



# The role of culture for coastal disaster risk reduction measures: Empirical evidence from northern and southern Europe

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## Abstract

Recent and historic high-impact events have demonstrated significant flood risks to many coastal areas in Europe and across the globe. Understanding the behavior of humans in relation to risk management poses grand challenges for both natural and social sciences and humanities. The study analyzes the cultural aspects of coastal risk management and illustrates path-dependencies of concrete disaster risk reduction measures in relation to local contexts in European coastal regions in Northern and South Western Europe. It adopts a comparative approach by targeting risk perception and risk management related to coastal floods and erosion, induced by storms and sea level rise, in two contrasting coastal areas: German coastal state Schleswig–Holstein at the Baltic Sea (especially the communities Eckernförde and Timmendorfer Strand) and the Portuguese barrier island system of Ria Formosa (especially the community of Faro Beach). Both regions are very low lying with only a few meters above sea level and exposed to similar hazards such as erosion and floods induced by coastal storms, and while they are both attractive touristic destinations, they are culturally, socio-economically and politically very different. The geographical and the socio-cultural contexts of the case study regions are assessed first using an explorative approach, followed by an analysis of the relevance of cultural aspects for the implementation of disaster risk reduction measures. The study addresses both first responders (city authorities, citizens) and scholars. It is found that the choice of risk reduction measures hinges on the values underlying people's perspectives about the desired outcomes of specific measures and that the role of identity and meaning making are still undervalued in decision making processes. It concludes that subjective capacities formed by cultural identities, knowledge, trust coupled with a variety of factors of socio-economic and political texture are important to understand local decision making processes. The authors found that lively 'culture of risk memory', 'trust in scientific information and community' as well as decision making of coastal authorities coupled with inclusiveness and participation of communities in formulating and implementing disaster risk reduction measures are prerequisites for successful collaboration and in turn execution of disaster risk reduction measures.

**Keywords:** Culture; Values; Knowledge; Risk perception; Disaster risk reduction measures; Coastal zones; Baltic Sea; Atlantic

## 1. Introduction

During the last decades alone Europe suffered from hundreds of damaging floods causing thousands of deaths, the

displacement of millions of people and billions in insured and uninsured economic losses (EEA, 2007). Arguably, floods have always been a part of Europe: ancient records starting more than 2000 years ago, tell the tragic stories of tens of thousands of Europeans drowned throughout the centuries. For example, in 1287 during the St. Lucias flood about 50,000 people died in one of the largest storm floods in recorded history (TEEB, 2019). The flood destroyed a sea wall in the northwestern Netherlands. The floodwaters

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transformed a shallow freshwater lake into the salty Zuiderzee and created direct sea access to what was then the village of Amsterdam. The St. Lucias flood was therefore directly responsible for the development of one of the world's leading port cities. Meteorologically, the St. Lucias flood was similar to the North Sea flood of 1953, when high tide and extreme low pressure systems created a huge storm surge in which more than 2000 people died in the Netherlands, England, Belgium and Germany. In response to the 1953 flood disaster, a massive protection system against floods and storm surges (so-called Deltawerke) was erected in the Netherlands protecting the hinterland but also changing the coastline to the North Sea.

Given the significant decrease in casualties, such numbers of fatalities seem to belong to Europe's past, climatic changes will lead to an increase in storm surges and the likelihood of more frequent extreme events including low probability, high impact events (Vousdoukas et al., 2018). Hence, it cannot be excluded that such extreme storm floods will occur again in the near future, mainly if no adaptation measures are taken (Vousdoukas et al., 2018). Preparation in form of coastal disaster risk reduction measures including prevention (e.g. dike protection including eco-system based solutions), mitigation (e.g. restrictions of constructions in flood-prone regions), preparedness (e.g. early warning systems) as well as managed realignments, is therefore crucial for European cities and their hinterlands. However, despite the implementation of such measures, a central problem remains that our methods for coping with hazards are to a large extent based on the idea that people can use technology to control nature. Ongoing losses from extreme events, and the fact that nations cannot seem to reduce them, seem to result from short-sighted and narrow conceptions of the human relationship to the coastal environment. In the light of these observations it seems to be appropriate to analyze how cultural prevent (or can help) in taken the best possible management decisions.

There is no uniform approach to culture. Typically, we link culture to something that is shared and learned of a specific group of people. In order to synthesize thoughts about culture, in 1953 Kroeber and Kluckhohn published a collection of over 150 different explanations. After systematizing and analyzing them, they proposed a comprehensive definition which states that culture focuses on patterns, explicit and implicit of and for behavior along with ideas and especially their attached values and that these patterns are influenced and created through symbolic behavior, action and other aspects formed by a given biophysical environment/place (Kroeber and Kluckholm, 1952). Since this attempt to synthesis the definitions of culture, the body of literature that deals with values in relation to nature and risks has grown (e.g. Brien and Wolf, 2010; Persson et al., 2015). Especially, the connections that people have with places they identify with and the way these places shape and alter them and vice versa are well documented (e.g. Lemée et al., 2019a,b; Clarke et al., 2018; Fresque-Baxter and Armitage, 2012; Devine-Wright, 2013). Other research has provided evidence that social vulnerability at a specific place, commonly defined as exposure, sensitivity, and resilience

(IPCC, 2014) is to a large degree a product of the cultural norms which frame governance structures and political ideologies, economic conditions, social networks and modes of communication (e.g., Adger et al., 2001; Brien and Wolf, 2010; Hesed and Paolisso, 2015).

These scholarly debates lead to the following research question for this study: 1) Which cultural values and experiences shaped the specific attitudes towards coastal disaster risk reduction measures in the two case studies? 2) How did these specific values emerge and how do they enable or hamper engagement in disaster risk reduction measures? Based on a mixed methods approach (Section 2) we then describe the underlying conditions and contextual background of the two case studies areas (Section 3), and focus on the particular coastal protection needs and actions. We discuss the influence of culture on the execution of the specific disaster risk reduction measures in the case studies and summarize our findings (Section 4).

## 2. Methods

To address the research questions, mentioned in the previous section, a mixed methods approach was utilized. This included interviews, participatory observations and a literature and policy review relevant to disaster risk reduction measures and climate change adaptation. Field work (semi-structured narrative interviews) and participatory observations took place between 2012 and 2018 in the frame of three European research projects: Regional Adaptation Strategies for the German Baltic Sea Coast (RADOST), Resilience Increasing Strategies for Coasts (RISK-KIT), and Innovation in Climate Service Provision (INNOVA). The individual length of each interview varied between one and three hours. The questions encouraged lengthy, rather than short answers. Given that conversations mainly took place in a comfortable environment, the informants were given scope to elaborate and bring up topics they considered relevant. Interviews were guided by a protocol of written questions grouped into three categories. 1) Memory of historical storm events and how such events have shaped levels of precaution and preparedness of what should be done, how and by whom. 2) Local/regional culture for dealing with risks (values, beliefs and knowledge), and the political and economic context, and 3) perception of and attitude towards disaster risk reduction measures. With the agreement of the interviewees, conversations were recorded and later transcribed.

For the analysis of the text and in order to answer our overarching research question regarding the role of culture in defining and implementing disaster risk reduction measures several sub-related research questions were defined. These are: 1) Do different socio-cultural configurations lead to different perceptions of risks, do they create different values and in turn different disaster risk reduction measures? 2) Does a specific mode of governance lead to different perceptions of risks and in turn disaster risk reduction measures? To answer these questions a first set of codes was developed to enable organization and clustering of the various

statements of the interviewees. These were: perceptions of risks, values, mode of governance, and activities (disaster risk reduction measures). In a next step those interview statements which fell in the above categories were assigned to the different codes using qualitative data software MAXQDA. In a subsequent step all text falling under each pile of codes were compared about how they were similar or different considering the socio-political and economic and ecological context of each case study area as described by the interviewees. Finally, the opinions expressed in the interview texts were contextualized through further literature research based on other studies in the case study areas (Costas et al., 2015; Freitas and Dias, 2013) to justify the interpretation of data which lead to the described explanation of perceptions, risk reduction measures taken or not taken and views regarding climate change in the discussion and conclusion. The information obtained from the stakeholder interviews were also compared with policy structures and economic data relevant to coastal management. This enabled us to identify specific local and regional disaster risk (reduction) cultures, which function as enablers and/or barriers for the management of disaster risk reduction measures.

In the German Baltic Sea communities, nine interviews were conducted in November 2012 in Timmendorfer Strand, and eight interviews between April and May 2018 in Eckernförde. In the Portuguese site, Ria Formosa, twelve interviews were carried out between February and March 2013. The duration per interviews differed between one and three hours and took place at various locations (e.g. in offices, homes, at the beach or in a boat). The interviewees were chosen among different groups of stakeholders that included coastal managers and local political decisionmakers from different institutions and that are developing different works, knowledgeable local residents, chairpersons representing local citizen groups, chroniclers. The following classifications were made: SH 1 Coastal manager; SH 2 Land use planner; SH 3 Civil protection agency; SH 4 Academic working in coastal zone management; SH 5 Consultant previously engaged in managing the coastal environment; SH 6 Local residents previously affected by hazards; SH 7 Chairperson of local citizen group.

### 3. Case studies

#### 3.1. Baltic Sea

##### 3.1.1. Bio-physical place

The Baltic Sea is considered the largest brackish sea worldwide bordering Germany, Denmark, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, and Poland. The water level of the Baltic Sea is subject to constant fluctuations, the highlights of which are storm surges. Low and/or high pressure systems in the region are frequently able to generate strong winds, which can push water through the sound and belts into the Baltic Sea, raising the sea level in the entire basin. Sometimes, these storms can reach hurricane strength (Hupfer, 2010).

##### 3.1.2. History of coastal floods in the Baltic Sea

The first records of extreme storm surges on the Baltic Sea date back to medieval times. From the 17th century onwards more detailed records on high water levels can be found (see Table A1). An exceptional storm surge arose in the southern Baltic Sea in the 19th century. On November 13, 1872 an extreme storm surge in combination with large waves caused high-scale devastations on the Danish, German, and Swedish Baltic Sea coast. In total, about 300 people died and more than 15,000 people lost their homes (Feuchter et al., 2013). To date the Baltic storm flood of 1872 is the most known extreme event in the Baltic Sea. The highest measured peak water level was about 3.3 m above sea level.

##### 3.1.3. Coastal communities: Eckernförde and Timmendorfer Strand

The southern Baltic Sea coast of Germany is known as a bathing paradise. In the summer months, thousands of holidaymakers populate the towns and villages. The coastline is 2247 km long, mostly sandy beaches marked by bays, fjords, and cliff lines shaped by peninsulas and islands. The two settlements (Eckernförde and Timmendorf Beach) are situated at two bays in the state of Schleswig–Holstein (Fig. 1), which comprises 644 km of the entire German Baltic sea coastline. They lie approximately 100 km apart. With only a few meters above sea level and their long sandy beaches, they are both very socio-economically vulnerable to coastal storms surges, erosion, and degradation of water quality (Fig. 1). Both places are typical for the Baltic coastline in terms of the described biophysical features but also regarding the socio-cultural perspectives of long hanseatic traditions of ship craft, trading, and fishing. In the 19th century, when bathing tourism became fashionable, tourism gradually developed into a key driver of today's economy.

Eckernförde has been a well-known spa and holiday destination for over 700 years. In the small community of about 22,000 inhabitants, coastal tourism is the main economic driver. The inner city is surrounded by the Baltic Sea to the east and to the west. Eckernförde has a natural harbor from which a long sandy beach opens to the south (Fig. A1). During the extreme storm flood of 13 November 1872, Eckernförde suffered the most severe damage of all the coastal towns of the Baltic Sea due to its low elevation and its location on the bay which opens far to the sea at its northeastern part. The entire city was flooded for days, 78 houses were destroyed, 138 houses were damaged, and 112 families became homeless (Kiecksee, 1973).

Timmendorfer Strand developed around 1880 from a few individual settlements mainly run by local fishermen on the beach into a pure seaside resort. With around 1.5 million overnight stays per year (approximately 10% of the overall touristic traffic at the entire German Baltic Sea Coast), Timmendorfer Strand is considered one of the most fashionable Baltic seaside resorts with a wide range of tourist attractions. The village comprises several kilometers of long fine sandy coastline (Fig. A2) and has only about 4000 inhabitants, many of which are second home owners.

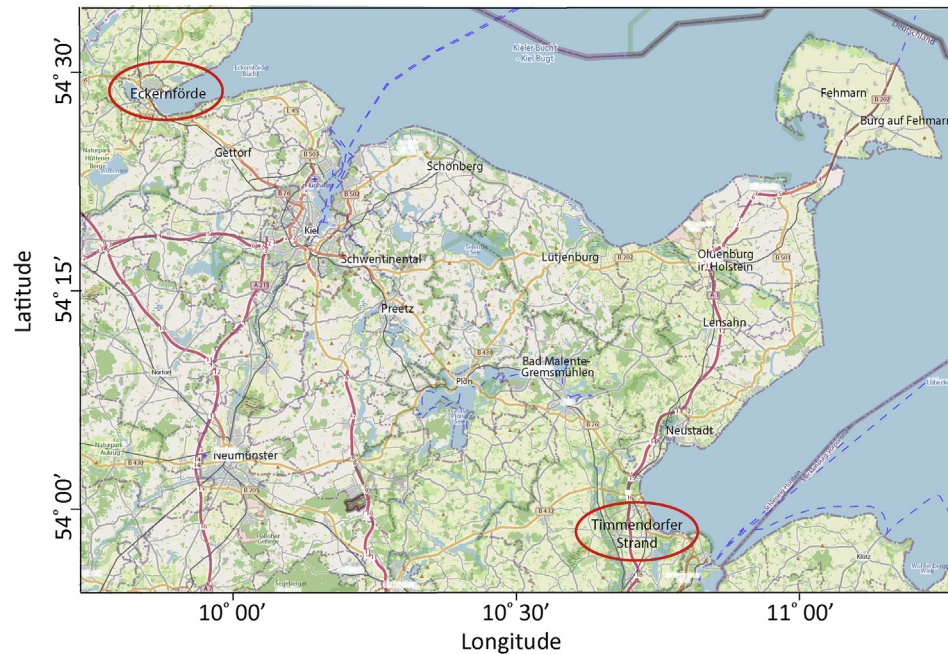


Fig. 1. Location of Baltic Sea cases: Eckernförde and Timmendorfer Strand (Created by using map data © 2020 Google/INEGI).

### 3.1.4. Collective memory and risk awareness

In Germany, the collective memory and awareness of coastal storm floods and storm surges (as illustrated in Table A1) is generally very high. For instance, today the 1872 storm surge is still used as an example for design criteria for coastal protection (Hofstede and Probst, 2002). There might be several explanations for such a strong memory culture: Firstly, in addition to the Baltic Sea, Germany has a coastline fronting the North Sea and thus extreme events are not unusual. It can be assumed that these circumstances have led to an increase in risk perceptions leading to a memory and risk management culture. Secondly, in Germany memory marks can be found frequently along the entire German Baltic coastline (see Fig. 2) which is quite rare compared to other Baltic Sea nations e.g. Sweden (Fredriksson et al., 2018). Thirdly, with the foundation of the German Empire in 1871 coastal protection became part of the state duties. The 1872 storm accelerated the turning point in coastal flood management. From now onwards the Prussian authority's developed and implemented public defense programs along the German Baltic Sea coast which still build the foundation of today's coastal protections system (Hofstede, 2008).

**3.1.4.1. Eckernförde.** In Eckernförde, the authorities are aware that 1) “the predicted rise in sea levels is already having a strong impact. Coastal erosion is increasing and the coasts seem to be moving more, at least than they used to. At present, storms come from different directions at different times of the year than was the case in the past. We therefore need to rethink our coastal development system.” (Interview 1, SH 1) Another coastal manager states: 2) “Once again I take the example of coastal demolition here at Eckernförde Bay, that the municipality is not helped by building a stage to protect the low-lying

holiday home area, but may have to consider whether to move the holiday home area to other areas in the long term, return higher areas and the lower part of nature as a buffer zone. ... but most communities don't like to hear that perhaps they need to be forced a little to their luck.” (Interview 2, SH 1) This is not only the case in Eckernförde alone but rather a problem for the entire region: 3) “In the vicinity of Eckernförde I could certainly name 15 or 20 municipalities that have any climate adaptation problems, but have no one at all who could really deal with them and who are dependent on external help.” (Interview 3, SH 1).

In alliance with these statements from the managerial and planning levels also local residents in Eckernförde seem to be likewise aware of the changes of their seacoast (especially erosion, inundation and eutrophication). For instance, a local resident said: 4) “Coastal protection measures need to be improved. I heart that our groynes shall be stabilized. Also it has been discussed amongst local authorities to raise the promenade because of the increased danger of flooding.... I would welcome such initiatives.” (Interview 4, SH 7). Another resident claimed that 5) “I am aware that in the last years we had more often severe winter storms which resulted in flooding and destruction of the beach ... and so I really think we really need to take action to protect ourselves”. (Interview 5, SH6).

**3.1.4.2. Timmendorfer Strand.** After the devastating consequences of the storm surge of 1872 in Timmendorfer Strand, the area which later developed into the community of Timmendorfer Strand was provided with subsidies for reconstruction which laid the foundation to the development of a renowned spa resort. Soon the devastating consequences of the storm surge were forgotten and so was protection. After the Second World War, the tourist infrastructure developed rapidly at the



Fig. 2. Storm flood mark in Eckernförde, left picture with the mark of 1872, right with the entire house (Photographed by Michael Packschies, November 2019).

expense of agriculture and fishing. The image of the community has therefore for a long time been based primarily on the tourist image and the material standard that can be achieved as a result. In spite of the existing intangible appreciation of nature and landscape, the Baltic Sea and the beach are primarily regarded as material capital: 6) *“The Baltic Sea with its beaches and coasts is the life factor, this is our capital”* (Interview 6, SH 7). Due to the lack of sustainable alternatives, the municipality will continue to focus on the high-priced spa and bathing tourism in the future. Against this background, the investments made in coastal protection and the choice of an expensive adaptation strategy are to be understood primarily as a protection strategy for primary economic values and future development opportunities. Tourism and the associated, more consumer-oriented values (including profit orientation, entrepreneurial thinking, defense of the high standard of living) can therefore be understood as the primary driver of coastal protection measures: 7) *“A municipality that is actually spoiled by nature, but (...) a prime example of a municipality that is more money-oriented.”* (Interview 7, SH 1). 8) *“There are many newcomers who want to make the big bucks, the fast bucks.”* (Interview 8, SH 6) The attitude of the inhabitants of Timmendorfer Strand towards nature and landscape is rather utilitarian. The high leisure value of the landscape and its contribution to the general quality of life are emphasized. Nature is regarded as resilient and within limits tolerant of human intervention; only a few interviewees describe nature or the Baltic Sea as sensitive. The Baltic Sea is described as untamed, it is emphasized that one must also prepare oneself for possible threats: 9) *“The Baltic Sea feeds us, the Baltic Sea brings tourists, but it also threatens us and we have to adjust to the threat.”* (Interview 9, SH 7). Here again the classification of the Baltic Sea as an economic good becomes clear.

Ultimately, community members have a conflicting attitude towards the sea, but this also reflects the fundamental acceptance of coastal protection measures: 10) *“On the one hand, one always wants to have a beautiful view of the Baltic Sea from all points of the town, on the other hand one wants to be protected from the dangers.”* (Interview 10, SH 3).

### 3.1.5. Governance at the German Baltic Coast

In Germany disaster risk reduction management is organized by different public authorities, who are responsible at different levels. For example, when a disaster occurs which affects various regions, such as floods usually do, the federal ministries of the interior will coordinate activities. Vice versa, lower level authorities take action when the event impacts their region of influence. Lower level authorities along the German Baltic Coast take climate change issues but also climate science very seriously. Based on information from a survey exploring the construction of perceptions, mayors along the Baltic Sea Coast were inclined to perceive the threat of climate change as more imminent than climate scientists themselves and, in turn, advocated for preventive strategies such as mitigation and adaptation measures (Bray and Martinez, 2011). Given the fact that sea-level rise for the German shores of the Baltic Sea is predicted to be rather conservative compared with the global outlook, this might come as a surprise to policymakers and scientists alike. When looking at the socio-cultural context in which these perceptions are embedded, it might seem less surprising. Historically, scientists and academic bodies generally enjoy a high societal regard and a good reputation in Germany (Martinez et al., 2018). The fact that regional political decisionmakers in Germany seem to easily accept the fact that climate change puts their communities at risk and, in turn, demand prompt

action—despite the fact that climate predictions for the region in which they live are rather conservative—points to significant trust in climate science and in coastal authorities.

### 3.1.6. Risk perception and disaster risk reduction management

For coastal communities, whose primary economic driver stems from the touristic sector, dealing with coastal risks has different aspects. The beaches have to be maintained for tourists, which can go against/threaten coastal protection efforts. Therefore, the coastal managers strive to prevent or minimize possible adverse effects. While rising temperature provide opportunities to increase the number of tourists and extend the touristic season, risks can arise when the quality of the beach will be impaired. For example, these impairments can arise from erosion of the beaches but also from changing amounts of beach wrack washed on shore. (Mossbauer et al., 2012). Local residents seem to be well aware that while they are at risk they need to install protection efforts which do not hamper the touristic activities by making the beaches less attractive for tourists e.g. by putting hard structures such as concrete walls on the shoreline or by allowing beach wrack to rot at the beaches. The following quotes illustrate such understanding: 11) *“In the local news we can hear that our authorities are thinking about risk reduction measures..... although there’s not much action yet, but they want to get there.”* (Interview 11, SH6). Another local residents are convinced that 12) *“Without appropriate measures, the risk posed by environmental factors to life, health and economy of the people in our region will be very high”* (Interview 12, SH7).

Eckernförde is a very low lying coastal community with no hard coastal defense measures in place (Fig. A1). Plans are under discussion on how to improve coastal defense measure. A practical solution tested recently by the community is the usage of seagrass for building a dike. Due to its geographical location at the edge of a bay, Eckernförde received fast amounts of seagrass during eastern winds: 13) *“When we have a longer east wind situation quite large quantities of seagrass tend to pile up in the bathing season (Fig. A3), which would normally not be a problem, but the bathing guests prefer the beach sandy and free of sea grass, so we have to clear it.”* (Interview 13, SH 7).

Formerly, seagrass was a major source of income for coastal communities. It was exported to many destinations in Europe where it was used to produce matrices, packaging material or insulation for houses. In the 1960s, after almost a century of intensive usage, the utilization of seagrass was gradually displaced from the markets due to cheaper and more convenient alternative materials in buildings. Reviving this tradition could not only save costs in dealing with the unwanted amounts of seagrass washed to the shores that influences the texture of the sandy beaches and possibly contributes to less tourists visiting the communities but also be built into defenses, as it also increases the coastal stability and reduces erosion processes. Triggered by influences from inside Eckernförde’s community (local authority, entrepreneurs, and

scientists) at present the utilization of seagrass for coastal protection measures (Fig. A4) has become accepted by local residents (Stelljes et al., 2019).

In Timmendorf Beach inhabitants live less than 3 m above mean sea level. In the past, the state authority has repeatedly highlighted this as critical for coastal dwellers, since existing defense structures would not withstand prospected extreme storm surges. The authority put forward technical solutions to the municipality for raising the dike. In the tourism-dependent community, however, there was fierce local resistance against this solution which was considered visually intrusive. Protests were motivated above all by the fear of reducing the tourist value of the coastal promenade. At the initiative of the state government and in close cooperation with the mayor in office from 2001 to 2012, the municipality of Timmendorfer Strand applied as a pilot for the implementation of participatory methods in coastal protection (Fig. 3). The pilot project resulted in a widely praised coastal protection solution that combines protection against storm surges based on a sea level rise of 0.5 m per century with local ideas. A scenically integrated protective wall now offers protection against storm surges of up to 2.75 m above sea level and at the same time maintains the lake view that is indispensable for tourism (Hofstede, 2008).

## 3.2. Ria Formosa

### 3.2.1. Biophysical place

The total coastline of Continental Portugal measures 1187 km. The mainland is exposed to storm erosion and flooding as well as to continuous shoreline retreat due to sediment starvation. Sea-level rise will aggravate these hazards leading to an increase on extreme water levels. Consequently, the main impacts for the Portuguese coastal zone include the flooding (and eventually permanent inundation) of dry- and wetland in low-lying areas as well as accelerated erosion (Ferreira et al., 2008). Ria Formosa is located at the southern coast of Portugal (Algarve, Fig. 4), which is affected by the



Fig. 3. The scenically integrated protective wall in Timmendorfer Strand (Photographed by Nico Stelljes in June 2015).

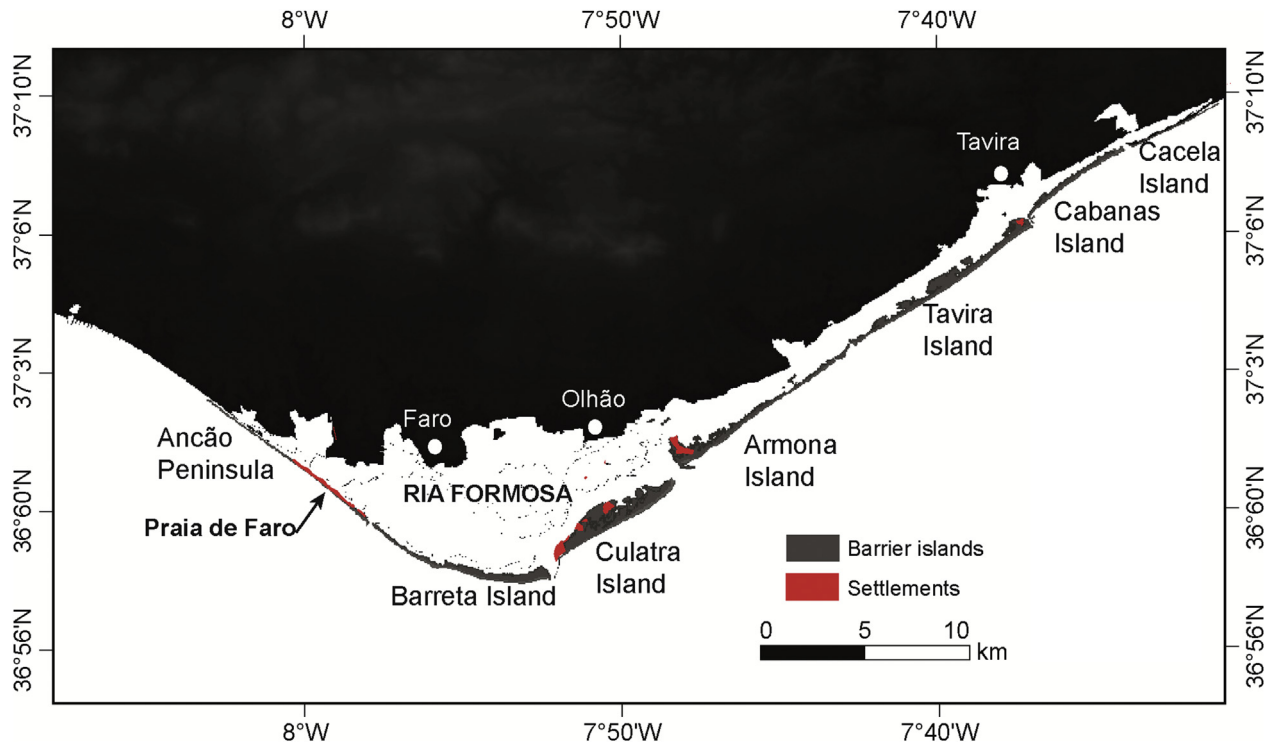


Fig. 4. Location of Ria Formosa case study.

passage of low-pressure centers following southwest-northeast storm tracks. The dominant storms approach from the west-southwest, although E-SE ('Levante') storms are also important. As a consequence of its cusped shape, half of the Ria Formosa is exposed to the westerly-southwesterly storms while the other half is exposed to the easterlies or 'Levante'. Today, Ria Formosa is a wildlife reservoir (protected area) with magnificent sand dunes and islands open to the Atlantic Ocean. The area is continuously shaped by the action of waves and tides and currently consists of five islands and two peninsulas, separated by six tidal inlets. The total length of the barrier islands is about 55 km. The islands' width varies between tens of meters to more than 1.3 km with dunes sometimes reaching 9-m height. The origin of the barrier-lagoon system is attributed to the sea-level rise rate attenuation circa 6400 years before present and to the inherited morphology of the inner continental shelf, which favored barrier island anchoring. The original sand supply for the longshore drift is attributed to updrift cliff retreat (circa 2 m per year) (Pilkey et al., 1989).

Storms constitute the major source of threat to the area as they may provoke substantial beach erosion and overwash. Beach erosion will in this case depend on the magnitude of the storm impacting the beach and on the state of the beach (i.e. in terms of sediment budget). In this regard, storm groups impacting the beach will likely have more severe consequences on beach erosion (Vousdoukas et al., 2011).

### 3.2.2. History of coastal floods in Ria Formosa

A summary of the major storm events affecting the region with prominent consequences over coastal infrastructures is

presented in Table A2. Especially, the storm of 1941 had a remarkable impact on the barrier islands system. Due to a very low number of people living there and the very low development of infrastructure on the island the small-scale references to the storm are related to the effects on the small fishing communities of the barrier island. Conversely, there is plenty of information regarding the effect of this storm at regional level, as it was acknowledged in the entire country. Sources report about destroyed fisherman's shacks and boats in Culatra Island, inundation of houses in Fuzeta, destruction of entire villages like in Ancão Peninsula and Cabo de Santa Maria, a tuna fishing camp, on Barreta Island (Muir-Wood, 2011; Freitas and Dias, 2013). The economy of the Algarve region was strongly affected. In additional regions where newly shaped. For example, at Ancão Peninsula a new inlet appeared, important fishing infrastructure was destroyed (Muir Wood, 2011; Garnier et al., 2018).

In the 1960ths, 1970ths and 1980ths further storms impacted the region strongly affecting tuna fishing infrastructure, seawalls, natural protection systems such as sand barriers and houses (see Fig. A5). However, damaged facilities were often rebuilt exactly at the same spots.

A new series of storm events occurred in the winter of 1998, resulting in the destruction of some houses (Teixeira, 2009). A series of storms had major impacts on the barrier islands during the winter of 2009/2010. The highly destructive storms partially or completely destroyed 44 of the 71 private buildings in Fuzeta (Armona Island) and opened a new inlet (see Figs. A6 and A7). The last storm with a high level of impact was Emma storm at the end of February and beginning of March 2018. The Emma storm was responsible for

overwash at Faro Beach, damage of walls and promenades, and threatened houses placed at the front line (Ferreira et al., 2019).

Following decades of multiple storm events, the decision making institution decided to demolish ‘beach houses’ used as summer houses in some of the most endangered areas, such as in Fuzeta (after the 2010 storm) and Faro beaches (in 2015).

### 3.2.3. Coastal communities of Ria Formosa

The Ria Formosa coastal lagoon is a protected wildlife reservoir at the southern coast of Portugal. It is made of a lagoon which is protected by five barrier islands and two peninsulas, separated by six tidal inlets. The population at Ria Formosa dates back to the 19th century when fishermen unequally started to scatter across the various islands in the lagoon (Freitas, 2011). For instance, in the Culatra and Armona Islands first evidence of populations date back to the last quarter of the end of the 19th century. The settlements were linked to fishing activities, namely to the collection of sardines, and the residents originally came from neighboring communities. At present, the populations have access to public water either transported to the island in tanks (Armona) or via the water network (Culatra). By contrast, with the very recent occupation in Ancão Peninsula, the occupation of Culatra and Armona Islands have longer stories (Fig. 6), most likely because the population is located in islands with lower vulnerabilities, as they are facing south and east. They were placed at the two borders of the same inlet (Lavajo or Armona Inlet), which at that time had more than 3.5 km width and was the most important entrance to the lagoon system (and access to the sea). Thus those populations were located at places from which boats could easily and safely get into the sea for fishing. Faro Beach did not have easy access to the sea since the inlet was always small and shifted position. In addition, it is worthy pointing out that the population of Culatra grew within the sheltered margin of the island, and would only be affected by the rise of the mean sea or water level in the lagoon and within the barrier island and not directly by waves.

The population of Culatra shows important fluctuations over time with considerable decreases in 1940 and 1970

(Fig. 5). In 1980, the census recorded a significant increase from 212 (in 1970) to 692 inhabitants. After 1980 the population remained relatively stable until 2011, when the population considerably increased. This information must be carefully considered because it is known that some of the people owning a house on the islands and using it as a second residence changed it to the first residence of choice to avoid losing it during the demolition process proposed by the authorities. On the other hand, there is a remarkable increase in the number of buildings in Culatra coinciding with the increase of the population.

By contrast, the population of Armona is very low and fluctuated over the years. Despite the very low number of people the number of buildings is the largest within the entire barrier island system (Fig. 6) although the vast majority is illegal.

Finally, in Faro Beach the occupation is very recent (Freitas, 2011). References document the oldest occupation around 1930 with a total of 10 buildings owned by fishermen in the sand barrier. The first buildings were built at the back barrier margin. However, new constructions derived from the increased interest of tourism in the area concentrated within the seaward margin of the barrier. The occupation of the barrier increased in an un-organized way after the Portuguese revolution in 1974. Officially, Faro Beach is divided into two parts (Western and Eastern Faro Beach). However, the actual division of the community includes three sectors: the central part, which is more densely built and managed by the council, and the western and eastern parts, which are managed by the Natural Park and the Environmental Portuguese Agency with mostly fisherman living there. Most of the buildings in the central part are second residences and buildings destined to tourism (hotels and restaurants). Between 1980 and 1990 the number of houses decreased in 176 units. This reduction partially results from the demolition of about 80 buildings in the area by the national government during the 1980s and to problems in the counting of houses within the nucleus due to the elevated concentration. In the case of Faro Beach, the population has access to the public network of tape water and power and pay their taxes even though their buildings are illegal.

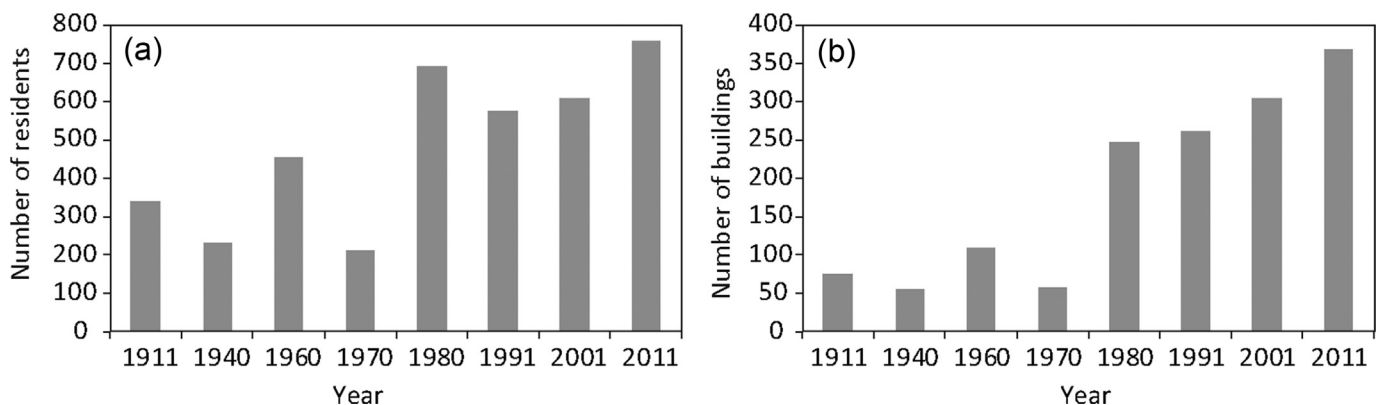


Fig. 5. Trends in the number of (a) buildings in Culatra and (b) number of residents registered in Culatra. Source (Statistics Portugal).



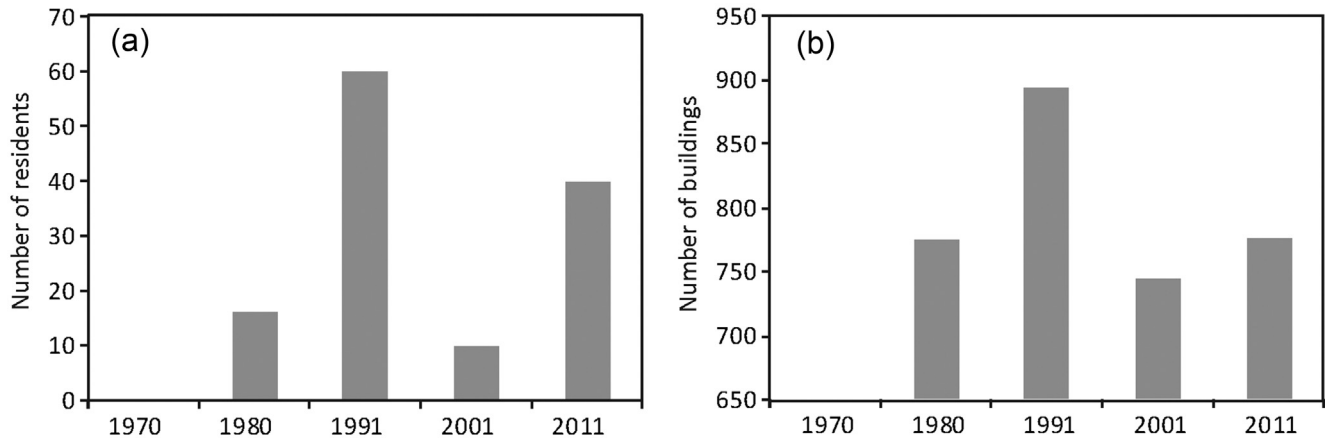


Fig. 6. Trends in the number of (a) buildings in Armona Island and (b) number of residents registered in Armona (Source: Statistics Portugal).

### 3.2.4. Collective memory and risk awareness

The way of living on the islands of Ria Formosa is still very much connected to the routines of traditional fishermen such as owning a small boat and going out to sea on a daily basis with small-scale fishing and shellfish farming dominating the activities. Besides that, salt harvesting also makes up a proportion of income as do touristic activities since the 1980s. However, there is a trend to shift economic activities from fishing to tourism and from clam to oyster farming because of the reduction of captures over time and the higher income associated to the new activities. Amongst the population of Ria Formosa, there are various local associations that represent different communities including fishermen, house owners and campsite residents. Although most of the interviewees are aware of the physical risks such as the coastal erosion, inundation during spring tides and storm surges in general it must be noted that they are usually not asked to participate in discussion about potential risk management measures. This often results in governmental plans that do not reflect the needs and claims of local communities, and exclude aspects of importance such as cultural preservation. Like in the Baltic Sea case studies, the local memory of risk is high due to the strong biophysical connection mostly first residents (fishermen) have to the area. However, due to the lack of active discussion and participation of local population in risk discussion and planning, inhabitants of the Ria Formosa feel less informed by the authorities as the coastal dwellers of Eckernförde and Timmendorfer Strand nor do they seem to have a similar trust in local coastal decision making.

### 3.2.5. Governance structures

Unlike in Germany, Portugal does not have a specific coastal policy aligned to disaster risk management. Instead, risk reduction measures are included in various programs such as in the Coastal Zone Spatial Plans (POOCs) and the Program on Urban Environment (POLIS). Moreover, risk reduction measures are decided at either national (Agência Portuguesa do Ambiente) or at a regional level (APA –

Algarve). At the later, however various institutions can be responsible for the execution and management of measures (Martinez et al., 2018). This results in a generally low level of trust between governmental and non-governmental actors. Groups of non-state actors in the area mostly interact with local and regional government organizations and very rarely with national ones. This is illustrated by the following quote (14): “It is not a question of money, it is a question of political courage, it is mostly that, the only way that could change, between the local and the national power, would be if a very strong storm impacts the area, and then that is it...” (Interview 6, SH 1). Unclear roles and lack of communication seem to lead to lack of trust between civil protection agencies, coastal managers and local residents.

### 3.2.6. Risk perception and disaster risk reduction management

The paradisiac connotation with the lagoon of Ria Formosa seems to determine the willingness of the local residents to live and accept the natural disasters a coastal environment brings with it. Most of the local residents that were interviewed are aware of the physical risks such as the coastal erosion, inundation during spring tides and storm surges in general. However, the readiness to cope with natural disasters by the local residents seems to be far greater than abstract ideas of retreat. The remark of a resident (15) “... for us this is paradise, and there are no risks in living here.” (Interview 4, SH6) can be categorized as an outlier amongst the sample, although it still underlines a certain conviction that the recreational value of the landscape and its contribution to the high quality of life at Ria Formosa compensates local residents for the natural hardships. This perception is very much related to the fact that local residents are very keen on defending the positioning of their simple and very fragile seaside houses against continuing governmental planning of relocation or permanent removal. Although a very sensitive topic, demolishing of houses has been a disaster risk reduction measure in order to recreate endangered dune environment.

In addition, local residents also expressed concerns about the water quality of the Ria Formosa. When risks are mentioned by the local residents they are interestingly rather associated with the local authorities and their decisions which often seem to leave local residents with no opportunity for engagement. 16) *“There is a general lack of respect for the people living here.”* (Interview 1, SH 6). Also the lack of communication between the local authorities and the communities is frequently mentioned during the interviews by the local residents which were interviewed. 17) *“I think that the people living here have much to tell, and they should be listened to, as you are doing (the interviewer), they should invite people to discuss and inform, and not only when they need votes, they should do this always.”* (Interview 3, SH 6). Moreover, the interviews with coastal managers, stakeholders from the civil protection agency, and the academia pointed to further risks such as the increasing occupation at the peninsula and the islands and the potential of a new inlet breaching into the Faro Beach.

In general, it can be said, that the interviewees in Ria Formosa hold a variety of knowledge about coastal defense and disaster risk reduction measures reaching from beach nourishment, recuperation of dunes and artificial reefs to channel dredging and demolition of beach houses. Hence it can be assumed that stakeholders' risk perception and knowledge on disaster risk reduction measures are directly linked to the relation they have with the coastal environment and/or the professional occupation they hold which in turn influences their knowledge repertoire of possible actions.

#### 4. Results and discussion: influence of culture on the perception of risk and its management

##### 4.1. Results: Baltic Sea communities

Table 1 captures the mind-sets of the two Baltic Sea communities in Germany (Eckernförde and Timmendorfer Strand) along the criteria (collective memory and risk awareness; governance and risk perception; disaster risk reduction management) which were used for the analysis and

Table 1  
Governance and risk perception, collective memory, risk awareness and disaster risk reduction management for the two Baltic Sea communities.

Governance and risk perception	The assistance of the state is very welcomed. Many residents believe that the coastal authorities acting responsively and adequately a) in the way they communicate risk and b) in the way they support communities to implement adaptive measures to increase their resiliency
Collective memory, risk awareness and disaster risk reduction management	Memories of storm floods (especially the exceptional flood of 1872) are kept alive and being vibrantly remembered. Risk awareness seems to be influenced by high level of trust in coastal defense mechanism and spurred innovative responses to cope with risks brought by extreme events.

illustrates the development of the communities' risk cultures and how these unfolds the adaptive measures they undertake.

The perceptions about coastal risks in the two Baltic Sea communities are shaped by recent, frequent but also by more distant events such as the extreme storm surge of 1872. However, as interviewees explained (18) *“Here on the eastern coast it's suggested you can feel safe because storm surges are less frequent than at the North Sea. But the Baltic Sea can be a dangerous surprise during proper wind out of the right direction too”* (Interview 7, SH 3), still people feel relatively safe. In examining the balance of historical floods since the flood of 1872, which claimed at least 271 lives at the Baltic coast, no significant fatalities happened since than along the German Baltic Sea coast. The Interviews in Eckernförde and in Timmendorfer Strand revealed knowledge on both emergency services, as well as coastal protection measures. They however claimed that risk management is predominantly organized by public authorities, mainly the government of Schleswig–Holstein and the Ministry for Energy Policy, Agriculture and Rural Areas (MELUR), but has been proven to be successfully organized for the safety of the inhabitants. Measures mainly focus on the protection of populated areas, agricultural land and partly on natural formations (sand cliffs), as far as major infrastructures are in close proximity. Both cases studies have well-organized civil protection systems, which can minimize personal injury in case of a flood. Moreover, both communities seem to have proactively sought ways for implementing specific measures.

##### 4.2. Discussion: Baltic Sea communities

For Timmendorfer Strand it can be stated that the interests of coastal protection coincide with the wishes for touristic development. This can be explained by looking back at the socio-economic development of Timmendorfer Strand. The storm surge of 1872 and the beginning of tourism development in the early 20th century can be understood as the founding myth of a fishermen's municipality developing into a renowned spa and bathing resort. As the driving force behind this development, tourism has thus been a source of identity for the municipality from the very beginning. The predominant value orientations of today's residents are well captured in the following quote (19): *“The Baltic, the beach and the coast are our life blood, this is our capital”* (Interview 5, SH 6.) In addition to the accumulated material values, this has also shaped the immaterial values in the municipality, such as entrepreneurial thinking, investments in culture, and infrastructure. Despite the fact that the threat of inundation is still perceived as low, it is accepted that the community must protect itself against possible threats (20) *“The Baltic feeds us and brings tourists, but it also threatens us and we need to be prepared for this.”* (Interview 12, SH 7).

The unifying force in the community is the protection of the invested material values and the future perspectives they contain. However, the possibility of exerting influence in Timmendorfer Strand also contributed decisively to the acceptance of the chosen adaptation strategy. Thus, a concept

was implemented which, in addition to coastal protection, also actively serves tourism. The decisive factors here were the good financial position of the municipality and the participatory planning process.

In Eckernförde the cultural heritage of harvesting and utilizing seagrass recently received a revival. Spurred by the discourse that the community has to please tourists with spotless beaches, the local authorities brought the idea forward to utilize organic materials washed to the beaches to build a dune, which mimics a naturally comprise dune but simultaneously serves as a small coastal defense structure (21) *“In the past, we used to transport the driftwood away as soon as it was washed ashore. We didn't separate and clean it either, it went straight to composting. We had a strong time pressure that it must be cleaned directly in the morning until 10 o'clock the beach. The building yard dumps it all into the container and the main thing is that it is gone.... But now we have a nice opportunity to utilize at least some of the beach wrack directly at the beach for building dunes.”* (Interview 12, SH 1). Costs for the construction of dunes from seagrass compared to other measures are rather low. In addition, the costs for removing the seagrass from the beach are saved and sand that sticks to the seagrass would not be removed from the beach. In the past, several transdisciplinary research projects that stressed the establishment of joint coastal mitigation and adaptation projects have been carried out in the bay of Kiel including community members of Eckernförde and other villages in the bay. The local values of the residents in Eckernförde seem to have coincided with the visions of researchers and local authorities. However, there demand has been expressed that (22) *“To receive data e.g. from climate service providers about the quality of the seagrass washed to the shores e.g. if for example whether it is heavily contaminated which could influence its utilization”* (Interview 4, SH 3) would be desirable.

#### 4.3. Results: case study Portugal

Analog to the results section for the Baltic Sea case studies, Table 2 again summarizes the mind-sets of the communities in

Table 2  
Governance and risk perception, collective memory, risk awareness and disaster risk reduction management in Ria Formosa.

Governance and risk perception	The risk perception of coastal residents especially fishermen seems to be high as they hold direct experiences with natural hazards while understanding their dynamics in relation the place they live and work. They however claim that there is almost no risk information provided by the government and they very much rely on their own knowledge and experience to cope with storm floods, inundation and erosion.
Collective memory, risk awareness and disaster risk reduction management	Although the collective memory and risk awareness of residents is very high due to manifold storm surges in the recent and less recent past in the area, insufficient information e.g. on early warning mechanism and disaster risk reduction results in spontaneous ‘ad hoc’ execution of small costal defense measures.

Ria Formosa along the above mentioned criteria (collective memory and risk awareness; governance and risk perception; disaster risk reduction management) to illustrate how risk cultures evoked and how they manifest in risk reduction measures or the absence of such.

In Ria Formosa, throughout the consultations numerous remarks were made on the usefulness of risk reduction measures which are often based on long-time daily observations by local fishermen and community members. In fact, local residents understand the natural dynamics e.g. of beach erosion and dunes movements very well and suggest a variety of measures. For example, voluntary services such as planting dune vegetation were offered mentioned during the interviews (23) *“I would like very much to participate on improving the state of the island. I would like to help planting herbs and would like very much to take care of them... They (the local authorities – comment by the authors) should do something with the plants of the dune... if they ask people to volunteer, they will help and it will be very cheap.”* (Interview 3, SH6). In fact, a coastal manager revealed the conviction (24) *“that we have not invested in protection of the system from the impact (of frequent storms) ... I think we are not ready for what is coming... for example since 2002 there has not been any activity on implementing new fences (around the dunes to recover), so this is a lot of time without doing anything.”* (Interview 8, SH 1). From the perspective of an informant from the civil protection agency the local population is quite resilient: (25) *“...the people living there (at the Ria Formosa) are extraordinary. They have a fantastic resilience because the people live there always...they have a historic knowledge and they always know if something is going to happen. However, the tourist...the people who do not live there, are actually a problem, because they do not know how to react, however the people living there, even help us to deal with a problematic situation, they are very resilient.”* (Interview 5, SH 1). Hence, it can be hypothesized that the trust of local authorities in the intuitive capability of the local residents to cope or escape in time in case of a disasters is rather high and this might help explain the relaxed attitude expressed by an informant from the civil protection agency regarding the implementation of emergency plans for Ria Formosa (26) *“The plan from my personal point of view, is just an instrument, because in practice the things happen in a different way.... I have to believe that all the people will do their best, we are confident that this will happen with our partners. However, we are not so confident with the population because they are the one at risk, and losing their belongings, they get nervous and not so easily controlled.”* (Interview 5, SH 1).

#### 4.4. Discussion: case study Western Portugal

The above expressions confirm a mutual low level of trust between the civil protection agency and the local residents of Ria Formosa as they were equally and manifold contested in the interviews with local residents, e.g. (27) *“They (the local authorities – comment by the authors) have never met with us, they only invited us when everything is decided, they never*

came to ask us, like you (the interviewer) are doing.” (Interview 4, SH 6). Although in general community members think they are prepared to take care of themselves in an emergency event, some local residents also expressed their concern that they do not hold knowledge about early warning- or evacuation procedures for the Ria Formosa (28) “*I think they should have an evacuation plan... but we never have been contacted for a training plan... and we are in the XXI century...so...I would say that we are abandoned, but at least we are healthy.*” (Interview 3, SH6). Hence, the contradictions imposed by unclear definitions of disaster risk reduction measures coupled with blurred roles of the responsibility of agencies at all level for the implementation of measures seems to lead to a vacuum in which ‘ad hoc’ execution of small coastal defense measures (e.g. placement of sand bags or planting of dune vegetation) are often undertaken by the local population. However, resource intensive measures such as beach nourishment or the removal of houses are undertaken by the local and regional authorities often without consultation with the local population.

## 5. Conclusion

The two case studies of the coastal communities in Northern Germany and Western Portugal underline the importance of culture for understanding the rationale of decisions for coastal protection. Although coastal managers acknowledge the current achievements of coastal protection in Ria Formosa they state at the same time that what has been achieved and done so far is not enough to reduce the risk to an accepted level. Since the trust between the local population and the coastal managers and policy makers appears to be low, achieving accepted and effective measures will be difficult. In contrast, in the cases studies on the Baltic Sea in Germany it seems that disaster risk reduction measures are implemented in consultation with local residents while meeting their needs, while in Portugal this link does not exist, and measures are chosen to protect the environment, meet ideas but not necessarily citizen's needs.

The authors found that a lively ‘culture of risk memory’, ‘trust in scientific information and community’ as well as decision making of coastal authorities coupled with inclusiveness and participation of communities in formulating and implementing disaster risk reduction measures are prerequisites for successful collaboration and in turn execution of disaster risk reduction measures. Moreover, it also illustrates that a separation of environmental threats and cultural perspectives on solutions can result in misleading mitigation and adaptation efforts. Subjective capacities formed by cultural place-based identities, values and knowledge, coupled with a variety of factors of socio-economic and political texture are important to understand local decision making processes and might help to improve acceptance of decisions.

## 6. Key conclusions

- (1) Geo-morphological characteristics and physical impacts are not the only forces shaping risk perceptions and

responses to coastal threats. Culture and the related socio-economic and political circumstances of a community significantly influence and shape actions.

- (2) Technical measures form a major part of solutions to reduce exposure and vulnerability of coastal communities. More dialog, coordination, political will and transparency are necessary to build long-term disaster risk reduction solutions. They are a product of the specific culture in a given region.

## Declaration of competing interest

The authors declare no conflict of interest.

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## Appendix A. Supplementary data

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