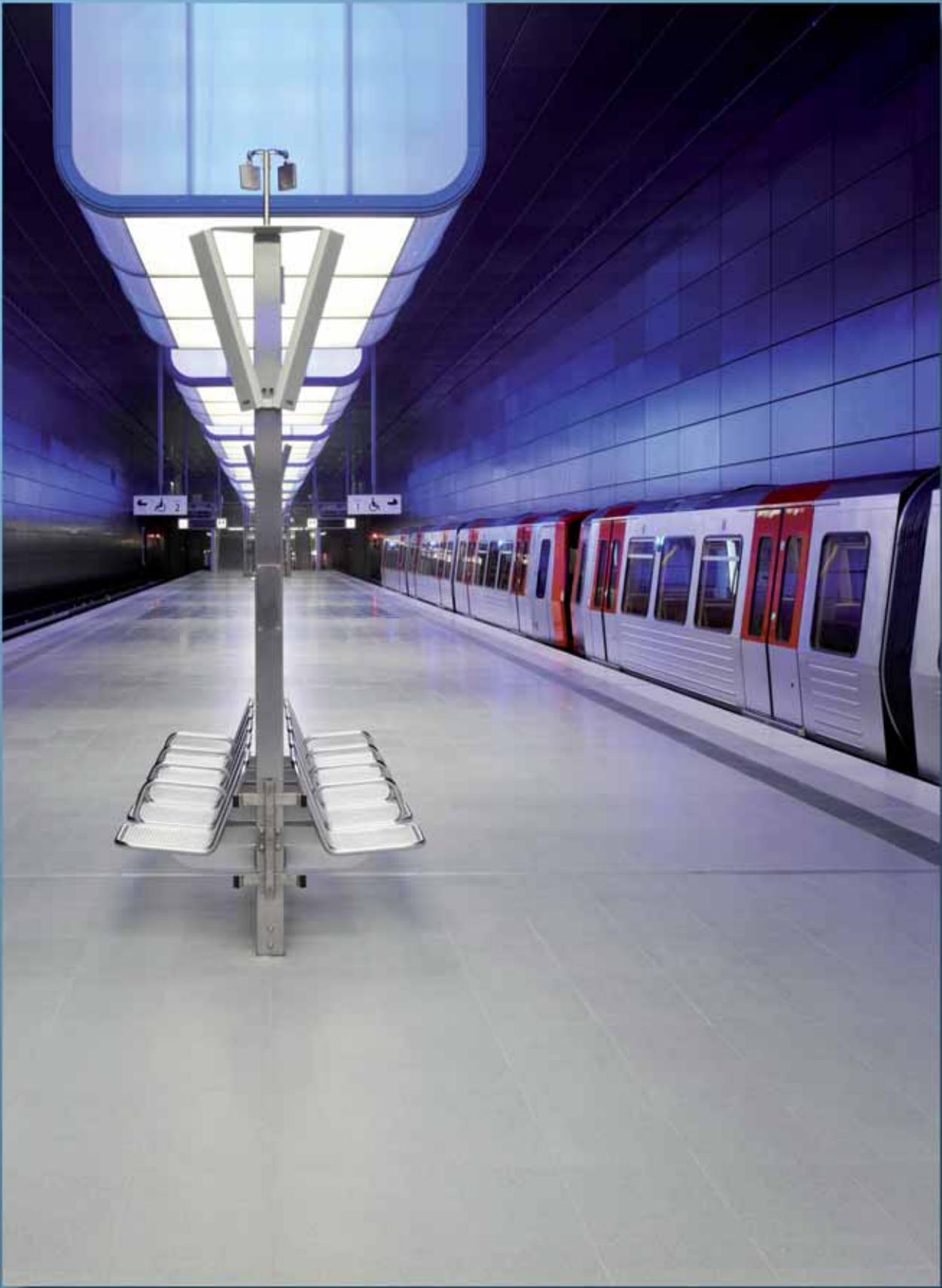


# PROFESSIONAL LIGHTING DESIGN



Magazine for professional lighting design

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To light or not to light?

**REVIEW**  
PLDC 2013

# To light or not to light?

**Exterior illumination of tall buildings and bridges and its negative impact on the life of birds and fish – what professional lighting designers need to know.**

Text: Dr. Karolina M. Zielinska-Dabkowska MSc. Arch, Dipl. Ing. Arch (FH), PhD, PLDA



2,000 dead birds collected by members of the Fatal Light Awareness Program (FLAP) during a single migratory season in fall, 2003 in Toronto's Downtown Financial District, Canada.

Photo: Mark Thiessen/ National Geographic Society.

*Over the last hundred years, people have radically altered the appearance of the night sky. The development of industry, change in lifestyle and mass consumption depending on time of day – have all contributed to the loss of natural darkness in vast areas of our planet.*

*The studies conducted so far indicate that lighting installations visible after dark negatively impact flora and fauna<sup>[1]</sup>.*

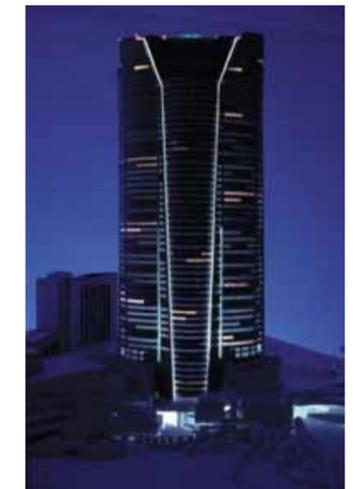
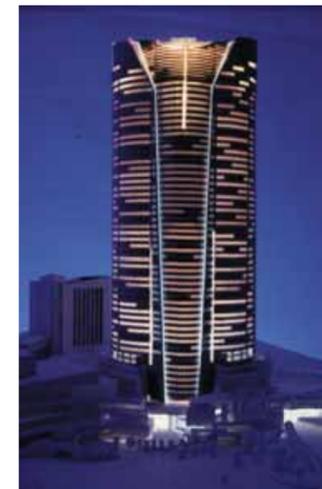
Artificial lighting disrupts the functioning of specific organisms such as birds, fish, bats and insects. Observations have shown that too much artificial light, especially coloured light, can have a huge impact on nocturnal species, misaligning their circadian rhythm. Animal preference for nocturnal activity may be due to factors such as: avoiding predators, aversion to heat, safer feeding or reproduction. Also changes in the intensity of ambient light at night may lead to problems with reproduction, avoidance of suitable habitats, changes in seasonal migration routes, and to a reduction in numbers or even the extinction of certain species.

In spite of the fact that increasingly more research has been performed on the negative impact of external illumination on flora and fauna, unfortunately this is rarely considered in professional lighting design practice, the reason being that researchers and scientists focussing on biodiversity do not share the findings of their scientific work with those who design the lighting – professional lighting designers. On the other hand, lighting designers lack any information available on the above topic and there are no established guidelines to follow.

With this article I would like to start a discussion based on the relatively recent discoveries of how much all life on earth relates to natural light, and to question the idea that evolution has embodied



**The iconic form of 30 St Mary Axe is created by interior lighting only. No external lighting to the façade has been applied to promote the concept of a green building and reduce light pollution.**  
Lighting design: Speirs and Major Associates.  
Photo: Edmund Sumner.



**Mori Tower, Roppongi Hill Tokyo/J. Four different lighting scene settings have been applied to support the night-time environment.**  
Lighting design: Lighting Planners Associates (LPA).

within all living organisms a natural sensitivity towards their native environment, in particular towards white and coloured light. Additionally, I would like to establish a set of guiding principles on how to reduce the negative consequences of external illumination on the lives of birds and fish.

**Illumination of tall buildings and structures**  
Since the invention of the electric bulb the concept of exterior illumination on buildings has captured the imagination of architects, buildings owners, lighting designers and the general public. Exterior architectural lighting is associated with power and prestige. However, with the change in people's perception of the environment and ecological issues it has become a "hot" topic.

For millions of years birds evolved under a day-night cycle, where the bright light of the sun during the day was replaced at night by weak light from the moon, stars and planets. This situation ended very recently when humans started to artificially light the nighttime sky, which is most visible in industrialized areas. Globally, hundreds of millions of migrating birds are affected by the presence of artificial light on a yearly basis during their spring and autumn migration, many of which do not survive the encounter.

The attraction of birds to light has been known for a long time. High bird mortality rates have been recor-

ded in connection with lighthouses<sup>[2]</sup>, illuminated television towers and other uplift structures and buildings<sup>[3]</sup>. According to researchers, many hundreds of species of birds typically migrate at night<sup>[4]</sup>, using the stars as a way-finding system.

When the moon and the stars are shining and there are no clouds, and the night sky seems to be clear, the birds fly over the roofs of buildings, towers and bridges, avoiding the risk of collision. Most migrant birds soar to a height of about 450 metres<sup>[5]</sup>, but some species soar below 90 metres when the visibility is good<sup>[6]</sup>.

It is known that the reaction of local and migratory birds to artificial light is largely dependent on the characteristic wavelength of the light source. Birds also appear to have excellent colour vision, which attracts them to coloured light (they have five different types of visual pigment and seven different types of photoreceptor).

According to research, the long wavelengths such as red and white have disorienting effects on migratory birds due to light frequencies. Hardly any noticeable effect on orientation was recorded under short wavelength light (such as blue and green light)<sup>[7]</sup>.

Depending on the wavelength, artificial light may interfere with the functioning of the internal compass in a bird's brain, a key orientation mechanism. When there is no indication in the sky and the stars are obscured by clouds or fog, the



**Petronas Towers Kuala Lumpur/MAL.**  
This project is unfortunately a great source of light pollution. It directs the light into the sky, and the white light negatively impacts migrating birds.



**The Eiffel Tower as the highest point in the Paris skyline. It is illuminated using yellow light, thus attracting migrating birds.**

**Photo: roddh/ Flickr.**

magnetic orientation serves to help migratory birds<sup>[8]</sup>.

Artificial light under moonless conditions impairs birds' ability to orient themselves. Due to brightly, externally lit glass buildings, birds can become confused and fly into lit windows. At lower levels of the buildings, they may also fly into images of trees reflected in the glass.

Laboratory experiments have shown that migratory birds require light from the blue-green parts of the spectrum for magnetic compass orientation<sup>[9]</sup>. The use of magenta, blue and indigo light has a minimal effect on their disorientation, and red and white has a negative impact – the birds are "trapped" in a lit area, they cannot return to the darkness or designated migratory routes<sup>[10]</sup>.

Research has shown that this depends on the presence of light below 590 nanometers (yellow light). Thus, because of the lack of shorter wavelengths necessary for the operation of the magnetic orientation yellow and red light can lead to confusion and birds circulating around the light<sup>[11]</sup>.

If tall towers require warning lights placed on roof and walls for reasons

of aviation safety, the use of saturated red or pulsating red beacon lights at night should be avoided. Current research indicates that saturated or flashing red lights attract night-migrating birds at a much higher rate than white strobe lights<sup>[12]</sup>.

Unfortunately for non-migratory bird species, such as urban and rural European blackbirds (*Turdus merula*) in urbanised zones, conducted studies show that artificial light at night caused by light pollution is disturbing a broad range of behaviours and psychological processes. Exposure to blue-rich white light, similar to humans, reduces melatonin release. In birds, this impacts a progressive start to their morning singing activity<sup>[13]</sup> as well as considerable effects on the timing of procreative performance and individual reproducing patterns<sup>[14]</sup>.

An analysis of existing exterior lighting schemes for "skyscrapers" and other tall structures, indicate that only a few of them are bird-friendly, and that these few are designed by professional lighting designers.

One such excellent example is the scheme for the 30 St. Mary Axe pro-

ject in the heart of London, designed by architect Norman Foster and Speirs and Major Associates where there is no exterior lighting applied at all. Despite this decision, the building is recognizable in the city and regarded as an icon of architecture during the day and after dark.

Another remarkable and very sensitive lighting approach comes from Japan. To support the sustainable approach to reduce energy use and carbon emission, four different lighting scenes were proposed by Lighting Planners Associates (LPA) for Mori Tower in Tokyo, Japan. From dusk until 8 pm, from 8 pm to 11 pm from 11 pm to 2 am and from 2 am to dawn.

When thinking on a global scale it is worth mentioning a new initiative called Lights Out Boston [<http://www.cityofboston.gov/environ->

[mentalandenergy/conservation/lightsoutboston.asp](http://mentalandenergy/conservation/lightsoutboston.asp)] which was started in 2008. Under this voluntary programme participating building owners and managers agree to turn off or dim all architectural and interior lighting between 11 pm and 5 am during the spring (March 1 to June 1) and fall (August 15 to October 31) migratory bird season. Buildings committed to this programme have saved money through reduced energy consumption, reduced the risks of climate change, and made a substantial contribution towards protecting wildlife.

#### **Guidelines for bird-friendly illumination**

⇒ develop bird-friendly artificial lighting which does not attract and disorient birds  
 ⇒ use intelligent lighting control systems  
 ⇒ avoid white and red light which interferes with the magnetic compass of migrating birds (this magnetic compass is especially important to birds on overcast nights, when celestial cues are not visible)  
 ⇒ seek professional advice from specialists such as ornithologists

about the migratory seasons  
 ⇒ switch off lighting between midnight and dawn when most of the migration occurs  
 ⇒ recommend that architects and building owners block windows (opaque curtains, blinds, shades) on glazed facades after dark if the lights cannot be switched off  
 ⇒ avoid using uplighting on a facade, if necessary always shield the lights  
 ⇒ suggest to building owners and managers that office cleaning is carried out during the daylight hours.

#### **Illumination of bridges**

Another group of animals for whom light, both direct and indirect play a significant role are fish. In the majority of fish, visual organs play an important role in orientation during swimming<sup>[15]</sup>. The behaviour of fish, and in particular their diurnal activities, depends significantly on the degree of illumination. Based on research conducted by Nikolsky at the beginning of the 60's light has a strong impact on fish metabolism, growth, behaviour and colouration<sup>[16]</sup>. Fish, like humans, have photoreceptors (cone cells)

in their eyes which enable them to distinguish between colours and adapt to the brightness of light<sup>[17]</sup>.

Light conditions in the water differ from those on land not only in the luminous intensity but also in the penetration of various wavelengths depending on the depth of the water. The longer wavelengths (i.e. red, orange) are absorbed first, with over 25 per cent of red light being absorbed in the first metre of water, while blue and green light is not absorbed to a large extent. This is why we perceive the sea as being blue or blue-green.

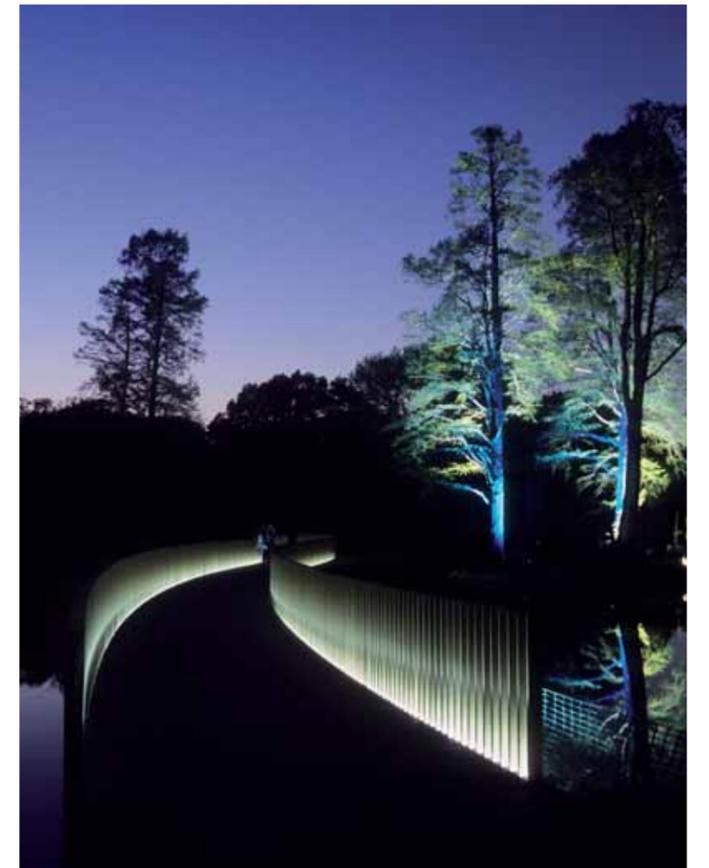
The visual spectrum of fish depends on the nature of their habitat. Those who live mainly in shallow water, such as ponds, lakes and rivers, are more sensitive to longer wavelengths of light (red, orange), while, as depth increases in seas and oceans, the visual spectrum narrows considerably to the colours blue and green<sup>[18]</sup>. The majority of fish can distinguish colours quite well up to 15 metres.

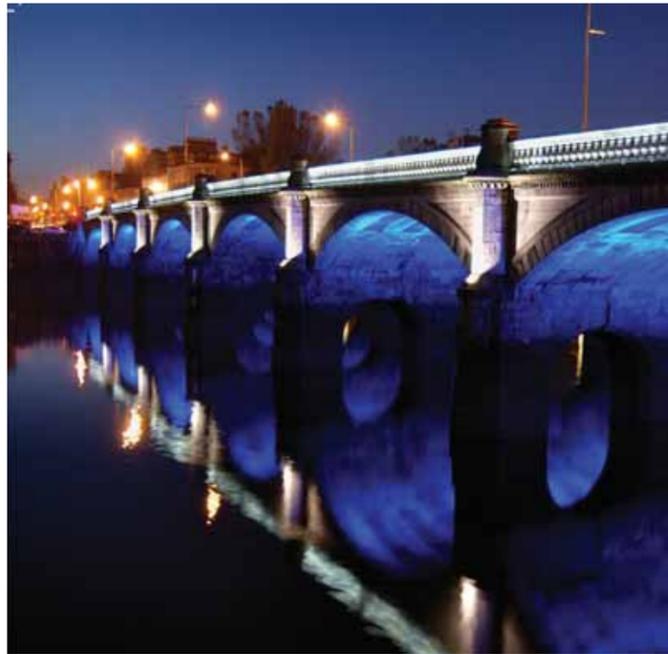
It is also known that light similar in intensity to that of a full moon (0.05 to 0.1 lux) or less can dramatically affect the behaviour and spatial



**Sundial Bridge in Sacramento/USA is illuminated by 120 large floodlights, some of which are directed upwards and the others downwards towards the water and have a negative impact on fish migration.**  
**Photo: Tarek Abdellatif.**

**Sackler Crossing, Royal Botanic Gardens, London/UK is an excellent example of the application of exterior illumination in an ecologically sensitive zone.**  
**Lighting design: Speirs and Major Associates.**  
**Photo: James Newton.**





Glasgow Bridge, Glasgow/UK lit with blue and white light reflected in the water, which attracts fish.

distribution of freshwater and estuarine fish, which are all affected by natural diurnal and lunar cycles of light<sup>[19]</sup>. Artificial light from a single source and equivalent to the intensity of starlight (0.0005 to 0.001 lux) is sufficient to affect the behaviour of some freshwater fish<sup>[20]</sup>.

Therefore artificial light from illuminated bridges can have a significant impact on the migration of certain fish. Young salmon species migrate through streams and rivers to the oceans and seas, the adult fish migrating upstream to spawn. These fish migrate at night, cued by artificial illumination levels when the natural lighting is reduced – for the fish, the easiest way to avoid the predators and increase their chances of survival.

Observations have shown that artificial illumination of many bridges presents a possible predator trap for wild salmon migrating from areas above the bridges. Predators position themselves under lights on a bridge to locate and capture the fish. Hunting increases the migrant shoal, which in turn reduces the number of fish successfully migrating<sup>[21]</sup>.

An example of the negative effects associated with the use of artificial light is Sundial Bridge in Turtle Bay, Redding, California designed by architect Antonio Calatrava. This unique pedestrian bridge across the Sacramento River

in California, although aesthetic in its appearance, is not environmentally friendly in regard to its illumination at night. The lighting under the bridge is a serious threat to the environment<sup>[22]</sup>.

Observations show that the illumination of the bridge is a trap for migrating wild salmon; predators lurk beneath the lit bridge, to locate and track down passing fish.

Sundial Bridge is illuminated by 120 large flood luminaires, some of which are directed upwards and some downwards towards the water. The luminaires directed "down" are switched off at 11 pm., while the "uplight" component remains switched on throughout the night<sup>[23]</sup>. Unfortunately, because the bridge is painted white, the light is reflected from the surface, causing constant illumination of the water surface.

The Sackler Crossing project in the Royal Botanic Gardens in Kew, near London, is an excellent example of the application of exterior illumination in an ecologically sensitive zone. Kew Gardens is a vast complex of landscaped gardens and greenhouses. The beautiful, sculptural, S-shaped bridge spans the surface of the lake blending harmoniously with the environment. Its night-time appearance is the result of a cooperation between architect (John Pawson), lighting

designers (Speirs and Major Associates), luminaire manufacturer (ACDC Lighting) and ecologists from the Royal Botanic Gardens<sup>[24]</sup>.

Based on the examples presented above it is obvious that during the design phase it is important to understand whether the object is located in a town or city centre with a high level of night-time urban activity where there is already light pollution or whether it is a naturally dark landscape such as a natural park, or an area of outstanding natural beauty where illumination may have negative consequences for the environment.

#### Guidelines for fish-friendly illumination

⇒ develop a design approach that considers fish life when applying artificial lighting  
 ⇒ avoid white, blue and green light which attracts and disorients fish  
 ⇒ use intelligent lighting control systems to allow maximum control of light during dark hours  
 ⇒ switch off any lighting components which are focussed directly onto the water or reflected by the water surface during migratory periods as well as every night from midnight onwards  
 ⇒ switch off lighting between midnight and dawn where most migrations occurs

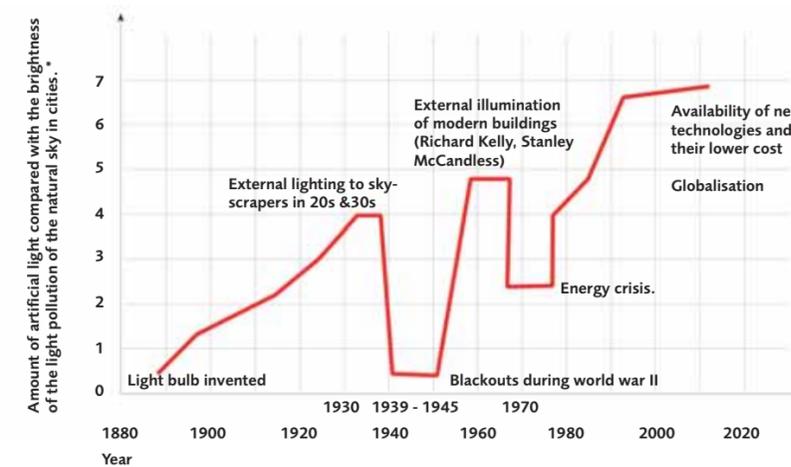
⇒ always shield light sources  
 ⇒ propose the use of non-reflective surfaces, finishes and paints to architects to minimize the reflectance of light  
 ⇒ seek advice from specialists such as ichthyologists about migratory times.

Today incorrectly applied exterior illumination to tall buildings, structures and bridges is adding to light pollution. This term is often used to describe excessive artificial lighting at night, especially in large urban agglomerations. Contamination of this kind makes it difficult for astronomers to observe the sky, and has a negative impact on the flora and fauna which are naturally nocturnally active. This effect is most pronounced in developed and densely populated cities in North America, Europe and Asia.

The graph on the right-hand page shows the development of exterior illumination in cities in developed and developing countries based on the increased light pollution of the earth's atmosphere. The extent of future exterior illumination will definitely continue to have negative consequences for flora and fauna.

#### Conclusion

In recent years we have already witnessed a shift in the approach



Development of exterior illumination in cities in developed and developing countries based on the increased light pollution of the earth's atmosphere.

\* The higher the number on the ordinate, the greater the pollution of the earth's atmosphere through artificial light. Source: PhD research work conducted between 2010-2013 by Dr. Karolina M. Zielinska at the Faculty of Architecture, University of Technology Gdansk/PL.

#### Legend

- 0 – Naturally dark landscapes as natural parks, areas of outstanding natural beauty (The Milky Way is sufficiently visible and clear.)
- 1 – Rural areas (Some light pollution on the horizon. Distant galaxies visible with the naked eye.)
- 2 – Rural and dark suburban areas of towns (Light pollution is more obvious. The Milky Way is visible but lacks details.)
- 3 – Semi-suburban areas (Light pollution extends to 45 degrees above the horizon.)
- 4 – Semi-suburban areas (The Milky Way is visible at the top of the sky, but not on the horizon. Clouds appear brighter than the sky.)
- 5 – Bright suburban areas (The Milky Way is faintly visible only at the top of the sky. The sky is grey up to 35 degrees above the horizon.)
- 6 – Towns and city centres with a high level of night-time urban activity (Urban sky glow in white or orange. Star constellations appear weak or are not visible.)

towards exterior illumination with a focus on understanding what the negative consequences of using artificial lighting at night are. However, many designers do not pay sufficient attention to the impact of our artificially lit surroundings and how they influence flora and fauna with negative consequences for evolutionary development. Artificial lighting is applied on towers and bridges almost nonchalantly with the sole purpose of achieving beautifying effects.

It is also necessary to understand that the only way to minimise such negative issues will be for cities to implement lighting masterplans developed by professional independent lighting designers commissioned by city representatives. Documents in the form of a set of guidelines will be helpful for lighting designers, engineers, architects and other members of the design teams responsible for the lighting design and give guidance on how to deal with problematic issues. They would also support planning authorities.

Furthermore, other vital documents forming part of environmental impact assessment of future external illumination for areas based on the degree of their sensitivity should be established after thorough consultation with ornithologists and ichthyologists as well as other consultants

from the biodiversity field defining the migratory times, when light should be switched off completely during the night and early hours of the morning and during non-migratory periods special procedures/designs should be in place to reduce the mortality of birds and fish.

Based on the above examples it is clear that anyone designing lighting has a social and environmental responsibility. It is our obligation as experts to be aware of the latest research, continue our professional development by expanding our existing knowledge, and frequently question our approach towards the projects we are involved in.

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