

NATURAL AND ANTHROPOGENIC TRANSFORMATIONS OF THE NATURAL ENVIRONMENT IN THE “KĘPA REDŁOWSKA” RESERVE

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Abstract:

The “Kępa Redłowska” reserve is located in the southern part of Kępa Redłowska. The location of the reserve is quite unique. Its eastern border runs along the coastline of the Baltic Sea, while on the other sides it is surrounded by highly urbanized districts of Gdynia. Its coastal location means that it is exposed to natural factors that operate in the coastal zone, whereas its urban surroundings are a threat to the natural environment through more or less controlled human activity. The landscape of the reserve owes its attractiveness mainly to the cliff coast it encompasses. Diversified geological structure of this area, both in terms of lithology and age, combined with progressive erosion, causes a continuous change in its appearance. It is this part of the reserve that is most exposed to the destructive activity of natural factors, mainly coast erosion as well as aeolian processes. The intensity of these processes is closely related to climate changes over the centuries, e.g. a significant reduction in the number of winters, during which there is ice cover in the shore zone means that cliffs are not protected against erosion by winter storms. A spectacular effect of winter storms in this area was a large landslide in the southern part of the cliff on February 15, 2018. The retreat of cliffs is a common phenomenon, however observations in recent decades clearly indicate its acceleration. The remaining part of the reserve area, not directly connected with the shore zone, is subjected to continuously growing anthropopressure. As mentioned above, the “Kępa Redłowska” reserve is located in Gdynia. The expansion of the Redłowo district has resulted in the housing development being located directly adjacent to the eastern border of the reserve. An additional element of anthropopressure is the creation of interpretive trails and tourist routes within the reserve. On the one hand, this is an attempt to “channel” tourist traffic in this area, on the other hand, it causes an increase in tourist traffic with all the negative phenomena associated with it, mainly for vegetation. Human interference in the reserve began already at the end of the 1930s. At that time, military facilities, such as bunkers and artillery positions, were built there. This process continued uninterrupted until the 1960s. Post-military objects are on the one hand an attraction for tourists, on the other hand they attract the attention of various types of seekers of military remnants who, during their explorations, cause additional damage to the surface of the area and vegetation.

Key words: Kępa Redłowska, Gdynia, Poland, cliff, fortification

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INTRODUCTION

For centuries, coastal areas have been of special interest to man. Initially, this interest resulted from purely economic reasons, such as shipping or fishing. With time, it was noticed how strongly the economic activity in these areas is influenced by climatic factors. This concerns both the significance of the direct impact of climatic factors, such as rainfall, winds or air temperature, and the related hydrodynamic processes within the coastal zone of the sea.

Currently, research conducted in these areas can be divided into two categories. The first, of the most practical significance, is research connected with protecting the shore against destructive and excessively accumulative sea activity. The second category is the study of environmental changes resulting mainly from climate change.

Within the Polish section of the Baltic Sea coast, hydrotechnical studies have been conducted since the 18th century. They focus mainly on the cliff sections, which are most exposed to marine abrasion. The research has resulted in the construction of numerous structures protecting the

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sea shore, such as: concrete bands, groynes and erratic boulders (Basiński, 1963).

In the last 30 years, research on changes in the sea level has gained importance. This concerns both the long-term changes as well as short-term ones related to, for example storm surges (Mojski, 1988; Dziadziuszko and Malicki, 1993; Jarosz and Kowalewski, 1993; Rosa, 1994; Zawadzka-Kahlau, 1994, 1999).

The high variability of climatic and hydrological conditions within the coastal zone has also been noticed by naturalists: climatologists, hydrologists, geologists, geomorphologists and botanists. The uniqueness of these areas underlies the idea of protecting selected fragments of the sea shore and its direct hinterland. The first information about nature conservation on the southern coast of the Baltic Sea dates back to the beginning of the 20th century (Wodziczko, 1929). Kępa Redłowska is a research object only in relation to the cliff. The last comprehensive study of this area is the one by Buliński and Przewoźniak (1996).

MATERIALS AND METHODS

The aim of the article is to present the current state of the natural environment of the “Kępa Redłowska” reserve and threats to this environment, both on the part of changing climatic and hydrodynamic conditions, as well as anthropogenic pressure. The main source of information was field studies conducted on the coast section covering the Orłowo cliff and the Gdynia cliff. During the field studies, observations of elements of the natural environment and emerging threats were made and photographic documentation was performed. This was to verify the data found in the current literature on this topic. The focus was also on desktop studies covering a literature survey and analysis of collected materials, including scientific publications and cartographic materials. This article is based on the descriptive method. Due to the legal protection of the nature

reserve, detailed and especially invasive research could not be applied.

In older geological and geographical literature, Kępa Redłowska is wrongly called Kępa Orłowska (Augustowski, 1977). Sometimes both these names are used interchangeably (Augustowski, 1972). An additional nomenclature problem concerns the cliff coast. In the stretch from Orłowo to the centre of Gdynia the following are distinguished: the Orłowo cliff with the Orłowo Cape and the Gdynia cliff (Subotowicz, 1982).

The cliff coast of Gdynia has been frequently described in literature. It is closely related to the abrasive activity of the gulf and the landslide processes (Pazdro, 1960; Bohdziewicz, 1961; Musielak, 1971; Subotowicz, 1982; Mojski, 1988; Dziadziuszko and Malicki, 1993; Jarosz and Kowalewski, 1993; Rosa, 1994; Zawadzka-Kahlau, 1994, 1999; Pępek and Olszak, 1995; Nowak, 2018). The anthropogenic impact on the geographical environment has been the subject of many scientific studies (Buliński and Przewoźniak, 1996).

LOCATION OF “KĘPA REDŁOWSKA” RESERVE

The landform of the Kashubian Coastline is characterized by the occurrence of isolated moraine plateaus called *kępy* (Kondracki, 1998). These plateaus are separated from each other by depressions, mostly in the form of ice-marginal streamways. One of such plateaus is Kępa Redłowska with an area of 3.3 km² and a maximum height of 90 m above the sea level (Buliński and Przewoźniak, 1996).

Kępa Redłowska is an isolated morainic plateau situated on the Kashubian Coastland between Gdynia and Sopot (Fig. 1). To the east the plateau ends with a 50-m shore-cliff descending to the Gulf of Gdańsk. On the west it borders with the Redłowo Lowering, occupied by dense building development of Gdynia Redłowo. The northern border is a

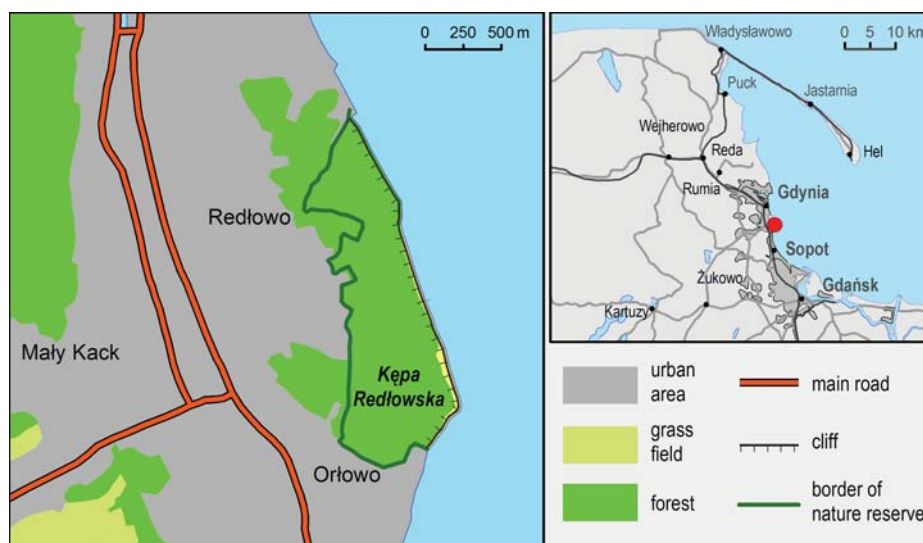


Fig. 1. Location of Kępa Redłowska. Source: own elaboration based on http://mapy.geoportal.gov.pl/imap/Imgp_2.html?gpmmap=gp0

fragment of the Kashubian meander, whereas the southern one is the Kaczy Potok valley. Kępa Redłowska encompasses a fragment of cliff shore, 2.5 km long. The most characteristic section of this stretch seems to be an active cliff called Cypel Redłowski of about 650 m long. The remaining part of Kępa Redłowska has a hilly landscape with numerous ravines.

The area of the reserve is a popular recreational site. Several tourist and interpretive trails have been designed there. For educational purposes the following trails are open to the public:

- nature and landscape – on the beach from Bulwar Nowowiejskiego (Nowowiejski Promenade) to GDY 13 entrance and further via a forest hard-surfaced road to the car park and bus terminus at the end of Legionów Street,
- geomorphology and landscape – a loop on the beach from Orłowo (GDY 15 entrance) to GDY 14 and *via* a forest road near the upper edge of the cliff,
- history and landscape – a loop via a forest road from Polanka Redłowska along the fence of the military area to an artillery unit 11 BAS and on the beach to Bulwar Nowowiejskiego to GDY 12 entrance and further via a forest road to an intersection with the road by the fence.

For recreational purposes and pedestrian traffic only, the following trails are open to the public:

- on the beach between Orłowo and Bulwar Nowowiejskiego,
- on a dirt road, partially in the forest along Polanka Redłowska,
- on a hard-surfaced forest road from the car park and bus terminus at the end of Legionów street to the beach,
- on a forest dirt road from Kopernika and Powstania Wielkopolskiego streets to the above-mentioned hard-surfaced road,
- on a forest dirt road from Saperska street to the beach with a branch to the Kacza valley,
- on a forest dirt road from Zapotoczna street to the above-mentioned branch and further to the beach.

PROTECTION FORM OF KĘPA REDŁOWSKA

The first form of protection which covered this area of 126.93 ha was introduced already in 1938 on the basis of the ordinance of the Pomeranian Voivod of July 29, 1938 on the protection of nature formations in the area of Kępa Redłowska in Gdynia (Official Journal No 23, point 271).

On March 23, 2001, under the ordinance of the Pomeranian Governor, the area of Kępa Redłowska was covered by a nature reserve. The reserve is located within the administrative boundaries of Gdynia. It encompasses land belonging to the municipality of the city of Gdynia and to the State Treasury under the management of the Minister of National Defence. Its area is 121.91 ha. The aim of establishing the reserve was to "preserve the unique landscape of the cliff coast with a complex of beech forest, specific natural processes that occur at the land-sea interface, natural plant

communities and sites of rare plant species, including the Swedish whitebeam (*Sorbus intermedia*) as a glacial relic" (Official Journal of 2001, No 27, point 283).

In 2010 a protection plan for "Kępa Redłowska" nature reserve was introduced under the regulation of the Regional Director for Environmental Protection in Gdańsk. The aim of nature protection in the reserve is to preserve the natural and semi-natural landscape of the seaside post-glacial isolated morainic plateau, the processes occurring on the sea shore as well as plant communities of the cliff and morainic plateau and valuable plant, animal and fungi species (Regulation No 6/2010 of Regional Director for Environmental Protection in Gdańsk of 7 April 2010, Official journal of 2010 No 97 point 1897).

In 2016 on the basis of the regulation of the Regional Director for Environmental Protection in Gdańsk of June 13, 2016, walking and cycling routes were introduced in the Kępa Redłowska nature reserve. The following regulation of the Regional Director for Environmental Protection in Gdańsk was issued on March 8, 2018 and delineated areas and sites in the reserve intended for walking and cycling traffic. This regulation was issued due to a change in the course of an interpretive trail as a result of cliff collapse resulting in threat to safety.

GEOLOGICAL STRUCTURE AND MORPHOLOGY OF THE RESERVE AREA

The geological outcrops located in the Orłowo and Gdynia cliffs provide a full insight into the geological structure of the reserve area. In these cliffs, the oldest exposed sediments are the Miocene grey and grey-brown silt and fine-grained sand. Within these sediments there are lignite insertions in the Orłowo cliff. However, they do not constitute a continuous bed (Pazdro, 1960; Bohdziewicz, 1961; Musielak, 1971; Pępek and Olszak, 1995). In the Orłowo cliff, the Miocene sediments are exposed only in its central part, where their roof is covered with moraine pavement. In both, the southern and northern part of the cliff, the Miocene roof has been strongly eroded. The whole wall of the cliff is made of glaciectonically disturbed Quaternary sediments. These are glaciofluvial vari-grained sands and, in the southern part of the cliff, a vertically-piled brown till. This till builds up the Orłowo Cape, which is one of the most characteristic sites of the Polish Baltic coast (Fig. 2).

The Gdynia cliff has a geological structure very similar to that of the Orłowo cliff (Figs 3, 4). However, there are some differences. Firstly, the roof of the Miocene sediments does not indicate major changes in its altitude. Secondly, the Quaternary sediments lying above are undisturbed. Thirdly, there are basins filled with clays within the Quaternary deposits. They are remnants of small reservoirs that were found in glaciofluvial sediments (Pępek and Olszak, 1995).

The area of Kępa is a patch of a moraine plateau. In the southern part it is a flat basal moraine, while in the northern part it is an undulating basal moraine. The area of Kępa



Fig. 2. Orłowo Cape (photo by A. Marek).

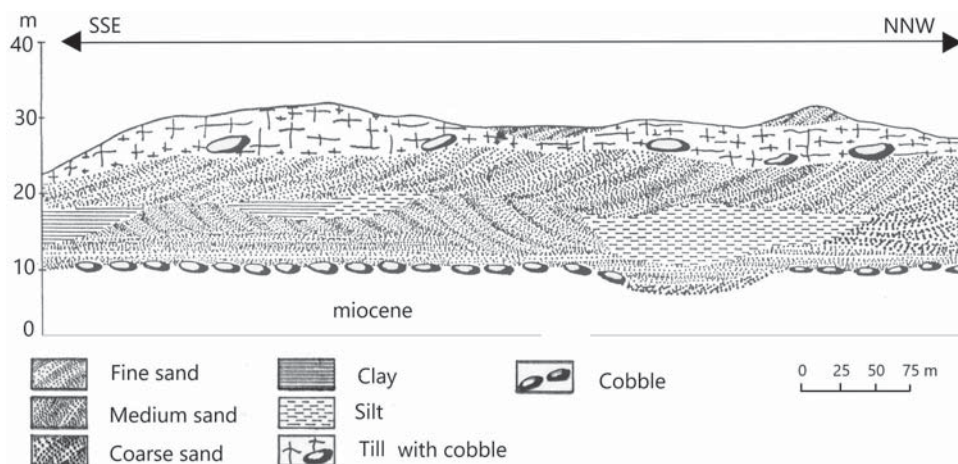


Fig. 3. Geological structure of the Orłowo Cliff. Source: Pępek, Olszak (1995).

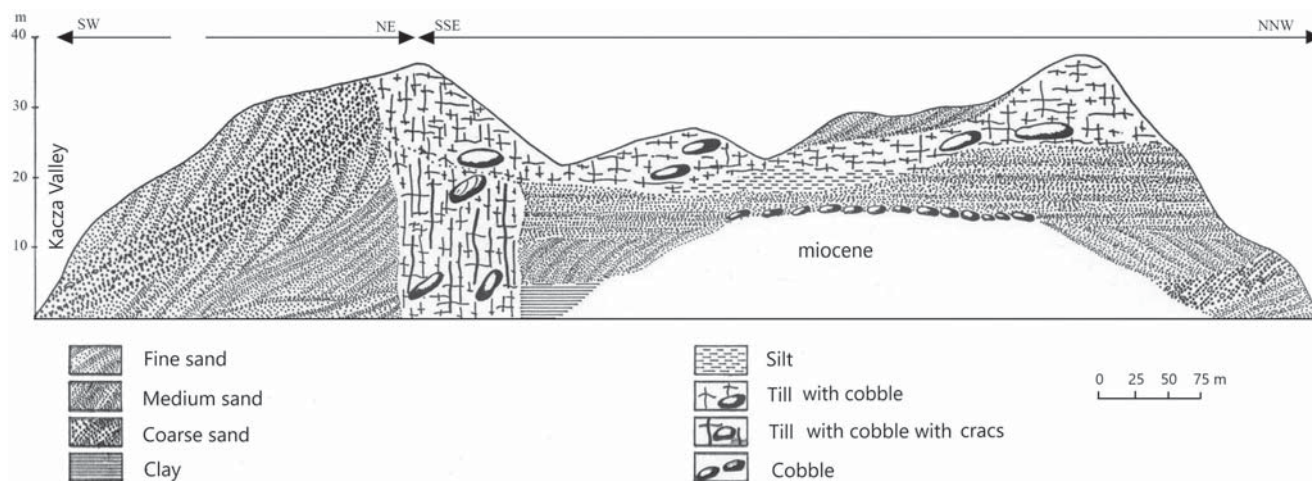


Fig. 4. Geological structure of the Gdynia Cliff. Source: Pępek and Olszak, 1995.

is inclined towards the west and falls gently to the Redłowo Lowering. The eastern edge of Kępa, forming the cliff, is cut with numerous small erosive valleys.

The surface of Kępa Redłowska is mainly made of brown till. Only in erosional cuts, glaciofluvial sand and gravel are revealed. In the coastal zone there are small patches of silt and fine-grained sand.

FLORA AND FAUNA OF THE RESERVE

The vegetation cover of the “Kępa Redłowska” nature reserve has undergone significant changes since its establishment mainly as a result of anthropogenic pressure. The currently dominant type is the fertile lowland beech wood and lowland acid beech wood. The protected tree species found here include the common yew (*Taxus baccata*) and, probably the most valuable species in this area, i.e. the Swedish whitebeam (*Sorbus intermedia*). In addition, there are other common tree species such as the common beech (*Fagus sylvatica*), common oak (*Quercus robur*), sessile

oak (*Quercus petraea*), common hornbeam (*Carpinus betulus*), silver birch (*Betula pendula*), sycamore maple (*Acer pseudoplatanus*), and Scots pine (*Pinus sylvestris*) (Buliński and Przewoźniak, 1996).

In the forest ground cover there are species which are rare in this area, such as: broad-leaved helleborine (*Epipactis helleborine*), bird’s-nest orchid (*Neottia nidus-avis*) or mountain speedwell (*Veronica montana*) (Buliński and Przewoźniak, 1996).

The area of the “Kępa Redłowska” reserve has never been studied in detail for the fauna present there (Goc, 1996). Single observations made on the occasion of other studies have shown that the fauna is very poor there. Among the species of mammals present there, the most common are moles (*Talpa europaea*), squirrels (*Sciurus vulgaris*), forest mice (*Apodemus flavicollis*) and foxes (*Vulpes vulpes*) (Goc, 1996). Recently, wild boars (*Sus scrofa*) have become increasingly frequent (Goc, 1996).

Slightly richer is a list of birds. Within the reserve and in its vicinity, the following species can be found: tawny owl (*Strix aluco*), black woodpecker (*Streptopelia martius*),



Fig. 5. Fragment of the command post of 32nd Squadron of Coastal Artillery (photo by I.J. Olszak).

song thrush (*Turdus philomelos*), blackbird (*Turdus merula*), goldcrest (*Regulus regulus*) or common raven (*Corvus corax*) (Goc, 1996). No amphibians or reptiles were found in the reserve and invertebrate fauna has never been studied (Goc, 1996).

The animal species found there are typical of the Pomeranian forest. Their scarcity, both in terms of species composition as well as the number, is related to the fact that this forest complex is an isolated one, surrounded by highly urbanized areas (Goc, 1996).

ANTHROPOLOGICAL OBJECTS WITHIN THE RESERVE

In the reserve, there are numerous disused military facilities. They were constructed in three periods. The oldest ones come from 1930–1939. They are located at the western border of the reserve. An example is the “Redłowo” anti-aircraft battery. There are also a few objects of German origin built in 1939–1945, for example, the “Adlerhorst” anti-aircraft battery or a large bunker-warehouse located at the back of the cliff in the southern part of the reserve.

The largest number of military facilities was created in this area after the Second World War. These are various types of bunkers, command posts (Fig. 5) and numerous trench stretches (Fig. 6; Woźniakowski, 2017).



Fig. 6. Trench intersecting the reserve area (photo by I.J. Olszak).



Fig. 7. Landslide in the Orłowo cliff which occurred on February 15, 2018 (photo I.J. Olszak).

The human interference in the natural environment of the Kępa Redłowska nature reserve began shortly after its establishment. The largest anthropogenic changes in the natural environment occurred during the construction of military facilities. Nowadays, after several dozen years, it is difficult to determine precisely which of the surface landforms of the reserve are natural ones and which are man-made.

THREATS TO NATURAL ENVIRONMENT OF THE RESERVE

Due to its location in the coastal zone, the reserve area is exposed to the abrasive activity of the sea. Destruction of cliff shores is a natural process. The level of the Baltic waters has been rising for over 6,000 years. This is confirmed, among others, by peat deposits present in the bed of Puck Bay, age of which is estimated at around 6,000 years. This process is completely natural and has no relation to human activity. According to some authors, it is a continuation of the so-called Littorina transgression (Rosa, 1963; Mielczarski, 1999).

The transgression itself, being relatively slow, does not pose a serious threat to the coastal zone. Much greater damage to cliffs occurs as a result of rapid wind surges and the accompanying waving (Zawadzka-Kahlau, 1999). Storm surges, with prolonged exposure to north-easterly winds, may reach about 3 m. Waves in the coastal zone reach a height of up to 4–5 m. Such rapid hydrodynamic changes in the coastal zone cause landslides in cliffs. In particular, this applies to winter periods, when due to air temperatures of over 0°C, there is no ice cover in this zone that would otherwise protect the shore against abrasion. The result of such a situation is the occurrence of a large landslide (Fig. 7) in the Orłowo cliff on February 15, 2018 when about 700–1200 m³ of deposits moved down (Nowak, 2018).

Another example that shows clearly a retreat of the Orłowo Cliff are anthropogenic objects, once located on its edge. Already in 1922, Pawłowski (1922) wrote: “*Starting from the Orłowo Cape, we can witness destruction almost everywhere. On the very cape there are hanging foundations of a building of some sort (brickyard?). Immediately behind the cape, there are significant landslides within a distance of 9.5 km.*” It is more likely that the building described by the author could have been an observation or a navigation object.

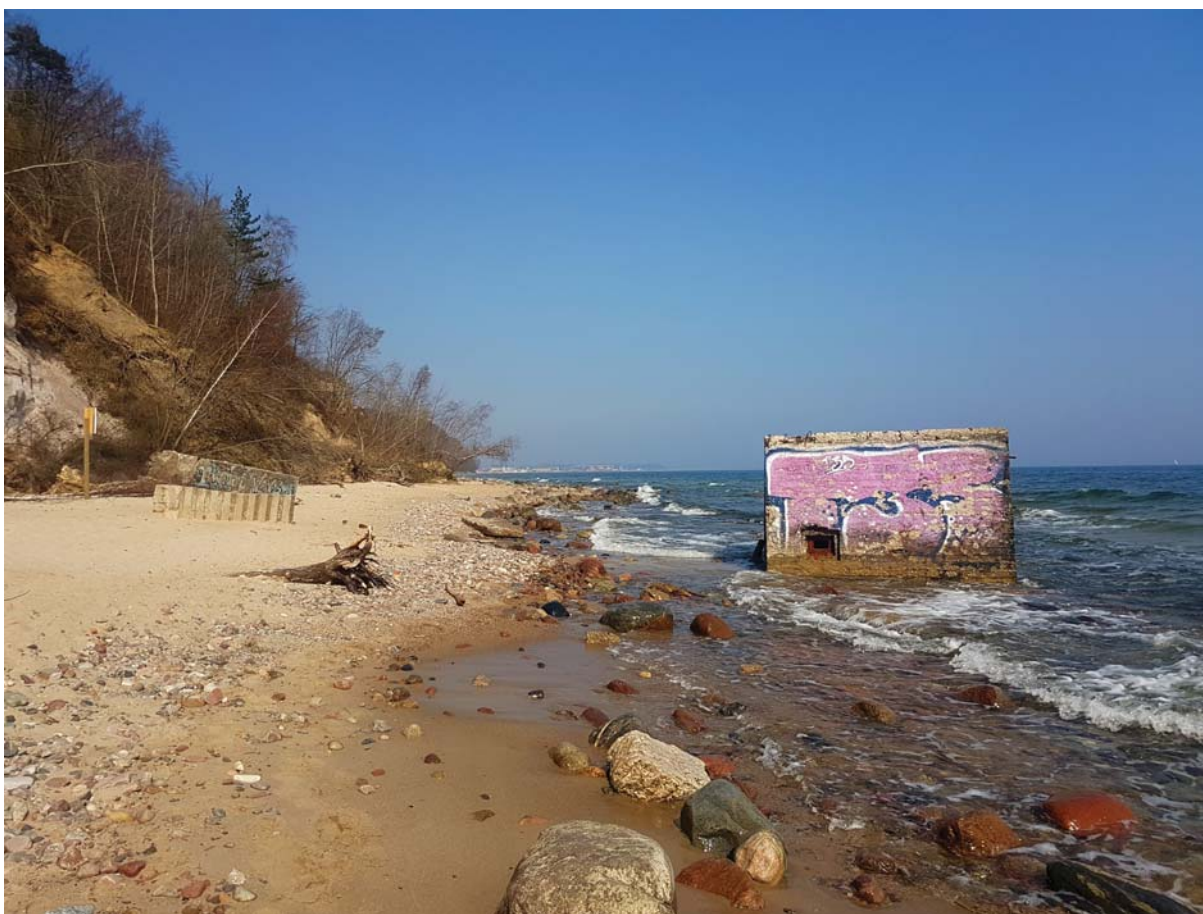


Fig. 8. Two-sided observation bunker after its fall from the Orłowo Cliff (photo by A. Marek).

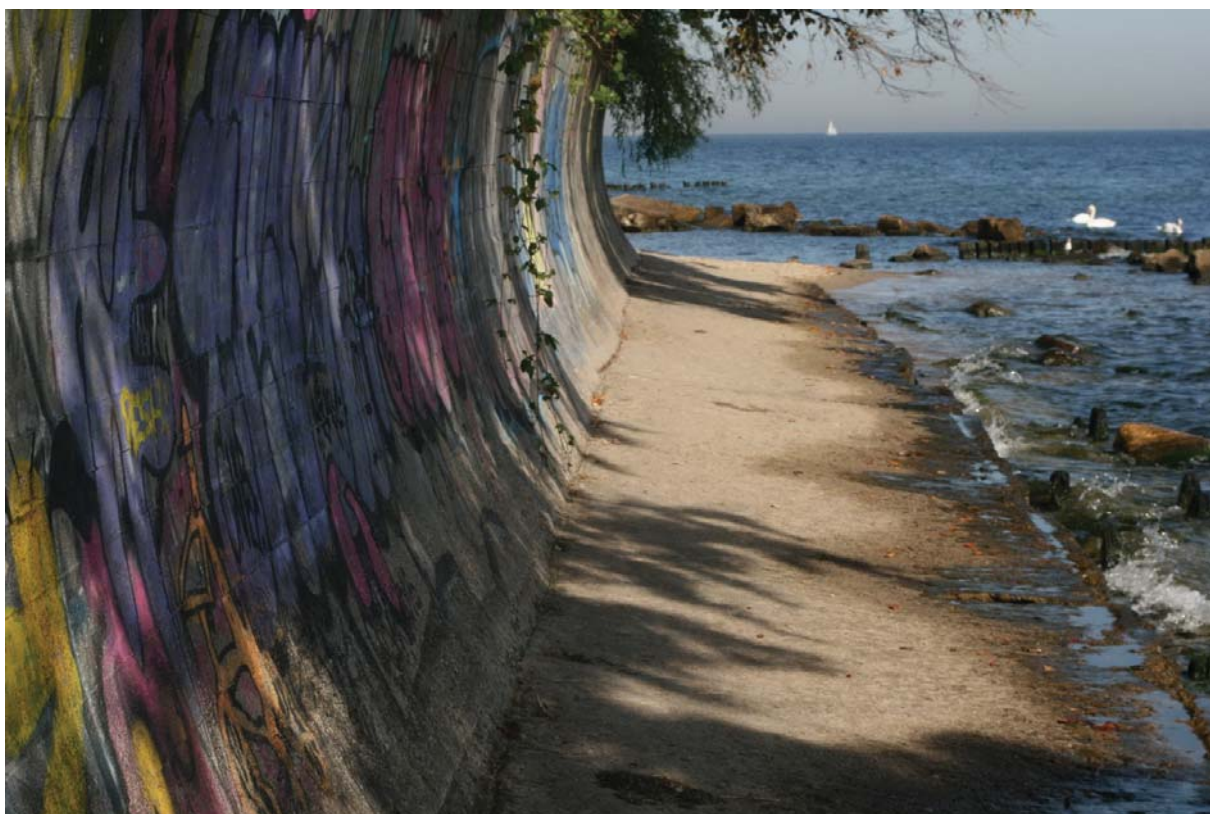


Fig. 9. Gdynia Cliff. Concrete band and groyne (photo by I.J. Olszak).



Fig. 10. Remnants of military objects in Kępa Redłowska (photo by A. Marek).

Also the bunkers, remnants of the 11th Permanent Artillery Battery in Gdynia Redłowo, built at the turn of the 1940s and 1950s are noteworthy. One of them slid to the beach in the 1980s. The second example is a bunker, which served as a two-sided observation point (Mielczarski, 1999). This bunker was located several meters from the edge of the cliff crown. In 2012, a controlled fall of the object from the edge of the cliff to the beach was performed. Currently, it is located in the waters of the Gulf of Gdańsk (Fig. 8).

Detailed studies of a retreat rate of the Orłowo Cliff were conducted by Subotowicz (1982). Based on archival photographs, he determined a retreat rate of the Orłowo Cape cliff at about 1 m/year in 1837–1959.

The Gdynia Cliff retreats definitely more slowly. This is due to the fact that part of this cliff was secured with a fascine band and groynes already in 1905. In 1936 this band was exchanged with the existing concrete band, additionally reinforced in 1957 (Basiński, 1963). This band was made to secure the cliff, in the back of which a military unit was located (Fig. 9). In addition to the threat from the Baltic Sea, the reserve area is also threatened from land. During heavy rainfall and rapid thaws, water flowing through ero-

sive cuts destroys additionally a surface of the area and the cliffs.

Apart from natural hazards, human interference in the natural environment seems equally important. In the area under discussion, there are visible traces of excessive penetration associated with tourism, recreation and sport. The most noticeable are: foot-worn patches devoid of vegetation, resulting in progressive soil erosion, followed by littering, mechanical damage to trees, shrubs and herbaceous plants, scaring off animals. The location of Kępa Redłowska in the neighbourhood of a housing estate also exposes it to many harmful factors. The negative impact of the urban tissue adjacent to the reserve is noticeable in air and surface water pollution, waste dumping, noise, constraining animal migration and scaring animals and anthropisation of the vegetation.

Negative manifestations of anthropogenic activity can also be observed on military facilities located within the reserve. These include graffiti, illegal landfills and littering. Acts of major vandalism, such as devastation of objects (Fig. 10), in order to obtain metal parts from the fixings are also noted.

CONCLUSIONS

The “Kępa Redłowska” reserve is a unique area located at the contact zone of land and the waters of the Gulf of Gdansk. As one of the first areas of Poland, it was covered by nature conservation, among others due to the *Sorbus intermedia* stand. This area is exposed to the activity of destructive factors. Storm surges cause cliff landslides. Another natural threat is the erosive activity of flowing waters, washing away the upper part of the cliff.

The interference of the army *via* the construction of military facilities and access infrastructure has caused irreversible changes in the landscape of this stretch of the coast. These changes, due to a passage of time are today difficult to discern in the field. The later progress of urban development surrounding the reserve from the north, west and south-west increased the interest in this area. The reserve started to be treated as a recreational place. Hence, clear traces of human interference are noted, indicated by damage in vegetation cover, foot-worn patches and waste dumping.

REFERENCES

- Augustowski, B., 1972. Niziny Nadmorskie (Pobrzeże Bałtyckie). In: Galon, R. (Ed.), *Geomorfologia Polski*, t. 2. PWN, Warszawa, 111–128.
- Augustowski, B., 1977. *Pomorze*. PWN Warszawa, 350 pp.
- Basiński, T., 1963. Protective buildings on the Polish Baltic coast (Budowle ochronne na polskim wybrzeżu Bałtyku). The materials for the monograph of Polish seashore, IBW PAN, Gdańsk, 4–220 (in Polish).
- Bohdziewicz, L., 1961. Cliff of the isolated moraine plateau at Redowo. In: Galon, R. (Ed.), *From the Baltic to the Tatras*, part 1, North Poland, PWN Łódź, 56–58.
- Buliński, M., Przewoźniak, M., 1996. Monograph of the nature reserve “Kępa Redłowska” (Monografia rezerwatu przyrody „Kępa Redłowska”). In: Przewoźniak, M. (Ed.), *Coastal nature reserves, Materials for the natural monograph of the Gdańsk region*. Wydawnictwo Gdańskie, Gdańsk, 5–77 (in Polish).
- Dziadziuszko, Z., Malicki, J., 1993. Growth of risk of storm surge flooding on the Polish coast. Reasons and history of the January and February storm surges. *Gazeta Obserwatora IMGW*, Warszawa, 4–5, 6–12.
- Goc, M., 1996. State of fauna, (Stan fauny), Materiały do monografii. In: Przewoźniak, M. (Ed.), *Coastal nature reserves, Materials for the natural monograph of the Gdańsk region*. Wydawnictwo Gdańskie, Gdańsk, 62–64.
- Jarosz, E., Kowalewski, M., 1993. The wind waving motion. In: Korzeniewski, K. (Ed.), *Zatoka Pucka*. Wydawnictwo Uniwersytetu Gdańskiego, 147–159 (in Polish).
- Kondracki, J., 1998. *Geography of Poland (Geografia regionalna Polski)*. PWN, Warszawa, 464 pp. (in Polish).
- Mielczarski, A., 1999. Post-litorina. Relative sea-level changes in the Gulf of Gdańsk in the light of new researches. *Peribalticum VII. Z problematyki badawczej wybrzeża południowobałtyckiego*. Gdańsk, 21–40.
- Mojski, J.E. (Ed.), 1988. *Zasady polskiej klasyfikacji i terminologii nomenklatury stratygraficznej czwartorzędu. Instrukcje i Metody Badań Geologicznych PIG 47*, 3–63.
- Musielak, S., 1971. The deep-seated Geological Structure of the Region of Gdańsk (Wglębna budowa geologiczna Regionu Gdańskiego). *Zeszyty Naukowe UG. Geografia 1*. Wydawnictwo Uniwersytetu Gdańskiego, 95–126 (in Polish).
- Nowak, P., 2018. The cliff in Orłowo disappears, but it does not die (Klif w Orłowie znika, ale nie ginie). *30 Dni*, 1–2, 40–42 (in Polish).
- Ordinance No 49/2001 of the Pomeranian Governor (Voivod) of 23 March 2001 on the recognition as a nature reserve of the area on Kępa Redłowska in Gdynia (Official Journal of 2001 No 27, point 283) (in Polish).
- Ordinance of the Pomeranian Governor of 29 July 1938 on the protection of nature formations in the area of Kępa Redłowska in Gdynia (Official Journal No 23, point 271) (in Polish).
- Pawłowski, S., 1922. Morphological characteristics of the Polish coast (Charakterystyka morfologiczna wybrzeża polskiego), *Skład Główny w Księgarnia Gebethnera i Wolffa*, Poznań, 25 pp. (in Polish).
- Pazdro, Z., 1960. Geological structure of the Gdańsk region. *Rocznik Polskiego Towarzystwa Geologicznego XXIX*, 4, 337–346 (in Polish).
- Pępek, A., Olszak, I.J., 1995. The Quaternary of the Kępa Redłowska cliffs (Czwartorzęd klifów Kępy Redłowskiej). In: Florek, W. (Ed.), *Geologia i geomorfologia pobrzeża i południowego Bałtyku 2*. WSP, Słupsk, 153–158 (in Polish).
- Regulation No 6/2010 of Regional Director for Environmental Protection in Gdańsk of 7 April 2010 on establishing a protection plan for the “Kępa Redłowska” nature reserve (Official journal of 2010 No 97, point 1897).
- Rosa, B., 1963. Morphological development of the Polish coast in the light of old shore forms, *Studia Societatis Scientiarum Torunensis, Sectio C, Toruń*, 5 (in Polish with English summary).
- Rosa B., 1994. On the changes in the level of the Southern Baltic and the urgent need for further studies in the field. In: Rosa, B. (Ed.), *Peribalticum VI*, GTN Gdańsk, 95–120.
- Subotowicz, W., 1982. The lithodynamics of the Polish sea coastal cliffs, *Wyd. PAN, Wrocław–Warszawa–Kraków–Gdańsk–Łódź*, 1–152 (in Polish).
- Wodziczko, A., 1929. Recognition of the Kępa Redłowska forests as a reserve (Uznanie lasów Kępy Redłowskiej za rezerwat). *Ochrona Przyrody 9 (97)*, 125–127 (in Polish).
- Woźniakowski, A., 2017. Fortifications of Gdynia and the surrounding area (Fortyfikacje Gdyni i okolic). *Tourist map*. Wydawnictwo Casamata, Gdynia (in Polish).
- Zawadzka-Kahlau, E., 1994. Determination of changes of South Balticspits and cliffs. *Bulletin Maritime Institute*, 21, 41–59.
- Zawadzka-Kahlau, E., 1999. Trends in South Baltic Coastal Development during the Last Hundred Years. *Peribalticum VII*, 115–136.