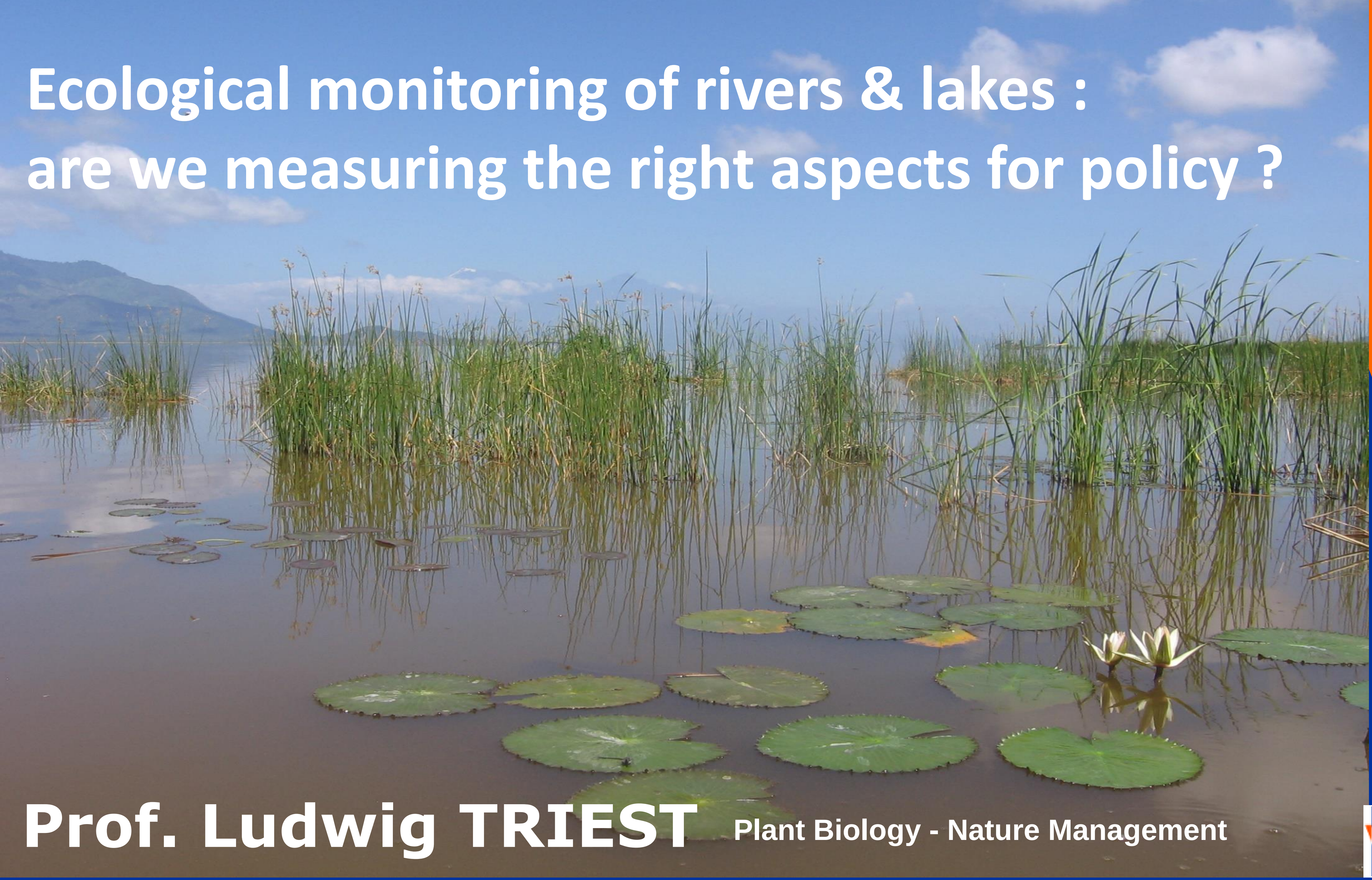


Ecological monitoring of rivers & lakes : are we measuring the right aspects for policy ?

Prof. Ludwig TRIEST Plant Biology - Nature Management

VRIJE UNIVERSITEIT BRUSSEL

RIVER & LAKE MONITORING

ECOLOGICAL QUALITY

In many countries there is a tradition of measuring the ecological water quality of rivers and lakes using the biodiversity and abundance of representative groups of organisms.

These ‘representative’ groups usually comprise

Phytoplankton – Phytobenthos – Macrophytes – Macroinvertebrates - Fish

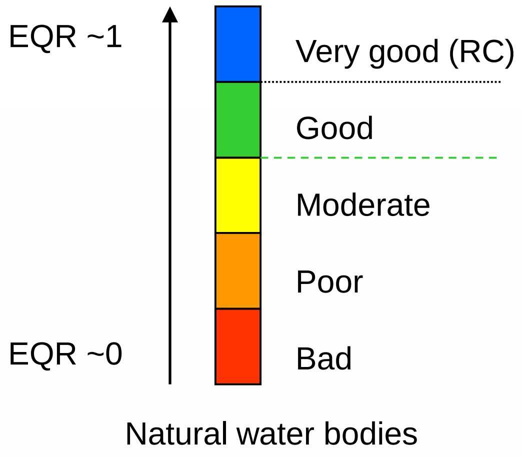
ECOLOGICAL QUALITY RATIO

EQR FOR NATURAL SYSTEMS

The water framework directive in Europe has initiated many studies to :

- compile indices
- use ecological quality ratios

For indicators of overall aquatic habitat quality



EQR = Observed biological value / Reference biological value

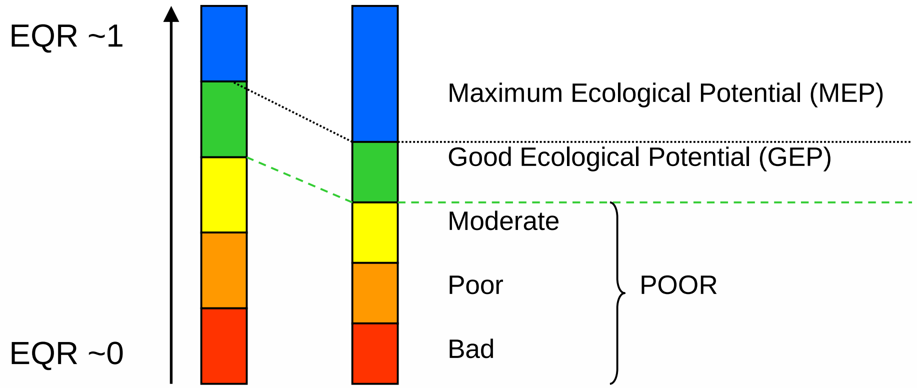
ECOLOGICAL POTENTIAL

EQR FOR ARTIFICIAL AND STRONGLY MODIFIED WATER BODIES

Man-made canals and dams

Strongly modified rivers

Concept of a GOOD ECOLOGICAL POTENTIAL



EU-WFD : CONSEQUENCES FOR POLICY

ONE-OUT-ALL-OUT PRINCIPLE

high
good
moderate
poor
bad

These signals of either good or bad water quality, are reported by the regional/national governments to the higher level of policy (EU) :

Good ecological quality = continued basic monitoring (as in EU-directive)

Bad ecological quality > a member country formally asked for restoration measures

> make a plan for improvement

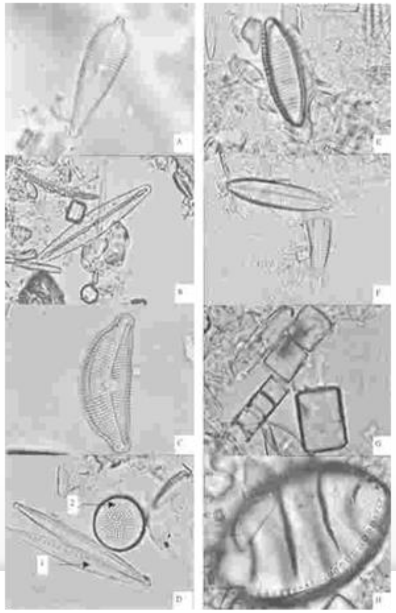
> conduct basic and targeted monitoring

BIOMONITORING TROPICAL RIVERS AND LAKES

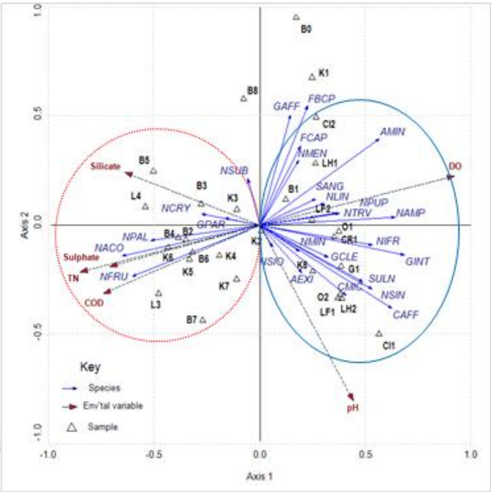
SIMILAR APPROACHES

FIELD WORK

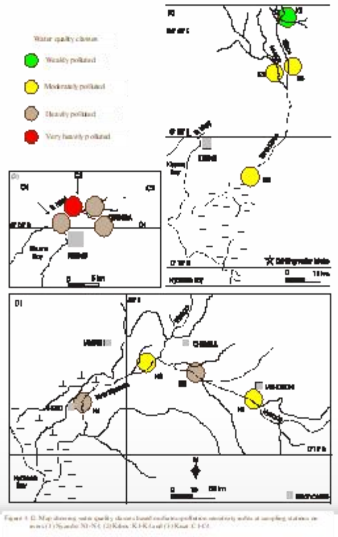
DIATOMS AS BIO-INDICATORS



MULTIVARIATE ANALYSIS



MAPS FOR POLICY



ARE THE SAME GROUPS OF ORGANISMS INFORMATIVE ?

JUST COPY & PASTE OF TEMPERATE REGIONS ?

We should ask the question whether the considered organisms groups really can be used in tropical rivers and lakes to the same extent as temperate aquatic habitats ?

Phytoplankton – Phytobenthos – Macrophytes – Macroinvertebrates - Fish

ARE THE SAME GROUPS OF ORGANISMS INFORMATIVE ?

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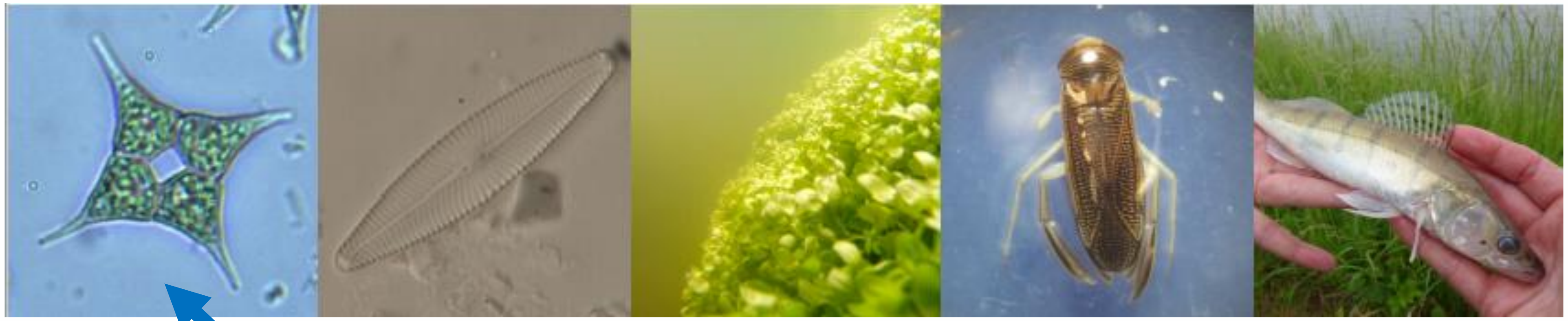
Phytoplankton



YES, but more and year-round cyanobacteria

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Phytobenthos

YES, but low diversity and 'homogenized' during rainy season

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Macrophytes

YES in flooded wetlands and lake margins; HARDLY or NOT in rivers

ARE THE SAME GROUPS OF ORGANISMS INFORMATIVE ?

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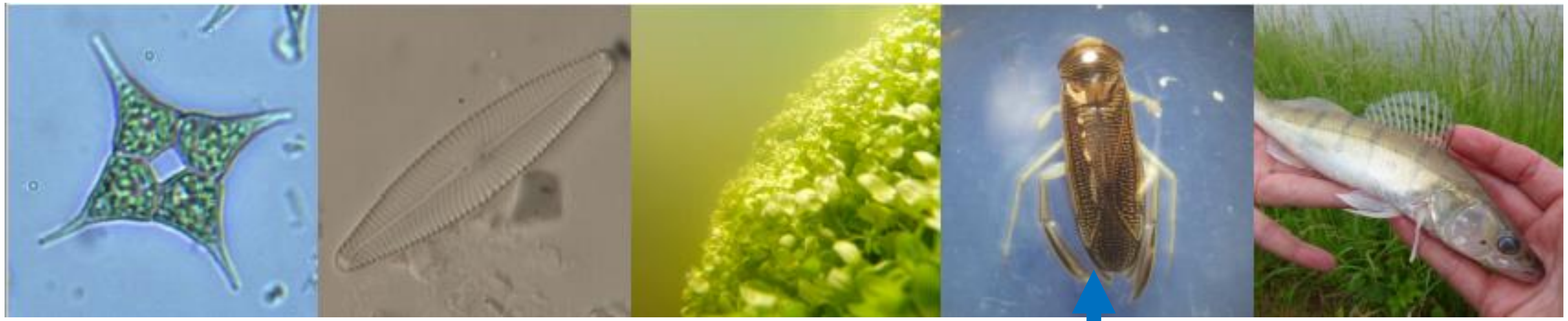
Macroinvertebrates



YES, and reflecting HABITAT quality

ARE THE SAME GROUPS OF ORGANISMS INFORMATIVE ?

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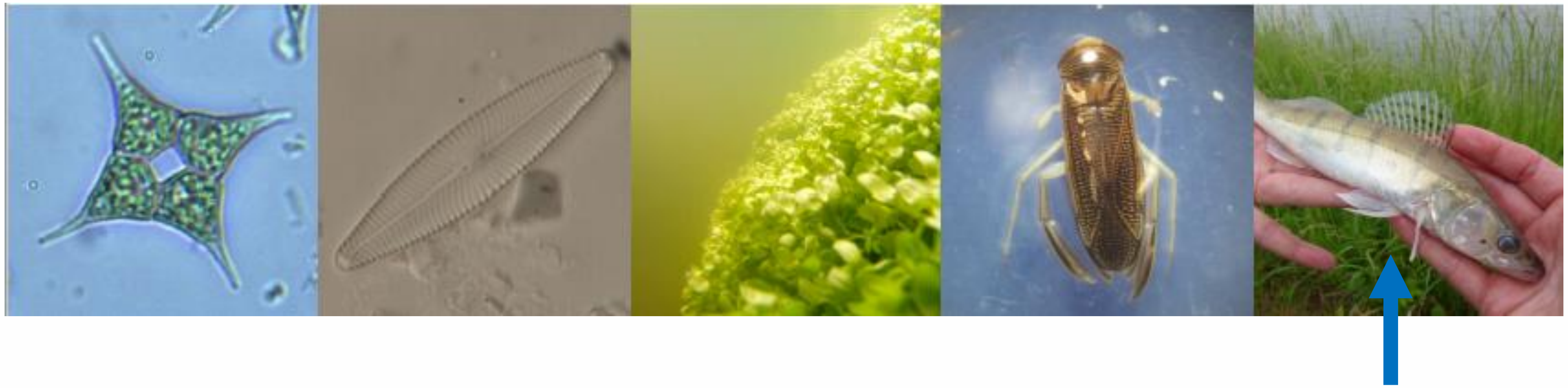
We should ask the question whether the considered organisms groups really can be used in tropical rivers and lakes to the same extent as temperate aquatic habitats ?

Fish



YES in flooded wetlands and lakes; DIFFICULT to use in rivers

RESPONSE TO PHOSPHATE LEVELS AND OVERALL 'URBAN' POLLUTION

AS EXPECTED

Hydrobiologia (2012) 695:343–360
DOI 10.1007/s10750-012-1201-2

ALGAE FOR MONITORING RIVERS

Epilithic diatoms as indicators in tropical African rivers (Lake Victoria catchment)

Ludwig Triest · Henri Lung'ayia ·
George Ndiritu · Abebe Beyene

Aquatic Ecosystem Health and Management Society

Taylor & Francis
Taylor & Francis Group

Characterization of environmental gradients using physico-chemical measurements and diatom densities in Nairobi River, Kenya

G. G. Ndiritu,[1,2*] N. N. Gichuki,[1] P. Kaur,[2] and L. Triest[2]

Biodiversity and Conservation (2005) 00:1–27
DOI 10.1007/s10531-005-0600-3

Distribution of epilithic diatoms in response to environmental conditions in an urban tropical stream, Central Kenya

GEORGE G. NDIRITU[1,3,*], NATHAN N. GICHUKI[2] and
LUDWIG TRIEST[3]

NEGATIVE EFFECT OF COFFEE PROCESSING AND SLUDGE

UPSTREAM POINT POLLUTION

PhD Abebe Beyene Hailu
PhD Aymere Assayie Awoke

Environ Monit Assess
DOI 10.1007/s10661-011-2479-7

The impact of traditional coffee processing on river water quality in Ethiopia and the urgency of adopting sound environmental practices

Abebe Beyene · Yared Kassahun · Taffere Addis · Fassil Assefa · Aklilu Amsalu · Worku Legesse · Helmut Kloos · Ludwig Triest

POSITIVE EFFECT OF WETLANDS IN PURIFICATION & SEDIMENTATION

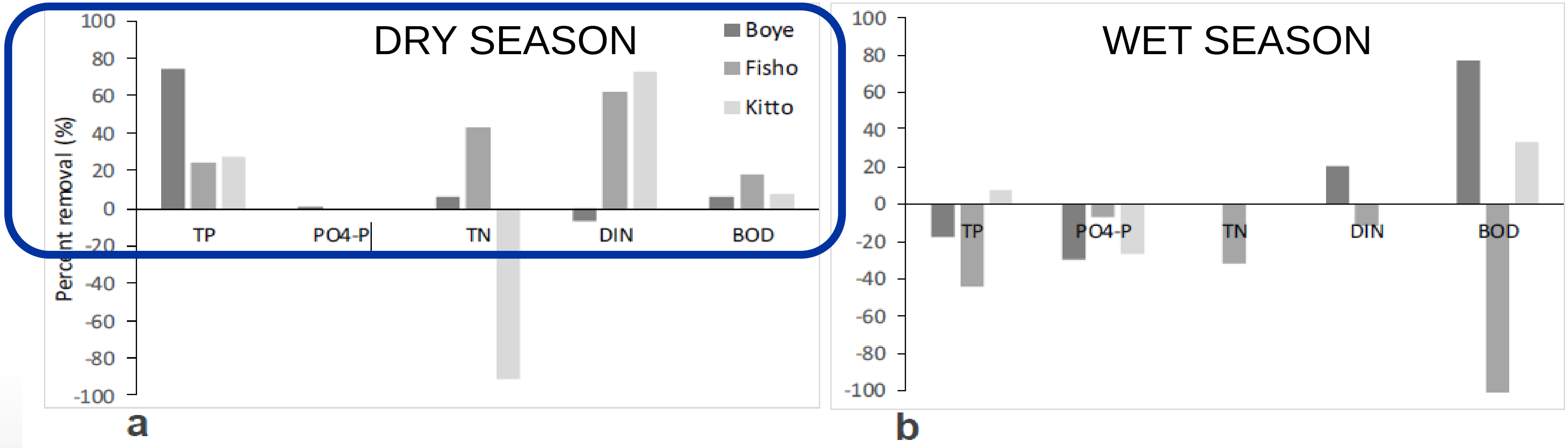


Figure 1. Percent reduction of nutrients and BOD by natural riverine wetlands of Jimma.

MSc Adey Sileshi,

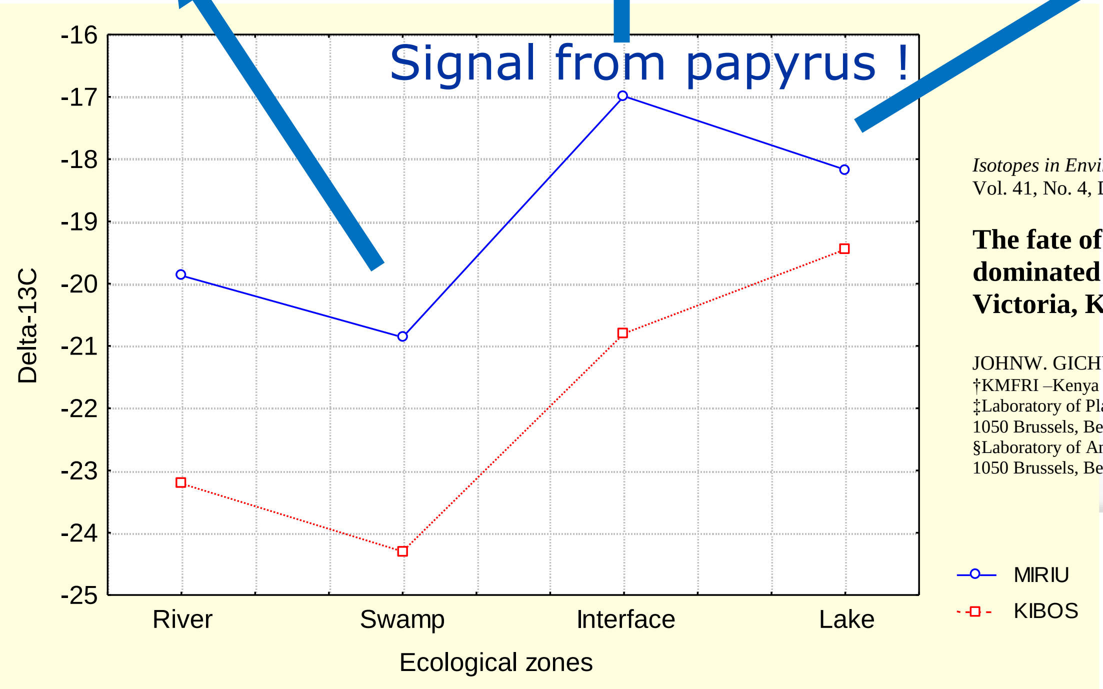
WETLANDS ECOLOGICAL ROLE

PRIMARY PRODUCTION, HABITAT DIVERSITY, COARSE SEDIMENT TRAPPING

VRIJE UNIVERSITEIT BRUSSEL

POSITIVE IMPACT OF WETLAND DETRITUS ON LAKE DIVERSITY

CARBON STABLE ISOTOPE RATIO'S THROUGH A PAPYRUS SWAMP IN LAKE VICTORIA (KENYA)



PhD John Gichuki

Isotopes in Environmental and Health Studies
Vol. 41, No. 4, December 2005, 379–390

The fate of organic matter in a papyrus (*Cyperus papyrus* L.) dominated tropical wetland ecosystem in Nyanza Gulf (Lake Victoria, Kenya) inferred from δ13C and δ15N analysis

JOHNW. GICHUKI*†‡§, LUDWIG TRIEST‡ and FRANK DEHAIRS§
†KMFRI –Kenya Marine and Fisheries Research Institute, PO Box 1881, Kisumu, Kenya
‡Laboratory of Plant Science and Nature Management, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium
§Laboratory of Analytical Chemistry, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium

PHYTOPLANKTON DYNAMICS IN LAKE VICTORIA (KENYA)

SPATIAL DIFFERENCE

DRY SEASON

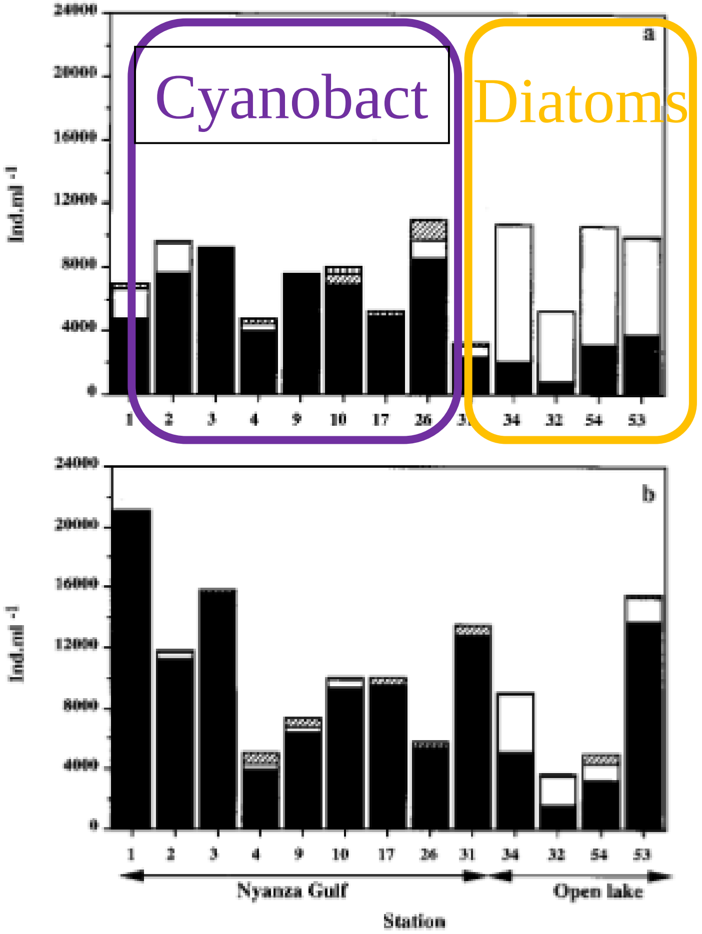


Fig. 3 Numerical abundance of phytoplankton in surface waters: (a) September 1994 (dry season); and (b) March 1995 (rainy season). Key: (dark-shaded areas) Cyanobacteria; (white areas) Bacillariophyceae; (obliquely hatched areas) Chlorophyceae; and (vertically hatched areas) Dinophyceae.

OPEN LAKE (40-50m)

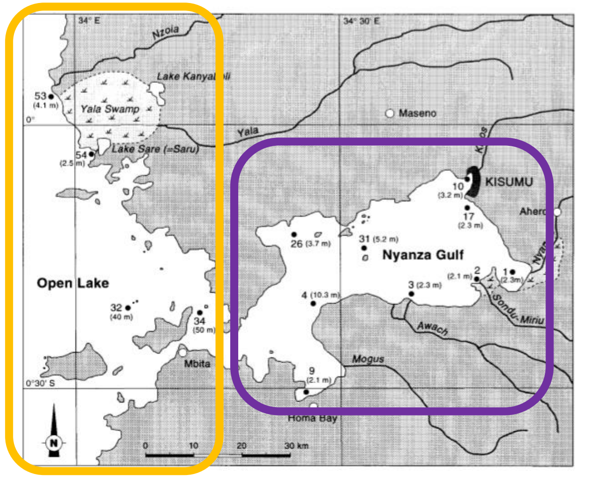


Fig. 1 Map showing the positions of the sampling stations in the Kenyan part of Lake Victoria. The brackets indicate depth. The gulf stations are numbers 1, 2, 3, 9, 10, 17 and 26 (coastal), and 4 and 31 (offshore). The open lake stations are numbers 53 and 54 (coastal), and 32 and 34 (offshore).

Shallow Bay (<5 m)

PhD Henri Lung'ayia

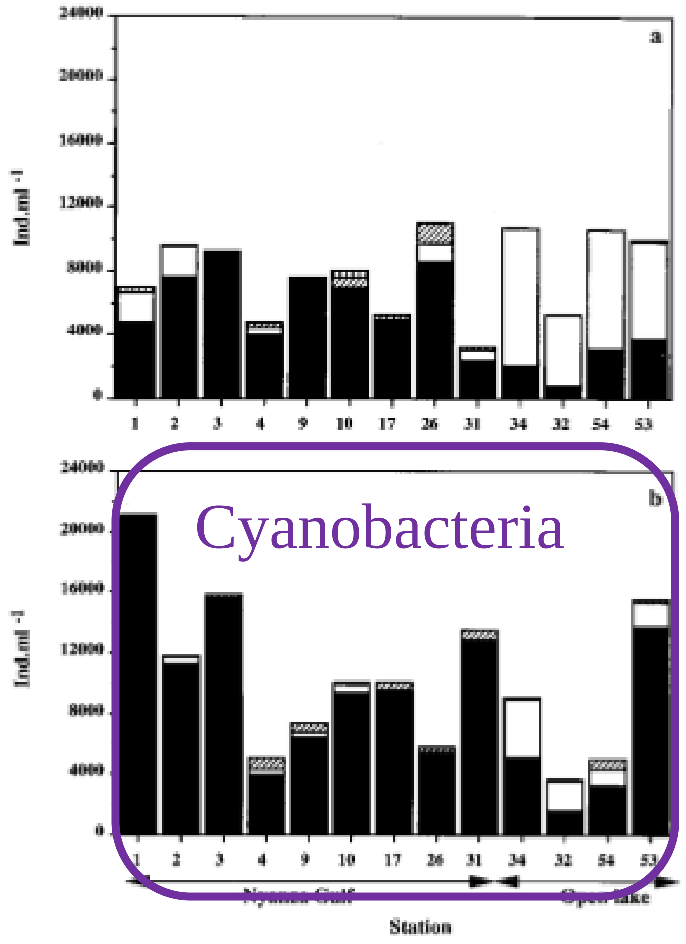
PHYTOPLANKTON DYNAMICS IN LAKE VICTORIA (KENYA)

DRY SEASON

FLUSHED CYANO'S

RAINY SEASON

(<5-fold)



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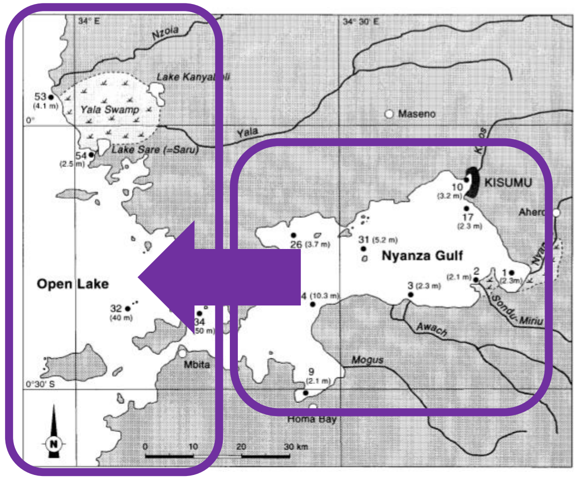

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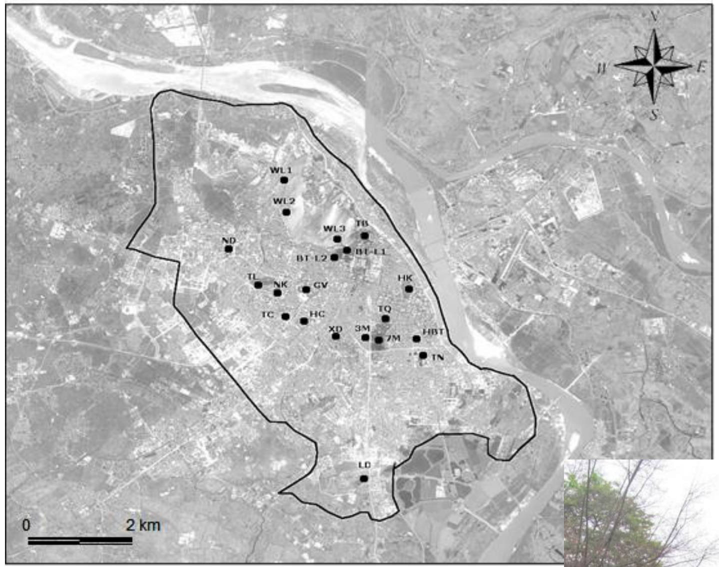
Shallow Bay (<5 m)

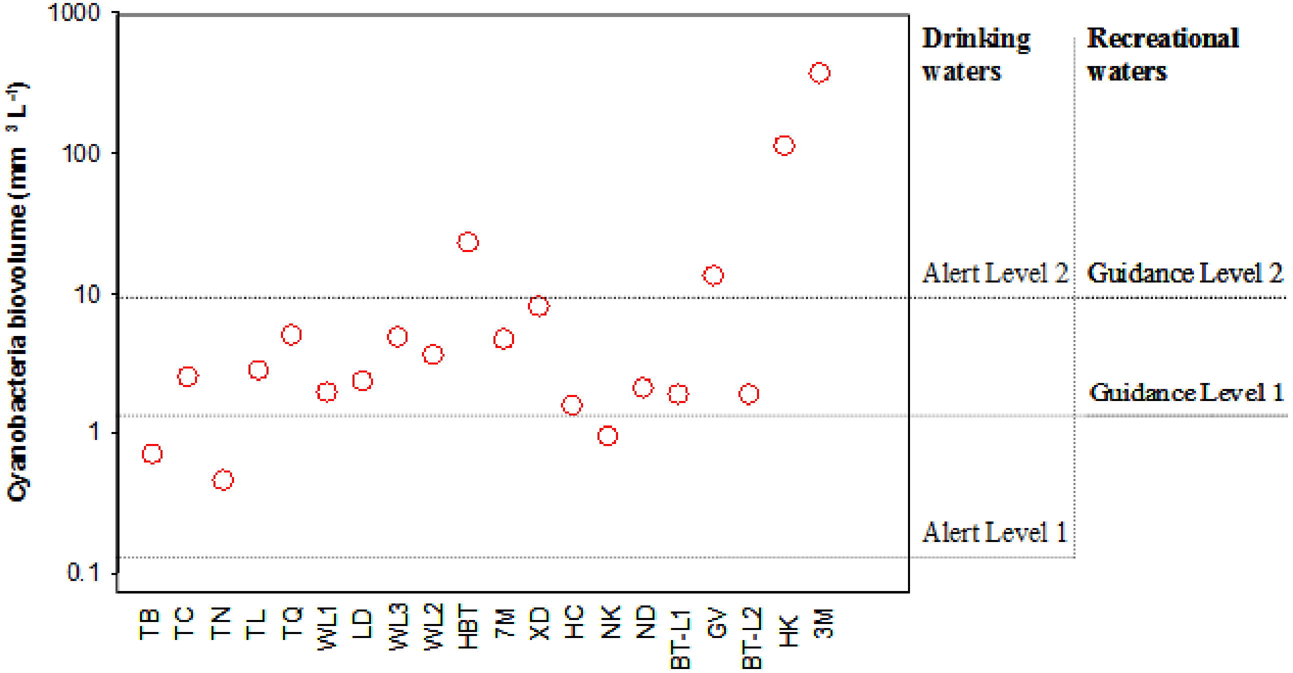
PhD Henri Lung'ayia

CYANOBACTERIA WHO GUIDANCE LEVEL

HANOI URBAN LAKES (VIETNAM)



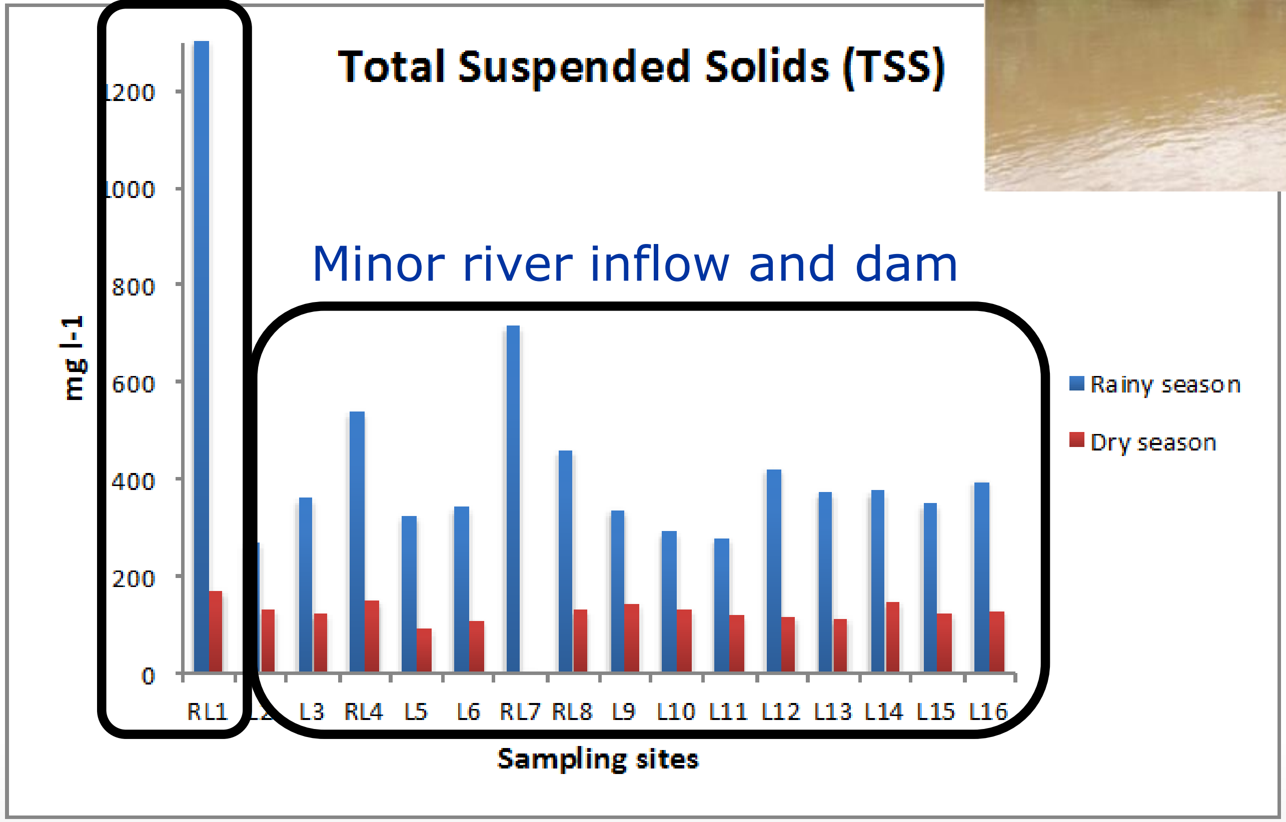
MSc Hien Nguyen Thanh

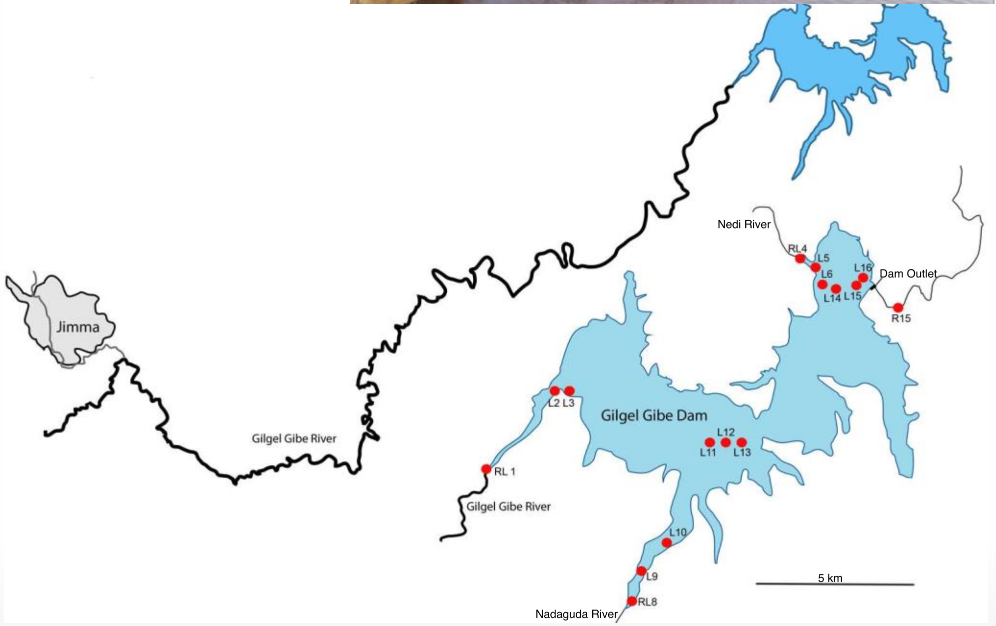


TOTAL SUSPENDED SOLIDS OF ARTIFICIAL RESERVOIR IN WET/DRY SEASON

GILGEL GIBE DAM, ETHIOPIA

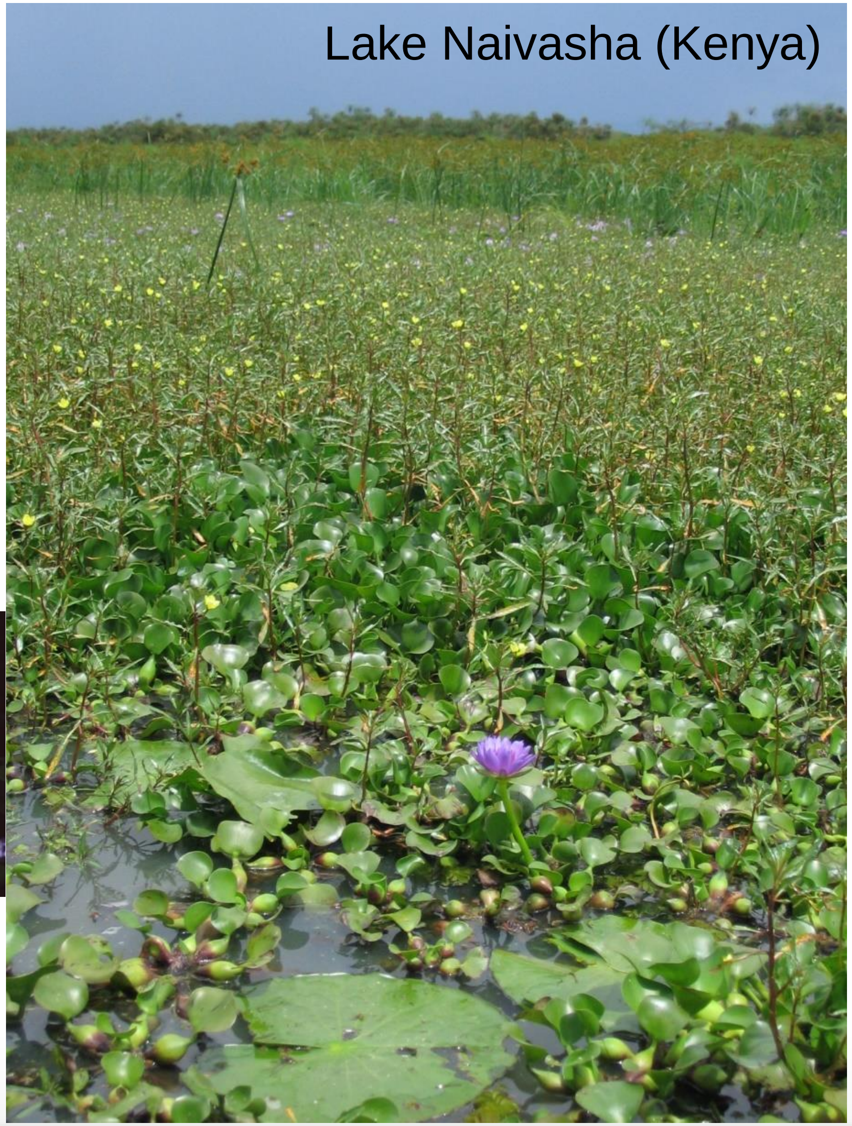
Major river inflow





DISTURBANCE: INVASIVE AQUATIC WEEDS

EFFECT ON PLANKTON ?



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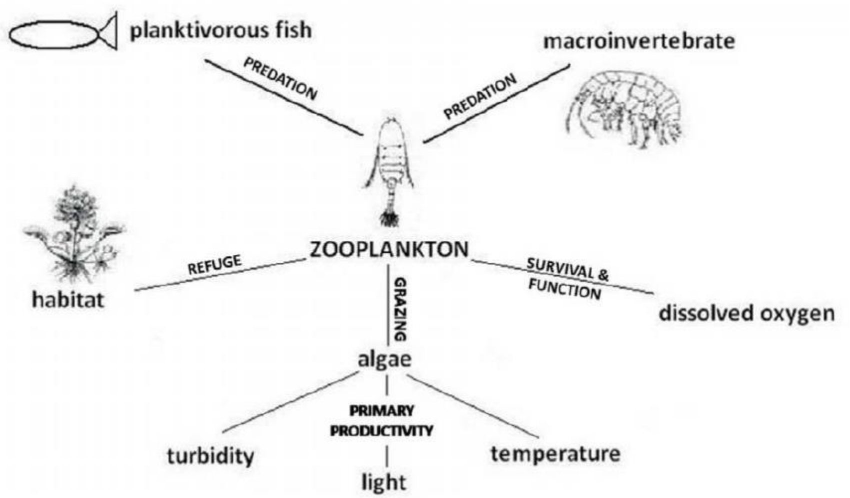
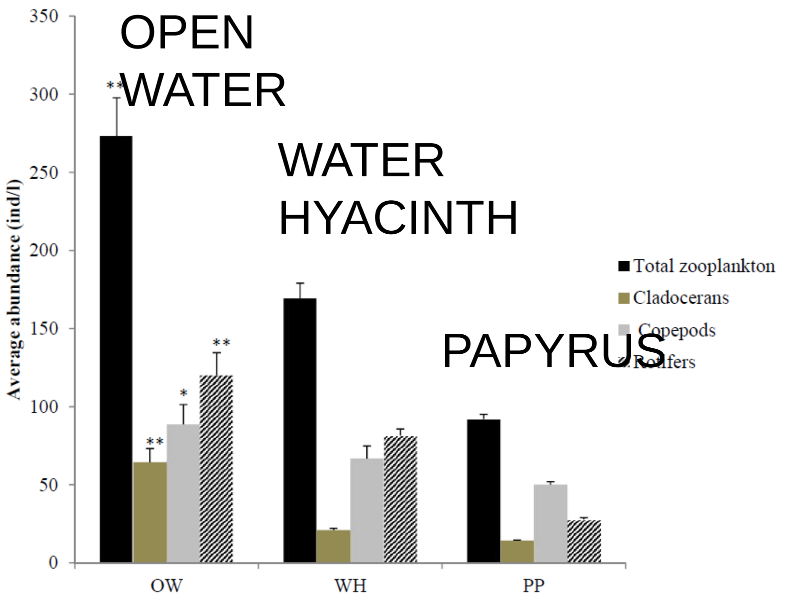
NEGATIVE EFFECT OF WEEDS & WETLANDS ON ZOOPLANKTON ABUNDANCES

LAKE NAIVASHA

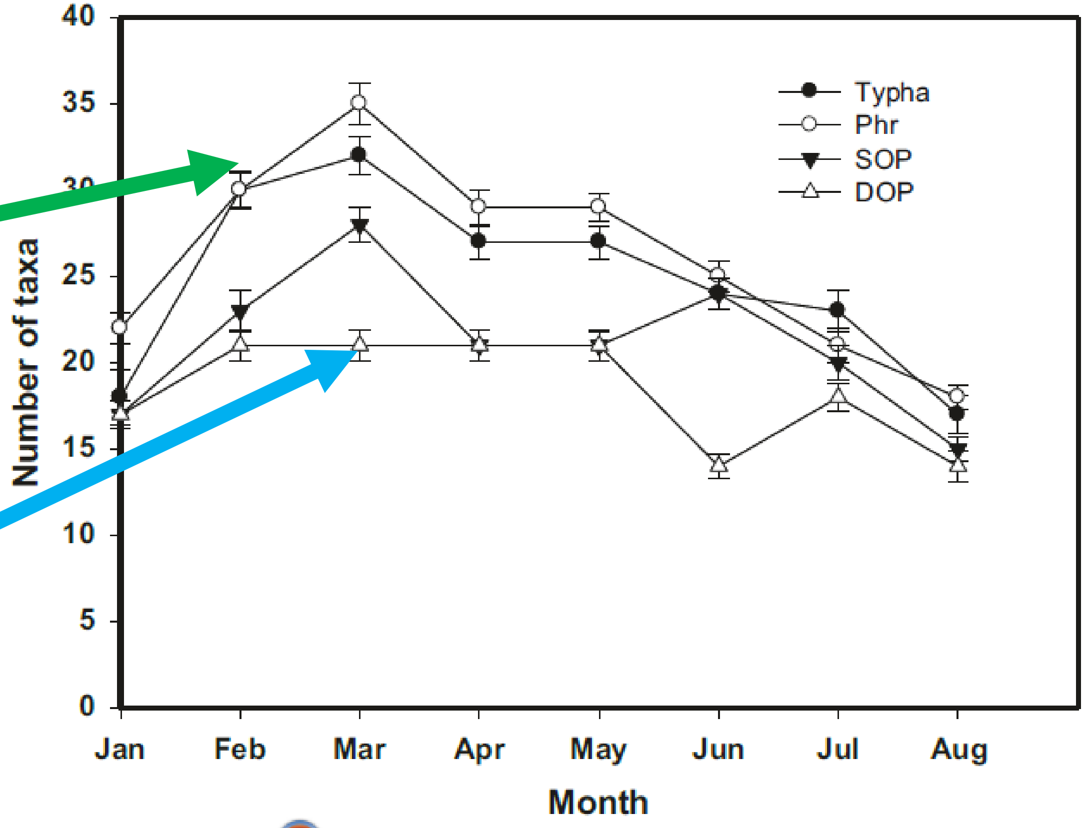




MSc Joylene Jepkemoi Kanyaris

POSITIVE EFFECTS OF WETLANDS ON ZOOPLANKTON

LAKE ZIWAY (ETHIOPIAN RIFT LAKE):



PhD Mesfin Damtew

Environmental Management
DOI 10.1007/s00267-017-0935-z
CrossMark

Emergent Macrophytes Support Zooplankton in a Shallow Tropical Lake: A Basis for Wetland Conservation

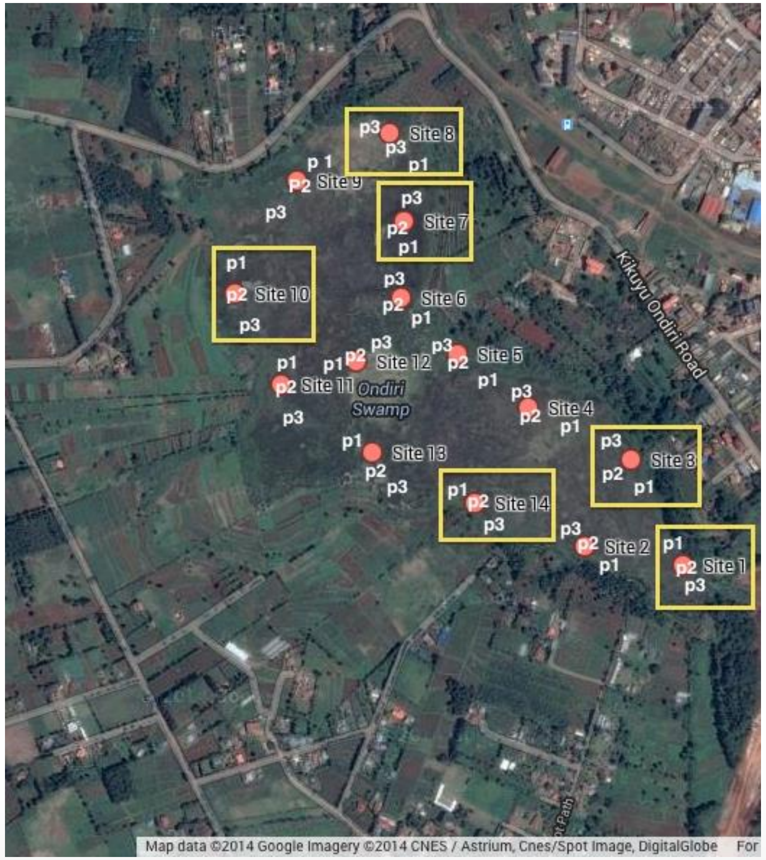
Mesfin Gebrehiwot[1,2] · Demeke Kifle[3] · Ludwig Triest[1]

ECOSYSTEM SERVICES AND LOCAL USE : AWARENESS

SOCIO-ECONOMIC SURVEY'S

Biodiversity and biomass

Ondiri swamp



MSc Irene Mate

ECOLOGICAL STATUS OF SHALLOW LAKES (ECOFRAME SCHEME, VERSION 8)

WE CAN NOT TRANSPOSE THIS MONITORING AND EVALUATION TO TROPICAL LAKES !!!

Overall ecological status	Ecotype no.	Conductivity (µS cm^{-1})	pH (log units)	TP (µgL^{-1})	Secchi depth (m)	Chlorophyl a (µgL^{-1})	Phytoplankton diversity	Plant community	Plant diversity (species no	Plant abundance	Cladocera (no. large:no. to
Before biomanipulation (2006)											
bad	17	748	7.9	673	0.7	52.1	A	CanNym	2	3	0.1
bad	17	570	7.7	174	0.8	54.3	A	Absent	0	0	0.0
bad	17	422	8.4	351	0.4	87.8	B	Absent	0	0	0.1
bad	17	781	8.4	426	0.6	82.8	B	Absent	0	0	0.0
bad	17	895	7.8	204	0.6	41.4	B	CanNym	2	1	0.1
bad	17	546	7.8	213	0.7	20.1	A	?	?	?	0.0
bad	17	473	8.2	354	0.4	113.3	B	Absent	0	0	0.0
bad	17	536	9.0	506	0.3	469.7	C	Absent	0	0	0.0
bad	17	735	8.0	428	0.6	40.2	B	Absent	0	0	0.0
bad	17	557	8.8	407	0.3	348.6	C	Absent	0	0	0.0
After biomanipulation (2007)											
moderate	17	935	7.7	247	1.4	28.7	A	CanNym	4	3	0.8
poor	17	525	7.6	100	1.3	7.3	A	CanNym	1	3	0.2
bad	17	433	7.9	191	0.9	18.0	A	Absent	0	0	0.7
poor	17	711	7.8	196	1.8	7.0	A	ElPo	2	2	0.8
poor	17	924	7.8	131	1.2	14.5	A	CanNym	2	1	0.4
moderate	17	480	7.8	142	2.1	6.0	A	Char	5	3	0.9
bad	17	448	8.5	626	1.4	170.8	B	ElPo	2	1	0.7
bad	17	634	8.3	517	1.2	19.8	B	ElPo	2	2	0.2
bad	17	624	8.0	324	0.4	151.1	A	Absent	0	0	0.1
poor	17	661	8.0	213	1.5	25.7	B	ElPo	1	2	0.5

← before

← after

high

good

moderate

poor

bad

high
good
moderate
poor
bad

ARE WE MEASURING THE RIGHT APSECTS?

HOW CAN BIO-INDICATOR MAPS BE CONVINCING TO POLICY MAKERS ?

MAYBE BIO-INDICATORS AND INDICES ARE TOO MUCH A KIND OF FUN JOB

So, could there be an alternative proxy for ecological water quality ?

high
good
moderate
poor
bad

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Could one think of separating effects of point pollution and urban pollution from the very diffuse pollution within a catchment, when reporting – usually informal yet - to a governmental agency

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good
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✓ Point and urban pollution usually is drastic (no need to prove with organisms?) > treatment

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✓ Wetlands along lakes > % and thresholds needed for lake system

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✓ Forests and wetlands in upstream river stretches > % and thresholds needed for conservation

✓ Wetlands along lakes > % and thresholds needed for lake system

✓ Ecological water quality also includes ‘maximization of ecosystem services’

TAKE HOME MESSAGE = FOCUS ON CENTRAL ROLE of WETLANDS

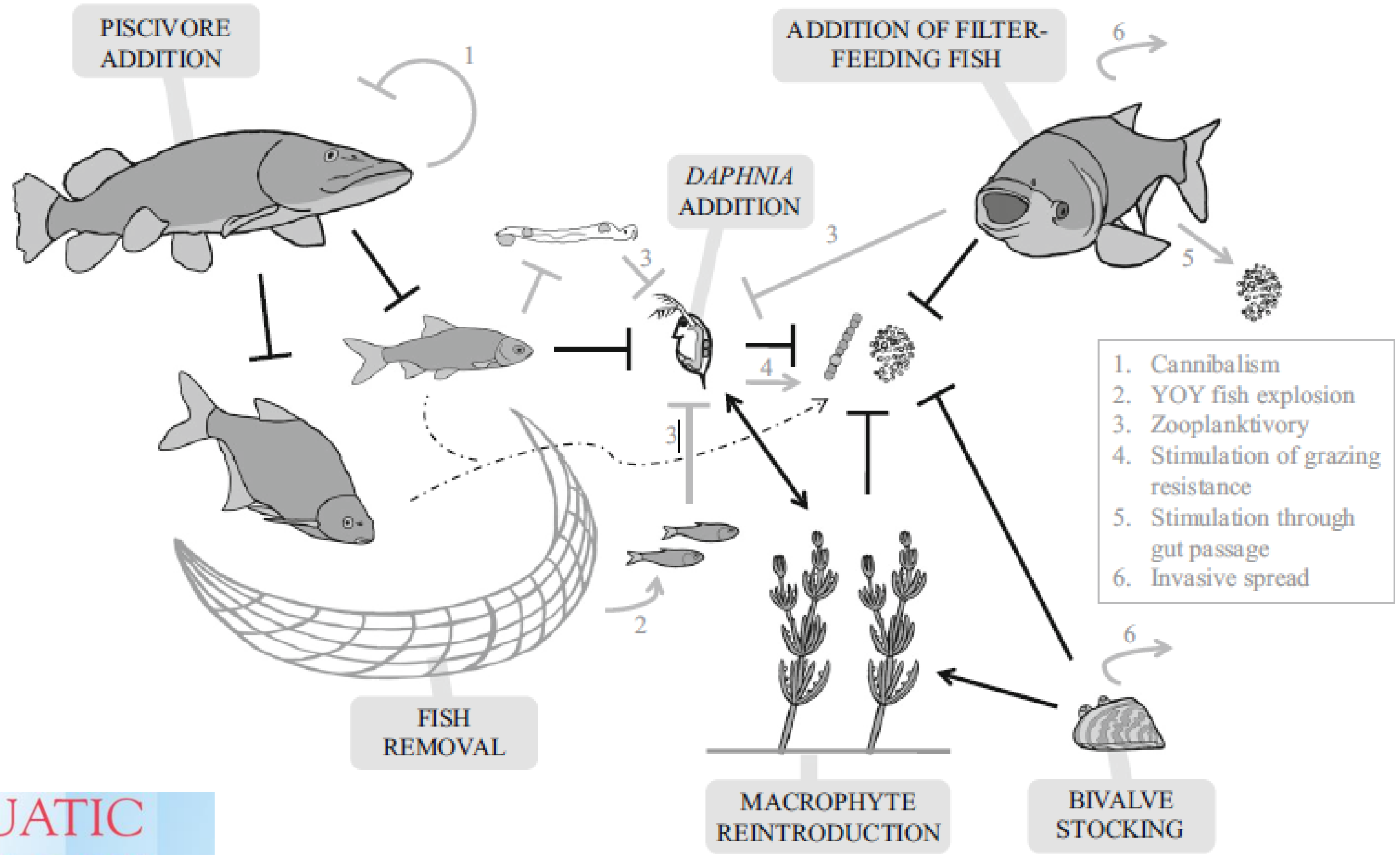
- ✓ Primary production and biodiversity
- ✓ Sediment trapping and purification
- ✓ Detritus (C-sink)
- ✓ Socio-economic importance

Thank you

VRIJE UNIVERSITEIT BRUSSEL

Biomanipulation tools to control cyanobacteria

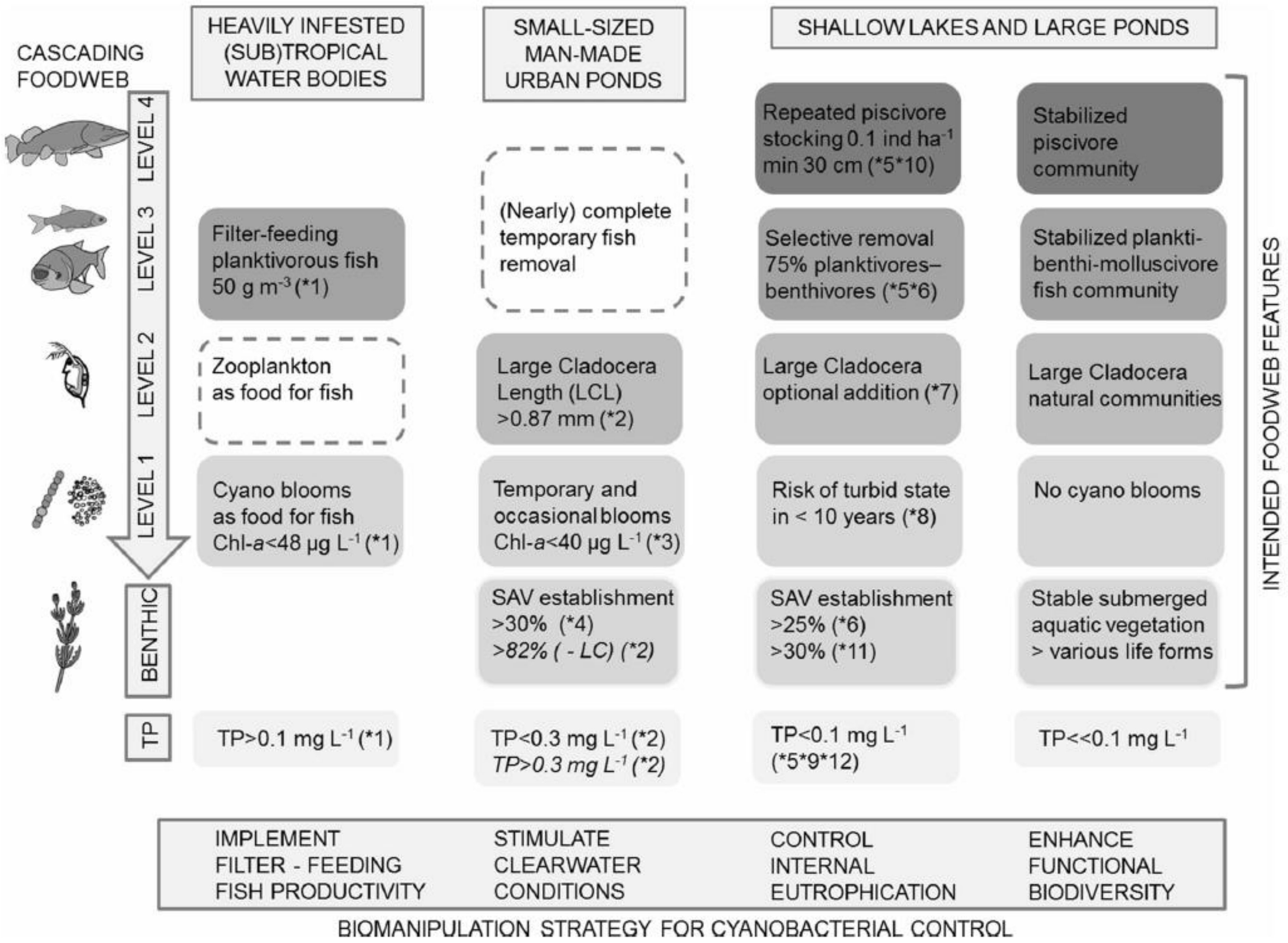
Fig. 1 Biomanipulation tools to control cyanobacteria. Biomanipulation-mediated biotic interactions preventing cyanobacterial growth are given in *black*. Undesired side effects of biomanipulation are shown in *gray* (see *box* for explanation). *Conventional arrows* represent facilitating effects, while——| interactions indicate negative influences. *Dotted arrow*: nutrient recycling by fish; YOY fish: young-of-the-year fish

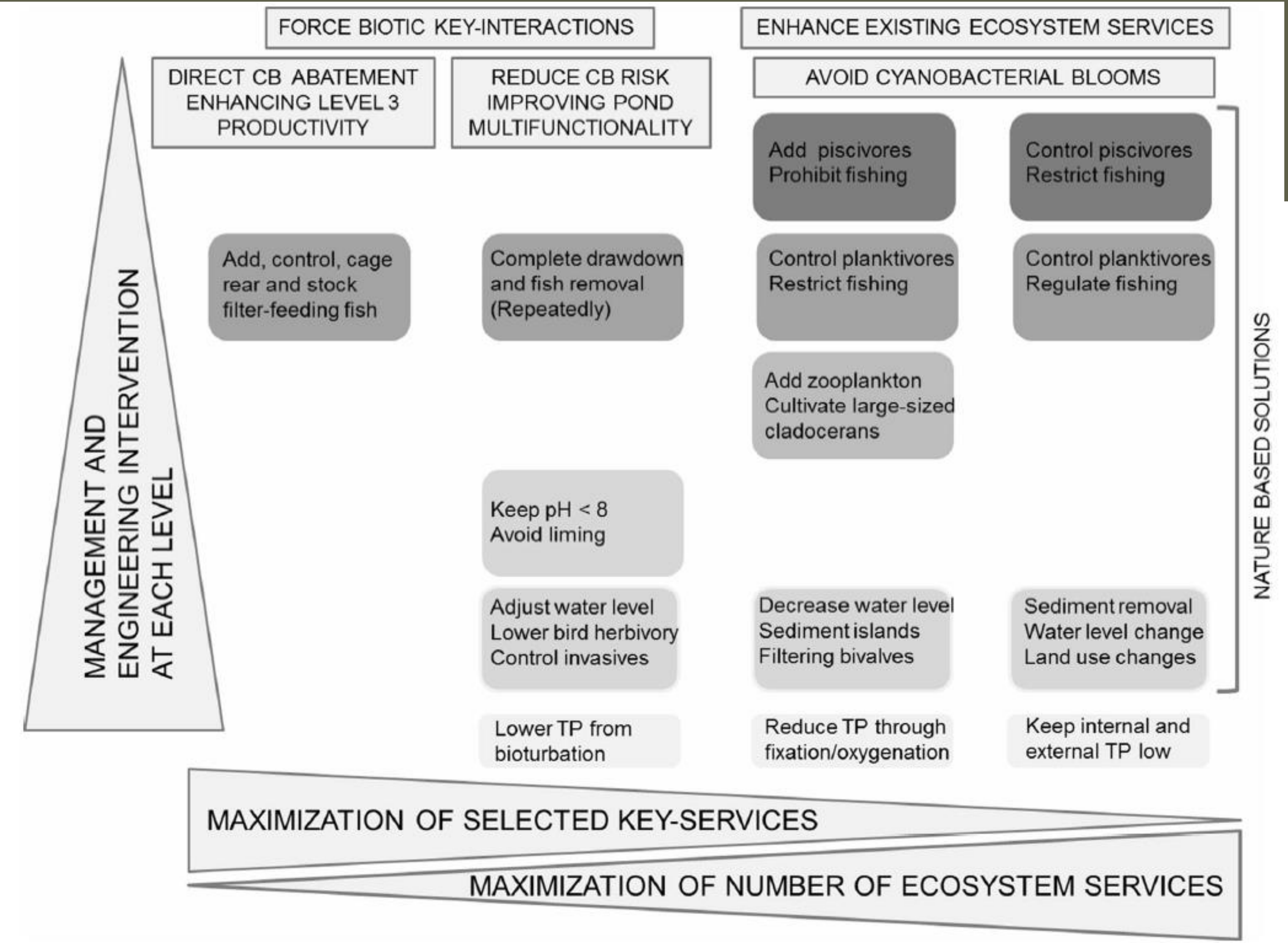


Aquat Ecol (2016) 50:461–483
DOI 10.1007/s10452-015-9548-x
AQUATIC ECOLOGY

Biomanipulation as a nature-based solution to reduce cyanobacterial blooms

Ludwig Triest · Iris Stiers · Stijn Van Onsem


CASCADING FOODWEB
HEAVILY INFESTED (SUB)TROPICAL WATER BODIES
SMALL-SIZED MAN-MADE URBAN PONDS
SHALLOW LAKES AND LARGE PONDS
LEVEL 4
LEVEL 3
LEVEL 2
LEVEL 1
BENTHIC
TP
Repeated piscivore stocking 0.1 ind ha-1 min 30 cm (*5*10)
Stabilized piscivore community
Filter-feeding planktivorous fish 50 g m-3 (*1)
(Nearly) complete temporary fish removal
Selective removal 75% planktivores–benthivores (*5*6)
Stabilized plankti-benthi-molluscivore fish community
Zooplankton as food for fish
Large Cladocera Length (LCL) >0.87 mm (*2)
Large Cladocera optional addition (*7)
Large Cladocera natural communities
Cyano blooms as food for fish Chl-a<48 µg L-1 (*1)
Temporary and occasional blooms Chl-a<40 µg L-1 (*3)
Risk of turbid state in < 10 years (*8)
No cyano blooms
SAV establishment >30% (*4) >82% (- LC) (*2)
SAV establishment >25% (*6) >30% (*11)
Stable submerged aquatic vegetation > various life forms
TP>0.1 mg L-1 (*1)
TP<0.3 mg L-1 (*2) TP>0.3 mg L-1 (*2)
TP<0.1 mg L-1 (*5*9*12)
TP<<0.1 mg L-1
INTENDED FOODWEB FEATURES
IMPLEMENT FILTER - FEEDING FISH PRODUCTIVITY
STIMULATE CLEARWATER CONDITIONS
CONTROL INTERNAL EUTROPHICATION
ENHANCE FUNCTIONAL BIODIVERSITY
BIOMANIPULATION STRATEGY FOR CYANOBACTERIAL CONTROL


FORCE BIOTIC KEY-INTERACTIONS
ENHANCE EXISTING ECOSYSTEM SERVICES
DIRECT CB ABATEMENT ENHANCING LEVEL 3 PRODUCTIVITY
REDUCE CB RISK IMPROVING POND MULTIFUNCTIONALITY
AVOID CYANOBACTERIAL BLOOMS
Add piscivores Prohibit fishing
Control piscivores Restrict fishing
Add, control, cage rear and stock filter-feeding fish
Complete drawdown and fish removal (Repeatedly)
Control planktivores Restrict fishing
Control planktivores Regulate fishing
Add zooplankton Cultivate large-sized cladocerans
Keep pH < 8 Avoid liming
Adjust water level Lower bird herbivory Control invasives
Decrease water level Sediment islands Filtering bivalves
Sediment removal Water level change Land use changes
NATURE BASED SOLUTIONS
MANAGEMENT AND ENGINEERING INTERVENTION AT EACH LEVEL
Lower TP from bioturbation
Reduce TP through fixation/oxygenation
Keep internal and external TP low
MAXIMIZATION OF SELECTED KEY-SERVICES
MAXIMIZATION OF NUMBER OF ECOSYSTEM SERVICES