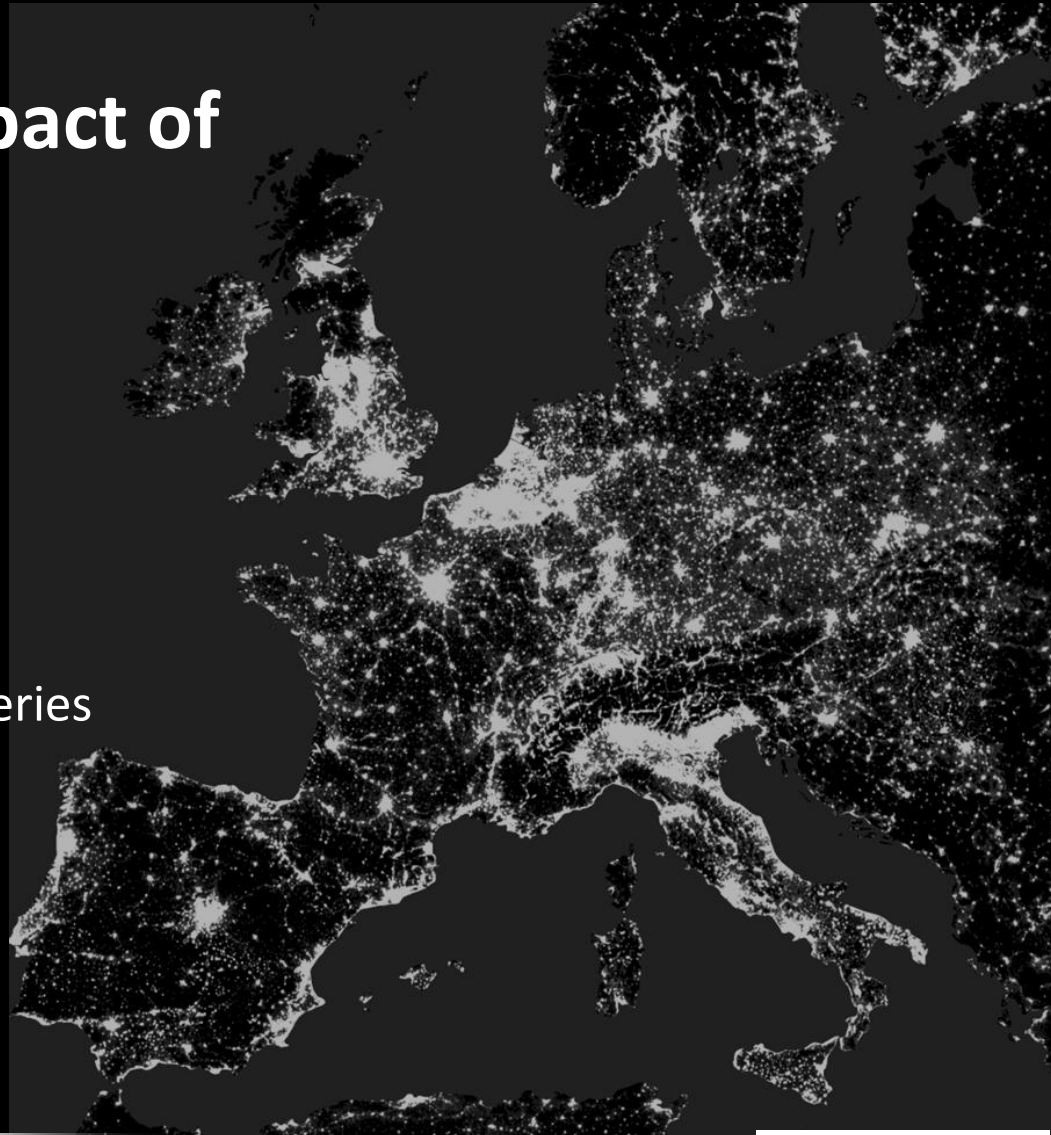


Port Emissions: the impact of artificial light (ALAN)

Dr. Sibylle Schroer
Leibniz Institut
of Freshwater Ecology and Inland Fisheries

“Greening Ports”, NABU HH, 01/06/2015





ESA-NASA, night time view on Northern Europe

9
Inner City sky

7
Suburban/urban
transition

5
Suburban sky

3
Rural sky

1
Excellent dark
sky site

Altair

Rasalhague

IC 333

IC 4665
Cebalrai

Sabik

Jupiter

Nunki

NGC 6530

Idia

Red is the new black

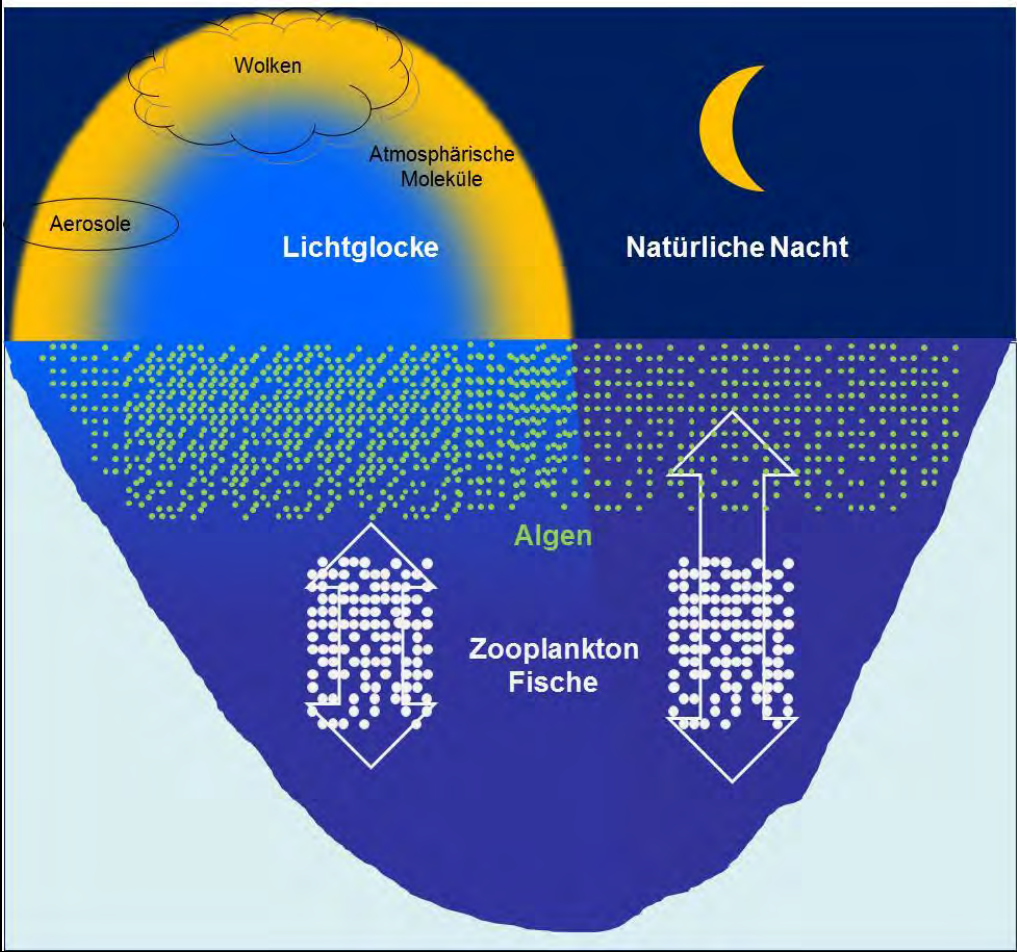
Kyba et al. Mon. Not. R. Astron. Soc. (2012)



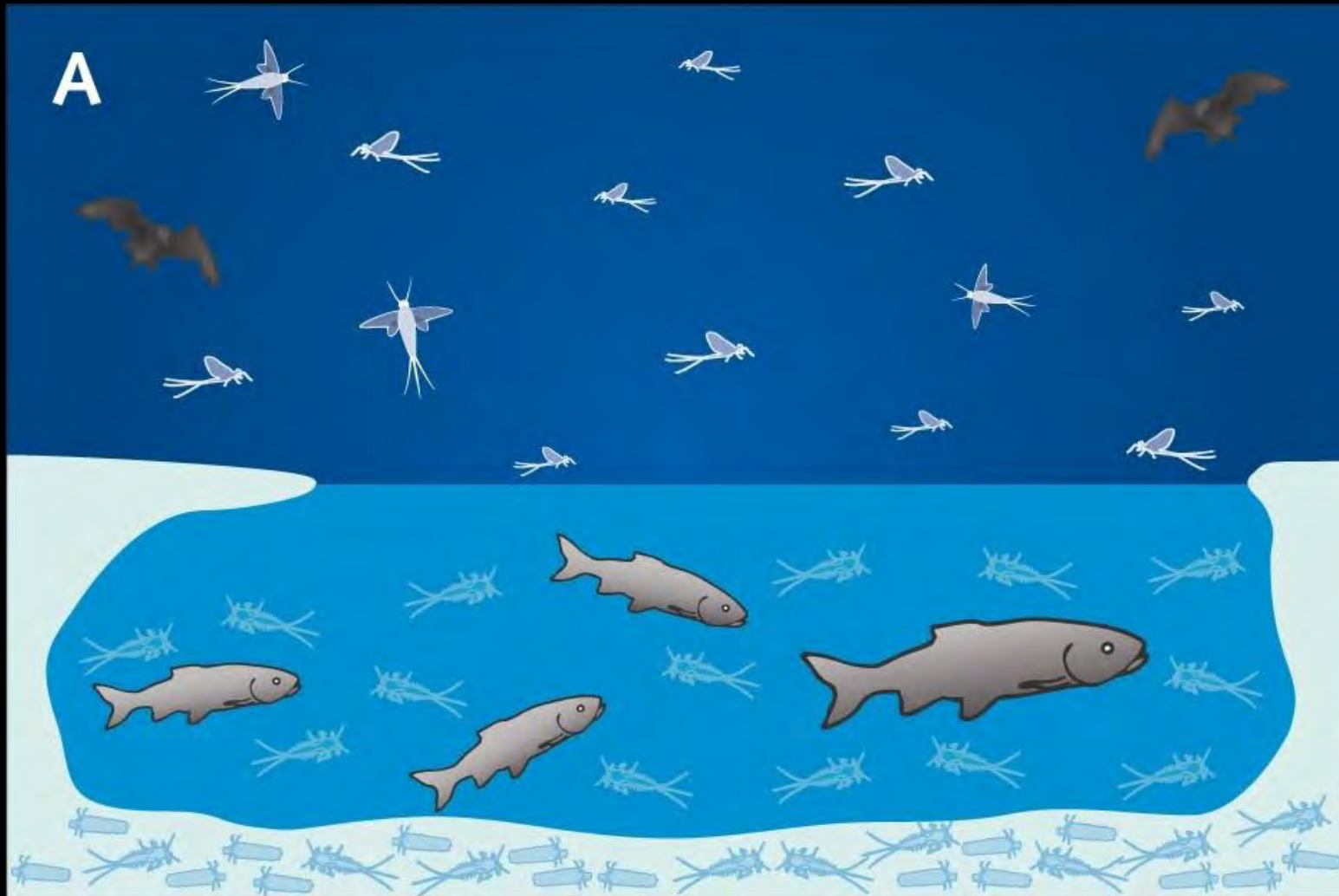
<http://airfactsjournal.com/files/2013/01/clouds-at-night.jpg>

<http://davidpj.files.wordpress.com/2009/11/night-clouds.jpg?w=800>

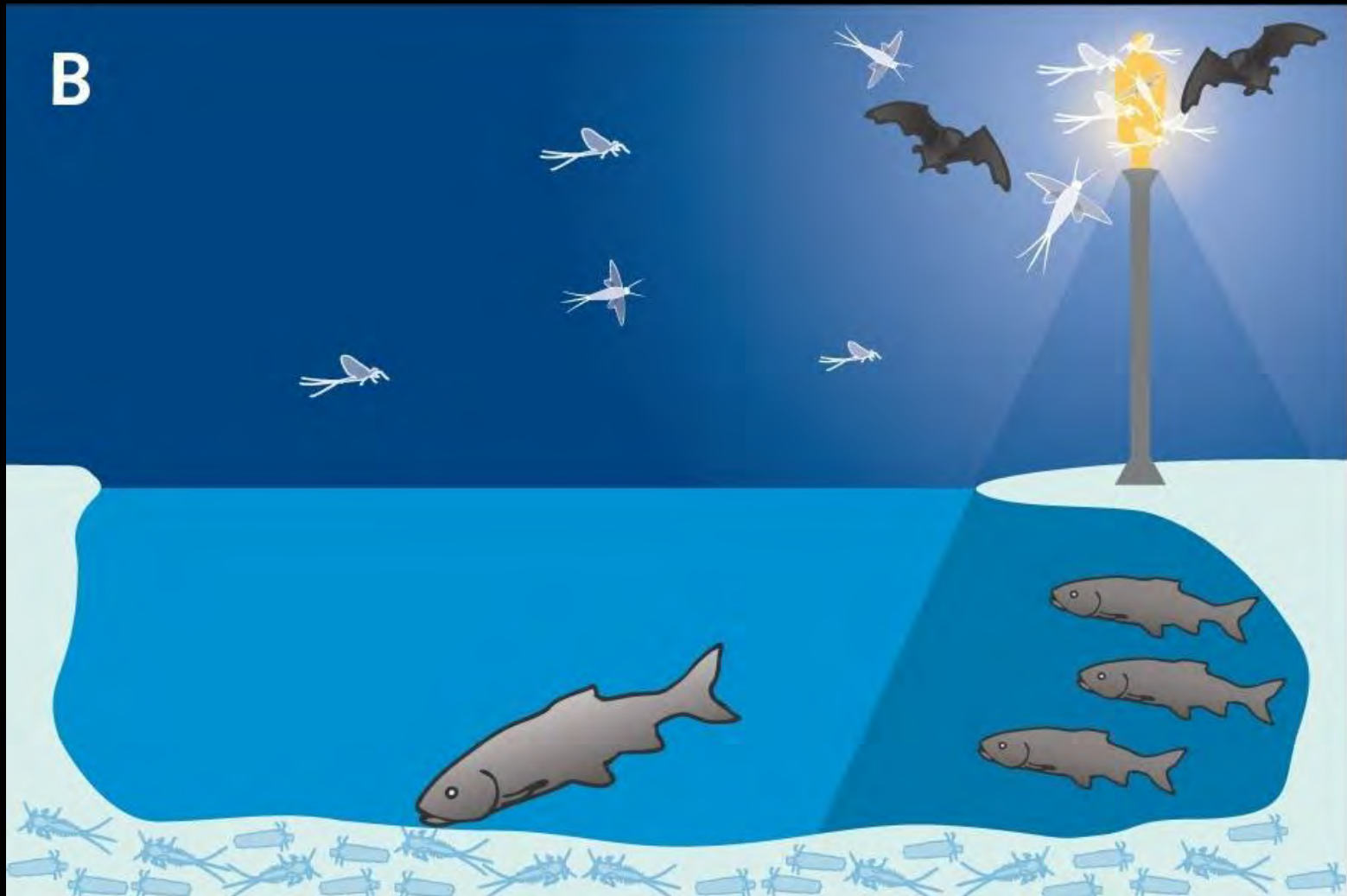
Skyglow can change ecological behaviour



The interest of ecohydrologists



...on light pollution



ALAN attraction



ALAN lures insects out of their ecosystem function, enforcing community shifts and loss in biodiversity



In water organisms like amphipods are as well attracted to ALAN in high numbers Navaro-Barranco C & Hughes LE. Marine Pollution Bulletin (2015).

Species navigating by celestial light cues can become disoriented



Migrating species can be obstructed by ALAN



© Jens und Kai Greve

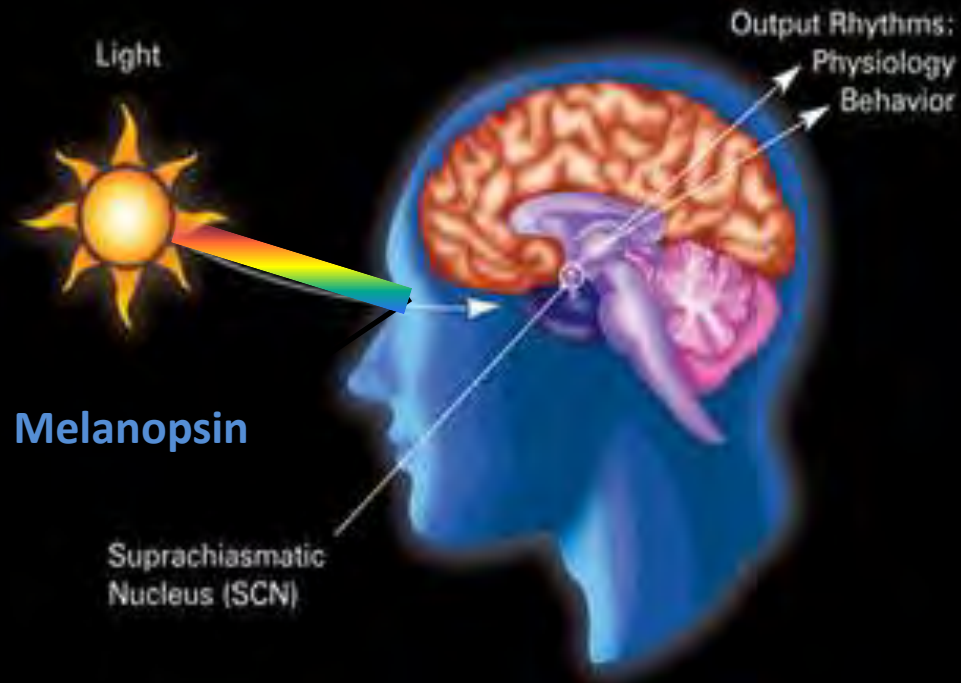


© E. Richter

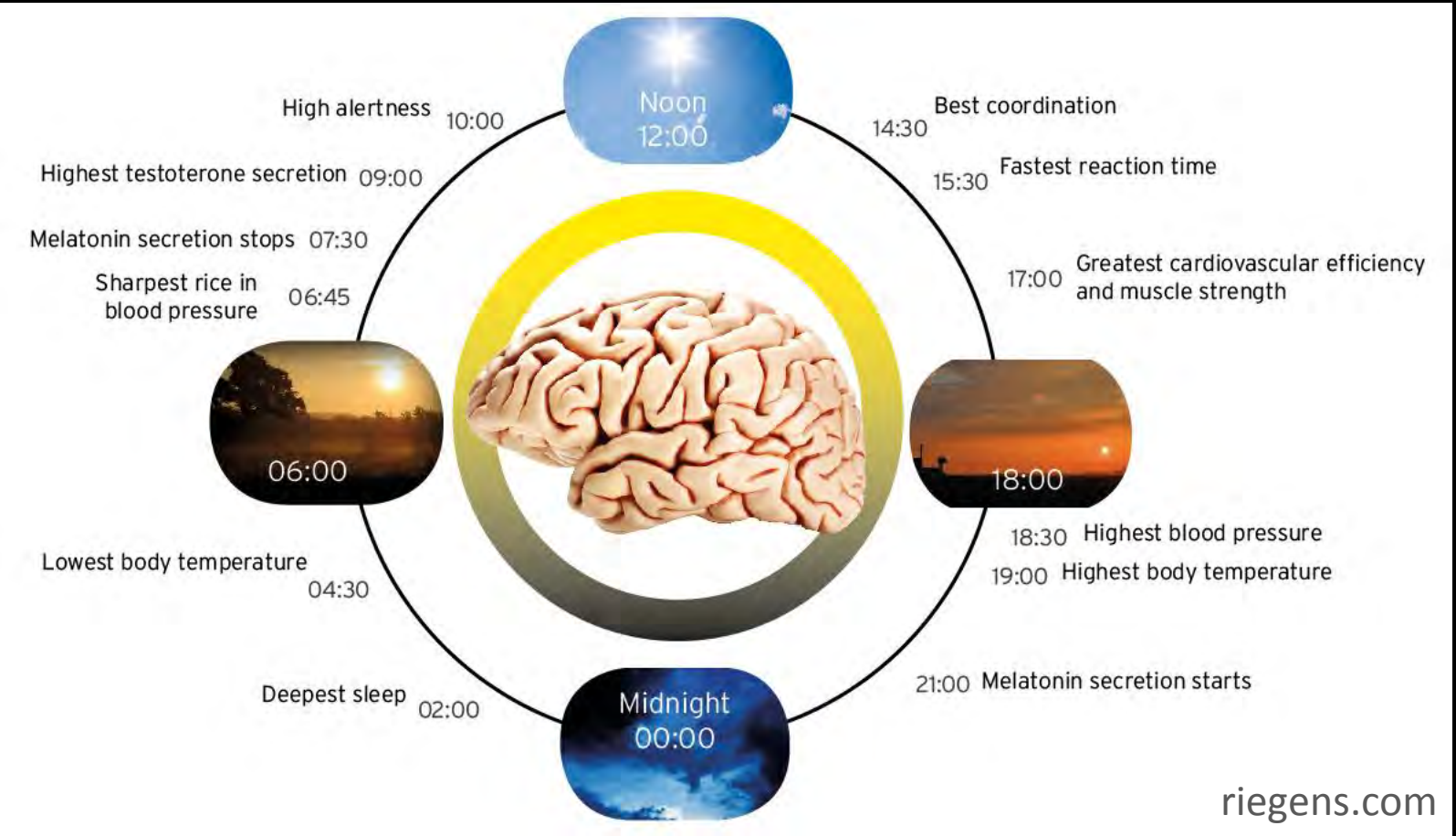
The night as living space

	Estimated number of described species	Thereof nocturnal[%]
Vertebrates		
Mammals	5 488	63,8
primates (incl. <i>H. sapiens</i>)	432	31
bats	1100	100
birds	9 990	19,6
reptiles	8 969	16,6
amphibians	6 433	93,3
Fishes	30 700	14,1
Total	61 580	28,0
Invertebrates		
Insects	950 000	49,4
Lepidoptera	180 000	77,8
Coleoptera	500 000	60
Crustacean	40 000	50
Arachnidae	98 000	5
Molluscs	81 000	?
Coral	2 175	?
others	61 209	?
Total	1 232 384	64,4

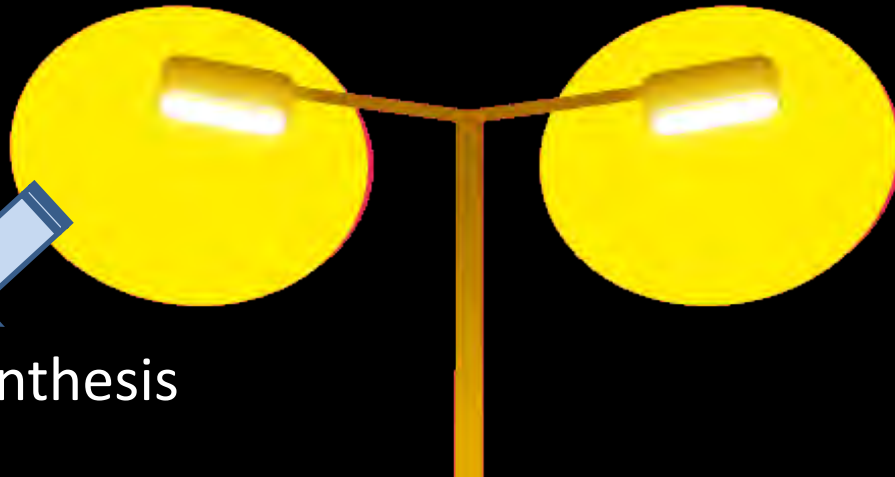
The circadian rhythm



The circadian rhythm



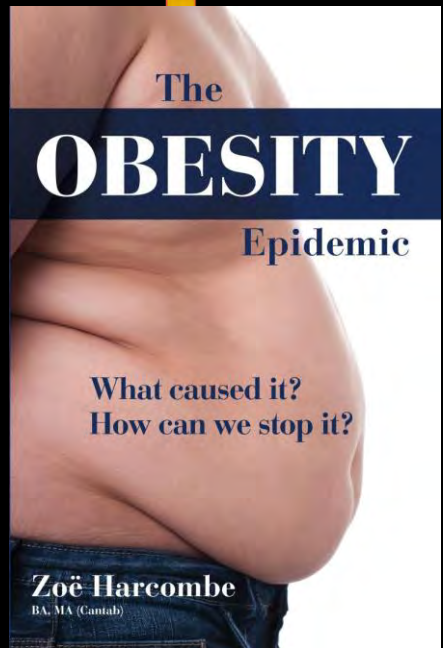
Health risks due to disturbed wake-sleep rhythms

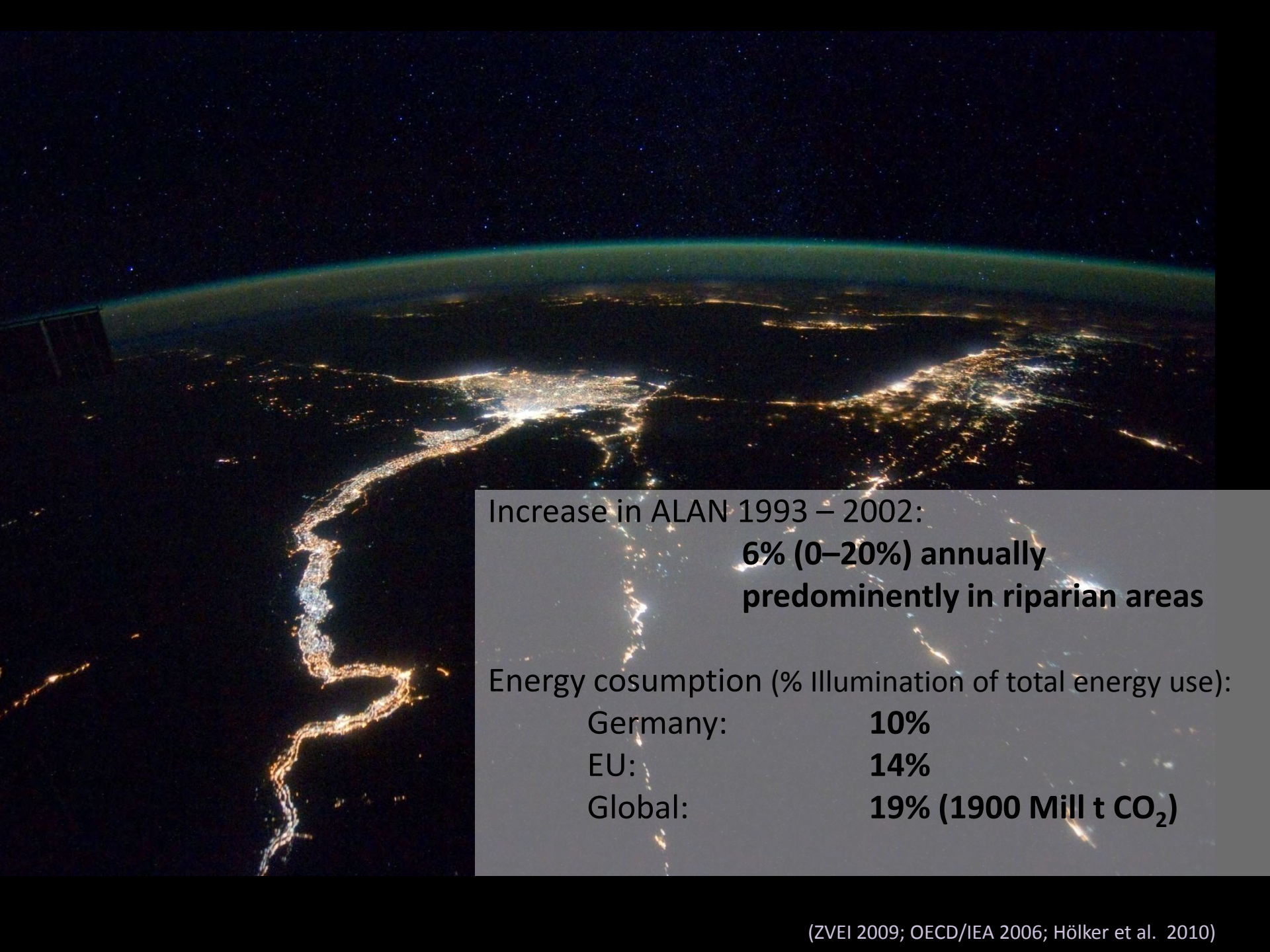


Suppression of melatonin synthesis



- sleep disorder
- cardiovascular disease
- weakening of the immune system
- increased risk of common public disease





Increase in ALAN 1993 – 2002:

6% (0–20%) annually
predominantly in riparian areas

Energy consumption (% Illumination of total energy use):

Germany:	10%
EU:	14%
Global:	19% (1900 Mill t CO₂)

Aerial survey and spatial analysis of sources of light pollution in Berlin, Germany

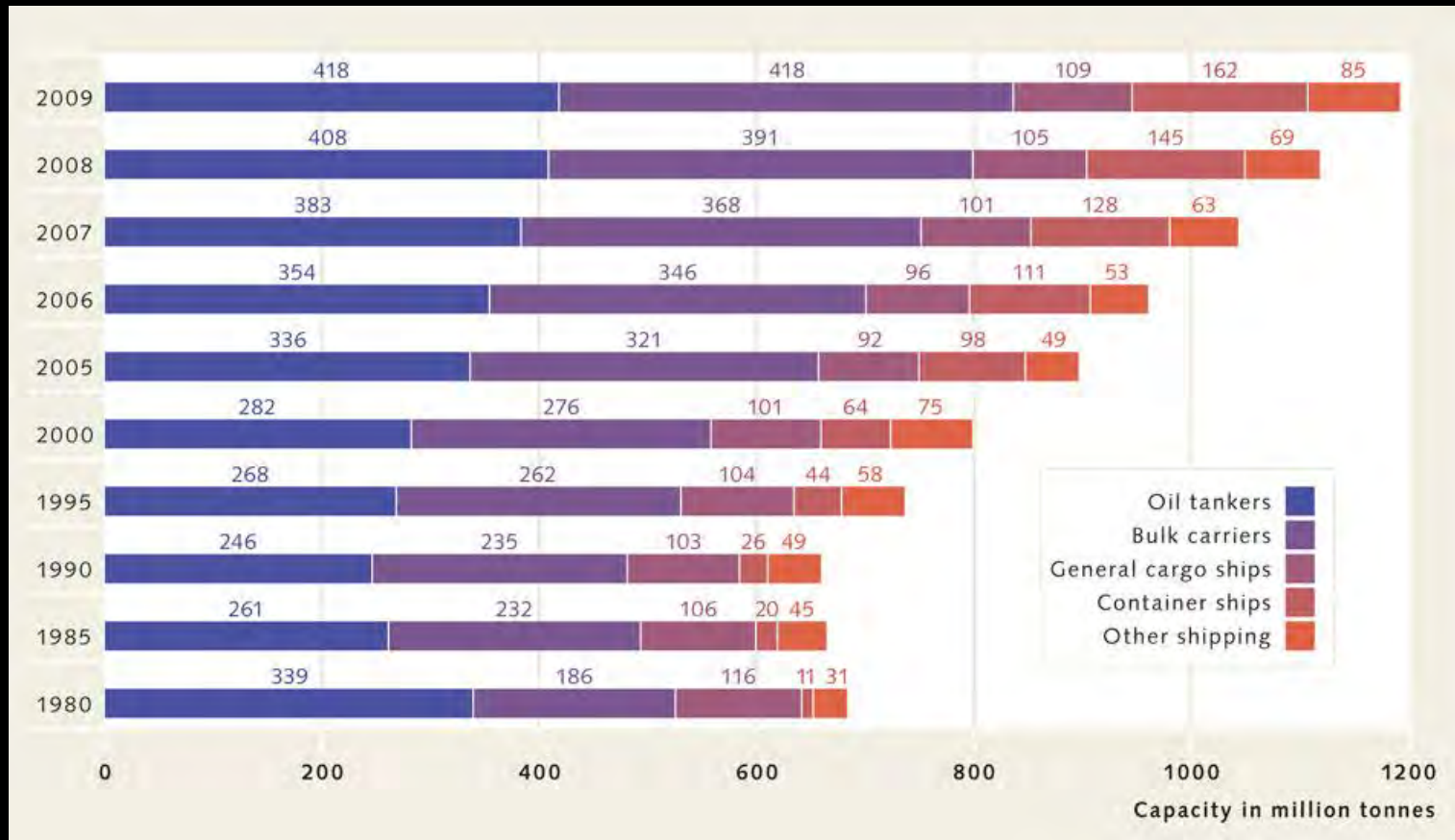
Kuechly et al. Remote Sensing of Environment (2012)



Numbers for annual economic growth rates in ports

- From 2000 to 2008 world trade increased by an average 5.4 % each year, while economic activity, as measured by the global Gross Domestic Product (GDP), increased by only 3 per cent per annum
- Seaborn trade has grown by 400% in the past 40 years, container sector is expected to grow another 400% until 2022
- World capture fisheries production has grown from 1950 with < 3 to about 80 Million tonnes in 2012, however, the world catch tonnage is falling as a result of serious resource problems
- The cruise industry has an worldwide estimated annual passenger growth rate of 6.55 % from 1990 - 2019
- Marinas and recreational boats: 6 % annual growth rate for recreational vessels, 95% of which are >8 m and operate close to shores

The growth of the global merchant fleet according to type of vessel



World ocean review

<http://worldoceanreview.com/en/wor-1/transport/global-shipping/>

Fishing boat with 12.000 W to attract fish

Till Credner, www.AlltheSky.com



Fishing with Lights, Croatia Lastovo 2013



Hidden costs





Bridge spider (*Larinioides sclopetarius*)

Native spider species

Food: emerging aquatic insects

Natural habitat:

riparian stones

Reproduction rate is 300 times increased
due to the living conditions in the
construction works of HH harbour city

Anja Kleinteich (2010) University HH



What can be done?

Direct the light to where it is needed

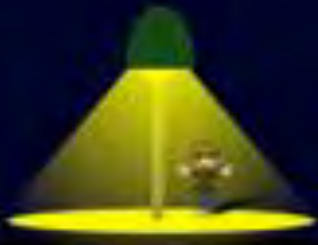


very bad

bad

better

best



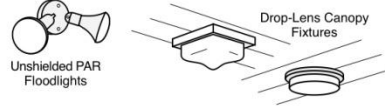
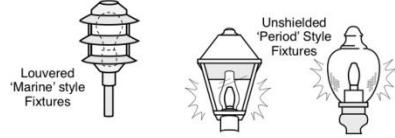
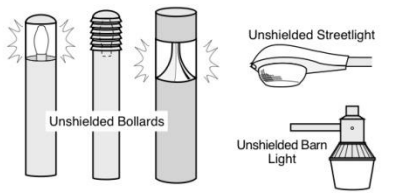
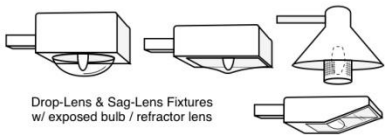
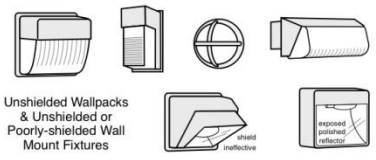
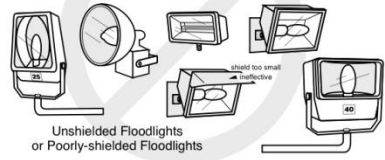
Acceptable and unacceptable lighting fixtures

www.crelin.com

Examples of Acceptable / Unacceptable Lighting Fixtures

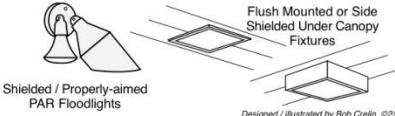
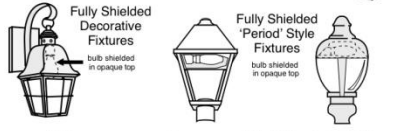
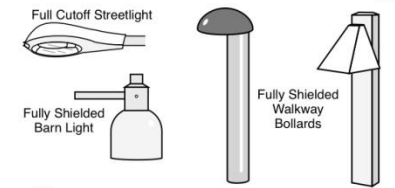
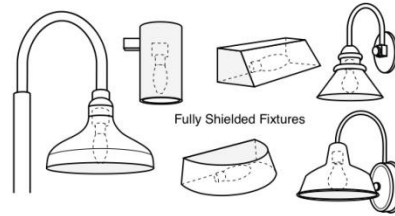
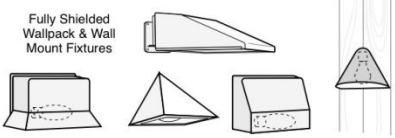
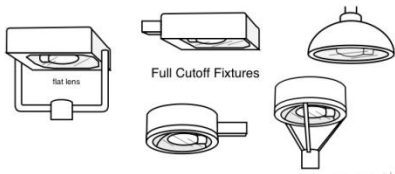
Unacceptable

Fixtures that produce glare and light trespass



Acceptable

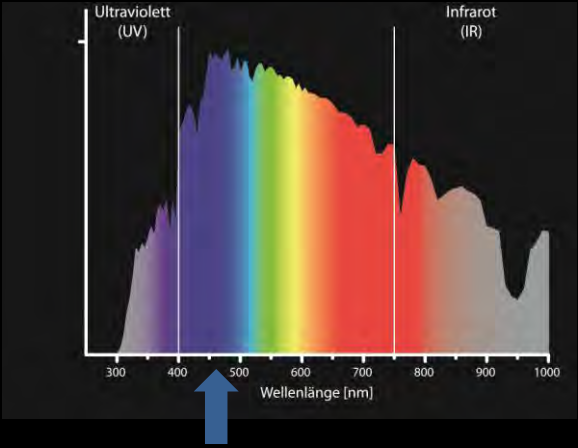
Fixtures that shield the light source to minimize glare and light trespass and to facilitate better vision at night



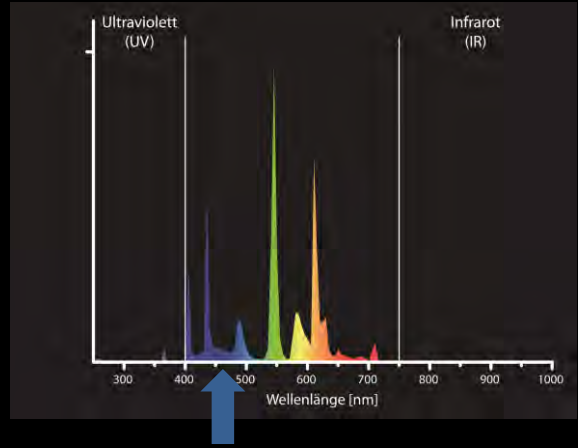
Designed / Illustrated by Bob Crelin ©205

The choice of the illumination is important!

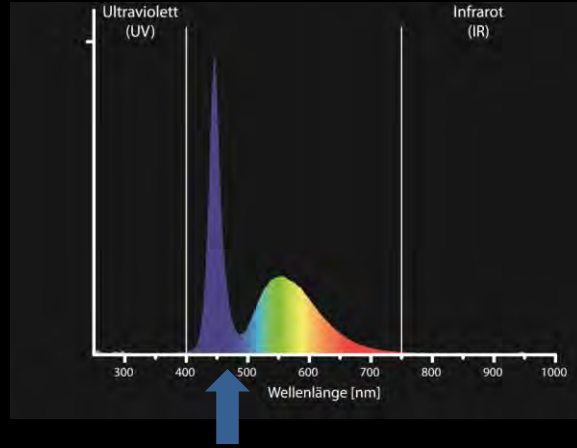
Sun light



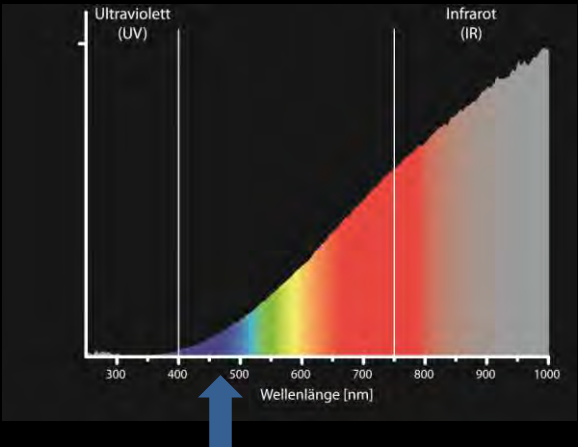
fluorescent



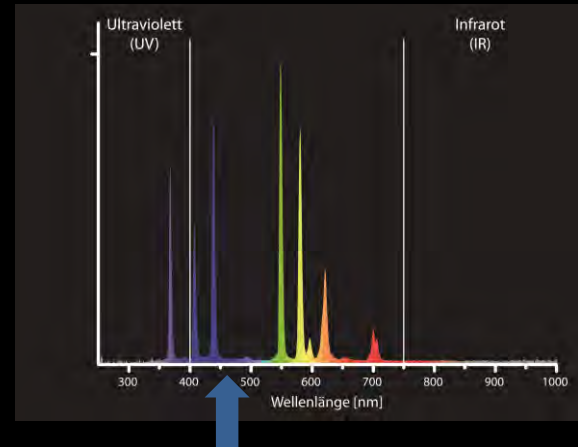
LED



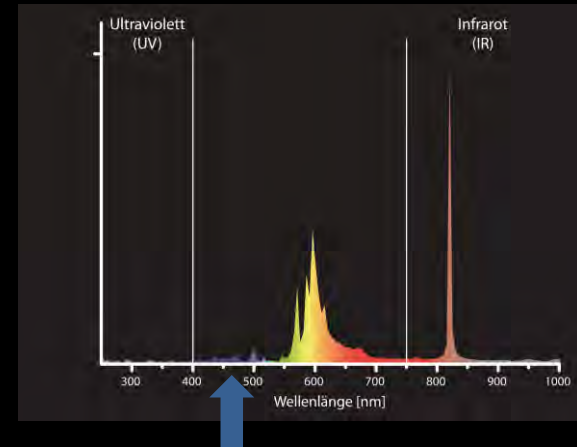
Incandescent



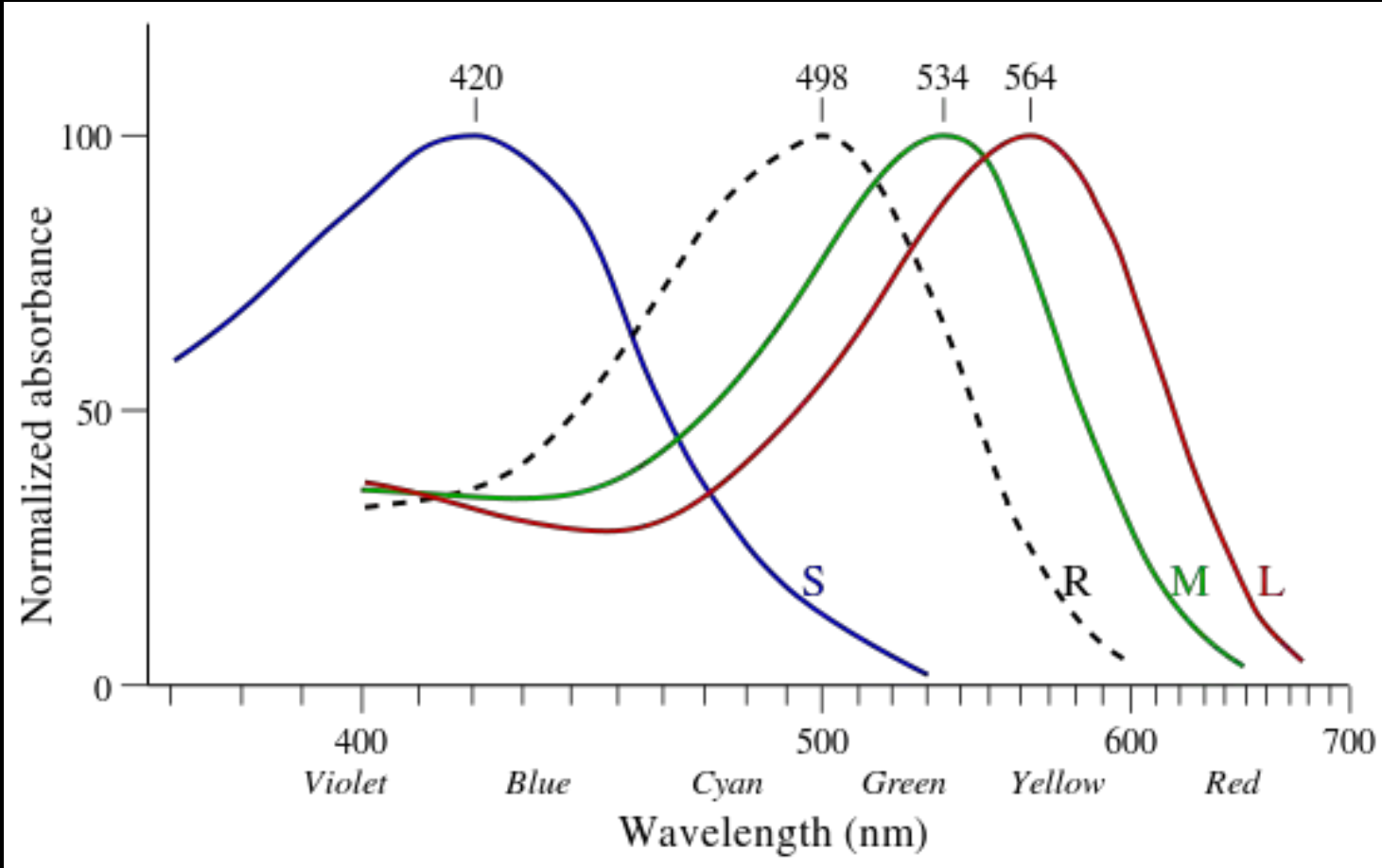
Mercury vapour



Sodium vapour

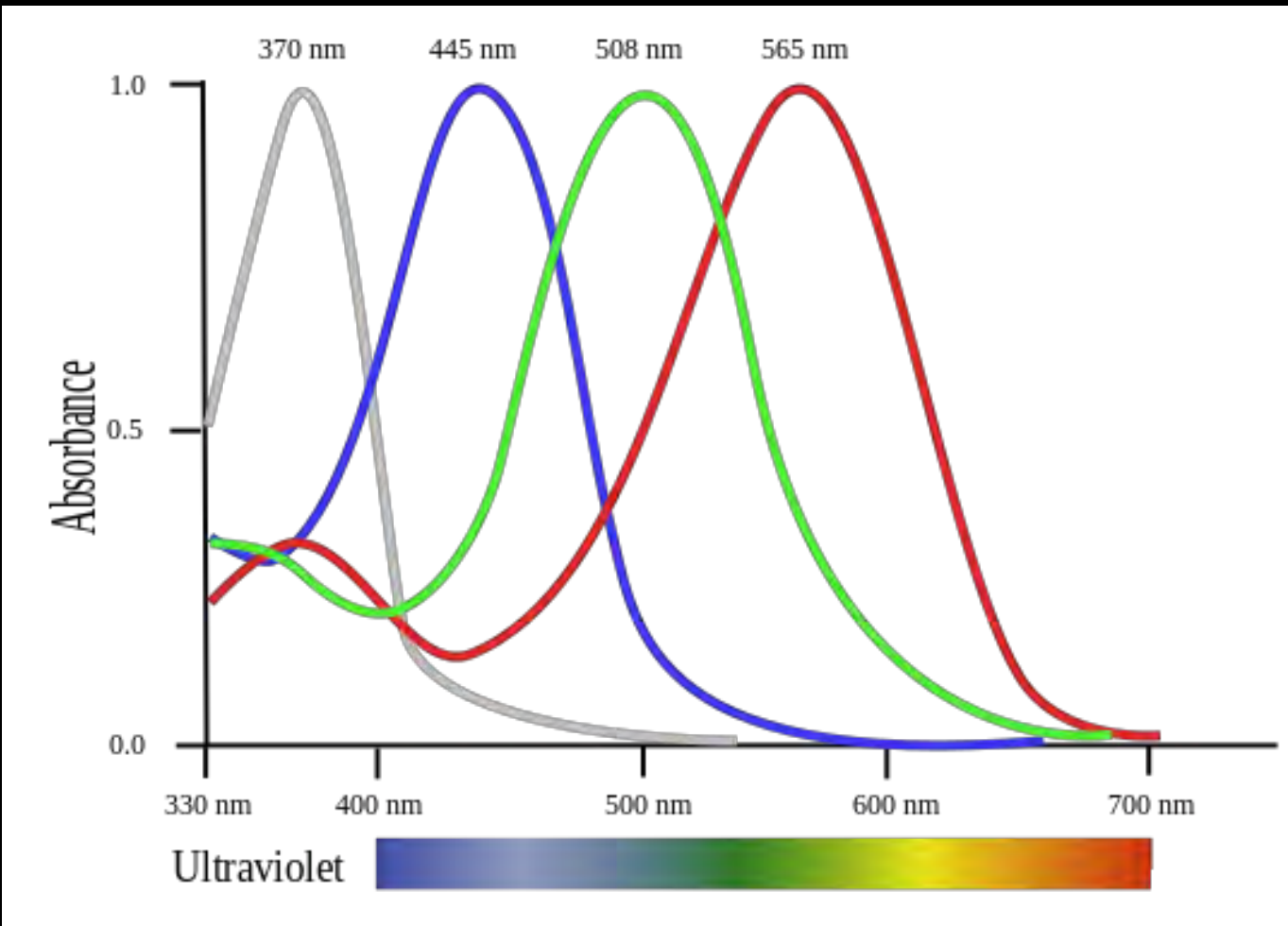


Human Cone-response and rhodopsin



Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:Cone-response.svg#/media/File:Cone-response.svg>

Several species of birds, fish, amphibians, reptiles and insects are tetrachromatic



"BirdVisualPigmentSensitivity" by L. Shyamal - Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:BirdVisualPigmentSensitivity.svg#/media/File:BirdVisualPigmentSensitivity.svg>

Philips solution for oil platform to attract less birds

Poot et al., Ecology and Society (2008)

Traditional Lighting



“Bird Lighting”



Tucson airport, USA



- In 2014 lighting was changed around the terminal, roadways and parking lots
- Energy savings of >1.5 million kwh
- Total project costs was \$ 813 000, payback is estimated by 4 to 27 years.

Tucson airport: Lumen comparison

9/17/2014

TUCSON INT. AIRPORT NEW AND OLD LUMENS COMPARISON FOR LED FIXTURES ACQUISITIONS PROJECT (2014).

AREA	OLD SYSTEM				
	QTY.	LGT. TYPE	DESCRIPTION	LUMENS	TOTAL
PARKING GARAGE	397	A,A2,A3	175W METAL HALIDE	12,500	4,962,500
QTA & Eco. Prk.	21	S (S3)	1000W HPS, 50' POLE	124,000	2,604,000
QTA & Eco. Prk.	60	S (S4)	1000W HPS, 50' POLE	124,000	7,440,000
QTA & Eco. Prk.	10	AAA	250W HPS @ CANOPY	26,000	260,000
QTA & Eco. Prk.	2	U2	1000W HPS, 20' POLE	124,000	248,000
QTA & Eco. Prk.	16	U4	1000W HPS, 50' POLE	124,000	1,984,000
CIRC. ROADWAY	18	R (R3)	1000W HPS, 50' POLE	124,000	2,232,000
CIRC. ROADWAY	32	R (R4)	1000W HPS, 50' POLE	124,000	3,968,000
CIRC. ROADWAY	5	P	250W HPS @ CANOPY	26,000	130,000
CIRC. ROADWAY	10	P (P2)	250W HPS @ CANOPY	26,000	260,000
CIRC. ROADWAY	24	AA	250W HPS @ CANOPY	26,000	624,000
TERM. APRON LGT.	52	T (T4)	1000W HPS, 50' POLE	124,000	6,448,000
OLD LUMENS				TOTAL	31,160,500

QTY.	LGT. TYPE	NEW SYSTEM		
		DESCRIPTION	LUMENS	TOTAL
397	A	53W GARAGE LED	4,400	1,746,800
21	S (S3)	218W LED POLE LGT	21,326	447,846
60	S (S4)	218W LED POLE LGT	21,326	1,279,560
10	AAA	53W CANOPY LED LGT	4,400	44,000
2	U2	131W POLE LED LGT	10,541	21,082
16	U4	218W LED POLE LGT	21,326	341,216
18	R (R3)	218W LED POLE LGT	21,326	383,868
32	R (R4)	218W LED POLE LGT	21,326	682,432
5	P	131W POLE LED LGT	10,541	52,705
10	P (P2)	131W POLE LED LGT	10,541	105,410
24	AA	53W CANOPY LED LGT	4,400	105,600
52	T (T4)	280W POLE ARM LGT	23,435	1,218,620
NEW LUMENS TOTAL			6,429,139	

NEW SYSTEM IS 21 % LUMENS OF OLD SYSTEM

Tucson airport: Watt age comparison

9/29/2014

TUCSON INT. AIRPORT NEW AND OLD WATTS COMPARISON FOR LED FIXTURES ADQUISITIONS PROJECT (2014).

OLD SYSTEM					
AREA	QTY.	LGT. TYPE	DESCRIPTION	WATTS	TOTAL
PARKING GARAGE	397	A,A2,A3	175W METAL HALIDE	210	83,370
QTA & Eco. Prk.	21	S (S3)	1000W HPS, 50' POLE	1,100	23,100
QTA & Eco. Prk.	60	S (S4)	1000W HPS, 50' POLE	1,100	66,000
QTA & Eco. Prk.	10	AAA	250W HPS @ CANOPY	310	3,100
QTA & Eco. Prk.	2	U2	1000W HPS, 20' POLE	1,100	2,200
QTA & Eco. Prk.	16	U4	1000W HPS, 50' POLE	1,100	17,600
CIRC. RODWAY	18	R (R3)	1000W HPS, 50' POLE	1,100	19,800
CIRC. RODWAY	32	R (R4)	1000W HPS, 50' POLE	1,100	35,200
CIRC. RODWAY	5	P	250W HPS @ CANOPY	310	1,550
CIRC. RODWAY	10	P (P2)	250W HPS @ CANOPY	310	3,100
CIRC. RODWAY	24	AA	250W HPS @ CANOPY	310	7,440
TERM. APRON LGT.	52	T (T4)	1000W HPS, 50' POLE	1,100	57,200
				TOTAL	319,660

NEW SYSTEM				
QTY.	LGT. TYPE	DESCRIPTION	WATTS	TOTAL
397	A	53W GARAGE LED	55	21,835
21	S (S3)	218W LED POLE LGT	220	4,620
60	S (S4)	218W LED POLE LGT	220	13,200
10	AAA	53W CANOPY LED LGT	55	550
2	U2	131W POLE LED LGT	135	270
16	U4	218W LED POLE LGT	220	3,520
18	R (R3)	218W LED POLE LGT	220	3,960
32	R (R4)	218W LED POLE LGT	220	7,040
5	P	131W POLE LED LGT	135	675
10	P (P2)	131W POLE LED LGT	135	1,350
24	AA	53W CANOPY LED LGT	55	1,320
52	T (T4)	280W POLE ARM LGT	280	14,560
			NEW TOTAL	72,900

NEW SYSTEM IS 23 % LUMENS OF OLD SYSTEM

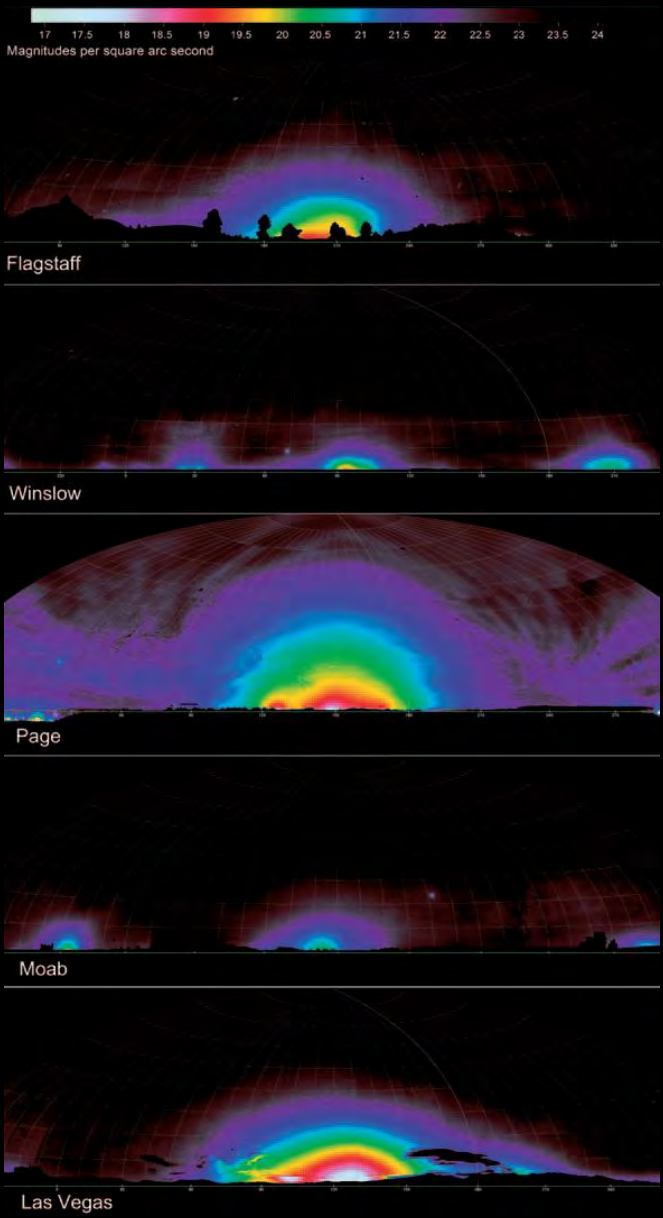
Tucson airport: Danette Bewley

Vice President of Operations and Projects

“The lighting project not only reduced energy use but it also improved the quality of lighting and the night time aesthetics of our facility for our tenants, the staff and the traveling public”

Observed sky glow of five towns in the US

Duriscoe et al., Lighting Res. Technol. (2014)



A = Flagstaff

B = Winslow

C = Page

D = Moab

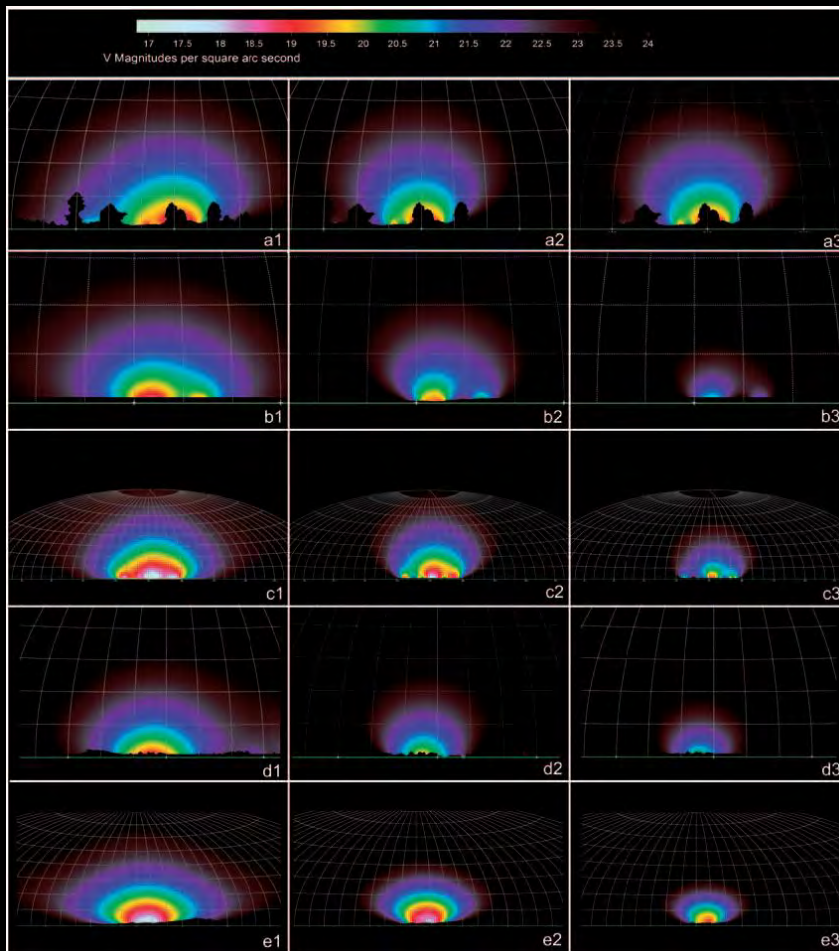
E = Las Vegas

Models of sky glow with best practice illumination compared to Flagstaff

Current

+full shielding

lighting amount Flagstaff (2075 lm capita⁻¹)
+ full shielding



A = Flagstaff

B = Winslow

C = Page

D = Moab

E = Las Vegas

Management to reduce negative impacts of ALAN at ports

- Direct the light to where it is needed
- Reduce the light intensity and number of light poles to the minimum amount needed
- Use light spectra outside of target organism sensitivity
- If white then with ,warm' colour temperature >3000 Kelvin
- Limit the use of light on the working hours

Thank you!
Enjoy the stars!



Foto: Andreas Hänel, Westhavelland