach wrack are indeed perceived very differently. While algae on the beach does have a negative effect on many beach visits, it is still a secondary problem compared to litter (→ see Figure 14), which is seen as overwhelmingly more problematic.

4.2 Public Tolerance of Beach Wrack

Using various beach wrack photos (shown below), the Hofmann et al. (in preparation) public survey aimed to improve the understanding of how tolerant people are of beach wrack on BSR managed beaches and whether current beach cleaning operations are meeting beach-goers' expectations.

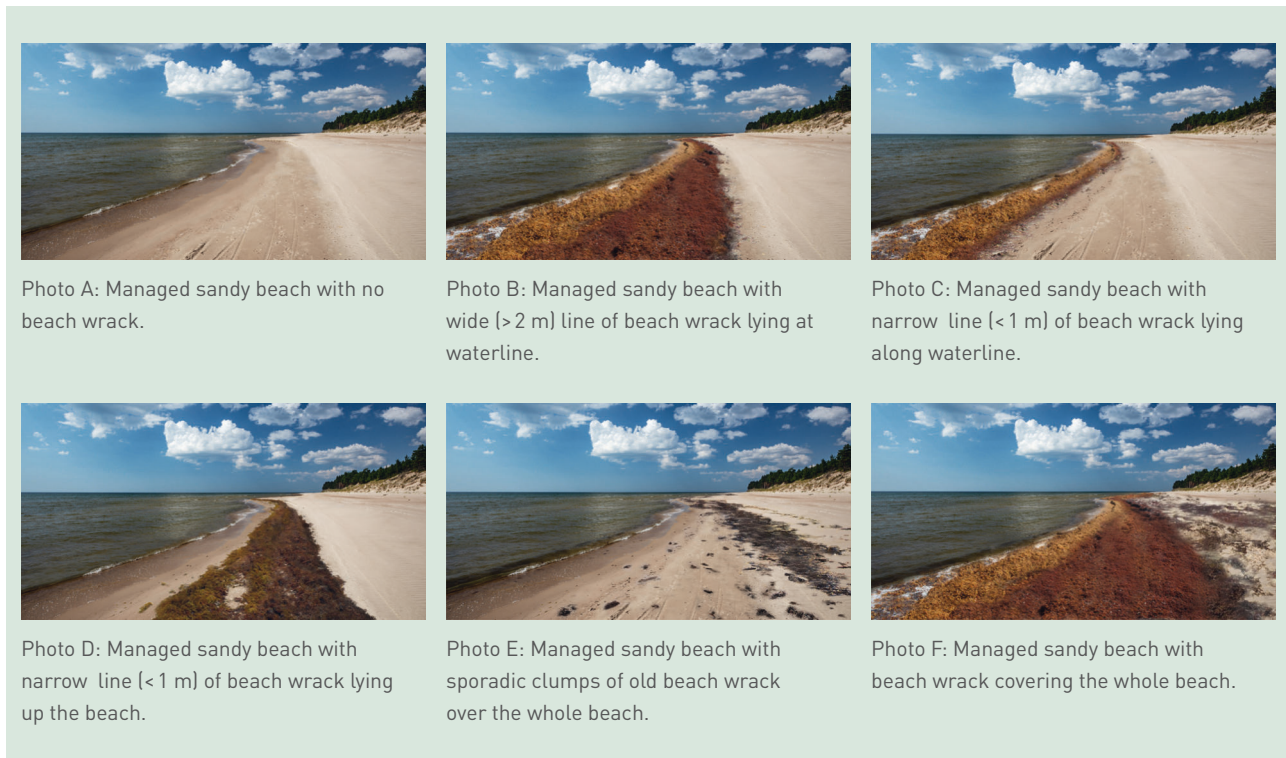


Figure 15 Various beach wrack photos used in the CONTRA public survey

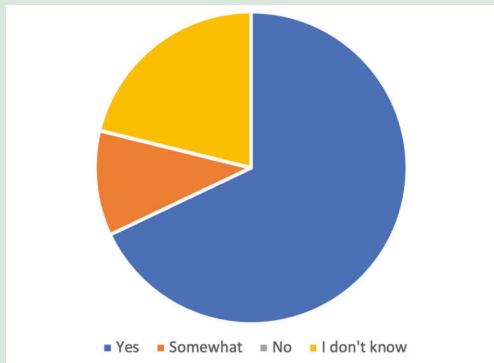


Figure 16 Beach cleaning satisfaction at Tappetstranden, Åhus, Sweden | (N=156, left; conditions similar to photo A, right)

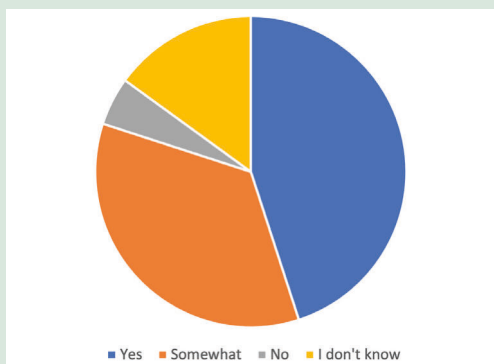


Figure 17 Beach cleaning satisfaction at Puck City beach, Poland | (N=20, left; conditions similar to photo E, right)

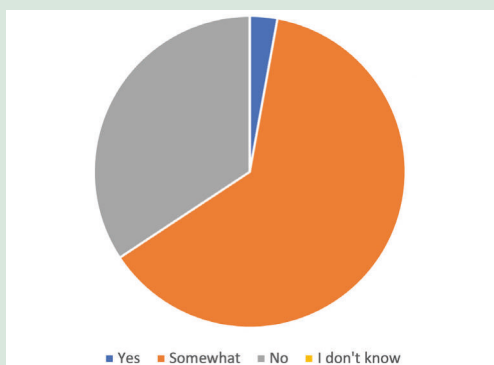


Figure 18 Beach cleaning satisfaction at Suchacz & Tolkumicko, Vistula lagoon, PL | (N=35, left; conditions similar to photo B, right)

Findings from over 700 filled-in public questionnaires indicate that, while beach wrack does not have a notably positive effect on a person's beach experience, respondents do feel neutral about small amounts that they can walk around or step over. The surveyed are fairly tolerant of beach wrack conditions similar to photo E (→ see Figure 15).

The study showed that there is a notable difference in tolerance levels depending on location. For example, beach goers in Germany are more accepting of beach wrack landings than their counterparts in Poland. People's direct experience and (to a lesser degree) knowledge also appear to play a role. In the areas where knowledge about eco-system services

is lower, tolerance levels tend to be lower as well. Other factors at play that contribute to differences in tolerance levels include the general appearance of a beach, upkeep of facilities, effectiveness of litter management and marketing of the beaches.

Beach Cleaning Satisfaction

Just as the perception and tolerance levels of beach wrack vary, so does the acceptance of beach cleaning operations. Hofmann et al. (in preparation) indicate that most respondents are satisfied with cleaning that still leaves a narrow line of beach wrack by the water line (→ see Figures 16–18). However, larger amounts of beach wrack present questions



Figure 19 Kite surfing beach with beach wrack (© J. Hofmann)

of health, safety and aesthetics. Correspondingly, beach cleaning satisfaction is lower under this type of beach-wrack-heavy circumstances. A balance from the tourists' perspective probably lies somewhere in the middle. They seem to mostly approve removing some beach wrack, but not always the systematic removal of all of it.

4.3 Public Impact

It should be noted that beach wrack is only one of many factors that impact the public's activity and destination choices. Indeed, it is one of relatively small importance; the public names litter and algae in the water as factors likely to have a much more important negative impact on their experience than beach wrack (→ Figure 14). Nevertheless, it does have an impact, which merited consideration in the CONTRA public survey.

Activity and destination choices

Beach wrack is more likely to affect activities that are bound to the beach, such as volleyball sporting events, much more than those requiring access to the sea like swimming.

The Hofmann et al. study (in preparation) also surveyed BSR beach goers on the basis of several

beach wrack photos (→ Figure 15) and the impact they had on their choice of activity. While a narrow line of beach wrack that can be stepped over or walked around was tolerated by swimmers, any line wider than a meter already had a dissuasive effect. The study notes the high importance of the conditions of the day for the respondents' answers. If a beach was filled with beach wrack, respondents gave it much more consideration than on beaches virtually free of it, where it was just a side thought.

Impact of the internet

The advent of the digital age has brought about the increased use of the internet, including online booking services and social media channels. Alongside other parallel socioeconomic developments, these have had some notable impacts on BSR beach tourism. Firstly, they have made it more international and larger in scope. The multilingual experience offered by major booking providers have made comparison of prices and amenities across destinations simpler and readily available to tourists in their native tongue. The drawback of this is that international tourism has been linked with a more negative impact on happiness of the local population than domestic tourism (Okulicz-Kozaryn and Strzelecka

2017). Next, the importance of the image of the resort and complying with tourist expectations has increased. In unstructured interviews, beach managers at the CONTRA case study sites said that they felt under pressure to present their beaches similar to the well-groomed Caribbean ones being represented in the media. Indeed, this shift has also made their way to their traditional marketing material. Social media and user generated content are a major source of such pressure, as they allow tourists to easily communicate their experiences to one another and indirectly influence the travelling expectations of potential future tourists. However, while tourists may have "Caribbean" expectations of BSR destinations, the beach wrack dynamics in the BSR can be quite different, presenting more complex management challenges which tourists do not consider. For example, concerns about cohabitating and preserving local traditions become more sidelined. From the managers' perspective, the extent to which tourist expectations are met will eventually determine the level of tourist satisfaction. If the overall performance while or after visiting a destination exceeds or meets the initial expectations, the tourist is considered satisfied (Narangajavana et al. 2017). Inevitably, some tourists will see beach wrack negatively and will continue to do so despite the feedback from experts. Social media channels are especially prone to amplifying these negative voices (Ott, 2017). In summary, the internet age has brought about new dynamics for BSR beach managers, which have presented new social and economic challenges, including those related to beach wrack and other beach conservation concerns. In the long-term, researchers predict that coexistence between beach conservation and touristic activities will require a socio-cultural change (Rotini 2020).

Culture, Heritage and Local Identity

Various beach wrack management traditions can be found along the Baltic coast. On one hand, we have the more recent one of all-encompassing beach wrack removal from managed beaches. Stemming from the notion of preserving the "traditionally clean" reputation of the beach resorts in question, this tradition is in large part based on the misconception that virtually all beach wrack is inherently dirty and to be classified as waste. On the other hand, there is the previous tradition of cohabitating with beach wrack. This implies not noticeably interfering with the natural processes of which beach wrack is part while reusing the material for various every day or dedicated purposes.

An example is the use of beach wrack for traditional biological roofing in Denmark. Historical sources indicate that other methods of traditional reuse of seagrass included using it as an insulation material, mattress filler, cattle bedding, livestock fodder, and tobacco supplement (Heywood 1996; Heimatmuseum Warnemunde 2020; Læsø Museum n.d.).

In general, there are several arguments in favour of promoting local, regional or national identities by keeping these traditions alive and by preserving them for posterity. This is particularly so where traditional beach wrack management policies promote reusing beach wrack with a social and/or economic benefit for beach goers. Ideally, they also aim at minimizing the negative impacts on the beach environment during collection and removal. However, it could be the case that traditional beach wrack practices can also have a net negative effect on the local environment if it leads to unnecessary removal of beach wrack and sand in the name of cleanliness. The question thus arises of what tradition(s) there are to protect, and which ones should be given priority.

The option of cohabitating with and sustainably using beach wrack will, in most cases, be financially cheaper in the short-term, as it requires less intervention that costs managers money. Assuming that the local beach wrack is not polluted or contains large amounts of nutrients or litter, this option also seems optimal from the perspective of preserving the ecosystem services for the society and environment. While beach managers can choose to pursue such an approach on their own, appropriate advocacy and citizen education activities would probably help to promote such a mindset shift in the eyes of tourists and other beach users as well. The latter two currently tend to lean in the direction of pressuring beach managers to preserve the more recent tradition of large-scale, mechanized removal.

Blue Flag Scheme

Another factor driving some beach wrack managers to remove beach wrack are beach award schemes. The Blue Flag award is likely the most famous such award, seen as a marker of a reputable, high quality beach environment suitable as a beach tourism destination. It is considered a valuable asset for any tourist beach to have and inspires confidence in beach goers that the beach is properly maintained and suitable for vacationing and recreation (McKenna et al. 2011). To receive and maintain the award, the beach management needs



Managing beach wrack in a dynamic cultural milieu
City beach, Puck, Pomerania Province, Poland (Photo: © D. Szponder)

Puck is the seat of the municipality of the same name in the Hel Peninsula on the Baltic coast of northern Poland. The town has 11,000 inhabitants. Our local working group coordinators describe it as a seaside resort as well as a local cultural center. The guarded sandy beach in Puck is 100 meters long and 30 meters wide. It is located just a few minutes' walk from the city centre. The city beach plays a significant role in social integration, serving as a space where age categories or social and economic divisions become secondary. The beach is used as sports and recreation in the summer for leisure and year-round meeting places for residents (pier, beach). The area also has historical and religious value going back a thousand years. A walking pier is used for cultural and social purposes as a meeting place. Various local groups join in cleaning and caring for beaches, including scouts, kindergartens, and elementary schools. This is related to learning about caring for the environment and cyclical events such as Earth Day, combining issues of pro-ecological education and increasing local social activity. The coastal area also has a religious function. A pilgrimage of people to the sea is organized in Puck and is becoming an independent tourist attraction. It is one of the most important events taking place in this city and dates back to the 13th century. In its current form, the pilgrimage was revived in 1981, when fishermen from Kuźnica and the entire Hel Peninsula set out on fishing boats to Puck. Finally, every year, a celebration of Poland's marriage to the sea a reenactment takes place on February 10. The event gathers hundreds of participants commemorating a major regional and national historical event, when General Józef Haller (Polish national hero) symbolically marked Polish "marriage to the sea" in 1920. To this day, the general's monument and the nuptial post stand to commemorate this.

to go through an application process and ensure that the Blue Flag criteria are met and complied with on a regular basis. Among the surveyed beach managers, we commonly observed the idea that removing beach wrack results in cleanliness, which

is essential to preserving a beach's legal status as a Blue Flag beach. The legal situation is, in fact, more complicated, with the rules often being quite ambiguous.



Figure 20 Blue flag flying on a beach (© J. Gorbunova)

For example, Criterion 16 of the Blue Flag Beach Criteria (BFF 2017) is named “Algae vegetation or natural debris should be left on the beach”. It states:

“Algal vegetation is generally accepted as referring to seaweed. Seaweed and other vegetation/natural debris are natural components of both freshwater and marine ecosystems. These ecosystems must be considered as living and natural environments and not only as a recreational asset to be kept tidy. Thus, the management of seaweed or other vegetation/natural

detritus on the shore should be sensitive to both visitor needs and biodiversity ... Vegetation should not be allowed to accumulate to the point where it becomes a hazard. Only if it is absolutely necessary should vegetation be removed ...”

Thus, the scheme is not very specific on the matter of beach wrack. As it does not clearly define it, it leaves a lot of legal leeway for the managers to define what a hazardous point of accumulation is and when biodiversity considerations become more important. This makes its usability as concerns beach wrack limited. Indeed, arguably, the scheme’s main purpose is to provide concrete guidance and to make these decisions more science-based and less arbitrary. Furthermore, beyond the legal aspect, managers would appreciate guidance on what is a recommended or safe amount of beach wrack to keep on the beach. This would help them streamline removal operations. The same goes for determining and informing what amount is or should be widely tolerated by the general public.

4.4 Summary

The public opinion and the way it shapes public perception and tolerance of beach wrack is an essential driver of beach wrack management policy. Beyond age-old valid concerns, such as beach goers’ health and safety, digitalization and internationalization have generally contributed to making the overall perception more negative and reducing tolerance levels. In the long term, effective communication is almost certain to help accelerate the shift in public’s expectations of a quality beach from one cleaned and devoid of organic material towards a beach in its natural or close-to-natural state. This would result in less demand for beach wrack removal and allow managers to introduce further zoning (spatial and temporal) to reduce long-term environmental damage by heavy machinery. From this study, beach managers can be assured that it is not always necessary to completely remove all beach wrack for beach goers to enjoy their beach- and water-related activities and their stay in the tourist resort in general. Gauging the attitude of the local visitors and providing information material on the socioeconomic importance of beach wrack is likely to tilt the balance towards removing less. However, the specific composition of beach wrack and other local socioeconomic and legal factors may sideline the tourist perspective when it comes to the final decision regarding the quantity that is removed.

5 Public Health and Safety

Other important decision-making factors for beach wrack managers are health and safety concerns. The state beach wrack finds itself in is crucial to determining if and how much of it should be removed. Beach wrack can be contaminated with bacteria, unhygienic marine litter, or pollutants such as mercury and other heavy metals, all of which can be risky to human health (see below). Litter within beach wrack can originate from various sources, both from the sea and from the land. It is not unusual to observe that litter previously dropped by beach visitors becomes concealed by the freshly washed up beach wrack. Litter on the beaches commonly includes glass bottles. Consequently, sharp edges that are difficult to see may be mixed in beach wrack or sediment, presenting an injury risk. In addition, toxic gases that occur during decomposition of beach wrack with a high algae content can result in severe health issues.

5.1 Toxic Decomposing Gases

If left untreated on the beach (especially on the foreshore) for a long time, beach wrack is exposed to the sea waves and tidal effects, keeping it wet.

Under such conditions, the disintegration process can lead to beach wrack with a high algae content to become rotten and smelly. Due to the release of ammonium gases and hydrogen sulfide (H₂S) during decomposition (Lastra et al. 2018), such beach wrack has a smell similar to rotten eggs which is undesirable for beach goers. Inhaling ammonia can cause coughing and nose and throat irritation. While ammonia's odour provides adequate early warning, it also might cause olfactory fatigue or adaptation. This reduces one's awareness of prolonged exposure to low ammonia concentrations (NYS DH 2005), potentially increasing health risks. Furthermore, decomposing beach wrack can be unpleasant to walk through due to its gooey texture and the increasingly intense odour as one comes closer to its source.

In extreme cases, decomposing beach wrack that released hydrogen sulphide has even proven deadly (Chrisafis 2019) in France. Such beach wrack has a high green algae content and only washes up in critically high amounts in regions with intensive agriculture and industrial sectors. There, the level of nutrients in the water, especially nitrates found in



Figure 21 Photo of decomposing beach wrack with fine particulate algae matter and slime (© J. Hofmann)



Figure 22 Land sourced litter trapped in drying beach wrack
(© J.Hofmann)

fertilizers, is higher. It should be noted that such phenomena have not yet been observed in the BSR. In the long-term, reducing the amount of nutrients and pollutants flowing into coastal waters, including the Baltic Sea, is needed to address this problem. A concerted effort by Baltic Sea nations, in line with the targets laid out in international frameworks such as the Water Framework Directive (WFD) and the EU Strategy for the Baltic Sea Region (EUSBSR), has gone a long way to improve the water quality situation. However, according to the most recent HELCOM report (2020), eutrophication levels remain unacceptable with a lot more work still to be done. Extreme algae events should alert the local authorities to the shared responsibility that exists for water quality within the region. CONTRA findings have corroborated previous scientific findings that removing beach wrack also contributes to removing harmful excess nutrients from the local ecosystem (CONTRA-report Möller et al. 2021).

5.2 Litter

Litter dropped by visiting tourists or washed up on the beach can carry a health and safety risk. An Australian study reports that, even in beaches considered clean of litter, 21.6% of respondents report having experienced injuries due to beach litter, with cuts and wounds being most common (Campbell et al. 2016). These injuries tend to be relatively minor, with little to no permanent damage. However, they can have a significant detrimental effect on the overall vacation experience, particularly if they involve hospital visits due to an infected wound. Litter can also be problematic for pets, causing injuries or poisoning. This increases the incentive for beach managers to groom their beach, removing litter and – something rarely considered separately



Figure 23 Local volunteer picking litter from beach wrack
(© J.Hofmann)

by beach managers we interviewed – beach wrack. In practice, the amounts of litter washed up within beach wrack on BSR beaches are generally reported as being very low (CONTRA-report Möller et al. 2021). Indeed, on a European level, the Baltic Sea beaches are regarded as some of the cleanest ones (HELCOM 2018a). Most of the litter found on the European beaches is plastic-based. On 18 sites periodically surveyed by CONTRA between 2019 and 2021, the share of plastic material among others was 72%, 9% for glass and 6% for metal (CONTRA-report Möller et al. 2021). Most common findings were cigarette remains, plastic pieces, food containers and candy wrappers, plastic bags, plastic bottle caps, glass fragments, glass bottles and jars, plastic rope (pieces), plastic foam sponge, metal caps and pull tabs. In accordance with earlier similar studies, most of the litter found on the public beaches is related to simple leisure activities and originate from land-based sources (Addamo et al. 2017). The amounts of litter increased proportionately to the level of urbanization of the surrounding area. Even in these cases, most beaches complied with the criterion of up to 20 items of beach litter items for every 100 metres of coastline, which is agreed to represent a good environmental status of beaches litter-wise at an EU level (Van Loon et al. 2020).

5.3 Heavy Metals

Heavy metals, including arsenic, cadmium, chromium, copper, lead, mercury and zinc, are a major environmental problem due to their toxic nature, non-biodegradability and accumulative behaviour. They originate mostly from industrial, agricultural and hydrocarbon-related activities, shipping and sewage. Once in the coastal and marine environments, they accumulate in sediments and soils. Thus, heavy metals concentrations in coastal areas around shipyards, ports and industrial sites often far exceed health and safety limits. This can negatively affect marine biodiversity, hurting the populations of fish and other organisms. Due to their persistence in the aquatic food chain, heavy metal contamination ultimately affects human health (Sharifuzzaman et al. 2016).

The main threats to human health from heavy metals are associated with exposure to arsenic, cadmium, chromium, mercury and lead (Järup 2003). Arsenic and chromium are classified in the US as priority pollutants and human carcinogens, while cadmium and lead are classified as probable human carcinogens (Pekey 2006). Heavy metal poisoning can lead to severe physical and mental health issues (McCluggage 1991). Long-term exposure to heavy metals can cause severe conditions, including kidney and skeletal damage, memory deterioration and loss of cognitive functions (Järup 2003; Young 2005, Rossi 2008).

In general, the content of heavy metals in BSR beach wrack is still to be precisely determined by field research. Nevertheless, CONTRA has started making the first inroads (CONTRA-report Möller et al. 2021). Heavy metals have been detected in beach wrack found along beaches close to the estuaries of major rivers flowing through large, old industrial areas, notably in Poland. The amounts within the sediment found close to beach wrack were generally higher than in other parts of the managed area on Polish beaches sampled by CONTRA. However, the differences were not significant in most cases. The exception were zinc and chromium in Puck Bay. There, chromium and zinc levels were significantly higher in sand collected below beach wrack. In addition, the total concentration of mercury in beach wrack was higher than in the living algae from the area, indicating continuous absorption of this metal by beach wrack from the surf water after the deposition. It is to be noted that the exact content and levels of heavy metals found varies and has to be determined at each case site individually. Thus, it is difficult to provide any concrete indications on

whether it is dangerous to human health in the BSR in the short or the long run.

5.4 Bacteria

Studies from non-BSR countries, including Australia and Great Britain, have shown that beach wrack could be a reservoir of fecal indicator bacteria (FIB), including Enterococci and *Escherichia coli* (Imamura et al. 2011; Whiley et al. 2018). FIB concentrations in beach water are monitored routinely throughout the world in an effort to protect public health. Direct exposure to FIB has been linked to human health risk (Heaney et al. 2009). However, a study conducted in California on multiple beaches has concluded that beach grooming or the removal of beach wrack does not have any impact on reducing or even increases the amount of FIB found in the nearby waters. This would mean that beach grooming is not justified as a microbial pollution remediation strategy (Russell et al. 2014). Further inquiry is required to identify the exact impact of beach grooming on bacterial presence in the BSR.

5.5 Microplastics

A further burden on the environment and thus also a threat to the health of humans as end consumers are microplastics. Every year, 5–14 million tons of plastic flow into oceans globally (Jambeck et al. 2015).

The widespread degradation and breakup of plastic is one of the key factors causing the build up of microplastics in the marine environment (GESAMP 2016) and they have been proven to have caused harm or death to marine fauna, biota and seabirds (Chatterjee and Sharma 2019). The toxins found in microplastics have also found their way to human bodies (Cox et al. 2020). However, the impact they have on public health is still being researched. Data from the Russian Baltic region of Kaliningrad indicates that there are no meaningful differences in the amount of microplastics found on beaches with a high and low anthropogenic load, and that these amounts do not drastically differ from those at other BSR beaches (Esiukova 2016). On the coast of Poland, no clear difference in microplastic contamination between urban beaches and national parks was noted either (Urban-Malinga et al. 2020). However, these areas of the Baltic are rather exposed and the coastline is straight. This is rather different in north-east BSR, which is much more diverse in coastal morphology and thus also has more sheltered and thus litter accumulating beaches. Preliminary results indicate that there, the rather



Figure 24 Decomposing beach wrack (© J. Hofmann)

sheltered urban beaches do contain more microplastic particles in the sediment than natural ones in remote areas (Urban-Malinga et al. 2020).

5.6 Summary

In certain circumstances, there are valid health and safety reasons to remove beach wrack. The first is possible contamination with litter and other pollutants undesired within the beach ecosystem, such as heavy metals (CONTRA-report Möller et al. 2021). Second, in case excessive amounts of nutrients are present in the beach wrack, removing it can help reduce the effects of eutrophication and the overgrowth of micro-algae in coastal waters. Third, removing beach wrack eliminates the problem of decomposing gases, which can be a risk to the health and safety of beach goers. This is indeed a prerequisite for tourism, recreation, and any other human activity at the beach. However, the removal of beach wrack on health and safety grounds should be done on the basis of data gathered through beach monitoring with local marine ecology experts. This helps managers follow best beach wrack management practices.

Overall, health and safety facets incentivize (drive) beach managers to remove beach wrack even if there is no evidence to suggest that it is contaminated or it is dry and not decomposing. There is a pressure for them to act, as they would like to ensure safe and healthy tourism and recreation for their visitors. However, the ensuing systematic removal of beach wrack changes the state of the beach ecosystem and the positive ecosystem services generated by beach wrack. The negative long-term impact of this can be an overall loss of beach value due to reduced biodiversity, loss of sand, and decreased resistance to extreme weather events. This would not only be negative for the local ecosystem, but for tourism and recreation usage as well. There are measures available to at least partially rectify this (e.g. importing sand, creating artificial dunes, water management through dams, reforestation etc.). However, they usually come at a high financial cost and involve manipulating the local environment in a way that could have other undesired side effects. A more detailed look at potential hazards, based on the findings of the environmental assessment undertaken at the CONTRA case study sites, can be found in the CONTRA-report Möller et al. 2021.

6 Coastal Landscape and Conservation

Another aspect of beach management affected by beach wrack is coastal landscape and conservation. The state of the coastal ecosystem at sandy managed beaches is dependent on landscape factors such as a consistent presence of sand, stable sea levels, and predictable meteorological impacts. All of these are affected directly and indirectly by beach wrack management.

6.1 The Challenges of Sand and Beach Erosion

In the BSR, tidal ranges are generally very low. The Baltic Sea is neither large enough to have significant own tides nor does it receive much of North Atlantic tides due to the narrow opening to the North Sea (SMHI 2014). The tidal range in the South Baltic region is exceptionally low, making it nearly tide-free. Thus, the only forces that can act on water-born drifting or beach-cast wrack are wind, wind-driven waves and near-shore currents. In practice, the latter are virtually irrelevant. Compared to tidally influenced beaches, wind-driven changes in wrack distribution happen more slowly, depending on weather conditions, and less predictably. Thus, the location of wrack deposition entirely depends on the wind-controlled water level and varies unpredictably within days (Hammann and Zimmer 2014). Marked short-term changes in

water level, corresponding to both wind direction and speed and accompanied by high variation of beach width, demonstrate their strong influence on small-scale hydrology and topology ashore.

Since the condition and size of a sandy beach is crucial for the tourist attractiveness of the adjacent resort, erosion can potentially threaten the resort's socio-economic functions. While it is possible to replace some of the lost sand, sand nourishments to combat erosion are expensive as sand availability in some Baltic regions is limited. In 2011, an average of 5 million € per year was spent on sand replenishment by federal (30%) and state governments (70%) in Germany alone (Haller et al. 2011). Interestingly, findings from the CONTRA beach wrack manager survey (CONTRA – Management Summary Report 2021) indicate that over 30% of BSR municipalities separate sand on the beach and thus avoid removing it. At the same time, over a quarter of the responding sites reported that they do not separate sand at all. The proportion of sand in dry weight of beach wrack being removed from beaches can be as high as 97% with an average of 58% (CONTRA-report Möller et al. 2021). Unless beach management practices are altered to reduce beach erosion of managed beaches, the costs of mitigating it erosion are likely to increase rapidly as the availability of sand diminishes and the demand



Figure 25 Breaking wave on beach wrack (© J. Hofmann)

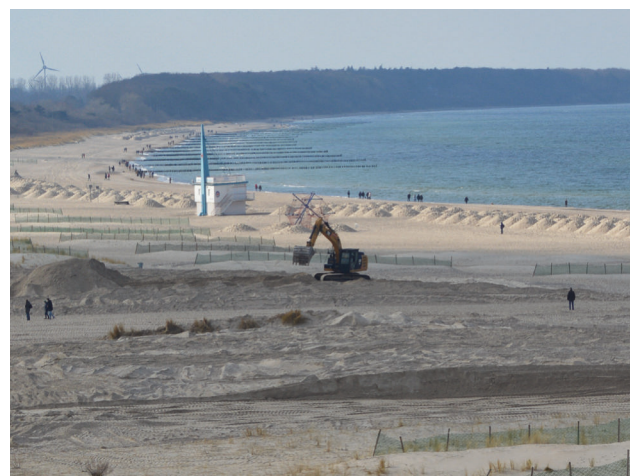
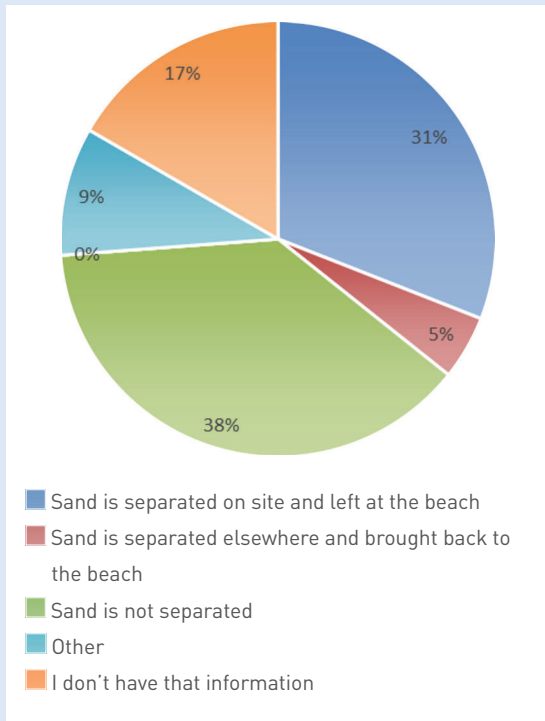


Figure 26 Sand nourishment in progress (© EUCC-D)



Sand separation statistics: How is collected sand dealt with? (Chart: © CONTRA)

CONTRA findings indicate that the majority of municipalities do not separate out sand when collecting beach wrack (CONTRA - Management Summary Report). Out of 42 surveyed municipalities, 13 (31%) state that they attempt to separate sand and leave it on the beach whereas 16 municipalities (38%) do not make an effort to separate sand at all.

increases. Thus, there is a good financial (as well as environmental) reason beach managers should consider sustainable beach wrack treatment options. CONTRA findings indicate that sand erosion is probably the biggest single impact of beach wrack removal.

6.2 Preparation for Climate Change Impacts

Climate change should be considered in future planning of tourist resort management.

Catering for tourism trends and expectations

In the short-term, due to the ongoing coronavirus pandemic, the importance of domestic tourists and intra-BSR vacationing is likely to increase whereas international tourists reliant on air travel are likely to be less important. In the mid- and long- term,



Alleviating sand erosion through beach wrack management policy
Timmendorfer Strand, Island of Poel, Mecklenburg-Vorpommern, Germany

(Photo: © EUCC-D)

CONTRA has interviewed the resort management at the Island of Poel, which has adopted a unique approach for one of its beaches, the Timmendorfer Strand. On the managed part of the beach directed at tourist use, they are experiencing sand loss, partially due to the regular grooming during the high season. They have found a way to partially compensate for this loss. The local company they partner with processes and separates the components of beach wrack. The sand they recover is transported back to the beach and discharged. The beach manager has also contemplated shifting beach wrack from one area of the island's beaches to another. This would indeed temporarily further address the problem. However, as the supply of sand in both areas is limited, a local assessment of the long-term consequences would help determine the long-term feasibility of this strategy. At present, local laws currently err on the side of caution and do not support this as a coastal protection measure. The long term environmental consequences of the direct use of beach wrack on the beach is yet to be investigated.

the attractiveness of the area is likely to increase as the global temperatures increase, making colder destinations in the north of Europe more appealing. Due to lower solar exposure in the BSR compared



Figure 27 Storm damage on beach (© EUCC-D)



Figure 28 Beach wrack as a nutrient source for dune plants at the back of the beach (© EUCC-D)

to the Mediterranean, visitors in the BSR are less likely to get sunburned or develop skin conditions, such as sunstroke or sun cancer, from solar radiation. The lower tidal ranges and corresponding lower currents make the sea safer for recreation, which is important to families with small children. In addition, increasing temperatures will allow the tourist season to start earlier and end later, extending the window of opportunity for profitable tourist activities. However, all of these drivers of tourist activity become irrelevant if the main underlying attraction, the managed sandy beach, loses its primary function due to sand loss (Orams 2003).

Coastal Landscape Preservation

Having beach wrack on the beach helps alleviate the effects of beach erosion. As the beach wrack accumulates on the beach, it covers up and stabilizes the sand below. During extreme weather events, this helps keep the sand in place (CONTRA-report Möller et al. 2021). If the beach wrack accumulates higher up on from the shore, it performs this function even better. This holds true since it is not exposed to continuously high levels of humidity, which slows down the rate of decomposition and allows it to stay firmer. Consequently, beach wrack increases the level of protection against the negative effects of climate change, such as sand erosion and rising sea levels. It is also integral to preserving local biodiversity (Defeo et al. 2008). Furthermore, it can be used as an effective tool in creating manmade dunes, which help to additionally shield the surrounding area from the effects of climate change. Finally, floods and droughts can be effectively managed by wetlands and forests, which absorb and provide water as needed, often found in

the vicinity or behind the beach. These ecosystems often depend on the biodiversity fostered by beach wrack. This is also true on BSR coasts, where many species depend on beach wrack as a source of food, living space and nursery (CONTRA-report Möller et al. 2021).

Carbon Footprint and GHG Emissions

Beach wrack has a potential application as a carbon sequestration mechanism. Several species of algae found in large wrack accumulations can bind high levels of emissions of CO₂ (Coupland et al. 2007), potentially affecting the functioning of land-sea interfaces. For instance, the high carbon-to-nitrogen ratio makes this algae species a very efficient vehicle for sequestering carbon in the oceans (Smetacek and Zingone 2013; Krause-Jensen and Duarte 2016). The term blue carbon was coined to describe the disproportionately large contribution of coastal vegetated ecosystems to global carbon sequestration. The role of blue carbon in climate change mitigation and adaptation has now reached international prominence (Macreadie et al. 2017). While beach wrack has a locally beneficial impact from the perspective of climate adaptation and mitigation, it also has a global downside. A Chinese study estimates that decomposing seagrass is responsible for GHG emissions equivalent to those of “the annual emissions of 0.63–9.19 million Chinese citizens” (Liu et al. 2019). These emissions contribute to global warming. This can be reduced by ensuring beach wrack remains dry during decomposition, for example, by moving it up the beach. Furthermore, it can be removed from the beach and stored in dedicated facilities. However, this causes some transportation emissions and



Figure 29 Beach wrack and coastal vegetation (© EUCC-D)

introduces the problem of nutrient leaching. The share of these emissions is relatively small compared to the emissions from industry, transport and agriculture. More information and findings on CO₂ emissions from beach wrack landings can be found in the CONTRA-report Möller et al. 2021.

6.3 Summary

As one of many components of the coastal ecosystems, beach wrack is integral to preserving the natural balance that characterizes the coastal

landscape as we know it. How it is managed by humans has an impact on whether that balance is maintained or lost. On managed beaches in the BSR, beach wrack management is especially relevant for reducing the effects of beach erosion. It is also important with a view to alleviating the effects of climate change and protecting biodiversity. On a global scale, reducing the greenhouse gas emissions stemming from decomposing beach wrack also merits consideration.

7 Knowledge and Development Systems

Beach wrack at managed tourist beaches is also important from the perspective of knowledge and development. Coastal environments are complex. While every component plays its own role, the components are in many ways interconnected. Distinguishing the management of a single component, such as beach wrack, in such a system, can be counterproductive if it does not take into account the impact of beach wrack for other aspects of the coastal environment, as well as the local economy and society.

7.1 Integrated Coastal Zone Management

The discipline of integrated coastal zone management (ICZM) has gained importance in recent years. According to the European Commission, “[ICZM] covers the full cycle of information collection, planning, decision-making, management and monitoring of implementation. It is important to involve all stakeholders across the different sectors to ensure broad support for the implementation of management strategies.” The aim of ICZM is “the coordinated application of the different policies affecting the coastal zone and related to activities such as nature protection, aquaculture, fisheries, agriculture, industry, offshore wind energy, shipping, tourism, development of infrastructure and mitigation and adaptation to climate change”. The goal is to “contribute to sustainable development of coastal zones by the application of an approach that respects the limits of natural resources and ecosystems [through the so-called ecosystem-based approach.” (EC 2020b).

The vast conflicts of interests in coastal areas are making the importance of long-term planning and knowledge transfer ever more important. One consideration of ICZM is beach wrack management. It is most relevant for the wrack zone, a foreshore area where organic material (e.g kelp, seagrass, shells) and other debris is deposited by wave action and currents. This zone acts as a natural input of marine resources into a terrestrial system, providing food and habitat for a variety of coastal organisms (Strain et al. 2018). Thus, the presence of beach wrack helps researchers generate

knowledge on various hot coastal and marine topics for ICZM purposes. In the BSR, these include water quality and contamination, eutrophication, coastal protection and soft engineering, and rediscovering sustainable resources as part of bioeconomy initiatives.

7.2 Water Quality

Water governance topics, including water quality, have been the subject of action for the Helsinki Commission (HELCOM). It is the inter-governmental organisation responsible for overseeing the protection of the Baltic marine environment. HELCOM has prepared an action plan to improve the state of the Baltic Sea. The action plan’s objectives include addressing eutrophication, biodiversity problems, maritime activities, and hazardous substances. It lays out concrete actions needed to do so (HELCOM 2019).

One indicator for water quality in recreational areas is FIB (Fecal indicator bacteria), as described in section 6.1.4. Beach wrack is seen as a non-fecal source of FIB in sea water (Russell et al. 2014). As with the impact of FIB on human health and safety in the BSR, further inquiry is also required to identify the exact impact of beach grooming on water quality. The existing studies mostly tackle water bodies in the USA and are somewhat inconclusive



Figure 30 Island of Poel, Germany (© J. Hofmann)



Figure 31 Mechanical collection of beach wrack (© J.Hofmann)

on whether beach grooming significantly affects FIB growth (Byappanahalli et al. 2003). It is also not sure how beach wrack as an indicator of water quality ranks in terms of accuracy and practicality. Beach wrack also has several other applications. It helps us understand nutrient balance and nutrient cycles. In beach ecosystems, marine soils "can play a major role in nearshore biogeochemical processes, particularly the decomposition of organic material and mineralization of nutrients. During the summer dry season, beach wrack can be very important to beach ecosystems' ability to accumulate dissolved nutrients needed by primary producers (Dugan et al. 2011). It also helps us understand dune formation and the supply of nutrients to dune stabilizing plants. Finally, it is a useful indicator of biodiversity – monitoring beach wrack availability can help explain changes in endemic avian and crustacean populations at BSR beaches. In addition, the Beach Wrack Macrovegetation Index (BMI) has been developed and tested in the Riga Gulf to measure benthic macrovegetation biodiversity as required by the EU Marine Strategy Framework Directive (Torn et al. 2016). All of these ecological functions and the corresponding ecosystem services are relevant to local communities as well

7.3 Bioeconomy and Marine Resource Management

The European Commission defines the bioeconomy as "using renewable biological resources from land and sea, like crops, forests, fish, animals and micro-organisms to produce food, materials and energy." It expects that "stronger development of the bioeconomy will help the EU accelerate progress towards a circular and low-carbon economy". The Commission also believes that it would "help modernise and strengthen the EU industrial base, creating new value chains" and greening industries "while protecting biodiversity and the environment." (EC 2020c). As part of the EU's political efforts to make European economies more sustainable, multiple documents have laid out targets promoting the blue (marine) economy, circular economy and bioeconomy. They include the EU Strategy for the BSR and the Sustainable Blue Growth Agenda for the BSR (EC 2014a). The former specifies multiple target sectors to promote the Baltic blue economy, various maritime-related innovations and enhanced cooperation in research and fisheries management (EC 2009). Smaller national and local initiatives have also been established with the aim of fostering sustainable, innovative uses of



**Exploring beach wrack treatment options
Municipality of Køge, Sjælland Region,
Denmark** (Photo: © One Trick Pony)

Køge is a medium-sized Danish town 39 kilometers southwest of Copenhagen with a population of around 38.000. Our local CONTRA working group correspondents note that the beach is not considered the town's main attraction, as Denmark has plenty of other more famous ones. While the medieval town centre attracts a moderate amount of tourists, Køge is considered a residential town with beach access rather than a resort town. Thus, the local residents have a lot of say in beach wrack management. The municipality beach has a total length of 1.5km, of which 0.9km is managed. During the summer, the municipality provides daily pictures of the cleaned beaches so that visitors can check these pictures before they decide to visit. A lot of beach wrack washes up on the beaches. Presently, it is moved to the unmanaged part of the beach or pushed back into the water. The municipality would like to adopt a more sophisticated beach wrack management strategy in the future. One of the options would be to utilize beach wrack as a compost material in landfill bio-covers. In addition, they could also transport a part of the collected beach wrack to the biogas plant in nearby Solrod. It is important to note that the beach wrack from Køge would make up only a very small side input of around 0,5% for the biogas plant. The rest comes from agricultural manure, food waste and beach wrack from another beach. It is also essential that the biogas plant is located within a radius of 30 kilometers from the beach because of the transport costs.

local marine resources. Recent growth rates in the BSR blue economy sector are above the EU growth average: offshore wind has increased in the region by 20%, cruise tourism by 11% and marine aquaculture by 13%. The most promising sectors of the BSR maritime economy include short-sea shipping, coastal and cruise tourism, offshore wind, shipbuilding, aquaculture and blue biotechnologies (EC 2014a).

Promoting the bioeconomy in the BSR is also a special focus for the Nordic Council of Ministers. They aim for the Nordic bioeconomy to replace unsustainable and fossil-based resources by upgrading side streams and waste, as well as by creating circular and sustainable local solutions. This goal is part of the grand vision of making BSR the world's most sustainable and integrated macro region (NCM 2020). To this end, BSR economies must become more circular, i.e. reduce new resource inputs and minimize the creation of waste, pollution and carbon emissions. The BSR, especially its eastern countries, have a lot of room for improvement in this regard (Grigoryan and Borodavkina 2017).

The BSR can become a global leader in green growth and sustainable development. It has "well-developed infrastructure, technological and environmental knowledge and a large concentration of biomass". The bioeconomy offers many new economic opportunities, especially for growing primary industries and new development in rural areas. Ongoing projects promoting the BSR bioeconomy tackle topics such as slurry acidification of soils, manure governance, water management, forestry, food webs, and coastal fishing (NCM 2020). A subject that could also feature in BSR bioeconomy discussions is beach wrack. In CONTRA, we have observed it can be used as a circular economy input: biomass fuel in biogas plants (see text box). It has also shown promise in agriculture as a low cost and eco-friendly fertilizer and soil improver (CONTRA-report Chubarenko et al. 2021, Sachpazidou et al. 2020). Precisely defining the extent of the potentials of beach wrack would require a lot more research, as work in this direction is merely starting off. However, it can certainly be a resource in the BSR bioeconomy, as the existing and traditional uses described in the report affirm. Another water governance topic is marine resource management. As mentioned in section 2, a lot of attention is being paid to blue growth, the bioeconomy and the circular economy in the BSR at the macropolitical level. However, according to feedback from our interviewed managers, concrete

policy recommendations for local governance at the municipality level, including beach managers, have so far been scarce. A few good practice examples have been highlighted in this study and other CONTRA outputs.

Beach wrack collected from managed beaches does not have a sufficient economic value to become an independent money-making resource (CONTRA-report Almqvist et al. 2021). The main financial value is the sandy beach itself and the tourist activities that depend on it being attractive, healthy and safe for its visitors. Nevertheless, there is added value to be extracted from beach wrack in waste management, exercising environmentally friendly recycling and usage options, and the removal of nutrients and pollutants (CONTRA-report Chubarenko et al. 2021). However, this remains to be more precisely quantified.

7.4 Summary

Beach wrack has an important role to play in the complex beach environments of the BSR. Among other aspects, it merits consideration in spatial planning, water quality assurance, the bioeconomy and resource management. It also has value for knowledge and education systems. From a research perspective, the presence of beach wrack in the natural environment enables more accurate beach ecology research. The environmental effects it has, e.g. on preserving biodiversity, have an indirect impact on the work of other researchers working with endemic plants and animals. There is also the potential for other uses of beach wrack that may only be discovered through innovation or a new market niche appearing in the future, possibly with government help. Further scientific inquiry

into quantifying these benefits is essential in supporting these decision-making processes. For example, understanding the local conditions, such as the presence of pollutants, is key for the local beach managing authorities to make informed decisions on removing beach wrack from a particular area or during a particular time of year.

One possible difficulty in increasing the attractiveness of beach wrack to science and education lies in introducing a distinction between beach management and beach wrack management. Currently, very few of the surveyed beach managers consider beach wrack management to be a standalone beach management activity. Thus, researchers are often unable to gather accurate data on the costs of beach wrack management, as it is not considered by the managers to be separate from other “grooming” activities that account for the majority of the costs, such as litter collection. Similarly, any data on long-term impacts (risk management related to climate change and extreme weather effects, loss of beach value over time, ecosystem degradation, biodiversity loss ...) is not available either, as our data shows it is simply not a part beach managers’ finances and their short- to mid-term business models and plans.

To summarise, what CONTRA has ascertained is that, from a social and environmental perspective, beach wrack is an acceptable input for the circular economy. However, from the economic view, it does not generate enough value to support standalone private initiatives. Ventures reusing beach wrack sustainably require public subsidies to succeed. Politicians and beach managers need to decide on a case-by-case basis whether these subsidies are justified given the environmental benefits.

8 Socioeconomic Practicalities of Beach Wrack Management

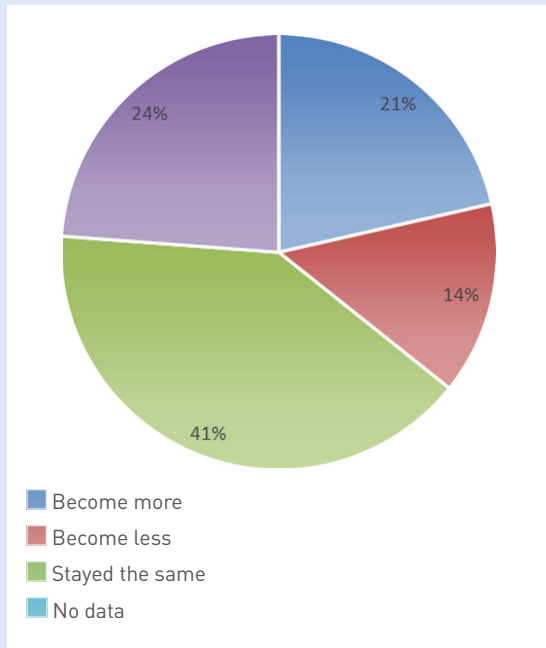
In the following subsections, we look at the socio-economic practicalities and implications of beach wrack management in the BSR, highlighting best practices and lessons to be learned from our case studies and beyond. Our primary source of information for this section is the CONTRA management questionnaire. It was a semi-structured survey of 42 beach managing authorities from six countries across the BSR conducted in 2019. The respondents were mostly officials of various public bodies, such as municipalities and spa management offices. A minority of respondents came from private undertakings. While the data was gathered for six of CONTRA case study sites, only five consented to their data being publicly available.

8.1 Removal and Collection

In this section, we discuss several options for beach managers to optimize removal and collection from a socioeconomic perspective. Firstly, forecasting beach wrack accumulations effectively would help optimize removal and collection operations. However, in the short-term, forecasting is difficult due to unpredictable weather patterns and lack of data; in the long-term, the big underresearched question is the impact of climate change. Despite this lack of predictability, it is becoming increasingly vital that beach managers begin employing sustainable beach wrack treatment with a long-term perspective. Sadly, overall, there are too many variables and insufficient data to make reliable and



Figure 32 Mechanical beach cleaning (© J.Hofmann)



Statistics on beach wrack trends: What has been the trend of beach wrack quantities over the past 10 years? (Chart: © CONTRA)

The majority of municipalities responding to the CONTRA survey stated that they felt beach wrack quantities have remained the same over the past 10 years. Of the 42 respondents, 9 (21%) said that quantities have increased whereas 17 (42%) said they have stayed the same (CONTRA-Management Summary Report).

concrete predictions in the scope of this report. The best managers can do is to rely on a combination of historical data and weather forecasting tools, as they most likely already do.

Beach managers can adopt zoning for the purposes of beach wrack removal. The managers CONTRA interviewed utilize two types of zoning: spatial and temporal. Zoning the beach spatially into managed and unmanaged sections means that the unmanaged sections remain relatively untouched by grooming, with the existing ecosystem mostly unaltered. On managed beaches, there are also various methods of spatial zoning (→ see Figure 30). At the managed sites we surveyed (→ Figure 33), it is more usual for the whole beach to be cleared of material. The unmanaged sections can also be used for temporarily storing the beach wrack from the managed side in small piles. Another possibility that was raised by the interviewed managers

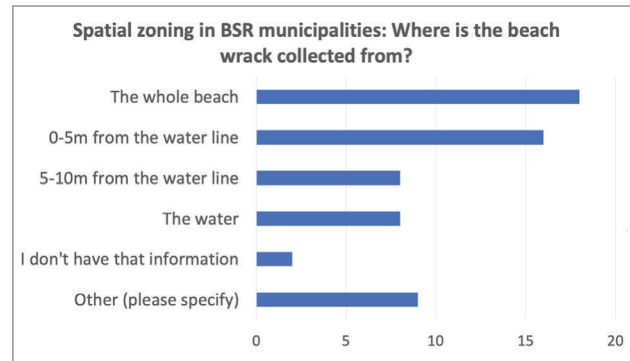


Figure 33 The number of municipalities collecting beach wrack from different sections of the beach, CONTRA management questionnaire (n=42)

was that, in the manner of agricultural crop rotation, the zones could be swapped every season. This would allow one part of the beach to “recover” from grooming while the other is managed to cater to tourists. We note that we do not have any data of this being a current practice. Zoning the beach temporally implies adopting specific time and date intervals for beach grooming. This allows for similar benefits: ensuring the negative impacts of grooming on the ecosystem are limited while also saving costs associated with removal, transport, storage and processing.

Due to clearer cost-saving impacts and practicality, temporal zoning on a seasonal basis is common. In most cases, beach wrack removal is limited to the high tourist season (May–September). In a plurality of the sites studied, short timeframe temporal zoning (→ Figure 34) does not follow a fixed schedule. There, beach wrack is only removed when deemed necessary or on public/stakeholder request.

Small scale spatial zoning on one particular beach is less common and practiced at a minority of sites (ibid). On several German case sites, where a daily beach tax was charged, the frequency of beach cleaning was higher (CONTRA – Management Summary Report 2021).

We detected several particularities among our survey respondents. A pattern was present at beaches that were zoned neither temporally nor spatially: all sites that collect beach wrack daily also clean the whole beach (CONTRA – Management Summary Report 2021). Beach wrack material is also collected in the water prior to landing at nine sites in Sweden, Denmark, Estonia and Germany (ibid). In most BSR countries, this practice is not legally allowed (CONTRA documents – Legal aspects of beach wrack management 2021). Many sites report using a combination of mechanical equipment.

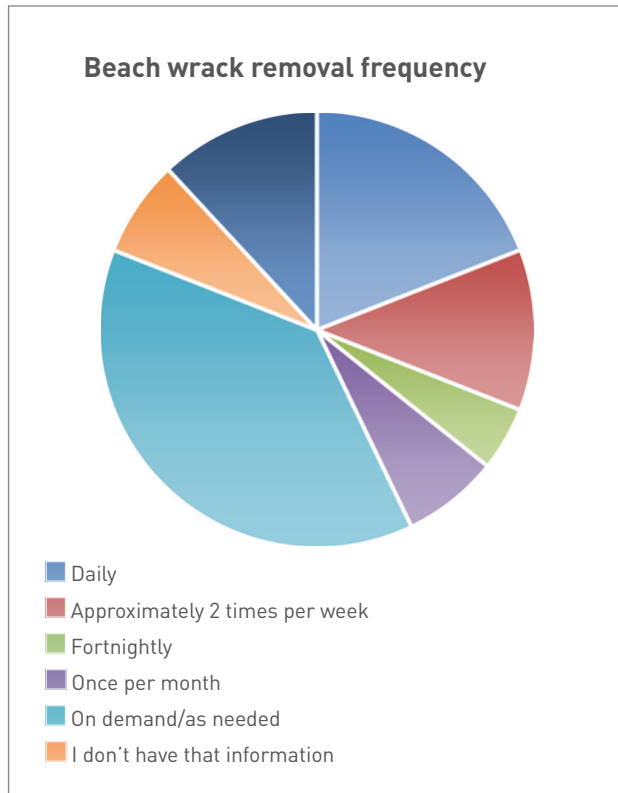


Figure 34 The proportion of municipalities applying different short term temporal zoning to beach wrack removal (CONTRA management questionnaire)

Combining a tractor with a pitchfork and rake is most common.

8.2 Transport, Storage and Processing

CONTRA management survey data indicates that transport, storage and processing merit consideration as cost factors. In this section, we present several best practices and lessons learned from our case studies.

In transport, an important and underestimated consideration is sand weight. Sand is rather heavy (around 1500 kg/m³), even more so when wet (around 1700 kg/m³; Rajput 2021). Managers could allow beach wrack to dry on the beach and/or ensure that sand gets separated from the beach wrack that is finally removed. In doing so, they not only do something good for coastal protection and the integrity of their main tourist attraction, the sandy beach – they also save on the weight that has to be transported and thus, on transport costs.

A further way to save here is to reduce the distance to the storage facility. Managers should always be on the lookout for a closer option. Depending on the quantities of beach wrack they face and an environmental assessment, they may use a modified storage facility not primarily meant for storing beach

wrack. They could also look into constructing their own facilities or cooperating with nearby farmers who could use beach wrack for fertilization on farmland near the beach. This may, however, pose legal problems due to restrictions regarding direct use of beach wrack due to the unknown composition and possible harmful substances.

Another consideration is noise. While smaller quantities can be removed by hand, beach wrack is generally removed using tractors with purpose-made attachments or dedicated vehicles (CONTRA-report Möller et al. 2021), all powered by diesel engines. They release local emissions, smell and noise, which may disrupt the local flora, fauna and human visitors (CONTRA – Ecological aspects 2021). As the removal takes place outside of the main visiting hours to avoid displeasing the tourists, they tend to annoy nearby residents in the early mornings or late evenings. Both are sub-par options from the residents' view. Beach managers could consider reducing the removal frequency and acquiring hybrid vehicles which can operate in electric mode while on and near the beach. Cleaning frequencies could be reduced if they are presently too high and not directly linked to the demand for beach wrack removal. It should also be mentioned that the beach grooming vehicles could have a scare effect on the beach fauna. However, CONTRA data indicates most birds found on managed beaches are there specifically because they rely on leftover high-energy food from the tourists (CONTRA-report Möller et al. 2021). Only a few natural species were found on such beaches.

Finally, there is the issue of sand compacting. Compacted, solid sand that does not regularly cave in under the feet of people walking on the beach is desirable for recreational users (CONTRA-report Möller et al. 2021). However, compacting the sand mechanically with dedicated vehicles or vibrating plates has a negative environmental impact. It can compromise the long-term integrity of the beach and damage the foot of the dunes. A similar impact, known scientifically as footfall load compaction, can be ascribed to beach users walking on the beach.

With regard to storage, beach wrack can normally be left on the beaches to dry temporarily if an unmanaged section is available and then taken to a dedicated storage facility. While the former is often preferable environmentally and saves on costs, the latter facilitates processing and reuse later on. It is to be noted that German laws are strict on preventing the leaching of heavy metals and toxic content,



Beach wrack challenges on a touristy island
Juliusruh-Breege, Rügen Island, Germany (Photo: © Timo Garrels)

Julisruh-Breege is a small resort town on the east coast of Rügen, Germany’s largest island. The data gathered by our working group indicates that the island generates 7.2 million overnights every year (CONTRA – Case studies Report 2021). Juliusruh beach is the island’s longest. Of around 8.5 km of the entire beach, 1.5 km is managed. Around 30 thousand cubic meters of beach wrack landings are estimated every year. During the season (May – September), the beach management employs several machines to remove beach wrack. The beach cleaning is done in the evening and early morning to avoid disturbing tourists. The machines are not purpose made for beach wrack and thus not always effective, particularly when there is fine, wet, particulate algae on the beach. The same machines are also used for road and tree maintenance.

sometimes also found in beach wrack, into rain waters (Umwelt Bundesamt 2020). On our case study in Poel, sewage water monitoring at the dedicated beach wrack storage facility has been implemented at the cost of the municipality. National and European grants may also be available for the construction or upgrading of storage facilities with this health and safety risk in mind. This was the case for several municipalities in Mecklenburg-West Pomerania in Germany (Landtag MV 2017). When it comes to processing, an important and simple first step would be to have a worthwhile strategy and not just throw reusable beach wrack away. To start, the collection stage itself should be reoriented to facilitate effective processing. This would mean acting quickly when fresh material lands on the beach and separating it into distinct, reusable components, which can then be effectively processed by dedicated plants. It would make each processing option more viable. To this end, the managers would have to adopt the mindset that they are collecting and dealing with a resource and not a waste product. Indeed, some forward-thinking municipalities are already achieving progress here. Eckernförde beach managers in Germany

have created dunes, fences, municipal gardening fixtures, and added information signs (Schnepper 2017). This has increased the community awareness of the issue. In general, stakeholder cooperation is of great value here. This includes collaborating with other municipalities, companies, experts, NGOs, and lawmakers. It may be possible to create shared storage facilities with multiple managed beach sites and facilitate a recycling company to develop a sustainable business model this way. It would also make negotiations with the company easier.

8.3 Reuse and Recycling Options

Multiple tried-and-tested possibilities for the sustainable use of beach wrack from managed beaches exist (see CONTRA-report Chubarenko et al. 2021). Many social and economic benefits are created in doing so: it contributes to the circular economy, creates jobs and generates revenue for local businesses beyond those catering strictly to tourists. Thereby, it diversifies the local economy, and can offset costs and even generate extra income for beach managers. From the environmental perspective, it alleviates the negative impact of

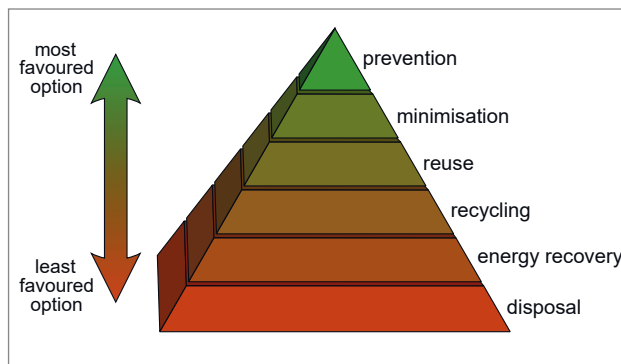


Figure 35 Waste management hierarchy (© Drstuey)

removing beach wrack along with the desired removal of litter and nutrients. Potentially generating energy from biogas from a renewable source improves the area's energy sustainability.

A classic use option for beach wrack is fertilizer and soil improvement. Studies have pointed to it being the best use of macroalgae-based beach wrack (Filipkowska et al. 2008). However, this does come with some considerations. For example, it is dependent on the beach wrack's state of decay and its composition, with many potentially problematic components. It also usually involves an undesirable removal of sand from the beach. Similar conditions apply to reusing beach wrack as a soil improver. Other options include using beach wrack that includes seagrass as a mattress and cushion filler, making souvenirs, fodder and bedding for livestock, roofing and insulation in construction, cosmetics, biogas, pharmaceuticals and medicine, as well as coastal and urban landscaping. A more comprehensive overview of these possibilities can be found in CONTRA-report Chubarenko et al. 2021. A comparison of the environmental impacts of the various use options, demonstrated within the CONTRA project, can be found in CONTRA-report Almqvist et al. 2021.

There are very few examples of private-public partnerships concerning beach wrack within the BSR that can be looked upon as best practices. Of the 40 municipalities that answered our questionnaire, only two indicated that they have some kind of cooperation in place (CONTRA – Management Summary Report 2021). The first was Solrod in Denmark, where the beach managers deliver their beach wrack to a local biogas plant, which processes it into energy. The second was the aforementioned Island of Poel and a local fertilizer company, Hanseatische Umwelt CAM GmbH (HU), who worked on beach wrack business development



Figure 36 Beach wrack processing at compost plant, Sandhagen, Germany (© J.Hofmann)

during the CONTRA project.

The company has built relations with local municipalities including Poel, and is now processing beach wrack from four beach spots (in four municipalities) within a radius of approx. 50 km. The company processes beach wrack into various soil improvement products. This is a promising outcome, as it offers a way to process beach wrack into environmentally sustainable outputs while ensuring the collection and processing takes place with a high cost efficiency. It also can be done at a scale which allows beach wrack to be resold for additional income.

The fact that this business model remains unique highlights several problems. Namely, the irregularities of the beach wrack deposits, the complexity and costs of transport and storage, and the lack of customer awareness of the final products all make this business model difficult to replicate. Ideally, if beach wrack were an economically sustainable resource, the beach managers could charge the company for it. However, the limited financial value that can be extracted currently results in zero interest from the buyers. Nonetheless, it is a proof of concept that could work elsewhere under favourable conditions. Unique business model canvases and an economic comparison for each use option, demonstrated within the CONTRA project, can be found in CONTRA-report Almqvist et al. (2021).

In the end, the optimal solution for the individual beach has to be identified by its manager, who has to scan the local area for possibilities and see what works best for the quantities and composition of beach wrack they face. It is beyond the scope of this report to provide a comprehensive overview for the entire BSR. However, we do wish to motivate managers to do their research and consider the various available options to achieve the most favourable financial, social and ecological outcomes.

8.4 Operating within the Legal Framework

What managers are allowed to do is subject to various local, regional, national and European legal acts, depending on the political entity they are operating in. An overview of the responsible national authorities and relevant legal acts has been created as a separate CONTRA output – legal aspect document Armknecht et al. 2021. Our Estonian partners have also created a detailed overview of the Estonian legal framework (Consultare OÜ 2021). A comprehensive overview of all relevant legal acts for each BSR managed beach is beyond the scope of this report. However, we can list and discuss some similarities, overlaps and regular complaints expressed by the beach managers we surveyed.

Beach management is regulated in several legislative acts of the European Union. One of these acts is the Directive 2006/7/EC on the quality of bathing water. It contains no specific clauses regarding beach wrack. The closest it comes to addressing it is in Article 9 (Other parameters), stating:

- 1 *When the bathing water profile indicates a tendency for proliferation of macro-algae and/or marine phytoplankton, investigations shall be undertaken to determine their acceptability and health risks and adequate management measures shall be taken, including information to the public.*
- 2 *Bathing waters shall be inspected visually for pollution such as tarry residues, glass, plastic, rubber or any other waste. When such pollution is found, adequate management measures shall be taken, including, if necessary, information to the public."*

From a legal standpoint, it is questionable as to how a directive on water quality can be taken as a legal basis for managing beach wrack, which is specifically the material that lands on the beach, outside of the bathing water. Nevertheless, it is quoted by multiple surveyed managers for having an impact on their beach wrack management decisions.

The legal framework of the EU-wide Natura 2000 nature protection areas network is generally designed to forbid or discourage human intervention in the area. Human activities to be avoided range from settlement and construction to military, industrial and tourism use. In general, such protected areas and tourist beaches located within them should strive to leave nature in place as much as possible rather than cater to the expectations of (some) groups of tourists. Here is an excerpt from the Guidelines for the establishment of the Natura 2000 network in the marine environment (EC, 2007): *"More than 200 million tourists per year visit the*

European coasts (most of them the Mediterranean Sea), leading to huge and often uncontrolled development of recreational activities, mainly in coastal areas and shallow water, in particular during summer. Over-exploitation by tourists of natural, well-conserved sites constitutes a real problem in some coastal plains by their action of trampling, noise, lighting, etc., or more specific issues, such as disturbing turtle nests due to off-road 4x4 vehicles In the marine environment, the main problems are the destruction of intertidal and shallow subtidal bottoms, and the presence of divers at unsustainable levels, causing erosion of sensitive ecosystems, such as coral reefs, or the modification of fish behaviour due to feeding practices."

We were unable to find specific provisions on beach wrack in the Natura 2000 guidelines. This implies that there is no obligation in the criteria to automatically and periodically remove beach wrack from tourist beaches within Natura 2000 protected areas. Instead, the decision-making process would ideally be more holistic and take into account that all tourist (and other human) activities in such protected areas should be dissuaded in the first place. Indeed, the latest Habitats Directive, commonly alluded to by the Natura 2000 network, specifically designates the drift line as a habitat to be protected, implying that no beach management should take place there. Furthermore, CONTRA researchers informally express concerns about a lack of appropriate monitoring, infrequent reviews of the guidelines, and sanctioning.

Beach managers have expressed a desire for the legal frameworks to evolve in a sense to allow them the flexibility to adopt the best suitable reuse option. Even though beach wrack can in some cases have environmentally harmful components, these can and should be sorted out during the collection phase. This should not be a blank legal obligation to dispose of all beach wrack as a waste product. Direct use of beach wrack for coastal protection, public-private cooperation for removal, processing as well as further research should be legally allowed and, when possible, stimulated.

To summarise, for many aspects of beach wrack management, there is no single, uniform management guideline or legal practice across the BSR or even the European Union. Beach managers and responsible municipalities often struggle to find legal and affordable ways to manage beach wrack while meeting the (perceived) public demand for clean beaches. Often specifically due to legal hindrances, the potential for sustainable beach wrack



Figure 37 Beach wrack mound on Åhus beach, Sweden (© J.Almqvist)

management and reuse is far from being fully realised (Chubarenko 2020).

8.5 Overall Cost Factors and Cost Estimates

Information on quantities of beach wrack removed is sparse. There are very few records, and the surveyed beach managers either did not have this data or were unwilling to disclose it. Over the past 10 years, there have only been a few national studies which help give us a general picture. In 2012, one such study looked at 15 beaches along the 720 km long German Baltic Sea coastline. It determined that an average of 269 kg of beach wrack plus sand per meter of beach was being removed annually. German spa authorities removed up to 1000 kg of beach wrack per meter beach line every year (Mossbauer et al. 2012). While the available figures give us an idea of the scope of the problem, the measurements are sporadic and there is still a need for a lot more of localized data, especially outside Germany.

The situation is almost identical with removal costs and other cost factors. Some national studies, such as the work done in the project POSIMA in Germany, estimated that municipalities are paying average of 38 € per meter of beach line (Mossbauer et al. 2012). However, the costs vary widely depending on factors such as the collection methods used, investment in machinery and personnel costs. The most recent available figures from CONTRA indicate that the cost for beach wrack removal for municipalities in the BSR ranges between 20 €–40 € per meter of beach line. The costs are lowest in Russia and the

Baltic states whereas they are highest in Denmark and Sweden. The cost factors most commonly cited as most expensive at our survey sites were personnel costs, machinery hire and processing off beach (→ Figure 36).

8.6 Practical Socioeconomic Considerations

The following canvases display the summary of the socioeconomic data from our five case study sites in Germany, Denmark, Sweden, and Poland. The information is based on the management interviews we had in 2019 and categorized according to the driver-pressure-state-impact-response (DPSIR) framework. This method was selected to present the sequence of beach wrack management using an established analytical framework.

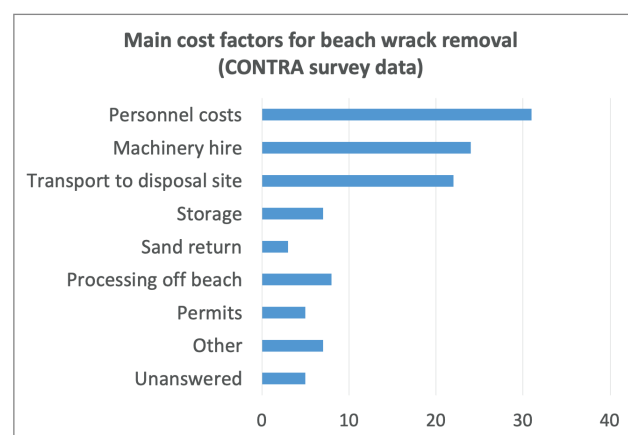


Figure 36 The cost factors that most commonly affect municipalities

Figure 37 Socioeconomic canvas for Køge, Denmark (Søndre Strand and Nordstranden)

	Driving forces of beach wrack management	Stakeholder interests pressuring the managers	Resulting state	The impacts of the management policies	The suggested responses by CONTRA
Tourism and recreation	Residents who live close to the beach, or use the beach Tourism revenue: 20 mio DKK/ 2.7 mio € directly attributed to beach; 150k yearly overnights in municipality; 60% business tourism, 40% vacation Cultural attractions (medieval town), recreational possibilities	Local residents have a lot to say about beach management. Tourist expectations of cleanliness and good bathing water quality are relatively low. Domestic DK tourists more tolerant. Most people don't think beach wrack is dirty. Public knowledge of beach wrack is relatively high. 1057 full time local jobs depend on tourism (3.7% of all jobs)	Beach widened in 2015 Near daily manual and mechanical removal during the tourist season (1 May–30 September); whole beach width cleaned. Beach wrack often simply pushed back into water upon landing or moved to other parts of beach;	Catering to local residents over tourists; other beaches in Copenhagen region are more famous/ have better facilities. Low beach wrack management costs Public satisfaction with beach cleaning routine very high; over 80%	More cooperation between municipalities (build on working group activities) More knowledge on the impact of beach cleaning and climate change on local environment and ex. biodiversity. Dissemination of knowledge.
Health & Well Being	Litter dropped by tourists on beaches (high season) Decomposing beach wrack	Residents and tourists dislike smell when large amounts accumulate in swash zone.	Bathing water quality measured from 1 May–1 September Very low litter content in beach wrack itself.	No litter bins on beaches, only nearby Social responsibility for litter collection high Non-polluted beach wrack being removed	Explore possibility of decoupling beach cleaning for litter and that for beach wrack. More development of beach management technologies which will limit the amount of degradation of the beach wrack on the beach or in shallow waters.
Culture & Heritage	Strong DK traditional uses of beach wrack; roofing, agriculture, coastal protection	Some interest to keep old practices going remains, but most recycling industries have died off – subsidies needed	Cultural ties with beach wrack not being explored nor exploited.	Cultural identity and skills associated with beach wrack use have been lost.	Further development of feasible recycling options – increase private interest. Re-visit traditional uses. Explore subsidies. Local EIA of treatment would be beneficial.
Environment	Strong local awareness of sustainability and ecosystem importance of beach wrack.	Political interest in coastal protection (beach erosion, storm surges, climate change). Most local residents want it removed, but others think it is a natural part of the beach	Some spatial and temporal zoning in place, incl. beach cleaning limited to just 0.9 km out a total 1.5 km of beach and summer season collection	Impact (+/-) of operations on eco-system services unknown. Whole beach is mechanically cleaned daily during summer – ecological impact unknown	Environmental Protection Law ambiguous – clarification needed. More research on the environment consequences of intensive cleaning routine and release of material back in water.

Figure 38 Socioeconomic canvas for Åhus near Kristianstad, Sweden (Täppetstranden)

	Driving forces of beach wrack management	Stakeholder interests pressuring the managers	Resulting state	The impacts of the management policies	The suggested responses by CONTRA
Tourism and recreation	Beach tourism worth ≈ €17 mio; Local jobs dependency. Täppetstranden is the only official tourist beach in area. Strong recreational focus, festivals and large sporting events	Tourist expect cleanliness and good bathing water quality. Reliant employers/employees want strong business	Near daily manual and mechanical removal by local municipality during the season (April–September). Area up to 10 m from the waterline is cleaned. Dedicated beach cleaning machine.	Mixed structure residents vs domestic/foreign tourists; majority is domestic. Public satisfaction with beach cleaning routine very high; 86% Y, 14% somewhat, 0% N	Further spatial zoning could be explored, i.e. small amounts of beach wrack left.
Health & Well Being	Past complaints of smell and aesthetics made by public.	Health and safety concerns (blue algae) Several reports made about illness in animals & people due to toxic blue algae associated with bathing Authorities aware of possible heavy metal contamination of beach wrack	Municipality monitors bacteria levels, takes samples at 19 spots Bathing water monitored 3–4 times per season, about every 30 days. Very low litter content in beach wrack	Blue algae risks are kept under control (warning signs/ bathing closures put in place if safety cannot be guaranteed)	Public information campaign about blue algae and its difference to beach wrack may be of value. Research /expert exchange on contamination levels.
Culture & Heritage	Strong history of beach wrack being used as a resource; agricultural uses, tobacco, fertilizer, e.g. for coastal forest	Authority reports that beach wrack amounts have been increasing over the past 10 years	Non-profit organisations clean the whole beach once per year	Large (3 week) sporting event dominates in summer (July) – but beach cleaning operations unaffected.	Further development of feasible recycling options – increase private interest. Clarity on the legal framework and effective communication of new policy (still in draft) about beach wrack and marine biomass needed
Environment	Above average local awareness of sustainability and ecosystem importance of beach wrack	Coastal protection – wind blown beach erosion is problematic. (Coastal pine forest established in 1800s)	Policy of spatial and temporal zoning: 2.5 km of a total 27.5 km cleaned. Sand is separated and left on the beach.	The immediate effects of beach grooming on beach erosion are ameliorated.	More research on the environmental impact of beach wrack management required. Broader stakeholder exchange. Increase awareness of beach wrack as a resource at local authority level.

Figure 39 Socioeconomic canvas for Puck, Poland (Puck city beach)

	Driving forces of beach wrack management	Stakeholder interests pressuring the managers	Resulting state	The impacts of the management policies	The suggested responses by CONTRA
Tourism and recreation	Beach tourism accounts for 10–15% of tourist revenue.	Nearby tri-city area (Gdansk, Gdynia, Sopot) with over 1 million people. High domestic tourism. Tourist expectations of cleanliness, water quality also includes a beach free of beach wrack; conflation of beach litter and beach wrack Reliant employers/ employees want strong business	On demand manual and mechanical removal during the season (1 May–30 September) 0–5 m from the waterline is cleared by hand or mechanical means, then temporally stored	Public satisfaction with beach cleaning routine ok; 53 % Y, 41 % somewhat, 6 % N	Choices are political and to be made by elected officials/ appointed experts
Health & Well Being	Periodically there are reports of the smell and aesthetics of beach wrack. Touristic litter on beach problematic over summer period. Occasional blooms of cyanobacteria	Health and safety concerns of public (cyanobacteria). 5 warnings in 2018. The public has a poor understanding of the difference between beach wrack and litter; largely negative perception of beach wrack as a result	Monthly bathing water quality monitoring during the season by the state inspectorate	Blue algae risks are kept under control; black flag is displayed when	More distinction made between beach litter (plazowy odpad) and kidzina (beach wrack) on the management level.
Culture & Heritage	Cultural events, yearly celebrations, historic centre, religious tourism all boost cultural tourism	Authority reports that beach wrack amounts have remained the same over the past 10 years (Historical beach wrack treatment information lacking due to lost documentation post-WW2)	While cultural events and celebrations continue, knowledge of beach wrack and its management seems to have been largely lost due to tumultuous 20th century history	Poor understanding of definition and role of beach wrack by tourists not improved after visiting	Distinction and positioning of beach wrack should be made clearer and promote distinction from waste material..
Environment	Natura 2000 protected area and Program for the Protection of the Puck Bay and the Hel Peninsula. In principle, there is an argument against removal.	Coastal protection (beach erosion, storm surges, climate change – rising sea levels)	Natura 2000 legal framework causes complex governance and difficulties in decision making. Policy of spatial & temporal zoning, litter separated but not sand; some beach wrack left on beach to decompose	Exploitation of sand from the Bay of Puck, used to stabilize the Hel Peninsula and restore campsite beaches.	Improved cooperation between local and regional governments, and other stakeholders.

Figure 40 Socioeconomic canvas for The Island of Poel, Germany (Timmendorfer Strand and Schwarzer Busch)

	Driving forces of beach wrack management	Stakeholder interests pressuring the managers	Resulting state	The impacts of the management policies	The suggested responses by CONTRA
Tourism and recreation	Tourism revenue 770k € generated annually from "Kurtaxe" (spa tax) alone	Tourist expectations of cleanliness and good bathing water quality (Kurtaxe – payment asked of beach users, clean beach provided in return) Reliant employers/ employees want strong business. Local wages dependent on beach tourism: resort administration, tourist accommodations, souvenir shops, retail, lifeguards	Near daily mechanical removal during the season (1 May–30 September) Public satisfaction relatively high (70 % Y, 0 % N)	Tourists desiring beach wrack free beaches continue to be drawn; cleaning made more responsive since social media boom	Political decision to be made by the beach manager on what tourists to cater to More info required on residents' views
Health & Well Being	Blue algae (vibrios) problematic during warm summers	Health and safety concerns (blue algae, vibrios). Sporadic public complaints about smell (moved online). Local authority feel driven to avoid negative press/ reviews.	Bathing water quality is regularly checked.	Algae problem is kept under control	Policy optimal under available data
Culture & Heritage	Cultural identity with beach wrack use for animal feed, mattress filling. Beach wrack amounts have increased over past 10 years	No data on local community lobbying for a particular use is available	Partnership with Hanseatische Umwelt, local private fertilizer company, removing the beach wrack at municipality's expense	Beach wrack is processed into sustainable outputs, such as fertilizer; municipality chooses to do so despite paying for it	Policy optimal under available data
Environment	Natura 2000 protected area; argument against removal/interference in general	Coastal protection (beach erosion, storm surges, climate change – rising sea levels)	Policy of spatial and temporal zoning, rotating the managed and unmanaged sections of beach on yearly basis	Impact to the beach ecosystem is reduced	Policy optimal under available data

Figure 41 Socioeconomic canvas for Juliusruh-Breege, Island of Rügen, Germany (Juliusruh beach)

	Driving forces of beach wrack management	Stakeholder interests pressuring the managers	Resulting state	The impacts of the management policies	The suggested re-sponses by CONTRA
Tourism and recreation	<p>Tourism revenue important for local economy</p> <p>7.2 million yearly overnights on island of Rügen, Juliusruh is longest beach</p> <p>Spa tax exists but revenue unknown. On other such surveyed German beaches, removal frequency generally higher</p>	<p>Tourist expectations of cleanliness and good bathing water quality</p> <p>Reliant employers /employees want strong and consistent business.</p>	<p>Mechanical removal on demand during season (May–September) with machines otherwise used for road and tree maintenance, limiting effectiveness.</p> <p>Most beach wrack is stored on unmanaged beach section (8.5 km total/1.5 km managed). Around 30 thousand m³ of beach wrack lands per year. Beach is cleaned in evening and early morning to avoid disturbing tourists.</p> <p>Public satisfaction with beach cleaning mixed (45% Y, 45% N)</p>	<p>Policy caters to users who prefer more removal. Storing beach wrack on unmanaged section saves costs and is better for beach integrity. No rotation reported between managed and unmanaged sections.</p>	<p>Better surveying of possible reuse options, cooperation options with private companies, other municipalities for storage</p> <p>Adopting a cost effective, scalable and legally approvable method for reusing beach wrack, such as biochar</p>
Health & Well Being	<p>Health and safety concerns</p> <p>Beach wrack is composed of a specific particulate matter, which turns very gooey and with a strong smell while decomposing</p>	<p>Tourists find gooey texture and intense smells particularly displeasing.</p> <p>Surveyed residents see it as belonging to the beach</p>	<p>Once beach wrack lands, it is generally an unusually displeasing factor on the beach due to texture and smell. The texture also makes it difficult to collect – algae collection and transport is biggest cost factor.</p> <p>Municipality evaluates removal need on case by case basis.</p>	<p>Direct health and safety concerns are taken care of.</p> <p>Decomposition on unmanaged section of beach in dry state</p>	<p>Improving collection methods to make removal more efficient and enable economically feasible processing and reuse</p>
Culture & Heritage	<p>Cultural causes – local identity and heritage</p>	<p>Residents see beach wrack as a natural component of the beach and the beach as a distinctive marker of local and regional identity</p>	<p>Beach wrack is removed with few other considerations in mind beyond catering to tourists and other beach users who prefer removal. Sand is separated on site and left on beach</p>	<p>Beach wrack is no longer perceived as a natural part of the beach, pristine beaches with no beach wrack and compacted sand become part of identity</p>	<p>Improve interaction with local stakeholders, experts and NGOs who push for a more balanced, holistic and inclusive view of beach wrack management</p>
Environment	<p>Secondary force: Coastal protection concerns</p> <p>No specific issue known/reported</p>	<p>Existential social, environmental and economic concerns about preserving the beach in its current state</p>	<p>Policy of spatial and temporal zoning in place. No dunes. Extra cleanings at season start/ before special events.</p>	<p>The short-term negative effects of beach grooming on the environment are ameliorated.</p>	<p>Policies generally optimal under available data; more environmental research required</p>

The canvases could be considered a useful illustration of the different dynamics that go into play at the various case study sites. There are some parallels common to all, including the importance of tourism revenue and a general concern for tourist health and safety. However, depending on the beach, even the level of prioritization of tourists can vary, as seen in Køge. The specific concerns vary depending on the composition and amounts of beach wrack. Several sites can be lauded for a more proactive approach as regards the provision of information to tourists, stakeholder involvement, monitoring of health and safety criteria and the use of beach wrack after collection.

8.7 Summary

The average findings for each parameter of the DPSIR framework according to the relevant sections are summarised in the canvas below. With the importance of beach wrack as described in mind, it is concerning that, in some interviewed municipalities, the conversation about sustainable beach wrack treatment has not even started. This is coming at a time when the prolongation of the main tourist seasons is resulting in an increased (perceived) pressure to groom the beaches longer (Mossbauer et al. 2012). On one hand, some progressive local authorities are trying hard to independently find legal, affordable, and socially, environmentally and economically sustainable solutions. On the other, they are restricted by having limited resources, a lack of knowledge and a lack of cooperation from the authorities and various stakeholders. Discussions with beach managers have helped us identify a specific set of recurring local challenges hindering sustainable beach wrack management (see below):

To conclude, cleaning the managed beaches of beach wrack is only the beginning of an extensive recycling process chain. And it is here where municipalities would ideally employ solution-based approaches aiming for realistic, cost effective and locally sustainable use options. The political goal of making the economy more sustainable, the social pressure to diversify BSR coastal economies beyond tourism, and a growing consumer demand for natural raw materials makes the search for meaningful recycling paths of beach wrack ever more topical.

Challenges needing to be addressed on a local level

- Costs and cost factors of beach wrack management, specifically for municipalities in 'beach wrack hotspot' areas
- A confusing legal framework - particularly with respect to non-market reuse options on the beach for, e.g. coastal protection, and the waste classification
- A lack of local knowledge about the environmental pros and cons of beach wrack removal incl. contamination levels
- Time pressure relating to 1) public demand for its removal and 2) storage/degradation of beach wrack material for recycling.
- A lack of means to cooperate, both with neighbouring municipalities and with private recycling companies/industry
- Lack of knowledge about trends and climate change impacts on beach wrack quantities

Figure 42 Socio-economic considerations of BSR beach wrack management – overview of findings for all case study sites

	Driving forces of beach wrack management	Stakeholder interests pressuring the managers	Resulting state	The impacts of the management policies	The suggested responses by CONTRA
Tourism and recreation	Primary force: Tourism revenue	Tourist expectations of cleanliness and good bathing water quality Reliant employers wanting to keep their businesses going; employees want to stay employed	Removal during high tourist season regular/on demand for big beach wrack deposits Public satisfaction with beach cleaning relatively good	The existing visitor structure is reinforced (people who like their beaches beach wrack free tend to return, whereas visitors preferring more natural beaches choose non-managed destinations)	Better public opinion monitoring to measure general pool of people interested in given beach destination rather than depending on social media that amplifies negative voices N.B. Choices are political and to be made by elected officials/appointed experts
Health & Well Being	Secondary force: Health and safety concerns, including cyanobacteria, blue algae, vitrios	Tourist expectations of high health, safety and well-being standards during their stay	Bathing water quality is generally monitored during season (except RU). Sites with specific concerns monitor them and take action if needed	Health and safety risks are kept under control (warning signs/bathing closures put in place if safety cannot be guaranteed)	Implement monitoring where there is none; communicate the risks clearly, also to foreign tourists; appoint inspection responsibilities clearly between state/regional/local level
Culture & Heritage	Secondary force: Cultural causes – local identity and heritage to be preserved through long-running beach wrack management policies	Above average local/national awareness of sustainability and ecosystem importance of beach wrack in DK, SE; average in DE; below average in RU, PL	Per survey: Residents see beach wrack as mostly negative, visitors are more neutral	Cultural causes are rarely officially considered by beach wrack managers, who rarely distinguish between beach management and beach wrack management	More inclusive, holistic approach to be undertaken, discrete beach management and beach wrack policies and data collection and analysis, wider consideration of social and economic factors
Environment	Secondary force: Coastal protection concerns (beach erosion, storm surges, climate change – rising sea levels)	Existential social, environmental and economic concerns about preserving the beach in its current state	Most have policy of spatial and temporal zoning. Some coastal protection (dunes) considered or put in place	The short-term negative effects of beach grooming on the environment, such as beach erosion, are ameliorated.	Policies generally optimal under available data; some beaches still do not zone; more environmental research required; each case site is unique

9 Conclusion

This report has analysed the socioeconomic value, role and impact of beach wrack in Baltic Sea tourist resorts. It has pointed out that the main driver of economic activity is the sandy beaches that attract tourists. Managing beach wrack is an essential obligation for beach managers trying to accommodate their tourists, keeping them happy, healthy and safe as they generate income for a plethora of local businesses. CONTRA has reaffirmed that the pure economic value of beach wrack does not compare favourably to that of the sandy beach and the tourist activities dependent on it. Nevertheless, beach wrack management also affects the society and the environment, giving beach wrack social and environmental value. Some of these beach wrack management practices corroborate the positive aspects of removing it, others do the opposite. Due to the complexity and intermixing of these factors, it is difficult to provide broad recommendations on general best practices for all beach

(wrack) managers. Doing so confidently would require complex and expensive calculations specifically tailored to each beach site. These would in the end only underpin what are, in essence, political decisions as to what – the society, the environment, or the economy – is to be favoured. In the end, what we hope to have achieved is to have pointed out the various factors at play. This includes the various aspects that merit consideration in beach wrack management decision making as well as the multiple traditional and modern ways to recycle the collected beach wrack. The aim is that the beach managers who have read this become better aware of the dynamics of beach ecosystems, that beach wrack management is a specific issue and that it comes with many challenges and opportunities. Perhaps some managers can readjust their beach management policies after taking into account one or more of these aspects and possibilities that they may not have considered previously.

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