Natural night protection through adapted lighting in the Wadden Sea region

Andreas Hänel, Fachgruppe Dark Sky der Vereinigung der Sternfreunde and Carl von Ossietzy Universität Oldenburg, ahaenel@uos.de
Katrin Kirfel, Nationalparkverwaltung Niedersächsisches Wattenmeer, Wilhelmshaven
Cristina Nazzari, Common Wadden Sea Secretariat, Wilhelmshaven,
Björn Poppe, Carl von Ossietzy Universität Oldenburg, Oldenburg

Kurzfassung

Problemstellung

Verschiedene Regulierungen zum Natur- und Artenschutz, wie die Naturschutzgesetze in Deutschland, die Biodiversitätsstrategien 2030 und die Gesetze zur Wiederherstellung der Natur, adressieren die Reduzierung der Lichtverschmutzung. Geringerer Energieverbrauch durch energieeffiziente Lichtquellen, sowie zunehmender Wunsch nach gefühlter Sicherheit und Komfortdenken verursachen eine Zunahme künstlichen Lichts.

Ziel

Das UNESCO-Weltnaturerbe Wattenmeer ist eine der größten dunklen und geschützten Flächen in Europa. Es erstreckt sich von den Niederlanden über Deutschland bis Dänemark. Obwohl noch weitgehend ungestört, wird es durch industrielle und kommerzielle Aktivitäten beeinträchtigt, besonders in den Häfen, aber auch durch die zunehmende Nutzung für erneuerbare Energien. In der Leeuwarden Deklaration, die 2018 die Umweltminister der Anrainerstaaten verabschiedeten, wurde die Reduzierung der Lichtverschmutzung gefordert, was auf verschiedene Weisen erfolgen soll.

Beschreibung der Innovation/»best practice«

„Best practice“-Beispiele sind die Einrichtung von „Sternenparks“ nach den Richtlinien der Vereinigung Dark Sky International (vor 2023 International Dark Sky Association). Sie wurden auf vier Inseln, auf Terschelling mit dem Naturpark Boosplaat, auf Spiekeroog, Pellworm und Mandø, sowie im Nationalpark Lauwersmeer im Wattenmeergebiet eingerichtet. Maßnahmen zur Reduzierung von Lichtverschmutzung umfassten einfache, aber effektive Änderungen, wie Reduzierung des Lichtstroms, volle Abschirmung der Leuchten oder geringere äquivalente Farbtemperaturen. Sie werden detaillierter vorgestellt.

Realisierungsgrad

Es haben sich weitere Initiativen gebildet, wie die „Trilateral Vision on Dark Sky over the Wadden Sea”, die von Kommunen und anderen im Nordseebereich unterstützt wird. Auch das niederländische Programm “Donkerte van de Wadden” unterstützt diese Bemühungen. Daraus entwickelten sich auch weitere Aktivitäten in den Kommunen der Biosphärenregion Niedersächsisches Wattenmeer und das Projekt „Sternenfunkeln über Friesland“ im Landkreis Friesland in Niedersachsen, die erfolgreich zur Reduzierung der Lichtverschmutzung beitragen. Ferner entwickelten sich zwei Interreg North Sea-Projekte - “Keep It Dark” und “DARKER SKY” über die in anderen Vorträgen berichtet wird.

Abstract

Issue

Various regulations, such as nature protection laws in Germany, the EU and national Biodiversity Strategies 2030, along with nature restauration laws, have addressed the reduction of light pollution for nature and species protection. On the other hand, less energy consumption from more energy-efficient lighting sources, as well as increased safety and comfort concerns lead to increased lighting.

Aim

Extending from the Netherlands to Germany and Denmark, the UNESCO World Heritage Wadden Sea is one of Europe's largest protected areas, where natural processes proceed largely undisturbed and is also one of the darkest areas in Europe. Nevertheless, light pollution is increasing also in this area mainly due to, industrial and commercial activities, particularly in harbours, also due to the increase of renewable energy infrastructure. In 2018, the Leeuwarden Declaration on the protection of the Wadden Sea, adopted by the Environmental Ministers, called for a reduction of light emissions, which is being pursued through various methods.

Description of the innovation/»best practice«

The establishment of Dark Sky Places, following the guidelines of the Dark Sky International association (formerly the International Dark Sky Association), represents a „best practice". These have been implemented on four islands - Boosplaat on Terschelling, Spiekeroog, Pellworm, and Mandø – as well as in the National Park Lauwersmeer within the Wadden Sea region. Measures to reduce light pollution include simple and effective lighting modifications, such as reducing luminous flux, full shielding, and lower correlated colour temperatures. These approaches will be discussed in detail.

Level of realization

Additional initiatives, such as the "Trilateral Vision on Dark Sky over the Wadden Sea", have been developed and endorsed by a broad range of stakeholders along the North Sea. The Dutch "Donkerte van de Wadden" program also contributes to these efforts. Other follow-up activities in the Biosphere Region of the Lower Saxon Wadden Sea and the "Sternenfunkeln über Friesland" program in Friesland County have reduced light emissions successfully. Furthermore, two Interreg North Sea projects - "Keep It Dark" focused on measurement methods and "DARKER SKY" will be addressed in other presentations.

This work has been partially funded by European Union Interreg Programs.

1 Reducing Light Pollution in the Wadden Sea

The trilateral Wadden Sea Region of Denmark, Germany and The Netherlands is globally unique for its ecological value and therefore was designated as a UNESCO Natural World Heritage site. Especially for the Netherlands the northern parts along the Wadden Sea are the darkest regions of this country, that due to its dense population is impacted by high light emissions. To protect these dark areas and reduce light pollution several initiatives were started under the program “Naar een rijke Waddenzee” in the Netherlands [1]. The reduction of light emissions was one item in the working package for the following years of the Leeuwarden Declaration 2018 signed at the Trilateral Governmental Conference. [2]

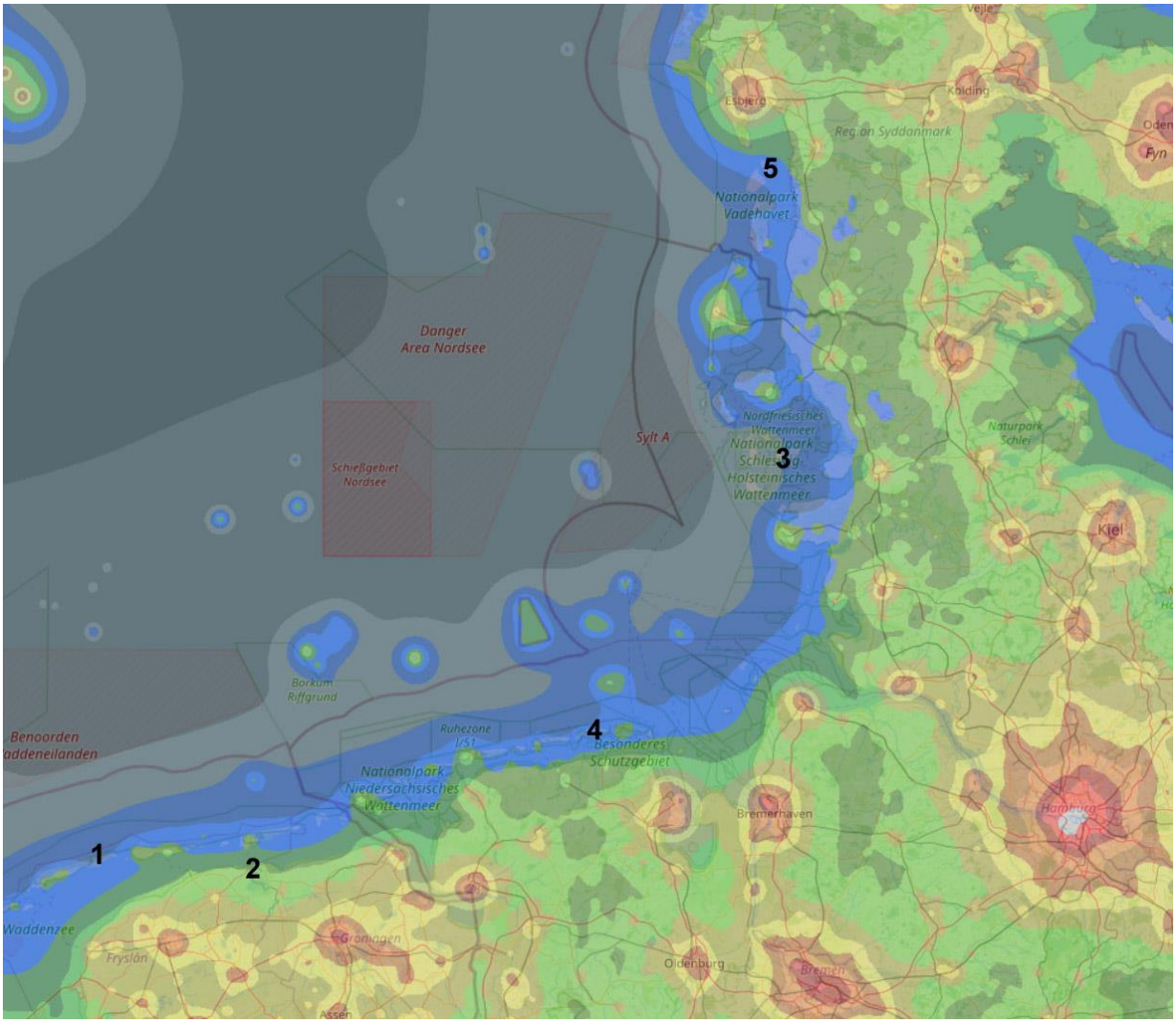

Fig. 1: Light pollution map of the North Sea region for 2022 with International Dark Sky Places: 1 Boschplaat, 2 Lauwersmeer, 3 Pellworm, 4 Spiekeroog, 5 Mandø (Lorenz, 2022, [3])

In 2019 the Wadden Sea Forum formed a Dark Sky working group with participants from the Netherlands, Germany and Denmark to exchange information and actions around Dark Skies in the Wadden Sea region. In April 2021 a Webinar “Erlebe die Finsternis” was organized where activists from other European International Dark Sky Places reported about their experiences. Later the working group was transferred to the Common Wadden Sea Secretariat.

2 Star Parks/Islands as Best Practice

Certifications are important tools to reach certain aims. Two international associations certify places that reduce light pollution: the Starlight Foundation that is mainly active in Spanish language countries and the International Dark Sky Association (IDA, since 2023 Dark Sky International), an association based in Tucson, Arizona, which certifies International Dark Sky (IDS) Places worldwide. Dark Sky International provides several categories, of which IDS Reserves (area larger than 700 km²), IDS Parks (mostly protected landscape) and IDS Communities (municipalities) are the most relevant [4].

2.1 Criteria for Dark Sky Places

IDS Places must have a minimum level of darkness, that must be controlled through sky brightness measurements, using measuring methods approved by the organisation. Essentially these are the handheld Sky Quality Meters SQM-L of the Canadian firm Unihedron. Sky brightness is measured in the astronomical unit “magnitude/square arcsecond” (mag/arcsec²), corresponding to a small luminance, measured in candela/square meter (cd/m²). More accurate data can be achieved through continuous measurements with SQM-LUs (with USB interface) or the TESS-W detectors of the EU funded Stars4All project. Even more accurate data can be taken with calibrated cameras with all-sky fisheye lenses and special reduction software (Sky Quality Camera or DiCaLum). The bright limit of the sky brightness for IDS Parks and Reserves is set to 21.2 mag/arcsec² or 0.000 36 cd/m² (or 0.36 mcd/m²) [5].

The management of the Dark Sky Place must accept and follow a Lighting Management Plan (LMP) with the most important criteria being:

All luminaires must be fully shielded, that no light is emitted towards and above the horizontal plane of the installed luminaire. Luminaires with a luminous flux less than 1000 Lumen (lm) in IDS Communities or 500 lm in IDS Parks should, but must not be fully shielded. To limit the blue amount of white light, the correlated colour temperature (cct) must be not higher than 3000 Kelvin (K).

Within the IDS Place public observing of the starry sky should be possible and a public outreach program must be offered. All essential activities must be documented in annual reports, especially the compliance of the lighting to the LMP.

2.2 The Dutch Star Parks De Boschplaat/Terschelling and Lauwersmeer

A local entrepreneur of the bungalow village Tjermelan on the island Terschelling had the idea to install an IDS Park on the island because it offered a dark sky. However, with about 4720 inhabitants and 1040 public light fixtures, the change of all lighting according to the guidelines of Dark Sky International would become difficult. Sky brightness measurements on the island have been taken by *Wim Schmidt* since 2011 and showed that the eastern part is the darkest. This is the Natura 2000 Nature Reserve De Boschplaat which is about 10 kilometres long and 4 kilometres broad. It is governed by the Staatsbosbeheer (state forest) and as it is uninhabited, no artificial light is installed. Typical sky brightness values (measured with a handheld SQM-L) were 21.6 mag/arcsec², while continuous measurements since 2015 with two fixed installed SQMs were about 21.2 mag/arcsec². In addition, an all-sky camera was installed at nearby Tjermelan holiday park. The IDS Park De Boschplaat was designated in 2015.

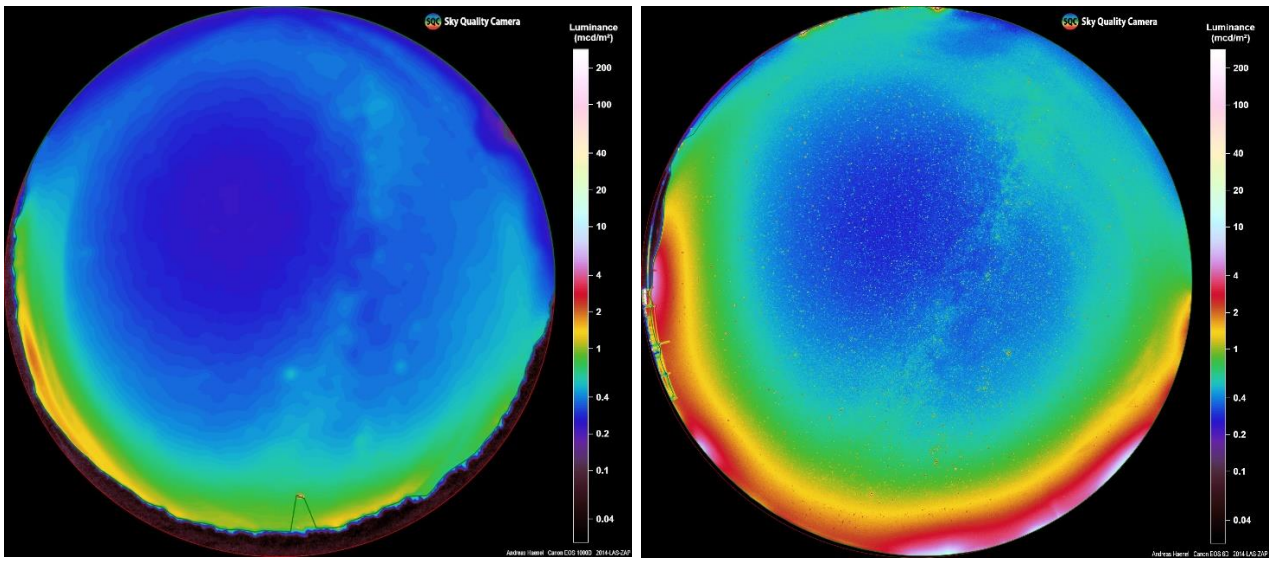

Fig. 2: Luminance maps (in mcd/m²) of the sky derived from all-sky digital camera pictures at left: De Boschplaat on Terschelling (taken on Febr. 1, 2014) and right: in Lauwersmeer (taken on Jan 15, 2020). From this the sky on Terschelling is darker than in Lauwersmeer. (photo: A. Hänel)

Lauwersmeer was originally a bay of the North Sea, but became an inland lake when it was protected 1960-1969 through a dyke. It developed to a freshwater lake with new flora and fauna and therefore became in 2003 a National Park surrounded by recreation parks and woods. The 60 km² Natura 2000 area without any inhabitants is governed by the Staatsbosbeheer. Night sky brightness measurements in 2015 showed that the darkest parts were in the North with about 21.2 mag/arcsec², interrupted by the lights of the port of Lauwersoog. These fixtures were changed in 2016 and reduced the sky brightness in this area. This lighting shall be further improved within the Interreg project DARKER SKY: Further changes have been done on the lighting around the park, especially at a military camp. The IDS Park was designated in 2016. During the last years the astronomical institute of the university Groningen installed a robotic telescope and measurement instruments at the National Park information centre Lauwersnest.

Fig. 3: Road lighting in the harbour of Lauwersoog with a mean illuminance of about 5 lx (photo: A. Hänel)

2.3 Pellworm

Pellworm belongs to the North Frisian Islands and lies at –1 m below the sea level, while it is protected by an 8 m high dyke. The whole island has 37 km² and is mainly used for agriculture and 1230 inhabitants live there. Therefore, the island applied for a designation as IDS Community.

First ideas for a Dark Sky Place came from the tourist manager in 2014 but were not followed further. During the process of application as an UNESCO biosphere community in the North Frisian Wadden Sea area, inhabitants developed the concept of a starry island as a form of sustainable tourism, but also to protect insects through lighting that attracts less insects.

The measurements showed that the sky brightness is nearly as dark as on Spiekeroog (see below), however light sources on the horizon are fewer: the light dome of Husum, a city with 24 000 inhabitants about 25 km away, and some light houses which are not everywhere visible (and disturbing the view) on the island. Due to the remoteness of the island and confirmed through satellite data and the measurements, Pellworm could be designated as one of the darkest places in Germany. The sky brightness was measured as 22.0 mag/arcsec² or 0.17 mcd/m² on a dark sky area without Milky Way resulting in an illuminance of 1.0 mlx. During a completely covered sky, the brightness was 22.5 mag/arcsec² or 0.1 mcd/² resulting in an illuminance of 0.27 mlx. To monitor the evolution of sky brightness continuously two TESS-W had been installed, one in the dark western part and one at the city hall as one of the brightest (but still very dark!) places on the island.

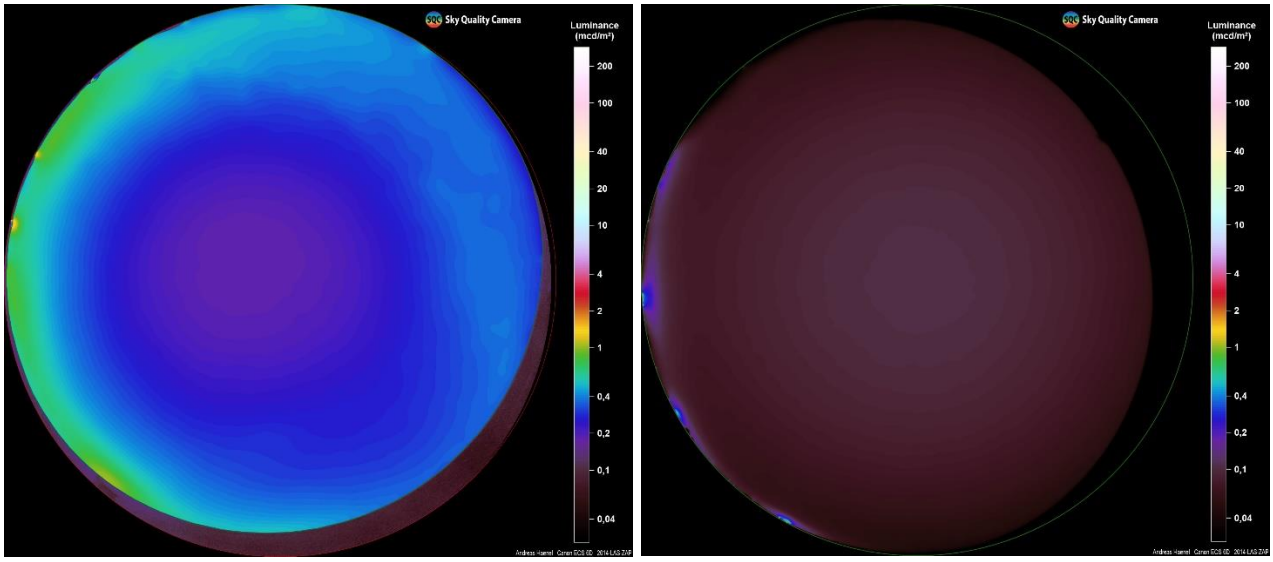

Fig. 4: Luminance maps (in mcd/m²) of the sky derived from all-sky digital camera pictures on Pellworm at left: clear spring night without Milky Way (taken on March 16, 2021) and right: completely covered sky (taken on Nov 26, 2022). (photos: A. Hänel)

Fig. 5: View from the western coast of Pellworm over the Wadden Sea. Due to the darkness the arc of the Milky Way and the cone of the zodiacal light – dust in the solar system that is still illuminated by the sun – are visible on the western evening sky. (photo: A. Hänel)

The public lighting used mainly two types of luminaires: 70 “bell-shaped” luminaires that were retrofitted with LED lamps with 1220 lm and cct 2200 K. 70 “mushroom” and “Koffer” luminaires were changed to full cut-off luminaires with cct 2200 K and 1000 lm on the roads and 5000 lm in the old harbour. The street lighting is switched off between 22:00 and 5:00. Only 12 “Koffer” luminaires with sodium high pressure lamps in the ferry harbour were not yet exchanged as the harbour has to be renovated for building safety, then the lighting will also be adjusted.

Fig. 6: Left: these “bell-shaped” luminaires are full cut-off and the lamps had been replaced to 2200 K lamps. Middle: these “Koffer” luminaires were replaced by fully shielded 2200 K luminaires (photos: A. Hänel)

Pellworm was designated as IDS Community in 2021.

2.4 Spiekeroog

On the request of the Lower Saxony Wadden Sea National Park Authority to reduce light emission it was considered to develop an IDS Place according to the Dark Sky International criteria as a best practice example. From a preliminary study the island of Spiekeroog was identified as one of the darkest of the East Frisian islands. In addition, Spiekeroog supports sustainable development and municipality and National Park Authority agreed to develop the idea to become an IDS Community.

First measurements of the sky brightness in April 2019 were a surprise, as they were the darkest measurements, that A. Hänel ever made. This was confirmed through two different measurement methods: a handheld Sky Quality Meter SQM-L and a calibrated digital camera with fisheye optics. The measured sky brightness of 22.1 mag/arcsec²) corresponds to a luminance of 0.000 16 cd/m². The darkness of the whole sky is mainly disturbed around the southern horizon by the lights from the mainland and towards the North Sea in the North by brightly illuminated ships sailing towards or from the harbours of Hamburg and Bremerhaven.

According to the Dark Sky International criteria Spiekeroog could apply as IDS Park for the whole island and/or as an IDS Community for the village with about 800 inhabitants. As artificial light is mainly installed in the village, it was decided to apply as IDS Community. The application was partially funded through the working package “Reducing light pollution” within the European Interreg project Wadden-Agenda 2.0.

Just before this decision public luminaires had been replaced to shielded 3000 K LED with funding from the Federal Government, an exchange to lower cct was therefore not possible. However, the illuminance was about 3 times higher than the old lamps due to the extremely high luminous flux of 3300 lm. As poles are only 3 – 4 meters high and there is no general motorized traffic on the island, luminous flux was reduced to 990 lm by reprogramming the power supplies yielding a maximum illuminance of 20 – 25 lx, which is adapted to pedestrian traffic. Inhabitants were content because the lamps appear less glary than before. In addition, public lighting was switched off at 0:30, since 2022 (energy crisis due to the Russian war against Ukraine) already at 23:30.

Some luminaires on the paths from the village to the beach through the National Park were exchanged to full cut-off 2200 K LED with low luminous flux, resulting in a considerable improvement of darkness (fig. 8). In 2021 the application of the island as IDS Community was approved.

The lighting of the harbour had been exchanged in 2022. During working hours, when a ferry arrives or leaves, a 3000 K LED lighting is used, which otherwise is switched to a 1800 K reduced “night time” lighting.

To support dark sky friendly lighting for private households an information panel with good lighting examples was fabricated and is on display in the National Park House on Spiekeroog.

Fig. 7: Information panel demonstrating bad and good private lighting (photo: A. Hänel)

In the village a TESS-W measurement instrument was installed to monitor sky brightness. Since 2024 a continuously measuring SQM-LU and all-sky camera were installed in a dark place at the Hermann-Lietz school in the East of the island, funded through the EU Interreg project “Keep it Dark” [6]. These instruments continuously monitor the development of the sky brightness on Spiekeroog.

Fig. 8: Lighting changes on Spiekeroog: Left: view towards the East over the dark National Park. Middle: view towards the West with intense lighting illuminating the paths from the village towards the beach. Right: the view after changing the luminaires to fully shielded 2200 K LEDs demonstrating a great improvement (photos: A. Hänel).

2.5 Mandø

The island is situated in the Danish Wadden Sea between the islands of Rømø and Fanø, south of the city of Esbjerg. The 8.5 km² small island has only 30 inhabitants and is accessible over a dam only at low tide. The Danish Wadden Sea National Park Center is situated at the mainland access to the dam.

Public lighting on the island consists of 25 bollard fixtures that originally were not shielded and had a cct of 4000 K. They were all changed to fully shielded luminaires with 3000 K LED

and are switched off at 23:00. Most of the private lighting conformed to the Dark Sky International guidelines or has also been changed to conformity.

Fig. 9: The old glary bollards and the new exchanged and full cut-off bollards of the public lighting on Mandø (photos: A. Hänel)

Due to the remoteness and the sparse lighting, nights are very dark on the island, zenith sky brightness measurements in fall were about 21.4 mag/arcsec² with the Milky Way near zenith. Light domes dominate mainly the North and East.

Mandø was designated as IDS Park in 2024.

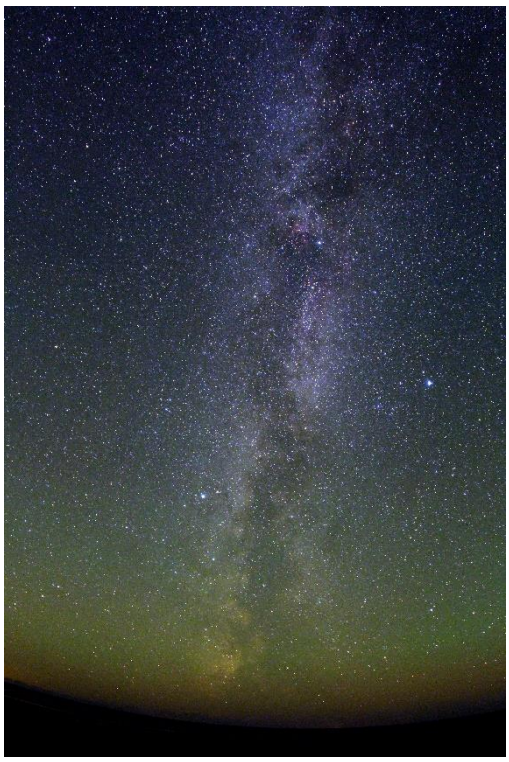

Fig. 10: The Milky Way as observed from Mandø without light sources near the horizon (photo: A. Hänel)

3 Follow-up Activities

The “Trilateral Vision on Dark Sky over the Wadden Sea” [7] is intended to guide and strengthen the efforts to preserve nocturnal darkness and enjoy starry skies in the Wadden Sea Region through awareness raising, stakeholder engagement and monitoring activities. It was signed during the trilateral Governmental Wadden Sea Conference 2022 in Wihelmshaven, where also the new Wilhelmshaven Declaration was signed, which asks for increased activities to protect dark skies in the Wadden Sea Region.

Since 2023 two EU Interreg projects were granted, the smaller project “Keep It Dark” [6] was a cooperation of the universities of Groningen, Oldenburg and Aarhus and aimed at developing robust measurement methods of the sky brightness in the Wadden Sea. The larger Interreg project “DARKER SKY”, led by the university of Brest, aims at reducing light pollution at different pilot sites [8].

Cooperating with NPorts, a society responsible for many Lower Saxony harbours, the reduction of lighting in the harbours where the ferries connect to the islands through adaptive and warmer colour lighting is planned.

A project “Sternenfunkeln über Friesland” [9] in the county Friesland intends to reduce lighting during night through switching-off lights in the late night. It shall be transferred to other municipalities in the Biosphere Region of the Lower Saxony Wadden Sea.

Funding

This work has been partially funded by European Union Interreg Programs “WaddenAgenda 2.0”, “Keep It Dark” and “DARKER SKY” .

References

[1] https://rijkewaddenzee.nl/

[2] https://www.waddensea-worldheritage.org/

[3] https://djlorenz.github.io/astronomy/lp2020/overlay/dark.html

[4] All applications with details and annual reports of the IDSPlaces are available on https://dark-sky.org/what-we-do/international-dark-sky-places/.

[5] CMS (2024) CMS International Light Pollution Guidelines for Migratory Species, p.42 (https://www.cms.int/en/publication/international-light-pollution-guidelines-migratory-species)

[6] https://www.interregnorthsea.eu/kid

[7] https://www.waddensea-worldheritage.org/trilateral-vision-dark-sky-over-wadden-sea

[8] https://www.interregnorthsea.eu/darker-sky

[9] https://www.friesland.de/sternenfunkeln