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New Emphasis on Water Clarity as Socio-Ecological Indicator for Urban Water

– A SHORT ILLUSTRATION

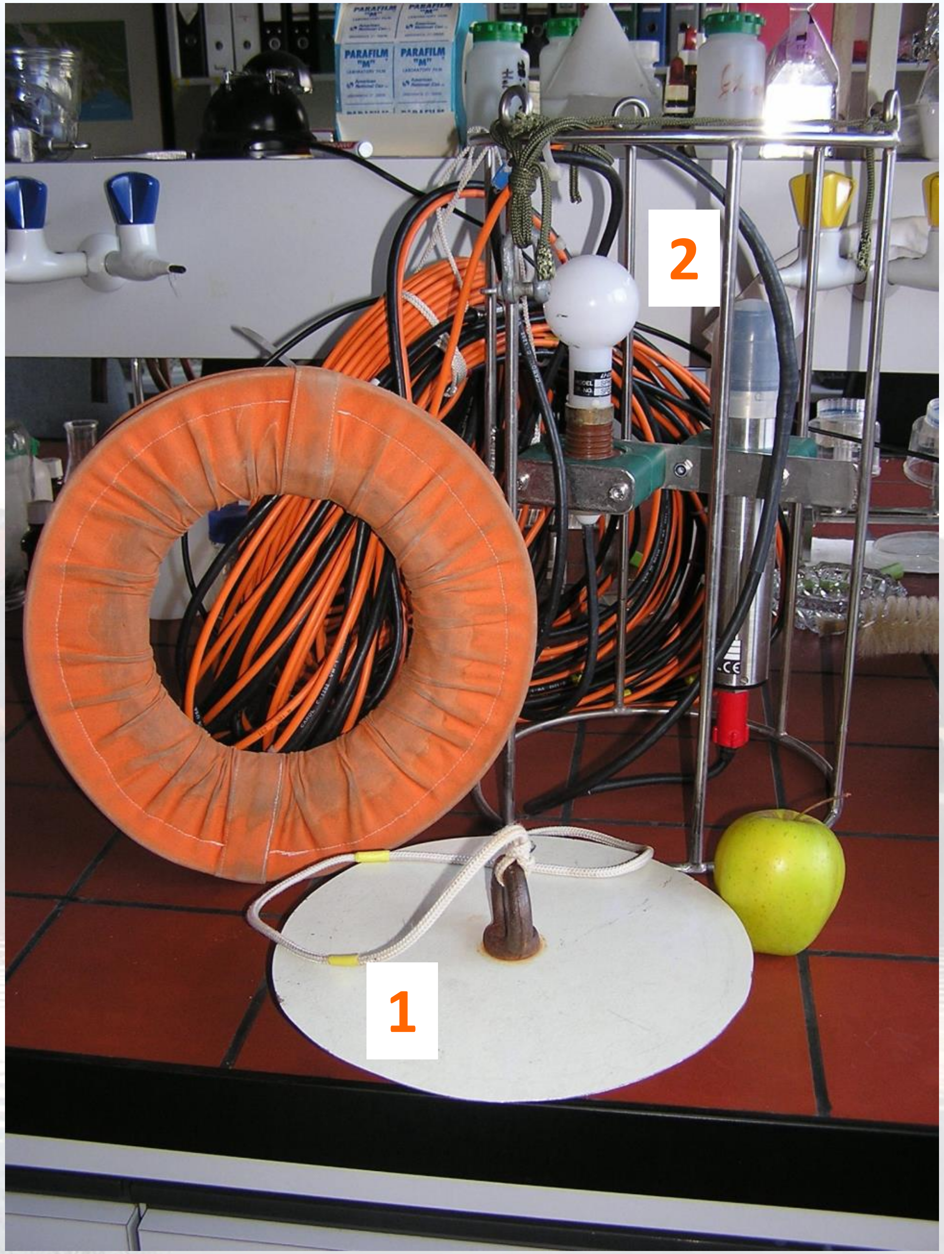
Katrin Teubner, Irene E. Teubner, Karin Pall, Wilfried Kabas, Monica Tolotti, Thomas Ofenböck, Martin T. Dokulil

43rd IAD-conference, Aueninstitut Neuburg a.d. Donau, Germany: ***Rivers and Floodplains in the Anthropocene – Upcoming Challenges in the Danube River Basin,*** **9 – 11 June 2021**

Measuring **Water Transparency** by light attenuation under water:

1 Secchi Disk

2 Light Sensor



from FBA by Irene Teubner (2006)

Measuring **Water Transparency** by light attenuation under water:

https://www.fishersci.ca/shop/products/united-scientific-secchi-disk/s12871

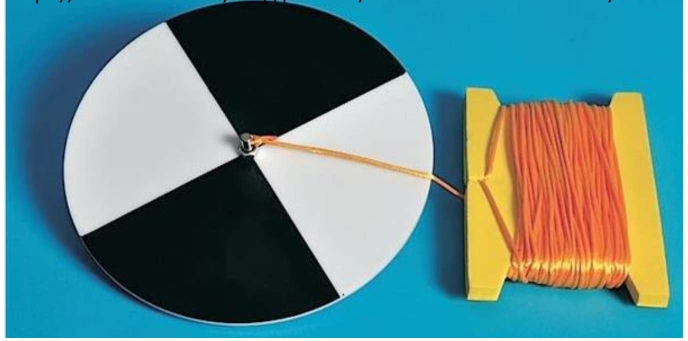



Photo: K Teubner


Photo: K Teubner

1 Secchi Disk


Photo: K Teubner

2 Light Sensor

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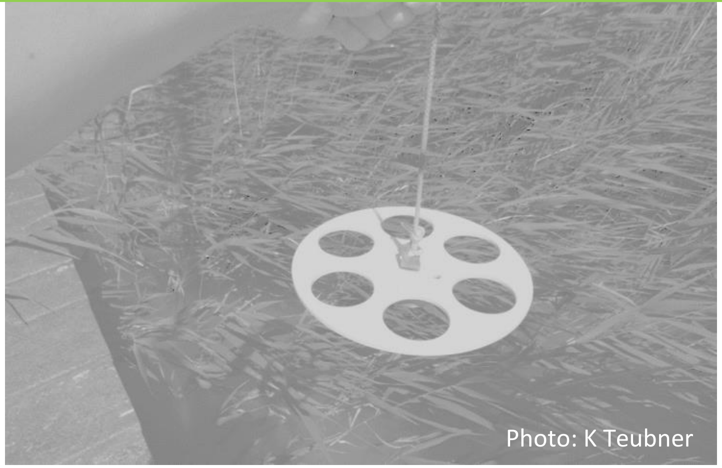
Measuring **Water Transparency** by light attenuation under water:

Black-and-white Secchi Disk



1 Secchi Disk

2 Light Sensor

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Photo: K Teubner

43rd IAD-conference, June 2021

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…thinking about such a disk,
that begs the question:

Who was the first measuring water visibility by lowering items under water, like a disk – and for what this is good for?

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1815 – **Marine environment,** WT measured by Lowering items under-water as e.g. a disc

1866 – **Marine, Secchi-Disc depth** method established

1892/1893 – **Lake Secchi Depth**, Limnology founded as „oceanography of lakes“ (Forel, 1892)

1968 – **WT** used for **trophic classification schemes,** Eutrophication mirrored by low WT due to algal turbidity (Vollenweider, 1968)

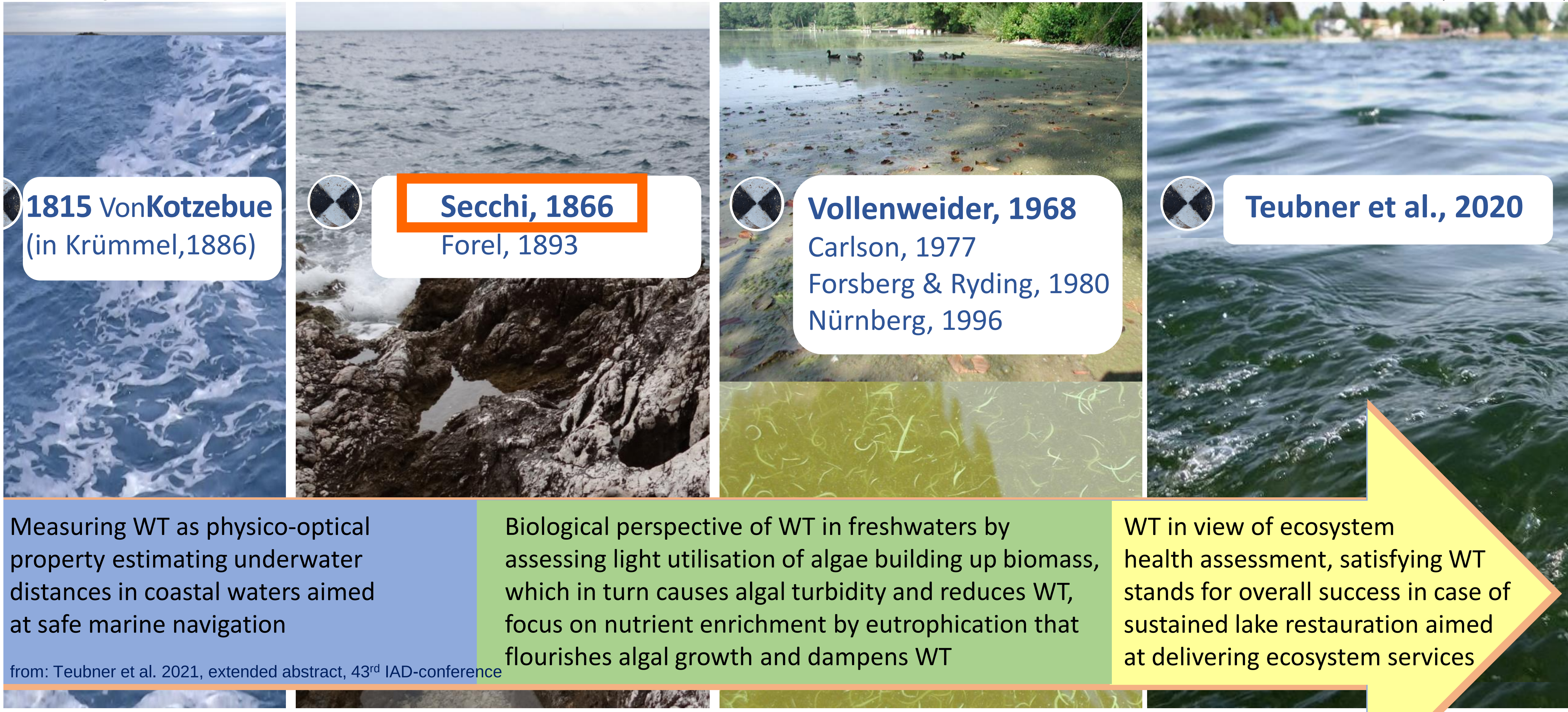
1995 – Ecosystem health (Rapport, 1995)

2000 – WFD (EC, 2000)

2002 – Anthropocene (Crutzen, 2002)

2005 – Ecosystem services (MEA, 2005)

2020 – **WT** as **socio-ecological indicator** (Teubner, 2020)



from: Teubner et al. 2021, extended abstract, 43rd IAD-conference

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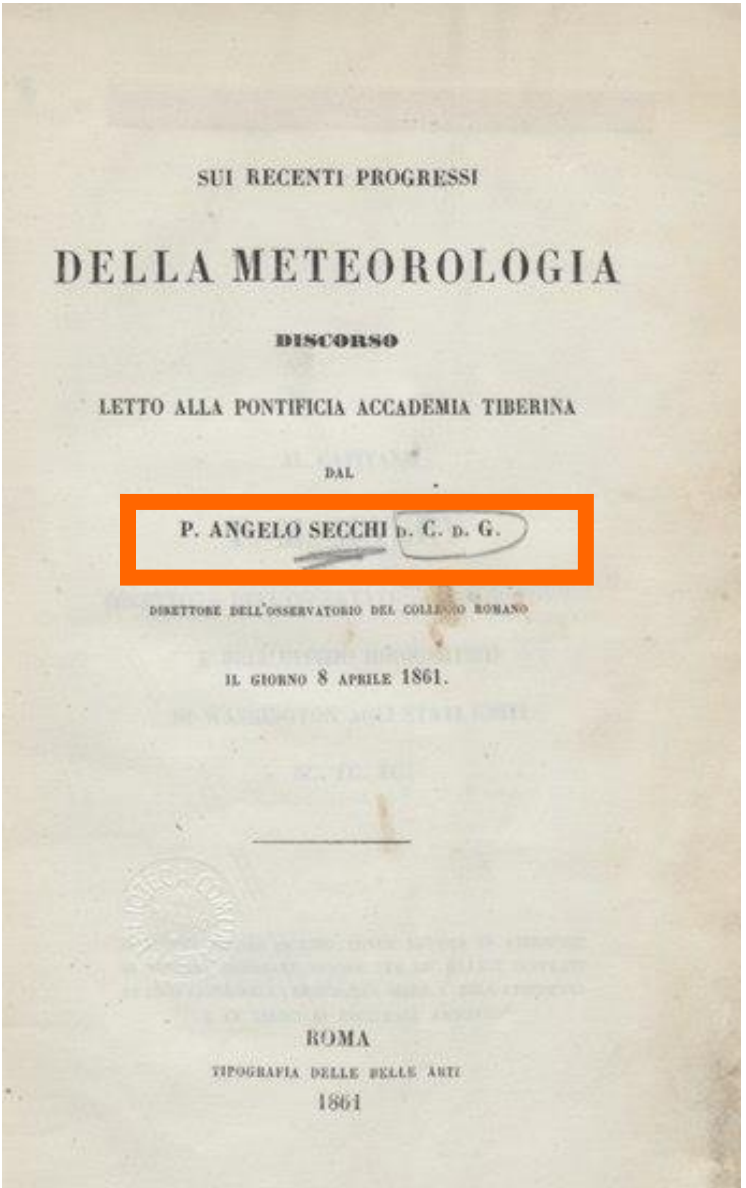
Meteorology: Visibility is a distance measure at which a landscape mark (e.g. tree, house) can be clearly seen – Visibility thus depends on transparency of the air in the environment –

In German we call this meteorological measure to look into the open landscape "**Sichtweite**",

and in aquatic sciences it became named "**Sichttiefe**" measuring water transparency at water depths.



SUI RECENTI PROGRESSI

DELLA METEOROLOGIA

DISCORSO

LETTO ALLA PONTIFICIA ACCADEMIA TIBERINA

DAL

P. ANGELO SECCHI D. C. D. G.

DIRETTORE DELL'OSSERVATORIO DEL COLLEGIO ROMANO

IL GIORNO 8 APRILE 1861.

ROMA

TIPOGRAFIA DELLE BELLE ARTI

1861

Sui recenti progressi della meteorologia (1861)
Translated: On recent advances in meteorology (1861)

Source of photo of the book cover: https://de.wikipedia.org/wiki/Angelo_Secchi

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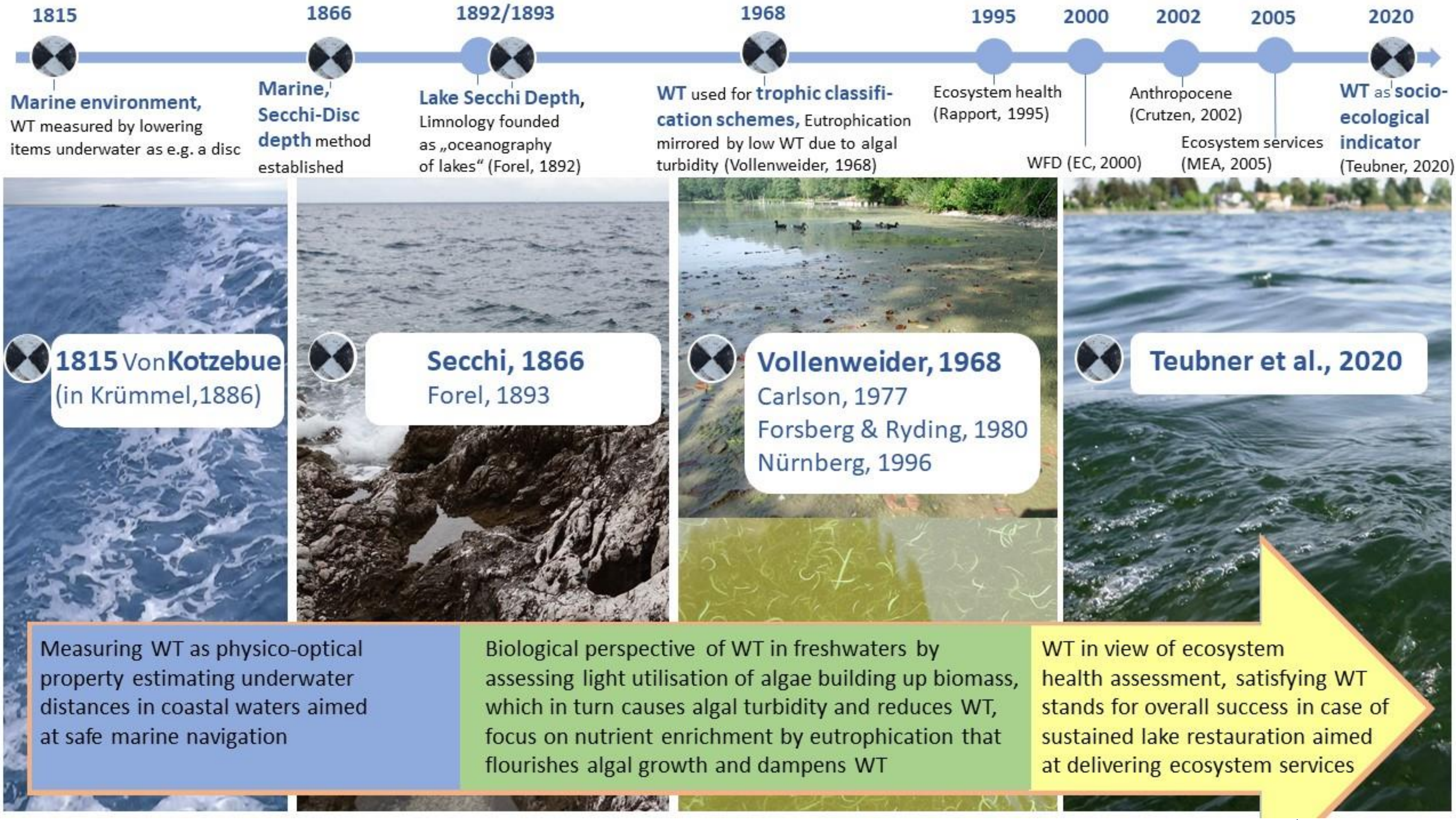

from: Teubner et al. 2021, extended abstract, 43rd IAD-conference

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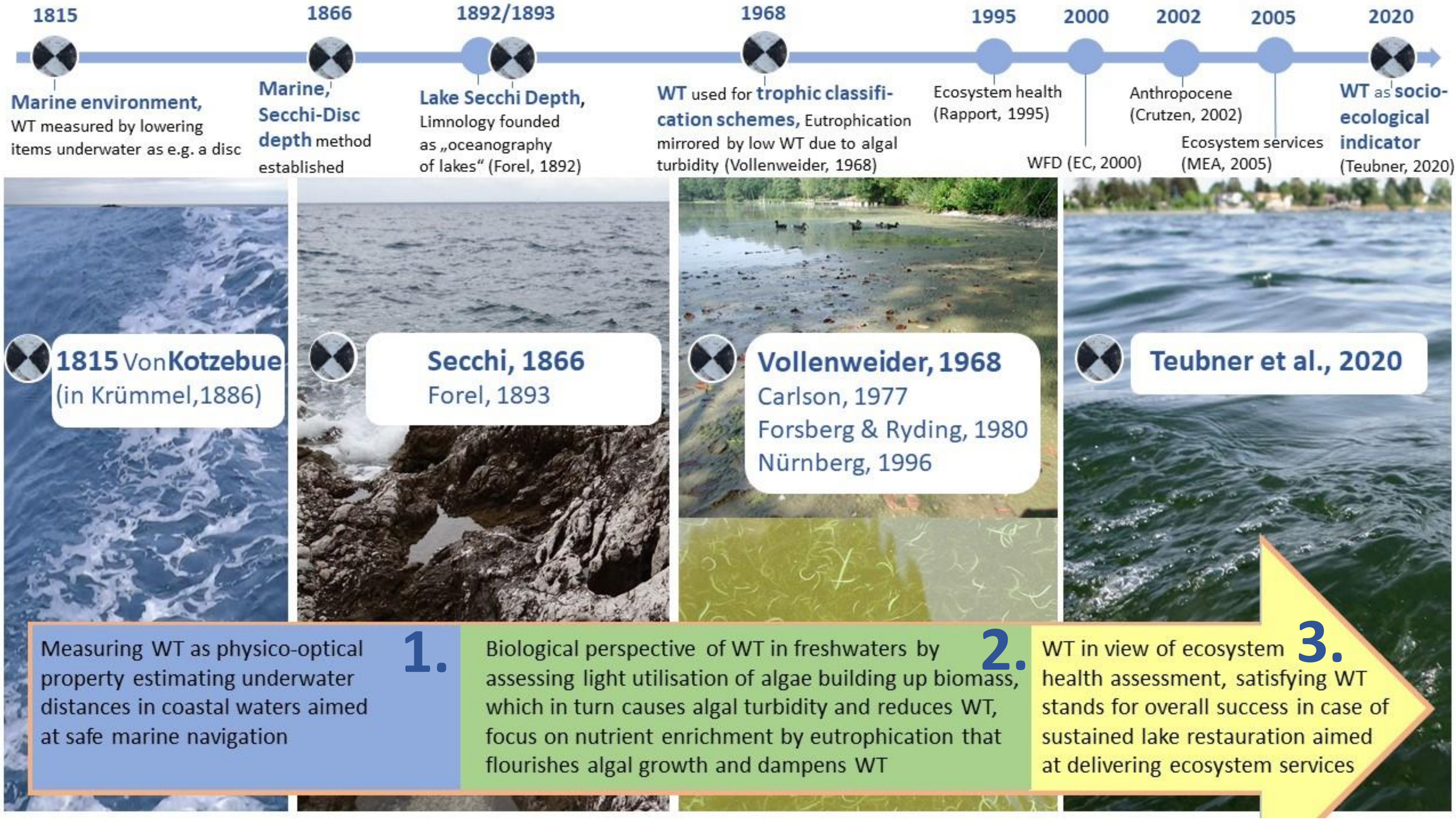

from: Teubner et al. 2021, extended abstract, 43th IAD-conference

Response to (algal) turbidity

Stimulation for macrophyte growth

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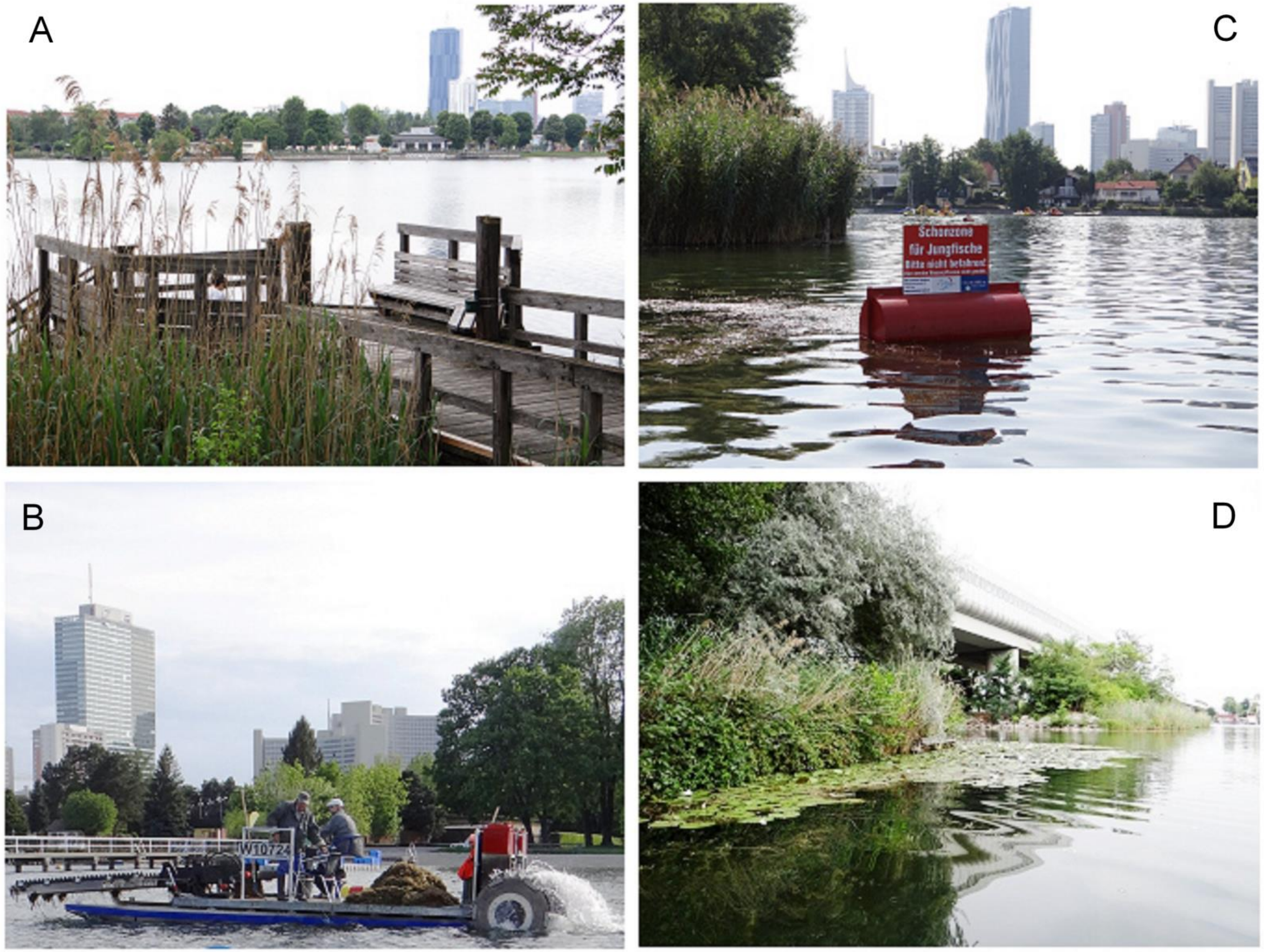
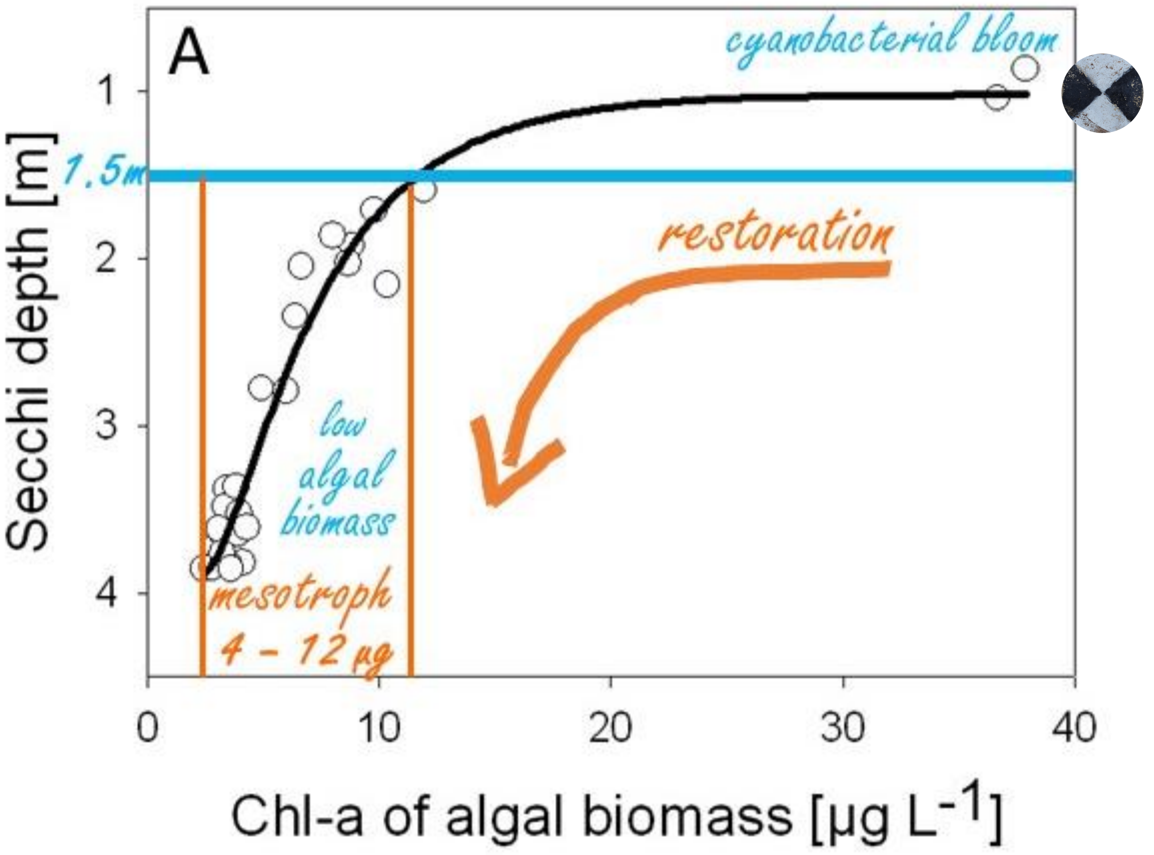
Response to (algal) turbidity

Stimulation for macrophyte growth

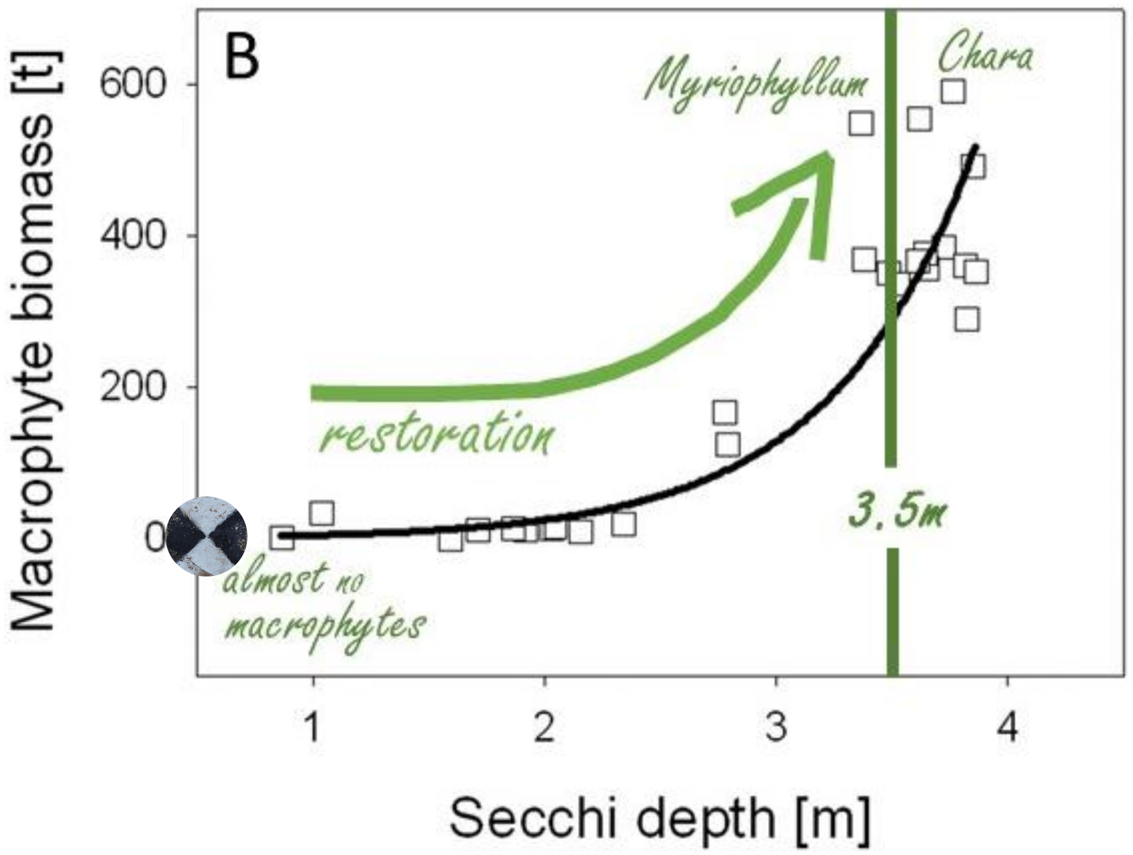


Case study: Oxbow Lake Alte Donau, Vienna

Response to (algal) turbidity



Stimulation for macrophyte growth



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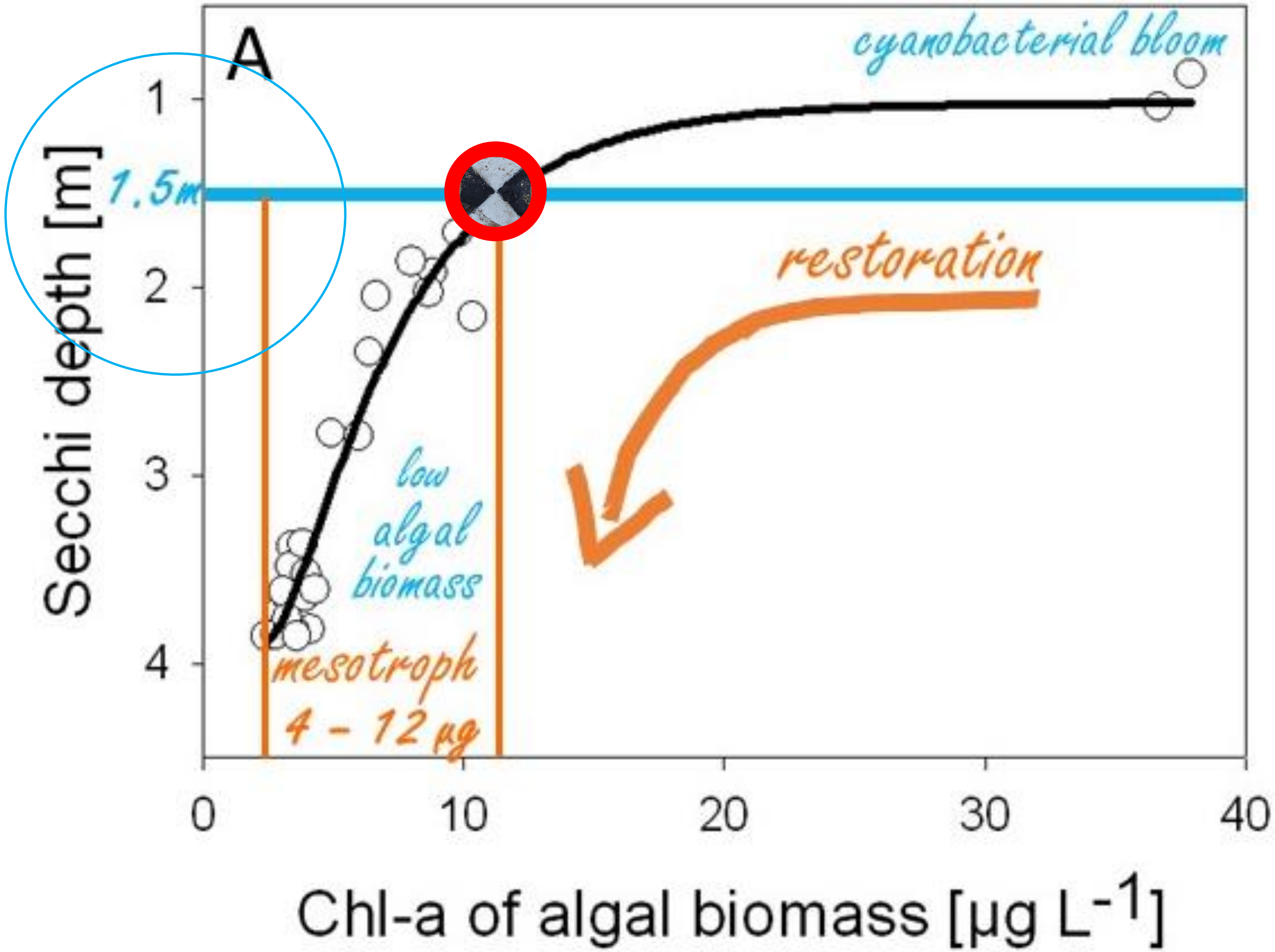
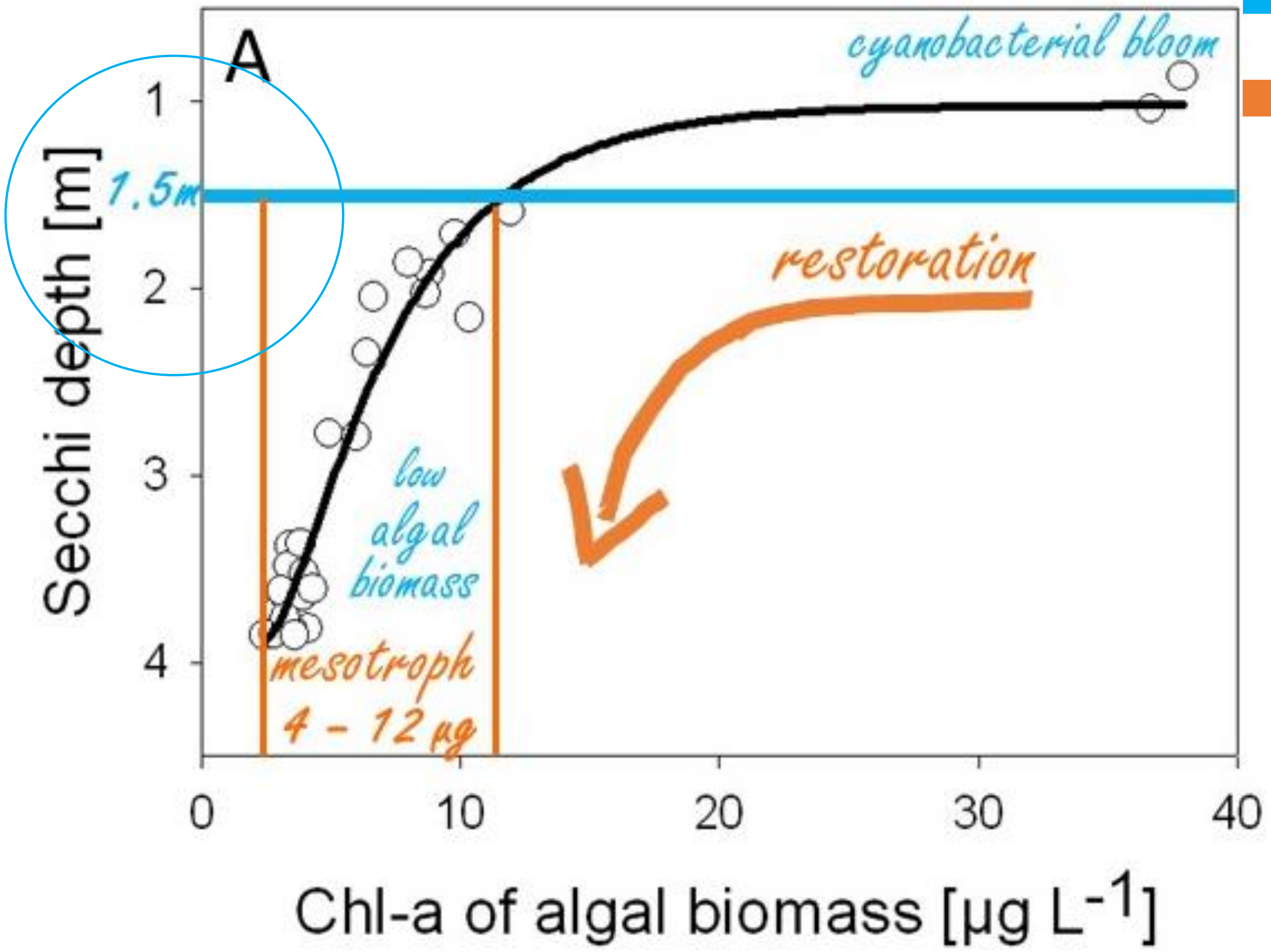
Response to (algal) turbidity



1.5 m Secchi depth = critical point

from: Teubner et al. 2021, extended abstract, 43rd IAD-conference

Response to (algal) turbidity



1.5 m Secchi depth = critical point

- *shift from eutr. to mesotrophic state*
- *judged as good water quality, satisfying bathing aesthetics by human perception,*

Why?

from: Teubner et al. 2021, extended abstract, 43rd IAD-conference

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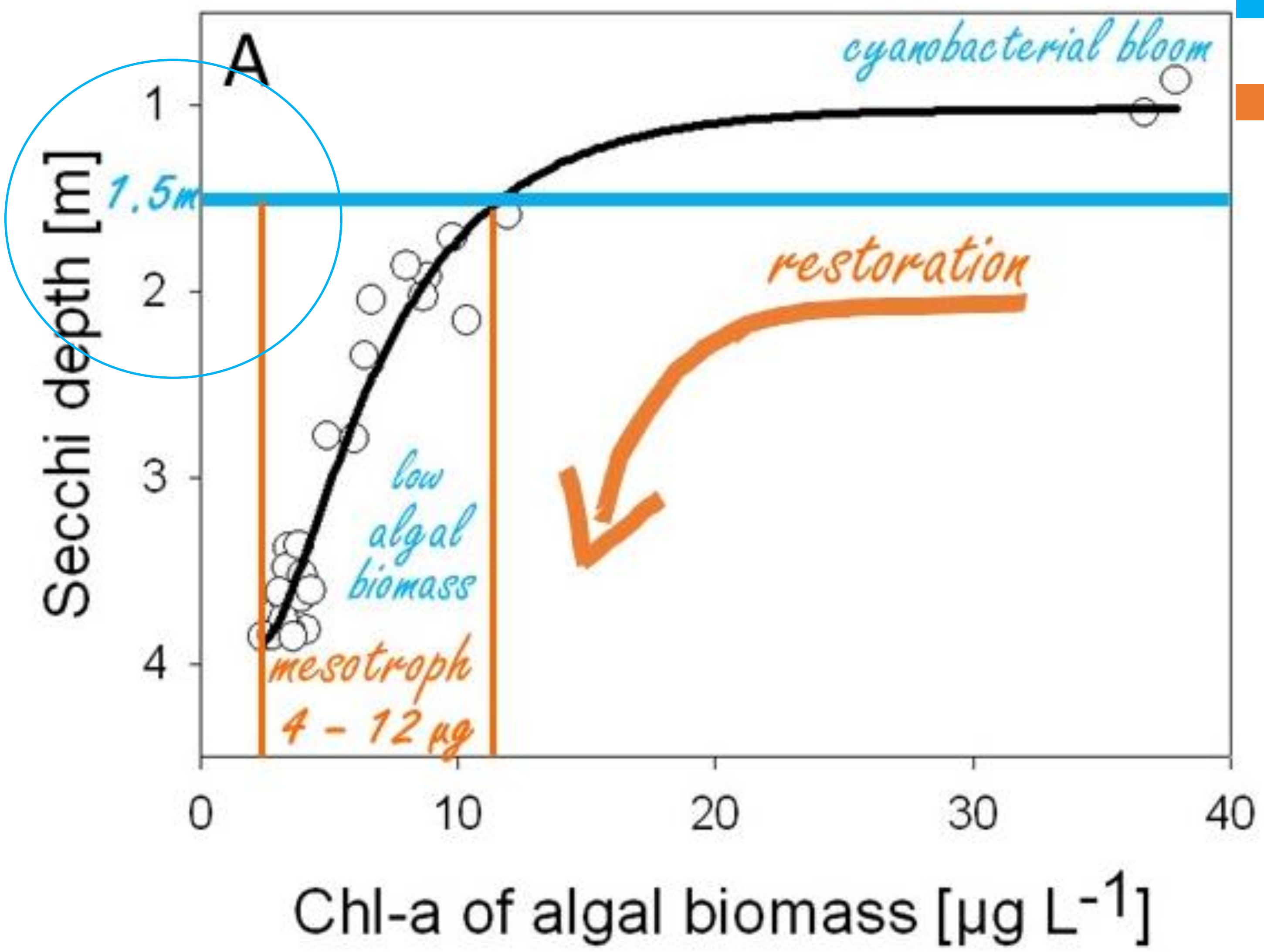
Response to (algal) turbidity

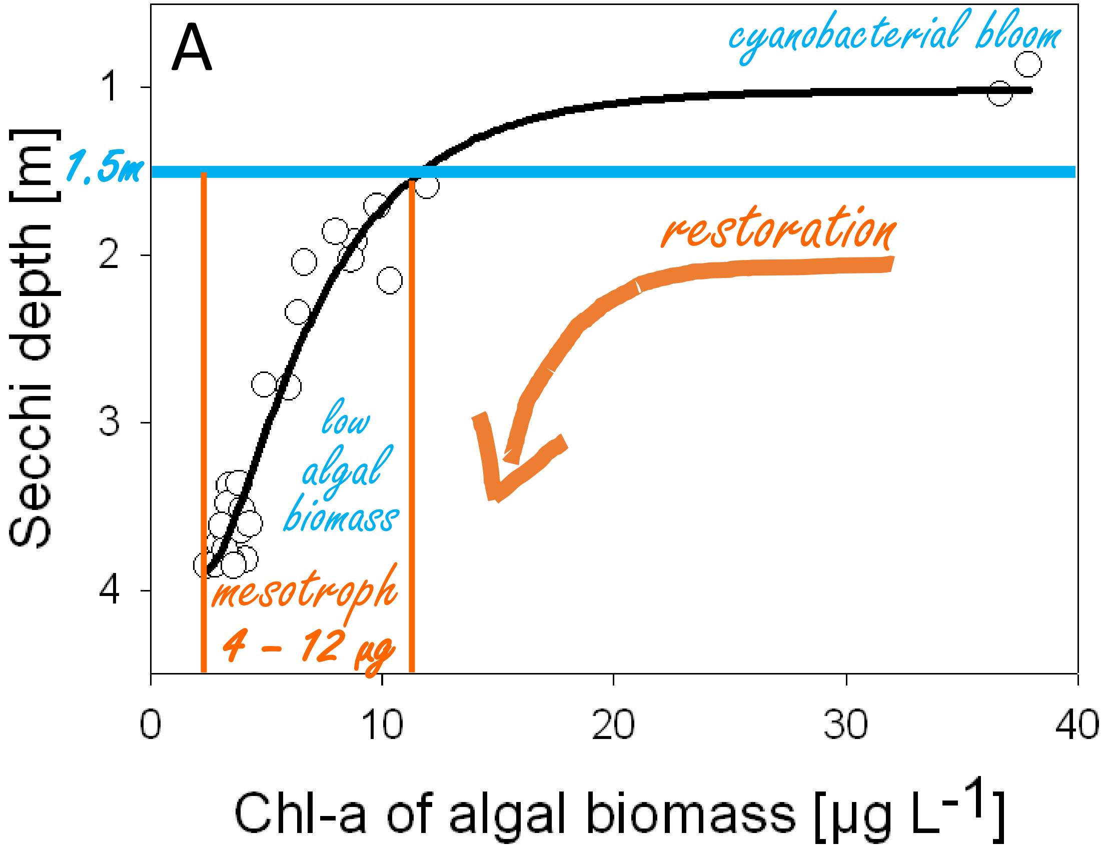


1.5 m Secchi depth = critical point

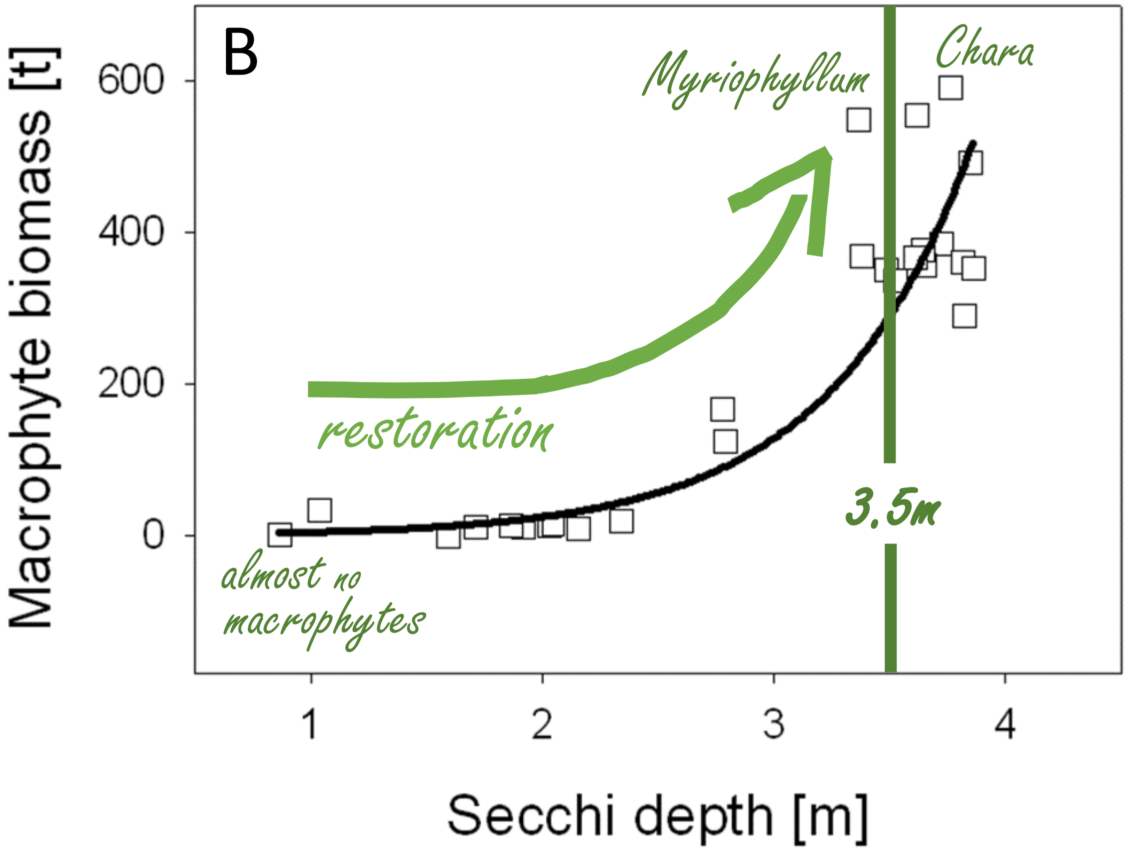
- *shift from eutr. to mesotrophic state*
- *judged as good water quality, satisfying bathing aesthetics by human perception, littoral "**lake bottom view**"*

from: Teubner et al. 2021, extended abstract, 43rd IAD-conference

Response to (algal) turbidity



Stimulation for macrophyte growth

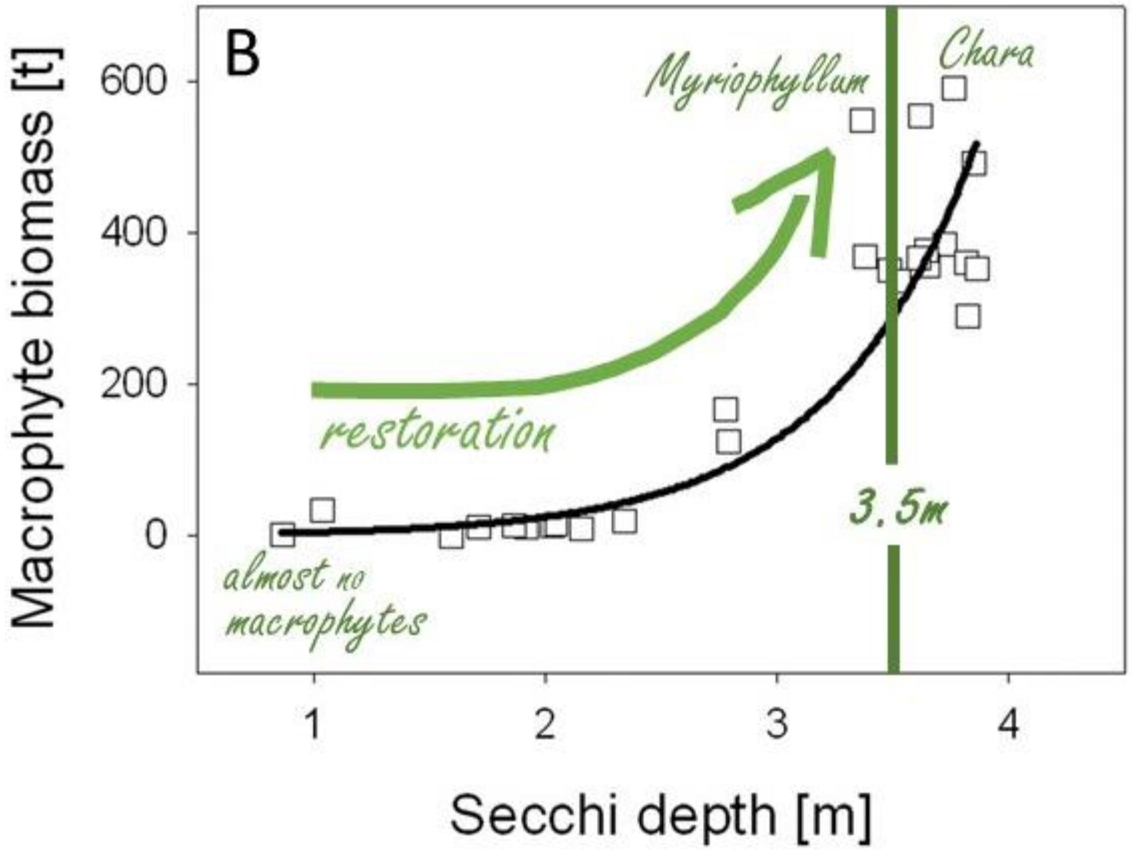


from: Teubner et al. 2021, extended abstract, 43rd IAD-conference

Stimulation for macrophyte growth

Underwater macrophyte cutting

Myriophyllum spicatum – tall growing plant with canopy near water surface



***Chara** spec. – bottom dwelling Charophytes*

frontiers in Environmental Science | Freshwater Science

EDITED BY
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REVIEWED BY
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ORIGINAL RESEARCH article
Front. Environ. Sci., 01 October 2020 | https://doi.org/10.3389/fenvs.2020.573724

Check for updates

New Emphasis on Water Transparency as Socio-Ecological Indicator for Urban Water: Bridging Ecosystem Service Supply and Sustainable Ecosystem Health

Katrin Teubner[1]*, Irene Teubner[2,3], Karin Pall[4], Wilfried Kabas[5], Monica Tolotti[6], Thomas Ofenböck[7] and Martin T. Dokulil[8]

[1]Department of Functional and Evolutionary Ecology, Faculty of Life Sciences, University of Vienna, Vienna, Austria
[2]Research Group Climate and Environmental Remote Sensing, Department of Geodesy and Geoinformation, TU Wien, Vienna, Austria
[3]Climatology Section, Division Customer Service, Zentralanstalt für Meteorologie und Geodynamik, Vienna, Austria
[4]Systema GmbH, Vienna, Austria
[5]Department of Limnology and Bio-Oceanography, Faculty of Life Sciences, University of Vienna, Vienna, Austria
[6]Department of Sustainable Agro-ecosystems and Bioresources, Research and Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige, Italy
[7]Municipal Department 45 – Water Management, Vienna City Administration, Vienna, Austria
[8]Research Department for Limnology, Mondsee, University of Innsbruck, Mondsee, Austria

Teubner et a. (2020). New Emphasis on Water Transparency as Socio-Ecological Indicator for Urban Water: Bridging Ecosystem Service Supply and Sustainable Ecosystem Health. *Frontiers in Environmental Science*, *8*, 162. https://www.frontiersin.org/articles/10.3389/fenvs.2020.573724/full

Category	(A) all	(B) Seasonal development				(C) Trophic lake classification scheme			(D) Human water-quality perceptions for bathing		
		Spring	Summer	Autumn	Winter	Oligo-trophic	Meso-trophic	Eu–trophic	z_{Secchi} > 1.55 m	z_{Secchi} 1.45–1.55 m	z_{Secchi} < 1.45 m
z_{Secchi} [m]	1.62	1.75	1.36	1.56	2.3	2.45	1.72	1.17	2.07	1.50	1.17
$I_{Z_{Secchi}}$ [%]	26	27	28	24	21	21	26	28	23	25	29
k_{PAR} [m^{-1}]	0.918	0.796	0.981	1.012	0.802	0.728	0.838	1.149	0.747	0.934	1.096
z_{eu} [m]	**5.35**	**6.04**	**4.93**	**4.82**	**6.2**	**6.62**	**5.72**	**4.18**	**6.33**	**5.02**	**4.40**
f_{eu}	3.45	3.58	3.65	3.24	2.99	3.05	3.42	3.62	3.17	3.35	3.78
$z_{macrophytes}$ [m]	**4.08**	4.60	**3.75**	**3.67**	**4.83**	**5.04**	**4.36**	**3.19**	**4.82**	**3.82**	**3.35**
$f_{macrophytes}$	2.63	2.73	2.78	2.48	2.28	2.32	2.60	2.76	2.42	2.55	2.88
$z_{peak-phyto}$ [m]	**2.47**	**2.78**	**2.27**	**2.22**	**2.92**	**3.05**	**2.64**	**1.93**	**2.91**	**2.31**	**2.03**
$f_{peak-phyto}$	1.59	1.65	1.68	1.49	1.38	1.41	1.58	1.67	1.46	1.54	1.74
Chl-a [μg L^{-1}]	10	7.5	11	12.5	5.9	3.1	7.7	17	6.6	11	13
n	131	38	43	37	13	11	82	38	55	16	60

Depth of surface ambient light at 1% refers to minimum light requirements of phytoplankton (euphotic depth, z_{eu}), at 3% to minimum light requirements of submerged macrophytes (maximum colonization depth, $z_{macrophytes}$) and at 12% referring to light required for phytoplankton optimum indicated by epilimnetic phytoplankton peak ($z_{peak-phyto}$) (see section "Materials and Methods"). Euphotic depth (z_{eu}) exceeds z_{Secchi} by the factor f_{eu} (more details in Kabas, 2004). Analogous factors for $z_{macrophytes}$ and $z_{peak-phyto}$ exceeding z_{Secchi} are $f_{macrophytes}$ and ($f_{peak-phyto}$), respectively. Mean values are shown for the whole data set ***(A)****, the four seasons* ***(B)*** *along three trophic states* ***(C)****, and for threshold of bathing aesthetics* ***(D)****. Further for* ***(C)*** *Trophic classification scheme refers to samples of chlorophyll-a (Chl-a) concentrations which were simultaneously taken when measuring z_{Secchi} and k_{PAR}, and applies here to ÖNORM M6231 (2001): oligotrophic: Chl-a < 4 μg L^{-1}, mesotrophic: 4 μg L^{-1} to 12 μg L^{-1}, eutrophic > 12 μg L^{-1}. Further for* ***(D)*** *To correspond water-quality perceptions for bathing (threshold of z_{Secchi} = 1.5 m according to Smith et al., 1991, 1995a), a narrow range of sampling dates with z_{Secchi} between 1.45 and 1.55 m is compared with those of higher and lower z_{Secchi}, respectively* ***(D)****. Depth [in m] of critical light requirements for phytoplankton and macrophytes growth are plotted in bold. Data based on mean values from biweekly to monthly measurements of z_{Secchi}, k_{PAR}, and Chl-a, in Alte Donau (1995–2001, n = 131).*

Teubner et a. (2020). New Emphasis on Water Transparency as Socio-Ecological Indicator for Urban Water: Bridging Ecosystem Service Supply and Sustainable Ecosystem Health. *Frontiers in Environmental Science*, *8*, 162. https://www.frontiersin.org/articles/10.3389/fenvs.2020.573724/full

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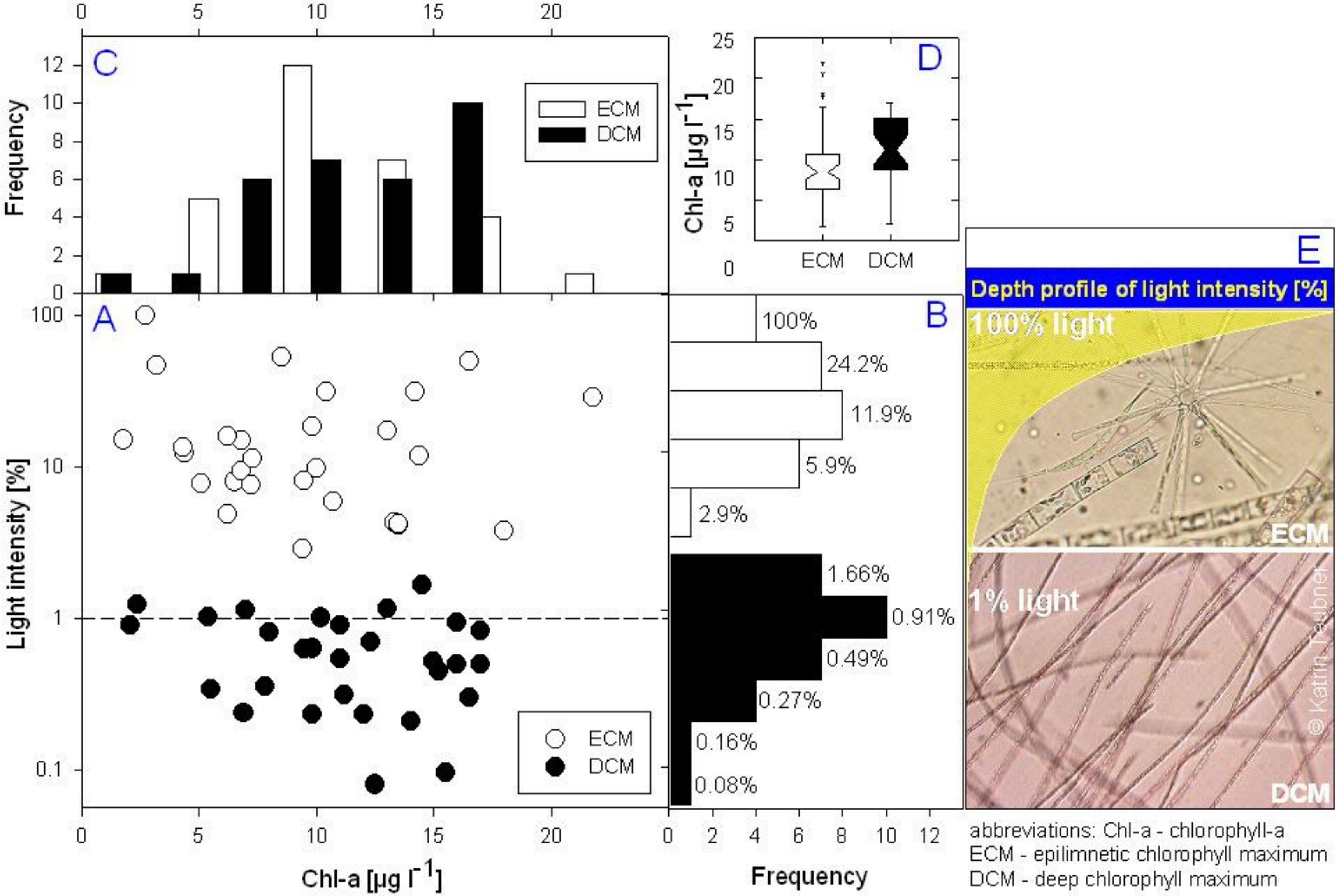
Lake Ammersee



abbreviations: Chl-a - chlorophyll-a
ECM - epilimnetic chlorophyll maximum
DCM - deep chlorophyll maximum

Under water light intensity and chlorophyll maxima near the surface (ECM) and in the deep layer (DCM). A-D: Ammersee, modified from Teubner *et al.* 2004; phytoplankton ECM, DCM in Teubner *et al. Hydrobiologia* 2003); E: Illustration of the two different phytoplankton assemblages.

Figure from: www.lakeriver.at

from: Teubner et al. 2021, extended abstract, 43rd IAD-conference

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Water Transparency

= socio-ecological indicator in urban blue space

Ecosystem Services

Ecosystem Health

public awareness to protect urban nature

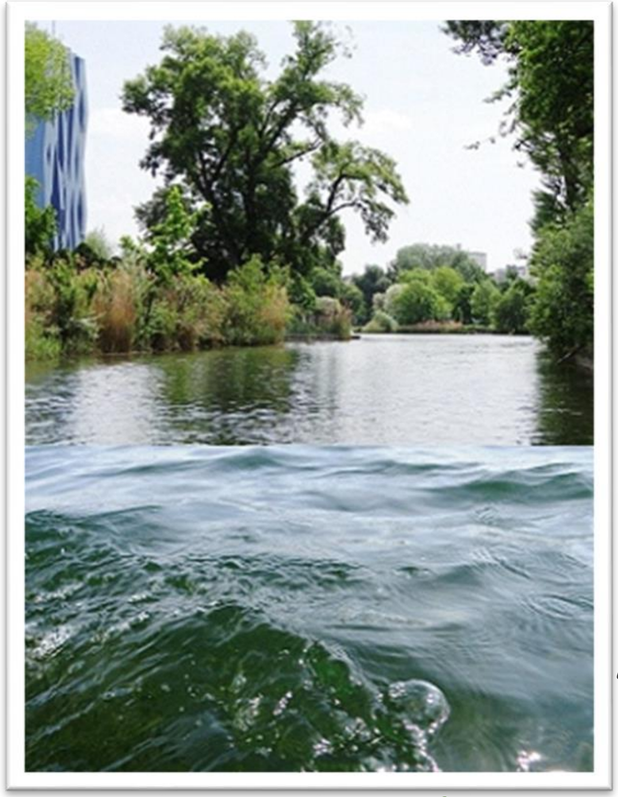
Secchi depth:

> 1.5m

(„lake bottom view")

Bathing & Swimming

human perception about healthy environment



high water clarity

strengthen of ecosystem functioning

Secchi depth:

> 1.5m

Mesotrophic state, suppression of cyanobacterial blooms

> 3.5m

Sustained macrophyte growth, mainly of bottom-dwelling Chara

reference ecosystem with high habitat structure & biodiversity

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In conclusion:

Water transparency is identified as a key parameter which is important far beyond how we see it in limnology. It is the only parameter that the public can use by human perception for assessing the water quality or the progress of a lake restoration. In turn, a good status of water transparency close to ecosystem reference conditions attracts public awareness to take advantage of various ecosystem services enhancing well-being in urban life. In this view "green-blue" spaces are ranked higher for a better quality-of-life in cities than "green" spaces.

Thanks for your attention!

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In conclusion:

Water transparency is identified as a key parameter which is important far beyond how we see it in limnology. It is the only parameter that the public can use by human perception for assessing the water quality or the progress of a lake restoration. In turn, a good status of water transparency close to ecosystem reference conditions attracts public awareness to take advantage of various ecosystem services enhancing well-being in urban life. In this view "**green**-**blue**" spaces are ranked higher for a better quality-of-life in cities than "green" spaces.

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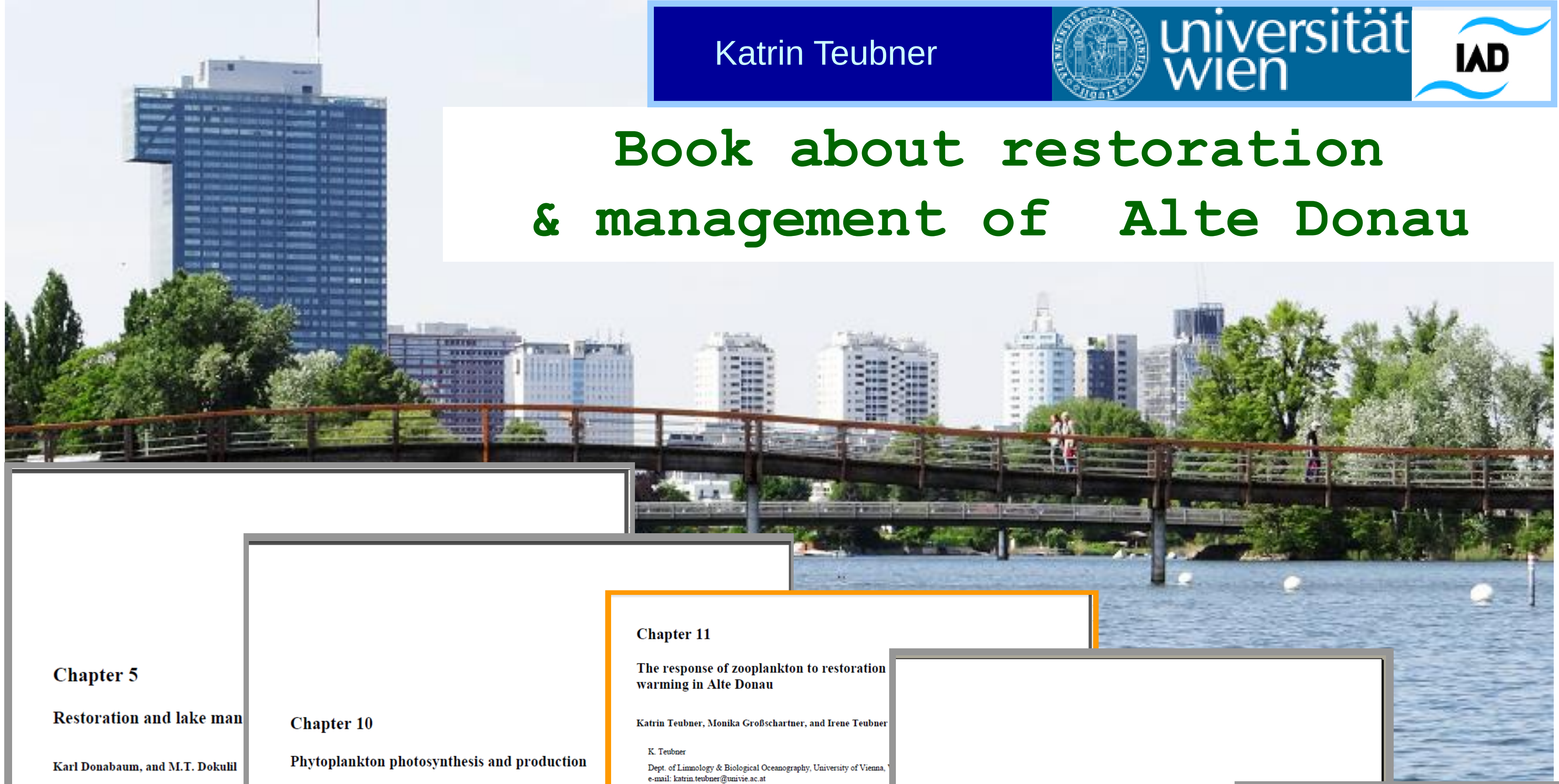
Book about restoration & management of Alte Donau



Chapter 5

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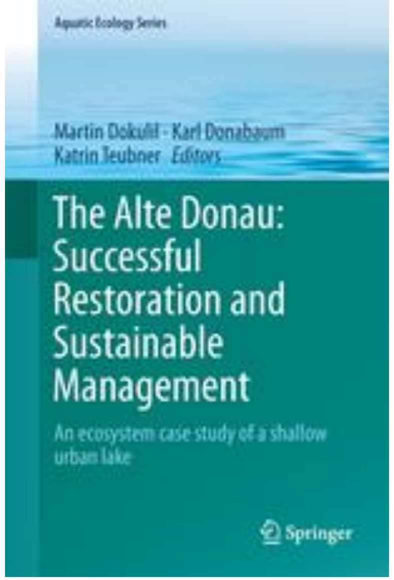
Dokulil MT, Donabaum K, Teubner K (Eds). (2018). *The Alte Donau: successful restoration and sustainable management: an ecosystem case study of a shallow urban lake* (Vol. 10). Springer.



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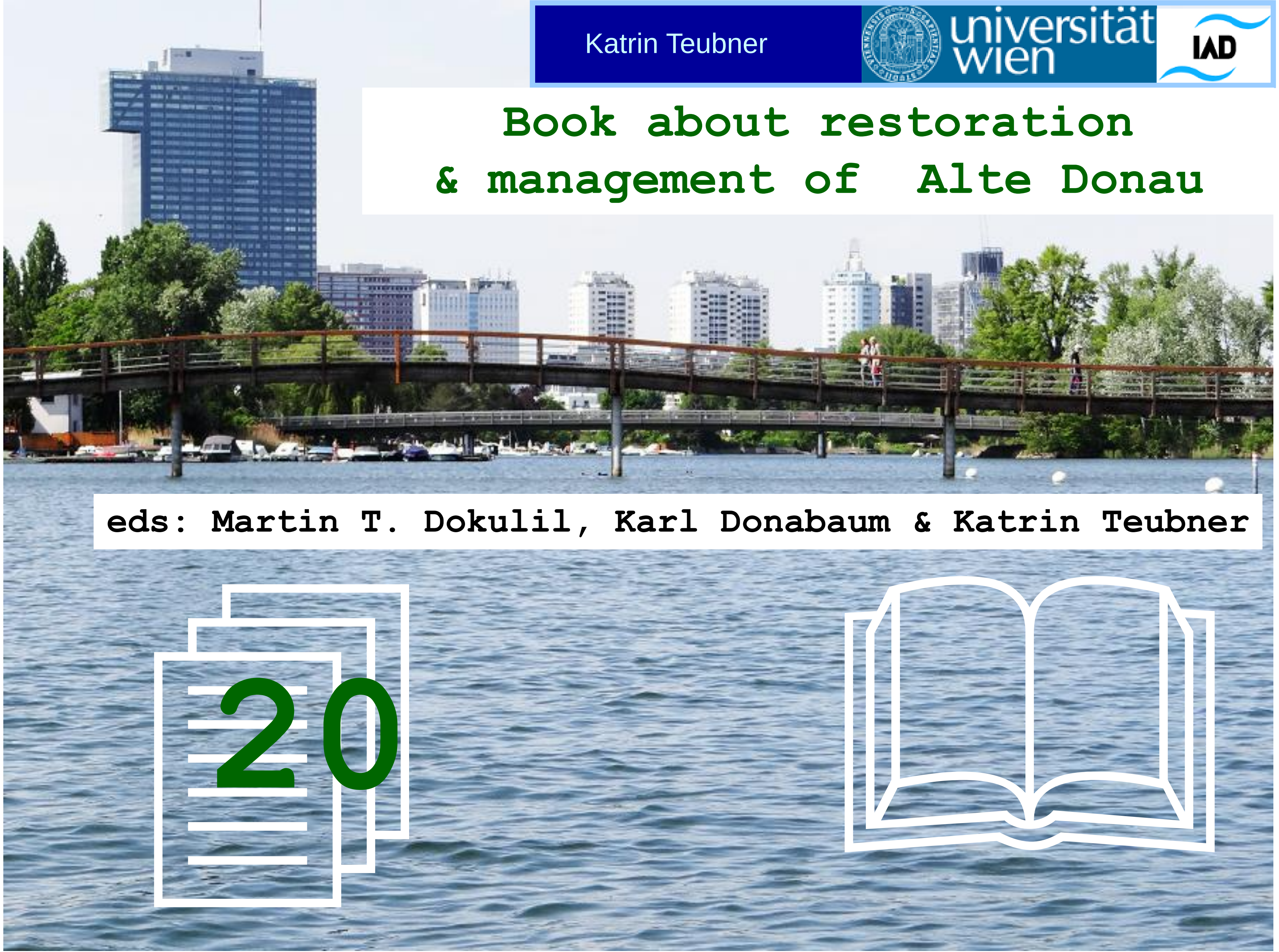
eds: Martin T. Dokulil, Karl Donabaum & Katrin Teubner



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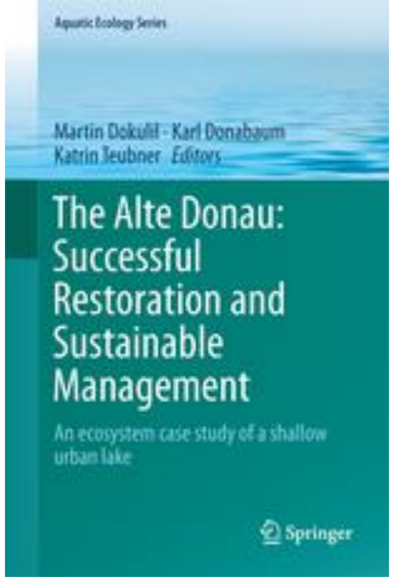

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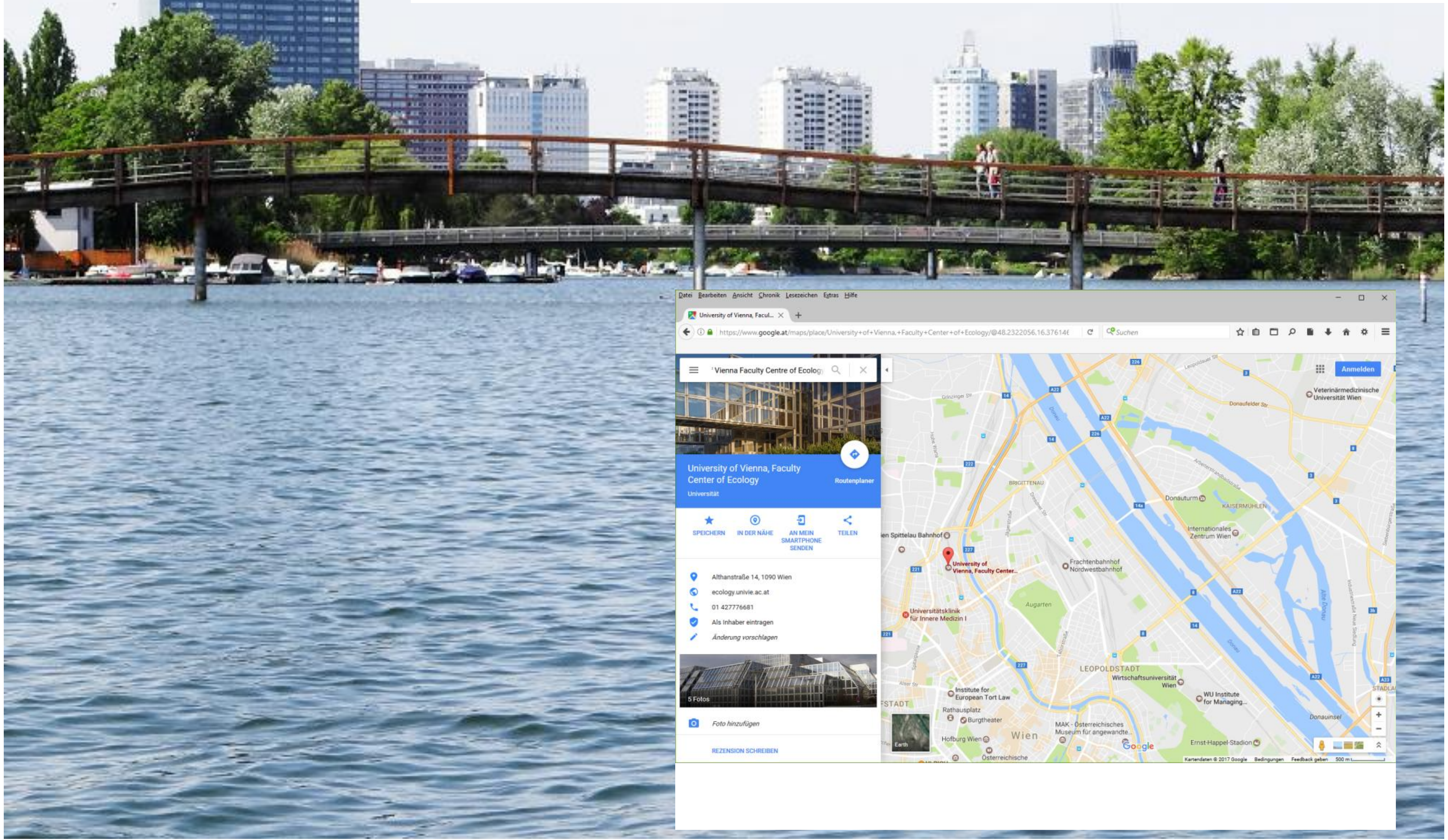

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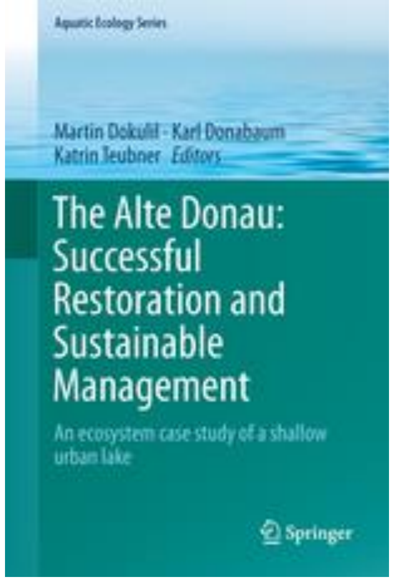

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Alte Donau, urban oxbow lake, Vienna

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