National and Kapodistrian University of Athens
Faculty of Biology
SECTION OF ECOLOGY & SYSTEMATICS

9 July 2019, Manzherok, Russia

Teaching Challenges in Inland Water Biology

Dr. Ioanna Louvrou
Dr. Athena Economou-Amilli

Contents

Introduction

- ✓ Inland Water. What does it mean ?
- ✓ Inland Water Biology and the Similar Term 'Limnology'.
- ✓ Why study Inland Water Biology ?
  - ➢ Goods & Services

What is 'Inland Water' ?

According to the **Convention on Biological Diversity** (United Nations Environment Programme)
https://www.cbd.int/waters/inland-waters/default.shtml

'Inland Waters' is a term we use for aquatic-influenced environments located within land boundaries.

'Inland Waters' Include:

- Lakes; rivers; ponds; streams; springs; cave waters; floodplains; marshes swamps
- Groundwater
- Estuaries. Transitional zones between rivers & sea.

  Most coastal aquatic habitats are best considered as the lower sections of river basins.

→ can be fresh; saline or brackishwater

➢ **Location counts; not salinity**

➢ Salinity of Inland Waters, S < 0.3 ‰
(S > 0.3‰ of Saline Waters)


Doxa Lake


Evinos River

Stream, mountainous Nafpaktia

Inland Water Biology ≈ Limnology

Inland Water Biology

the study of the biological characteristics and interactions of organisms of inland waters.

This study is often largely restricted to the **organisms** themselves, such as their biology, life cycles (life histories), populations, or, occasionally, communities.

Limnology

the study of the **structural and functional relationships** and **productivity** of organisms of inland aquatic ecosystems as they are regulated by the **dynamics of their physical, chemical, and biotic environments**.

Wetzel 2001

Inland Water Biology ≈ Limnology

Inland Water Biology

Focus on the Anatomy of the Ecosystem

Limnology

Focus on the Physiology of the Ecosystem:
the functional metabolism, and
the controlling factors of the regulation of that physiology

Wetzel 2001

Why study Inland Water Biology ?

Goods & Services

- Biodiversity Conservation
- Nutrient Recycle
- Habitat Provision
- River-bank Stabilization
- Primary Production
- Groundwater Recharge
- Provisioning (fish, genetic ressources, biochemicals etc)
- Recreation Tourism
- Climate Regulation
- Water – Air Purification
- Flood Control

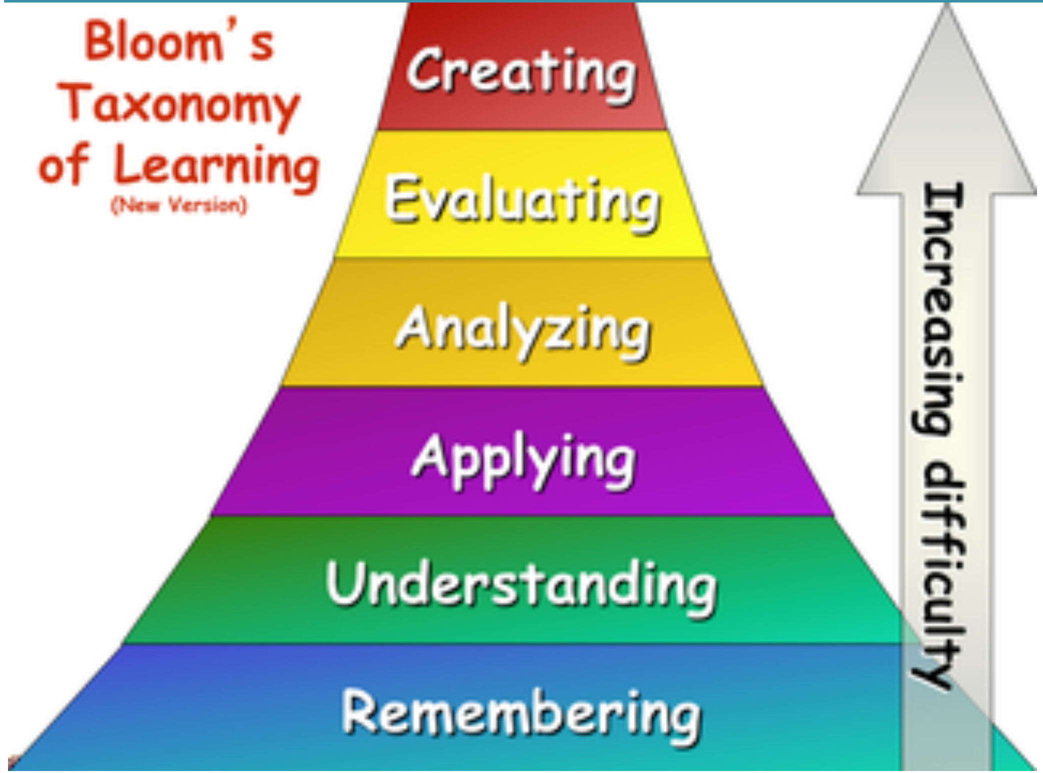
Finlayson *et al.* 2005

- Pollution (land, air, or water)
- Climate change
- Habitat & Integrity loss (dams etc)
- Water over-use
- Invasive species/ pathogens
- Over-harvesting

Key Aspects of Inland Water Biology. An Educational Approach

- ✓ Undergraduate modules. Learning outcomes.
- ✓ Postgraduate modules. Learning outcomes.

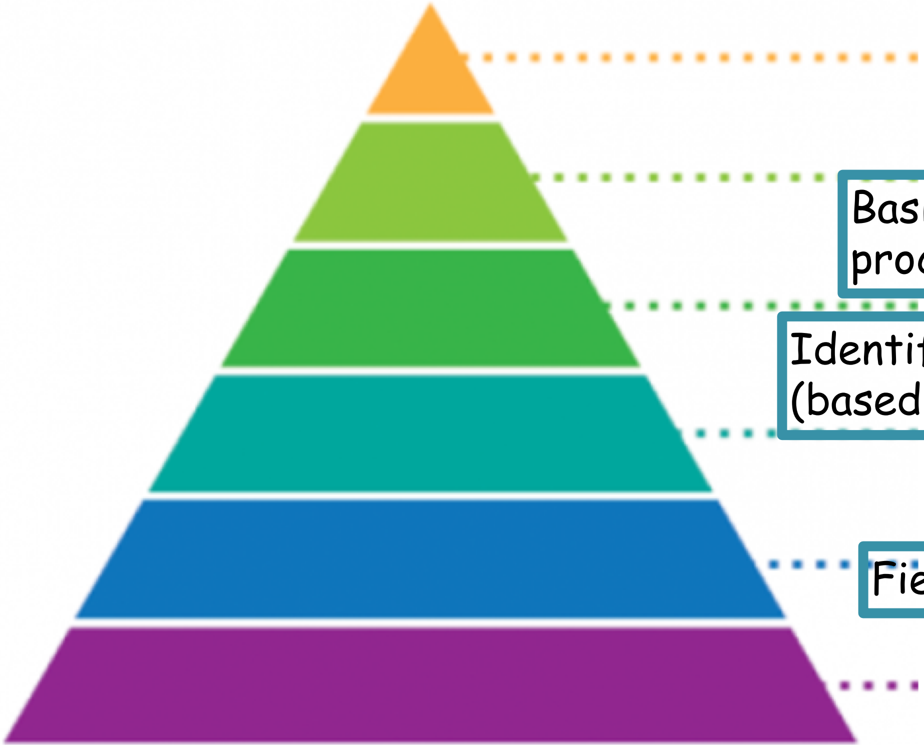
Bloom's Taxonomy (1956) Revised Anderson & Krathwohl's (2001)



http://veronikanengsi.weebly.com/uploads/2/3/9/8/23988806/1391709.png?320

Undergraduate modules. Learning outcomes

Integrated view of structure and a basic understanding of functioning, dynamics



Basic water quality assessment & monitoring

Potential impacts of human activities

Basic biological processes → biological interaction processes and their importance to ecosystems

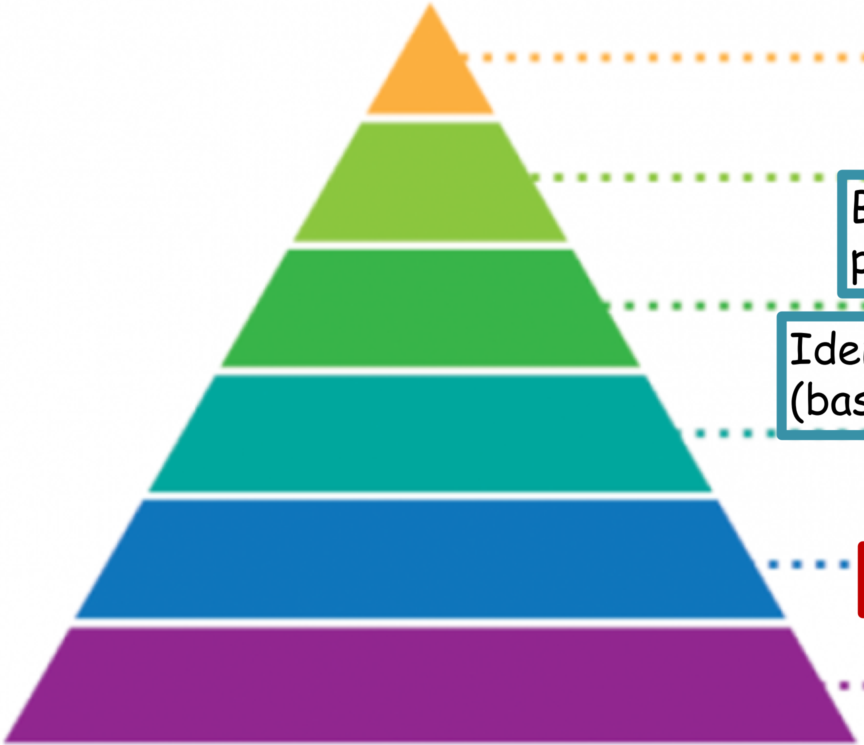
Identification of characteristic groups of organisms (based on morphology) & Habitat adaptation

Habitats & Evaluation of abiotic conditions

Field work (sampling), laboratory work (analyses)

Team work, Scientific publications, Presentation (oral & written)

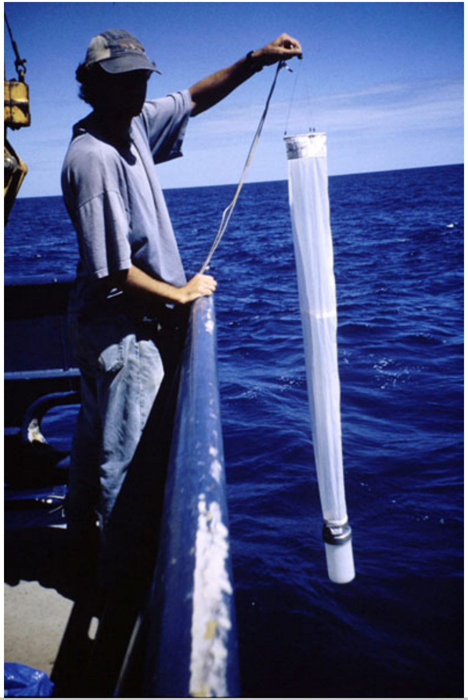
Undergraduate modules. Learning outcomes

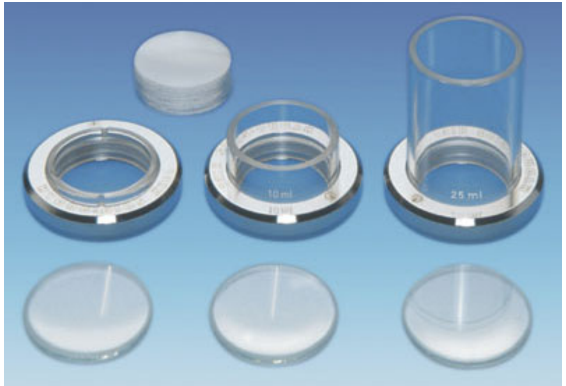


- Integrated view of structure and a basic understanding of functioning, dynamics
- Basic water quality assessment & monitoring
- Potential impacts of human activities
- Basic biological processes → biological interaction processes and their importance to ecosystems
- Identification of characteristic groups of organisms (based on morphology) & Habitat adaptation
- Habitats & Evaluation of abiotic conditions
- Field work (sampling), laboratory work (analyses)
- Team work, Scientific publications, Presentation (oral & written)

Sampling techniques

Microscopic analyses





# Drainage Basin		Abiotic Factors

Inland Water **Ecosystem**

= Lake; River; Reservoir etc. **& its Drainage Basin**

Inland water ecosystems are ecologically dynamic.

Drainage Basin

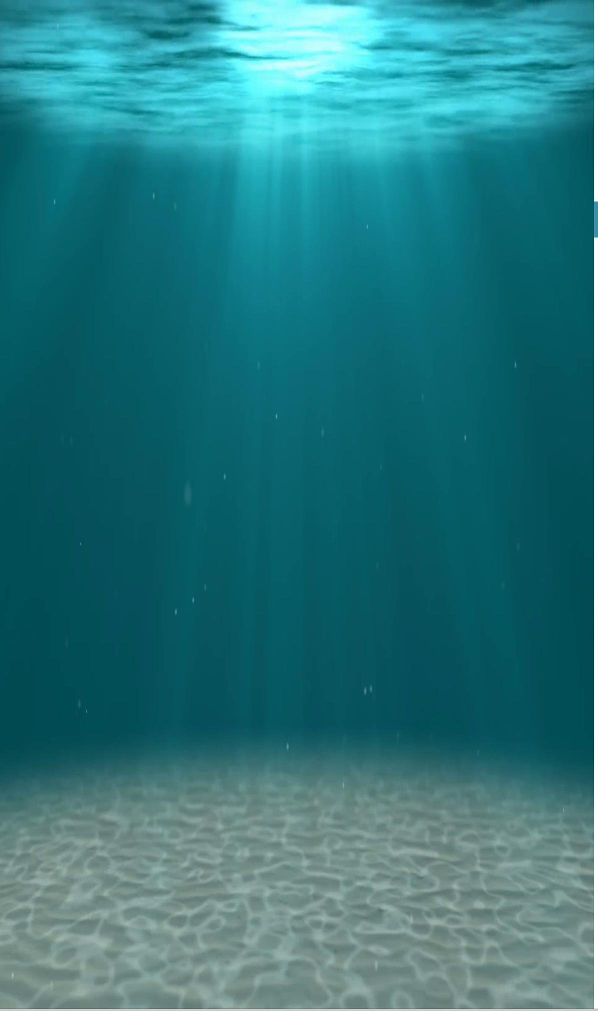
Burabay National Park; Kazakhstan; 2018

→ Lake; River Characteristics

Geomorphology; soil composition; vegetation and the biota including humans

Aquatic Ecosystem

i. Lake; River; Reservoir etc. &
ii. The corresponded Drainage Basin



Abiotic Factors

1. Geomorphology

(sediment types, soil stability and grain size, elevation and slopes, geomorphological and sedimental properties of the drainage basin, filling rates etc)

2. Hydrodynamic characteristics

Water level fluctuations, Inflow, Outflow, Flushing rates

3. Morphometry

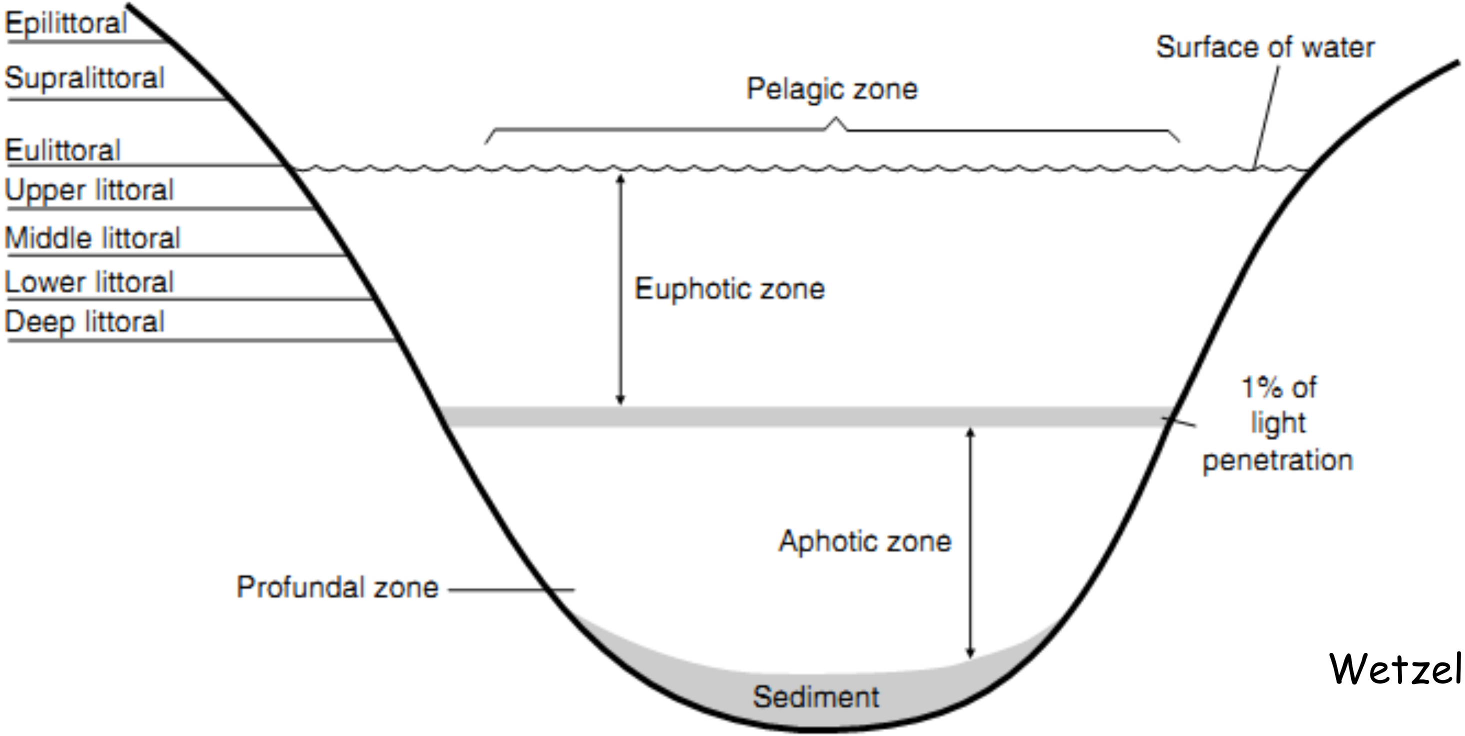
Drainage Basin and Channel Characteristics

Lake/ River basin shape & size (A, V, z, L, DL etc)

4. Physical & chemical parameters

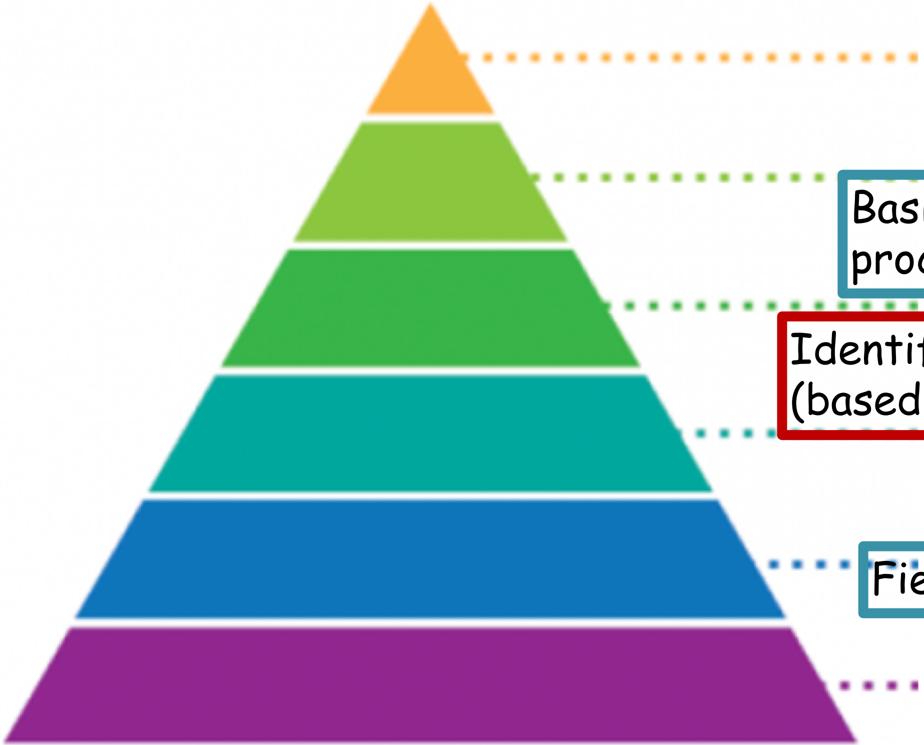
Light, T, O_2, S, conductivity, climate, nutrient concentrations, TDS, pH etc

Zonation & Terminology



Wetzel 2001

Undergraduate modules. Learning outcomes



Integrated view of structure and a basic understanding of functioning, dynamics

Basic water quality assessment & monitoring

Potential impacts of human activities

Basic biological processes → biological interaction processes and their importance to ecosystems

Identification of characteristic groups of organisms (based on morphology) & Habitat adaptation

Habitats & Evaluation of abiotic conditions

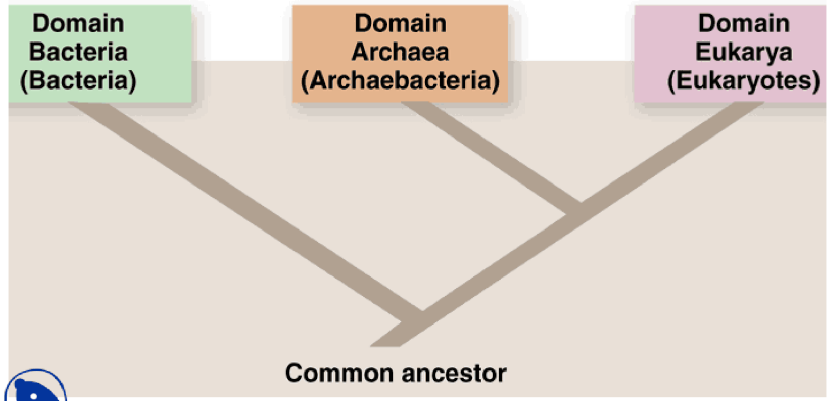
Field work (sampling), laboratory work (analyses)

Team work, Scientific publications, Presentation (oral & written)

Biota Biodiversity

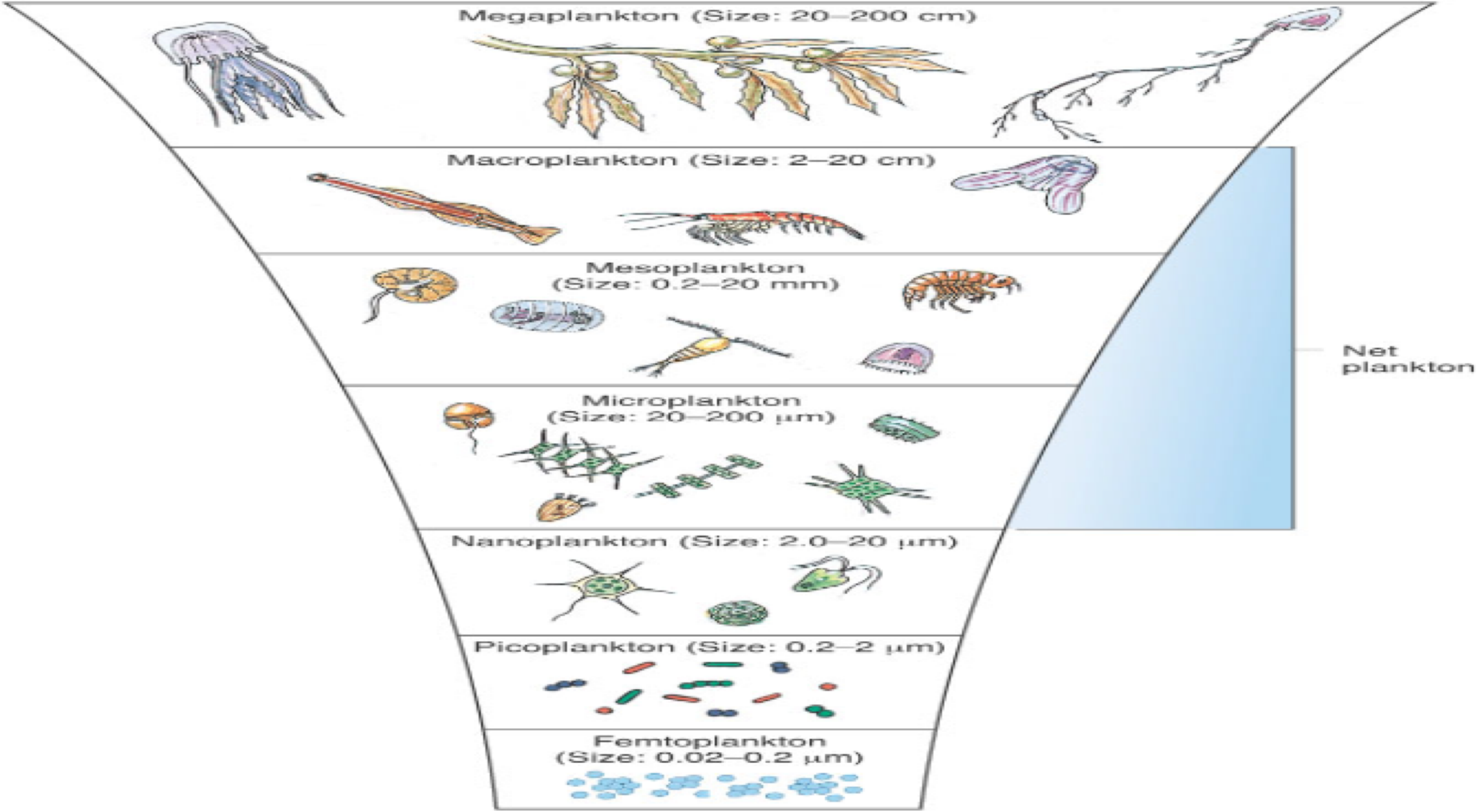
Taxonomy & Systematics

- Archaea, Bacteria
  and Eukaryotes (Algae, Vascular Plants, Fungi, Invertebrates, Vertebrates, etc)



Woese and Fox **1977**
Distinguish *Archaea from Bacteria*

Woese; Kandler & Wheelis **1990**
Archaea Domain Description


Megaplankton (Size: 20–200 cm)
Macroplankton (Size: 2–20 cm)
Mesoplankton
(Size: 0.2–20 mm)
Microplankton
(Size: 20–200 μm)
Nanoplankton (Size: 2.0–20 μm)
Picoplankton (Size: 0.2–2 μm)
Femtoplankton
(Size: 0.02–0.2 μm)
Net
plankton


Periphyton
Biofilm
Bangia sp.
Trichonida lake

Chara sp.

Stonewort
= stone plant


Outflow of thermal spring, Kythnos Island
A population of
Ventrosia ventrosa


egg-capsules
on *V. ventrosa*
background square = 1 mm^2

Biota Biodiversity

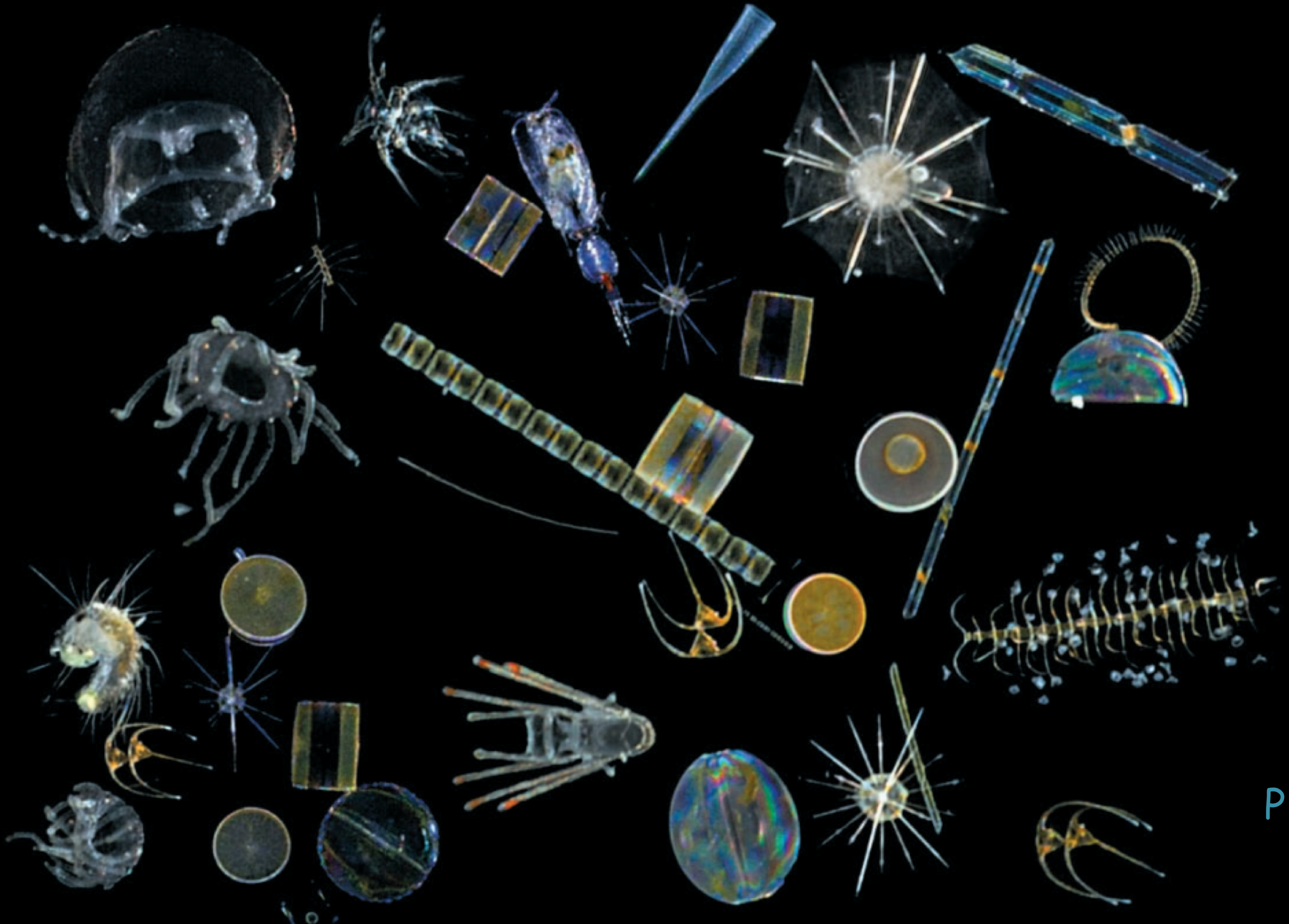
Ecology

- Aquatic,
- Hydrophilic,
- Aerophytic,
- Terrestrial

- Planktic,
- Nektic,
- Pleustic, Neustic,
- Benthic,
- Periphytic,

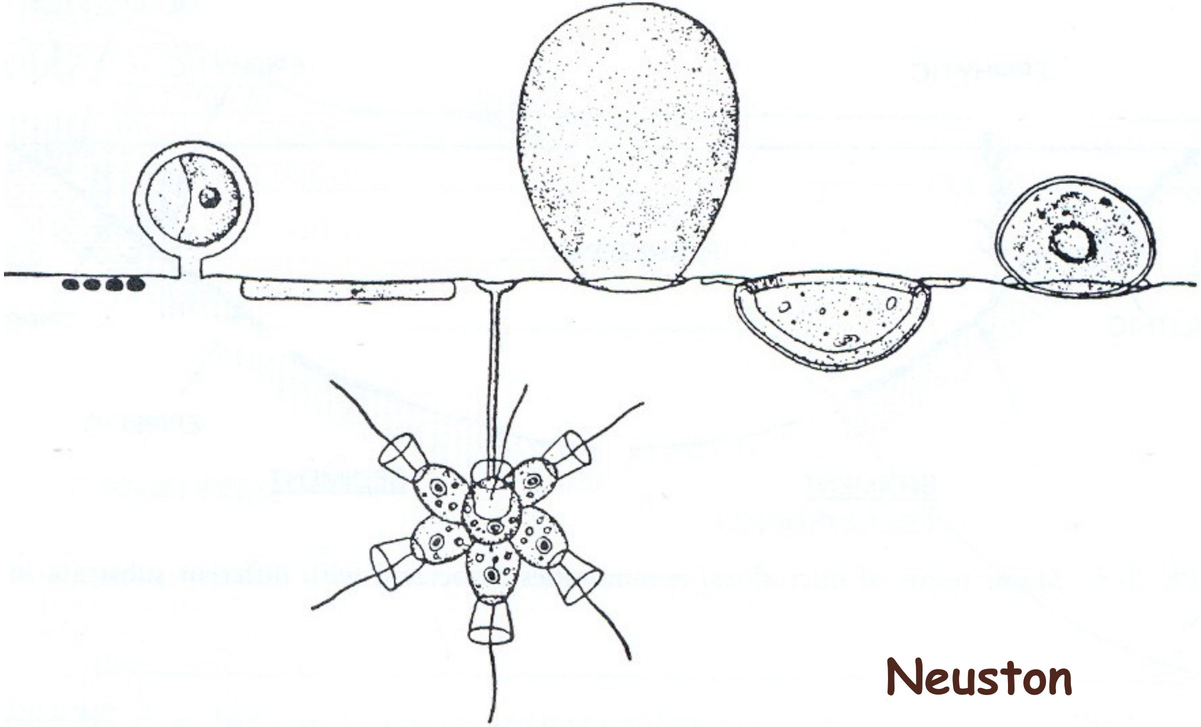
- Emergent, Floating-Leaved, Submersed Aquatic macrophytes attached to the substratum or freely floating etc.

- Permanent /Seasonal organisms,
- Meroplanktic, holoplanktic organisms



Plankton

Necton



Neuston

Pleuston

Wetzel 2001


Benthos
Trichonida lake

Benthos


Trichonida lake

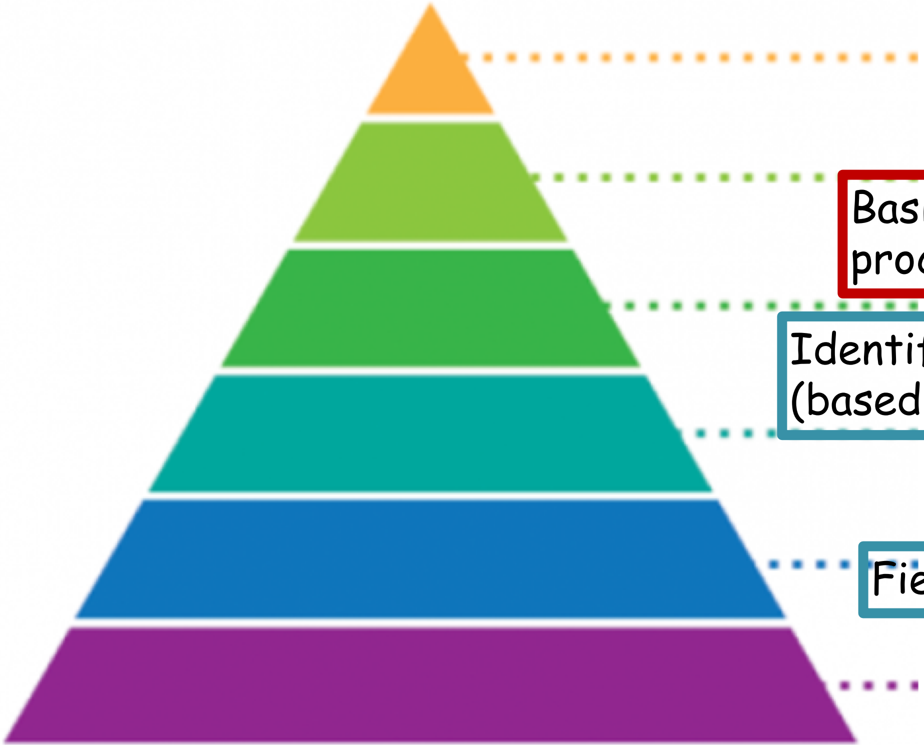
Undergraduate modules. Learning outcomes

Integrated view of structure and a basic understanding of functioning, dynamics

Basic water quality assessment & monitoring

Potential impacts of human activities

Basic biological processes → biological interaction processes and their importance to ecosystems



Identification of characteristic groups of organisms (based on morphology) & Habitat adaptation

Habitats & Evaluation of abiotic conditions

Field work (sampling), laboratory work (analyses)

Team work, Scientific publications, Presentation (oral & written)

Biota Function

- Primary producers,
- Grazers,
- Consumers (1st, 2nd, 3d .....class),
- Decomposers, Detritivores,

  * Mixotrophs, omnivores, parasites, symbionts.

Food Web Levels

Plankton

Phytoplankton

Zooplankton

Archaeoplankton

Bacterioplankton

Mycoplankton

Viroplankton

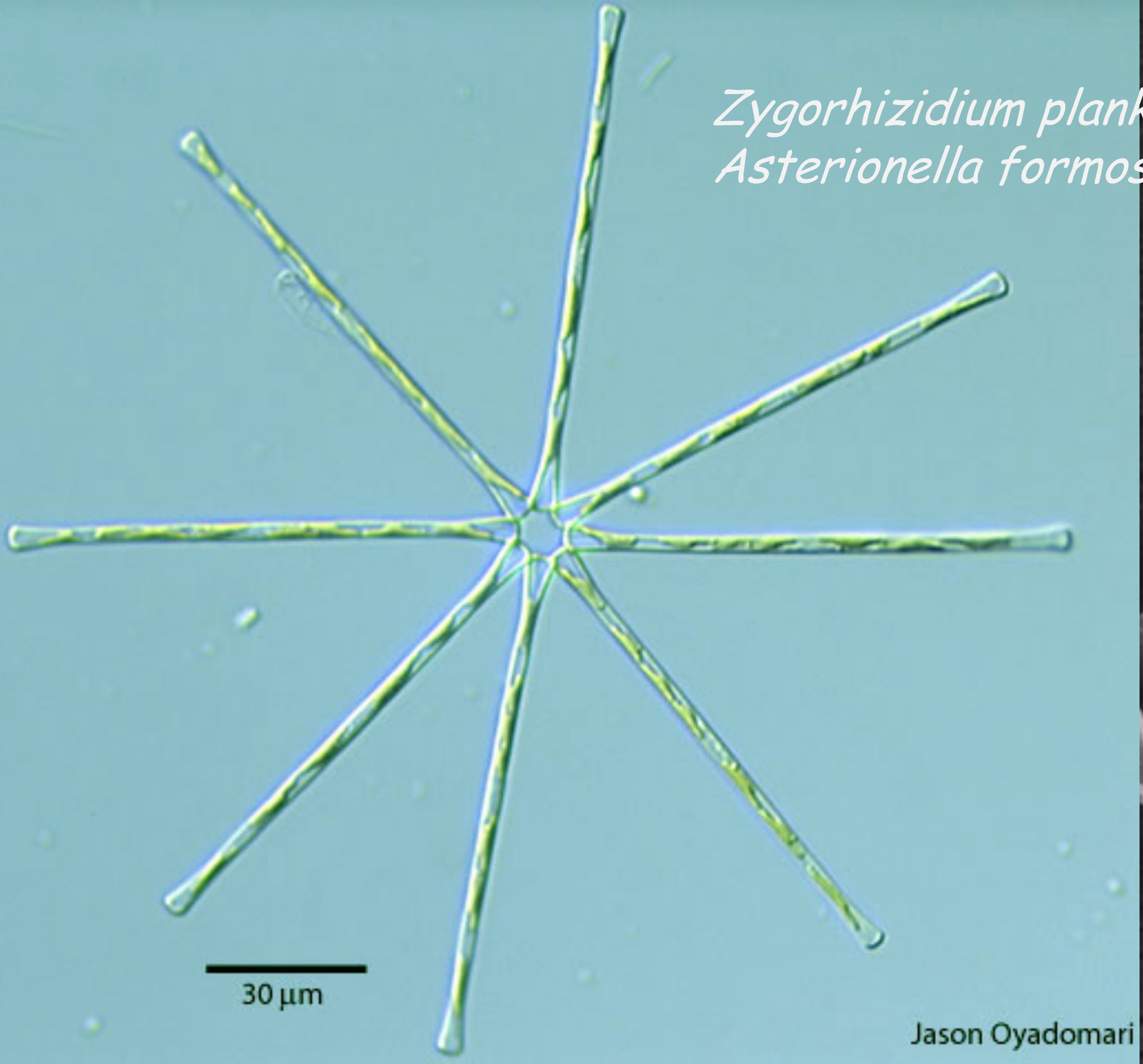
……

A spoon: > 10^6 living organisms !!!

Zooplankton

https://i.pinimg.com/736x/80/60/28/806028913b4edd7cc1d093aa28736f1d--science-and-nature-microbiology.jpg

Zygorhizidium planktonicum
Asterionella formosa



https://nioo.knaw.nl/sites/default/files/1_1_thumb.jpg

Fungi

- Saprotrophic
- Parasitic,
- Symbiotic

Example of Mixotrophy

Dinobryon ; Chrysophyceae

Colony of photosynthetic cells
Inside a lorica made of cellulose

2 flagella

Mixotroph = Facultative Heterotroph
able to shift between photosynthesis
and ingesting smaller organisms
or particles for food.

∀ Cell 3 bacteria /min

The large size of Dinobryon → difficult for
herbivorous zooplankton to consume.

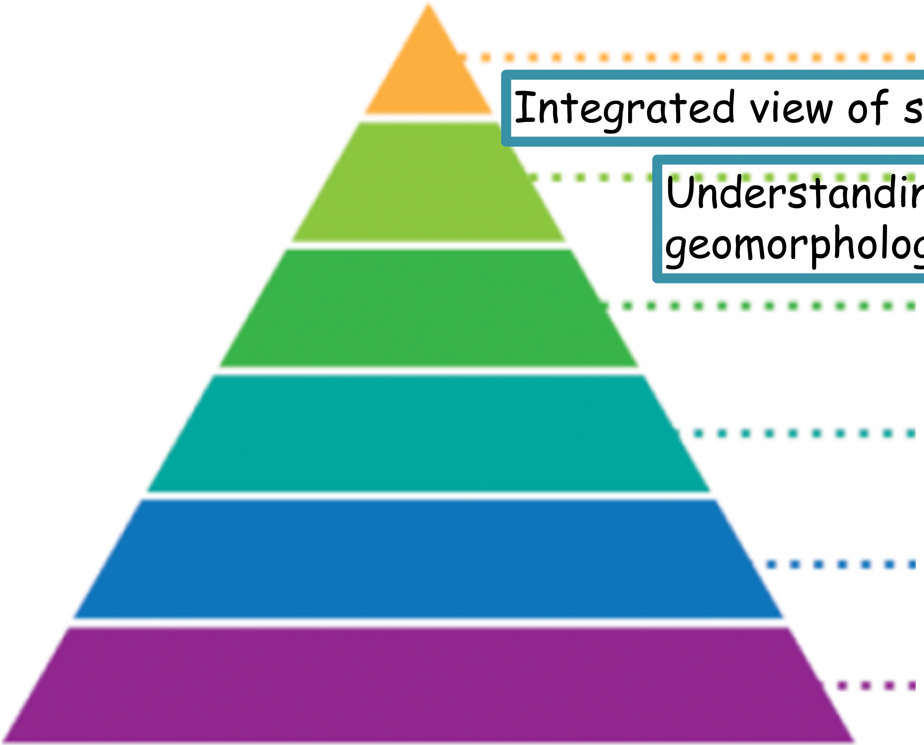
Biota

Ecosystem dynamics

- **Population ecology**
  (community structure, succession, plankton paradox etc)

- **Food webs**
  (compartments, microbial loop, primary production, blooms etc)

Posrgraduate modules. Learning outcomes



Biotechnology – Ecosystem Management

Water quality assessment & monitoring

Integrated view of structure, **functioning, dynamics of Ecosystem**

Understanding of the critical linkages between hydrological, geomorphologic, biogeochemical and ecological components

Identification of group of organisms by different techniques

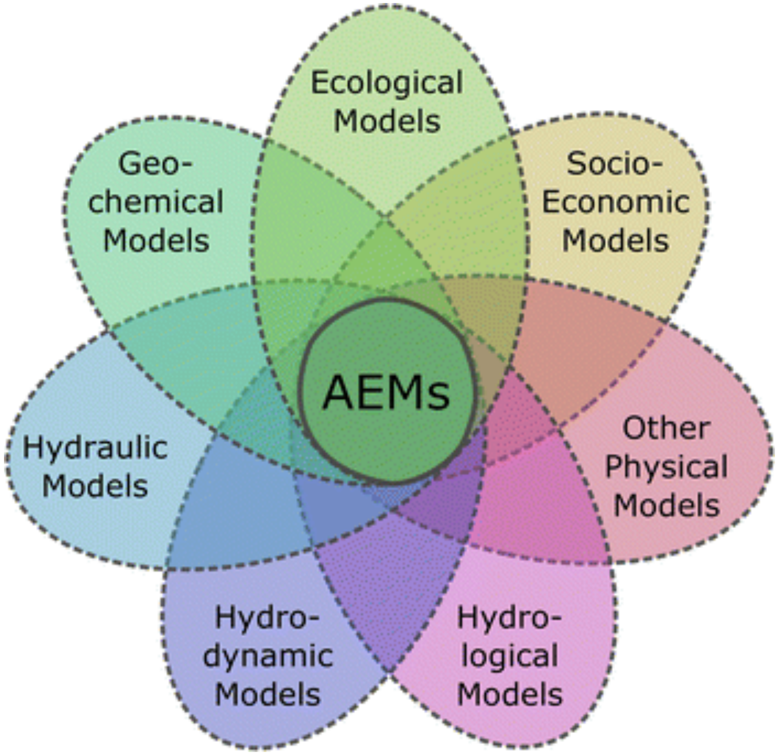
Field work, laboratory work
(plan and carry out experiment/field studies, modern analytical and computational methods)

Team work, Scientific publications, Report Presentation (oral & written)

(E) pond mesocosms, UK (Dossena *et al.*, 2012);
(F) pond mesocosms, Denmark (Liboriussen *et al.*, 2005);
(G) experimental flumes, Australia (Thompson *et al.*, 2013)

Stewart *et al.* 2013.

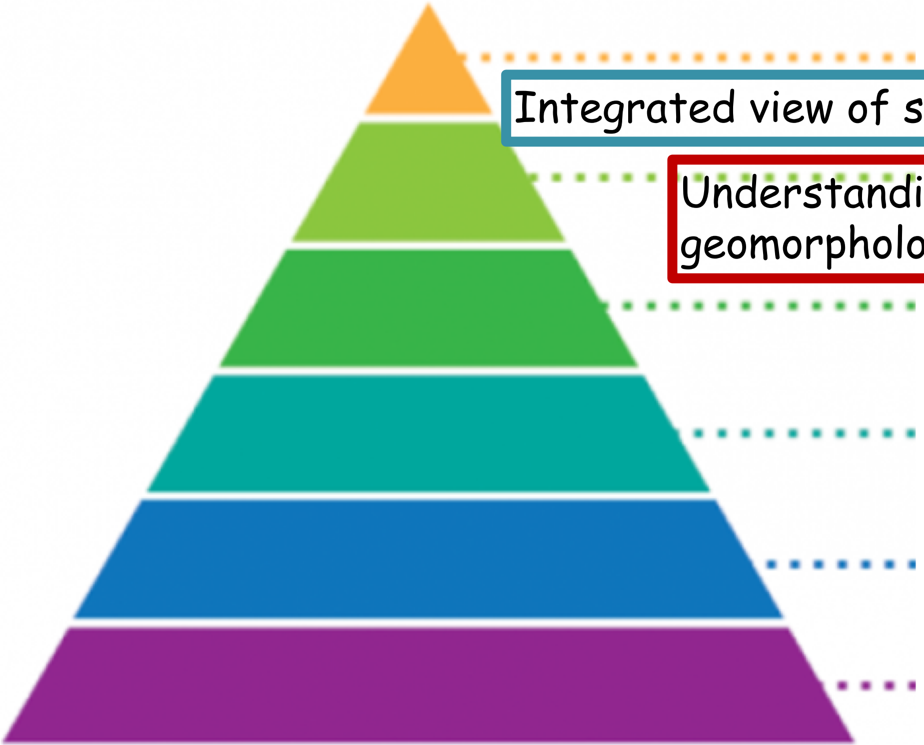
Major modelling disciplines that can contribute to aquatic ecosystem models (AEMs).



a great diversity among AEMs
each modeller should select
the most appropriate combination
and size of the petals
to fit the research question

Janssen *et al.* 2015

Posrgraduate modules. Learning outcomes



Biotechnology – Ecosystem Management

Water quality assessment & monitoring

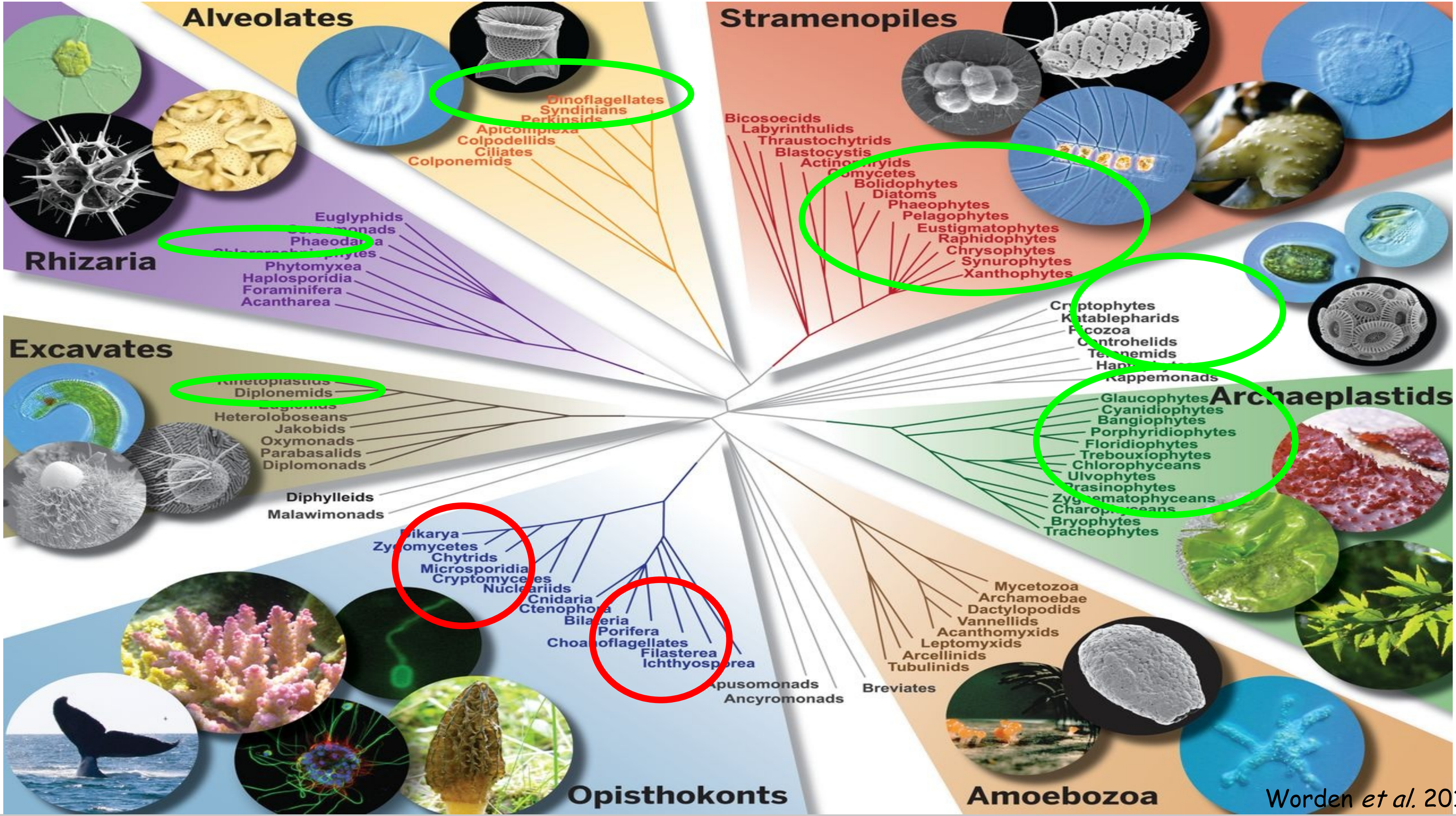
Integrated view of structure, **functioning, dynamics of Ecosystem**

Understanding of the critical linkages between hydrological, geomorphologic, biogeochemical and ecological components

Identification of group of organisms by different techniques

Field work, laboratory work
(plan and carry out experiment/field studies, modern analytical and computational methods)

Team work, Scientific publications, Report Presentation (oral & written)



Worden *et al.* 2015.

Species concept

- **molecular** species concept
- **biological** species concept
- **morphological** species concept

} (Cell size; shape and contents; Cell wall; extra cellular matrix; Thallus organization)

***Species concept in Algae**

The latter dominates algal systematics

➢ **strong connections between Algal Morphology; Physiology & Ecology**

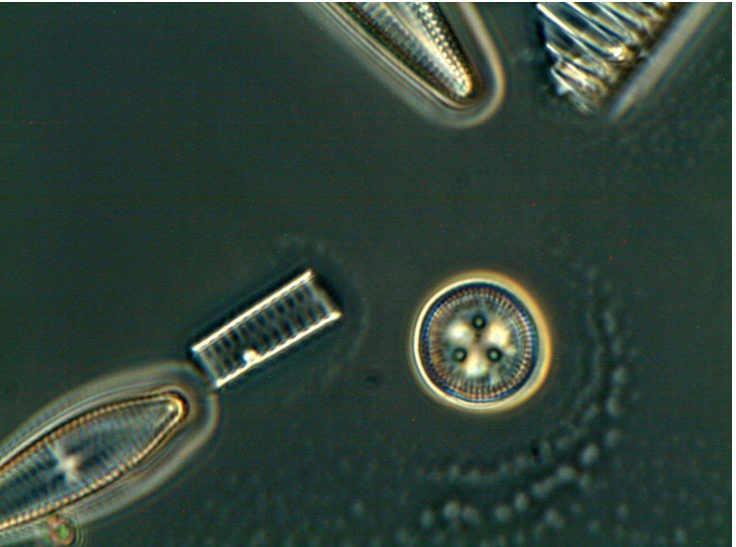

Trichonida lake


Trichonida lake

Endemism

Pantocsekiella trichonidea
(Economou-Amilli) Kiss & Ács

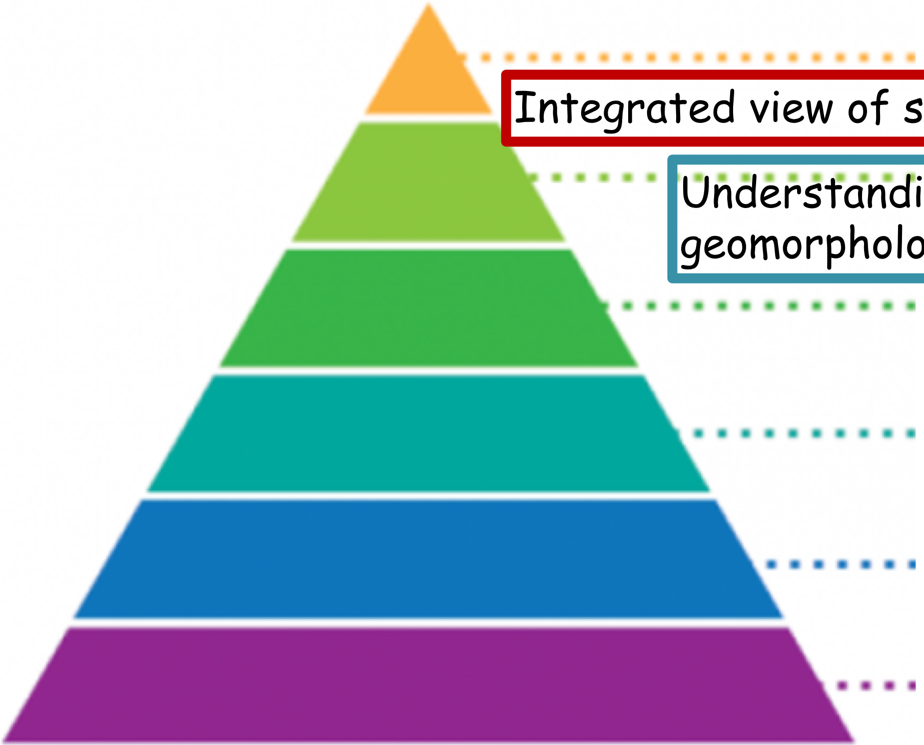
Endemic Taxa, Lake Trichonis



Lindavia trichonidea var. *parva*
(Economou-Amilli) Nakov *et al.*

10µm

Posrgraduate modules. Learning outcomes



Biotechnology – Ecosystem Management

Water quality assessment & monitoring

Integrated view of structure, **functioning, dynamics of Ecosystem**

Understanding of the critical linkages between hydrological, geomorphologic, biogeochemical and ecological components

Identification of group of organisms by different techniques

Field work, laboratory work
(plan and carry out experiment/field studies, modern analytical and computational methods)

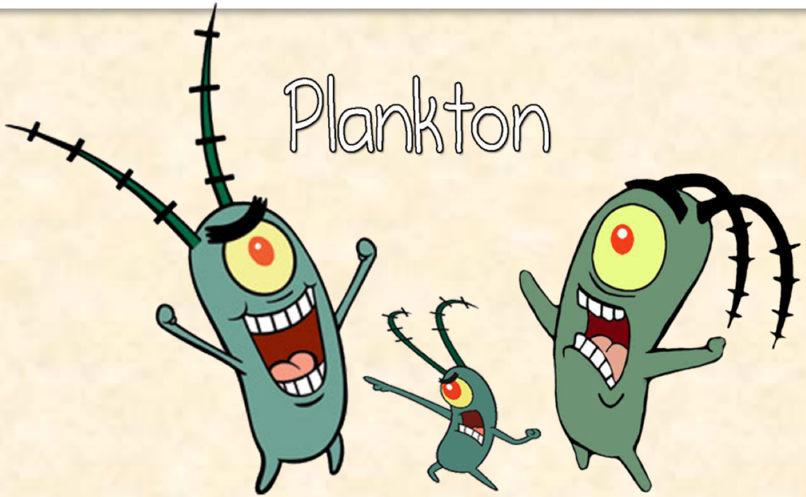
Team work, Scientific publications, Report Presentation (oral & written)

Vol. XCV, No. 882 The American Naturalist May–June, 1961

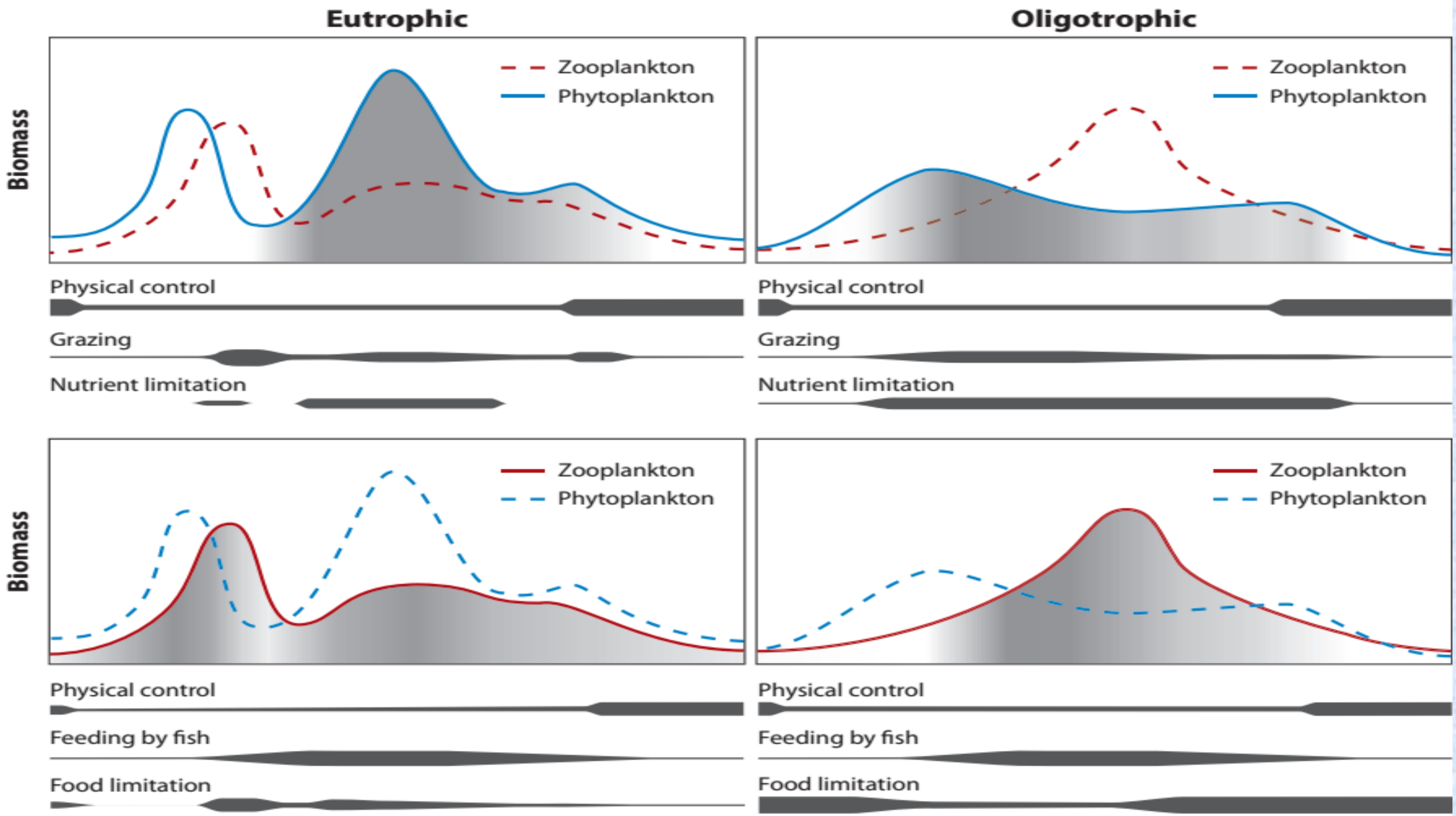
THE PARADOX OF THE PLANKTON*

G. E. HUTCHINSON

Osborn Zoological Laboratory, New Haven, Connecticut



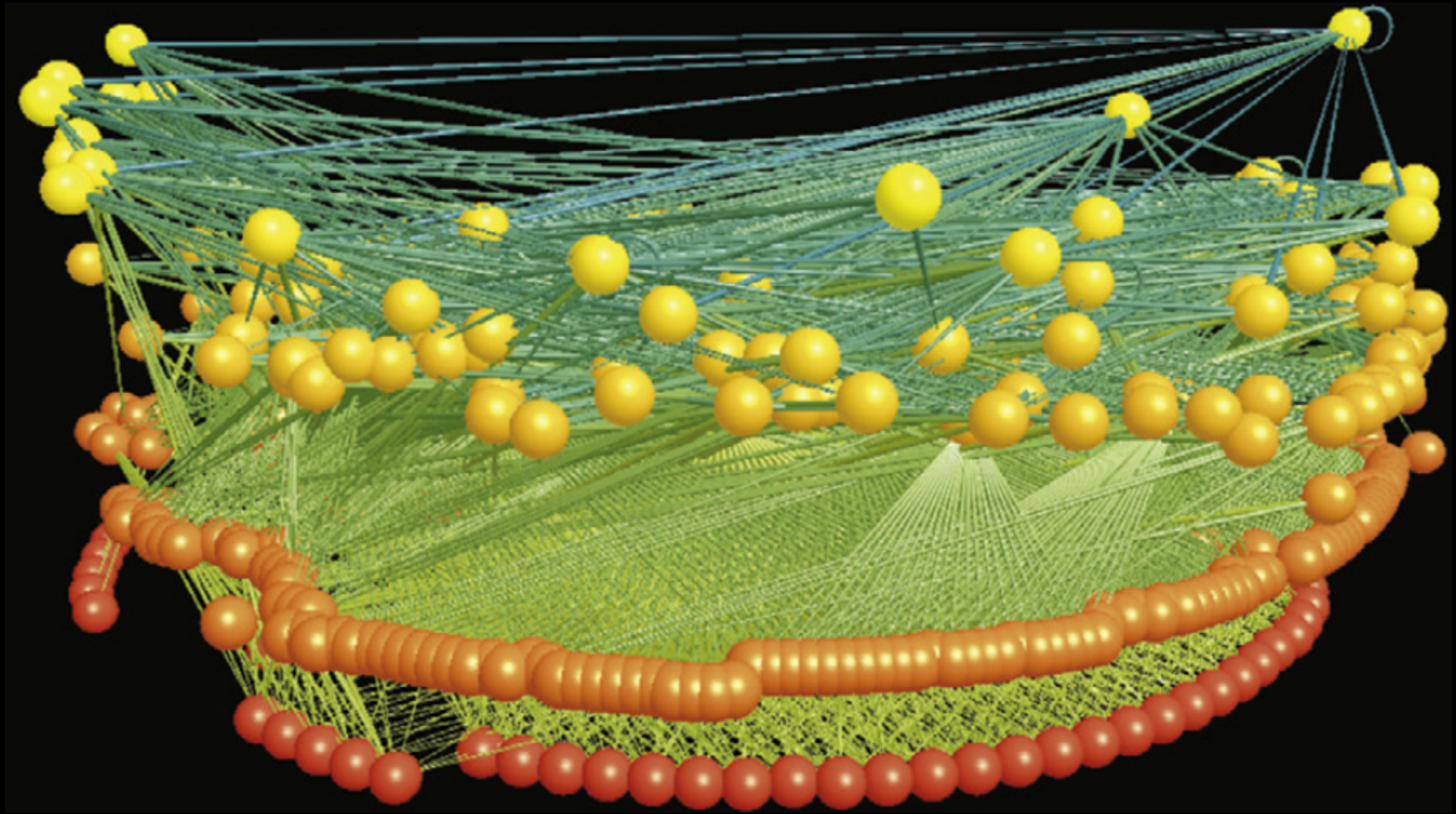
Plankton Succession. PEG Model



Sommer *et al.* 2012.

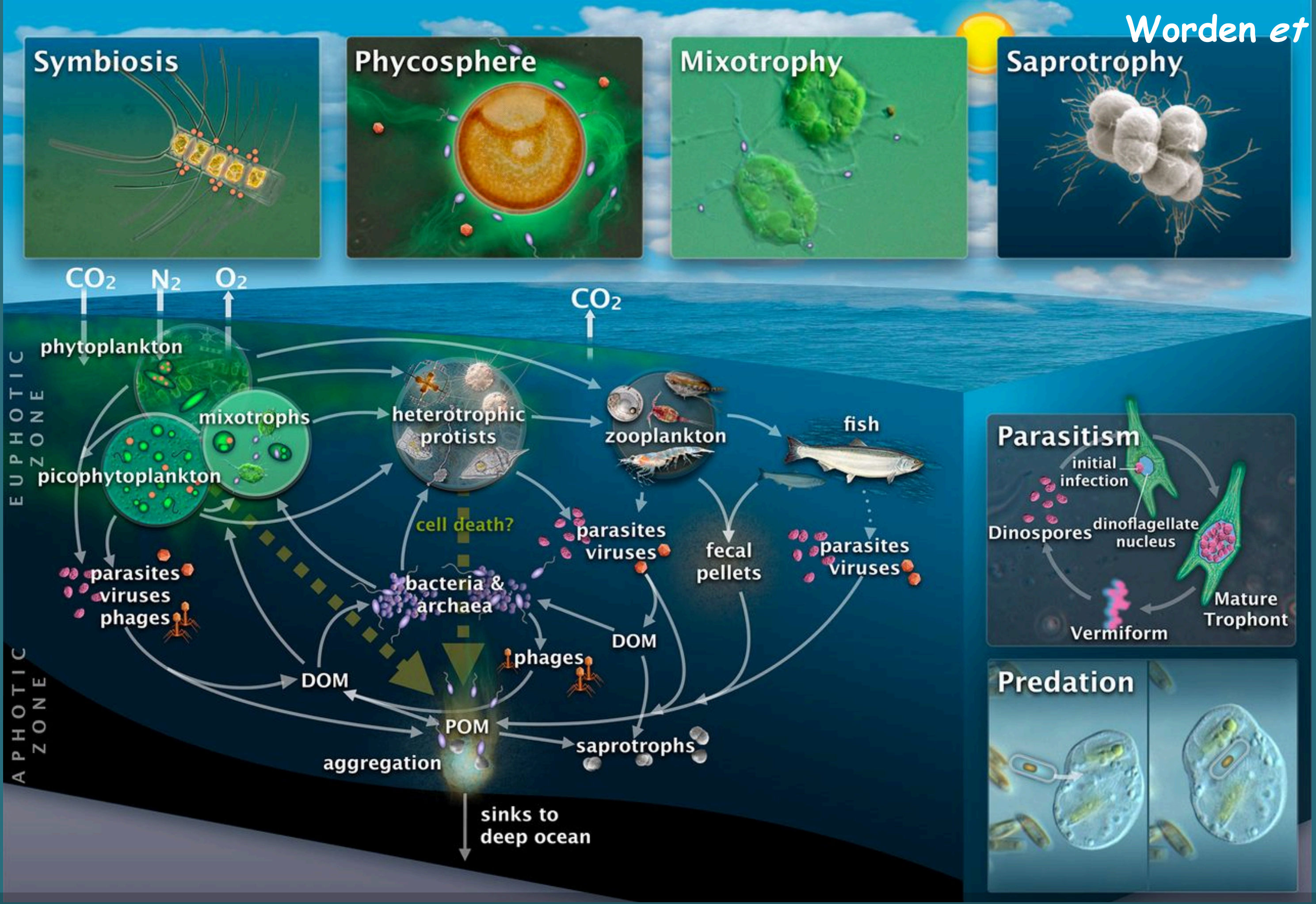
Lower 2010 created using the software Foodweb3D, which was provided by Rich Williams, J.A. Dunne and N.D. Martinez (Williams, R.J. Network3D Software. Microsoft Research, Cambridge, UK)

.



Worden *et al.* 2015.

Microbes from the **three domains** of life interact to structure ocean ecosystems and the carbon cycle.



Biotechnology

- Source of food,
- Food additives,
- Chemical and
- *Pharmaceutical* products.

- Genomics,
- Proteomics,
- Research
- Biological Resource /Bioresource Centers

- Protection & Remediation of the Environment (Biomonitoring, sewage & water treatment, Recycling, Bioremediation)
- Mitigation technologies (biofuels) etc


FOOD


PHARMA


FEED


PERSONAL CARE & COSMETICS

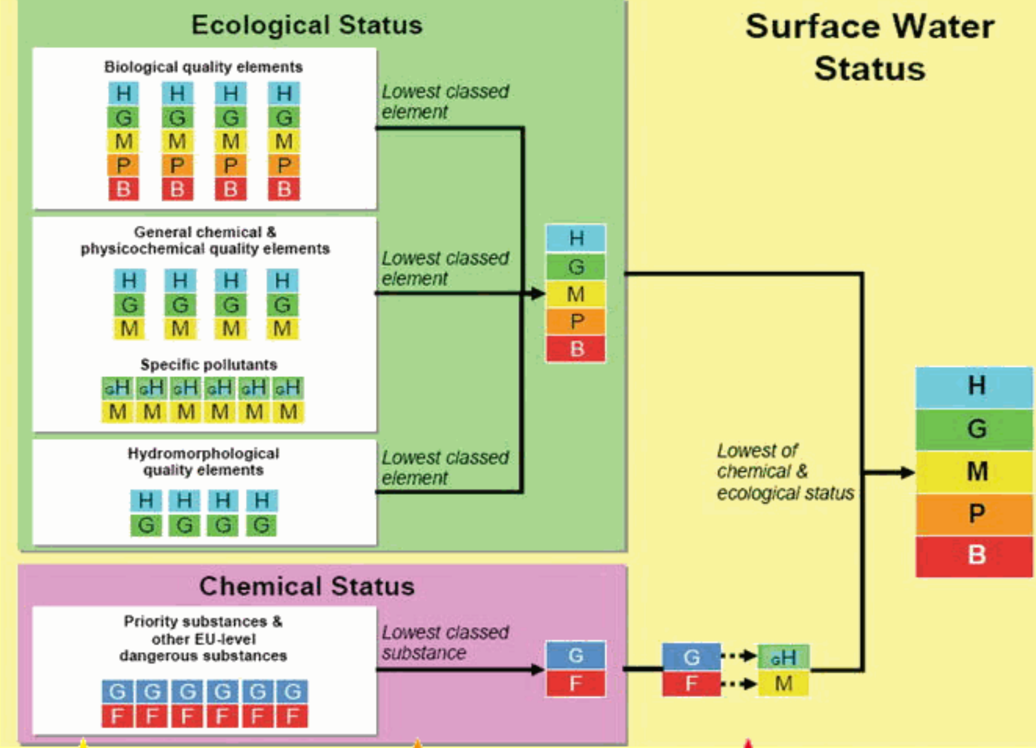

HOUSEHOLD PRODUCTS


INDUSTRIAL

Integrated Approach

Monitoring of

- Biological Quality Elements (QE)
- Chemical & Physicochemical QE
- Hydromorphological QE



Sewage treatment plant,
Psyttaleia

Water treatment plant,
Aspropyrgos

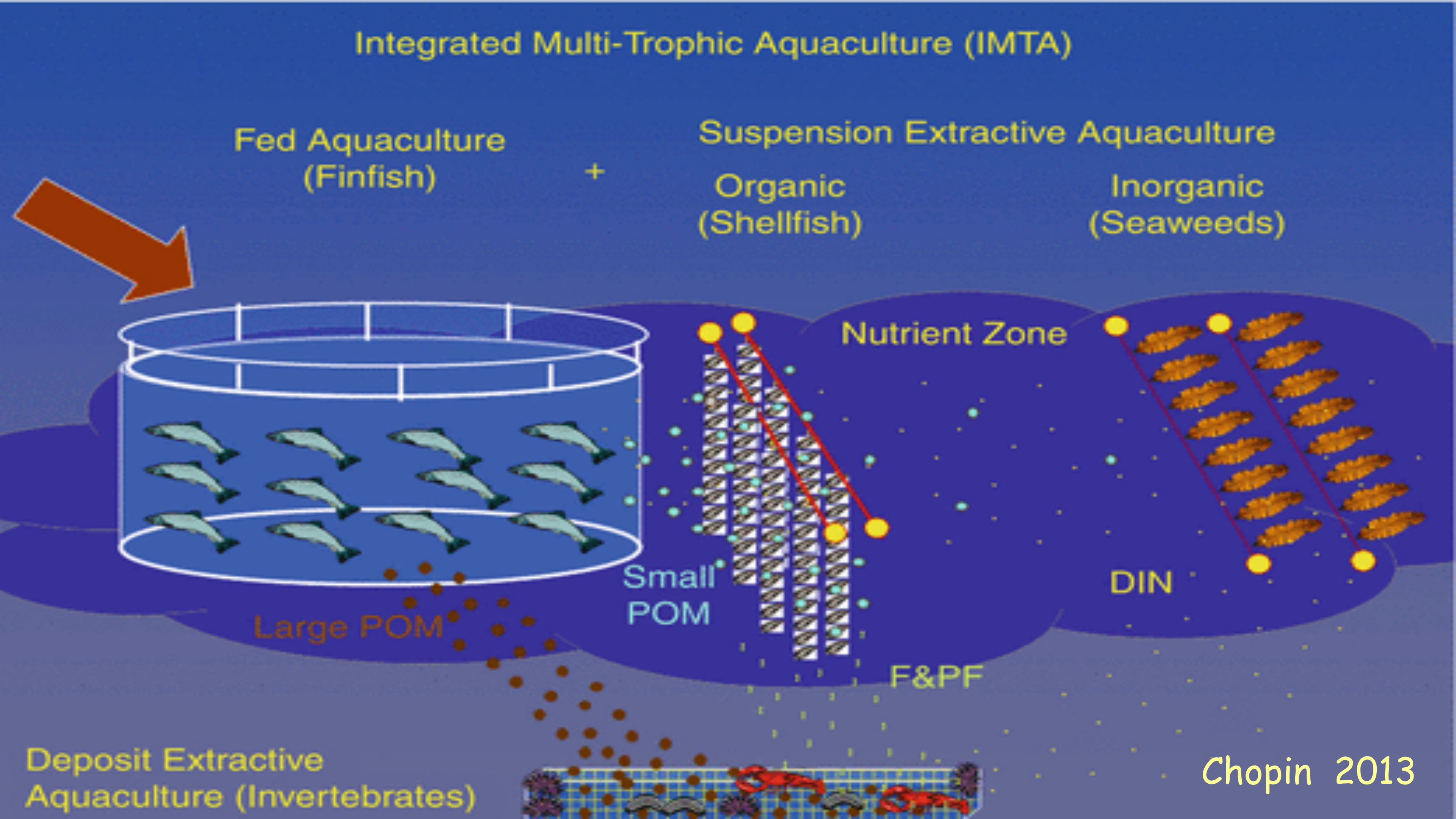
https://www.niwa.co.nz/file/37211

High Rate Algae Ponds, HRAP

SolarLeaf

Algae bio-reactive facade

http://www.morethangreen.es/wp-content/uploads/2014/08/solarleaf-solar-leaf-fachada-algas-bioreactivas-more-than-green-ml_ARUP-Fachada-algas_01_900.jpg


Integrated Multi-Trophic Aquaculture (IMTA)
Fed Aquaculture
(Finfish)
+
Suspension Extractive Aquaculture
Organic
(Shellfish)
Inorganic
(Seaweeds)
Nutrient Zone
Small
POM
Large POM
DIN
F&PF
Deposit Extractive
Aquaculture (Invertebrates)
Chopin 2013

References

Anderson L.W., & Krathwohl D.R. 2001. A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives: Complete Edition. New York: Longman.

BloomB.S. 1956.Taxonomy of Educational Objectives, Handbook: The Cognitive Domain. David McKay, New York.

Chopin T. 2013. Aquaculture, Integrated Multi-trophic (IMTA). In: Christou P., Savin R., Costa-Pierce B.A., Misztal I., Whitelaw C.B.A. (eds) Sustainable Food Production. Springer, New York, NY.

Finlayson C.M. *et al.* 2005. Inland Water Systems. In Millenium Ecosystem Assessment: Ecosystems and Human Well-being: Current State and Trends, Vol. 1 (Hassan R., Scholes R. & Ash N., eds) pp. 551 – 583. Washington, DC: Island Press.

Janssen A.B.G., Arhonditsis G.B., Beusen A., Bolding K., Bruce L., Bruggeman J., ... Mooij W.M. (2015). Exploring, exploiting and evolving diversity of aquatic ecosystem models: a community perspective. *Aquatic ecology*, *49* (4), 513-548.

Hutchinson G.E. 1961. The Paradox of the Plankton. The American Naturalist, Vol. 95, No. 882. pp. 137-145.

Sommer *et al.* 2012. Beyond the Plankton Ecology Group (PEG) Model: Mechanisms Driving Plankton Succession.

Wetzel R.G. (*2001*) Limnology Lake and River Ecosystems. *Third Edition*, Academic Press, San Diego, 1006p.

Woese C.R., & Fox G.E. 1977. "Phylogenetic structure of the prokaryotic domain: the primary kingdoms". Proceedings of the National Academy of Sciences of the United States of America. 74 (11): 5088–5090.

Woese C.R., Kandler O., Wheelis M.L. 1990. "Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya". Proceedings of the National Academy of Sciences of the United States of America. 87 (12): 4576–4579. Bibcode:1990PNAS...87.4576W.

Worden *et al.* 2015 Rethinking the marine carbon cycle: Factoring in the multifarious lifestyles of microbes. Science 347 (6223).


Thank you !
Спасибо за внимание
National and Kapodistrian University of Athens
Faculty of Biology
Department of Ecology & Systematics