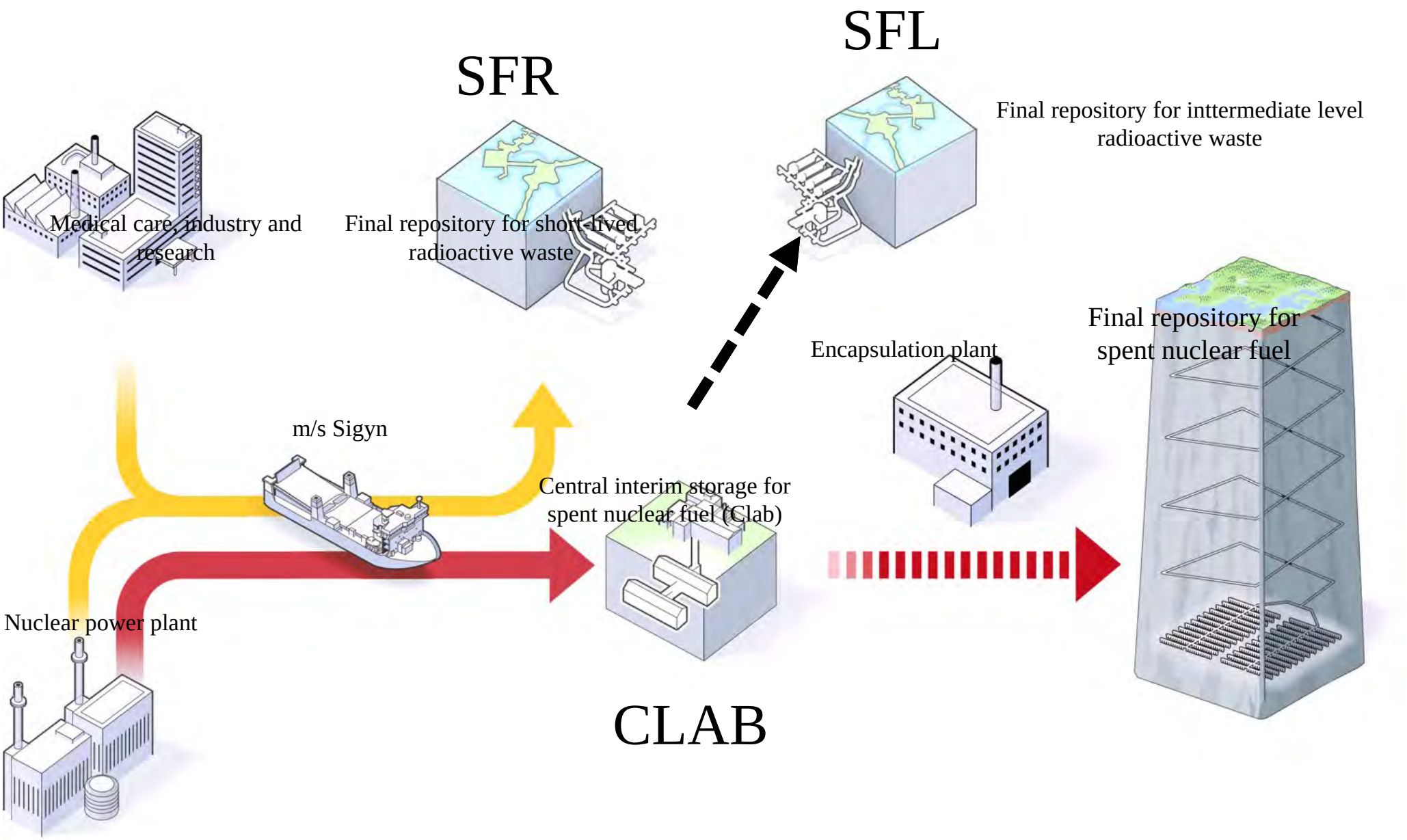
Implementing an ecosystem approach in practice

Ulrik Kautsky

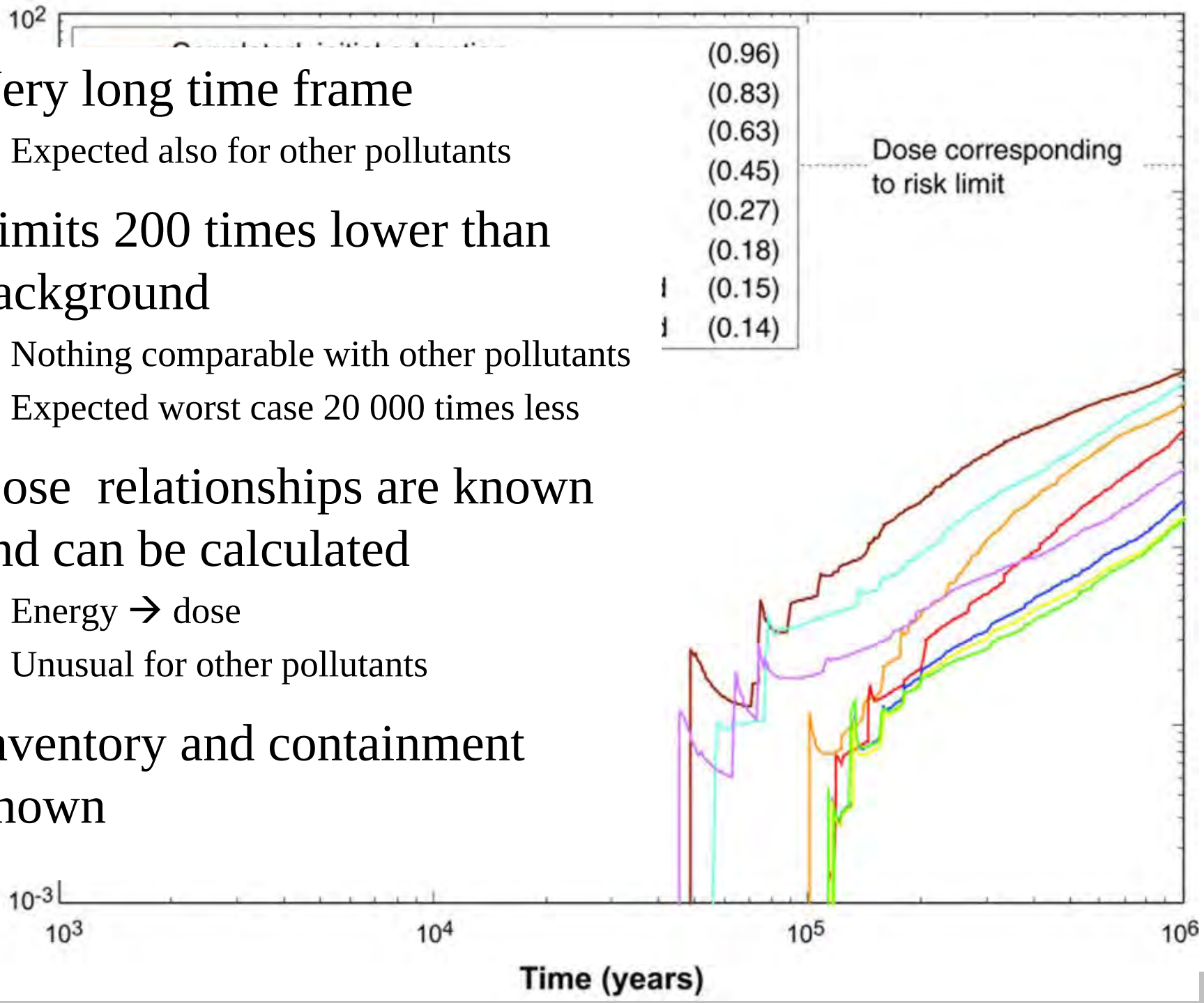
Swedish Nuclear Fuel and Waste Mngmt Co.

SKB

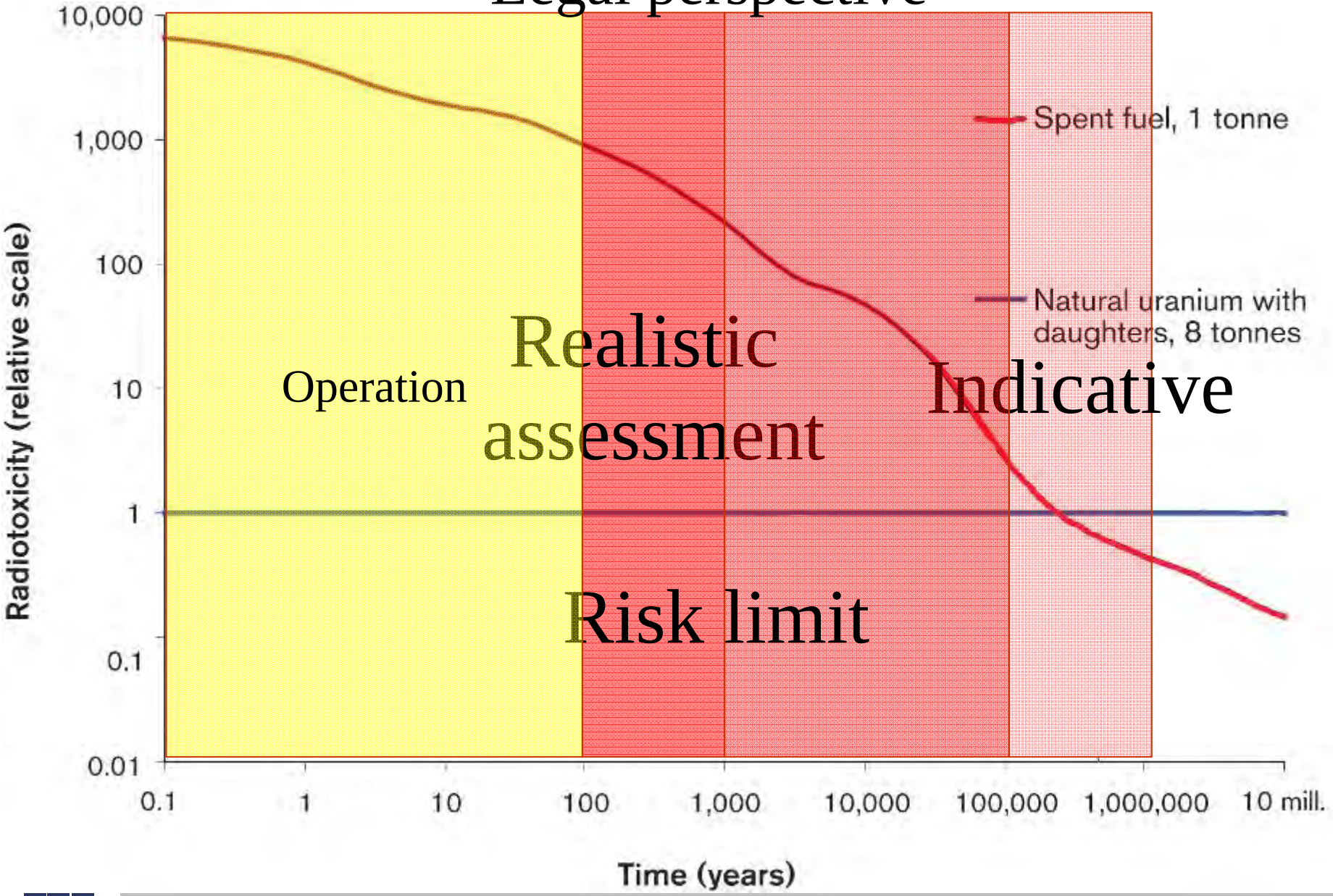
SKB's system


SFL
SFR
Final repository for inttermediate level radioactive waste
Medical care, industry and research
Final repository for short-lived radioactive waste
Encapsulation plant
Final repository for spent nuclear fuel
m/s Sigyn
Central interim storage for spent nuclear fuel (Clab)
Nuclear power plant
CLAB

- Very long time frame
  - Expected also for other pollutants
- Limits 200 times lower than background
  - Nothing comparable with other pollutants
  - Expected worst case 20 000 times less
- Dose relationships are known and can be calculated
  - Energy → dose
  - Unusual for other pollutants
- Inventory and containment known



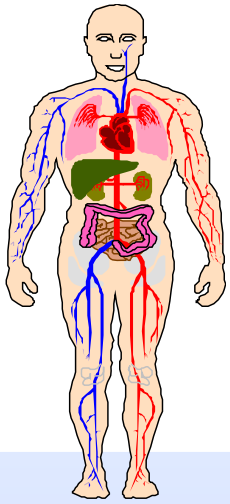
Timeframe
Legal perspective



In the past (1977)

- “Although the principle objective of radiation protection is the achievement and maintenance of appropriately safe conditions for activities involving human exposure, the level of safety required for the protection of human individuals is thought likely to be adequate to protect other species, although not necessarily individual members of those species. Therefore the Commission believes that if man is adequately protected then other living things are also likely to be sufficiently protected”
- ICRP, 1977. Recommendations of the International Commission on radiological protection. Oxford: Pergamon. (ICRP Publication 26; Annals of the ICRP 1).

Ecological approach



Dose

BCF

kD

Dilution

Fooduptake

Sedimentation.

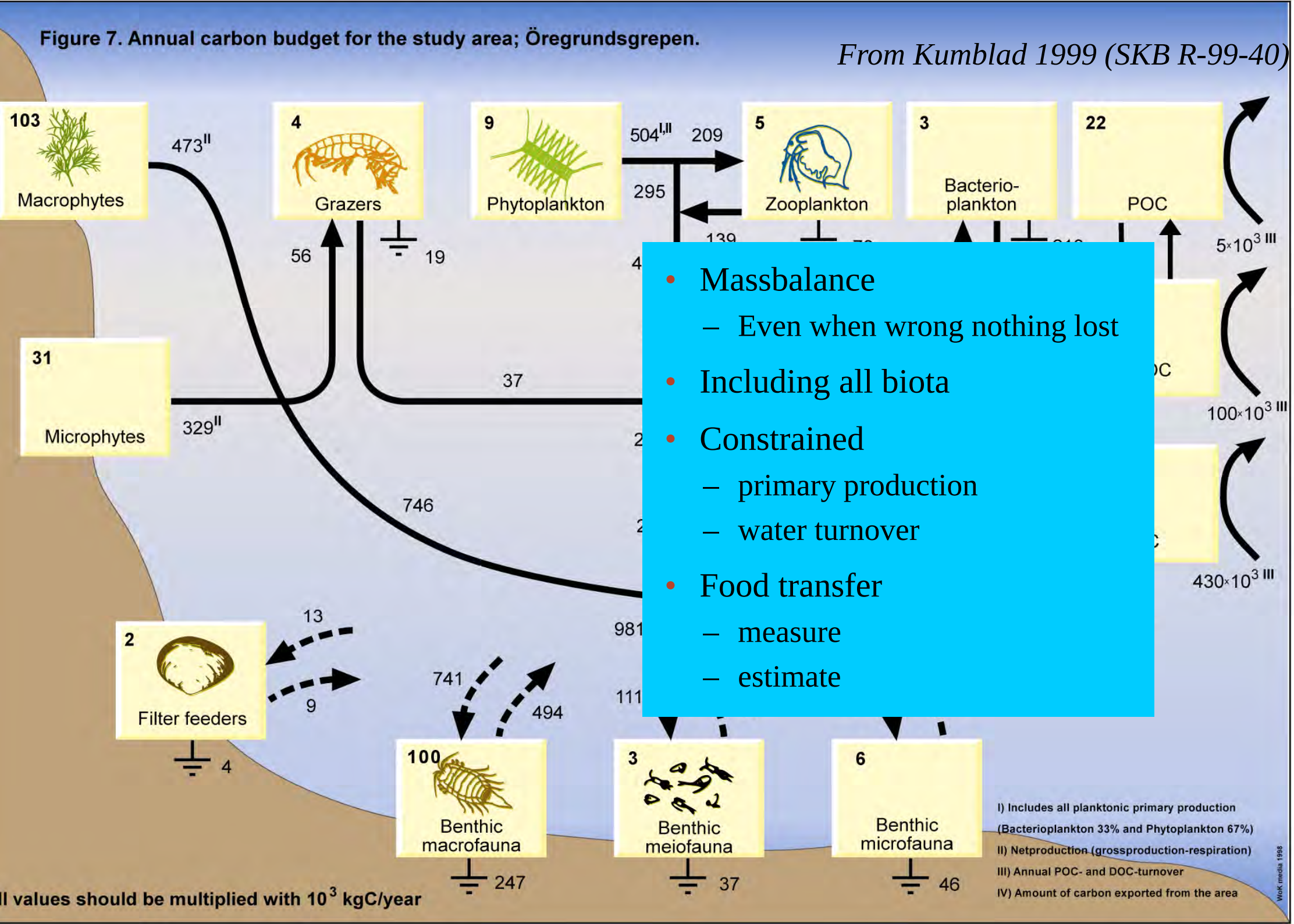
Resuspension

Bq/y

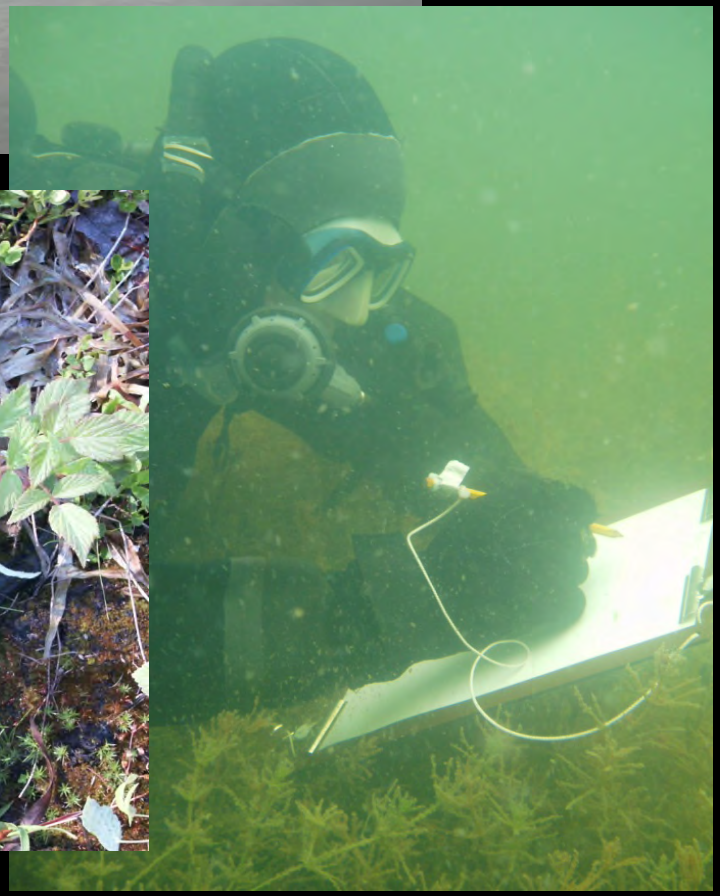
Geosphere

Accumulation

1 - 10000 year

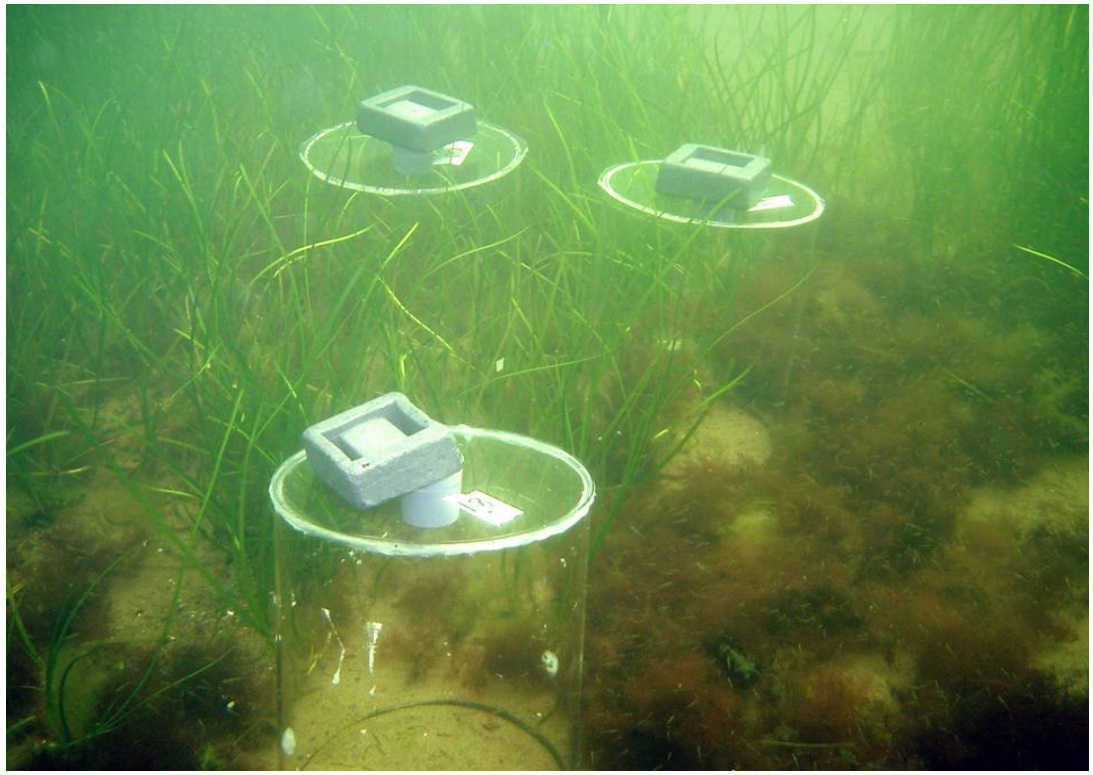


- Massbalance
  - Even when wrong nothing lost
- Including all biota
- Constrained
  - primary production
  - water turnover
- Food transfer
  - measure
  - estimate

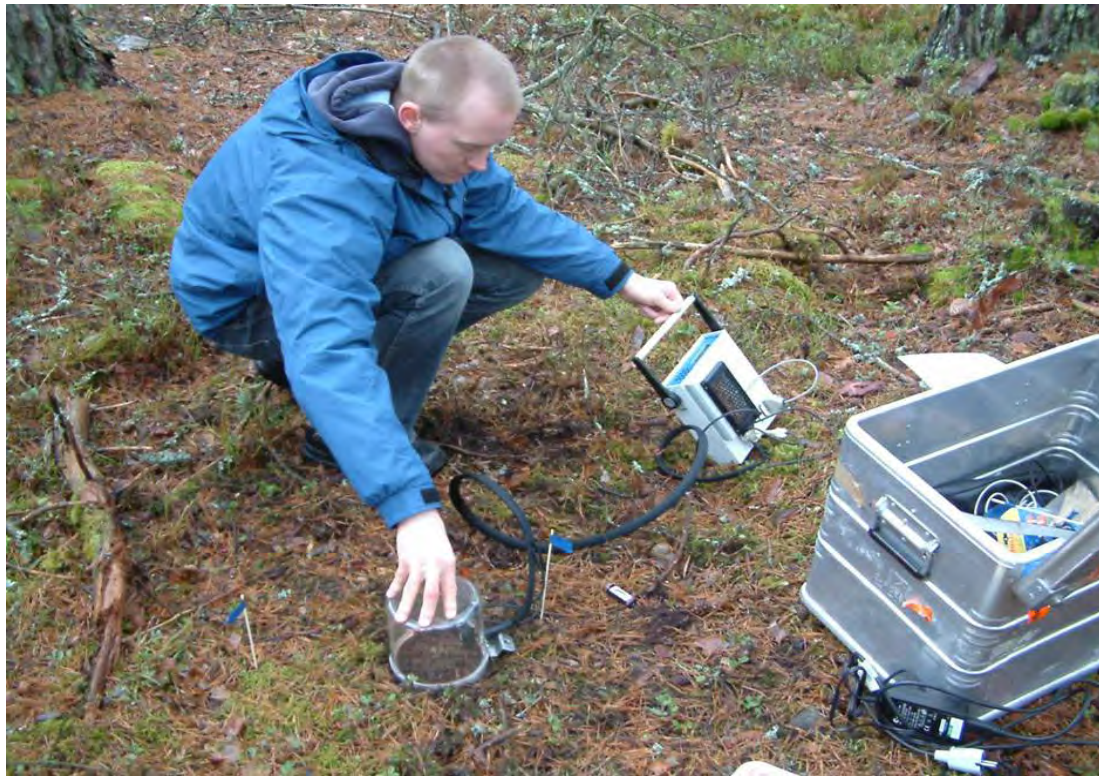


Fluxes in ecosystems –primary production, respiration

Primary production of Eel grass



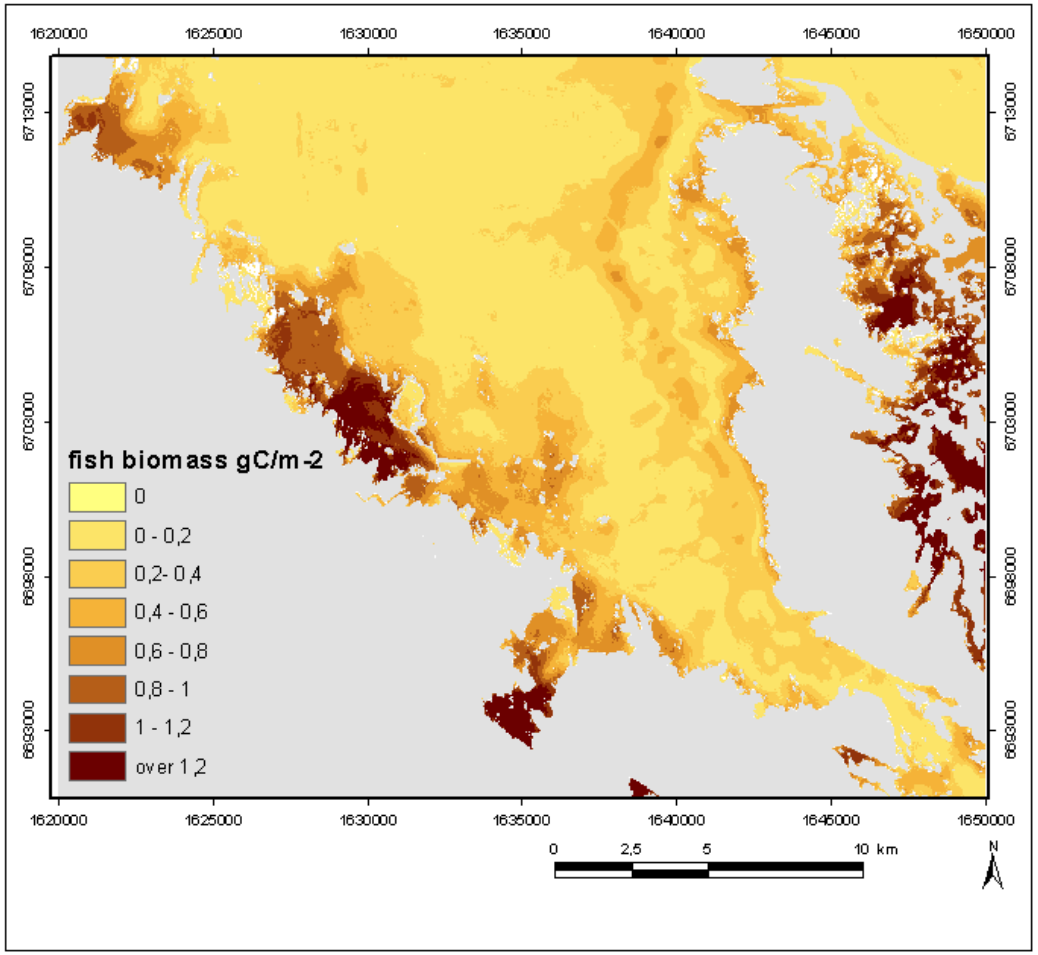
Respiration in forest



Modelling Amount of fish

•Coastal fish community, Herring and sprat dominates (60-70 kg/ha)

•Inner bays, perch, roach and white bream dominates



Ecosystem aspects
AMBIO 35:8 (2006)
AMBIO 42:4 (2013)

Aims to protect populations and function of the ecosystem

- Only radiation effects addressed not toxic effects
- Low levels are concerned (i.e below background)
- High levels already protected with human framework
  - i.e. we are simply not allowed to release anything that should have acute effects
  - But accidents needs to assessed also


Environment
Resilience
Stakeholder
Diversity
Sustainable
Population
Ecosystem
BAT
Something digestible

- Ca 99% are killed by hunters
- Ca 1% in traffic

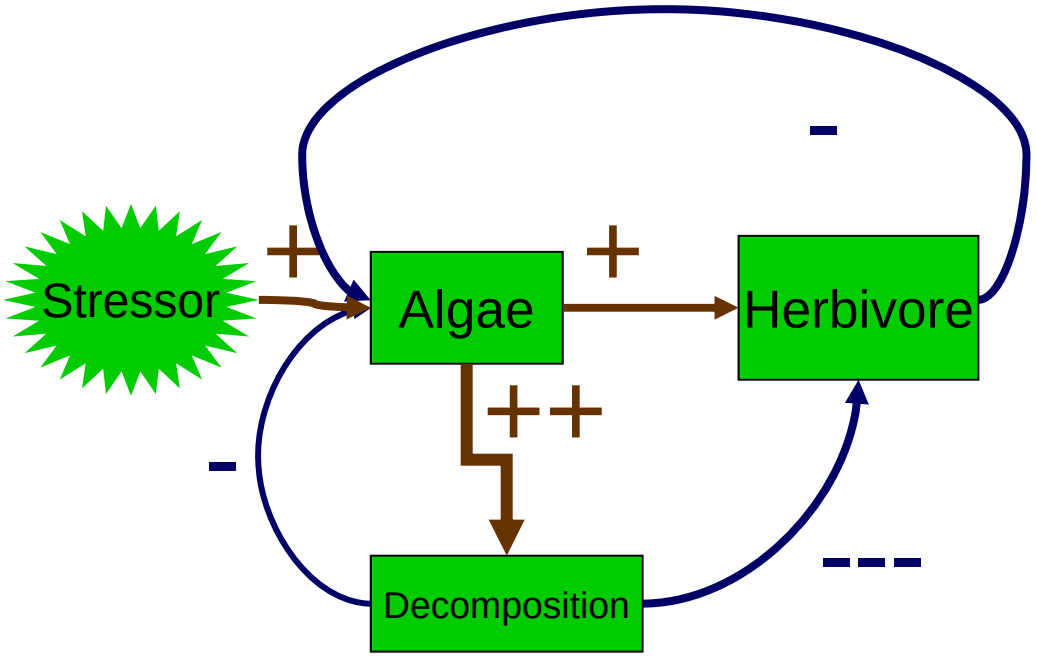
Clarification of Environment

- Radiation
  - impact on living matter at the low levels concerned
  - not the physical environment
- Thus differentiate
  - Habitat
  - Abiotic (physical) environment
  - Ecosystems
- Attractive ecosystems can be very perturbed

Any radiation specific effect beyond individuals?

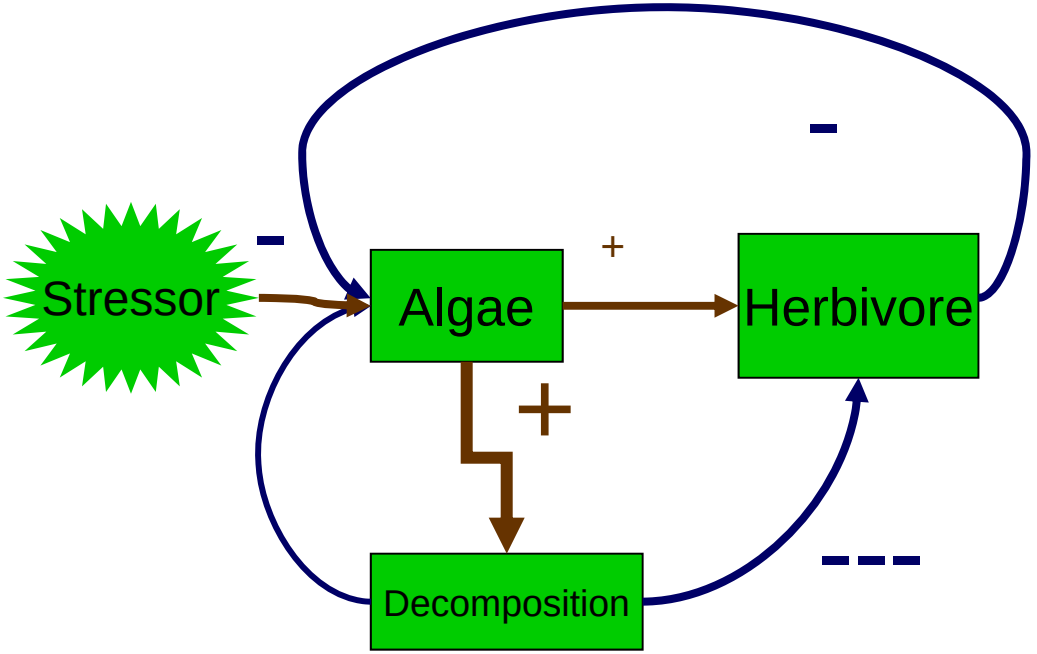
- Effects on ecosystems and population
- Comparisons with other environmental hazards

Ecosystem effects
Stimulation



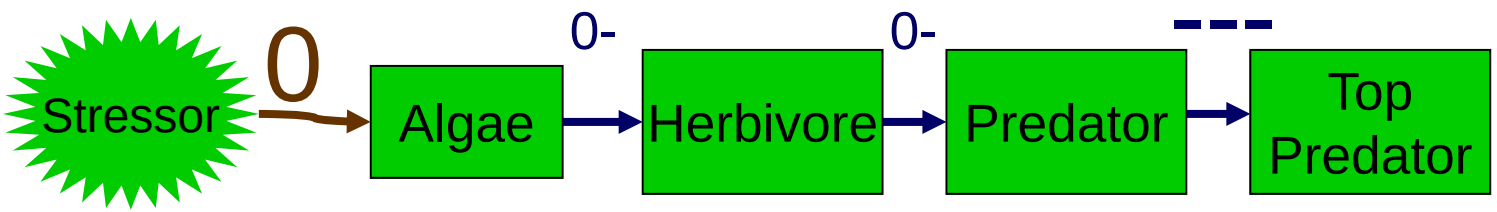
- Stimulation
  - Nutrients (N,P, Fe) i.e eutrophication
  - Requires massflow of substances
- No example from radiation except mutations
- Not likely of stimulating effect
  - Radiation positive ?
  - Large amounts to maintain flows

Ecosystem effects
Process interaction



- Inhibitors of enzymes
  - Photosynthesis blocking
  - Turbidity
  - Hormone analogues
- Specific process can affect individuals but the ecosystem much more
- No example from radiation
- Not likely that radiation act specifically at low levels
  - then toxin
- When are RN toxins?

Ecosystem effects
Biomagnification



x10 x10 x10 x10

100 1000 10000

- Biomagnification modest for radionuclides (maximum 3?)
- No zero effects for some organisms for Radionuclides

Any radiation specific effect beyond individuals?

- It seems that there are no radiation specific effects directly affecting ecosystems at low level radiation
- However there are effects above individual depending on single individuals fitness→ population → ecosystem
- We need still to describe the implication from individual to ecosystem

Population

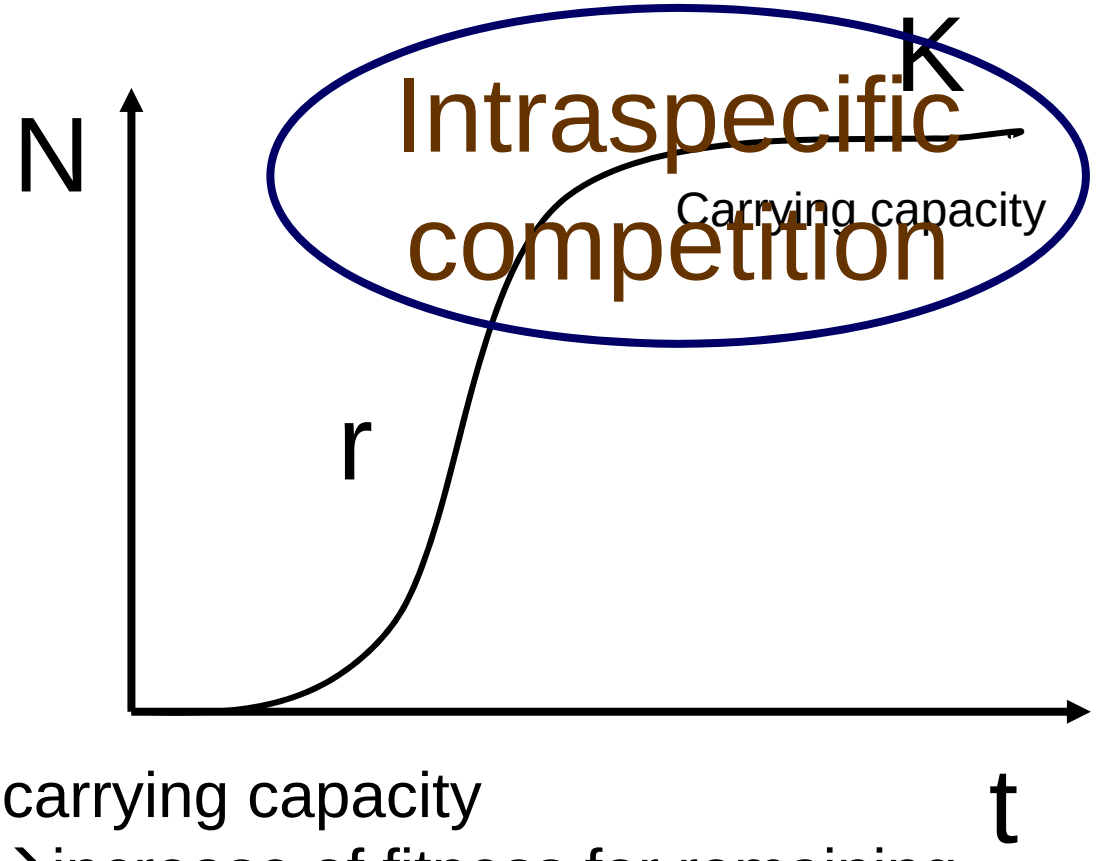
- Collection of individuals usually in a geographical area
  - Humans
- A group of genetically similar individuals which can produce viable offspring
  - Biological population
  - That is what we want to protect !
  - Some times geographical boundary = genetic population

Population size

- Minimum viable effective population
  - A survival the next 100 year of 95%
  - 50 ind. for short time assuming 1% inbreeding per generation
  - 500 ind. balance gain in genetic variation due to mutation and loss to genetic drift
- Minimum viable census population
  - 1000-10000 adults for mid-sized vertebrates
  - Most often *N*=5,000 population for vertebrate species
- >>1 individual loss to affect the population

Population size is limited

- Disturbance
  - Predation
  - Climatic
- Resource limitation
  - Nutrients water
  - Prey (food)
  - Space territory



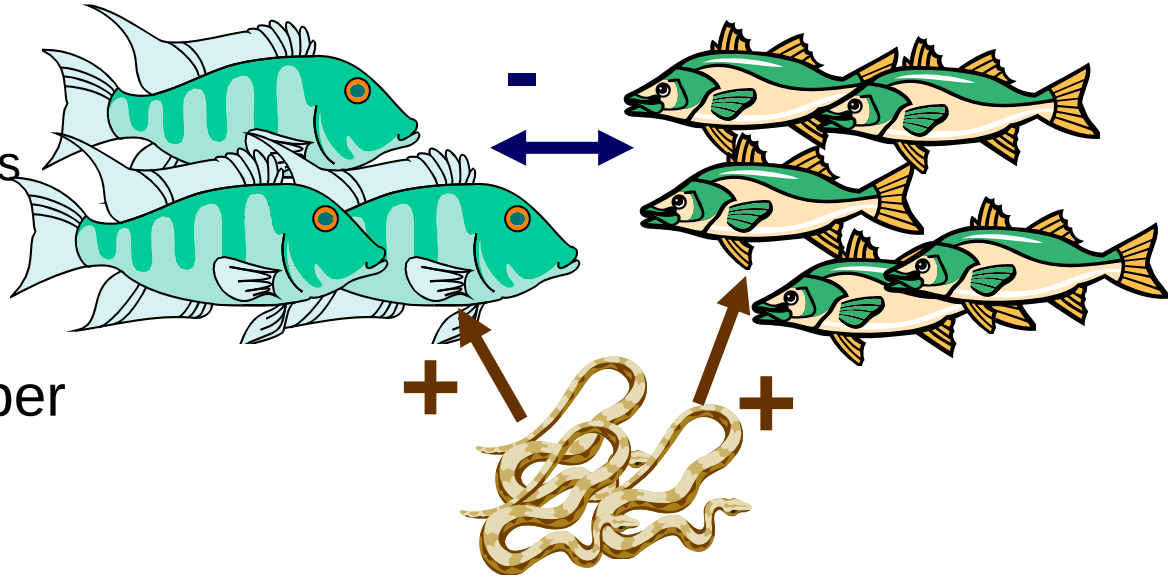
Near carrying capacity
removal of individual →increase of fitness for remaining
→population benefits

The populations is not alone

Interaction with other population/species

Interspecific competion

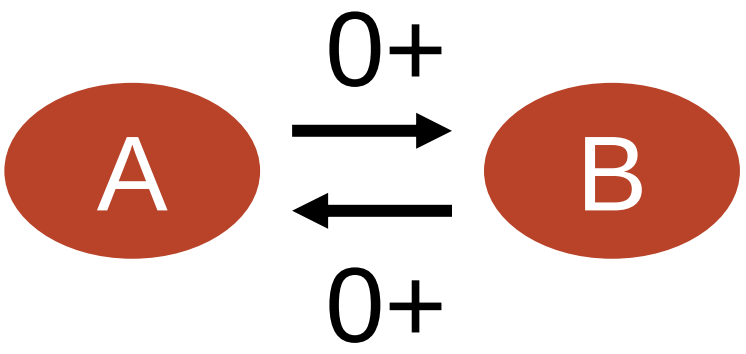
- Competition of resources
  - Food
  - Habitat
  - Territory
- Coexisting species
  - Cannot fully overlap in resources
  - Competitive exclusion
- Intraspecific competition strongest (i.e between member of the same species)
- Loss of individuals → competitor in advance → species shift
- Can radionuclides only act on one population ?



The populations is not alone

Mutualism

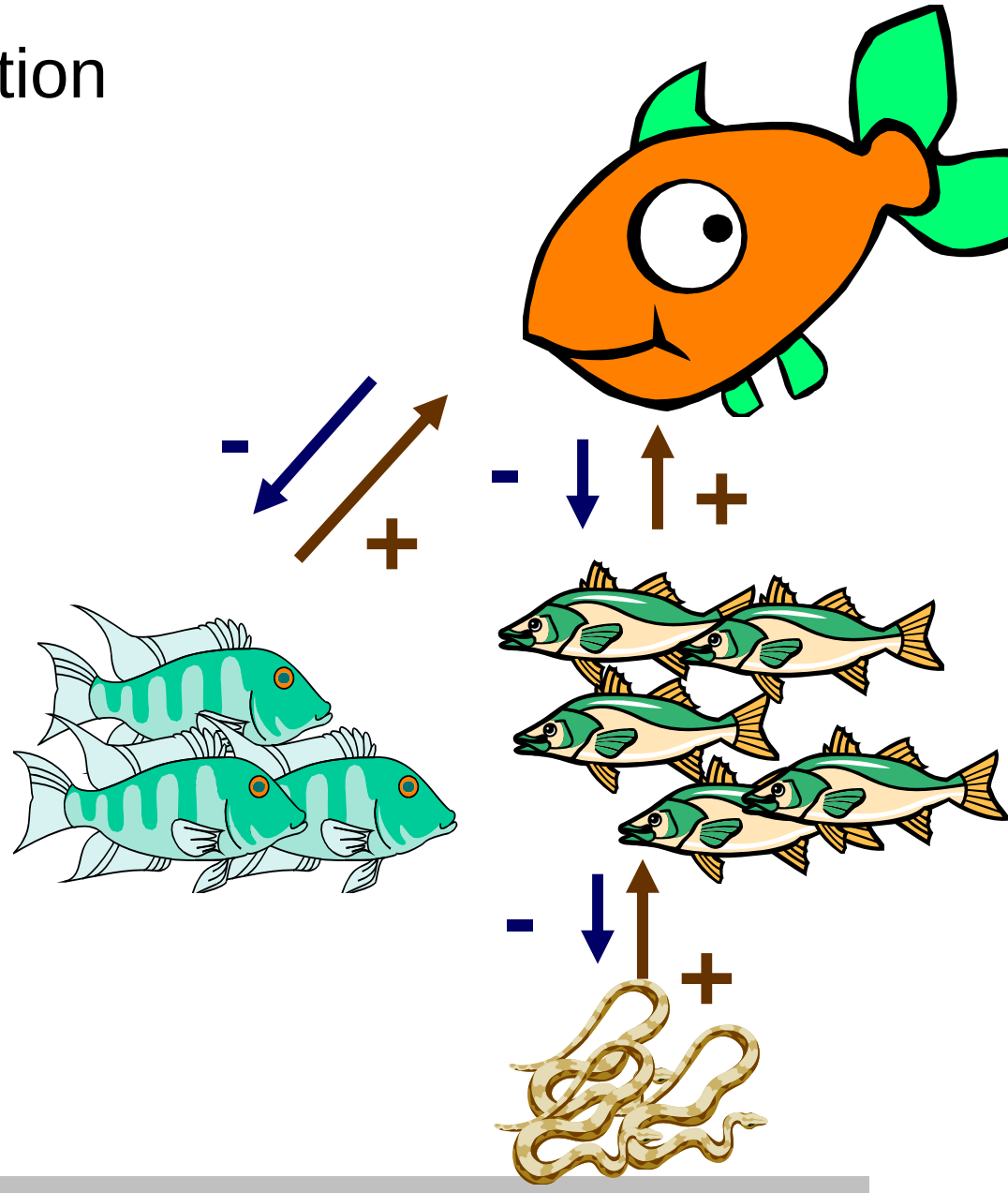
- Different species interact positively
- Symbiosis
  - obligate
    - lichens
  - nonobligate
    - mycorhiza
- Loss of individuals → maybe loss of symbiont
- Can radionuclides only act on one population ?
  - No for endosymbionts (lichens, corals)
  - Yes for pollinators



The populations is not alone

Predation

- What will be the worst effect?
  - A radiation to prey
  - B radiation to predator who is eating contaminated prey
- If A
  - Predation can enhance effect → population decrease
    - is it likely ? (eg K)
- If B the prey will be in advance
    - biomagnification ?
    - Radiation sensitivity
- Predation may or may not enhance the effect of radiation



Conclusions

- There seems not to be any radiation effects acting more strongly on the ecosystem level
- → Radiation effects are mediated through changes of the population
- The minimum viable population >1000 individual → several individual must be affected → do we need safety factors?
- There are some interaction between population which enhance the effect on individuals but surprising few
  - assuming low levels and that radionuclides are non-specific
- Protection of human individuals is maybe adequate to protect populations of other species
- How should the long time frame be handled regarding populations?

Some aspects covered in SKB TR-13-23 coming soon
www.skb.se/publications