



Kärntner Institut für Seenforschung Naturwissenschaftliches Forschungszentrum



ESD Schulprojekt Se(h)en und verstehen



Endbericht



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Im Auftrag des Amtes der Kärntner Landesregierung, Abteilung 8 (Kompetenzzentrum Umwelt, Wasser und Naturschutz),
Flatschacher Straße 70, 9020 Klagenfurt am Wörthersee

Klagenfurt am Wörthersee, im August 2012



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1 Das Projekt SILMAS

Das Projekt SILMAS (www.silmas.eu) ist Teil des Programms für den Alpenraum, das zum INTERREG IIB der Europäischen Gemeinschaft gehört. Die Programme der Kategorie B betreffen die transeuropäische Zusammenarbeit zur Förderung einer harmonischen und ausgewogenen Entwicklung des Europäischen Raums. In diesem Zusammenhang entwickelte das Projekt SILMAS (Sustainable Instruments for Lakes Management in the Alpine Space) eine transnationale Zusammenarbeit zwischen den fünf Partnerländern: Deutschland, Österreich, Frankreich, Italien und Slowenien. Die überregionale Zusammenarbeit trägt zur territorialen Zusammenarbeit bei und stärkt den Alpenraum als einen attraktiven und leistungsfähigen Raum zum Leben und Arbeiten.

Das Projekt SILMAS lief über drei Jahre (September 2009 bis August 2012) und wurde von Rhône-Alpes Region (France) geleitet. Das Gesamtbudget betrug € 3.260.993,00 und 76 % wurden durch die Europäische Gemeinschaft (ERDF) finanziert. SILMAS ist ein Projekt zum Austausch von Erfahrungen und Know-how zur nachhaltigen Bewirtschaftung der Alpenseen. Es zielt darauf ab, konkrete, nachhaltige Instrumente zu schaffen, die die Bewirtschaftung der Seen im Alpenraum verbessern und das allgemeine öffentliche Bewusstsein für eine nachhaltige Seenentwicklung zu schärfen.

15 Partner aus lokalen Behörden, Forschungsinstitutionen und Universitäten waren in das Projekt involviert. Erhebungen und Untersuchungen wurden in 22 Alpenseen durchgeführt.

SILMAS Prioritäten

- Untersuchung der Auswirkung des Klimawandels auf die Alpenseen
- Lösung von Nutzungskonflikten im Zusammenhang mit den Alpenseen
- Erziehung zur nachhaltigen Entwicklung der Alpenseen



2 SILMAS ESD-Toolkit: „Se(h)en und verstehen“ – Unterrichtsmaterial für Primärschulen

2.1 Entwicklung und Inhalt:

Das Unterrichtsmaterial wurde vom Kärntner Institut für Seenforschung erstellt. Der Lehrbehelf soll Lehrern und anderen Pädagogen im Umweltbereich eine Hilfestellung im Unterricht sein.

Ziel war eine altersgerechte Aufbereitung des umfangreichen Themas „Stehende Gewässer“. Grundschüler (Alter: 8-12) lernen spielerisch und leicht verständlich die wichtigsten Charakteristika des Ökosystems „See“ kennen. Mit Hilfe von Arbeitsblättern und Magnetfolien für ein individuelles Tafelbild und unter Anleitung eines Pädagogen, können die Schüler das umfangreiche Thema erarbeiten.

Der Leitfaden zu diesem Projektunterricht ist die Lehrermappe. Der Lehrinhalt ist in vier große Themenblöcke unterteilt:

- Kapitel 1 - Grundlagen: Die verschiedenen Gewässertypen, Die Zonierung im See, Sauerstoff, Licht, Temperatur und Nährstoffe, Zirkulation im See, Einteilung der stehenden Gewässer, Unsere heimischen Seen, Arbeitsblätter mit Erläuterungen
- Kapitel 2 – Das Leben im See: Vögel und Säugetiere, Die Uferzone, Das Feiwasser, Fische und Krebse, Räuber – Beute Beziehungen, Arbeitsblätter mit Erläuterungen
- Kapitel 3 – Untersuchungen im See: Messungen im See, Arbeiten vor Ort, Arbeitsblätter mit Erläuterungen
- Kapitel 4 – Gewässerschutz: Gefährdungspotenzial, Schutz des Sees, Naturschutzgebiete, Arbeitsblätter mit Erläuterungen

Mit didaktisch unterschiedlichen Arbeitsmethoden, die verwendeten Materialien sind ausführlich beschrieben, wird den Schülern Grundsätzliches Wissen über die Funktionsweise eines Sees vermittelt. Ein Kapitel beschäftigt sich mit dem „Leben im See“ und stellt die pflanzlichen und tierischen Organismen entsprechend ihrer bevorzugten Habitate vor. Mit dem ergänzenden Bestimmungsheft lernen die Kinder die wichtigsten Wasserorganismen zu bestimmen. Ebenso finden sie hier kurze Beschreibungen über die Lebensweise der Tiere und Pflanzen.

Die praktischen Untersuchungen am See ergänzen den angewandten Projektunterricht. Das Erleben der Natur nimmt einen pädagogisch wertvollen Teil des Projektes ein. Vorbereitend auf die Exkursion zu einem Gewässer werden im Vorfeld Mess- und Beprobungsmethoden besprochen und Untersuchungs-Utensilien gebastelt.

Im Kapitel Gewässerschutz werden Fragestellungen wie: „wie werden Abwässer behandelt, wie werden Seen geschützt und vor allem was kann ich selbst zum Schutz des Sees beitragen“, behandelt.

Begleitend zum Unterricht stehen Spiele sowie Bastelanleitungen zur Verfügung, die mit dem Inhalt korrespondieren und den Unterricht auflockern. Spannende Geschichten, Bilder und Filmsequenzen machen die Fauna und Flora eines Sees erlebbar. Alle Dokumente für den Unterricht sind über die SILMAS-Homepage zugänglich.

2.2 Pilotprojekte:

An zahlreichen Schulen in den verschiedenen Regionen der Projektpartner wurde die Unterlagen des Schulprojektes „Se(h)en & Verstehn“ (englischer Titel: „Take the lake“) getestet. Insgesamt waren in Slowenien, Italien und Österreich über 500 Schüler aus 28 Klassen in die praktische Prüfung der Unterlagen involviert.

Tab. 1: Liste der Pilotschulen

SILMAS Partner	Nation/ Region	Schultyp	Schule	Schul- stufe	Anzahl / Schüler	Zeitraum
KIS	Österreich/ Kärnten	Primärstufe	VS 8 St. Andrä/ Villach	4	15	Jun.11
		Primärstufe	VS Hermagor	4	25	Mai-Juli 2012
		Primärstufe	VS St. Stefan	4	12	Mai-Juni 2012
		Primärstufe	VS St. Stefan	3	17	Mai-Juni 2012
		Sekundarstufe	NMS St. Ursula	1	25	Mai-Juni 2012
APPA Trento	Italien/ Trento	Primärstufe	Pergine Valsugana	3	22	Feb.-Mai 2012
		Primärstufe	"Gianni Rodari"	3	23	Feb.-Juni 2012
		Primärstufe	Caldonazzo	3	25	April - Mai 2012
		Primärstufe		3	24	April - Mai 2012
		Sekundarstufe	Pergine Valsugana "Tullio Garbari"	1	23	März - Mai 2012
		Sekundarstufe	Pergine Valsugana "Ciro Andreatta"	1	20	Feb.-Juni 2012
NIP	Slowenien/ Ljubljana	Sekundarstufe	Bohinjska Bistrica (2 Klassen)		48	Sept. 2011 - Mai 2012
		Sekundarstufe	Cerknica (3 Klassen)		65	
		Primärstufe	Cerknica (2 Klassen)		20	
DTL	Italien/ Stresa	Primärstufe	Region um Stresa	1-4	156	Sept. 2011 - Mai 2012

3 Anhang

3.1 Kurzbericht von zwei ausgewählten Pilotprojekten (in englisch)

Abstract about pilot site: primary school St. Andrä/Villach - 4th class -.

1. Day:

Come together:

We start with a kind of sitting circle. All the children were sitting in a circle. In the middle there were a couple of pictures about lakes and water organisms. Every pupil took a picture and tells something about its individual impression from the chosen print.



Basics:

First we talked in a more or less short way about the different water types. What is the conspicuous difference between running and standing waters? What is ground water?

We talked about the water circle and then recapitulate it with the worksheet (B_02) and the role play "The water circle".

To keep the attention of the children it is always a good way to allow them to move. With some games (e.g. the water circle) they can run around and recapitulate the topic at the same time.

After that and a short brake we started again with the "hard stuff" – the zoning in lakes.

On the black board we started with a profile of a lake without any organisms. Together we tried to find the animals and plants we can normally find in standing waters.



What is the difference between the benthic and the pelagic zone? How deep can the sun light the water?

For recapitulation the children filled out the worksheet "The zones in the lake" (B_03).

Some knowledge about the importance of oxygen, light, water temperature and nutrients is basic to understand the process of the circulation in standing waters.

The circulation is a difficult topic. I started with the stagnation in summer. To make it a little bit easier to understand we made a lot of work on the black board with the magnetic foils. For

recapitulation the pupils formed teams. With the help of the magnetic foil they create the 4 different situations in spring, summer, autumn and winter on the black board.

The role play “The density anomaly of the water” helped the children to understand, why water has the highest density at 4°C.

The division of standing waters and the local lakes are the last two topics of this day. With the local lakes on magnet foil we place the lake on a drawn map and find out how deep they are.

2. Day:

Recapitulation and Organisms of the lake

In the morning we recapitulate the zoning of standing waters on the black board and further on we talked about the animals we can find at the lake and where they live.

The organism of the lake is a very big chapter. In most cases it is not possible to talk about all the content. We talked very shortly about the phytoplankton. The children liked the worksheet Org_06 where they can cut out the water flea.

3. Day:

Field work

First we tried to sample insects and other benthic animals at the shore zone of Lake Ossiacher See. The children formed teams with 2 or 3 persons. With magnifiers the children could research their samples. We also used the determination book for determining the animals.

We caught some fish (electric fishing). We talked about the important characters of fish.



In a final step we went (with the motor boat) to a big pier to catch some planktic organism with a plankton net. We also talked about some sampling equipment.

4. Day:

Recapitulation of the field work and determining zooplankton

At school again we recapitulate the found animals with the help of the determination book. The children looked on the plankton samples of the day before with the help of a binocular. For children at this age it is not so easy to look through such instruments. Therefore we watched some videos about zooplankton.

Again we played a role game “The food web”

5. Day:

Water protection

The water protection (Chapter IV) was the main topic of the last day. We talked about the situation at local scale. How do we protect our lake from influence, how does a clarification plant work and –a very important topic – what can I do to protect my lake?

Time runs and so we are at the end of the project. To have a good conclusion, we made a knowledge race between two groups (it depend on the children to find two groups and they want to play boys against girls). We drew a knowledge highway on the blackboard with two fast (magnetic) cars. For each right answer the car drive on.

3.2 Report from the JANEZ MENCNGER school in Bohinjska Bistrica

REPORT OF EDUCATIONAL PROGRAM IN ELEMENTARY SCHOOL JANEZ MENCNGER BOHINJSKA BISTRICA

Term of education: 21., 22., 23. September 2011

Location of education:

- lectures: Elementary school Bohinjska Bistrica;
- fieldwork: Lake Bohinj

Organizer of education: Notranjski Ekološki Center Cerknica (Polona Zevnik), Nacionalni inštitut za biologijo (Tina Leskošek)

Number of participants: 48 learners (from 7.a and 7.b grade elementary school Janez Mencinger)

Detailed report on the progress of educational process

Educational process and related activities were held for 3 days. Participants were learners from 7 grade elementary school, aged 12 years. After knowing and introducing the teacher as well as students, also project SILMAS was represented. Later we sat in a circle and made 'ecological network' with which we 'broke the ice' and start using words on the topic of water. That was also a tool for symbolically illustrated food web, which we learn in details later. We continued with the classical frontal method of giving lessons, but learners were actively engaged with discussions, interviews and reflections on each topic during lectures. Learners were absorbing the knowledge also by help of worksheets. Following topics were discussed:

- Water cycle and some physical processes associated with the Earth's water cycle (evaporation, condensation)
- Water types (flowing, underground, stagnant),
- Zoning in lakes (bentic zone, pelagial,..)
- Terms related to environment (ecology, limnology, community, plankton, nekton, ecological status of lakes,..)
- Photosynthesis- explanation of the process, chemical equation, discussion on importance of oxygen
- Learners expressed a desire to talk about drinking water, so we dedicate some time to the issue of drinking water and pollution
- We defined what of organisms can be found in certain areas of water body, and explain why could be they present there (ecological niche, also biomonitoring- *D. magna* was mentioned)
- Protection of water (what are the risks for water and how those risks can be reduced in the way of prevent and preveservation; pollution, tourism, invasive species,..)

Further work was done on the field at Lake Bohinj, where we studied phenomena on site in the natural conditions. There were considered and included some didactic principles; demonstrative, adequacy and activity. In this day, we were focused on sampling in littoral zone of the lake, also some other devices and sampling techniques were presented (temperature and oxygen probe, Secchi disk for determination of water transparency, planktonic net,...). We were talking also about natural and cultural heritage of the area and the lake basin. Then we repeated the food chain, and explain see water circulating through the seasons and so-called lake stratification. We also repeated the phenomena and causes for different (negative) effects on the lake, and then we tried to find solutions to reduce the risk for negative impacts. We have defined many possible actions for lake preservation.

Learners had to determine the species of organisms on the field work. They used identification books. Learning in nature enabled us to bring up and develop a special care and attitude to nature. At the same time learners also enhanced different learning objectives:

- Intuitive goals (content knowledge and methods for researching)
- Process goals (obtaining skills and abilities)
- Affective goals (a sense of security, confidence, acceptance)
- Psychomotor goals (coordination of body and mind)

We estimate that the educational process was successfully implemented. Participants have expressed satisfaction and enthusiasm for the performance as well as for the topic itself.

Cerknica, 27.9.2011

Polona Zevnik, NEC Cerknica



3.3 Lehrermappe



Living waters

Take the lake

Educational tool
for the ecosystem of standing waters




The SILMAS Project

SILMAS (Sustainable Instruments for Lakes Management in the Alpine Space) is a European project on the Alpine lakes, financed by the European Territorial Cooperation Alpine Space Programme 2007-2013. It began on 1 September 2009 and will end on 31 August 2012.

The programme covers 18 lakes in Germany, Slovenia, France, Austria and Italy. The lakes vary widely: the largest of them, Lake Constance in Germany, has a surface area of 536 km², whereas the smallest, Lake Bohinj in Slovenia, measures 3.3 km²! Despite their diversity, the lakes are all part of the Alpine arc and, as such, face similar issues.

The purpose of this project is to facilitate dialogue between the different institutions involved in managing Alpine lakes. Over a three-year period, scientists, academics and technicians from the public authorities in charge of managing the lakes will pool their knowledge, with a particular focus on three main areas:

1. The effects of climate change on the Alpine lakes (work package 4)
2. Resolving conflicts between the different uses of the lakes (work package 5)
3. Educating the public in sustainable development as it relates to the Alpine lakes (work package 6)

The ESD Tool Kit

(Educational for sustainable development)

The guide line through the whole project is the teacher's map. In this map are described all contents and materials.

This educational material was prepared in the work package 6 of the SILMAS project by the Carinthian Institute for Lake Research and translated by the Partners. It is meant as a support for teachers and other educators in the wide field of standing water ecosystems

The aim is an age-appropriate treatment of the extensive subject that is "Standing waters". Elementary school students (ages 8-12) should learn by playing and easily understand the main characteristics of the ecosystem "Lake". Under the guidance of a teacher and using age-based worksheets and magnetic foils for an individual panel on a magnetic blackboard, students could develop this substantial theme on their own.

The guide line through the whole project is the teacher's map. In this map are described all contents and materials.

The teacher's map is subdivided into four major themes:

Basics: Using age-appropriate worksheets and magnetic films, the basic knowledge about the functioning of a lake should be taught to the students.

Organism in the lake: The second chapter deals with plants and animals that live in and around the lake. A determination booklet resumes the main groups and gives brief information about each species.

Field work: The third part is the practical unit of the project. Preliminary to an excursion to a water body, measurement and sampling methods will be explained.

Protection of the lake: The issues of this chapter are: how to treat waste water, how could lakes be protected and how I can actively participate in such protection measures?

Some highlights:

- The lessons are recurrently accompanied by game and handicraft work instructions.
- A glossary provides information on technical terms.
- Exciting stories, combined with images and film clips, should transform the plants and animals of a lake in a tangible experience!

Content

Introduction and familiarisation

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Introduction and familiarisation

Glossary

Ecology:	Branch of biology that explores the relationship of organisms with each other and their environment
Limnology:	science of inland waters
Inland waters:	are surrounded by land and are not oceans



Worksheets and material:

Name cards

Ball of wool

Worksheet „Find the words“ (B_01)



Questions:

- What is the name of the teacher, what are the names of the pupils?
- What do the pupils expect from the project?
- How long are we going to work on the topic?
- What is an ecosystem?



Explanations:

The familiarisation between teacher and students (in the event that it is not the class teacher) can be supported through giving out the name cards.

A discussion at the beginning of the project (possibly in a seated circle) enables pupils and teacher to express their respective expectations.

The project lasts a maximum of 5 days. If it is only possible to work through a part of the project, 1- 4 days is also possible.

After the game „The Econet“ (see exercises and games) the sheet „find the words“(B_01) is given out. The children attempt to find as many of the terms discussed in the game as possible. This sheet can give the teacher an idea of the level of knowledge in the class/group.



Exercises and games:



The Econet

All participants form a circle. The teacher has a ball of wool in his hand and holds the end tight. He calls out a term from the theme (depending on the age of the pupils, either from the topic „water“ or more specific from the topic standing water) and throws the ball to a pupil, preferably opposite. It is now his turn to call out a term from the theme holds the end tight and throws the ball further. During the game a net is formed by the wool, like an ecosystem. Like in an ecosystem, all participants are interwoven. If someone pulls on one side, or lets the wool slacken, the other side must react to maintain the tension. If it is pulled too hard the connection can be broken and the ecosystem is damaged.

Chapter 1 - Basics

In the first chapter of this project among others we will talk about the water types, the different zones in standing waters and the chemistry of the water. What's about the mixing behaviour of lakes and how does this effect the organism are topics we want to discuss in this chapter "Basics".

1	The different water types.....	11
2	The zoning in lakes	14
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1 The different water types

Glossary

Evaporation: Transfer of a substance from liquid to a gaseous state

Condensation: Transfer of a substance from a gaseous state to liquid form



Worksheets and material:

Worksheet "circulation of water" (B_02)

magnetic foil: sun, cloud, rain



Questions:

- How are the waters distributed?
- How does the water cycle function?
- Where does the stagnant water come from and where does it flow to?
- What influence does the sun have?



The difference between the specific waters (flowing-, underground- and stagnant water) shall be worked on in teams using a blackboard (see Explanations). The children form three teams. Following a discussion the groups explain and illustrate the respective water types on the board.

Where the water comes from and where it flows to, as well as the influence of the sun – the worksheet „Circulation of the water“(B_02) explains.



Explanations:

The waters shall be divided into: flowing- underground-, and stagnant-, waters.



fig. 1: Small river in the alps

Flowing waters: originate from a source and flow to other waters. The water is always moving downhill.

Stream: small flowing water with a water width under 5 m.

River: flowing water with a width of over 5 m.

Major River: very large flowing water with a length over 500 km, which usually flows to the sea.

Underground waters: This includes groundwater and cave waters. Groundwater supplies large scale water body fractures, cracks and pore spaces of hard and soft rocks. Over impermeable layers, the groundwater builds up and continues as groundwater current with less, sometimes laminar movement to the slope of the terrain. Cave waters are underground ground water-fed habitats. The underground water is often accessible as a cave lake. Cave rivers are mostly flowing underground surface water.

The ground water level gives the distance between the ground water and the surface. Groundwater plays an important role for drinking or for irrigation of agricultural land.



fig. 2: Lake Ossiach in Carinthia

Stagnant water or ponds: These waters are characterised by the fact that through precipitation, an underground or surface inflow a basin is filled. Also in stagnant waters the water is usually subjected to a flow although much lower than in a river. The lakes in Carinthia are of glacial origin, resulting from the retreat of the great glaciers at the end of the last Ice Age, about 12 000 to 15 000 years ago.

The circulation of water: Every water surface emits water into the atmosphere through evaporation. The larger the water surface area the more the evaporation. Therefore through the largest lakes and in particular through the sea, the most water evaporates. Humidity is created through the evaporation which rises and condenses in higher, colder layers of air resulting in clouds. A cloud is therefore nothing more than a collection of fine water drops or ice crystals. Through the wind movement, the clouds are transported over land. Through the ascent into higher air layers the cool down further, can not contain the water drops any longer, resulting in precipitation. The water falls to the ground in the form of rain, hail or snow. It either seeps into the ground and passes through the groundwater back into the waters, or it falls directly on a body of water. The cycle is closed.

Specifics

The evaporation is, amongst other things, dependent on air temperature, humidity and wind intensity. In our zone approximately 500 mm water head evaporates per year. On a water surface, thus on a surface, on which there is sufficient water available for evaporation, one can reckon with an evaporation of 1.3 litres per square meter per day.

That would mean for the Lake Millstätter See (area: 13.28 km²), that per day, an unbelievable sum of 17 million litres of water evaporates.

Exercises and games:

Teamwork on the board

Role-play: The Water Circulation



The water-cycle as a role-play for warming up

The following roles must be distributed: water drops (5-10 children), Mountain (2-3 children), wind (1 child) and Sun (1 child with a pocket torch, as well as 2-3 additional children, who control the darkening of the room);

Activity: It is still night time. The sea is cold and calm. At last the sun comes up. At dawn it does not have much power yet (only the pocket torch), but it rises steadily higher in the sky and gains an energy (the curtains, or blinds as the case may be, are slowly raised. The water and the air begin to warm up.

The water drops become restless. They want to begin their journey at last. Finally the first drops climb into the atmosphere (the water drops stand on chairs), they evaporate. More and more water drops evaporate and form a cloud. Now it is already midday, the wind gets going. It blows the clouds over the land and up to the mountains (the water drops stand on tables. Through the cooling off of the clouds, the water drops rain down. They fall in the stream. The stream flows through a lake. Here the first water drops evaporate again. Having traversed the lake and the land, the river finally flows into the sea.

Where the river flows should be defined on the floor, where the lake is and where the river flows into the sea. For the path of the water drops into the atmosphere, 1-2 tables and chairs should be used.

2 The zoning in lakes

Glossary



<i>Biotope:</i>	a defined habitat of a community
<i>Community or Biocoenosis:</i>	the community of organisms in a defined habitat
<i>Benthic:</i>	Ground zone of a water body
<i>Littoral:</i>	shore zone of a water body (illuminated part of the ground zone)
<i>Profundal:</i>	deep zone of a water body (lightless part of the ground zone)
<i>Pelagic:</i>	open water area of a water body, without contact to the ground
<i>Epilimnion:</i>	summer warm upper layer of open water
<i>Metalimnion:</i>	also called the thermo cline, here the water temperature changes a lot (minimum by 1 ° C per meter)
<i>Hypolimnion:</i>	cold deep water layer
<i>Euphotic:</i>	flooded with light
<i>Aphotic:</i>	lightless
<i>Nekton:</i>	animals of the pelagic which can actively swim against the flow
<i>Plankton:</i>	organisms of the pelagic, which are dependent on water flows
<i>Photosynthesis:</i>	through this process plants are making grape sugar with water, carbon dioxide and with the energy of the sun. (also see page 24)

Worksheets and material:

worksheet: "The zones in the lake" B_03)

magnetic foil: sun, characeae, house, phragmites, potamogeton, typha, waterlily, icons, title_B03, willi_boat;



Questions:

- What is a habitat?
- What is zoning?
- Why are deeper lakes zoned?
- What habitats exist in lakes?



Explanations:

A habitat or biotope is a defined area which is inhabited by a community of organisms (biological community). Biological communities and habitat, this means the community with its special habitat, form an ecosystem.



Shallow lakes, like ponds have as a result of their low depth no zoning of the water body. Aquatic plants can grow anywhere in the water. The water temperature is approximately equal in the entire water body. These standing waters have no "real" open water area, because you can attribute growth of the water plants in the area to the shore zone.

Deep lakes, from a depth of 8-10 m, different zones in the water body show. Aquatic plants are restricted to the shore zone, as the light in the depths no longer extends to the bottom.

In deep lakes two habitats exist: the **ground zone (Benthic)** and the **open water zone (Pelagic)**.

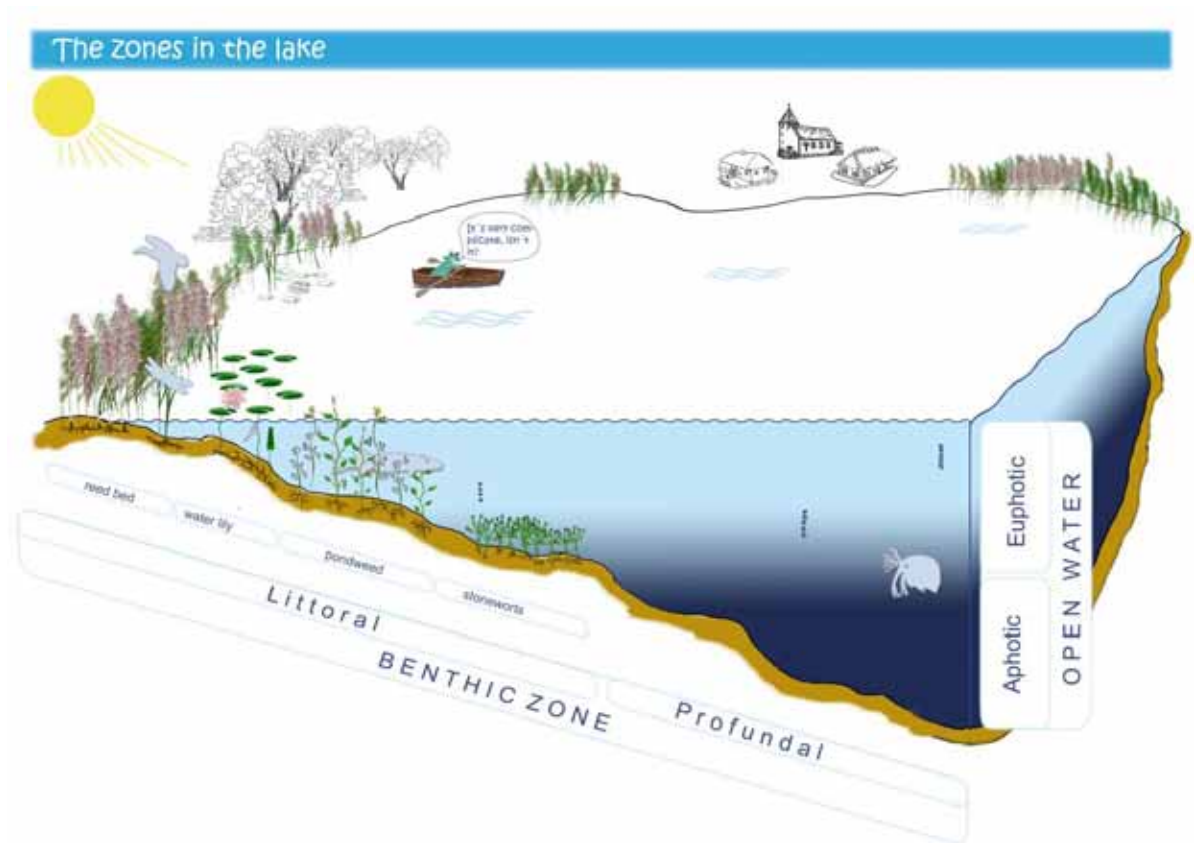


fig. 3: Worksheet „The zones in the lake“

2.1 The ground zone (Benthic)

The plants and animals that live in and on the bottom and water plants that are rooted in the soil are expected in this zone. The floor area is divided again into the illuminated, covered with vegetation shore zone (Littoral) and in the lightless deep zone of the bottom of the water (profundal).

a) The illuminated bottom zone, the Littoral

The living areas of the bank zone starts above the water line, with the bank accompanying woody plants such as alders (*Alnus sp.*), birch (*Betula sp.*) and willows (*Salix sp.*). Mostly already in the water is the reed (*Phragmites australis*), which forms the main part of the **reed bed zone**. Here you can find also cattail (*Typha sp.*), calamus (*Acorus calamus*), and other reed-like plants. The reed bed zone is an important habitat for many species of birds that hide and breed here. But also amphibians and many species of insects can be found here.

In many places the reed beds will sharply recede due to human activities. The reed is very sensitive to water level regulation and reductions. Also, the wave caused by the motor boat traffic can affect the reed beds.

Further offshore water lilies grow (*Nymphaea alba*, *Nuphar lutea*), the most important plants of the **floating-leaf zone**. Even the water knotweed (*Persicaria amphibia*) can be found here. Plants that are rooted not in the ground as the duckweed (*Lemna sp.*) or the frog bit (*Hydrocharis morsus-ranae*) are also found in the floating leaf zone.

With increasing water depth the floating-leaf zone changes over to the **pondweed zone**. This zone is characterized by completely submerged aquatic plants. (*Potamogeton sp*) The pondweed, as the main plant of the region can form underwater forests in which many fish lay their eggs – to use for spawning and breeding grounds. Accordingly, many young fish hide from predators here. But also many species of insects and small crustaceans and amphibians live in the pondweed and floating leaf zone. A special feature among the underwater plants is the bladderwort (*Utricularia sp.*) (see peculiarities).

The lowest zone in the light-flooded shore zone is covered with **stoneworts** (Characeae). This group of green algae, which look similar in shape to flowering plants, can form entire underwater meadows.

b) The lightless ground zone, the Profundal

The littoral attaches to the profundal. In this zone, the light availability for plants is too low; a production of biomass through photosynthesis is no longer possible. Here, only animals and bacteria live. They feed on the sinking (dead) plant material or other animals. The larva of the midge (Chironomidae) is a typical representative.



fig. 4: Water lily (*Nymphaea alba*)

2.2 The open water (*Pelagic*)

This is the area with no connection to the ground. The border is at the end of the littoral zone, exactly up to the rooted aquatic plants. The pelagic zone is home to animals and plants that are not attached to the shore and the water bottom. The living world in open water can be divided basically into two main groups:

a) Nekton

These animals are able to swim active against the flow. In inland waters this is only the fish.

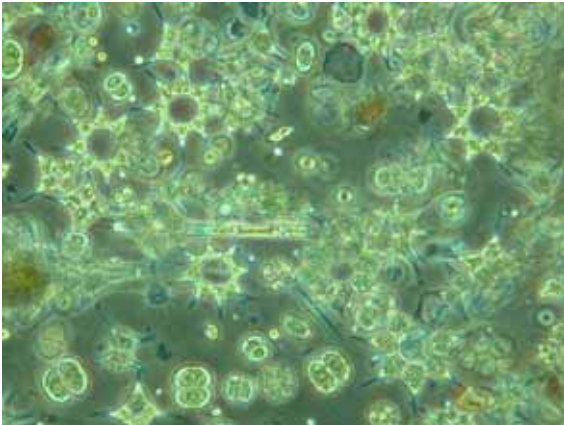


fig. 5: Phytoplankton

b) Plankton

This refers to plants (phytoplankton) and animals (zooplankton) that are competent in part to proper motion, but are drifting with flows in the lake.

The **plant plankton**, the algae are mostly microscopically small. There are many different groups that look very different. What they all have in common is photosynthesis as the mechanism of energy generation.

The **zooplankton** is formed in the internal waters of small crustaceans, rotifers and unicellulars. These organisms can not carry out photosynthesis but are nourished by other organisms (plant or animal). They are up to 2 mm in size and usually only seen well with a microscope.

Many unicellular organisms live in water, thus organisms that consist only of one cell. Also countless bacteria live in the water. This organism are also single-celled organisms, but without a real nucleus. Both play a major role as a food source. But also the self-cleaning process of the water is closely associated with these organisms.

As in the shore area open water can be divided into different zones. The decisive factor for it is on the one hand the light and on the other, the water temperature:

The light-flooded open water - the euphotic zone

The area in which the algae can still find enough light to grow is to be referred to as the light-flooded area.

The lightless open water - the aphotic zone

Below the euphotic zone begins the aphotic zone. Here, the plant organisms have too little light to practise photosynthesis. Many zooplankton stay here during the day to protect themselves from predators in the dark (see peculiarities). At night they migrate to the euphotic zone for food intake.

Peculiarities

The bladderwort

A peculiarity among the underwater plants is the carnivorous bladderwort (*Utricularia vulgaris*). The plant has no roots and floats freely in the water. Only the yellow inflorescence protrudes beyond the surface. Small crustaceans and rotifers are caught using a snare bubble. In the bubble there is a vacuum. The snare bubble is closed with a flap that is purely mechanically opened by contact of the prey. The animal is taken in and digested inside the bubble. The opening of the flap happens within 2 milliseconds and is the fastest known movement in the plant kingdom.



fig. 6: Bladderwort (*Utricularia vulgaris*)



Lake-marl

In many lakes you can find along the banks, white deposits upon plants and the ground. These are calcium deposits, giving the bank an almost "Caribbean" look. The responsible calcium carbonate (CaCO_3) is a waste product from photosynthesis of algae in lime-rich lakes.

**fig. 7: Lake-marl in lake Wörthersee
(source: Kagis)**

Daily migration of zooplankton

Almost all small crustaceans have limited movement in the water. It is mainly vertical movement as protection from predators. The animals spend the day in the depth of the lake. It is dark and they can not easily be noticed by predators. In the evening the crustaceans begin the migration to get to their food source - algae or other zooplankton organisms. The feeding takes place at night and in the morning the animals migrate again. The crustaceans thereby cover, twice a day, a total distance of 5 to 15 m, for an animal of 1-2 mm, a considerable distance.




Exercise:

If a 2 mm animal covers a distance of 15 m, how many metres must a 1.8 m tall person cover?

3 Oxygen, light, temperature and nutrients

Glossary

<i>eutrophic:</i>	waters with a high phosphorous content and high algal biomass	
<i>mesotrophic:</i>	waters with a medium phosphorous content and medium biomass	
<i>oligotrophic:</i>	waters with a low phosphorous content and low biomass	
<i>algal bloom:</i>	mass occurrences of algae, usually only one species	
<i>inorganic compounds:</i>	chemical compounds without carbon	
<i>organic compounds:</i>	chemical compounds containing carbon, all organisms are composed of organic compounds	
<i>absorption:</i>	absorb, soak up	

Worksheets and material:

Magnetic foil: oxygen_nutriens



Questions:

- What is oxygen?
- Who needs oxygen?
- How does oxygen get into the water?
- Who needs light?
- Why is the water temperature important?
- What are nutrients?



With the help of magnetic foil the questions should be worked out on the board.

Explanations:

As with life on land, life in the lake depends on several factors. The most important are:



3.1 Oxygen



Oxygen is a chemical element. The chemical symbol is O, from Oxygenium, the scientific name of oxygen. Basically, without connection with other elements oxygen is mostly in connection with other oxygen atoms. Elementary oxygen can also be describe with the formula O₂. Oxygen is colourless and odourless and is contained in the air at about 20%.

**fig. 8: magnetfoil
"oxygen"**

Plants produce oxygen. It is created by photosynthesis as a "waste product". Nearly all living things need oxygen for respiration. It is in every cell of the organism. In every cell of the organism, in special cell organelles - the mitochondria - is oxygen consumed and energy is generated. The plants need oxygen for energy generation.

Oxygen enters the water on one hand through the exchange with the air and on the other hand by the photosynthesis of algae and aquatic plants. With high algal biomass in the water, more oxygen can be dissolved, than in the air.

3.2 Light



fig. 9: Magnetfoil "sun"

The light from the sun hits the lake. Some of the light is reflected (3-14%) and the other part penetrates into the water. How deep the light reaches in the water depends strongly on the dissolved particles and the number of algae in the water. With a high proportion of inorganic and organic particles, the light can not penetrate very deeply due to the high dispersion. The algae and underwater

plants need light as an energy source in photosynthesis. Therefore, life and growth of plant organisms in the lake are bound to the well lit part of the water. Almost all animals in the water have eyes. They need light to see something.

The sunlight is also responsible for another very important attribute of water - the water temperature.

3.3 Water temperature

The heat absorption of the water occurs mainly by the light. The temperature of the water depends on the season. In the summer the water heats up in the upper layers, the deeper layers have a constant water temperature of 4-5 ° C throughout the year. The temperature has a decisive influence on the rate of chemical processes. The warmer it is, the faster the chemical processes within the organisms. In the spring the algae show rapid growth, which is also connected with the rising water temperature. However, growth is only possible if sufficient nutrients are available.

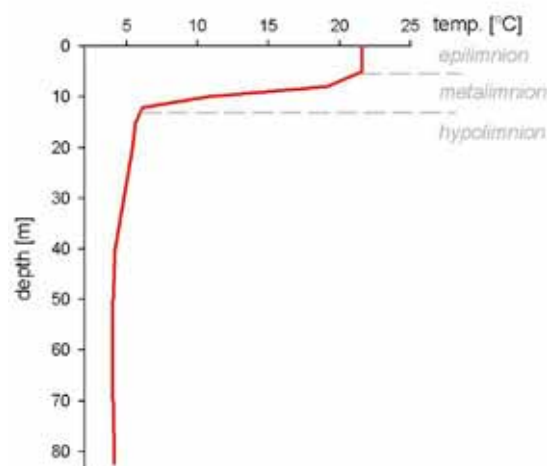


fig. 10: Water temperature in summer

The water temperature in different depths of the lake depends on the season. In spring and fall, a lake has in the depth profile through the entire water column, nearly the same temperature (4 - 5 °C). In summer the surface water is much warmer than the deep water, the lake is layered (fig. 10). In the highly heated surface layer (epilimnion between 0 and 6 - 10 m), the water can be over 25 ° C in the summer. With decreasing light intensity the water temperature decreases also. The area, in which the water temperature decreases very strongly, is called the thermo cline (metalimnion). Subsequently, one finds the deep layer (hypolimnion) - the water here is approximately the same temperature throughout the year, 4 – 5 °C.

3.4 Nutrients

The algae are the most important group of plants in the lake. They produce chemical compounds from biological material. The necessary energy is provided by photosynthesis. However, to produce cell material it is necessary to have, as well as an energy source, to also have cell blocks, for the nutrients needed. The most important nutrients for the growth of algae, in addition to the carbon, which is always present in sufficient quantity, are phosphorus and nitrogen in various compounds. Phosphorus is essential for all biological organisms. Phosphorus compounds are part of the DNA and RNA, the carrier of genetic information. The nitrogen needed in plant growth is just as essential.



fig. 11: magnetfoil “nutrient”

These two nutrients are therefore important indicators for assessing the nutrient content of a lake. If phosphorus and nitrogen are dissolved in high concentrations in the water, the algae can also grow well; these are called nutrient-rich lakes (eutrophic lakes). Such lakes are usually strongly influenced by man; here you can always come across algae blooms. Lakes are known as nutrient-poor lakes (oligotrophic lakes) when nitrogen and especially phosphorus is released in very small quantities in the water. Lakes with moderate nutrient levels are called mesotrophic. The majority of lakes uncontaminated by people are oligotrophic or slightly mesotrophic lakes.

Peculiarities

Photosynthesis

Photosynthesis is driven by plants and algae and some groups of bacteria. With photosynthesis, sugar is generated from water and carbon dioxide using the energy of the sun. The sugar is used to store energy. A by-product of photosynthesis is the oxygen that is released from the plants to their environment.

The empirical formula for photosynthesis is: $6 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2$

Organisms that can produce from inorganic raw materials (water, carbon dioxide and light), i.e. from compounds without carbon, organic material (sugar) are called the primary producers. Animal organisms can not carry out photosynthesis. They must obtain the cell blocks and energy from plants or animals (food intake). They consume organic matter and are referred to as consumers.

Why pure water appears blue

The colour spectrum of light includes colours from violet to red. All of these combined result in the light. Upon entry of the light in the water it is slowed down and absorbed. Not every colour is absorbed equally strongly. Red and green colour components are absorbed very quickly. The blue colour components are scattered and reflected, which is why clean water appears to be a deep blue.

4 Circulation in the lake

Glossary

Anomaly:	an exception to the rule
Circulation:	the water of the various layers of a lake mix
Stagnation:	the lake is layered due to the water temperature and (almost) no mixing takes place
Temperature layering:	the lake is home to various temperature-horizontal layers of water.



Worksheets and material:

“The lake, a mixing machine“ (B_04)

Magnetic foil: sun, cloud, rain, snow, oxygen_nutriens;



Questions:

- At which temperature is the water heaviest?
- What is a circulation?
- Where is the motor of circulation hidden?



Explanations:

The density anomaly of water

Pure water has, at 3.98 °C, the highest density, which means it is heaviest at this temperature. At temperatures above 3.9 °C the water molecules begin to move and also need more space - the density decreases. At 3.9 °C, there are no bonds, and the thermal proper motion of the molecules is lowest - the density is highest. At temperatures below 3.98 °C the water molecules form hydrogen bonds, all water molecules align themselves; this requires more space - the density decreases.



That is why ice floats on the water surface - our lakes freeze from the top. For life in the lake it is of crucial importance, since the deep regions of a lake always remain free of ice. The density anomaly is also responsible for the deep water of the lakes in the temperate latitudes being never colder than 4 ° C, because colder water rises due to the lower density.

4.1 Circulation

In the process of circulating, the water of a lake is mixed. It is essential that there is approximate temperature uniformity (4-5 ° C) throughout the water body. This process usually takes place in lakes in the Alpine range twice a year, in spring and late autumn, or once a year over the winter. The motor for the mixing is the wind. Through the wind, the cursory, nutrient-poor but oxygen-rich water is set in motion and pushed down, while the nutrient-rich, oxygen-poor deep water circulates up. As a result, oxygen and nutrients spread evenly throughout the water body. For the growth of algae it is very important because the nutrients are returned to the light-flooded water regions and can be used for growth.

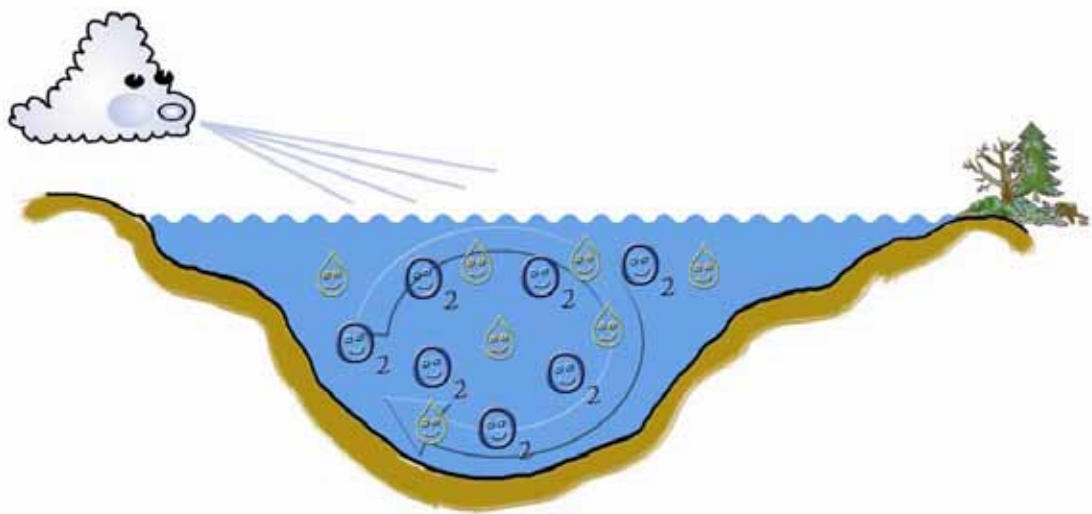


fig. 12: Circulation in spring and autumn

4.2 Stagnation in summer

In summer the lakes are in a "quiet" period. The surface body of water (epilimnion) is significantly warmed. Below this after a transitional zone - the thermo cline - (metalimnion), the deep layer (hypolimnion) are found where the water temperature is the same throughout the year at 4-5 ° C. We speak of a layering of the water body. Because the density differences of the different layers of water the force of the wind is not sufficient to stir through the entire water body. There is no exchange with the deep water. The surface water has enough oxygen due to the algal growth and proximity to the air, the nutrients become less and less, as they mostly fall with the dead organisms into the deep water. It depends on the decomposition of sunken biomass. This process consumes a lot of oxygen, whereby the deep water at the end of the summer stagnation period may be free of oxygen.

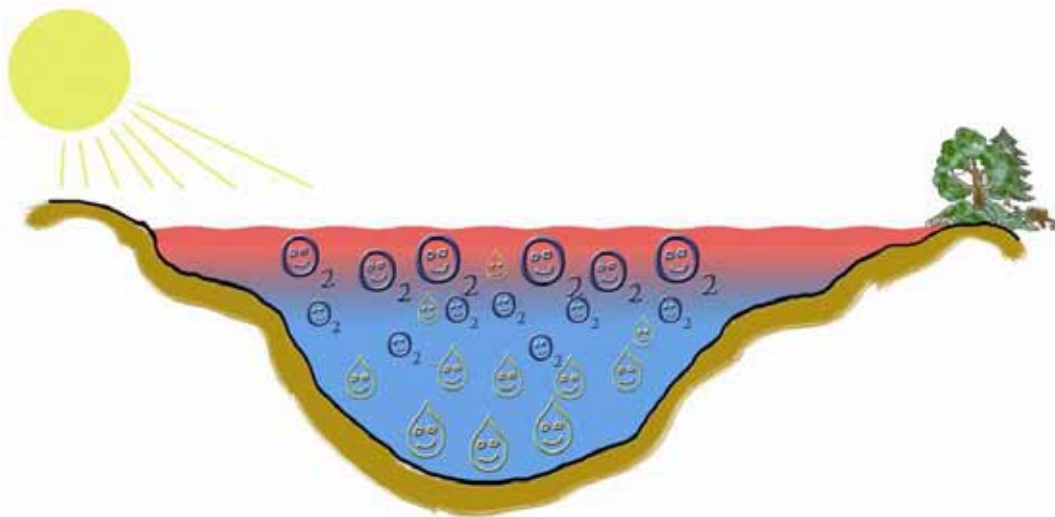


fig. 13: Stagnation during the summer

4.3 Stagnation in winter

In winter, the lake is also in stagnation, whereby the superficial water is colder than the deep water. In very nutrient-rich lakes with ice cover it can lead to oxygen depletion of the water body in winter. In extreme cases this can go hand in hand with the death of fish.

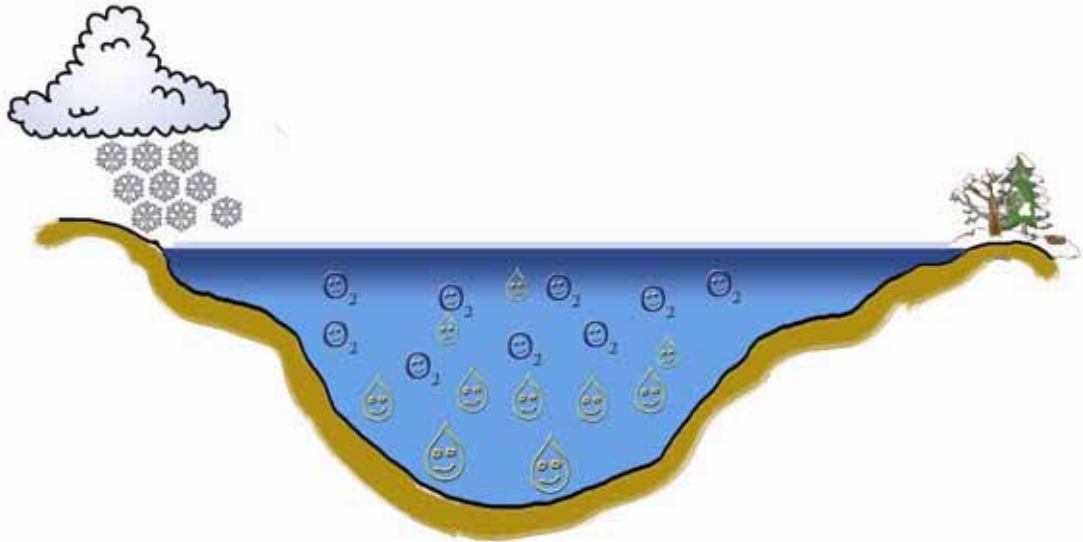


fig. 14: Stagnation during the winter

Exercise:



We have three vessels with the same volume. In the first we pour 20 °C water. In the second 4 °C water and the third vessel is filled with ice. We put all three, one after the other, on the scales. Which is the heaviest? Which is the lightest?

Peculiarities

Not even all lakes are mixing their water two times or one time a year. In some cases lakes are mixing the whole year. This take place in many shallow lakes, like the lake Neusiedler See.



Exercises and games:

Role game: “The anomaly of the water density”

roles: even every children plays a water molecule.

Together the children are one litre water. The water is in (not visible) a pot. We warm up the water in this pot on the stove up to 40°C. With the rise of temperature the water molecules begin to move, they need more place and move around in the pot. The water expands when heating up. Now we take the pot of the stove and place it into the refrigerator. The water cools slowly down, the water molecules moves no longer so strongly. They move more closely together, since the individual molecules do not need any longer so much place. With 4°C the molecules (the children) finally stand completely close together. The water achieved its largest density. During further cooling of the water a lattice structure over hydrogen bonds begins itself to train. The children lift their arms. Only the hands touch themselves. The water becomes to ice, the space requirement become very large...

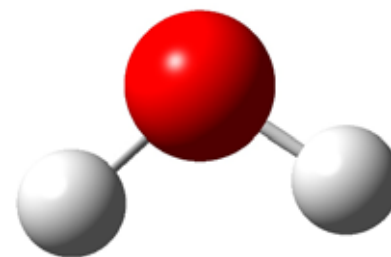


fig. 15: the water molecule

5 Division of the stagnant waters

Glossary

macrophytes:	aquatic plants which are visible to the naked eye living under water or on the water surface	
floating (emers):	aquatic plants which grow in whole or in part, on the water surface	
submerged:	aquatic plants which are entirely emersed in water	

Worksheets and material:

Worksheet: „standing waters“ (B_05)

Magnetic foil: tree, water tap, phragmites, potamogeton, thypha, water lily;



Questions:

- How can we classificate the standing waters?

The standing waters are mainly divided due to their depth. The worksheet „standing waters“ illustrates this.





Explanations:

Based on the water depth standing waters are different in:

5.1 Lakes

Depth: over 8 m

Water temperature in summer: above warm, in the depths cold

Genesis: natural

Aquatic plants can only grow in the shore zone.

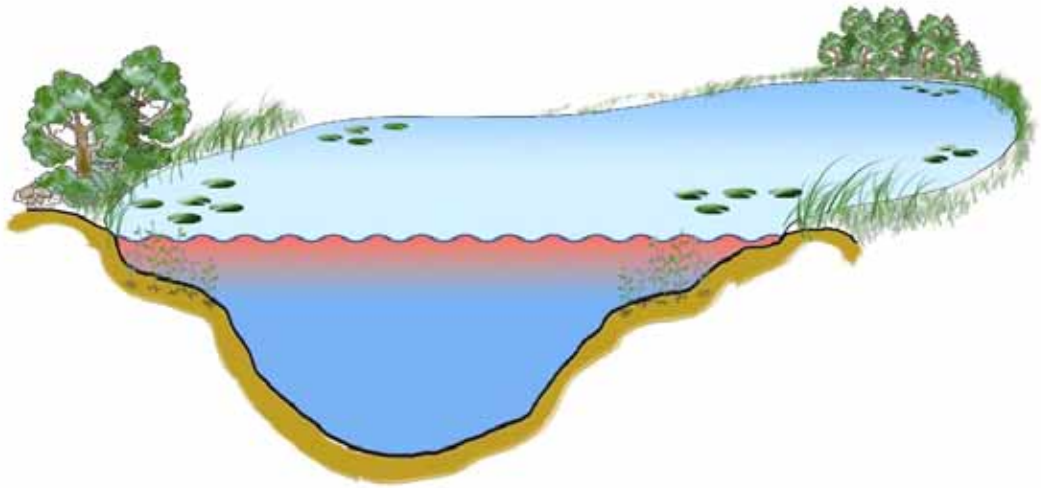


fig. 16: Figure of a lake

There are different zones in the lake. The water body is layered with (in summer), warm surface water and cold deep water. Aquatic plants can not grow to the lowest point, as in the deeper regions of a lake there is no longer sufficient light for photosynthesis.

5.2 Ponds

Depth: very shallow

Water temperature in summer: the same above and below

Genesis: natural; often overgrown with **aquatic plants**

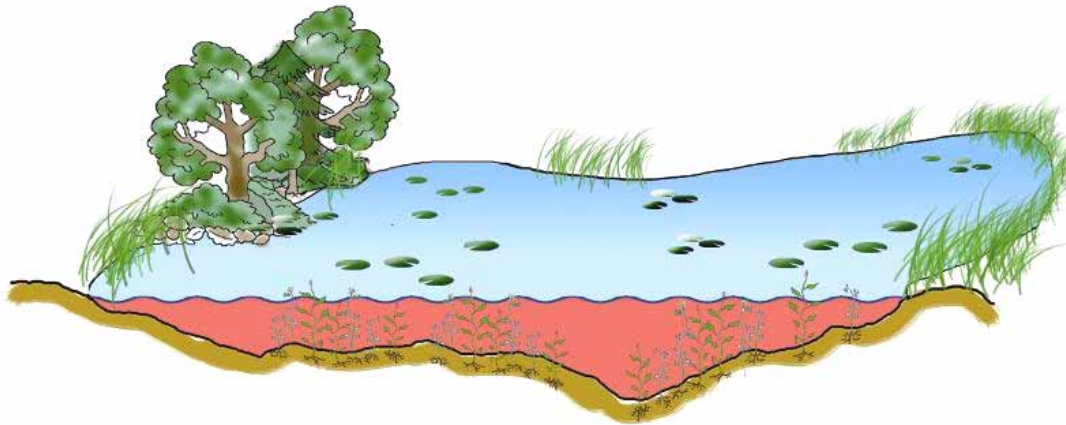


fig. 17: Figure of a pond

A pond is a shallow body of water which has water all-year-round. The pond, also in summer, rarely has layering. Aquatic plants can potentially appear anywhere. Ponds as shallow lakes are natural or caused by silting from deep lakes.

5.3 Pools

Depth: shallow

Water temperature in summer: the same above and below

Genesis: natural or man-made

Aquatic plants can grow everywhere.

The pool is a shallow, natural or artificially body of water. The water level is highly variable. The pond may dry up periodically.

5.4 Artificial ponds

Depth: shallow to deep

Water temperature in summer: above warm and cold at the bottom or the same in the whole lake

Genesis: by people, man-made

Aquatic plants can grow everywhere or only in the shore-zone.

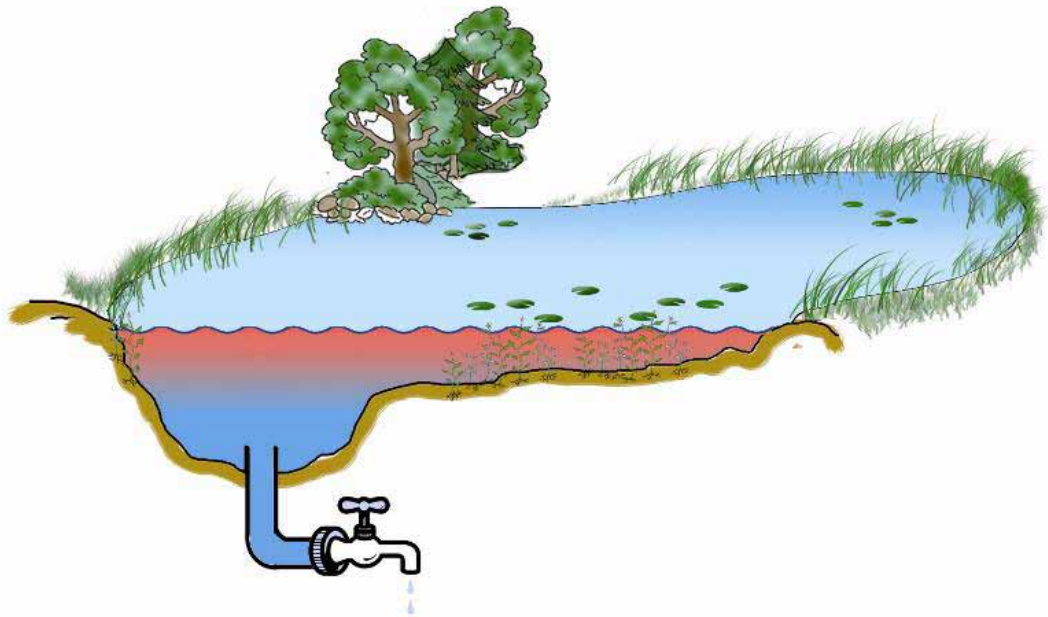


fig. 18: Figure of an artificial pond

A pond is created artificially. The water level is regulated. The water can be drained.

5.5 Back water

Depth: shallow

Water temperature in summer: nearly the same in all depths

Genesis: natural, was a flowing water before

Aquatic plants can grow everywhere.

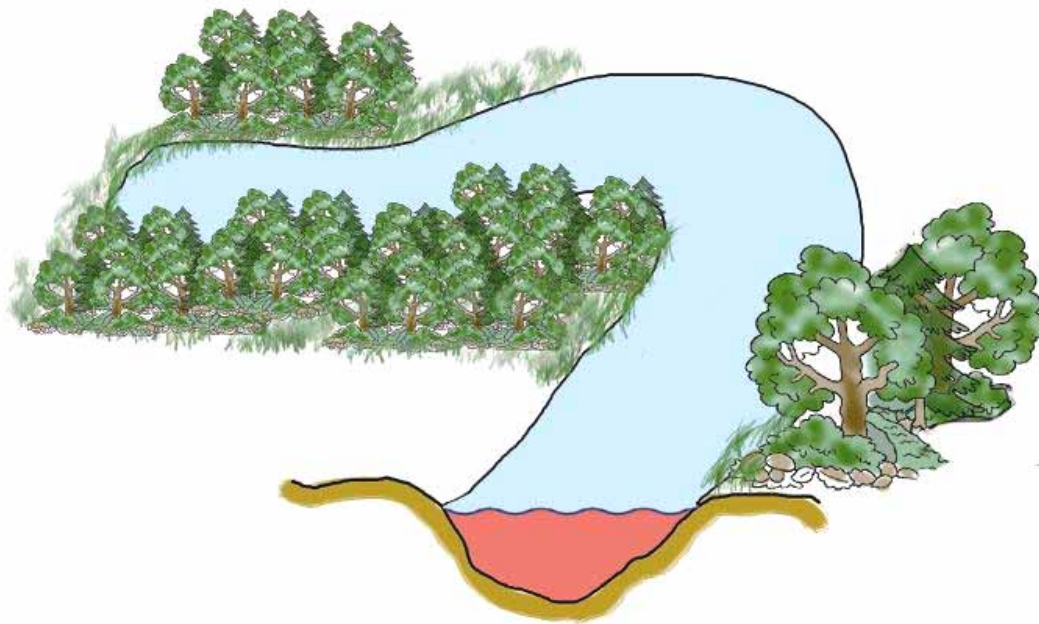


fig. 19: Figure of a back water

These waters are caused by constriction of a river. They are among the standing waters, since they only have contact with the main channel during floods.

5.6 Artificial lakes

When the mining in a gravel pit is over, the hole is filled up with water from the groundwater. After saving the shoreline they are often used as bathing places.

Also, a reservoir is one of the artificial waters. Depending on the mode of operation (daily power generation, or only during the winter months) it may also build up a thermal layering.

6 Our local lakes

Glossary:



Glacial origin: formed by glacier



Worksheets and material:

“Our local lakes“ (B_06)

Magnetic foil: the Carinthian lakes

Questions:



- How many lakes are there in Carinthia?
- What is the biggest and deepest called?

In this chapter, the students learn about the lakes in their region and therefore strengthen their knowledge. If no knowledge of regional geography exists, a discussion about the main lakes with position and maximum depth should take place in the beginning. The worksheet "Our local lakes"(B_06) can - depending on the age of the students -be used as a competition. The first 5 (or 10) children with the correctly answered worksheets may start first during the subsequent lake game.

Explanations:

An important goal of this school project is the sustainable education of students regarding the importance of our water resources. The stagnant waters are not only important recreational areas, but also serve the water supply for agriculture as well as supplying, to some extent, drinking water. To provide the adults of tomorrow with an awareness of the habitat and the lake water as a resource, a reference to local conditions is desired.



6.1 The Carinthian lakes

In Carinthia there are 1 270 lakes. Naturally, larger mountain pools and ponds are included. Of the 1 270 waters only 630 are at an altitude of 1 000 m. The water surface of all stagnant waters in Carinthia amounts to 60 km², of which the four large lakes of the region (Wörthersee, Millstatt, Ossiach, Weissensee) make up 50 km². Almost all the



Carinthian lakes are of glacial origin. They were formed during the retreat of the last ice age about 12 000 to 15 000 years ago.

fig. 20: Lake Wörthersee

Tab. 1: the most important lakes of carinthia

Lake	Area (ha)	max. depth (m)
Afritzer See	48,8	22,5
Aichwaldsee	3,3	7,2
Badesee Kirschentheuer	9,0	12,0
Faaker See	220,0	29,5
Feldsee	41,2	26,3
Ferlacher Badesee	6,7	10,0
Flatschacher See	3,0	3,4
Forstsee	29,0	35,0
Goggausee	10,5	12,0
Gösselsdorfer See	32,0	3,0
Greifenburger Badesee	5,0	14,5
Hafnersee	15,9	10,0
Hörzendorfer See	6,4	5,0

Lake	Area (ha)	max. depth (m)
Keutschacher See	132,7	15,6
Klopeiner See	110,6	48,0
Kraiger See	5,1	10,0
Längsee	74,8	21,4
Leonharder See	2,3	6,5
Linsendorfer See	3,0	7,5
Magdalensee	14,1	5,2
Maltschacher See	12,9	6,7
Millstätter See	1328,1	141,0
Moosburger Mühlteich	3,9	5,0
Ossiacher See	1078,8	52,6
Pirkdorfer See	3,5	3,5
Pischeldorfer Badeteich	0,8	2,4
Pressegger See	55,3	13,7
Rauschelesee	19,1	12,0
Silbersee	14,3	7,0
Sonnegger See	1,7	4,5
St. Andräer Badesee	2,5	5,0
St. Johanner Badesee	12,1	13,0
St. Urbaner See	9,0	3,0
Trattnigteich	5,3	3,0
Turnersee	44,2	13,0
Turracher See	19,4	33,0
Vassacher See	4,4	10,2
Weißensee	653,1	99,0
Wernberger Badesee	4,5	15,0
Wörthersee	1938,8	85,2
Zmulner See	1,8	7,5

Exercises and games:

Lake Game

The lake game: The game includes a regional map (approx. 2m x 1m) and templates of the regional lakes (rigid cardboard or wood in relative size to each other). A small card or a bar defines the maximum depth of the lakes. Depending on the number of lakes, the children from teams. The lakes are distributed and must be placed by the teams in place on the map. Each team must try to find the correct depth for each lake.

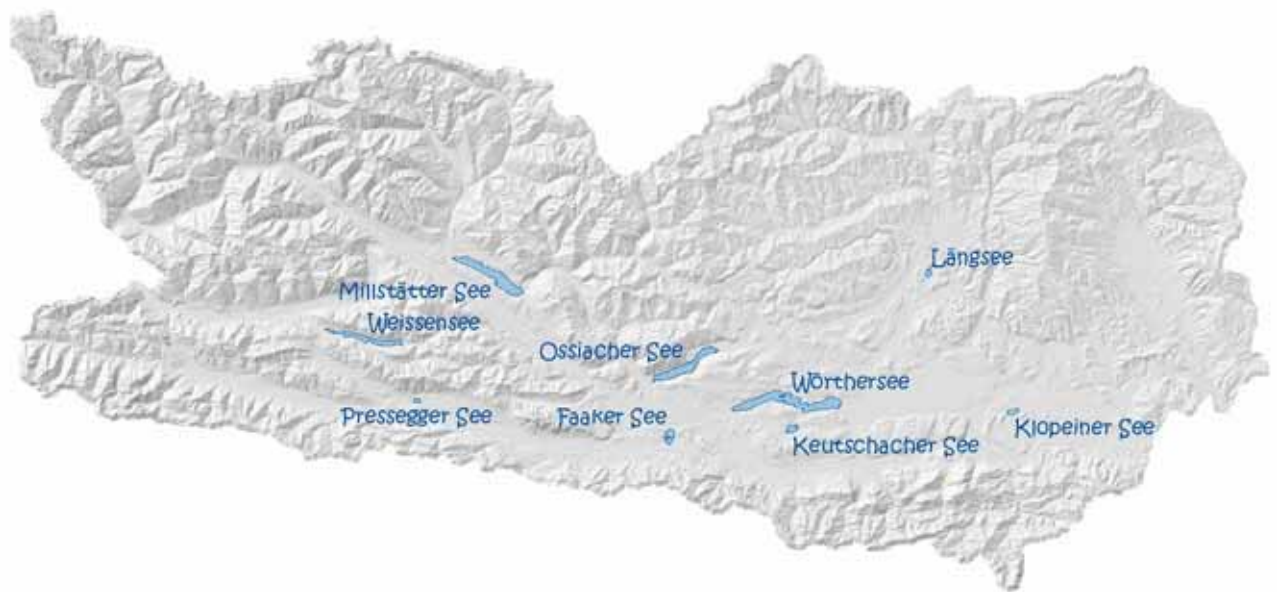


fig. 21: the carinthian lakes (for example)

7 Worksheets with Explanations

FOR TEACHER ONLY!

Find the words

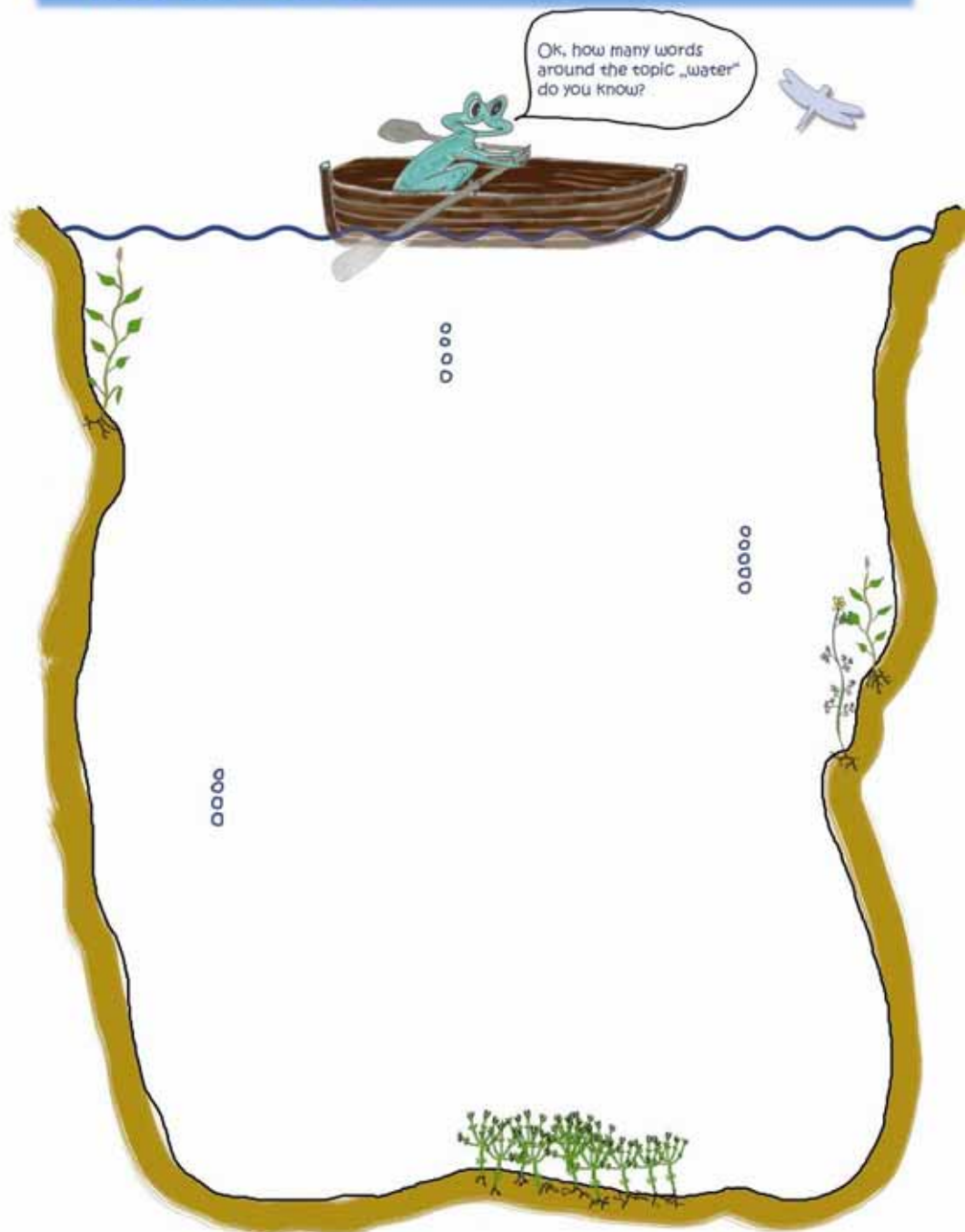


fig. 22: worksheet B_01 „find the words“

Printformat: A4

This worksheet should be an assistance for „entering“ the project and to help the children to focus to the topic. By fill out this worksheet at the end of the project again, it is easy to illustrate the increase of the technical vocable.

Printformat: A4

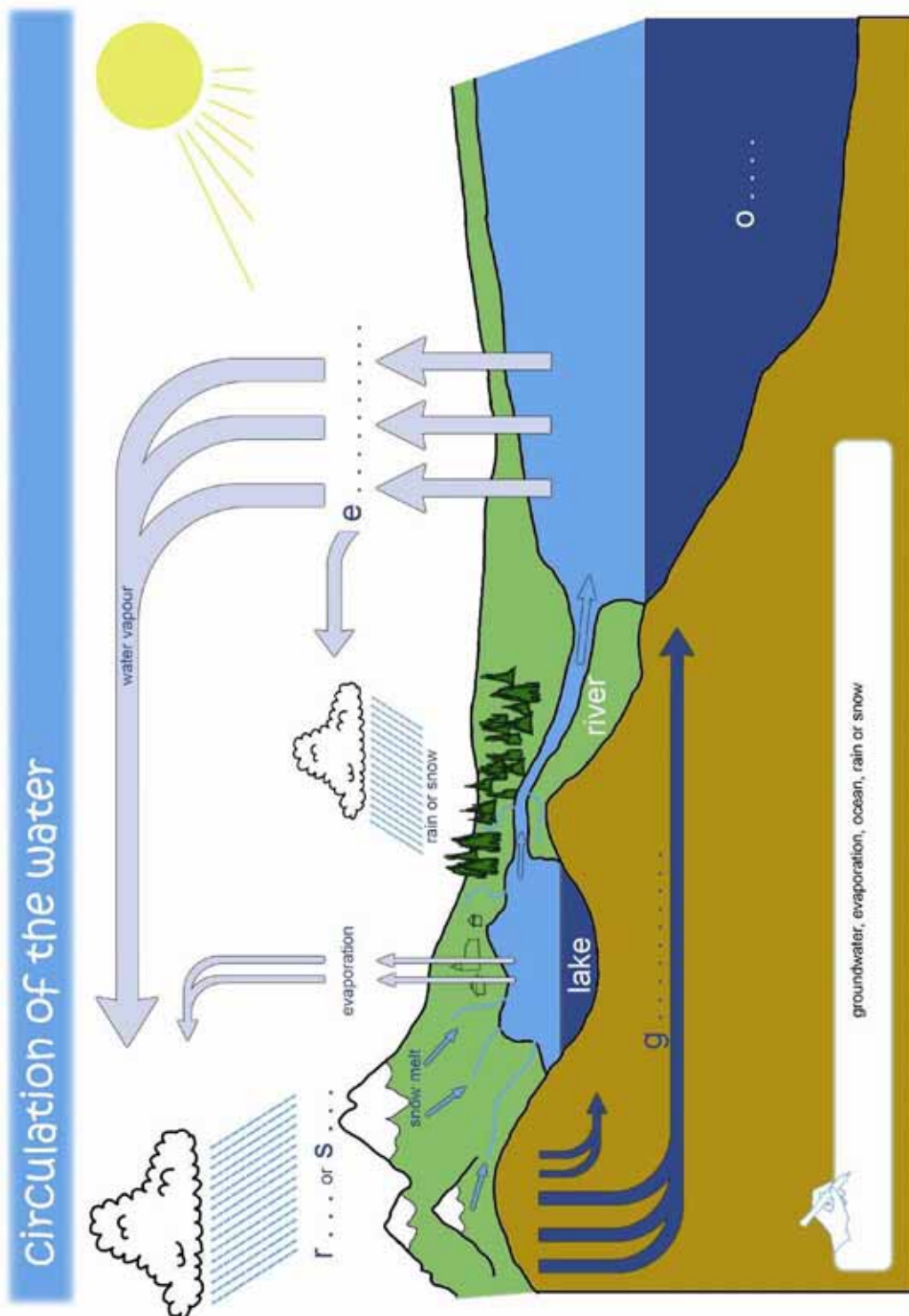


fig. 23: B_02 „circulation of the water“

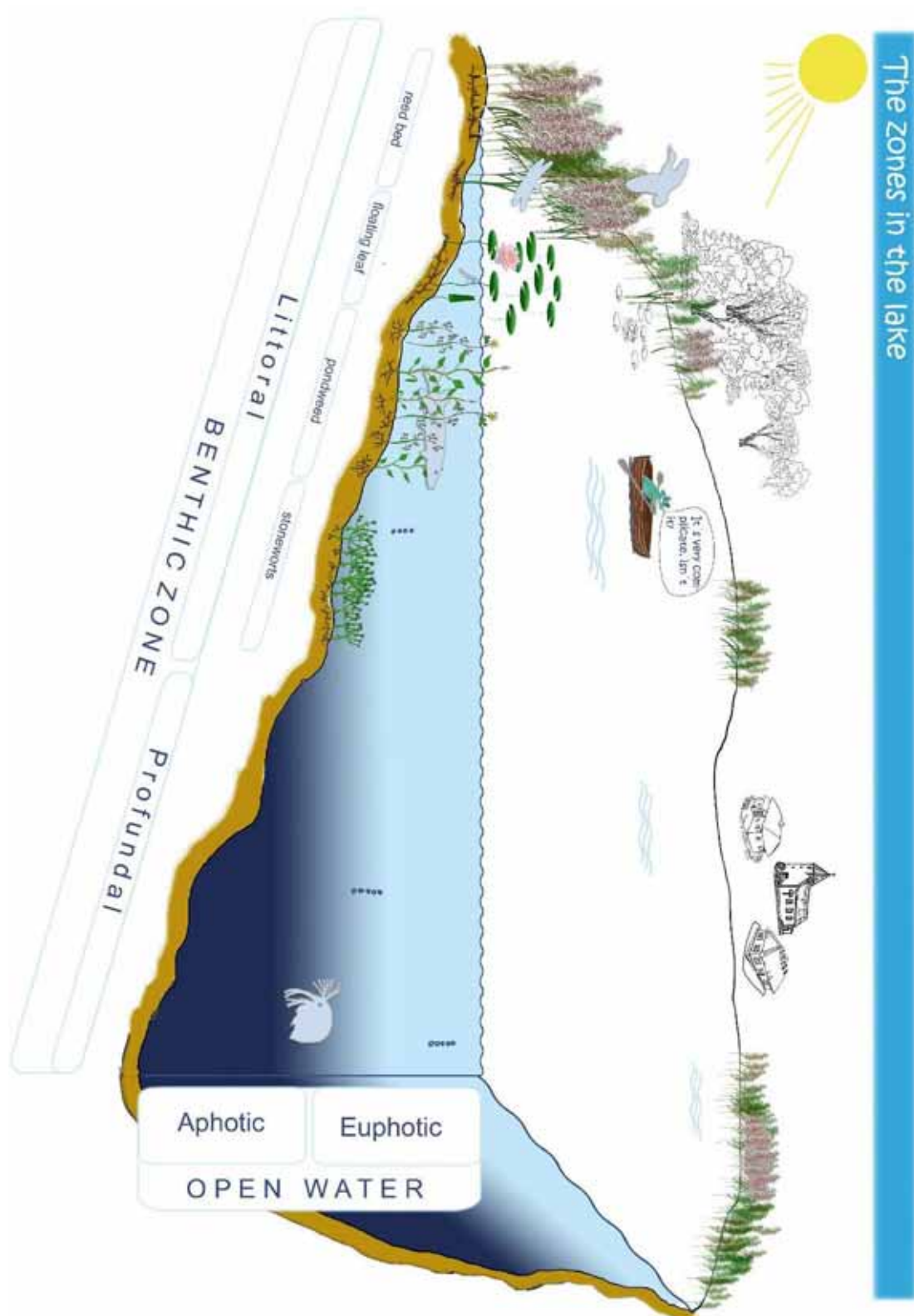


fig. 24: worksheet B_03 „ The zones in the lake“

Print format A3

The pupils handle this worksheet without titles of the different zones. With the assistance of the worksheet B_03_„to cut and to glue on“ they are able to finish the current worksheet. If there is time, the sheet can be coloured.

Printformat: A4

The lake, a mixing machine

periodical the water of the lake is mixed, just like in a mixing machine!

SPRING

Oxygen above: very high high few
 Oxygen in the depth: very high high few

Water temperature above: 15-22°C 4°C 0-3°C
 Water temperature in the depth: 15-22°C 4°C 0-3°C

SUMMER

Oxygen above: very high high few
 Oxygen in the depth: very high high few

Water temperature above: 15-22°C 4°C 0-3°C
 Water temperature in the depth: 15-22°C 4°C 0-3°C

I am the oxygen
I eat the nutrients
for the algae

WINTER

Oxygen above: very high high few
 Oxygen in the depth: very high high few

Water temperature above: 15-22°C 4°C 0-3°C
 Water temperature in the depth: 15-22°C 4°C 0-3°C

AUTUMN

Oxygen above: very high high few
 Oxygen in the depth: very high high few


Water temperature above: 15-22°C 4°C 0-3°C
 Water temperature in the depth: 15-22°C 4°C 0-3°C


fig. 25: worksheet B_04 „The lake, a mixing machine“

Printformat: A4

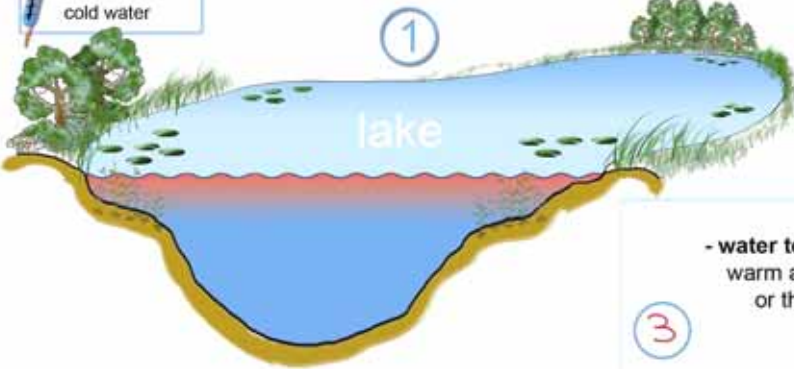
standing waters

Are you smart enough?
Then fill the right number
to the right descripton.





warm water
cold water



1
lake

- **depth:** shallow to deep
- **water temperature in summer:** warm above, cold at the bottom or the same in the whole lake
- **genesis:** by people, can be emptied

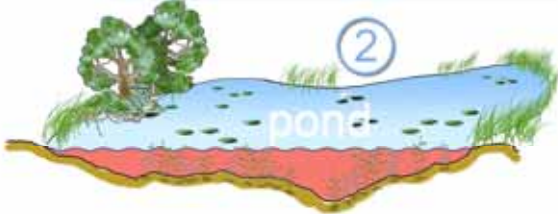
3

- **waterplants:** growing everywhere or only in the shore zone

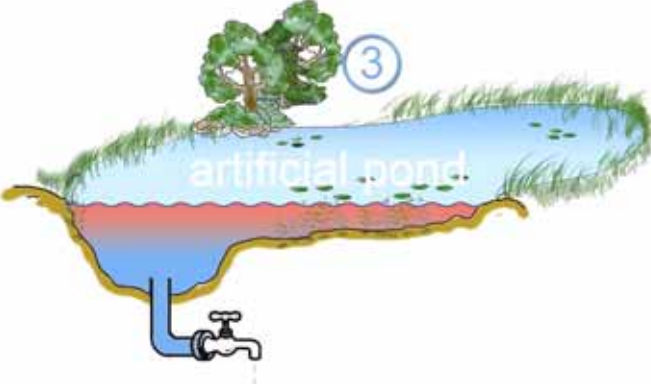
- **depht:** very shallow
- **water temperature in summer:** the same at all dephts
- **genesis:** natural

2

- in many cases filled with **waterplants**



2
pond



3
artificial pond

- **depth:** shallow
- **water temperature in summer:** nearly the same in all dephts
- **genesis:** a long time ago it was a river

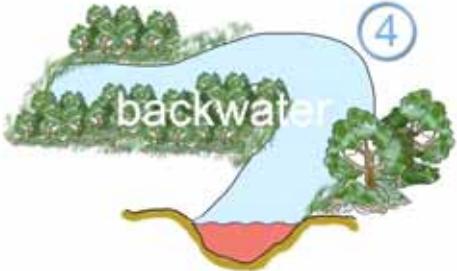
4

- **waterplants:** growing everywhere

- **depth:** more than 8 m
- **watertemperature in summer:** warm above, cold at the bottom
- **genesis:** natural

1

- **waterplants:** only in the shore zone



4
backwater

fig. 26: worksheet B_05 „Standing waters“

Printformat: A4

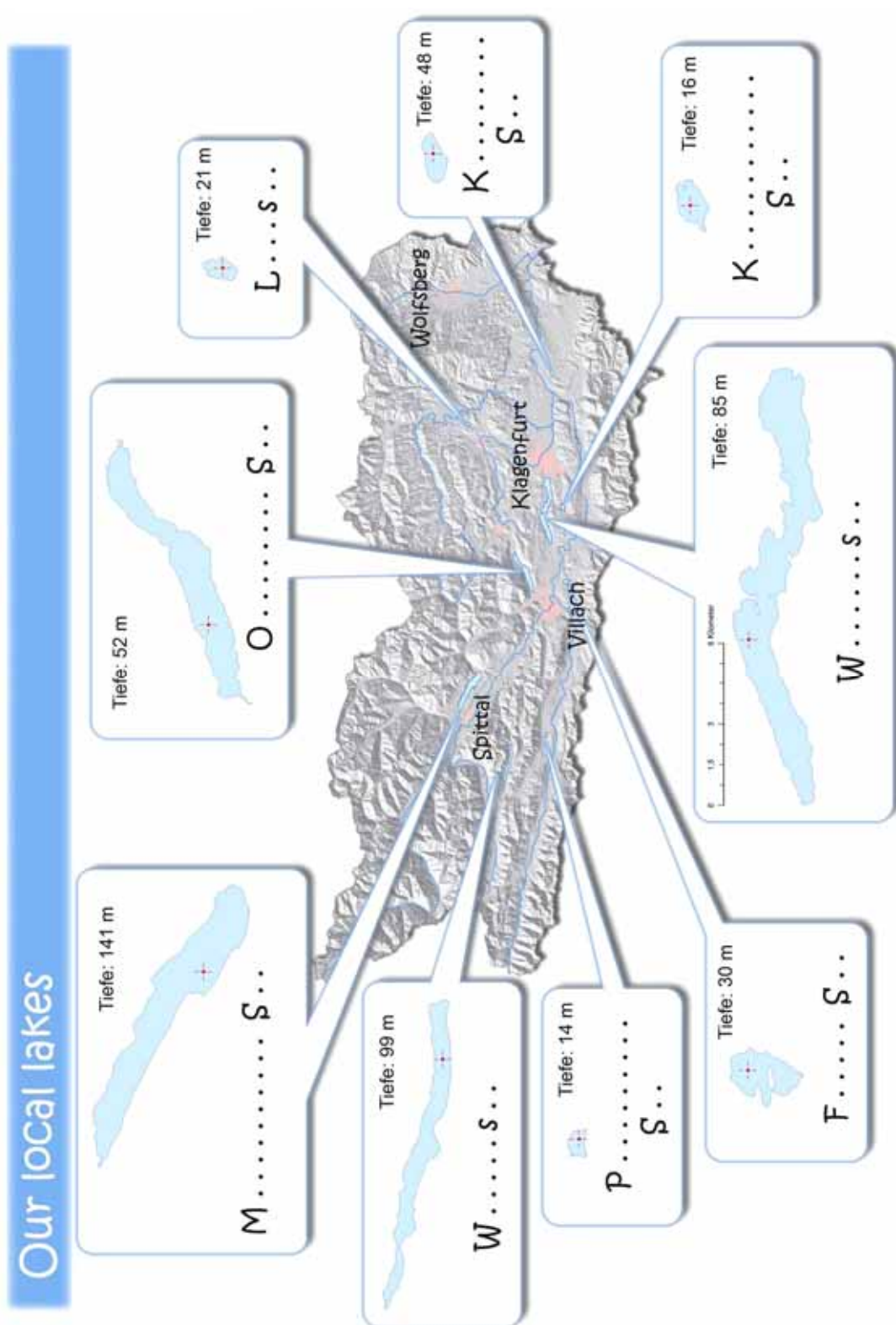


fig. 27: B_06 „Our local lakes“

Chapter 2 - Organism in the lake



In this chapter we will talk about the organism groups we can find in and around a lake. How do the animals of the shore zone look like? Are they different to those of the open water?

We will together work out this chapter on the black board and with some worksheets.

1	Introduction	47
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6	Predator-Prey Relationships	100
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1 Introduction

Worksheets and Material:

Animals and plants in the lake (Org_01)

magnetic foil: use all organism



Questions:


- Which groups of animals and which plants live in the lake?

We want to talk about the life in the lake with the help of the magnetic foils on the blackboard



2 Birds and mammals

Glossary:

<i>Courtship colouration:</i>	during mating season many male bird species have a different plumage.	
<i>Domestication:</i>	wild animals tamed by humans, which by breeding are "optimised" for cohabitation with, and use by, humans.	
<i>Moulting:</i>	the periodic replacement of feathers of birds by shedding old feathers while producing new ones.	
<i>Neozoa:</i>	animals introduced (naturalised) into a new area by human activity. Since these animal species are non-native to the new environment, they can damage the ecosystem they are introduced into and even destroy and extinct other species.	
<i>Upending / dabbling:</i>	to feed from the bottom of waters. Water birds like dabbling ducks and swans do not dive under water totally. Their head and neck are under water, but their back part stays above water.	

Birds and mammals as well as fish as a whole group cannot be confined to a specific ecological habitat (littoral zone, pelagic zone). While mammals are somewhat bound to the littoral zone, water birds can also be seen swimming in the middle of a lake (in the open water). Therefore, it seems appropriate to discuss the two animal groups separately.

2.1 Mammals

The characteristic feature giving mammals their name is the sucking of milk, produced in the mammary glands of the female, by the offspring. Mammals are warm-blooded animals. They can regulate their body temperature and are therefore relatively independent of the temperature of their surroundings. Mammals are air-breathers and have lungs. Many Mammals choose the littoral zone and the back country of waters as their habitat.



fig.28: Eurasian beaver (*Castor fiber*)

Eurasian beaver (*Castor fiber*)

The Eurasian beaver was once widespread in most of Europe and in many parts of Asia. The beaver is a semi-aquatic mammal (Latin: semi; English: half), i.e. partly lives in the water, partly on land. The beaver is perfectly adjusted to life at and in the water due to its thick fur (up to 23.000 hairs per cm² cf. human ca. 600 hairs per cm²) as well as diverse anatomical characteristics, e.g. webs between its hind paws' toes. A special anatomical feature in comparison to

humans is the "thumb" of the beaver, which is not used (in contrast to a human's thumb) to grab something. This grasping function is carried out by the beaver's "little finger."

The beaver (like all rodents) has enlarged front teeth which are constantly growing. Beaver mating takes place underwater between December and April independent of temperature and ice conditions. After a gestation period of 105-107 days, two to three and rarely also up to six babies, are born at the end of April or beginning of May. Eurasian beavers dig their burrows in the riverbank of a lake or river providing conditions are suitable, i.e. sufficient water depth of at least 50 cm, since the entrances are always underwater. In case the water level is too low, beavers create dams.

Eurasian water shrew (*Neomys fodiens*)

The top of the Eurasian water shrew's back is glossy black. They are well-adjusted to life in water. Their fur is long and dense. The underside of their tail has a prominent keel of elongated stiff hairs acting as a "rudder" and their hind feet also have stiff hairs which serve as a swimming aid. The Eurasian water shrew is one of the few venomous mammals in Central Europe. The venom in the saliva, produced by glands below the tongue, is lethal to small animals of a maximum size of mice. Eurasian water shrews are very good swimmers and divers. They forage almost exclusively underwater, efficiently preying on aquatic insects and their larvae, small crustaceans, snails and also small vertebrates such as fish and frogs. They dig extensive burrow systems and may take over burrows of other small mammals, usually with an entrance facing the water.



fig.29: Eurasian water shrew (*Neomys fodiens*)

Muskrat (*Ondatra zibethicus*)

The muskrat is a rodent species, originally native to North America. In Europe the muskrats were first introduced to Bohemia and later on to France and can nowadays be found in large parts of Europe and Asia, having successfully established themselves as a species into a new territory (Neozoa). Although often referred to as "rats", they are, in fact, overgrown semi-aquatic voles. Muskrats are perfectly adapted to life in water. The muskrats' ears can be closed off to keep water out and are almost invisible underneath the fur. The muskrats are skilful swimmers and divers and have a dense and water repellent fur, so that they can stay in water for longer. They are excellent swimmers and can remain under water for up to ten minutes. Muskrats mainly feed on aquatic and riparian plants.



fig.30: Muskrat (*Ondatra zibethicus*)



2.2 Water birds

The family of water birds is not a single taxonomic group. The designation “water birds” is rather a generic term for birds specifically adapted to life at and in water, one of the main criteria being the existence of webbing or partial webbing between their toes.

Swans and dabbling ducks are not divers, since their bodies have too much buoyancy. They generally feed on the surface of the water or from very shallow bottoms by upending on the water surface. While they search for food under water, their bottom stays above water.

fig.31: Mute swan (*Cygnus olor*)

In contrast to most birds whose bones are hollow in order to reduce their weight, this is not the case with diving ducks. As a consequence of the reduced buoyancy of the body, they can dive easily, some of them even as deep as 7 m.

Many water birds have a special system in order to prevent their unfeathered feet to lose too much warmth (see Peculiarities).

The feathers of water birds are in constant contact with water. In order for them to fly, however, they have to stay dry. Water birds constantly grease their feathers with the secretion of a special gland, the so-called preen gland (*Glandula uropygialis*), so that their feathers stay water repellent and they can fly off even after a dive.

Great crested grebe (*Podiceps cristatus*)

Great crested grebes breed in vegetated areas of freshwater lakes or in reed banks of larger ponds. They are especially famous for their elaborate mating display, which takes place in open water and is therefore easy to observe. These courtship rituals include heavy shaking of the head with splayed bonnet and the so-called penguin pose: the birds, facing each other, rise upright, almost vertically out of the water by rapid paddling of their feet. They often swim in the middle of lakes and regularly perform 5 to 20 metre dives to the bottom of the lake, which can last for up to one minute. Male and female great crested grebes are alike in appearance. They are a very vocal species, uttering often and loudly, eerie “keck keck” sounding vocalisations. They take off out of the water after a short run. Great crested grebes primarily eat small fish which they typically hunt under water, although also tadpoles, frogs, crustaceans, spiders and aquatic insects are part of their diet.

Great cormorant (*Phalacrocorax carbo*)

In the breeding season, cormorants have a dark plumage overall with a greenish or bluish shine to it. Their heads and necks develop a crest of short, 4 cm long, protruding white feathers. Males and females do not differ with regards to their colouration. Great cormorants almost exclusively eat fish which they pursue under water while diving. Dives are commonly initiated by a short jump. Cormorants have no preen gland and therefore cannot distribute oil onto their



fig.32: Great cormorant (*Phalacrocorax carbo*) while drying its feathers.

feathers like most water birds. They are excellent divers, with absorbent feathers and low buoyancy. Because their feathers are absorbent, great cormorants have to dry them before flying off. They propel themselves underwater with their feet, catching fish with their hooked beaks.



fig.33: Eurasian coot (*Fulica atra*)

Eurasian coot (*Fulica atra*)

The Eurasian coot is largely black-feathered except for the white facial shield on its forehead. It has a white beak and red eyes.

These diurnal birds are good swimmers and divers. The coot has partial webbing on its long strong toes of its green (sometimes yellow or grey) feet. Their short dives, usually less than two metres, are initiated by a little characteristic jump. Coots are omnivores and will eat a variety of small live prey including small molluscs like zebra mussels and snails as well as insects and their larvae and even small fish. Their principal diet consists of fresh, as well as rotting, plants and seeds. They also eat grain put out to attract ducks.

Mallard or wild duck (*Anas platyrhynchos*)

The mallard, or wild duck, is the largest and most widespread dabbling duck in Europe and the ancestor of almost all of the varieties of domestic ducks. The mallard inhabits most wetlands, including parks, small ponds and rivers. It is omnivorous and very flexible in its food choice, given it is easy to catch and can be digested. Mallards are excellent flyers and can reach a speed of up to 110 kilometres per hour.

During breeding season males (drakes) are unmistakable for their bright green head with white “torc”, their yellowish-green bill, their iridescent blue, white-rimmed ribbon (the so-called “speculum”) on the wings and curled black feathers on the tail (“drake locks”). Between July and August the drake wears its non-breeding plumage, looking more like the female, but is still distinguishable by its yellow bill. The preen gland located near the base of the tail supplies the oil. The bird will typically transfer the oil to its feathers by rubbing its head against the oil and then around the rest of the body. The mallard is carried on the water by an “air cushion”. Air is kept inside the mallard’s down and the covering feathers. In conjunction with the fat pad under the skin, this enclosed air layer prevents the mallard from cooling down. Wild mallards can reach an age of 10 to 15 years old, while domesticated birds may even live longer (40 years).

Mute swan (*Cygnus olor*)

As semi-domesticated birds, the mute swan inhabits many areas of Central Europe. It is both the largest water bird native to Central Europe and one of the heaviest flying birds in the world.

Mute swans have an extremely long lifespan, reaching ages of 16 to 20 years old. They moult once a year, becoming flightless for some time (six to eight weeks). The diet of mute swans consists of aquatic vegetation and small aquatic animals and insects (mussels, snails, water lice, etc.). They do not dive, however, but plunge their head and long neck below the water's surface.

Mute swans mate for life. Male swans are very aggressive, especially during the breeding season which starts in March. They defend their territory and may even attack people who approach their nests too closely. They usually hiss at predators trying to enter their territory.



fig.34: Mallards (*Anas platyrhynchos*) on the ice.

Peculiarities


The cold feet of water birds:

Water birds' feet very often come into contact with the cold, either in spring or autumn while swimming in the cold water or in winter while walking on the ice. Many water birds, however, do not get cold feet – they already have them. A counter flow mechanism prevents birds' feet from over-cooling, keeping the warm arterial blood from entering the feet. Thus, only

the very cold blood flows through the birds' feet. When re-entering the body, the venous blood is heated by the warmth of the arterial blood, which is cooled down simultaneously. Not only water birds, but also gulls, penguins, polar bears and many other animals take advantage of this very effective system.

3 The Shore Zone / Riparian Zone

Glossary

<i>Bastard, Hybrid:</i>	offspring resulting from the interbreeding between two different species or subspecies.	
<i>Cold-blooded:</i>	animals whose body temperature is not constant, but changes according to the temperature of their surroundings (fish, amphibians, reptiles, insects).	
<i>Evolution:</i>	the adaptation of plants and animals to their surroundings over the course of millions of years.	
<i>Invertebrate trachea:</i>	the tracheal system of insects, spiders, scorpions, etc., which consists of air-filled tubes branching all over the body and penetrating between cells	
<i>Metamorphosis:</i>	the transformation from an immature, larval stage to an adult stage.	
<i>Warm-blooded:</i>	animals which can regulate their body temperature (birds, mammals), which involves a lot of energy.	

Worksheets and Material:

Amphibian (Org_02)

Water bug, water beetle (Org_03)

Dragonfly (Org_04)

magnetic foil: common newt, water frogs, back swimmer, great silver water beetle, dragonfly larva, dragonfly, grass snake;



Questions:

- What group of animals live in the riparian zone?
- What does their anatomy look like?

With the help of magnetic foils groups of animals will be discussed separately on the blackboard. Respective worksheets aid retention of the acquired information.





fig.35: Water lilies (*Nymphaea alba*)



in the riparian zone are concerned. An edible frog (*Rana esculenta*), for example, can be found sitting on the swimming leaves of a water lily (*Nymphaea alba*). When someone tries to catch it, it escapes into the thicket of the pond weed zone. Larvae of the dragonfly sit and hunt in the shore as well as the pond shore zone and many water beetles are distributed all over the riparian zone.

Explanation

The riparian zone is a densely populated ecosystem in the lake. Animals appreciate the well-structured habitat for the manifold hiding places and excellent food supply which it offers. It comes as no surprise, then, that all animal species from worm to mammals can be found here.

Vegetation in the riparian zone shows wide transitional areas and cannot be divided into zones.

There is also no “zoning” as far as the animals living

3.1 Reptiles

Reptiles developed from amphibians during evolution. Like amphibians, they predominantly have four legs and a tail. Their body temperature depends on the temperature of the surrounding area, i.e. they are cold-blooded animals. Most reptiles lay eggs whose shells, however, are solid and therefore completely independent from water. Young reptiles hatch without a previous larval stage of development. They strongly



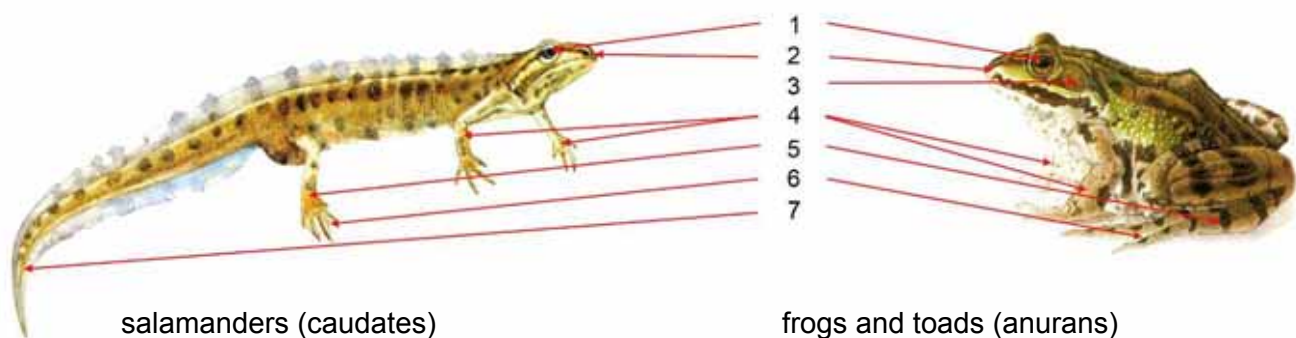
fig.36: Grass snake (*Natrix natrix*)

resemble the adult animals, apart from their size. The classification book only has one reptile, the grass snake (*Natrix natrix*). The grass snake belongs to the snakes, a group of reptiles whose feet have been reduced almost entirely. Their primary diet consists of amphibians, but they also eat small mammals, fish and birds.

3.2 Amphibians

Amphibians form the link between fish and terrestrial vertebrates and were the first group of vertebrates to leave water and walk on land. The strong connection to water, however, is still obvious in amphibians today. For the purpose of reproduction, most amphibians require water or a humid environment to lay their eggs, which lack a solid shell. The skin of the amphibians is very thin and not very horny. Most amphibians have to rely on their skin for respiration. Amphibians are cold-blooded animals, cannot regulate their body temperature and therefore have to rely on external sources of heat from their habitat.

Anatomy



1	eye	3	vocal sac	5	hind legs	7	tail
2	nose	4	front legs	6	webbed toes		

fig.37: Anatomy of caudates and anurans

On the basis of their external appearance, amphibians can be divided into two groups. Salamanders (caudates, Caudata) are typically characterised by their long tails which can either be rounded or flattened at the sides and also often have epithelial rims. The caudates' body is elongated and hind limbs and fore limbs tend to be of approximately equal size. When on land salamanders do not jump but run.

The second species of amphibians are frogs and toads (anurans, Anura). Adult frogs do not have tails, since the tails of their larvae degenerate during the metamorphosis into land animals. Their hind legs are considerably longer than their front legs. On land they either run or jump.

Diet

All adult amphibians, as well as the larvae of salamanders, are carnivorous and feed on live animals which are swallowed whole. In contrast, the larvae of frogs and toads are typically herbivorous, feeding primarily on organic particles.

Reproduction and development

Once adult amphibians reach maturity they will assemble at a water source to breed. Many frogs have one or two vocal sacs. The call, unique to the species, is created in the larynx. The vocal sac acts as a resonance chamber to intensify the call. The frogs' mating posture is called amplexus. Here the male frog mounts the female and grips her tightly. Fertilisation is external: The female releases her eggs, which the male frog covers with a sperm solution. The frogs' larvae are called tadpoles, which typically have oval bodies and long, vertically flattened tails. The hind extremities are visible long before the front legs. Only two to three days after hatching they develop a gill pouch that covers the gills.

There is no amplexus with salamanders. The fertilisation takes place internally. Only after the fertilisation takes place, the eggs are deposited into the water or in a moist environment by the female. Front extremities are visible first; gills can be seen during the whole larval stage.

Common types of amphibians in the riparian zone:

Caudates / Salamanders

All salamanders have a tail and their extremities tend to be of approximately equal size. They have no vocal sacs. In their larvae, front extremities are visible first. Gills can be seen clearly.

Common/Smooth Newt (*Triturus vulgaris*)

During the breeding season, the male newt is far darker than the female, with a jagged or wavy crest along the spine and tail. The stomach area is orange to yellow with dark blotches and spots. Their hind feet toes are webbed. The Common newt is very common in Middle Europe.



fig.38: Larvae of the common newt (*Triturus vulgaris*)

Alpine Newt (*Triturus alpestris*)

During the mating season the male wears a shallow crest. The stomach area is orange, without spots. This species can be found in mountains as high as 3000 metres.

Crested newt (*Triturus cristatus* spp.)

Males can be distinguished from females during the breeding season by the presence of a jagged crest running from the head along the back. Their undersides are either yellow or orange-coloured and often covered in large black blotches.

Anurans / Frogs and toads:

Frogs and toads have no tail, except during their larval stage. Their hind legs are always longer than their front legs. Their skin is penetrated by mucous glands and can have warts and skin folds. Many frogs have voice sacs.



fig.39: Edible frog (*Rana esculenta*) with voice sacs

Water frogs

Water frogs are a group belonging to the species of true frogs (Ranidae). They are closely bound to an aquatic habitat and often show a green colouring. The most common types of water frogs in Central Europe are: pool frog (*Rana lessonae*), marsh frog (*Rana ridibunda*) and edible frog (*Rana esculenta*), a crossbreed of the two other types. These types of frogs are hard to distinguish and are very often confused with one another

Peculiarities

Liberation cry of the male

During the mating season, before spawning, the (smaller) male mounts the female and grips her tightly. In the heat of the moment it can happen that a male clasps another male, which utters a “liberation cry” - a characteristic quacking of the false female - to signal to the other that he got something wrong.

3.3 Insects

Glossary:



Complete metamorphosis (holometabolism): the larvae are totally different from the adult animals. Insects undergo considerable change in form during the pupal stage and emerge from the pupa as adults (beetles, butterflies).

Compound eye: sensory organ consisting of hundreds or thousands of tiny optical units.

Exuvia: the remains of the skin from which an adult animal has moulted.

Imago: the final and fully developed stage of an insect after all metamorphoses.

Incomplete metamorphosis (hemimetabolism): after moulting from the egg, juvenile forms already closely resemble adults. There is no pupal stage (dragonflies, bugs).

At least 80 percent of all known animal species belong to the class of insects. They are strongly adapted to their habitat, which is why the physique of insects varies considerably.

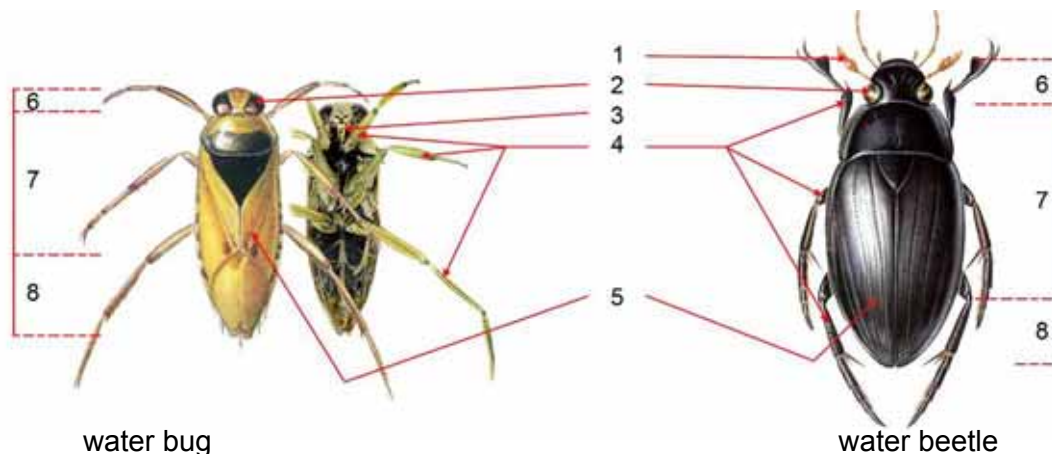
Many species of insects living at or in the water only spend their larval stage in the water such as dragonflies, caddis flies and midges. Other species, on the other hand, such as the water scavenger beetle and water bugs, spend their whole life in the water.

Water bugs and water scavenger beetles

Anatomy

Water bugs: Generally, bugs can be distinguished by the sucker on the bottom of the body. It is connected to the head and is coiled under the body when not in use. The forewings are only partially hardened and the hind wings are membranous.

Water scavenger beetles: These aquatic insects have, like nearly all insects, a hard outer covering made of chitin, the exoskeleton, and a three-part body divided into head, thorax and abdomen. The first pair of wings of the water scavenger beetle (elytrum) is hardened and only serves as protection for the second, membranous pair of wings.



1	antenna	5	elytrum covering the hind wings
2	compound eye	6	head
3	sucker	7	thorax
4	3 pair of legs	8	abdomen

fig.40: Anatomy of water bug and water beetle

Respiration

Since insects have no lungs, insect respiration is accomplished through a tracheal system which consists of air-filled tubes branching all over the body and penetrating between cells. Water insects are equipped with a variety of adaptations that allow them to carry a supply of oxygen under water or to get it directly from their environment. Many water beetles carry a bubble of air with them whenever they dive beneath the water surface. The bubble usually covers one or more spiracles so the insect can breathe air from the bubble while submerged (see Peculiarities). Many insect larvae living in the water have converted to gills. Other insects make use of a breathing tube which is located at the end of the abdomen.

Reproduction and development

Water bugs: Bugs are insects that show an incomplete metamorphosis. The insect changes gradually by undergoing a series of molts. The larva emerges from the egg, closely resembling the adult bug. With each molt the insect grows larger and becomes more similar in appearance to the adult. There is no pupal stage. After the last molt the adult emerges. While some insects spend their whole life in the water (backswimmer, *Notonecta* sp.), some only stay there as larvae (water striders, *Gerris* sp.).

Water scavenger beetle: Beetles undergo complete metamorphosis. In this group of insects the egg hatches to produce a larva which does not resemble the adult animal. After several moltings the larva grows and eventually becomes a pupa. The pupation always takes place on land. Finally, the larva emerges from the puparium as an adult beetle (imago).

With insects constantly living in water, the whole process of metamorphosis takes place in the water.

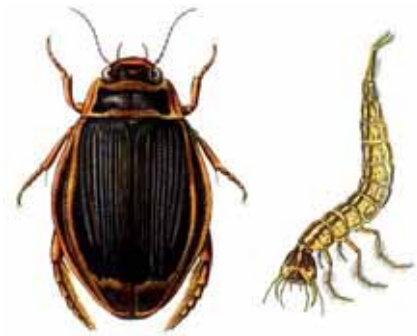


fig.41: Imago and larva of the Great Diving Beetle

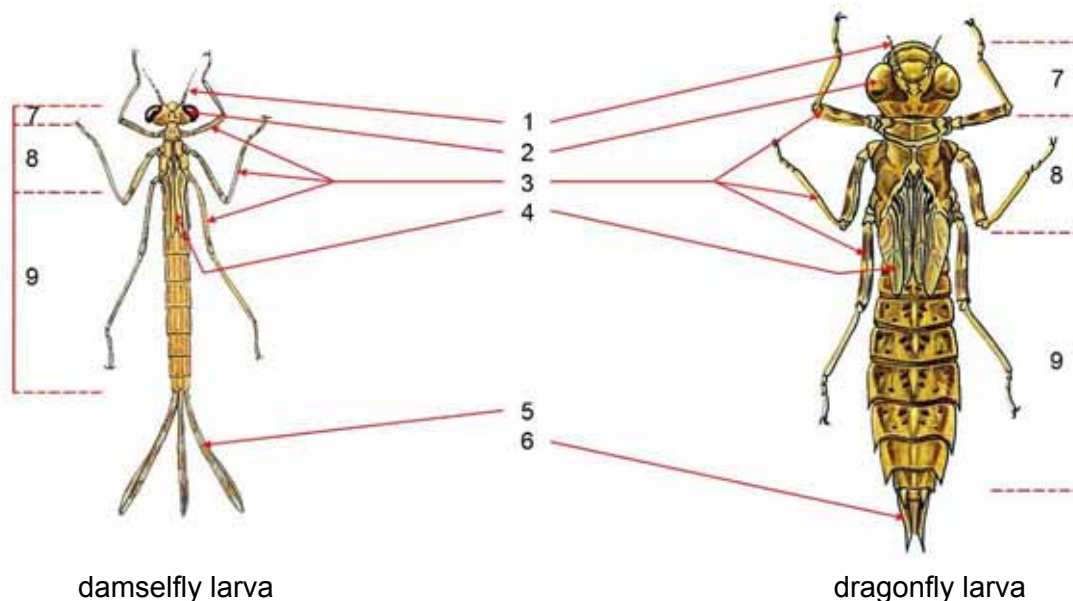
Dragonflies and Damselflies

Dragonflies and damselflies spend the major part of their life, an average of approximately one year, as a larva in the water. The adult dragonflies only have a short life span (not more than 14 days and a maximum of 6-8 weeks).

Anatomy

As with all insects, their bodies are made of three basic parts: head, thorax and abdomen. They have very large eyes and very good vision.

The dragonflies and damselflies have an elongated body with very slender abdomen which is somewhat thicker in dragonflies and sometimes even appears triangular when seen from the side. The damselflies' larvae have three characteristic leaf-like appendages or gills on their tail. These appendages are used for oxygen transport as well as a means of propulsion. In contrast, the larvae of the dragonflies have 5 short, spike-like appendages - the so-called tail pyramid.



1	antenna	6	tail pyramid
2	compound eye	7	head
3	3 pair of legs	8	thorax
4	wing pads	9	abdomen
5	gill lamellas		

fig.42: Anatomy of dragon- and damselfly larvae



fig.43: Moulting dragonfly

Reproduction and development

While mating, male and female fly in tandem in a wheel-like configuration (see Peculiarities). After 3-4 weeks the eggs hatch into larvae. Dragonflies show an incomplete metamorphosis, i.e. the larvae strongly resemble the adult insects. When the larva is ready to metamorphose into an adult, it climbs up a reed or other emergent plant to get out of the water. The skin splits at the back and the adult dragonfly crawls out of its old larval skin, flaps its wings, and flies off. What remains is the empty skin of the larva (Exuvia).

Respiration

Dragonfly as well as damselfly larvae breathe through gills in their rectum.

Diet

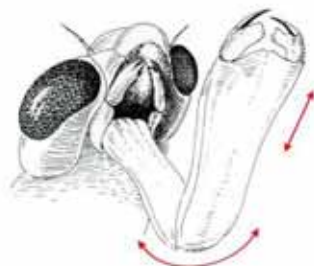


fig.44: Mask of the dragonfly larva

Most larvae, as well as adults are predators. While adults catch their prey in flight, the larvae hunt under water. Their lower lip is modified into a long, hinged jaw terminating in two sharp, hook-like mandibles. This is known as the “mask”. When a prey is in sight, the mask is thrust forward and the prey is instantly impaled on the hooks. They catch and consume anything which is smaller or of the same size.



fig.45: Mating wheel of dragonflies

Peculiarities

The mating wheel of dragonflies and damselflies:

The mating habits of dragonflies are unusual. The male flies above the female and lands on her back. Then, grasping the female behind the head with a pair of forceps-like structures at the end of his abdomen, he flies with her in tandem. The female curls her abdomen down and forward in order to receive the sperm. Most dragonflies start copulation in flight. Some may continue in flight and some may settle.

Jet propulsion of dragonfly larvae:

In order to breathe, dragonfly and damselfly larvae have to suck water into their rectum through the anus. The rectum is furnished with “rectal gills“. Dragonfly larvae use this mechanism to rapidly propel themselves forward by suddenly expelling water through the anus. The larva expands and contracts its abdomen to move water over the gills and can squeeze the water out rapidly for a short burst of underwater jet propulsion.

Respiration through physical gills:

While many larvae of water insects converted from air breathing (tracheal breathing) to gill breathing (tracheal gills) in the course of evolution, water beetles, some water bugs as well as the water spider (*Agryroneta aquatica*) still breathe through trachea. In order to breathe underwater they have to carry air with them in a bubble. The insects can breathe air from the bubble while submerged. This is called “physical gill“. As soon as there is no oxygen left in the bubble or when the nitrogen concentration is too high, the insects have to get to the water surface to renew the air bubble.

4 The Open Water / Pelagic Zone

Glossary:



- Autotrophic:** nutrition from inorganic sources. This refers mainly to organisms which carry out photosynthesis.
- Clone:** an organism created through binary fission, sharing the identical genetic information with the mother organism.
- Colony:** a group of several individual organisms of the same species living closely together.
- Eutely:** organisms with a genetically fixed number of cells. Binary fission is not possible, i.e. in case of injury, cells cannot be reproduced.
- Flagellum:** a tail-like projection that protrudes from the cell body of certain cells and functions in propulsion.
- Food web:** generic term for relations between predator and prey in an ecosystem.
- Heterotrophic:** nutrition from organic material (living organisms or fragments of living organisms).
- Nekton:** actively swimming aquatic organisms in the pelagic zone, able to move independently of water currents.
- Parthenogenesis:** is a form of asexual reproduction where descendants develop from an unfertilised egg cell and have exactly the same genetic code as the mother organism.
- Photosynthesis:** the process by which sugar is generated from water and carbon dioxide using the energy of the sun (see also page 1124).
- Plankton:** drifting organisms that inhabit the pelagic zone dependant on water currents.
- Vacuole:** structures in a cell which are enclosed by a membrane.

Worksheets and material:

Waterfleas (Org_05)

The water flea (Org_06)

Copepods (Org_07)

Life in open water (Org_08)

Labyrinth (Org_09)

mobile – open water (hc_01, hc_02)

**Questions:**

- What is Phytoplankton?
- What is Zooplankton?
- What do organisms of the zooplankton look like?

magnetic foil: bacteria, algae, rotifera, waterflea, bosmina, cyclops, eudiaptomus, copepod larvae;

With the help of magnetic foils groups of animals will be discussed separately on the blackboard. Respective worksheets aid retention of the acquired information.

**Explanation:**

Life in the pelagic zone, i.e. in open water which is not in contact with the bottom or near to the shore, is very diverse. It includes unicellular organisms like bacteria, as well as phytoplankton and zooplankton (as a food source) and even large predatory fish.

***The most important groups of organisms in stagnant waters***

bacteria	bacterioplankton
algae	phytoplankton
unicellular organisms, rotifers, small crustaceans, etc.	zooplankton
fish	nekton

Zooplanktonic organisms, but also some algae and bacteria are able to move by themselves. Their small size, however, makes them dependant on water currents (primarily created by wind) in stagnant waters. Only fish, the so-called nekton can move independently and actively change direction.

Sinking

The major problem the plankton (phytoplanktonic as well as zooplanktonic organisms) has to face is gravity. Plankton which are heavier than water tend to sink, since gravity is stronger than their buoyancy. Algae obtain energy through the process of photosynthesis and must therefore live in a specific layer of the water where water temperature, solar radiation and nutrient supply are ideally balanced. When they sink below this layer, sunlight becomes a limiting factor preventing them from carrying out photosynthesis. Consequently, they die.

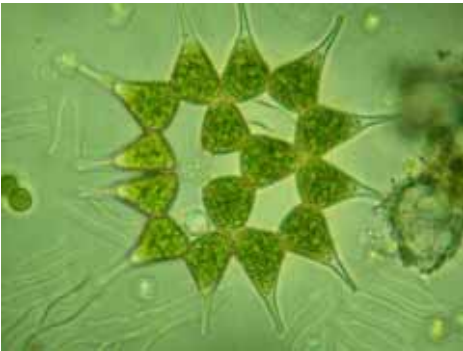


fig. 46: *Pediastrum simplex*

In the course of evolution, plankton developed a variety of mechanisms to minimise sinking. A very common strategy in algae is the forming of cell aggregates, so-called colonies. The larger surface area of these cell aggregates creates a “parachute effect,” which decreases the speed of sinking. Some phytoplankton avoid sinking by decreasing their density

through the creation of a gelatinous envelope. Other algae (e.g. *Plankthorix rubescens*, “Burgundy blood algae”) can stay in their favoured water layer with the help of gas vacuoles in the cell. Algae and bacteria with a flagellum can regulate their buoyancy and counter sinking by their own body movement. Zooplanktonic organisms, too, are known to form a gelatinous envelope. The *Chaoborus* sp. (“Phantom midge larva”) has two pairs of swim bladders in order to stay in exactly the right water layer.

4.1 Bacteria

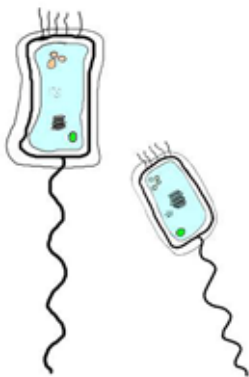


fig. 47: bacteria

Bacteria are characterised by their lack of a true cell nucleus. Genetic information (DNA) can be found in the whole cell. They multiply through binary fission, whereby a genetically identical clone of the mother cell is created. Bacteria living in the lake are called Bacterioplankton. With a size from 0.2 to 2 μm , that is 0.0002 – 0.002 mm, they are the smallest organisms in the water

4.2 Phytoplankton – Algae


The term Phytoplankton encompasses all unicellular aquatic plants in fresh or salt water which carry out photosynthesis either singularly or in colonies. Phytoplankton form the base of the aquatic food web in stagnant waters.



The most important groups are:

Green Algae

The green algae are a large group of algae in various forms. They include unicellular organisms with or without flagellum as well as several colonial organisms whose forms are either spherical or filamentous. Green algae have the same plant pigments as higher plants. This and other similarities led to the assumption that higher plants evolved from the green algae.



Profile:

Name: Green algae

Scientific name: Chlorophyceae

Size: colonies can reach a size of 2 mm.

Habitat: predominantly in fresh water, but also in the sea, as well as on land (soil, wood, ...)



fig. 48: Different kinds of green algae (Chlorophyceae)

Diatoms

A characteristic feature of this group of algae is the two-part shell consisting of silicic acid. Diatom cell walls comprise two separate valves (or shells), which typically overlap one over the other (similar to a cardboard box), thereby creating a smaller and a

larger shell half. Reproduction among these organisms is primarily asexual through binary fission. The two halves of a shell are divided and the missing half is created anew. The newly built shell half is the smaller one. This form of division results in a size reduction of the offspring from mother cell to daughter cell and therefore the average cell size of a diatom population decreases constantly. After reaching a certain cell size, however, and in order to restore the cell size of a diatom population sexual reproduction must occur, starting a whole new generation. Diatoms constitute a basic part of the food chain especially in cold waters.

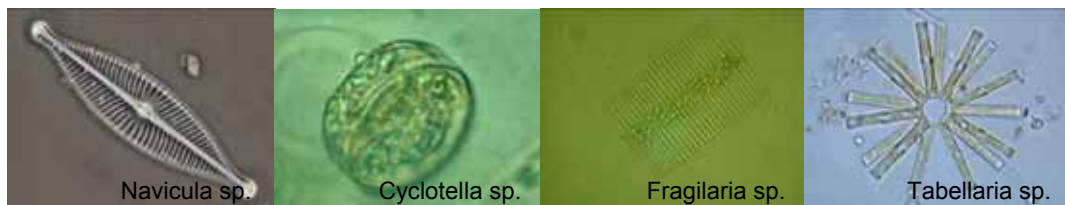


fig. 49: Different kinds of diatoms (Bacillariophyceae)

Golden algae

Many forms of golden algae have 1-2 flagellants which enable them to move independently. Most species are very small. Many live in shells or have scales and spikes. Some members of golden algae form colonies (spherical or branched).



fig. 50: Different kinds of golden algae (Chrysophyceae)

Blue-green algae

Blue-green algae are no real algae. They do not have a cell nucleus and therefore belong to the family of bacteria. They are one of the oldest life forms. Cyanobacteria colonies may form filaments or hollow balls.



Profile:

Name: Blue-green algae

Scientific name: Cyanobacteria

Size: colonies of blue-green algae can reach a length of several centimetres


Habitat: marine and fresh water



fig. 51: Different kinds of blue-green algae (Cyanobacteria)

Dinoflagellates

Dinoflagellates [German name: "Panzeralgen" ('armour algae')] have a solid cell covering and two flagella, set into a transversal and a longitudinal furrow. The covering can be leathery or even a sort of armour. Some of the dinoflagellates are carnivorous.



Profile:

Name: Dinoflagellates

Scientific name: Dinoflagellata

Size: between 0.2 and 2 mm

Habitat: marine and fresh water

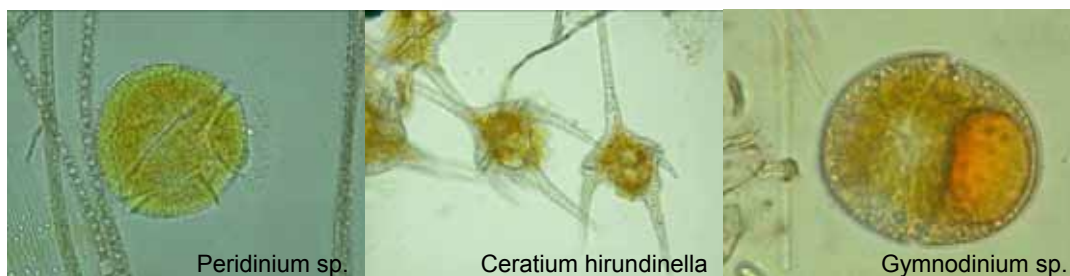


fig. 52: Different kinds of dinoflagellates (Dinoflagellata)

Cryptophyceae

Cryptophyceae [German name: “Schlundflagellaten” (‘gullet flagellates’)] are unicellular organisms with two flagella. They have a gullet coated with highly refractive granules. Some forms are carnivorous.



Profile:

Name: Cryptophyceae

Scientific name: Cryptophyceae

Size: between 0.01 and 0.1 mm

Habitat: marine and fresh water



fig. 53: Different kinds of cryptophyceae (Cryptophyceae)

Zooplankton

All planktonic organisms in the pelagic zone which do not carry out photosynthesis can be attributed to zooplankton, including some fish larvae and insect larvae.

Three groups are of primary importance for the food web:



fig. 54: *Stentor* sp.

their heterotrophic way of life are often considered animal-like. They live as single cells as well as in colonies of diverse sizes (from only a few cells to hundreds of cells of 2 – 200 µm).

Protozoans

Protozoans are unicellular organisms. In contrast to bacteria they have a cell nucleus. Protozoa populate fresh water and show a wide diversity of species. There is no exact definition for the term “protozoa” and no systematic classification as far as protozoans are concerned. The term rather encompasses a group of unicellular organisms which because of



Rotifers

Rotifers, excel by the abundant variety of forms. The common feature of all species of rotifers, however, is the circlet of cilia located around the mouth which gives the impression of rotating wheels. This rotary organ, in addition to being used for swimming, sweeps food particles into the mouth.

The food is then processed in the mastax of the rotifer.



Profile:

Name: Rotifers

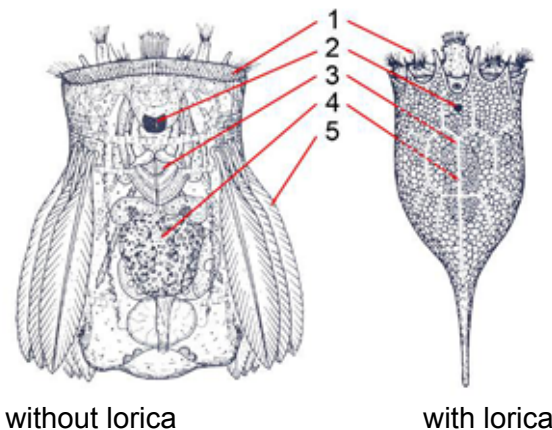
Scientific name: Rotatoria

Size: 0,3-1,5 mm

Habitat: trees, moss, soil, marine and fresh water

Diet: algae and organic particles

1	rotary organ
2	eye spot
3	mastax
4	reproductive organs
5	rudder bristles



Planktonic rotifers primarily reproduce by parthenogenesis. The female produces eggs with genetically identical material, which then again develop into females. Male rotifers are very rare and in many species absent altogether.

The wealth of forms of this species comprises wheel animals with thick and rigid coverings (lorica) as well as some with flexible, transparent cubicles. Typical forms which can often be found in planktonic water samples are:

Keratella quadrata*, *K. cochlearis [German name: "Facetten-Rädertier" ("facets rotifer")]

This wheel animal is characterized by a rigid lorica. It can reach a size of 0.3 mm and can be found in nearly all lakes as well as in ponds and pools.

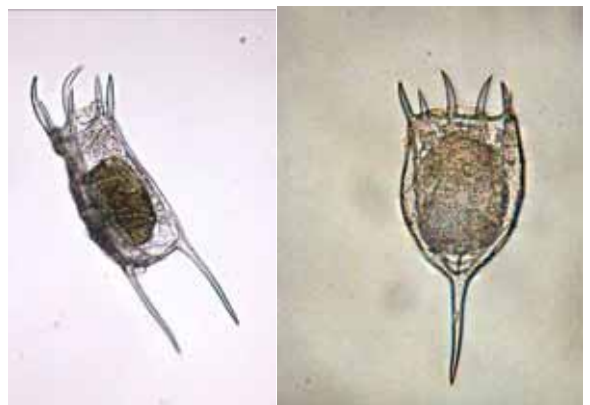


fig. 56: *Keratella* sp

***Asplanchna* sp.** [German name: "Sack-Rädertier" ("bag rotifer")]

With a maximum size of 2.5 mm this species is a relatively large rotifer. This unarmoured rotifer is omnivorous and inhabits almost all lakes, but can also be found in ponds and pools. Its powerful chewing claws can be projected forward to seize the prey. The undigested food is vomited.



fig. 57: *Asplanchna* sp.



fig.58: *Kellicottia* sp.

Kellicottia longispina [German name: “Einhorn-Rädertier“ (‘unicorn rotifer’)]

This rotifer has 4 to 6 elongated thorns and can reach a size of up to 0.8 mm. It is common in the pelagic zone.



fig. 59: *Polyarthra* sp.

***Polyarthra* sp.** [German name “Schwertborsten-Rädertier” (‘sword bristled rotifer’)]

Max. size: 0.46 mm; It has four bundles of 3 sword-shaped feet attached to its torso used for locomotion. With the spike located in its chewing apparatus the rotifer catches its prey.

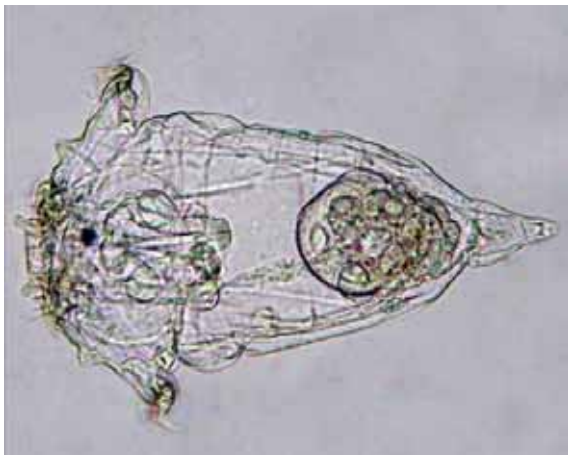


fig. 60: *Synchaeta* sp.

***Synchaeta* sp.** [German name: “Drachen-Rädertier” (‘dragon rotifer’)]

The *Synchaeta* is a conical-shaped rotifer with a maximum size of up to 0.5 mm. It can often be found in all stagnant waters. The rotary organ has two cilia-furnished outgrowths on the side (resembling ears).

Water fleas

Cladocerans, commonly called water fleas, inhabit the pelagic zone as well as the shore areas of lakes or slow-moving streams and rivers. Like the copepods they belong to the crustaceans. Their bodies are covered by a shell. They only have one eye, which is a compound eye. Sometimes cladocerans have an additional eye spot that can distinguish light from dark.

Profile:



Name: Water flea

Scientific name: Cladocera

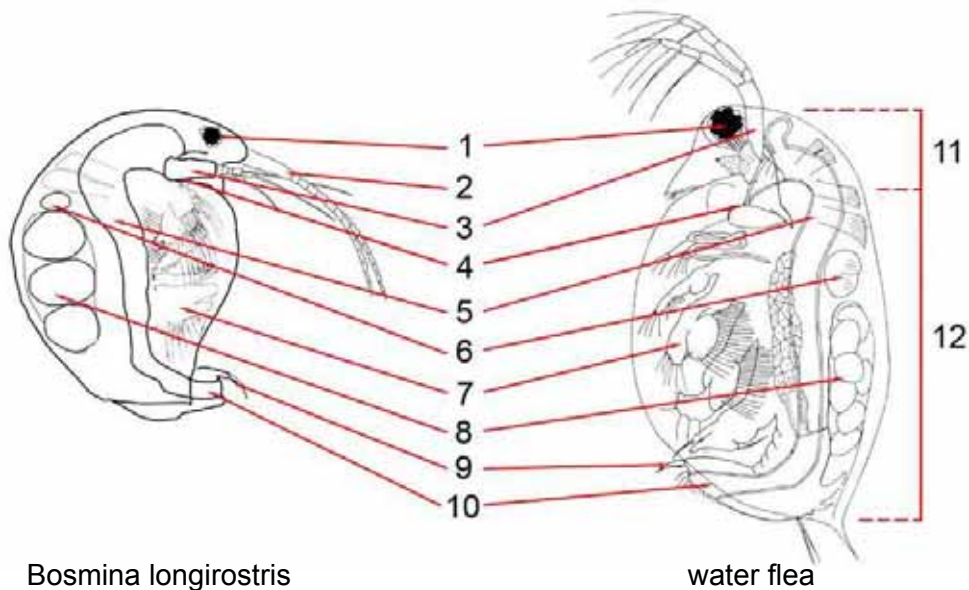
Size: 0.4 - 11 mm

Habitat: fresh water, some species in marine waters

Diet: algae, organic particles, water fleas



Anatomy



Bosmina longirostris

water flea

1	compound eye	7	legs
2	nuzzle	8	eggs in the brood pouch
3	antenna	9	claw
4	mouth	10	anus
5	intestine	11	head
6	heart	12	shell halves (enclosing the body)

fig.61: Anatomy of cladocerans

Diet

Most water fleas filter food particles out of the water by producing water currents with their legs. The legs are equipped with numerous feathery bristles which help them to filter food and carry it to their mouths. They also play a major part in breathing. The claw situated at the rear end of their body under the anus is used for cleaning their legs.

Reproduction and development

Cladoceran eggs develop in the female's brood pouch. There are two types of eggs, depending on environmental conditions: If conditions are favourable from spring to autumn the females create eggs with identical genetic code by parthenogenesis. These eggs have a single set of chromosomes, always developing into females. If conditions are unfavourable (drying up of the water body, decrease in water temperature, over-population) females produce eggs which result in male offspring. These males then fertilise the eggs. Fertilised eggs have a double set of chromosomes. They are termed winter eggs (latent eggs), since they are resistant to heat, desiccation and freezing. These eggs develop into females which moult in spring, and in turn continue the reproductive cycle by parthenogetic reproduction.

Only a small number of different species of cladocerans can be found in the pelagic zone, but with a high number of individuals. The littoral zone, in contrast, is populated by a greater diversity of species which can be found between aquatic plants and in the soil.

The following species are to be found in the pelagic zone of many Carinthian lakes:

Daphnia hyalina [German name: “Glas-Wasserfloh” (‘glass water flea’)]:

This large water flea can reach a size of 0.5 to 2 mm. The head is evenly rounded and never has a helmet.

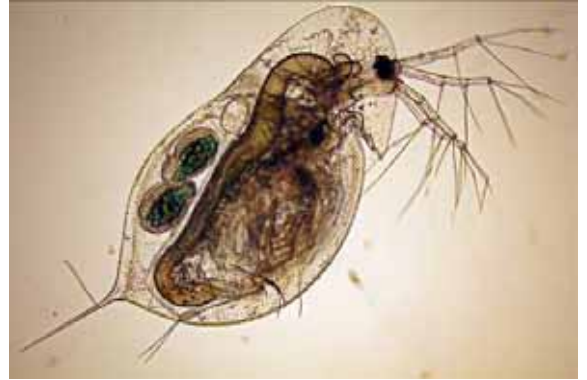


fig. 62: *Daphnia hyalina*

Daphnia cucullata [German name: “Helm-Wasserfloh” (‘helmet water flea’)]:

This species of water flea has a helmet, mostly during summer season (see Peculiarities). In contrast to the former species, its maximum size is only 0.4 to 1.3 mm.

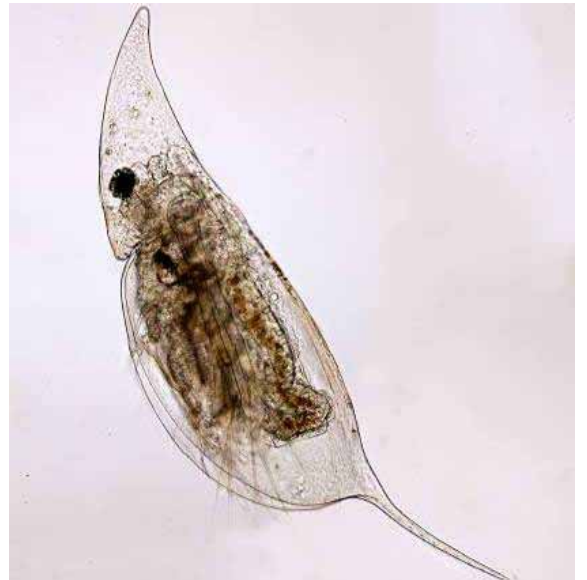


fig. 63: *Daphnia cucullata*

Bosmina coregoni [German name: “See-Rüsselkrebs” (‘lake trunk crab’)]:

This 0.2 to 0.8 mm long species is widespread in Carinthian lakes. *Bosmina coregoni* have a more or less strongly curved trunk and develop a big hump during summer.



fig. 64: *Bosmina coregoni*

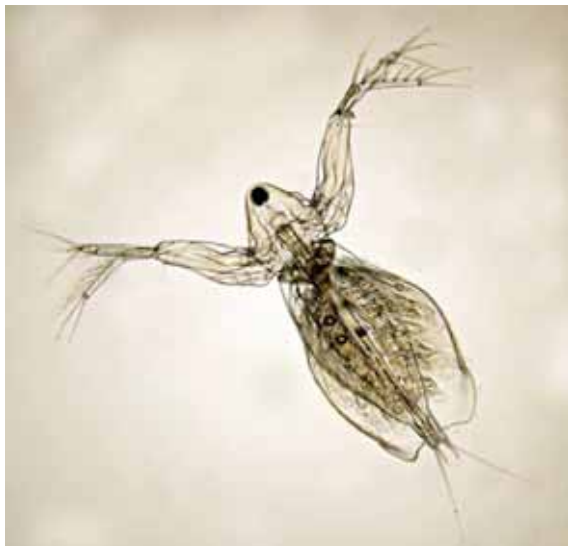


fig. 65: *Diaphanosoma brachyurum*

Diaphanosoma brachyurum [German name: “Spring-Wasserfloh” (‘jumping water flea’)]:

This thermophilic species of water flea is a typical example of summer plankton. The size of this species is between 0.4 and 1.5 mm.



fig. 66: *Leptodora kindti*

Leptodora kindti [German name: “Glaskrebs” (‘glass crab’)]:

With a size of 18 mm this animal is the largest small crustacean in our lakes. Nevertheless, it can be hardly seen with the naked eye because of its transparent body. It is a carnivore, feeding on other water fleas and larvae of copepods.



Copepods

The copepods form the second largest group of small crustaceans in stagnant waters. They inhabit the pelagic zone as well as the littoral zone.

Most species of the copepods can be found in the sea. Only about 125



Profile:

Name: Copepod

Scientific name: Copepoda

Size: 0.2 - 2 mm

Habitat: fresh water, marine

Diet: algae, organic particles, or carnivorous feeding on small crustaceans and their larvae

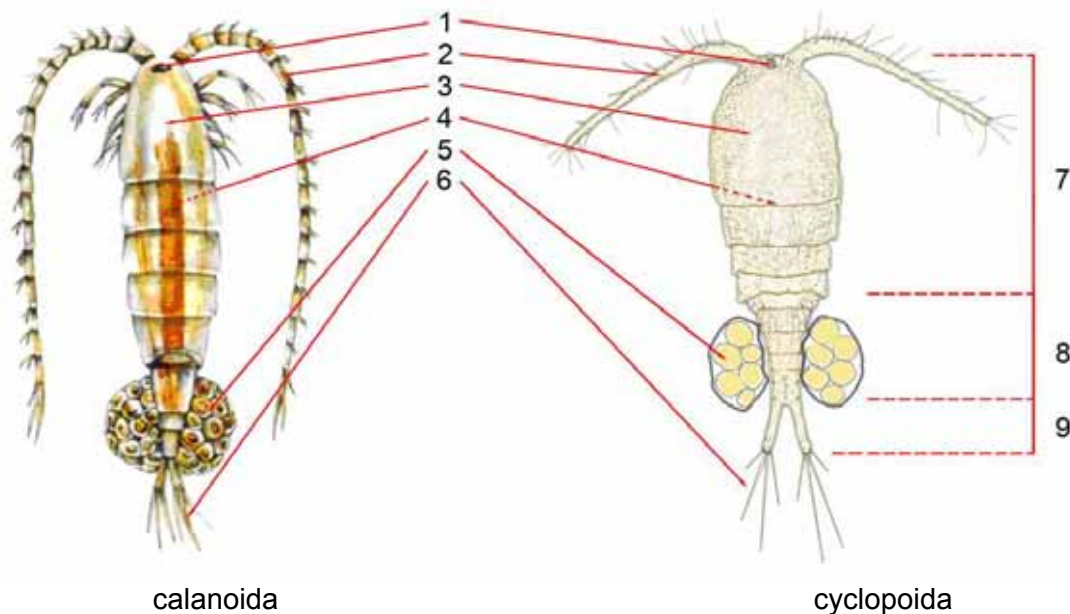
species live in fresh water. We will now discuss two major groups of copepods:

Calanoid Copepods: the antennae are very long, always longer than the thorax. The males' right pair of antennae is formed as prehensile antennae. Fertile females only have one egg sac attached to their body until they hatch.

Cyclopoid Copepoden: the antennae are always shorter than the thorax of the animal. Both pairs of antennae of a male are prehensile antennae. Females have two egg sacs.

Anatomy

The body is divided into head, thorax and abdomen. The head is fused with the thorax. This coalesced head and thorax is called Cephalothorax. At the end of the abdomen are fork-like appendages, the so-called furcal rami, which bear bristles that amongst other things are important to determine the species.



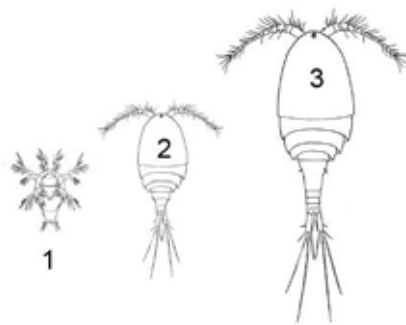
1	compound eye	4	legs (not visible)	7	cephalothorax
2	antenna	5	egg sac with eggs	8	abdomen
3	armour	6	tail bristles	9	furcal rami

fig.67: Anatomy of copepods

Diet

Calanoid copepods are primarily herbivores. With their feet they create water currents from which they grab food particles.

Cyclopoid copepods are mainly predators and even feed on smaller individuals of their own species.



1 nauplius larva 2 copepodid larva

3 adult

Reproduction and development

Copepod males and females reproduce sexually. During mating the male copepod uses his prehensile antennae to grip the female. Fertile eggs are enclosed in one or two egg sac(s) attached to the female's body until they hatch. The eggs hatch into nauplius larvae. The nauplius then moults

five times, before emerging in its second larva form, the copepodid. While the nauplius is totally different in

appearance from the adult, the copepodid already strongly resembles the adult. After a further five moults the adult copepod emerges.

Important copepods in our lakes:



fig. 69: *Eudiaptomus gracilis*, female

Eudiaptomus gracilis [German name: "Farbloser Schwebekrebs" ('colourless floating crab')]:

is common in ponds as well as in large and small lakes. This colourless calanoid copepod feeds on algae and plant particles. This species is very common. The egg sac attached to the female's body is clearly visible in the picture. .

Cyclops abyssorum [German name: “Gemeiner Hüpferling” (‘common copepod’)]:

This very large cyclops is free swimming or lives at the bottom of the lake. It is a predator feeding on other cyclopes and their larvae. Sometimes the *cyclops abyssorum* even eats the progeny of its own species. The picture shows a male cyclops with its two prehensile antennae.



fig. 70: *Cyclops abyssorum*, male

Peculiarities

Cell constancy / eutely of rotifers

Rotifers have a genetically fixed number of cells (eutely) and only grow by expansion of cells. While the damaged tissue of other organisms can be rebuilt, the regenerative ability of animals exhibiting cell constancy is severely limited and even small injuries can be fatal.

Clear-water phase

In spring the amount of algal biomass rises due to circulation and heating of the water, providing ideal living conditions for phytoplankton: plenty of nutrients and sufficient sunlight for photosynthesis. The enormous amount of algae cells in the water causes a strong dispersion of sunlight and, as a consequence, a rapid reduction of visibility and water transparency.

The rise in algal biomass also entails the increase of zooplanktonic organisms, especially of cladocerans which feed on algae. Consequently, the predation pressure on algae increases and only lessens when the concentration of nutrients in the water decreases again. Due to the dropping rate of phytoplankton, zooplanktonic organisms can decimate the algal biomass within a few days which results in an increasing water transparency. During this phase, the so-called “clear-water phase”, the water appears to be crystal clear.

Cyclical metamorphosis of Cladocerans

This term designates a procedure of growth of a helmet and a hump by some species of the cladocerans. A typical species is *Daphnia cucullata*. The animal show a pronounced helmet in the summer, while those of spring and winter have a round head. If no predators are present in the lake the transformation is pronounced much smaller. One assumes therefore that „the enlargement “of the body is to make this organism harder eatable for predators (fish and the larva of the midge, *Chaoborus* sp.).

5 Fish and Crustaceans

Glossary

Ecological niche: all organisms developed in the course of evolution specific abilities, which are completely adapted on their direct environment. The camel is adapted to large drynesses and can store water very well. The squirrel is adapted to a life at the tree and runs up and down here, like the hare on the meadow. The habitat with its specific characteristics and the organism with its specific abilities, living therein, is called the ecological niche.



Epithelium: skin

Worksheets and material:

Fish (Org_10)

Crayfish (Org_11)

magnetic foil: pike, rudd, carp, lavaret, arctic char, perch, lake trout, crayfish;



Questions:

- What's about the anatomy of fish and crayfish?

With the help of magnetic foils groups of animals will be discussed separately on the blackboard. Respective worksheets aid retention of the acquired information.



Explanation:

5.1 Fish

Like all other animals, the various species of fish inhabit their own ecological niches. They have adapted to their ecological environment. The whitefish (*Coregonus lavaretus*), for example, only lives in open water, while the pike (*Esox lucius*) rarely leaves the shore area. The favoured habitat of fish strongly depends on diet and reproduction. As a result, a general allocation of fish to a single ecological habitat (littoral zone, pelagic zone) is not possible. Fish, therefore, have been summarised into a separate group.

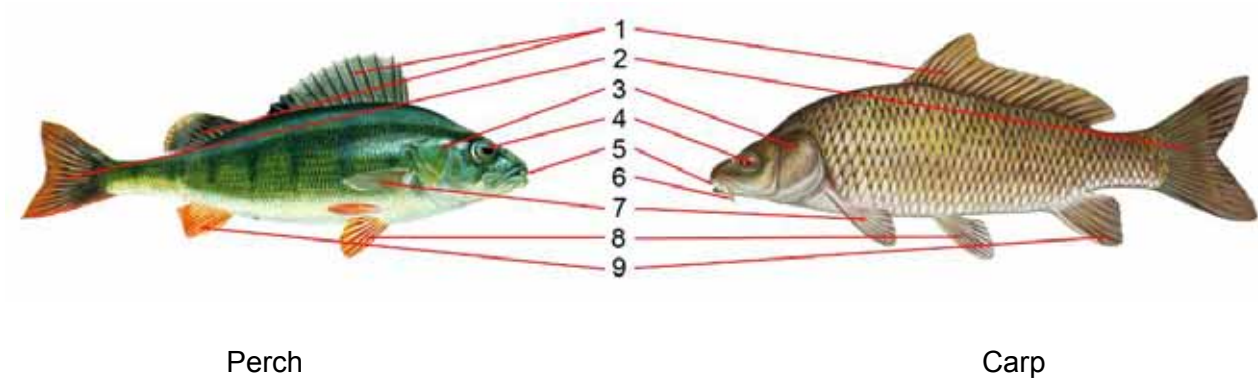
Fish are vertebrates. The body of vertebrates is supported by a cartilaginous or a bony skeleton. Fish show features typical for vertebrates, e.g. spines and ribs ("fish bones"). Generally, fish are divided into cartilaginous fish and bony fish. While the



skeleton of bony fish is made of bone, cartilaginous fish have a cartilage skeleton.
 Typical representatives of the group of cartilaginous fish are sharks.

All lakes of the Alpine range are exclusively inhabited by bony fish.

Anatomy

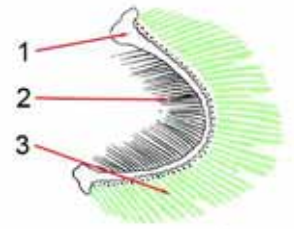


1	dorsal fin(s)	6	barbel
2	caudal fin	7	pectoral fin (paired)
3	gill cover with gills below	8	pelvic fin (paired)
4	eye	9	anal fin
5	mouth		

fig.71: Anatomy of bony fish

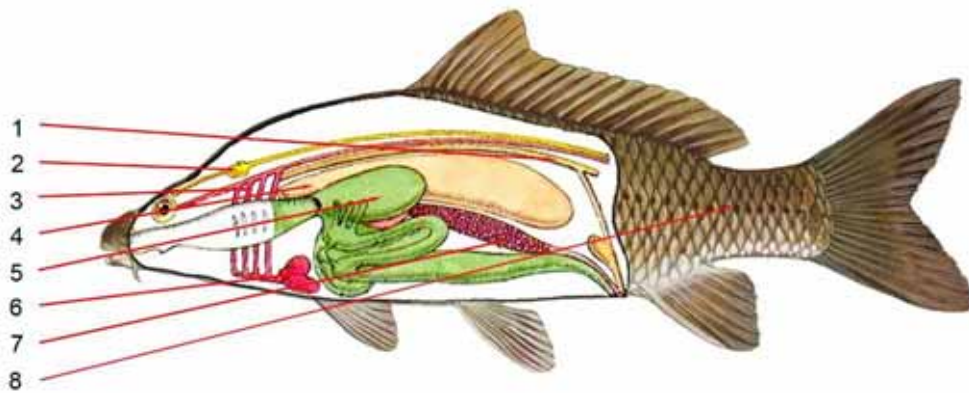
Gills:

In bony fish the gills are covered by a bony lid, the so-called gill cover. Gills consist of thin filaments of tissue that are attached to cartilaginous gill arches. Oxygen-rich water is sucked through their mouths and pumped over their gills with closed mouth. Oxygen dissolved within water reaches the blood through the thin skin of the gill epithelium. On the inner side of the gill arches are spike-like projections, so-called gill rakers, which protect the sensitive gill membrane from injuries.



- 1 gill arch
- 2 gill rakers
- 3 gills

fig.72: Gill arch of bony fish

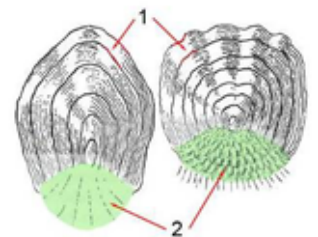


1	kidney	5	intestine
2	brain	6	heart
3	gills	7	ovary
4	swim bladder	8	lateral line

fig. 73: The inner organs of a bony fish.

Swim bladder:

The swim bladder enables bony fish to float in the water. It is an air-filled protuberance of the intestine.



- 1 annual ring
- 2 visible part of the scale

fig.74: Scales of bony fish

Scales:

The scales protect the fish from injuries. Some fish have them covered by a slimy epidermis (eel - *Anguilla anguilla*), some fish in turn have no scales at all (catfish - *Silurus glanis*). The growth of scales resembles that of trees in that they form annual rings, thus enabling the determination of age in fish.

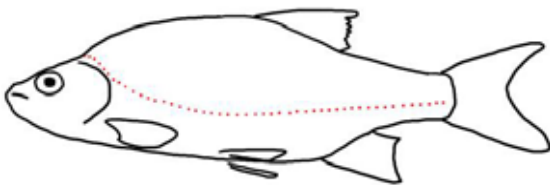


fig.75: Lateral line (red line)

Lateral line:

The lateral line is a sense organ which enables fish to detect pressure changes in the surrounding water.

This helps them to localise predators as well as prey which by their movements cause vibration in the water. Lateral lines run lengthwise down each side from head to the base of the caudal fin. In some fish it again branches around the head.

Reproduction and development

During the spawning season, many fish take on a special colouring. In some fish, especially male, even the form of the body can change during the reproductive phase. Carp-like fish may get a so-called “spawning rash”, rough, grainy particles on the scales around their heads.

Most fish release milk (seed) and roe (eggs) into the water, and fertilisation occurs externally.



fig.76: Fish spawn and fish larva

Some fish attach their eggs – the spawn – to aquatic plants in the littoral zone (tench, *Tinca tinca* carp, *Cyprinus carpio*). The pike (*Esox lucius*), too, lays its eggs near the shore. Other species of fish like the lavaret (*Coregonus lavaretus*) spawn in the open water where the eggs then sink to the bottom. Fishes like Lake Trout (*Salmon trutta f. lacustris*) or Danube Bleak (*Chalcalburnus chalcoides mento*) move upriver to lay their eggs.

The development of the eggs can last a few days as well as several months and primarily depends on the water temperature. The newly hatched young are very different in appearance from the adult fish. In the beginning almost all fish larvae feed on plankton. They stay in the shallow water of the shore area, often hiding among aquatic plants to keep safe from predators.

The following fish can be found in stagnant waters:

Trout-like fish

The common feature of all trout-like fish is the small fin along their back, between dorsal and caudal fin. This adipose fin is called fat fin and has no bones or musculature. The pectoral fins are situated in the middle of the body. Trout-like fish prefer oxygen-rich, not too warm water. They are predators.

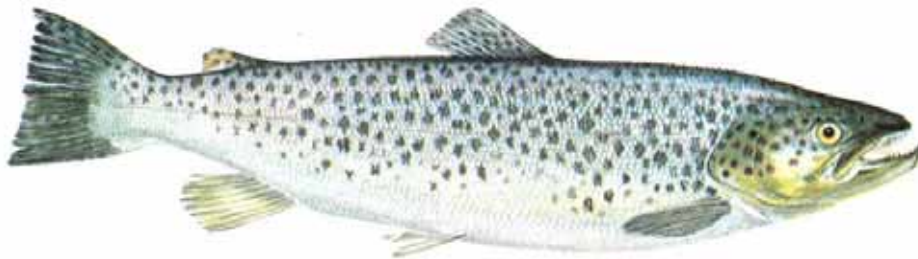
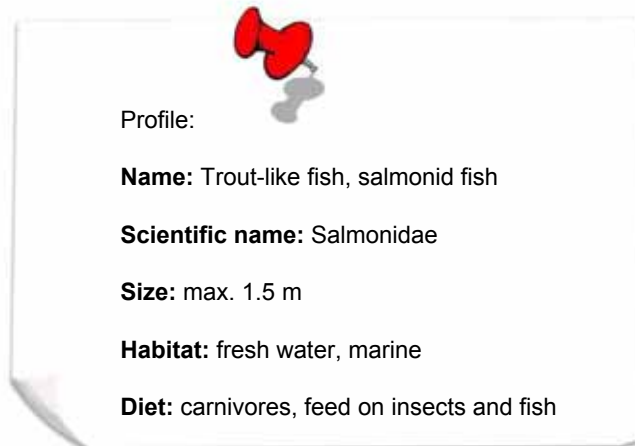


fig.77: Trout-like fish – Lake Trout (*Salmo trutta f. lacustris*)

Lake Trout (*Salmo trutta f. lacustris*):

Lake Trout have black spots on the sides of their bodies and are often hard to distinguish from river trouts. The lake trout inhabits large, deep lakes. During the spawning season it swims up confluent flowing waters to spawn in gravel. The lake trout's young feed on insect larvae as well as adult insects. Insects fly to the water to lay their eggs, thereby getting caught by the lake trout snatching for insects out of the water. Adult animals feed on fish.

Arctic Char (*Salvelinus alpinus*):

The arctic char has a luminous white seam along all paired fins and the anal fin. During the spawning season the fish is coloured bright red. This species can often be found in mountain lakes due to its preference for cool water. In case the arctic char does not find enough food (plankton and soil organisms) in this environment it often stays very small. Some fish then, however, start eating other fish and continue to grow (so-called wild catch).


Lavaret or common whitefish (*Coregonus lavaretus*):

The common whitefish has a silvery body and its caudal fin is deeply forked. Its mouth is very small. The fish primarily feeds on planktonic crustaceans which it filters from the water with its gill rakers.

Northern Pike (*Esox lucius*):

The Northern Pike has a long head with a broad flat snout which resembles a duck's bill. The dorsal fin is located far back on the body. The pike is a lurking predator, swimming between underwater plants and waiting for passing prey. Due to the position of its dorsal fin

and the large anal fin it can move forward with high speed and catch its prey. Its teeth which point backwards, act like barbed hooks, preventing the prey's escape.



Profile:

Name: Northern pike

Scientific name: *Esox lucius*

Size: max. 1 m

Habitat: fresh water – stagnant waters

Diet: predator, primarily feeds on fish



fig.78: Northern Pike (*Esox lucius*)

Perch-like fish

The dorsal fin of all perch-like fish is divided into anterior spiny, hard-rayed and posterior soft-rayed portions. Often the fin rays of the anterior part are pointed and sharp like spikes. Scales are usually ctenoid, feeling hard and rough to the touch. The pelvic fins are situated on the

front part of the body, on the breast. Fish belonging to this species are the tuna, the mackerel, as well as cichlids - favourite aquarium fish from the tropics.

Profile:



Name: Perch-like fish

Scientific name: Perciformes

Size: max. 1.2 m

Habitat: fresh and salt water

Diet: algae, plant particles, or as predator of small fish



fig.79: European Perch (*Perca fluviatilis*)

European Perch (*Perca fluviatilis*):

European Perch has a prominent dark spot on the back of the first dorsal fin and vertical stripes on its sides. The gill cover has a thorn. While young fish feed on insect larvae, worms and small crustaceans, adults prey on small fish. The perch spawn in the shallow parts of lakes and flowing waters.


Zander or Pike Perch (*Sander lucioperca*):

The fish has a vertically-stripped, elongated body and its first dorsal fin has horizontal stripes. The zander avoids the dense growth of the littoral zone, preferring warm lakes with good oxygen supply.

Carp-like fish

Carp-like fish are the most common species in the stagnant waters of the Alps. They have no teeth on their jaws, but so-called pharyngeal teeth located at the back of the carps' throats which are important for feeding. Most carp-like fish have many fish bones, which

is why they (with the exception of the carp itself) are not a very popular food. Our local species do not place great demands on the water bodies they inhabit. They can handle sparse oxygen supply as well as very warm water.



Profile:

Name: Carp-like fish

Scientific name: Cypriniformes

Size: max. 60 cm

Habitat: fresh and salt water

Diet: algae, plant particles



fig.80: Common Carp (*Cyprinus carpio*)

Common Carp (*Cyprinus carpio*):

The common carp has two long and two short barbels and its caudal fin is deeply indented. Some species of cultivated carp have only few scales (mirror carp) or no scales at all (leather carp). Carps search for food by stirring up the bottom of the water with their snouts. They attach their spawn to underwater plants in shallow water.

Chub (*Leuciscus cephalus*):

The body of the chub appears almost round in cross-section. It has very large scales and its belly and anal fin are reddish. The chub is very common in stagnant as well as flowing waters of our region.

Rudd (*Scardinius erythrophthalmus*):

The rudd has reddish pelvic, anal and caudal fins. This species prefers to live in groups, inhabiting underwater plant growth in the littoral zone. Their primary food supplies are underwater plants, to which they also attach their spawn.

Tench or Doctor Fish (*Tinca tinca*):

The tench has a pair of barbels and a dense, very slimy skin with deeply embedded scales. The tench's fins are distinctly rounded in shape. Tenches normally inhabit shallow, warm lakes with underwater plants. They feed on soil organisms by rooting in the mud at the bottom, especially at night. Like many other carp-like fish, the tench hibernates in the mud at the bottom.

Danube Bleak (*Chalcalburnus chalcoides mento*):

The Danube Bleak has an elongated, silvery body. Its mouth is directed upwards. The Danube Bleak is a typical shoal fish. When spawning the fish swim upriver to lay their eggs in shallow, gravelly areas.


**Bream** (*Abramis brama*):

The bream has a laterally flattened and high-backed body. It has a long anal fin and a triangular dorsal fin. Breams search for food by rooting in the mud. They prefer lakes rich in nutrients or slow-flowing rivers with a muddy bottom.

Wels Catfish (*Silurus glanis*):

The skin of the Wels Catfish is scaleless, covered by a protective slimy layer. It has a small dorsal fin and a long anal fin that extends to the caudal fin. The catfish's mouth has two long barbels on the upper jaw and four short barbels on the lower. It is a bottom dwelling fish

which hunts for fish, amphibians and crustaceans at night. Besides its strongly developed sense of smell, the barbels which function as tactile organs are also of major importance in locating prey. In our region the Wels Catfish lives in large, deep lakes. It attaches its spawn to plants in shallow water.



Profile:

Name: Wels Catfish

Scientific name: *Silurus glanis*

Size: max. 3 m

Habitat: fresh water

Diet: fish, frogs, small water birds and small mammals



fig.81: Wels Catfish (*Silurus glanis*)

Classification of lakes according to the species which inhabit them

Due to their position, their depths, the extension of the pelagic zone as well as the extension of the shallow areas, lakes offer fish very diverse environmental conditions. Since different species of fish have totally different demands as far as their habitat is concerned, not all stagnant waters house the same species of fish.

In Central Europe four main kinds of lakes can be distinguished according to the fish that populate them. They are named after the predominant species of fish which can be found in them.

Salmon lakes: These lakes are primarily inhabited by lake trout (*Salmo trutta f. lacustris*), charrs (*Salvelinus* sp.) and whitefish (*Coregonus lavaretus*). Even in summer the water temperature of these lakes is not very high. The deep-water of these lakes shows a relatively high concentration of oxygen even near the bottom – a major prerequisite for the development of the spawn of the whitefish.

Bream lakes: The primary fish to be found in this type of lake is the bream (*Abramis brama*). This moderately deep lake offers extensive shallow areas for the spawning of the bream and the bottom of the lake provides it with sufficient food.

Pike-trench-lakes: These waters, so-called ponds, have no deep zones. Underwater plants can be found everywhere – essential preconditions for the pike (*Esox lucius*). This lurking predator hides between water plants awaiting its prey. The trench (*Tinca tinca*) which feeds on soil organisms finds enough food here and is offered excellent conditions to reproduce.

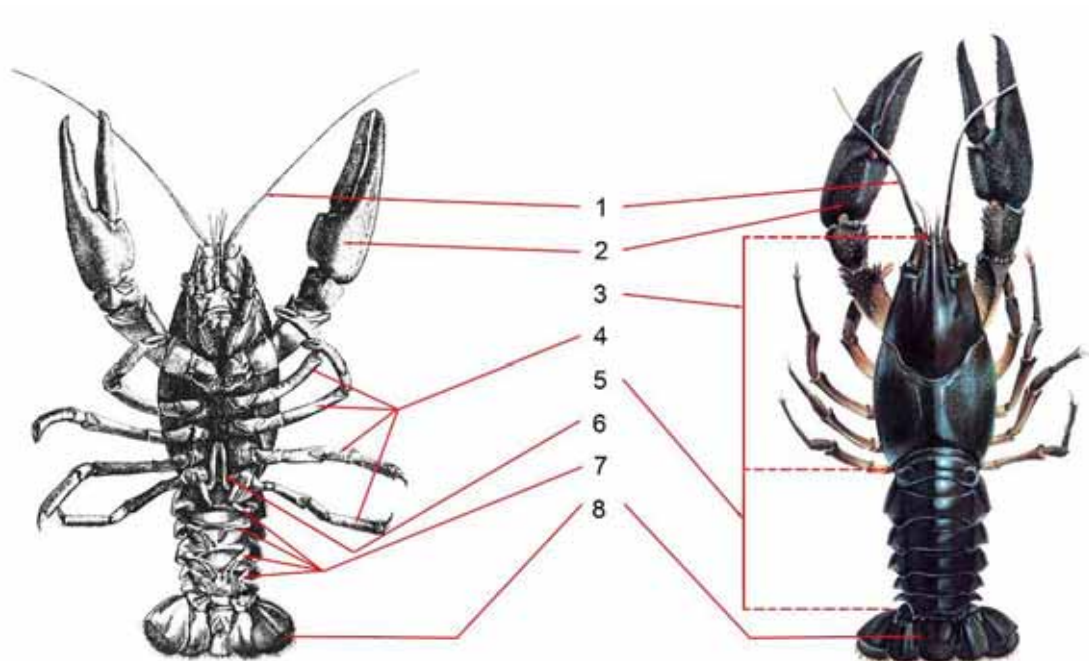
Zander lakes: These are shallow, often very muddy lakes featuring a sufficient amount of zooplankton. They have an extensive pelagic zone with sparse vegetation. The zander (*Sander lucioperca*) is a large predator which hunts for fish in the open water.

5.2 Crustaceans

Anatomy

The large crustaceans of European waters belong to the group of crayfish. All species of this group show a similar body structure. The head and thorax are fused into one segment, the so-called cephalothorax. The most striking body parts are their large claws or pincers. They have 4 pairs of walking legs. The abdomen is divided into 6 segments and also bears legs, the so-called pleopods or swimmerets. In male crayfish the first pair of swimmerets is modified and is used for sperm transfer. In females all five pairs of swimmerets are of the same size. This is a attribute to distinguish male from female.

Crayfish have two movable compound eyes for optical orientation. Their tactile sense is also strongly developed and is of major importance.



1	Antennae	5	abdomen
2	cheliped	6	first pair of pleopods - male
3	cephalothorax	7	pleopods, so-called swimmerets
4	walking legs	8	tail fan

fig. 82: Anatomy of crayfish on the example of the European or noble crayfish (*Astacus astacus*)

Diet

The animals go in search for food at dawn. Crayfish are omnivores. They feed on living animals like insects, frogs, snails, small fish and carrion as well as on aquatic plants.

Way of life

In contrast to vertebrates, crustaceans (like insects) have an external shell, the so-called exoskeleton, which must be shed for the animal to grow. In order to shed, the crayfish forms a second skeleton under the outer one. When the new, larger skeleton is completely formed, the outer skeleton splits along specific weak points and the animal pulls out. The new exoskeleton is still soft and elastic and takes another few days (up to 10 days) to grow hard.

The crayfish's habitat is the littoral zone. During the day crayfish hide in caves or under stones.

When facing a threat, crayfish move backwards in an escape reflex. Their abdomen thrusts forward like a paddle and fast tail flexions ("tailflips") propel them backwards through the water away from danger.

Reproduction and development

The female carries the eggs attached to her abdomen. After a long breeding season of 26 weeks the larvae hatch, but remain clinging to their mother for some time.

Crayfish plague

At the end of the 19th century the crayfish plague occurred in Europe for the first time. Crayfish plague is caused by a water fungus (*Aphanomyces astaci*). The plague spread quickly through Central Europe within only a few decades. North-American crayfish are resistant to infection. By introducing American species of crayfish to our local waters the distribution of crayfish plague has been intensified. While the American species are resistant to the plague, they act as carrier. After infiltration of the plague into a water body it only takes a few days or weeks to wipe out large populations of indigenous crayfish.

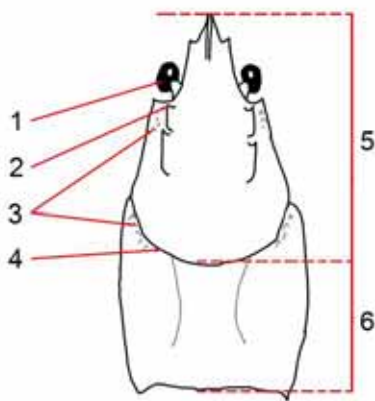


fig.83:
Cephalothorax of crayfish

1	compound eye	3	spines
2	post-orbital ridges	4	cervical groove
5	head	6	thorax

Determining characteristics

Important characteristics to determine domestic crayfish are the lumps and ridges of the carapace behind the eyes (post-orbital ridges) as well as the spines covering this part of the body and the furrow between head and thorax (cervical groove). The colouration of the carapace is of major importance, too.

Important species in our local waters are:

European or Noble Crayfish (*Astacus astacus*):

The European crayfish is the largest domestic crayfish species. It has two post-orbital ridges and two spines behind the cervical groove. The rest of the carapace of the cephalothorax is smooth without spines.

The European crayfish lives both in rivers and brooks of valleys and in lakes which are warm enough in summer. It is highly endangered by the crayfish plague, but also by the destruction of smaller waters and construction measures that reduce their natural habitats.

White-Clawed Crayfish (*Austropotamobius pallipes*):

This crayfish has one post-orbital ridge. One to six spines or humps are located behind the cervical groove. The rest of the cephalothoracic carapace is smooth and without spines. The colouration of the upper side of the claws is totally different from that of the rest of the body. The *Austropotamobius pallipes* is found in smaller forest streams and meadow brooks as well as in smaller standing waters.

Signal Crayfish (*Pacifastacus leniusculus*):

The signal crayfish has two post-orbital ridges behind its eye and no spines behind its cervical groove. The rest of the carapace of the cephalothorax is also smooth and without spines. Its major characteristic is the white to pale blue patch near the claw hinge. The signal crayfish is native to North America. It is resistant against crayfish plague, although it can still transmit it to other species, thereby displacing the European crayfish in many waters.

6 Predator-Prey Relationships

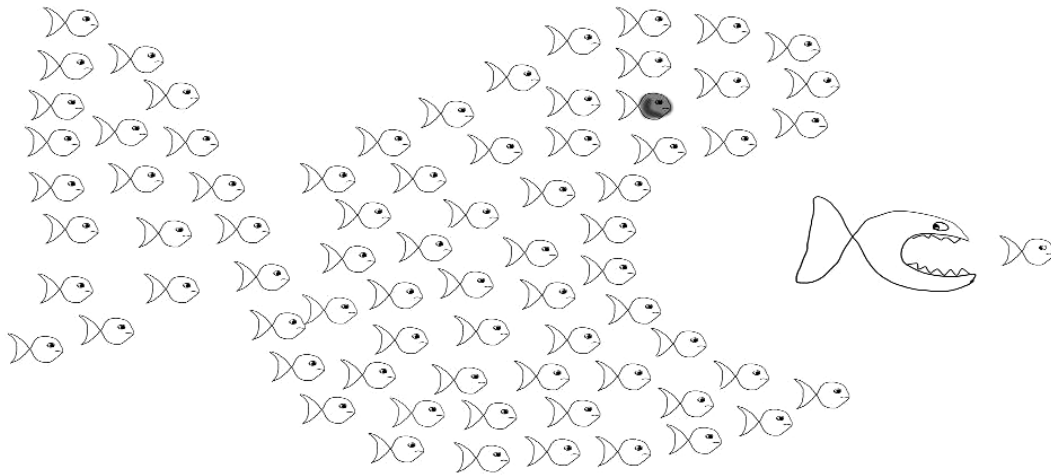


fig. 84: small and big fish

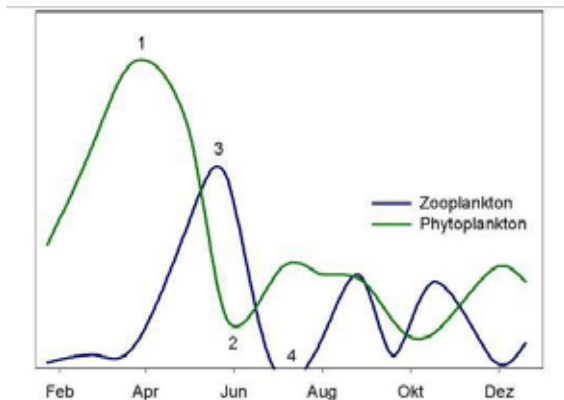


fig. 85: biomass of zooplankton and phytoplankton in the course of a year

Interaction in an ecological system is coined by the relations of the organisms among each other. One the most important is the interaction of predator and pray. Whereby the predator is mostly an animal, but the pray often of herbal origin is. The predator depends on its prey, since it forms the food basis. If the food basis is bad, i.e. the prey present in small quantity, it affects the reproduction ability of the predator. A good example is the relationship between zooplankton and their food basis the algae (phytoplankton). fig. 85 illustrates this connectivity.

In spring (after the circulation) sufficiently nutrients are present in the water body. The algae find optimal growth conditions. Their growth curve rises exponentially (1). Thus also the zooplankton find sufficiently food and can reproduce itself very fast (3). In consequence of the increasing food requirements of the zooplankton the algae biomass is reduced dramatically (2). The food basis of the zooplankton is decreasing thereby their biomass collapse (4). In the further course of the year the relationship is no longer combined so clearly, nevertheless it is present.

Exercises and Games:

Role-play “Food Web”

Roles: zooplankton (small crustaceans), fish, sun

Equipment: chairs, tennis balls or similar things, a sun

Procedure: The game starts with a small crustacean. As the sun sets it ascends from the depth of the lake (onto a chair) to eat algae (a tennis ball). Then it leaves again. It is now well-fed and breeds. The small crustacean give off the tennis ball, selecting one child as a second zooplankton organism. As the sun sets again, both ascend (onto the chairs) to feed on algae. They leave again (give off their tennis balls) and can breed once more. Now 4 children play zooplankton. The next evening, at sunset, all 4 small crustaceans ascend to eat algae. Unfortunately, they are threatened by a hungry fish which eats one off them. This rejoins the other children and can become a crustacean again. Each small crustacean which ate an algae (a tennis ball) can breed. As a result, the number of small crustaceans continuously increases. These are then in part eaten by the fish. The amount of algae, however, continuously decreases and not every small crab can find food. The fish keeps decimating the number of small crustaceans.

The supply of algae is exhausted; there are no algae in the lake anymore. The small crustaceans have to stay hungry.



7 Worksheets with Explanations

FOR TEACHER ONLY !

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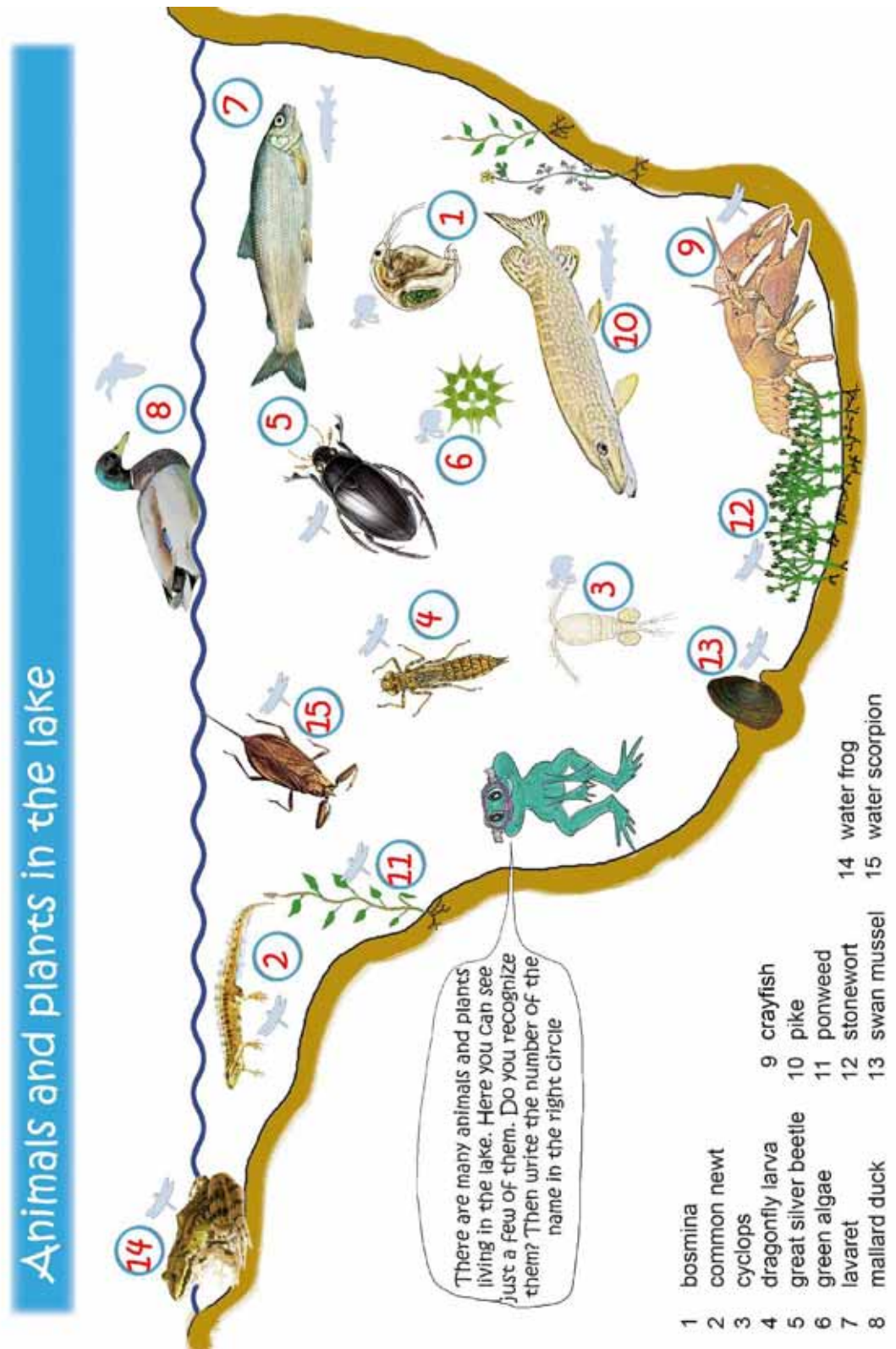


fig. 86: Worsheet „Animals and plants in the lake“ (Org_01)

Printformat: A4

Amphibian

salamander (urodela)

C S . .

l . .

e . .

f . . . l . .

h . . . l . .

t . . . with w . . .

t . . .

anuran

croaking sac, eye, foreleg, hind leg, lip, tail, toes with webs



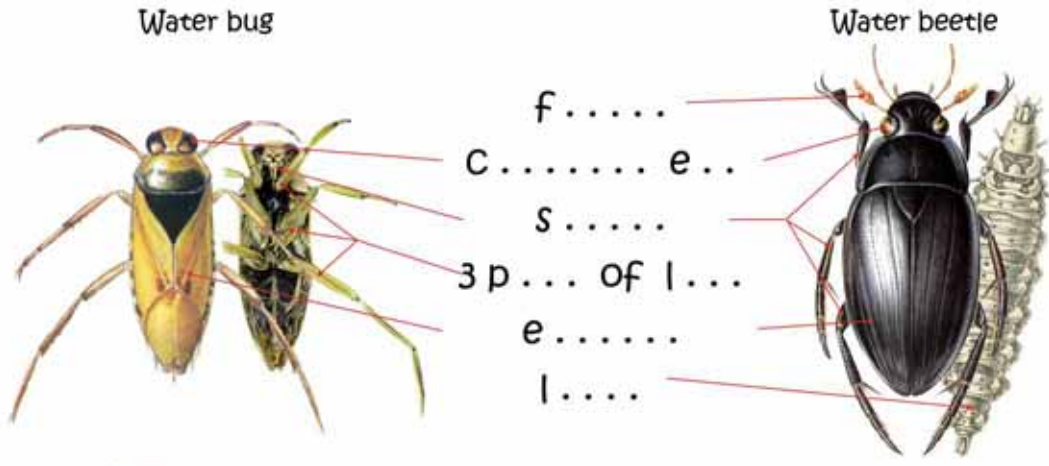
There are differences between the salamander and the anuran.
Do you know them?

- | | | |
|-----------------------------|--|--|
| The salamanders have | <input checked="" type="checkbox"/> a tail | <input type="checkbox"/> no tail |
| The anurans have | <input type="checkbox"/> a tail | <input checked="" type="checkbox"/> no tail |
| The salamanders have | <input type="checkbox"/> a croaking sac | <input checked="" type="checkbox"/> no croaking sac |
| The anurans have | <input checked="" type="checkbox"/> a croaking sac | <input type="checkbox"/> no croaking sac |
| The legs of the salamanders | <input checked="" type="checkbox"/> have all the same length | <input type="checkbox"/> have different lengths |
| The legs of the anurans | <input type="checkbox"/> have all the same length | <input checked="" type="checkbox"/> have different lengths |
| The amphibian can | | |
| | <input checked="" type="checkbox"/> also breathe with the skin | <input type="checkbox"/> only breathe with their lung |

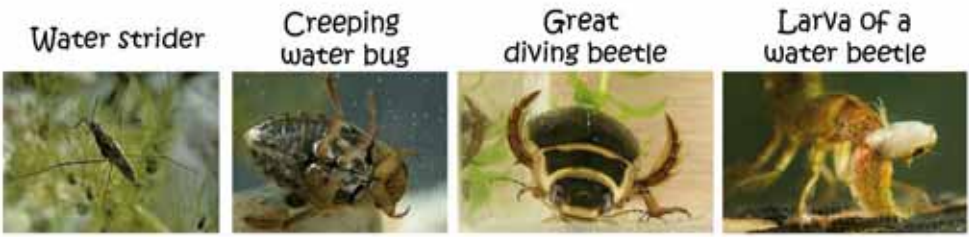
fig. 87: Worksheet „Amphibian“ (Org_02)

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Water bug, water beetle



compound eye, elytron, feeler, larva, sucker, 3 pair of legs



What do you know about water bugs and water beetles?

Water bugs have a incomplete metamorphosis complete m.
 Water beetles have a incomplete metamorphosis complete m.

Water bugs have mouthparts a sucker
 Water beetles have mouthparts a sucker


The most water bugs and water beetles are good flyers can not fly

The water bugs and water beetles uptake oxygen from the air from the water
 The larvae of the water beetles uptake oxygen from the air from the water

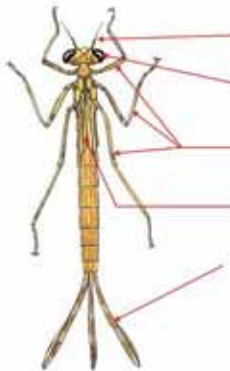
fig. 88: Worksheet „Water bug, water beetle“ (Org_03)

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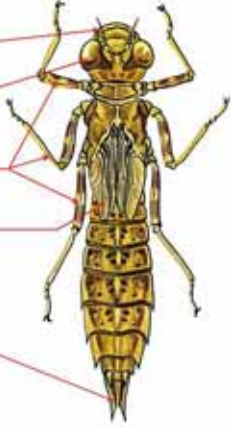
Dragon fly



Damselfly larva



Dragonfly larva



f.....


c..... e..

3 p... of l...

w... p..

g... l.....

t... p.....



compound eye, tail pyramide, feeler, gill lamellas, wingpad, 3 pair of legs

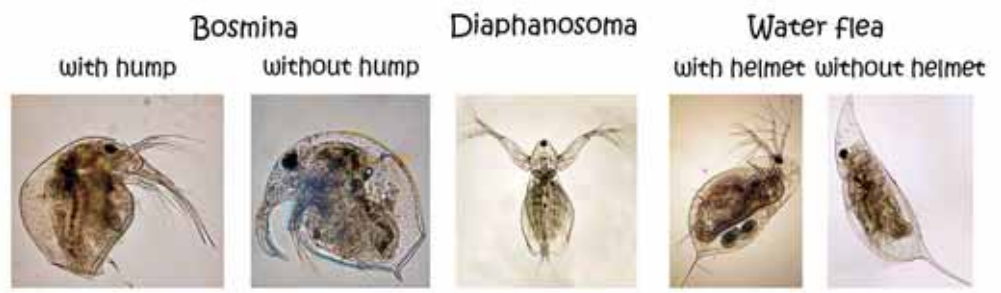
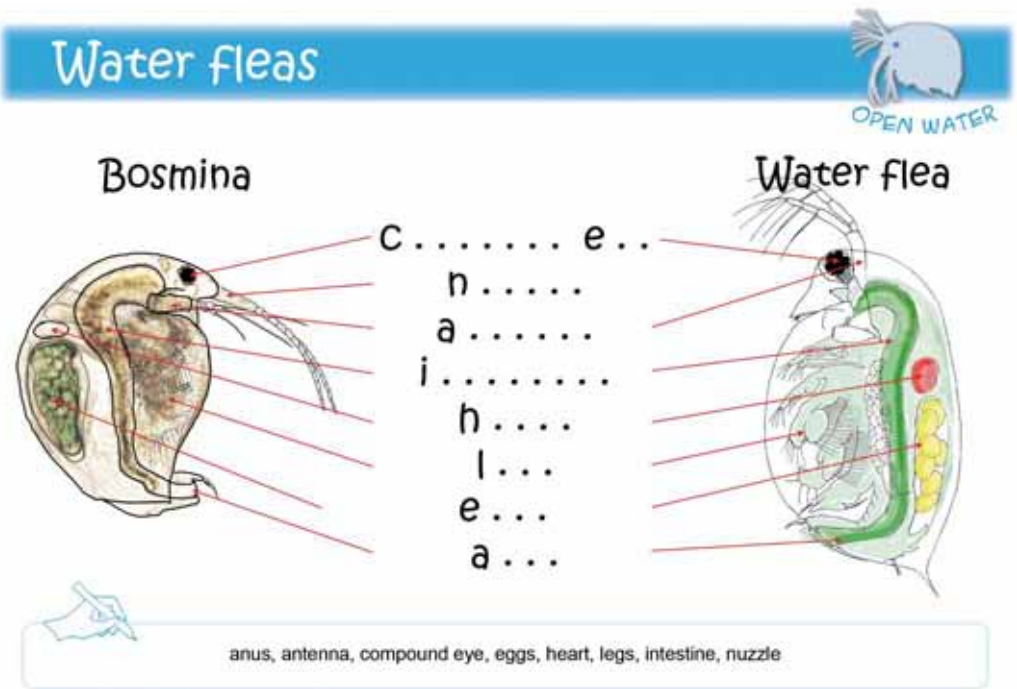


What do you know about dragonflies?

- | | | |
|-------------------------------------|--|--|
| All dragonfly larvae live | <input checked="" type="checkbox"/> in the water | <input type="checkbox"/> on the shore |
| All dragonfly larvae breathe with | <input type="checkbox"/> the mouth | <input checked="" type="checkbox"/> the anus |
| All dragonflies belong to | <input checked="" type="checkbox"/> the insects | <input type="checkbox"/> the spiders |
| The labium for catching prey have | <input checked="" type="checkbox"/> the larvae | <input type="checkbox"/> the adults |
| Damselfly larvae have on their tail | <input checked="" type="checkbox"/> 3 gill lamellas | <input type="checkbox"/> 4 gill lamellas |
| The mating cycle of the dragonflies | | |
| | <input checked="" type="checkbox"/> is typical for them during the pairing | |
| | <input type="checkbox"/> is made just for fun by them | |

fig. 89: Worksheet „Dragonfly“ (Org_04)

Printformat: A4



What do you know about the water fleas

- The bosmina has a nozzle no nozzle
 The water flea has a nozzle no nozzle
- The bosmina and the waterflea are looking with two eyes one eye
- Most of the waterfleas are female male
- During summer some species of bosmina have a hump a helmet
 During summer some species of waterflea have a hump a helmet

fig. 90: Worksheet „Water fleas“ (Org_05)

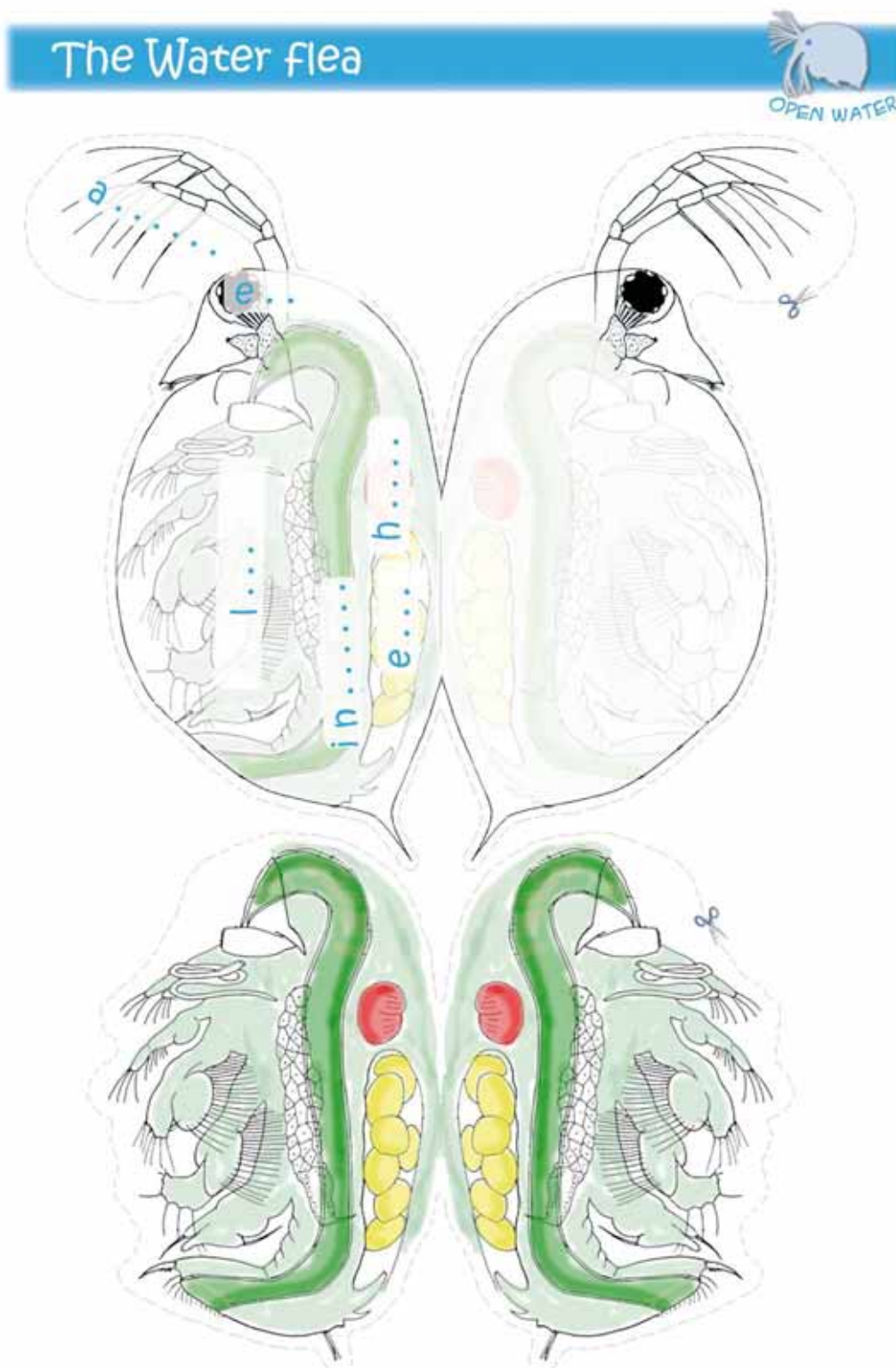


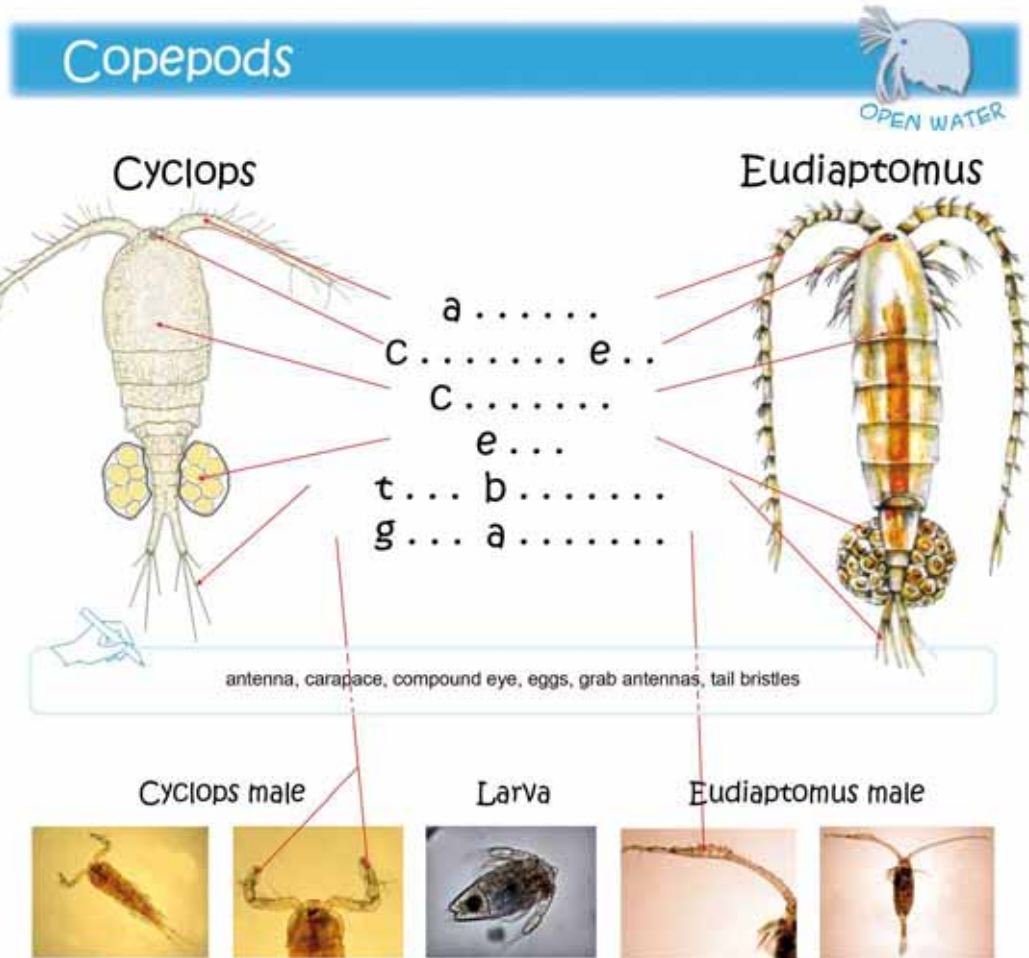
fig. 91: Worksheet „The water flea“ (Org_06)

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This worksheet the children can cut and glue together.

They have to put the cutted part with the intestine, eggs, heard, etc. in to the part with the daphnia torso.

Printformat: A4



What do you know about the copepods?

- | | | |
|--------------------------|---|--|
| The cyclops has | <input type="checkbox"/> long antennas | <input checked="" type="checkbox"/> short antennas |
| The eudiaptomus has | <input checked="" type="checkbox"/> long antennas | <input type="checkbox"/> short antennas |
| Copepods have | <input type="checkbox"/> 2 compound eyes | <input checked="" type="checkbox"/> 1 compound eye |
| The cyclops has | <input checked="" type="checkbox"/> 2 egg bags | <input type="checkbox"/> 1 egg bag |
| The eudiaptomus has | <input type="checkbox"/> 2 egg bags | <input checked="" type="checkbox"/> 1 egg bag |
| The male cyclops has | <input checked="" type="checkbox"/> 2 grab antennas | <input type="checkbox"/> 1 grab antenna |
| The male eudiaptomus has | <input type="checkbox"/> 2 grab antennas | <input checked="" type="checkbox"/> 1 grab antenna |

fig. 92: Worksheet „Copepods“ (Org_07)

Printformat A4

This worksheet is for recapitulation of the lesson.

Life in open water

1 **Bacteria** consist of one cell.
1 There are many of them in the lake.

2 **Algae** are plants.
2 For growing they need **water**, carbon dioxide and the energy of the **sun**.

3 **Rotifers** have a rotating ciliated structure above their mouth. Their favorite dishes are **algae** and **bacteria**.

4 **Water fleas** have only one eye.
4 Their favorite dish are **algae**, which are filtered from the water.

5 **Copepods** have two **antennas**. They can swim very quickly. Some are eating **algae**, some are eating larvae of other copepods and small **water fleas**.

fig. 93: Worksheet „Life in Open Water“ (Org_08)

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Labyrinth

The whole lake is filled with uneatable blue-green algae. The waterflea is already very hungry. Can you show him the way to the delicious green algae in the center?

You have to move along on the blue-green algae!

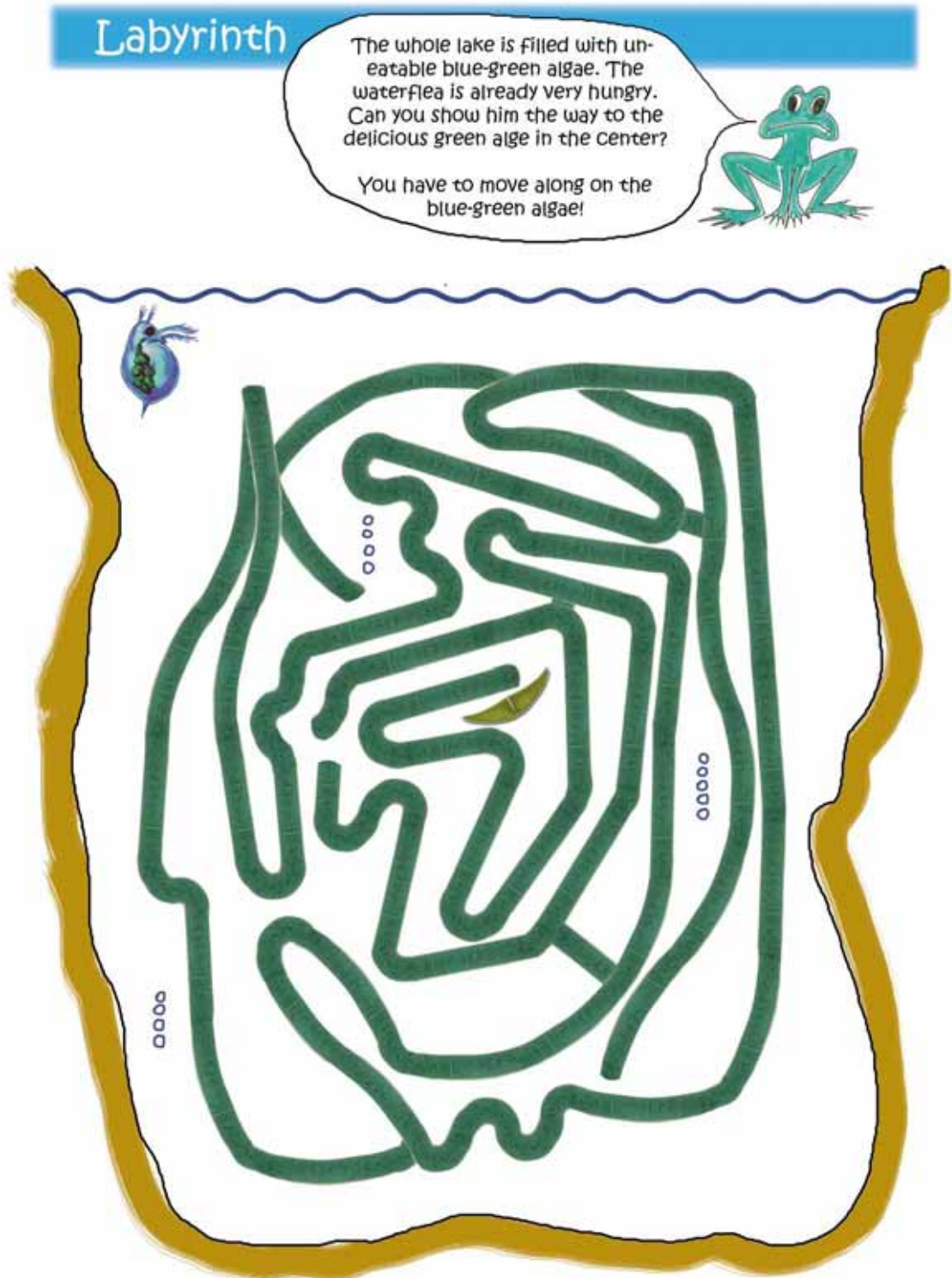

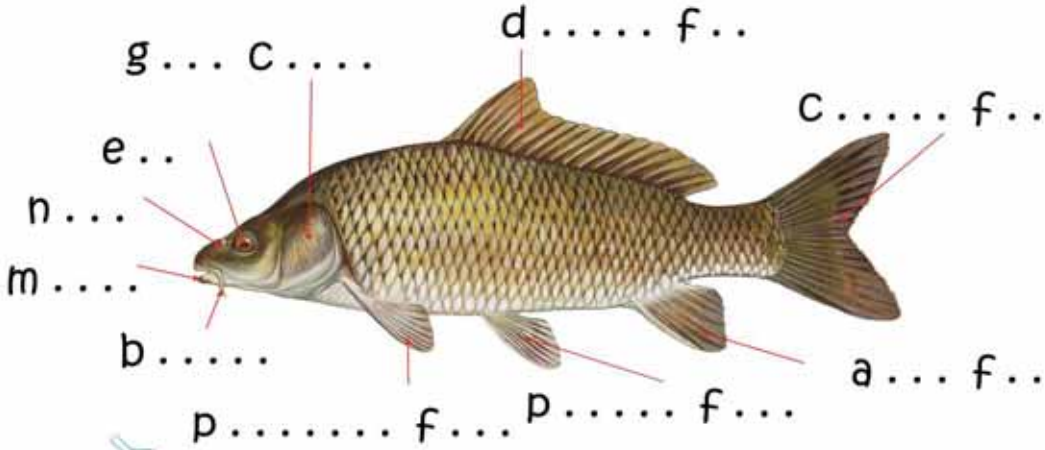



fig. 94: Worksheet „Labyrinth“ (Org_09)

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Fish









anal fin, barbel, dorsal fin, eye, gill cover, mouth, nose, pectoral fins, caudal fin, pelvic fins


perch




pike




arctic char




karp



rudd





Do you recognize the fish? What's his name?

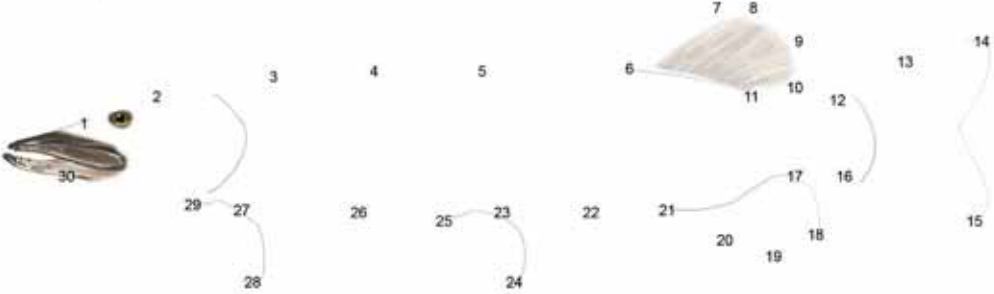
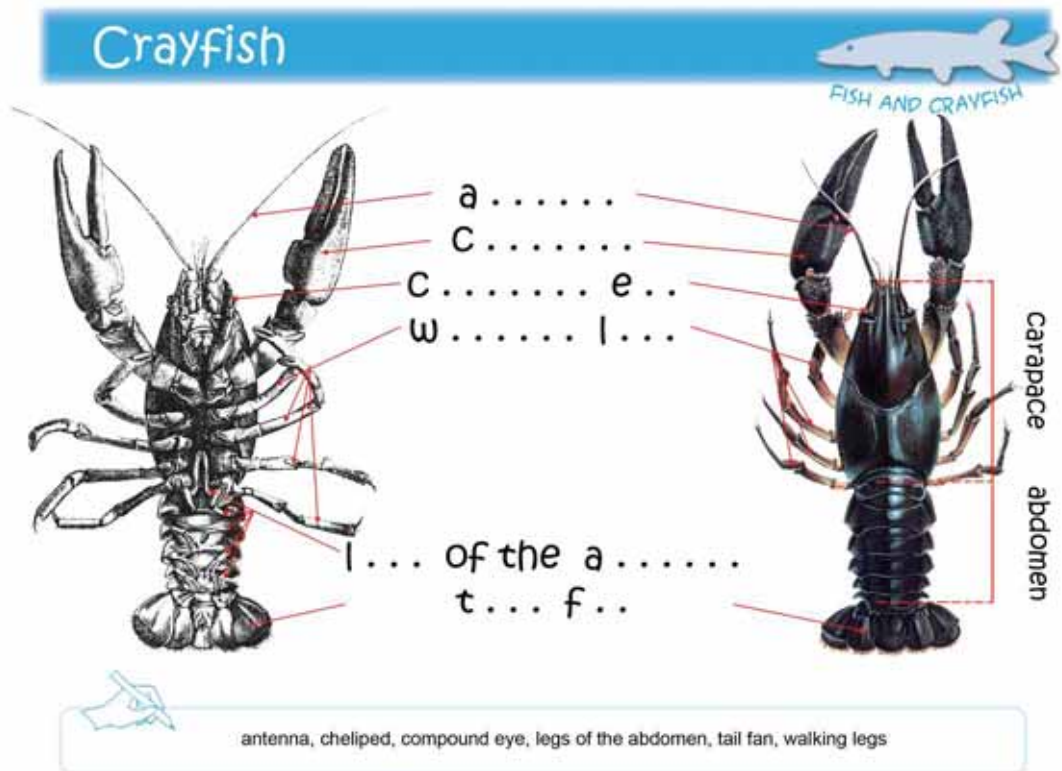


fig. 95: Worksheet „Fish“ (Org_10)

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What do you know about Crayfishes?

- Crayfishes breathe with gills a lung
- The chelipeds are modified antennas legs
- For growing the crayfish has to shed his carapace eat much

fig. 96: Worksheet „Crayfish“ (Org_11)

Chapter 3 – Field work



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2	Measurement in Lakes.....	115
3	Field work.....	117
4	Worksheets with Explanations	123

1 Introduction

The selection of a practical water body is very important. Preferably stagnant waters with an extended shore area are to be chosen. In the shore area, students can carry out investigations and gather. From an available footbridge, plankton can be caught with a plankton net. From here it may also be possible to observe fish. Plankton can, of course, be best sampled from a boat on the open water. This however should only be carried out with the necessary safety precautions (life jacket, sufficient space, sufficient supervisory staff).

The main focus of research at the lake is on the shore area. Here you can relatively easily gather and safely gather animals and determine plants.

For the work in the field at least a day should be estimated. A day in nature provides children with an awareness of the environment, which is not possible in four days of intensive work in the classroom.

Glossary



Binocular (stereo microscope): device for optical magnification (usually 40-40 times), which allows stereoscopic vision. With the binocular, objects are viewed which are considered too small for the naked eye and too large for viewing with a microscope.

Microscope: device for optical magnification (10-100 times and above);

Mesh width: the space between four filaments in a net



Worksheets and material

- Log sheet (fw_01)
- species list (fw_02)

Sampling devices, plankton net, water thermometer, magnifying glass, tweezer, bucket, colander

Questions

- What does the water body look like
- Where is the shore area
- How is the surrounding area used
- How do I find animals in the shore area
- What plants exist in the shore area
- How do I catch animals in the open water area



2 Measurement in Lakes

2.1 Measurement of water temperature:

A simple thermometer can measure the water temperature in the shore area. If a pier is present the temperature of the water surface over a slightly deeper area can be measured.

The shallow shoreline often indicates a higher water temperature than the open water area that is more exposed to the wind. The water temperature at depth is not easy to measure with a normal thermometer, as the thermometer shows the temperature of the water surface when pulled up again. You can do it with an "insulated" thermometer (see exercises and games).

If a water sampling device such as the Schindlerschöpfer is available, the temperature of the respective water depth can be read directly on the device.

2.2 Water transparency depth measurement by Secchi disc

The water transparency is an important parameter when assessing the levels of floating particles in the water. In a lake, these are usually algae cells that disperse the light. It is therefore possible, with the water transparency, to make a relative conclusion about the phytoplankton content in the water. The ratio is inversely proportional, at low water transparency a high phytoplankton content can be assumed, and vice versa. The water transparency is measured with the Secchi disc. It is a white disk, with a black quarter.



fig. 97: Secci Disc

2.3 pH value, electrical conductivity, oxygen concentration

These parameters are also collected on field. Measurement carried out with electronic field devices.

2.4 Sampling of water

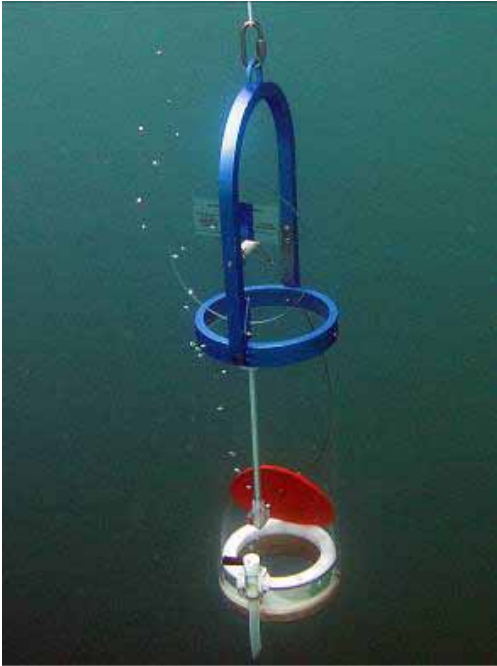


fig. 98: opened Schindlerschöpfer

For other issues, such as nutrient content (mainly phosphorus and nitrogen), heavy metal pollution, etc. samples must be taken and transported to the laboratory. For the sampling of different water depths, devices such as the Schindlerschöpfer are used. It is a cylinder with a sealable bottom and lid. The sampling device is lowered with open closures to the desired depth. By a short but vigorous pull on the rope on which the Schindlerschöpfer is suspended, the top and bottom are sealed and the unit can be pulled to the surface with water from the desired depth.

The sampled water can be bottled via a tap and a variety of analysis carried out. A thermometer is installed in the Schindlerschöpfer. This enables to measure the temperature of the water of the sampled depth.

2.5 Sampling of phyto- and zooplankton

For issues regarding the phyto and zoo plankton, plankton nets with different mesh sizes are used. With this algae, rotifers and small crustaceans are gathered. To this end, the net is lowered in the water and slowly pulled back up.



fig. 99: plankton net

3 Field work

On field there should be a brief discussion of the water body. Is it a lake or pond. What we know about the water, how deep and how big is it? How is the surrounding area used? Are there any visible discharges into the waters? Is the water level regulated? Are there natural shore areas? Are there any bank constructions? Is a reed belt present? Students should be able to deal with these questions, as subsequently, the sample point should also be drawn. For the physical measurements on field, professional equipment should be used. So you have the possibility to measure not only water temperature and water transparency, but also oxygen, and maybe conductivity, and pH.

We are working with living creatures:

Not least is the fact that you get to see live creatures at the water, for certain, the fascination of water makes a difference. Many children involved in such projects are in the nature for the first time. In many cases, creatures are initially considered only as objects and not as living beings. The protection of plants, animals and landscape is maintained in nature and wildlife protection laws and also a goal of this school project. Therefore, a careful and conscientious handling of the collected



creatures is required. It is up to the teachers to ensure that the children get close and to make sure that this does not lead to careless handling of fauna and flora.

The entering of reedy marshes and dense water lily pond lily populations is to avoid.

The plants will be discussed together to avoid unnecessary uprooting.



3.1 *Birds and Mammals*

Depending on the region and altitude of the water, as well as the naturalness of the lake, a number of different birds can be seen and heard. On the DVD there are a number of bird sounds and pictures, to facilitate the determination of birds, which can be found on the waters. The birds listed in the identification book are common, such as the Mallard Duck, or Mute Swan. They are easily recognizable even without the identification book.

The mammals listed in Chapter 2 are very shy and not so easy to find. Most likely you can find their tracks in the riparian zone.



fig. 100: beaver tracks



3.2 Shore Area

The shore area is the focus in the practical work on the water. For Thus it is important to choose a water body with a distinct shore zone. It need not necessarily be a large lake; it may could also be a pond.

Sampling Utensils

Colander: One of the most important sampling units for the waterfront area is the colander. With this many insects, but also tadpoles and other living organisms can be caught.

Bucket: in order to transport the gathered creatures as gently as possible a bucket of water must always be on hand.

Rubber Boots: rarely remain dry and can be replaced by bathing sandals in the summer months.

To protect the feet you always should use a kind of footwear.



fig. 101: Sampling the shore area

Sampling is in teams. At least two children form a team. Colander and magnifying glass frequently change hands. The carrier of the bucket is responsible for ensuring that the animals have enough water. The creatures caught with the colander must be immediately transferred to the bucket. After an appropriate time for the sampling of the shore area, the animals are examined using the magnifying glasses, discussed and identified. Depending on the age of the pupils, species lists are created. In the riparian zone lives also many small crustaceans. They can be examined with the magnifying glass, too.

What kind of animals did we find on which place? What adjustments to life in the water can be identified?

After all the children have seen all species found they are released back into the water.





3.3 Open Water

The emphasis here is on the sampling of small crustaceans, as these creatures can also be observed with the magnifying glass. If a bridge is available, students can relatively easily cast the plankton net (see practice and games). After it has dropped almost to the bottom of the water, it can be brought back up slowly. The contents are flushed into a vessel. Now the small crustaceans can already be observed as jumping dots. With the magnifying glass it is maybe possible to different water fleas and copepods. For a closer look a binocular or a microscope is needed. For this the water sample can be taken in to the classroom. When stored in the refrigerator, the organisms are viable up to a week.



There are several videos and photos of plankton organisms on the DVD.



3.4 Fish and Crayfish

The capture of fish and crayfish in Austria is subject to the Fisheries law. This is the right of the authorised angler and persons designated by him. Even a temporary catch of fish and crayfish to discuss the specific characters is not allowed. A approval of the authorised angler is required.



fig. 102: Crayfish

In the identification book, some of the most important fish species of stagnant waters in the Alps are given. Depending on the altitude and size of the lake, a large number of other species of fish live in the lake. Usually, the local fishermen can tell you something about the local fish.

With the consent of the authorised angler, crayfish traps can be set. The crepuscular crayfish walk in the evening in search of food, so the traps must be set the night before. In the crayfish cages, the creatures are caught alive, they will, after discussion of the characteristics, be released again. If there are waters on the

shore areas devoid of aquatic plants, different species of fish of the shore zone can be caught.

If there is no way to catch fish and view alive, you can also make fish observations from piers or bridges (at the outflow of the lake). Here, however, the species identification for the untrained eye is sometimes difficult. Further support to learn about the species is available on the DVD with pictures of fish and crayfish.

Exercises and Games

Constructing an "isolated" thermometer

Material: Thermometer, PET bottle, weight (stone), 5-10 m line, a piece of wire

The thermometer (4) should be attached to the bottle (2) with the wire (3) in a way that the thermometer is in the bottle. The weight (6) is fixed to one end of the line. About half a meter higher, a loop (5) with the circumference of the PET bottle is knotted in the rope. The PET bottle is inserted therein and fixed about 20 cm above with the bottle neck to the line. The loop should hold the bottle vertically so the thermometer does not fall out.

The construction is lowered to 5-10 meters. Now 30 to 60 min should be allowed for the water temperature in the bottle to adjust to the temperature of the environment. Then the bottle can be pulled up. After remove out of the water, quickly read the temperature of the deeper water.

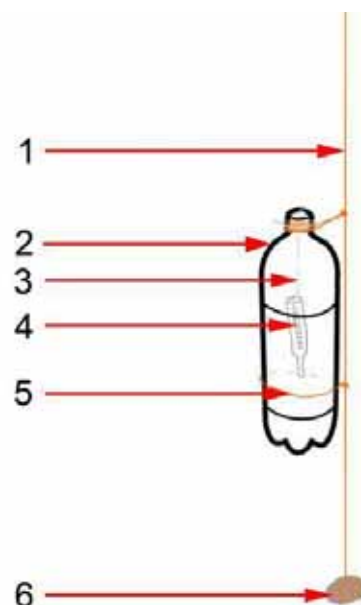
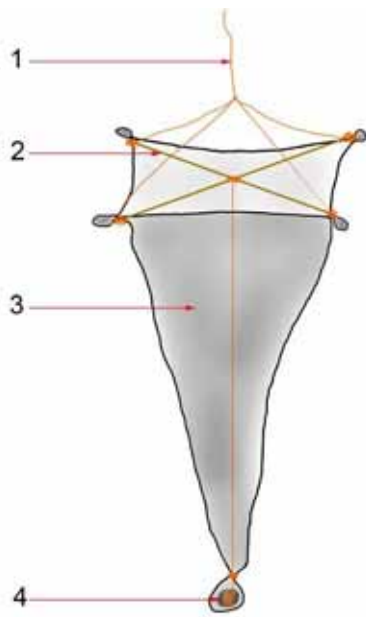


fig. 103: Sketch of an "isolate thermometer"

Constructing a plankton net

Material: nylon stockings, two wooden sticks (20 cm), string (waterproof). The two wooden sticks (2) are crossed in the centre and with the string (1), connected to each other. The nylon stocking (3) is tied to the four ends of the rods. From the 4 ends a string is attached to each (30 cm long). The 4 strings are tied together with a string (5 - 10 m). The plankton net needs a little weight so that it sinks well. This is a small stone (4) fastened to a piece of string and placed on to the end of the nylon stocking. So the stocking is not damaged by the weight of the stone, the cord of the stone is secured to the wooden cross.

Field work



From the pier, the plankton net can be cast out. It can be dropped and pulled back up slowly. The nylon stocking is turned inside out and rinsed with a little water.

fig. 104: Sketch of an plankton net

4 Worksheets with Explanations

FOR TEACHER ONLY !

name of the water body: _____

date: _____

time: _____

weather: _____

kind of the water body: lake pond artificial pond _____

air temperature: _____

water depth at the shore zone: _____

water temperature: _____

maximum water depth: _____

drawing of the sampling point:

How does the shore zone look like?
Is there a open water zone?
Portray what you see!


if you know the maximum water depth of the lake, fill out here.


let the children time to recognize their surroundings and the landscape before starting with the sampling. Make pictures, if there is not enough time on field, they can draw the sampling point later in the class room. If you make any further measurements (oxygen, pH, ..) the pupils can write it down here.

fig. 105: worksheet fw_01 "Log sheet"

Printformat: A4;

seen Animals and Plants



Aves and mammals: 

.....

.....



shore Zone: 


.....

.....

.....



open water Zone: 



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.....



.....



.....



fish and Crayfish: 



.....

.....

.....

fig. 106: worksheet fw_02 “Seen animals and plants”

Printformat A4;

Chapter 4 - Water Protection



1. Introduction	126
2. Potential dangers:	127
3. Protection of the lakes.....	129
4. Nature Reserves:	134

1. Introduction

Glossary:



algal bloom:	mass occurrences of algae, usually only one species
mechanical cleaning:	rough contamination is removed from the wastewater by mechanical means, such as rakes or sediment separation basins
biological cleaning:	the nutrients of the wastewater are removed with the help of aquatic organisms.
Catchment area:	refers to the area from which the rainfall arrives at through rivers or directly into the lake



Worksheets and Material:

Ring Canalisation (WP_01)

Sewage Plant (WP_02)

Water Consumption (WP_03)

Magnetic Foils: clarification plant, under water canal, washing machine, toilet, bath tube;



Questions:

- How much water does a person need in a day?
- How is the water used?
- How is waste water created?
- Where does the water come from, where does it flow to?
- Can you drink purified waste water?
- What can I do to contribute to the protection of our lakes?

Explanation:

Water is vital for humans. An adult human needs 2.5 to 3.5 liters of water per day, significantly more on hot days. But we do not use the water only for drinking, we also need it to wash, for irrigation and as an energy supplier. In addition, our lakes offer an attractive recreational area which is, in the form of tourism, of economic importance. Thus, the lakes are exposed to over exploitation. To maintain the quality of our standing waters, we must recognise the dangers and protect the waters from them. The European Commission has defined the water as inheritable

property, it is not a normal commodity and it must be protected and treated accordingly.

2 Potential dangers:

2.1 *Water withdrawal from lakes*

Water is taken from the lake for various purposes. This starts with the withdrawal of water for watering the garden or for the irrigation of agricultural land, to the drinking water and energy sector use.

In Austria, the use of water as an energy source plays an important role. In the form of storage plants, reservoirs exist in the high-alpine areas. The water is discharged through pipes into the valley and drives turbines that generate electricity.

Lakes are also important as drinking water reservoirs. The deep water of Lake Constance, for example, provides all of Stuttgart and the surrounding area with drinking water. Overall, 4 m³ of water per second are taken from Lake Constance, processed and passed on. This amount of water could fill 10 bathtubs in the blink of an eye.

The irrigation of agricultural land takes up about 35% of available freshwater in Europe. In dry areas the proportion is significantly higher. The lakes are often indirectly affected by the water from the tributaries. The worst example is the Aral Sea, located between Kazakhstan and Uzbekistan: due to the massive water extraction from the tributaries, the water level has dropped by about 20 m since 1960.

2.2 *Agriculture in the lake area:*

Fertilizers and pesticides in the water. As valuable as manure, slurry and manure as natural fertilizers for agriculture may be, they can be just as dangerous for life in the water body if not handled or processed.

Properly applied dung and liquid manure have little negative effect on water quality. Again and again, checks find that the storage and spreading of slurry and manure is carried out incorrectly.

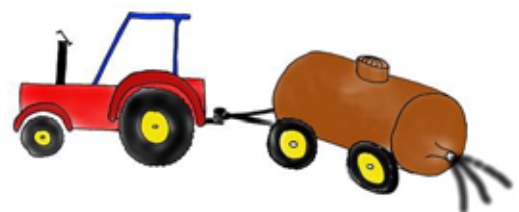
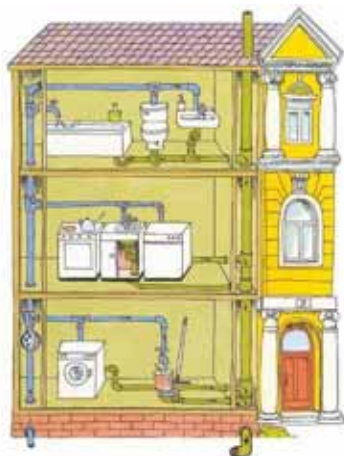


fig. 107: tractor with slurry trailer

Incorrectly means that too much fertilizer is applied or manure is stored near a body of water. Sometimes, the manure is applied up to the waters edge and then seeps into the water. The spilled agriculture pesticides can destroy the water life.

2.3 Domestic waste water:



Toilets and bath water, as well as other domestic waste water, threaten our lakes. By rising living standards and by the increased number of overnight stays for tourism in the 1960s, the impact on the lakes has been increasing. The waste water was partly untreated, or fed into the lake after a short mechanical cleaning. Through the waste water containing phosphorus, the lake was fertilized. This led to a massive presence of algae. Unsightly algal blooms, floating on the water surface.

fig. 108: wateruse in a house

2.4 Commercial and industrial waste water:

This waste water can be very different with respect to pollutant levels. Industrial waste water can not be compared with domestic waste water. It contains toxic substances which often require special cleaning procedures. It always comes back to accidents at industrial facilities. These toxic substances enter the water. This can cause the death of life in the lake. To prevent pollution of water, all waste water is treated in sewage plants.

3 Protection of the lakes

3.1 Ring canalisation:

In the 1960's the need for a clean-up of the lake basins was recognised. The introduction of sewage into the lake and thus the fertilization of the lake, led to unsightly mass emergence of blue and brown algae. The water quality of the lakes decreased dramatically. During the winter months fish deaths occurred in some lakes due to the low oxygen content under the ice. It began in the waste water in the lake environment and dissipated out of the lake drainage area. This was done largely through lake pressure pipes, which are pipes that are submerged in the lake and feed the waste water through pumping stations to sewage treatment plants. The financial cost of the construction work was enormous, and accomplished only through the cooperation of the neighboring communities and the state.

The term ring canalisation is derived from the shape of lake pressure and power lines which are sometimes encircled like a ring around the lake.



fig. 109: ring canal before sinking

3.2 Sewage Plant

A sewage treatment plant purifies the waste water flowing into it in several stages until it can be passed, largely free of organic and chemical contaminants, into streams and rivers. In a sewage treatment plant, similar processes are in operation as in an ecologically functioning river with a good self-purification capacity - but in a highly concentrated form:

1. Using screen and grit channel to remove debris particles such as sand and gravel from the wastewater.



fig. 110: screen and grit channel

2. Sedimentary solids are deposited in the primary sedimentation tank, which the wastewater slowly flows through in a few hours.

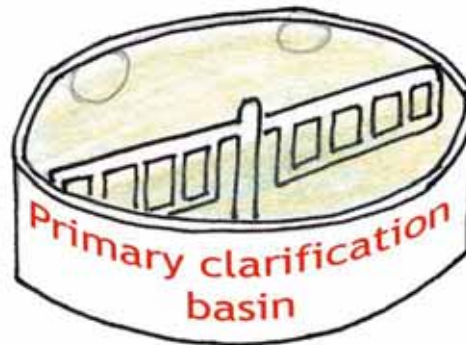


fig. 111: primary sedimentation tank

3. In the aeration tank, the dissolved and biodegradable contents of the waste water are degraded by microorganisms as in a natural river. Then they multiply due to the sizeable food source, as well as producing oxygen content and forming sludge flocs by artificial ventilation.



fig. 112: aeration tank

4. The sludge flocs are deposited in the final clarifier tank, which the wastewater slowly flows through. The treated waste water from the clarifier is fed into the waters.



fig. 113: final clarification tank

5. The bulk of the sludge, which settles at the bottom of the clarifier, is pumped back into the aeration basin in order to accelerate the biological treatment processes.

6. As necessary, the sludge extracted from the preliminary sedimentation tank and secondary clarifier tank comes into a digestion tower, in which, amongst other things, oxygen starved sewer gas exists. It is used to generate electricity. The purified water becomes a stream, flowing through the so called receiving waters. The common opinion that the purified water is of drinking quality, however, is wrong because the treated sewage still has a small residual contamination and is not germ-free. Up to 95% of the substances are cleaned from the waste water by good plants.



fig. 114: digestion tower

3.3 My lake needs my help

Much is being done to keep our lakes clean. Lake pressure pipelines and land drains collect the waste water and bring it to the sewage plant. Here, with great effort, the water is purified. In Carinthia, 90% of all households are connected to a public sewer system. Regarding the waste water at home in the toilet, the sink, the washing machine, etc. we do not need to worry. We cannot even do anything about it. Sometimes it seems that you cannot even make a contribution, since everything is already perfectly organised.

However, the waste water is drinking water that flows out of our water supply before it is waste water. Waste water reduction is an important part of the protection of our waters and protection of our water resources.

a) How can I save water?



fig. 115: water tap

Shower instead of taking a bath:

A full bath uses about 3 times as much water as a shower. About 200 liters of water fit in a bathtub. Water savings per person per day: 130 liters

Turn off the water:

When brushing teeth, washing hands or shaving, turn the tap off in between. Water savings per day per person: 1.5 - 3 liters

Constant dripping wastes water

A running toilet cistern wastes 50 liters of water a day, a dripping tap wastes up to 17 liters a day. Water savings per day: 67 liters

WC flush:

Many cisterns have an economy button; with this you save 2/3 of the water. (button)



fig. 116: washing machine

Washing machines:

New washing machines require, on average, much less water than older models. A 15 year old washing machine requires about 100 liters per load. Today's machines require about 50 liters. Also you can do without the pre-wash in most cases. Washing machines should only be operated with a full load. Water savings per day with a new washing machine: 25-35 liters (washing 5 times a week)

Water savings per day when operating with full machine: 25-35 liters (10 washes per week and half load)

b) How Can I Protect My Lake?

Careful use of water helps to reduce water consumption. But also when I walk by the lake, bathe or do sports, I can help protect my lake.

What I bring with me, I'll take away again.

It goes without saying that packaging, cans, bottles and the like that you brought with you - you take back home. Packaging material in the lake can injure the animals. Garbage can destroy the natural habitat of the lake inhabitants. Leftover food, sunscreen and leftover drinks do not belong in the lake.

Stay on the paths:

A walk along the lake is beautiful. In good weather you can enjoy the sun and with a little luck, watch birds, amphibians and other animals. In order to not disturb the young of these animals, you should always stay on marked trails. Birds are very nervous when they are disturbed at the nest. If they have to fly up too frequently the eggs cool down and die. If the amphibians leave the water in the early summer, they do so within a few days. The adjacent land areas are littered with little frogs and amphibians. Another reason to keep to the paths.

The right time for applying sunscreen:

At last you are at the beach. The sun is already shining bright in the sky. Quickly put some sunscreen on and then into the water to cool down. Wrong! The sunscreen needs some time to absorb into the skin. If you go into the water immediately after applying the sunscreen, the sun protection is gone straight away. So cool down first and then apply cream. Or apply sunscreen and wait 15 minutes before going into the water.

Reeds and Water Plant Populations

Reeds and water lily populations offer a hiding place to a variety of animals. Many animals spend their entire lives here, others only the infancy. Lily pads are anchored with their stems on the water's bottom. If you swim into such populations, the stem breaks off very easily and the leaf dies. As a bather you can already make out the aquatic plants from a distance and

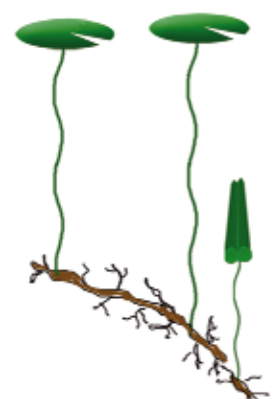


fig. 117: water lily

swim around them safely. The oar of a boat or the propeller of a motor boat can cause major damage in the water lily populations.

4 Nature Reserves:

Conservation areas are areas which serve the protection of plants and animals. They are largely natural or semi-natural areas. Through legal framework, it is clear as to what can be done in a conservation area, and respectively what is not allowed to happen under any circumstances.

In Austria there are about 380 protected areas (as of 2000), covering nearly 4% of state land. Many are also in line with international standards and recognized as such as designated Natura 2000 sites.

Tab. 2: List of the largest nature reserves in Carinthia

Name	Name
Auenmoos	Kleinfragant
Autertal	Koralm-Kar
Bretterich	Lavanteich
Drobollacher Moor	Lendspitz-Maiernigg
Egelsee	Meerspitz
Finkensteiner Moor	Moor- und Seenlandschaft Keutschach-Schiefling
Flachwasserbiotop Förderlach	Mussen
Flachwasserbiotop Neudenstein	Ossiacher See-Westbucht
Flattnitzbach-Hochmoor	Sablatnigmoor bei Eberndorf
Goesselsdorfer See Sued	Schütt - Graselitzen
Görtschacher Moos - Obermoos im Gailtal	Spintik Teich
Großedlinger Teich	Stappitzer See und Umgebung
Grünsee und Umgebung	Strussnig Teich
Guntschacher Au	Tiebelmuendung
Gurkursprung	Tiebelmündung

Name	Name
Gut Walterskirchen	Troegerner Klamm
Hallegger Teiche	Tuerkenmoos
Hoeflein Moor	Turner See
Hohe Tauern (Kernzone II und Sonderschutzgebiete)	Turner See
Hörfeld-Moor	Vellacher Kotschna
Innere Wimitz	Villacher Alpe (Dobratsch)
Inneres Bodental u. Vertatscha	Voelkermarkter Stausee
Inneres Poellatal	Wolayersee und Umgebung
Jammernspitz	Wurten (Ostteil)
Kaltschacher Moor	Wurten (Westteil)

Exercise:

A bathtub contains about 210 liters. How much water can you save when you take a shower, instead of a bath? We assume that bathing in the bathtub requires 3 x as much water as showering.

5 Worksheets with Explanations

FOR TEACHER ONLY!

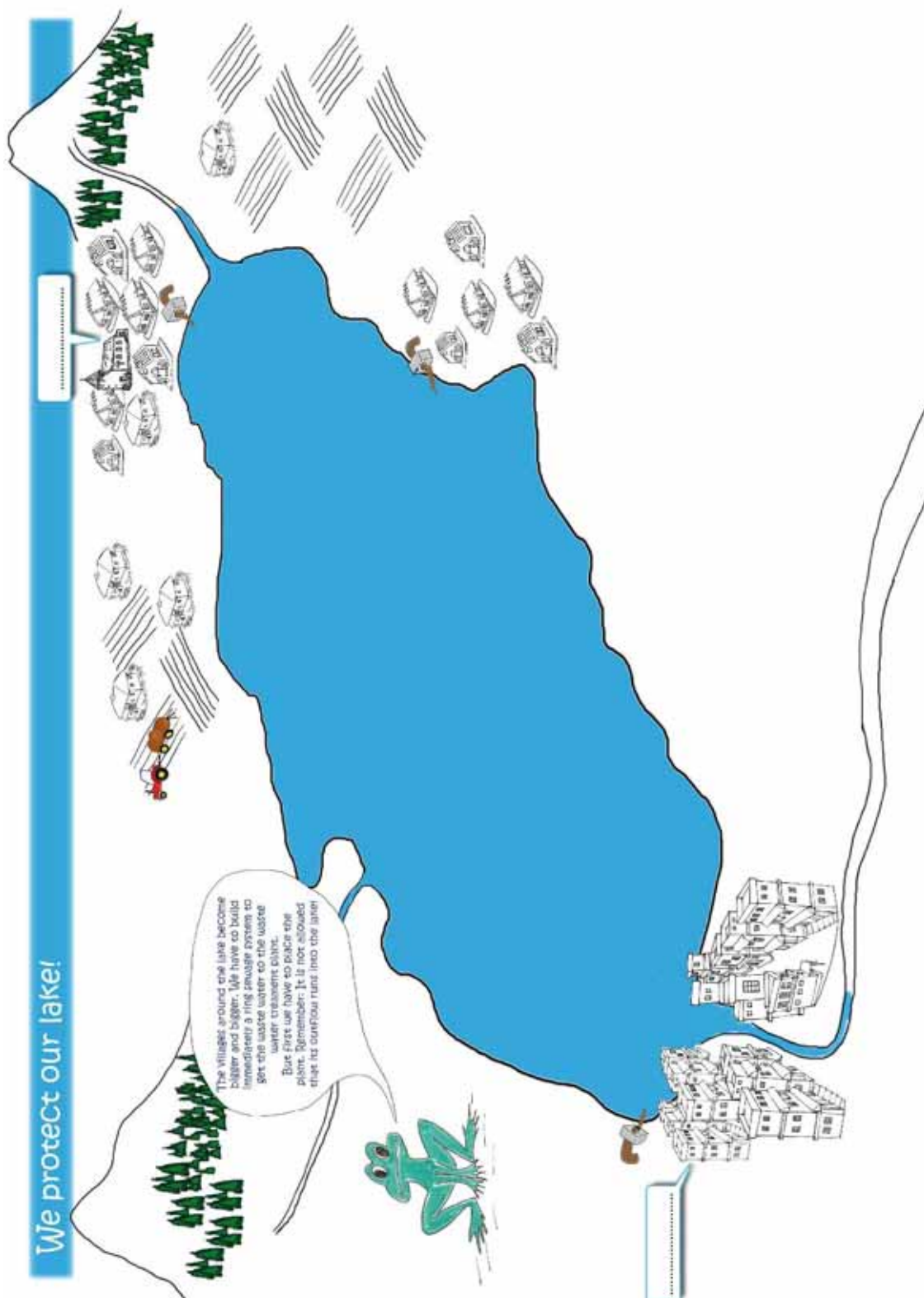


fig. 118: worksheet wp_01 "We protect our lake"

Printformat: A3; use the worksheet wp_01_2 to complete this one. Place the purification plant and the factory; make the canalisation complete.

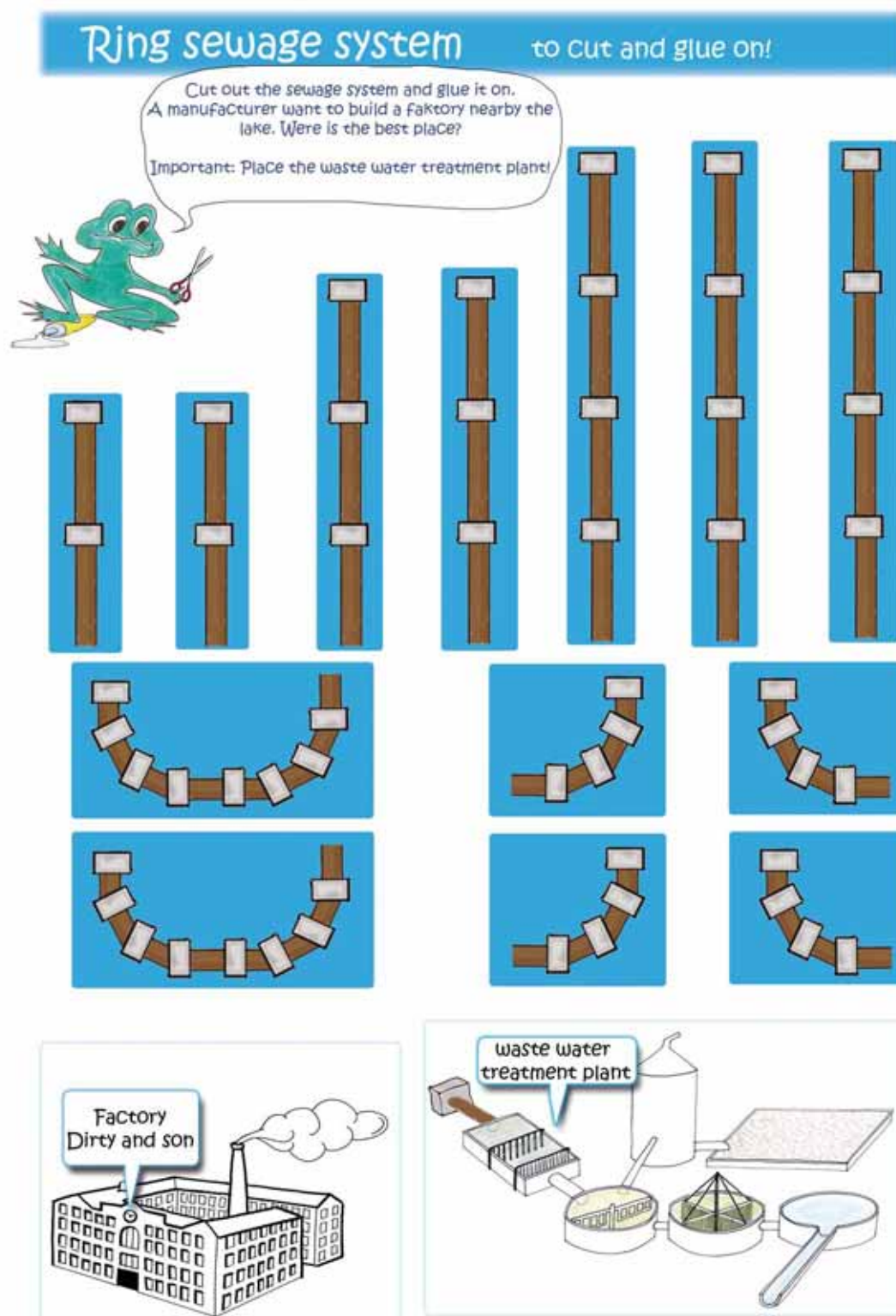


fig. 119: wp_01_2 “Ring sewage system”

Printformat: A4; use this worksheet in combination with the worksheet wp_01;

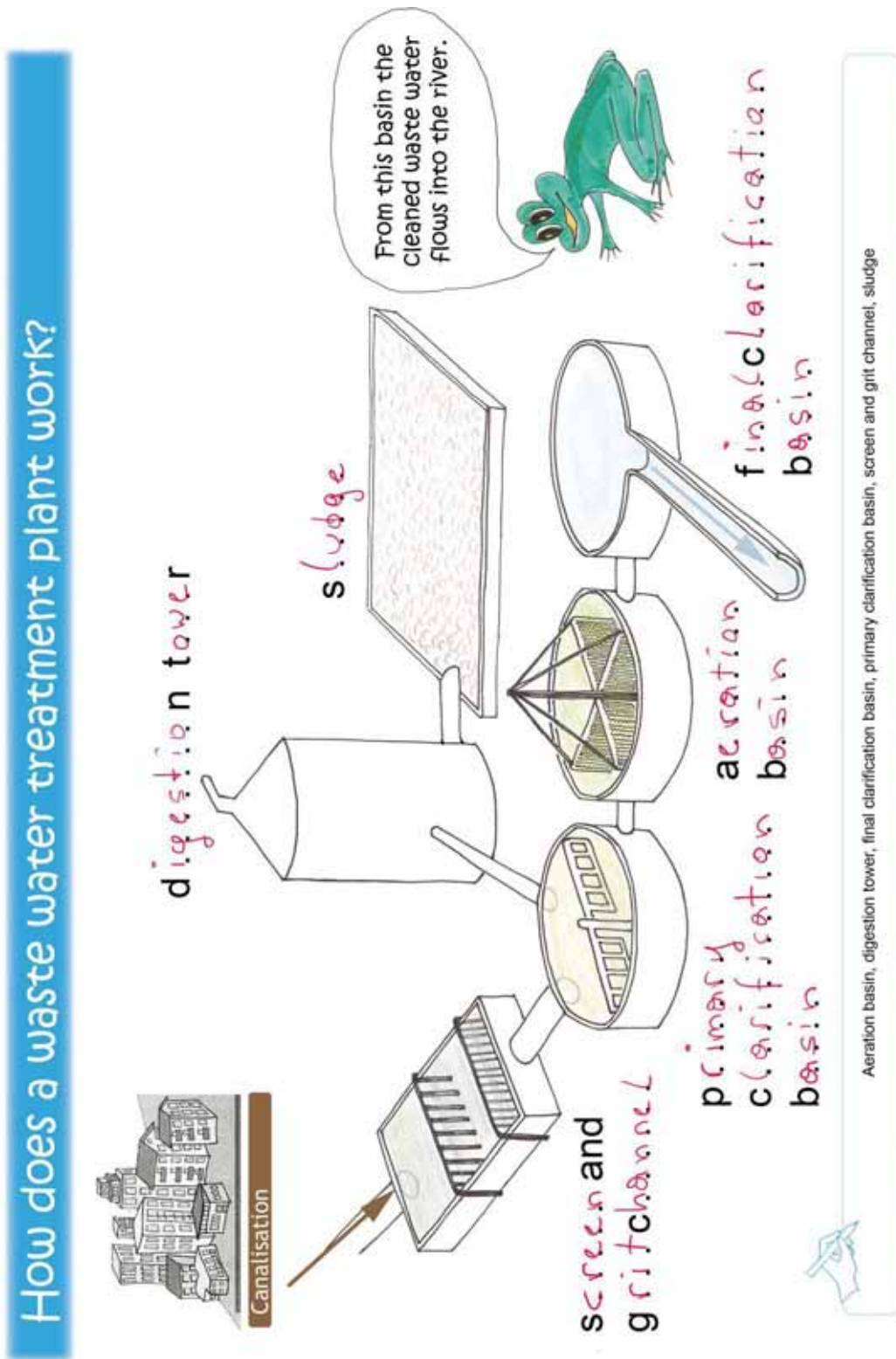


fig. 120: wp_02 "How does a waste water treatment plant work?"

Printformat A4;

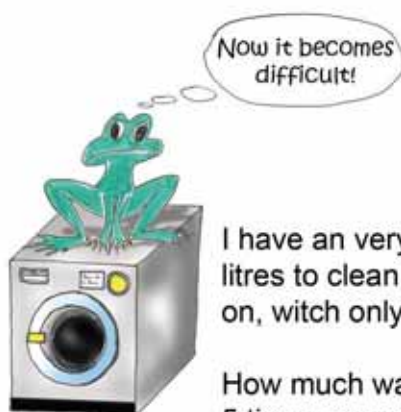
Tricky - save the water

Taking a **ba**th needs 3 times more water than taking a shower. Our bath tube has a volume about 210 litres. If I take a shower instead, this needs only

- a) 207
 b) 70 !
 c) 50 Litres of water.



With **wa**ter **sa**ving flush on toilets it is possible to save water.



I have an very old washing machine. It needs about 100 litres to clean the clothes. I am going to buy me an new on, witch only needs 50 litres.

How much water can I save, if I have to run the machine 5 times per week?

water consumption of the old machine per week:
 water consumption of the new machine per week:

500
250

saving of water per week:

250

fig. 121: wp_03 "Tricky – save the water"

Printformat A4;

Authors:

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Photos:

Aconcagua²: Fig. 31

Böhringer Friedrich²: Fig. 43

Dahlström P³: Fig.77, 79, 81

Edi06331²: Fig. 45

Kagis (kagis.ktn.gv.at): Fig.7

Kärntner Institut für Seenforschung¹: Fig. 1,108, 109

Knepp Timothy²: Fig. 78

Lorber Julia¹: Fig. 2, 4

Lorenz Edgar¹: Fig. 98

Mauruszat Axel²: Fig. 33

Menke Dave²: Fig. 30

Mildner Johanna & Friedl Maria¹: Fig. 48-53

Mildner Johanna¹: Fig. 5, 46, 110-114

Olsen Per Harald²: Fig. 28

Raver Duane²: Fig. 80

Reyes: Fig. 76

Santner Georg¹: Fig. 3, 6; 8-27, 34, 35, 37, 38, 40-42, 44, 47, 82-97, 99, 101-107, 115-121

Sebaho²: Fig. 39

Staszczuk Sławek²: Fig. 32

Szczepanek Marek²: Fig. 36

Tauno Erik²: Fig. 100

Cepická D., K. Drchal, K Hísek, J. Malý, F. Severa⁴: Fig 29

All figures of willy the water frog: Mildner Johanna¹

¹ Kärntner Institut für Seenforschung, Kirchengasse 43, A-9020 Klagenfurt

² Wikipedia (www.wikipedia.org)

³ B. J. Muus & Dahlström, P. (1998): Süßwasserfische Europas; BLV; 224pp.

⁴ Jiri Zahradnik & Cihar Jiri (1996): Der Kosmos Tierführer; 389 pp

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