We are what we eat: Human and Animal Nutrition

University Pathways Course

2017

Dr Watts

Pupils name:_____

“Dis-moi ce que tu manges, je te dirai ce que tu es.”
[Tell me what you eat and I will tell you what you are]

Anthelme Brillat-Savarin 1826

Course brief

We are what we eat: Human and Animal Nutrition

Energy and nutrients in food are vital for organisms to survive, grow, and reproduce. In this tutorial series students will delve into the world of food and nutrition, not just from a human context but also from the animal kingdom. We will investigate how energy will pass up the food chain. Advanced food web theory will be used to show the feeding habits of animals on an ecosystem level. Finally we will see how we need to better look after our world to ensure these food webs can remain stable.

In the initial tutorials, students will explore food from a plant, animal and human perspective. Later sessions will explore advanced food web theory. Here students will apply their mathematical knowledge to science understanding. At the end of the course students will be able to calculate trophic levels of multiple animals, the trophic level of themselves and put this into context of a worldwide estimate of human trophic levels. We will also look at our food in the future.

How about a nice crunchy insect?

Tutorial and Homework Timetable

For all tutorials you will need

Pen | Pencil | Colouring Pencils | Ruler | Calculator

Timetable – Tutorials

Fill this in with your teacher.

Tutorial	Date	Time	Location
1			
2			
3			
4			
5			
6			

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	Baseline test	
Tutorial 2	Food Diary	
Tutorial 3	Complete calculations	
Tutorial 4	Prepare presentation	
Tutorial 5	Final assignment	

Contents

Course brief 3

Tutorial and Homework Timetable 4

Contents 5

Tutorial 1 Food: Chain, Webs & Trophic levels 7

Objective 8

Introduction 8

Task 1: Match definitions and key words 9

Task 2: Identify which Trophic level 10

Task 3: Tutorial 1 Glossary 11

Homework 1: Baseline Test 12

Notes: 14

Tutorial 2 Food: Calculating Trophic levels 15

Objective 16

Introduction 16

Task 1: Understanding the equation 17

Task 2a: Calculating the trophic levels within the food web 18

Task 2b: Calculating the trophic level of the Bass 19

Task 3: Food ingredients 20

Table of different food items trophic levels 21

Tutorial 2: Glossary 22

Homework 2: Food Diary 23

Notes: 24

Tutorial 3 Food: Unknown Trophic Levels 25

Objective 26

Introduction 26

Task 1: Determine which Isotope is which 29

Task 2: Calculating Trophic levels 30

Task 2a: Using the equation given to you calculate the trophic level for each animal at each site 30

Task 2b: Plot the Stable Isotope values on to this graph 31

Tutorial 3: Glossary 32

Notes: 33

Notes: 34

Tutorial 4 Food: Biomass 35

Objective 36

Introduction 36

Task 1: How much biomass? 37
Homework 3: Prepare presentation 41
Tutorial 4: Glossary 42
Notes: 43
Notes: 44
Tutorial 5 Food: Population growth; the rise of meat eaters 45
Objectives 46
Introduction 46
Human Trophic level is changing 47
Meat production and Climate change 48
Task 1: Presentations from each person 49
Task 2: what are the consequences of these trends and what are the solutions 50
Task 3: Preparing for the final assignment 51
Tutorial 5: Glossary 52
Homework 5: Final assignment 53
Mark Scheme 54
Tutorial 6 Feedback 55
Task 1: Marking your own 56
Task 2: Responding to feedback 56
Task 3: Looking Forwards: Think, Pair Share 56
Notes: 57
Notes: 58
Notes: 59

Tutorial 1
Food:
Chain, Webs
&
Trophic levels

Image credits: John Gooday
https://500px.com/photo/20612947/it-s-tough-at-the-top-by-john-gooday

Objective

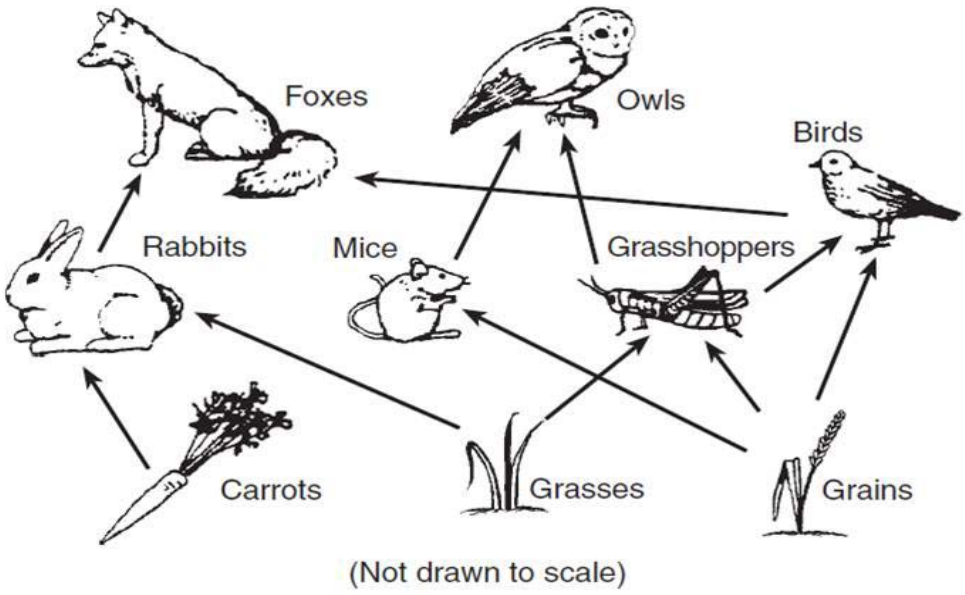
Why: It is important going forward we have a grasp of the basics of food webs and trophic levels as this will form the bases of the first half of the course.
What: Revisit the concept of food chains, food webs and trophic levels.
How: Learn the definition of each term and identify which trophic level a certain plant or animal is.

Introduction

Food and feeding are a necessary part of life. Food is defined as any substance which when consumed gives nutritional support for the body, providing energy to cells to maintain life, repair, reproduce, power activity and stimulate growth. Energy is a vital part of food.

Carbon dioxide (CO_2) and water (H_2O) is converted into glucose ($C_6H_{12}O_6$) by plants. This chemical reaction also known as photosynthesis is powered by light energy from the sun. Glucose is the basis for energy for plants; animals including us eat plants for energy. Animals that have derived energy from plants are then eaten by other animals to harvest that energy. In this way the energy that sustains us as humans is ultimately powered by the sun harvested by plants. Animals which consume plants are known as primary consumers or herbivores. Animals which eat herbivores are known as secondary consumers or carnivores. This process can be summed up via a food chain as seen opposite. Grain is the primary producer getting energy from the sun, the mouse being the primary consumer or herbivore will then eat the grain and assimilate (take up) the grain energy store. The owl being a secondary consumer or carnivore will then consume the mouse. Each time energy is passed from one organism to the other this is called going up a trophic level. Plants are at trophic level 1; herbivores at trophic level 2; carnivores are at trophic level 3.

In nature however it is not as simple as that. The mouse is not the only thing that eats grain and the owl will eat more than mice. This is where food webs come in. A food web is essentially multiple food chains joined together. It gives us a bit of a better sense of what is really happening in nature. So we can take the grain->mouse-> owl food chain and view it within a whole food web. The bird for example eats primary producers and primary consumers; this is known as an omnivore.



Question to think about

If Grains are TL 1 and grasshoppers are TL 2 what would that make Birds in this food web?

Task 1: Match definitions and key words

Food chain	Food web	Trophic level	Organism
Primary producer	Primary consumer	Secondary consumer	Decomposers

Each of the hierarchical levels in an ecosystem is called a _____, consisting of organisms sharing the same function in the _____and the same nutritional relationship to the primary sources of energy.

_____are organisms that break down dead or decaying organisms, and in doing so, they carry out the natural process of decomposition.

A _____ is an organism which consumes primary producers.

An individual animal, plant or single life form is called an _____.

A _____ is an organisms which coverts energy from the sun into organic substances via photosynthesis.

A _____is a system of interlocking and interdependent food chains.

A _____is an organism which consumes primary consumers.

Task 2: Identify which Trophic level

Lettuce

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Barn Owl

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Fox

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Shore Crab

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Cow

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Strawberry

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Mushroom

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Squirrel

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Worms

Trophic level:____

☐ Primary producer
☐ Primary consumer
☐ Secondary consumer
☐ Decomposer

Task 3: Tutorial 1 Glossary

During this course you will discover some scientific terms which you may or may not be familiar with. Throughout the course you will be given the opportunity to write your own glossary of key words. This glossary will form part of your final assessment. There are spaces at the bottom of each glossary to add in your own terms. Extra marks will be awarded for new key words.

Please write you definitions in your own words (do not simply copy the workbook, website or text books). Please also write in full sentences.

Term	Definition
Food chain	
Food web	
Trophic level	
Species	
Primary producer	
Primary consumer	
Secondary consumer	
Decomposer	

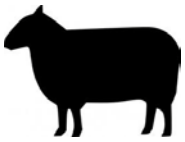
Homework 1: Baseline Test

Do not worry too much about doing 'well' or 'badly' on the baseline test, it takes into account the fact that you may not be familiar with the subject area. It is designed to help you and your tutor identify where you are at the start of the programme and to help you measure your progress along the way. That said good presentation is essential.

1. Food chains

Food chains show the flow of energy through the organism in a habitat
Here are three elements of a simple food chain.

Grass



Sheep

Humans

- Draw arrows between each box to illustrate the food chain. (2 marks)
- Label each box: a primary consumer; a primary producer; a secondary consumer. (3 marks)
- Give each box a numerical trophic level (3 marks)

The biomass in each stage of the food chain changes as food passes along the food chain

Draw a pyramid of biomass for this food chain, label in the same way as above.

(4 marks)

Draw another food web and pyramid of biomass of a primary producer, consumers and secondary consumer that does not contain humans

(6 marks)

2. Making observations in data

As part of this course you will be required to look up values from tables and be able to use it for other means. This next task will be an opportunity for you to test the skills required to do this. The following is purposefully nothing to do with the subject of this tutorial just to test your skills.

The Office for National Statistics (ONS) run a census every 10 years, this collects data on the people that live in certain areas (called wards). This data is used for many purposes such as planning infrastructure (schools, hospitals etc), developing new housing polices and track what industries are large employers in an area to assist with new jobs and training policies. This data is available in anonymised statistics via the nomisweb website.

Go to www.nomisweb.co.uk under profiles click 2011 ward profile.

The post code of the school is BS15 3LA, enter this and click search. Answer the questions below for the ward (area) around the school.

How many of the following are in this ward?

1) Females: _____

2) Males: _____

   a. What percentage of people are male? _____

3) Unemployed people: _____
   a. Are there more males than females unemployed in your ward? Y/N
   b. Is the number of unemployed people higher than the national average? Y/N

4) Retired people: _____

(7 marks)

Notes:

Tutorial 2
Food:
Calculating
Trophic levels

Raymond Lindeman

1915-1942

The creator of modern ecosystem science theory

http://cbs.umn.edu/about/cbs-greats/lindeman

Objective

Why: As we saw in tutorial 1 it is not always possible to determine trophic levels just looking at food webs, it is also important to know how much it eats. We will need to know how to apply this equation for our homework and final assignment.

What: Learn how to determine trophic levels of animals that consume more than one food source.

How: Learn how to use an equation to determine trophic level of an organism based on what and how much it eats.

Introduction

The concept of 'Trophic Dynamics' was first outlined by Lindeman (1942), who coined this term to describe the flow of energy from exogenous inputs (food) throughout food webs in an ecosystem. This concept refers to the quantitative and qualitative study of how organisms interact as predators and as prey. Trophic dynamics are important for an understanding of ecosystem health since differences in feeding in relation to habitat, season and even sex, can be indicators of differing life history strategies in a species.
Lindeman (1942) stated that energy from prey organisms will pass to the consumer organisms through discrete trophic levels (TL), where the consumer is at one trophic level higher than the prey organism. Therefore he envisaged discrete trophic levels, where TL 1 is defined as a primary producer, TL 2 a first order consumer (herbivore), TL 3 a predator of herbivores and so on. Odum & Held (1975), however, stated that most species consume prey items at more than one trophic level. (i.e the food web from the last tutorial). Therefore they proposed a system that used the proportion of the diet (observed through gut contents) to generate fractional trophic levels. This can be summarised via the following equation:

$$\tau_i = 1.0 + \sum_{j=1}^{n} (\tau_j * F_j)$$

Where:

τ =Trophic level
i = Predator species (consumer)
j = Prey Species (Food)
F = Fraction of the consumed food (Mass)

Today we will learn to use this equation to work out the trophic levels of the food web we looked at in week 1 and then go onto calculating the trophic level of the Largemouth Bass (*Micropterus salmoides*). This is a large freshwater fish species and is the top predator of certain reservoir ecosystems in the USA. Adams (1983) used the above equation to calculate its trophic level.

Largemouth Bass

Task 1: Understanding the equation

$$\tau_i = 1.0 + \sum_{j=1}^{n} (\tau_j * F_j)$$

Where:

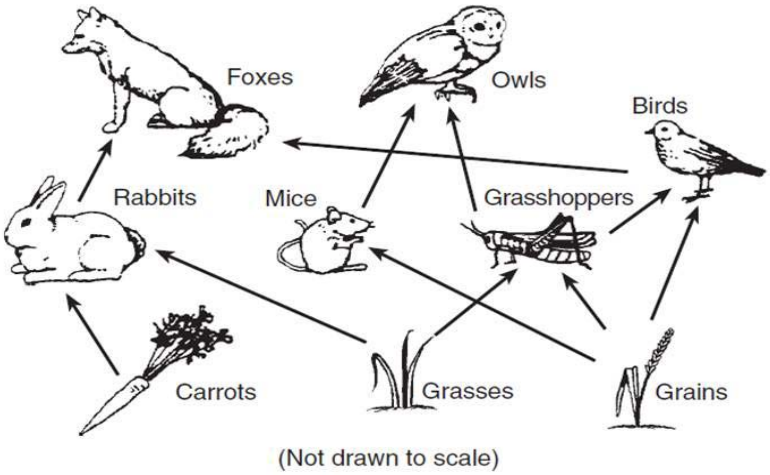
τ =Trophic level

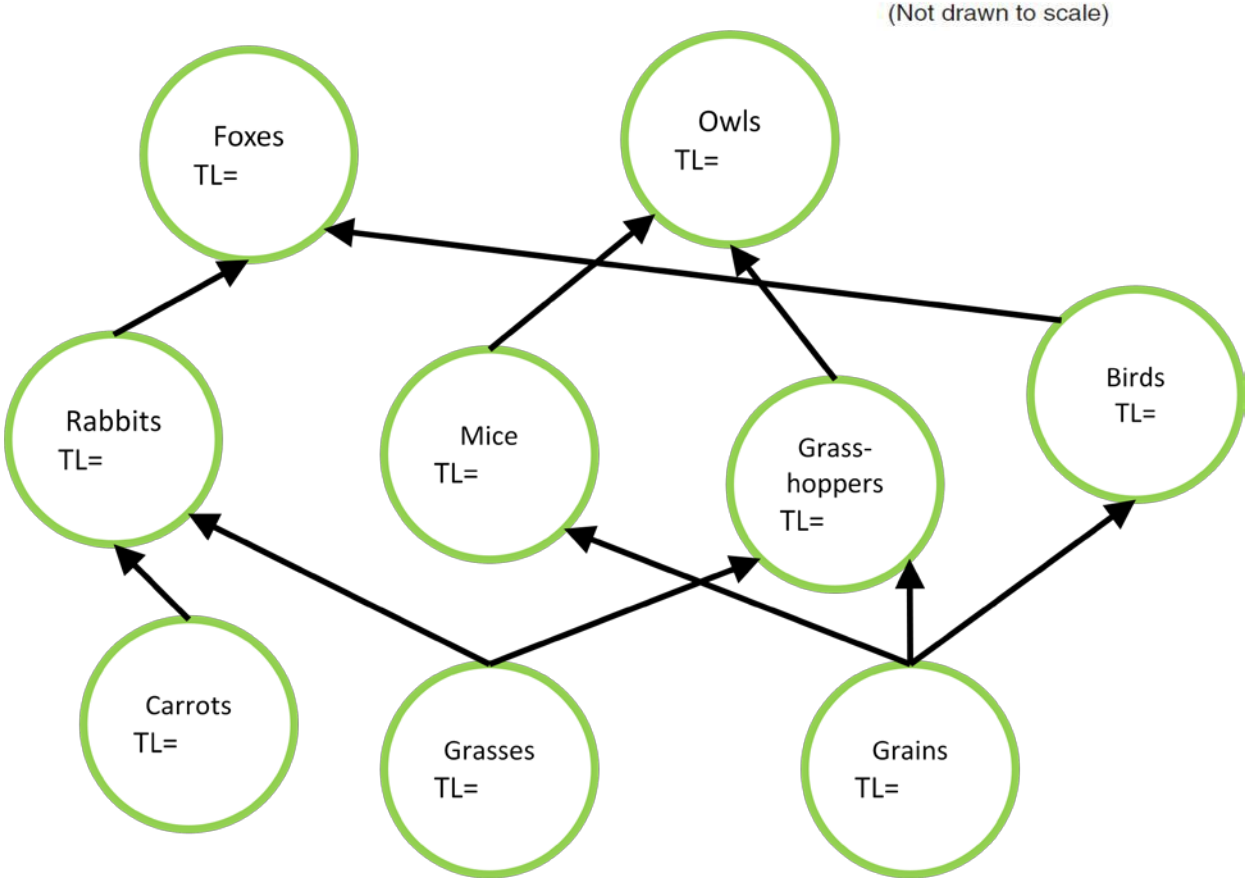
i = Predator species (consumer)

j = Prey Species (Food)

F = Fraction of the consumed food (Mass)

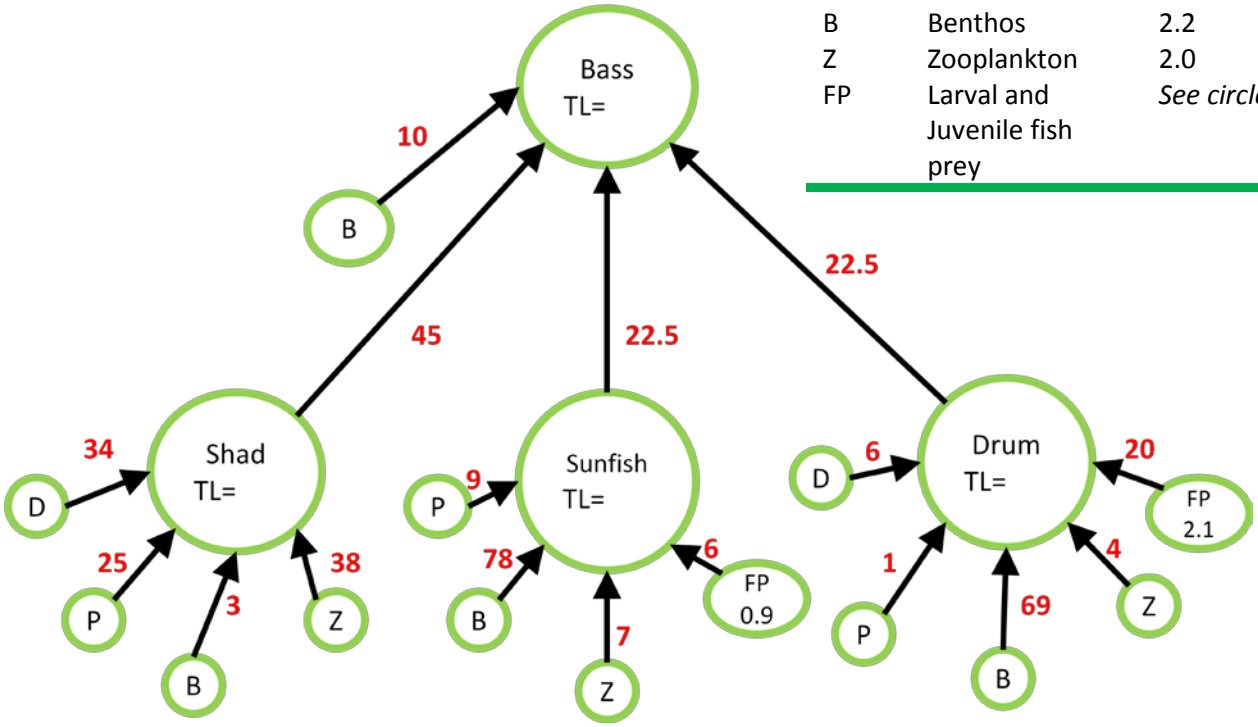
Task 2a: Calculating the trophic levels within the food web





Task 2b: Calculating the trophic level of the Bass

Code	Material	Trophic level
D	Detritus	1.2
P	Plant Material	1.0
B	Benthos	2.2
Z	Zooplankton	2.0
FP	Larval and Juvenile fish prey	*See circle*



Task 3: Food ingredients

As humans our food is very rarely single food items as we have learnt to combine food to create our cuisine; a burger for example is a mix of meat, bread, sauce, lettuce etc.

Therefore to apply trophic dynamics to ourselves (part of today's homework and the final assessment) we need to be able to look at our diet and identify the ingredients and trophic level of each of them. Here we will take a recipe for a fish pie. Using the table on the following page calculate if you were to eat nothing but fish pie what would be your trophic level?

<u>The ingredients for a fish pie that serves 4 people</u>
400g cod (a marine fish)
400g trout (a freshwater fish)
600ml full-fat milk
60g onion
4 eggs (an egg is approx 55g)
100g butter
50g plain flour
1kg potato
50g cheese

Table of different food items trophic levels

Fruit and Vegetables	TL
Apples	1.00
Aquatic Plants	1.00
Bananas	1.00
Citrus (Lemon,Limes)	1.00
Dates	1.00
Fruits	1.00
Grapefruit	1.00
Grapes	1.00
Olives	1.00
Onions	1.00
Oranges	1.00
Peas	1.00
Pepper	1.00
Pineapples	1.00
Plantains	1.00
Potatoes	1.00
Root Vegetables	1.00
Sweet Potatoes	1.00
Tomatoes	1.00
Vegetables	1.00
Yams	1.00

Oils and Fats	TL
Vegetable Oils	1.00
Animal Fat	2.05
Coconut Oil	1.00
Fats, Animals, Raw	2.00
Fish, Body Oil	3.00
Fish, Liver Oil	3.00
Groundnut Oil	1.00
Olive Oil	1.00
Palm Oil	1.00
Rapeseed Oil	1.00
Rice bran Oil	1.00
Sesame seed Oil	1.00
Soyabean Oil	1.00

Cereals/nuts/pulses	TL
Barley	1.00
Beans	1.00
Cereals	1.00
Cocoa Beans	1.00
Coconuts	1.00
Maize	1.00
Millet	1.00
Nuts	1.00
Oats	1.00
Pulses	1.00
Rice	1.00
Rye	1.00
Sesame seed	1.00
Soyabeans	1.00
Sugar (all)	1.00
Sunflower seed	1.00
Wheat /Flour	1.00

Meat and meat products	TL
Hides & Skins	2.00
Meat (Beef, Lamb, Pork)	2.05
Mutton & Goat Meat	2.00
Offals, Edible	2.00
Poultry (Chicken, Turkey)	2.10

Dairy	TL
Butter, Ghee	2.00
Cheese	2.00
Chocolate	2.00
Cream	2.00
Eggs	2.10
Milk	2.00

Drinks	TL
Coffee	1.00
Tea	1.00
Wine	1.00
Beer	1.00
Beverages, Alcoholic	1.00
Beverages, Fermented	1.00

Fish/seafood	TL
Aquatic Animals	3.00
Aquatic Mammals	4.00
Cephalopods (Squid)	3.26
Crustaceans	3.00
Demersal Fish	3.50
Fish, Seafood	3.00
Freshwater Fish	2.50
Marine Fish, Other	3.00
Molluscs, (i.e. snails)	2.27
Pelagic Fish	2.50

Other	TL
Cloves	1.00
Honey	2.00
Molasses	1.00
Mushrooms	2.00
Spices	1.00
Sweeteners, Other	1.00
Whey	1.00

Taken from Bonhommeau et al (2013) PNAS 110: 51, 20617-20620

Tutorial 2: Glossary

Term	Definition
Trophic dynamics	
Ecosystem	
Discreet Trophic Level	
Fractional Trophic Level	

Homework 2: Food Diary

Create a food diary of one day, list as many of the ingredients as you can. Draw one meal into a food web like the wide mouth bass and our fish pie. Calculate your trophic level.

If there are ingredient that are not on the table then make an educated guess. Is it a vegetable or a fruit? If so it will be a primary producer (TL=1) is it an animal? (Cows sheep pigs are all TL=2.05). If it is a mineral or an additive (E numbers for example) then disregard it in your calculations. If you are really stuck then decide on a number you think it could be and make a note why you think this (you will not get marked down for the wrong number if you have had a good go at working it out).

Notes:

Tutorial 3
Food:
Unknown
Trophic Levels

Langoustine (*Nephrops norvegicus*)
It is difficult to determine the trophic level in this species

Objective

Why: It is not always possible to watch animals eat or determine what the items in their stomach is therefore scientists have developed other methods. This will also test your mathematical skills.

What: Learn how to determine trophic levels of animals that consume more than one food source but we can't observe them feeding.

How: Using data from a method called Stable Isotope Analysis to determine trophic levels of fish and other marine life.

Introduction

In the last session we looked at calculating the trophic of a species from the food it consumes. For this to be possible we have two criteria for success: (1) we know all the organisms it is eating; (2) we know how much of the said organism it is consuming. This is not always the case. To look at what an animal has consumed we either have to observe it consuming that food or dissect out the gut of the animal and see what is left. This is very effective for something like a barn owl where you can dissect out bones and fur from their pellets identifying what it has eaten. However for other animals this can be more difficult. For example crustaceans (crabs, lobsters) when 60m under water, identifying food in their guts can be very difficult. First you cannot observe them eating, secondly they grind up their food, meaning the guts are full of tiny bones and 'muss'. This will mean if we use the gut content then we will under estimate some food items and overestimate others. This was an issue I faced in my PhD. I was studying Langoustine which is a crustacean (hard shell) which is small species of lobster. They live 60 metres below the sea surface on muddy sea bottoms. We can only get to them by putting out pots for them to climb in or to trawl for them in trawlers like the one above, so we cannot observe them feeding.

So to work out how we can determine the trophic level of these species we need to go back to first principles about trophic dynamics. Trophic dynamics as described before is where energy is transferred through the various trophic levels. However, along with the transfer of energy between trophic levels, other things will be transferred. For example the elements Carbon and Nitrogen are also incorporated into the tissues when fats (lipids) and proteins are used from the diet. Carbon enters the food chain through CO_2 to be utilised in photosynthesis, Nitrogen enters through the growing substrate (soil) of plants (for more information look at your work on the carbon and Nitrogen cycle). Carbon and Nitrogen have different isotopes (Carbon; ^{12}C and ^{13}C: Nitrogen; ^{14}N and ^{15}N). The ratio of the different Carbon isotopes and the Nitrogen isotopes will alter depending on the position within the food web.

These are stable Isotopes so unlike radioactive isotopes they do not decay and do not produce harmful radiation. They are stable as thir proton and neutron number is very similar.

Carbon

There are two stable isotopes of carbon of interest within living organisms, the heaver (^{13}C) isotope and the lighter (^{12}C) isotope. In general ^{13}C is preferentially used and then expelled following photosynthesis, and so the ratio of ^{13}C:^{12}C will be lower in carbon fixed in plant tissues than in the atmosphere. Plants can be categorised according to the particular photosynthetic pathway that they use to convert CO_2 into $C_6H_{12}O_6$. Each pathway uses the isotopes in different proportions, with the result that the ratio of ^{13}C:^{12}C will be less in C_3 plants than in C_4 plants. Carbon therefore helps sets which food web the animal is within. The ratio is noted as $\delta^{13}C$.

Nitrogen

Two nitrogen isotopes of interest, which make up the predominately protein-based nitrogen pool within an organism, are ^{14}N and ^{15}N. The lighter isotope (^{14}N) is preferentially involved in enzymatic reactions compared to the heavier isotope (^{15}N), and therefore ^{14}N is preferentially excreted by the body. For this reason the proportion of ^{15}N in the body is greater than that of the source (the food consumed). As amino acids are passed from one organism to another, the enrichment of ^{15}N increases, and for this reason the ratio of ^{15}N:^{14}N reflects the trophic level of the organism. This is noted as $\delta^{15}N$.

In isotope terms, the difference in the ratio in a consumer and ratio within its food is known as the Trophic Enrichment Factor (TEF) where,

$$TEF = \delta_{animal} - \delta_{food}$$

This was estimated by Peterson and Fry (1987) to be around 3.4‰ for $\delta^{15}N$ and 0-1‰ for $\delta^{13}C$ (Post, 2002).

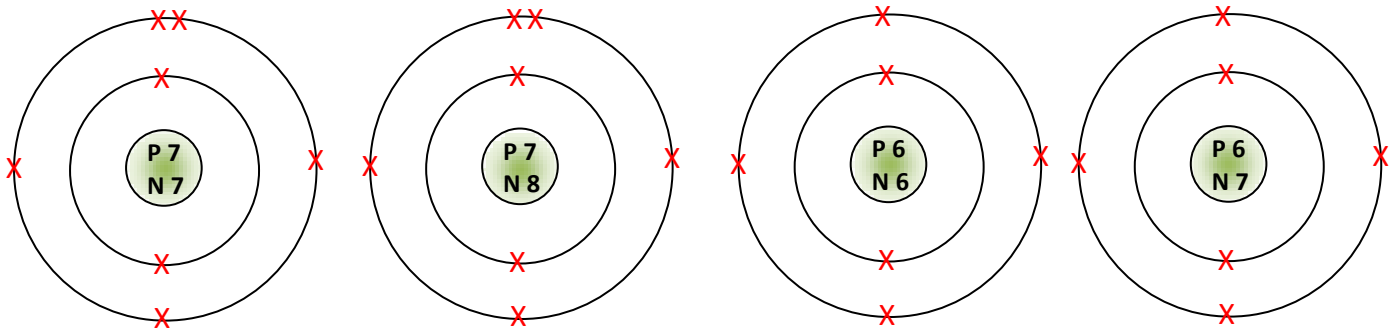
To convert $\delta^{15}N$ into a trophic level we need to understand the environment the organism has come from. Nitrogen can enter the environment from a number of sources which can influence the $\delta^{15}N$ of the primary producer. For example artificial fertilisers and animal faeces contain nitrogen therefore can influence $\delta^{15}N$. We therefore need to calibrate the measurement with a baseline.

A traditional way of establishing this baseline is to use the primary producer (TL=1) in the ecosystem. Within the marine ecosystem, this is phytoplankton. Phytoplankton is extremely small photosynthic plants which float in the sea. From the photos you can see Dr Watts collecting water samples from a Niskin Bottle, to collect the phytoplankton. One issue with this though is the $\delta^{15}N$ value of phytoplankton can, however, vary between 6-10‰ throughout the year due to nutrient availability and light levels (Jennings & Warr, 2003). Hill (2008) showed that during the spring bloom of phytoplankton in 2004-05 the particulate organic matter (POM) decreased in the value of $\delta^{15}N$ from 7.4‰ pre-bloom to 2.9‰ during this bloom.

We therefore need to use something else. Filter feeders will consume this phytoplankton throughout the year therefore will have a more stable $\delta^{15}N$ than phytoplankton. The filter-feeding queen scallop, *Aequipecten opercularis* (see opposite) can therefore be used. The assumption in using these types of animals is that they will be feeding at a fixed Trophic Level of 2.5, and that they represent the community from which they are taken. The following equation will estimate TL:

$$TL_{sample} = \left(\frac{\delta^{15}N_{animal} - \delta^{15}N_{base}}{TEF}\right) + TL_{base}$$

Task 1: Determine which Isotope is which



Task 2: Calculating Trophic levels

In June 2010 Dr Watts went to two Scottish fishing grounds: one in the North of Scotland (near Stornoway (the North Minch); one in the South just outside Glasgow (the Clyde Sea Area). Here he sampled 6 species of marine organism to see how the two fishing individuals differ in terms of the same animals feeding at different trophic levels. We have to use a filter feeder as the base with the assumption that the Queen scallop (*Aequipecten opercularis*) was at TL 2.5.

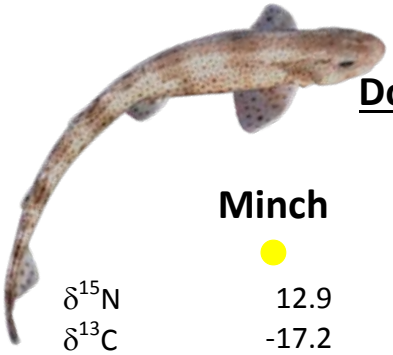
Task 2a: Using the equation given to you calculate the trophic level for each animal at each site

Queen scallop

	Minch ●	Clyde ▲
$\delta^{15}N$	7.2	10.9
$\delta^{13}C$	-17.4	-16.0
TL	2.5	2.5

Long rough dab

	Minch ●	Clyde ▲
$\delta^{15}N$	12.4	15.3
$\delta^{13}C$	-17.6	-16.2
TL	_____	_____



Dog fish

	Minch ●	Clyde ▲
$\delta^{15}N$	12.9	16.8
$\delta^{13}C$	-17.2	-15.3
TL	_____	_____

Langoustine

	Minch ●	Clyde ▲
$\delta^{15}N$	11.2	12.9
$\delta^{13}C$	-16.4	-15.1
TL	_____	_____

Squat Lobster

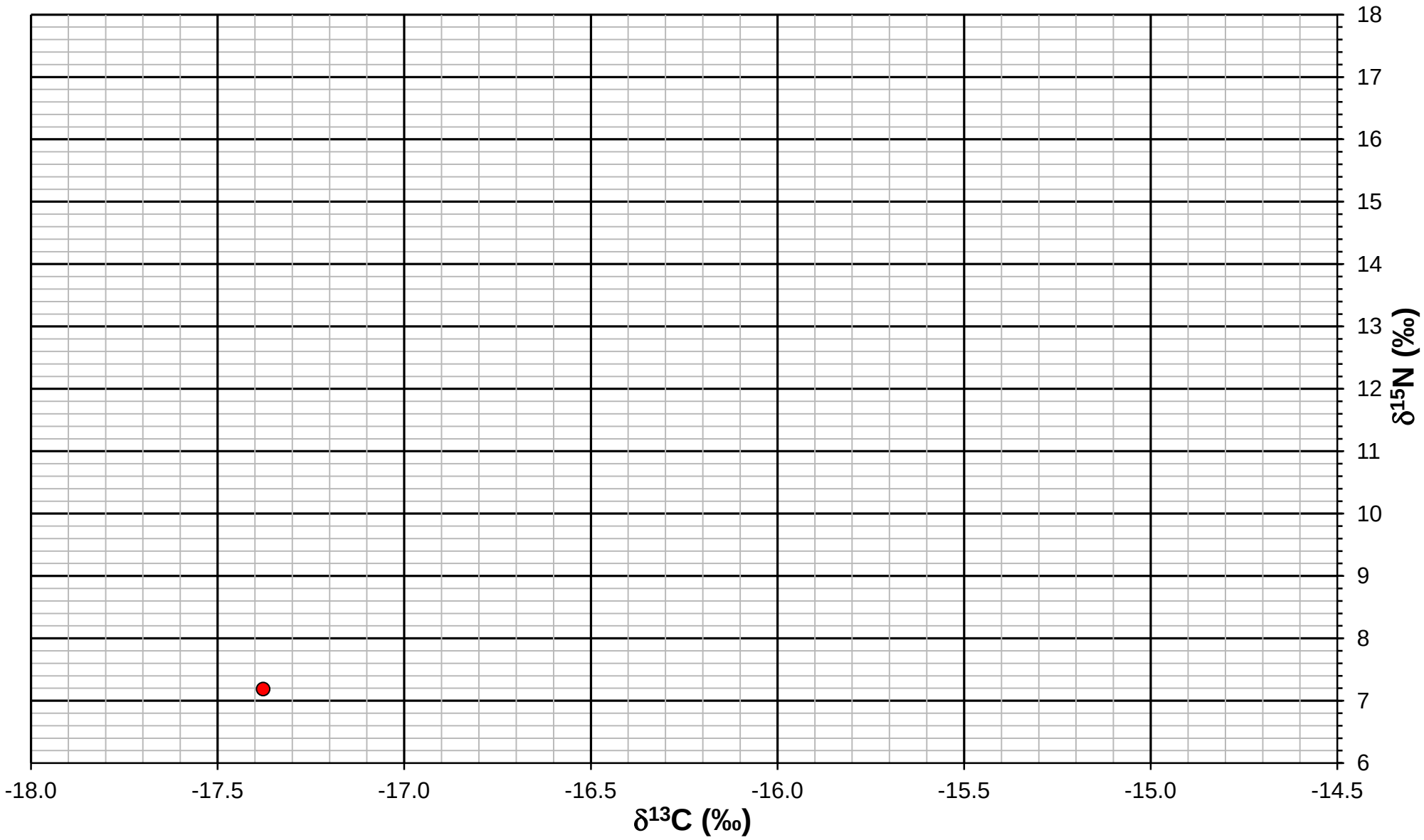
	Minch ●	Clyde ▲
$\delta^{15}N$	11.3	14.4
$\delta^{13}C$	-16.4	-15.4
TL	_____	_____

Whiting

	Minch ●	Clyde ▲
$\delta^{15}N$	13.9	16.4
$\delta^{13}C$	-17.7	-16.8
TL	_____	_____

Task 2b: Plot the Stable Isotope values on to this graph

Scallop from the Minch has been done for you



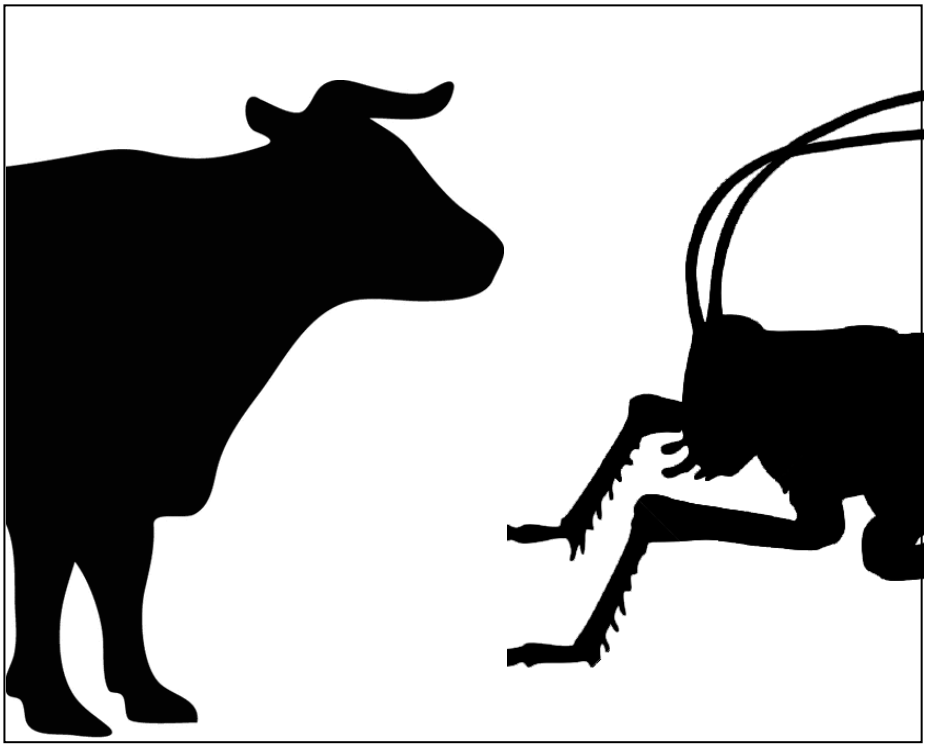
Tutorial 3: Glossary

Term	Definition
Isotope	
Stable Isotope	
^{12}C	
^{13}C	
^{14}N	
^{15}N	
Trophic Enrichment factor	
Trophic baseline	

Notes:

Notes:

Tutorial 4
Food:
Biomass



Animals will transfer more energy to the next trophic level than others

Objective

Why: Not all energy is passed from one trophic level to the next; this has consequences when eating animals high in a food chain.

What: Learn how to determine how much energy is converted from an animal's food into stored energy in its body, which is then available to the next level on the food chain.

How: Using data about energy consumed and energy used for living to determine the energy left over for growth, we will then consider what this means for our food.

Introduction

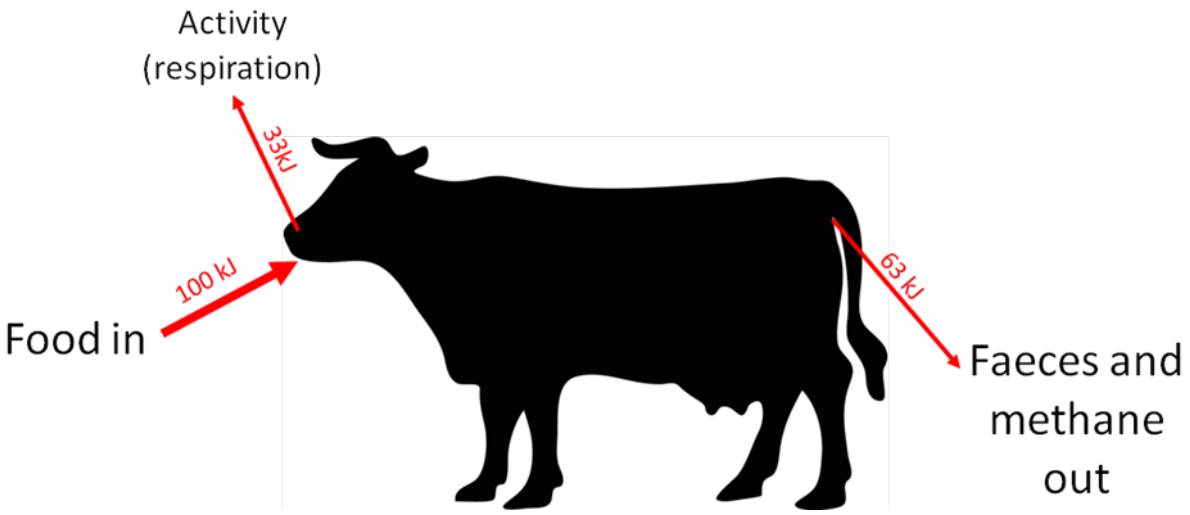
We have been learning about the transfer of energy from one organism to the other. An organism will accumulate energy over from feeding however not all of it will be passed onto the next trophic level. Not all energy is assimilated into tissues for growth. Other processes also require energy, staying alive is a costly energy business, our background functions, breathing, digestion, repair, reproduction all requires energy. Also we will not consume all the energy within the food, there will be unconsumed parts (bones, skin etc) even if we do it we might not digest and assimilate everything. In your first homework you were asked to draw food pyramids to show that not all energy is passed from one trophic level to the next. It is generally assumed that 10% is lost between trophic level however this is just an average and different trophic relationships will generate different percentages. To calculate how much energy is assimilated into an animal we can calculate the scope for growth.

Scope for Growth is defined as the amount of energy which is left after all other metabolic costs are subtracted. Positive values indicate excess energy to be used in growth and negative values indicate the depletion of internal energy stores. It is quite difficult to measure directly energy used in movement and other metabolic active activities, However assuming these activities are done via aerobic respiration we can use oxygen consumption as a proxy for activity (more activity more oxygen consumed) Scope for Growth can be calculated by the equation:

$$\mathbf{SfG = C - (R + W)}$$
$$\mathbf{W = (F + U + G)}$$

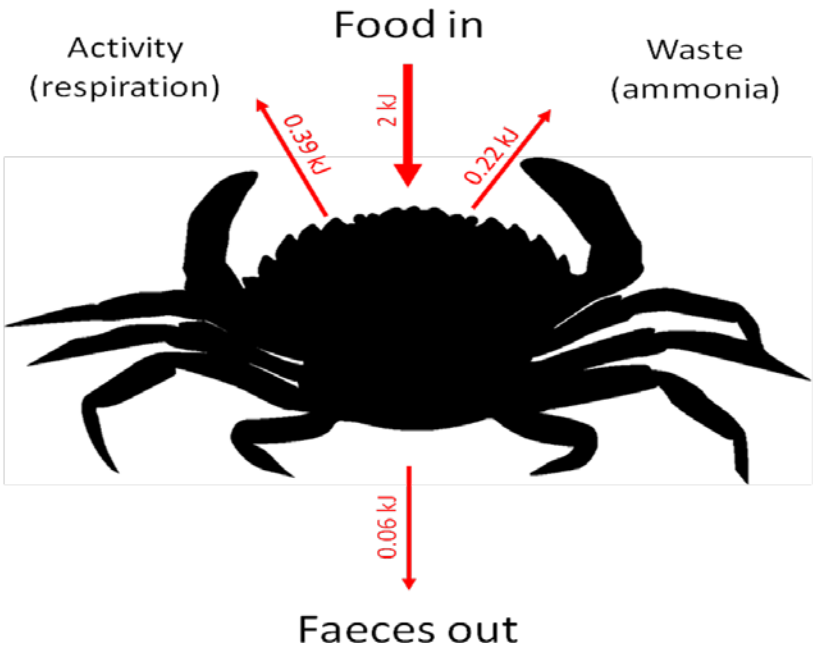
where
SFG = scope for growth;
C = energy consumed from food,
R = energy lost from respiration (oxygen consumption)
W = energy lost as waste made up of
F = energy excreted as solid material (faecal pellets);
U = energy excreted as liquid material (urine, urea or ammonia).
G = energy excreted as gaseous material (methane)

Task 1: How much biomass?



How much energy is being used for growth and maintenance?

What percentage is converted into biomass?



How much energy is being used for growth and maintenance?

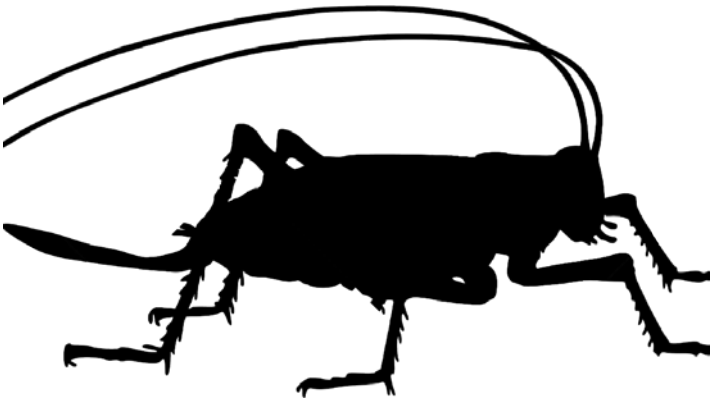
What percentage is converted into biomass?

C) Food in =3 kJ
R) Respiration =0.54 kJ
U) Waste =0.04 kj
F) Faeces out = 0.02 kJ

Draw the arrows on the diagram

How much energy is being used for growth and maintenance?

What percentage is converted into biomass?



C) Food in = 1kJ
R) Respiration = 0.3kJ
U) Waste = 0.15kj
F) Faeces out = 0.07kJ

Draw the arrows on the diagram

How much energy is being used for growth and maintenance?

What percentage is converted into biomass?

Homework 3: Prepare presentation

Insects are the future of food
Prepare a 3 minute presentation to argue for or against this statement
(Your position will be given to you before the end of this session)
Be prepared to defend your position

It is up to you how you want to present (Poster, PowerPoint, using props)

Here is an article you can look at to get started.
http://www.bbc.com/future/story/20141014-time-to-put-bugs-on-the-menu

Tutorial 4: Glossary

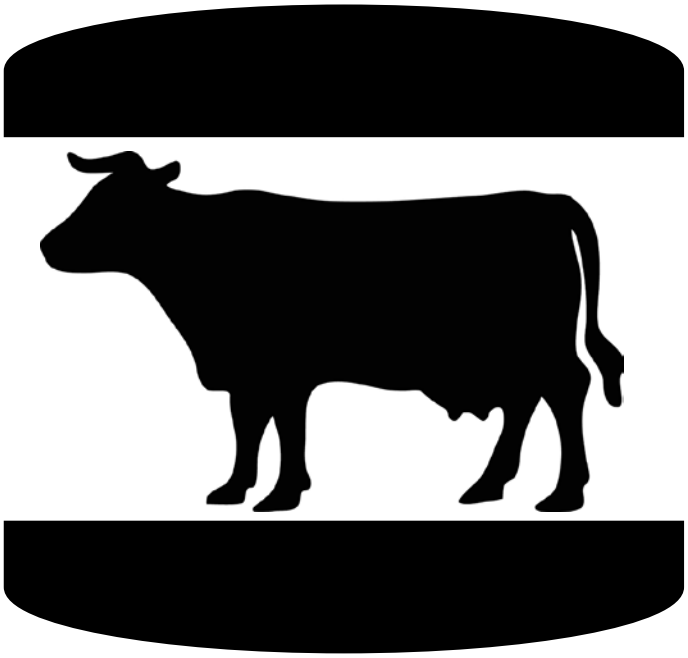
Term	Definition
Scope for growth	
Assimilation	
Biomass	
Energy	
Respiration	

Notes:

Notes:

Tutorial 5
Food:
Population growth; the rise of meat eaters

.



Objectives

What: Discuss issues relating to our food and how secure it will be in the future

How: Using published literature and your presentations from your homework we will discuss issues we will have as a worldwide population concerning our food production and consumption.

Why: The population of the world is growing all the time, this growing population needs to eat and people in developing countries are now consuming a more westernised meat based diet, this is going to have consequences on our resources and climate change, something needs to be done about it.

Introduction

So far this course has covered a few general principles of food both within nature and within our diets. In the last tutorial we introduced possible issues with the what we might eat in terms of biomass reducing as we increase in trophic levels and certain animals (i.e. Cows) being less efficient at converting energy from food into biomass (meat). Today's tutorial is going to focus more about other issues that we as a species are facing when it comes to what we eat and how much of it we do.

We live in a world of a growing population, rising greenhouse gases leading to climate change and the knowledge that our ever convenient lifestyle could actually be damaging to our health. I start this tutorial with an announcement, I am not a vegetarian and my aim in this next hour is not to make you one. I do however want to challenge you to think critically about society's attitude to science and to what it eats.

We have been learning about trophic levels, even calculated our trophic level for a meal we had a few weeks ago. Bonhommeau et al (2013) calculated this using the table we have in tutorial 2 to estimate the human trophic level for the whole world. They concluded that the world average is 2.21 with the spread between 2.04 (a vegan diet) to 2.57 (an omnivores diet with slightly more meat consumption than plant consumption). They did however show that although this is remaining stable in many parts of the world as countries such as India and China are developing so is their love of meat. More information on this can be seen on later pages.

As we noted in tutorial 4, cows release a lot of methane. Methane is a major contributor to climate change, and much more potent than carbon dioxide. McMichael et al (2007) indicates that over 22% of all greenhouse gases come from livestock production. Gases produced each year have been estimated to be 1906 million tonnes in Cattle, 590 million tonnes from pigs and 61 million tonnes from poultry. 83 million tonnes of gases Cattle produce is methane gas (75 from the cow directly and 8 from manure). Methane has more impact on climate change than Carbon dioxide. Therefore not all meat has the same impact on climate change. Climate change itself will have an impact on our food, increasing temperatures and an increase in 'freak' nature events will cause greater failed crops especially in developing countries. It will also cause natural population (especially fish) to migrate further away from the equator to keep within their optimum temperature range. The key findings from McMichael et al (2007) can be found later.

Human Trophic level is changing

"Trophic levels are critical for synthesizing species' diets, depicting energy pathways, understanding food web dynamics and ecosystem functioning, and monitoring ecosystem health. Specifically, trophic levels describe the position of species in a food web, from primary producers to apex predators (range, 1–5). Small differences in trophic level can reflect large differences in diet. Although trophic levels are among the most basic information collected for animals in ecosystems, a human trophic level (HTL) has never been defined. Here, we find a global HTL of 2.21, i.e., the trophic level of anchoveta. This value has increased with time, consistent with the global trend toward diets higher in meat. National HTLs ranging between 2.04 and 2.57 reflect a broad diversity of diet, although cluster analysis of countries with similar dietary trends reveals only five major groups. We find significant links between socio-economic and environmental indicators and global dietary trends. We demonstrate that the HTL is a synthetic index to monitor human diets and provides a baseline to compare diets between countries."

Taken from Bonhommeau et al (2013) PNAS 110 51 20617-20620

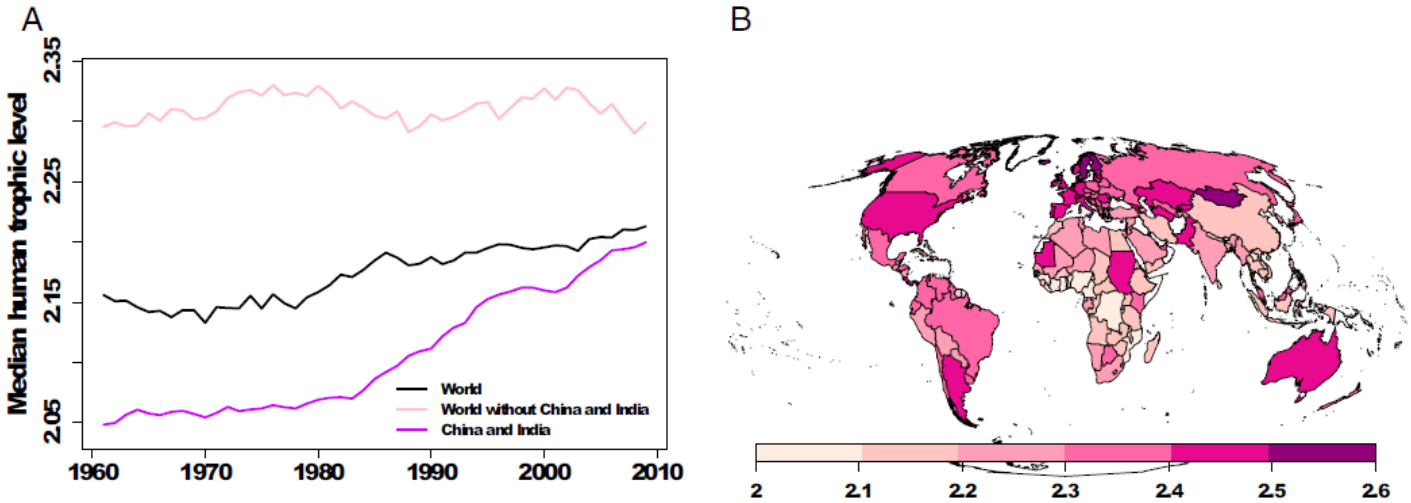
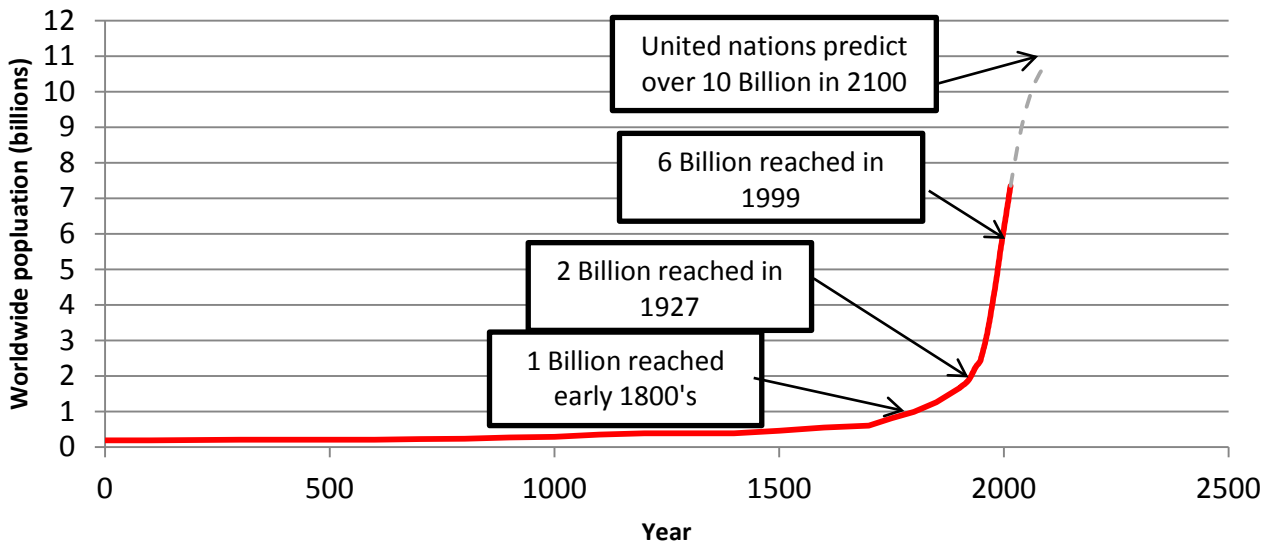


Fig. 1. (*A*) Trends in the human trophic level (1961–2009) and (*B*) map of the median human trophic level over 2005–2009.

Population rise



Meat production and Climate change

- *Greenhouse gas emissions from the agriculture sector account for about 22% of global total emissions; this contribution is similar to that of industry and greater than that of transport. Livestock production (including transport of livestock and feed) accounts for nearly 80% of the sector's emissions*
- *Methane and nitrous oxide (which are both potent greenhouse gases and closely associated with livestock production) contribute much more to this sector's warming effect than does carbon dioxide*
- *Halting the increase of greenhouse-gas emissions from agriculture, especially livestock production, should therefore be a top priority, because it could curb warming fairly rapidly. However, livestock production is projected, on current trends, to increase substantially over the next four decades, mainly in countries of low or middle income.*
- *Available technologies for reduction of emissions from livestock production, applied universally at realistic costs, would reduce non-carbon dioxide emissions by less than 20%. We therefore advocate a contraction and convergence strategy to reduce consumption of livestock products, mirroring the widely supported strategy proposed for greenhouse-gas emissions in general. Contraction of consumption in high-income countries per head would then define the lower, common, ceiling to which low-income and middle-income countries could also converge*
- *Assuming a 40% increase in global population by 2050 and no advance in livestock-related greenhouse-gas reduction practices, global meat consumption would need to fall to an average of 90 g per person per day just to stabilise emissions from this sector. Such a decrease would require a substantial reduction of meat consumption in industrialised countries and constrained growth in demand in developing countries, especially of red meat from ruminant (methane-producing) animals*
- *A substantial contraction in meat consumption in high-income countries should benefit health, mainly by reducing the risk of ischaemic heart disease (especially related to saturated fat in domesticated animal products), obesity, colorectal cancer, and, perhaps, some other cancers. An increase in the consumption of animal products in low-intake populations, towards the proposed global mean figure (convergence), should also benefit health*
- *The resultant gains in health and environmental sustainability should help to offset any (initial) discomforts from restrictions on some popular foods and altered dietary customs. Replacing ruminant red meat with meat from monogastric animals or vegetarian-farmed fish would reduce methane production and lower the pressures on wild fisheries as sources of fishmeal for aquaculture*
- *Climate change will, itself, affect food yields around the world unevenly. Although some regions, mostly at mid-to-high latitude, could experience gains, many (eg, in sub-Saharan Africa) are likely to be adversely affected, with impairment of both nutrition and incomes. Compensating vulnerable populations for this and other climate-mediated harm caused by other populations should be an important element of global climate change policy*
- *Global population growth is continuing, although slowing. The eventual peak size is not predetermined: it can be lowered by education, leadership, and wider contraceptive availability. Slower population growth will help achieve the Millennium Development Goals and will limit population size, climate change, and the environmental effects of food production*

Key messages reproduced from McMichael et al (2007)

Task 1: Presentations from each person

Over to you, use this space to make notes. Come up with a couple of questions from each presentation.

Task 2: what are the consequences of these trends and what are the solutions

Discuss in pairs, mind map ideas and be ready to share to the rest of the group

Task 3: Preparing for the final assignment

Tutorial 5: Glossary

Term	Definition

Homework 5: Final assignment

Calculate trophic levels in animals and humans. Are we eating sustainably?

Details of final assignment:
Report (Maximum 1,000 words not including tables of figures.)

1. Calculate the trophic level of someone who would eat nothing but the one dish on the handout handed to you. Compare this with your trophic level based on your homework Tutorial 2. What is different and what is similar? Which is more sustainable?

(Calculation showing working out and 500 word comparison)

2. Based on the science, what is the future of food? What are the challenges we face going forward? Make special reference not just to ecological sustainability under growing population and changing food consumption patterns, but also to the health and social aspects of this challenge.

(1000 words)

3. Reproduce the glossaries from each tutorial into one glossary; ensure that the words are in alphabetical order and the definitions are written in full sentences.

(Between 30-50 terms, I have provided you with 26 terms but no terms for the last tutorial)

The Deadline is:

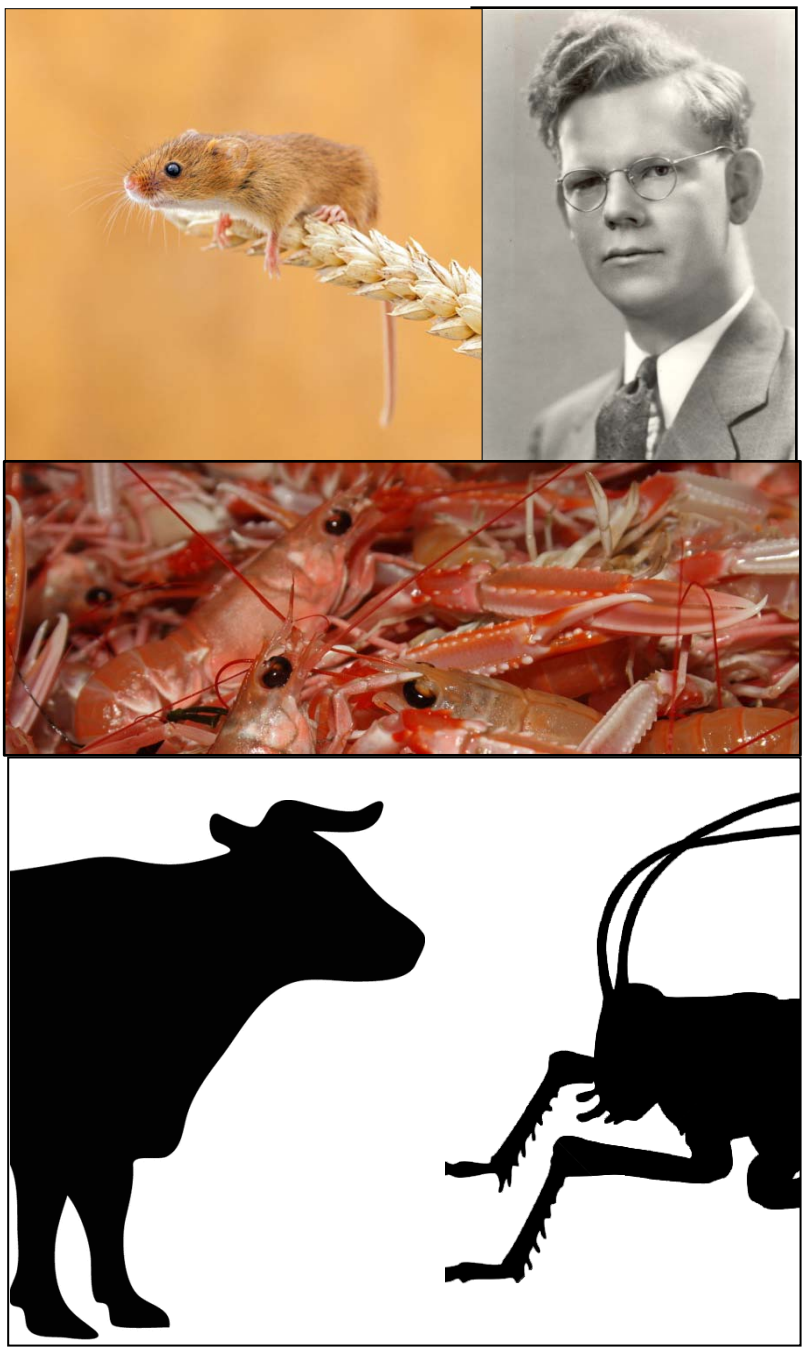
Mark Scheme

Key Skill	1st	2nd (2:1-2:2)	3rd
Scientific communication	☐ Writing is coherent and organised following a logical structure. ☐ Almost faultless spelling, punctuation and grammar. ☐ Writing is of an appropriate style for the scientific document written in the third person.	☐ The writing at times is poorly organised with a lack of coherent structure. ☐ The spelling, punctuation and grammar are weak in places. ☐ Inconsistent in use of style throughout resulting in lack of clarity.	☐ Writing is poorly organised with a lack of logical structure. ☐ The spelling, punctuation and grammar is weak.
Applying knowledge and understanding	☐ Gaining new insight from wider reading. ☐ Suggesting new ideas that were not taught in the class. ☐ An extensive glossary with many relevant terms with correct meanings in most.	☐ Some attempt at applying wider reading to the written. ☐ Suggesting new ideas that were not taught in the class. ☐ A glossary with just the terms set out in the workbook.	☐ Insight from provided reading. ☐ No new ideas suggested. ☐ A fair attempt at a glossary. Let down by either with too few terms (<26) or errors in many of the description.
Analytical evaluation	☐ Well worked through example clear and precise with no mathematical errors. Working has been shown. ☐ Able to discuss the differences within the two diets and brining in other part of the course or wider reading.	☐ A fair attempt at the Trophic level task with a few errors in the calculations. ☐ Some ingredients which are in the table provided have the wrong Trophic level. ☐ Making some comparisons but not linking it to any wider reading.	☐ Worked through to answer but no working, or many issues applying the equation. ☐ No or little comparisons made between diets.

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-Level
2:1	60-69	Performing to a good standard at A-Level
2:2	50-59	Performing to an excellent standard at current key stage
3rd	40-49	Performing to a good standard at current key stage
Working towards a pass	0-39	Performing below a good standard at current key stage
Did not submit	DNS	No assignment received by Dr Watts

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Tutorial 6
Feedback



What is the Purpose of Tutorial 6?

Reflect on skills learned on the programme with a view to encouraging resilience
Receive feedback on final assignment

What are the key questions?

What strengths have I demonstrated in my work and what areas of development are there left for me to address?
What steps do I need to take to improve my academic output?

Task 1: Marking your own

Using the mark scheme, identify three things you did well and three things you could improve.

What went well?

1.
2.
3.

What could be improved?

1.
2.
3.

Task 2: Responding to feedback

Read through your feedback sheet and highlight on your assignment where you received positive feedback (one colour) and areas for improvement (different colour). You might find it helpful to annotate this with a brief comment or two.

Task 3: Looking Forwards: Think, Pair Share

Think about how you can use this feedback in your future school work.
Talk to your partner about how you both plan to make changes to your school work in the future as result of this feedback
Share your ideas as a group.

Notes:

Notes:

Notes:

RESEARCHERS IN SCHOOLS
R
RESEARCHERS IN SCHOOLS