EXERCISE II fish
Preliminary analysis

There are no experimental data on the dynamics of OBT in fish of larger mass than 15 g. Some experiments are planed at AECL. This fish exercise is tuned on the planed experiments.

Phase 1. Rainbow trout of an initial mass near 200 g is grown in tritiated water with concentration 7000 Bq/L for about 140 days. At end exposure, the mass of trout is expected to be close to 1 kg. Water temperature is maintained constant at 10, 15 and 18 ^{0}C. The dynamics of OBT in fish edible mass and also main organs must be predicted.

Phase 2. Considers the fish in phase 1 but now we feed him with OBT in food at a level of 7000 Bq/Kg dm. Water temperature is 10, 15, 18 C. Asses the dynamics of OBT in fish edible mass .

ONLY 2 WG7 member respondendt

Franz Baumgardner

OBT Kinetics of Rainbow Trout. BIOCHEM

Step 1. Growth function of rainbow trout: By assumption of a final weight of trout A = 3000g the precondition to grow within 140 days from 200g to 1000g results in the growth function

$$3000 - 200*2^{(-t/285)} \quad (1a)$$

or reshaped : $$3000 - 2^{(-(t - 28,37)/285)} \quad (1b)$$

Step 2, OBT formation:
1. Assumption specific BIOCHEM: OBT ≡ XBT_{buried} , (X≡ N,O,S).
$M_{unknown\ protein}$ =10.891. XBH in M is 182,56. Equilibrium constant in triton-proton exchange is 2 which results in XBT_{buried} = 2*XBH*(HTO/HOH).
2. Assumption optional: 20% protein and 7000 Bq/L: XBT_{buried} = 140.805 Bq/L of 3000g rainbow trout. According to "growth correspondence of OBH and XBT" the XBT(t) is adjusted to W(t) as given in Fig.3 and equation (2):

$$XBT_{buried} = OBT(t) = 140.805*(1 - 2^{(-t/280)})$$

Step 3, respecting fast OBT formation:
200g rainbow trout contain XBT = 9.387. Assumption optional: 20% of available XBT are occupied by tritons with a half-time of one hour. This assumption results in fast OBT formation according to equation (3):

$$XBT_{fast\ buried}(t) = 0,2*9387*(1- 2^{(-t/0,042)}) \quad (3)$$

Fig. 4. Weight and OBT Kinetic (fast + metabolic) of Rainbow Trout.
HTO 7000Bq/L, exposure start at 200g, growth rate from 200g to 1000g during 140d, final growth 3000g.

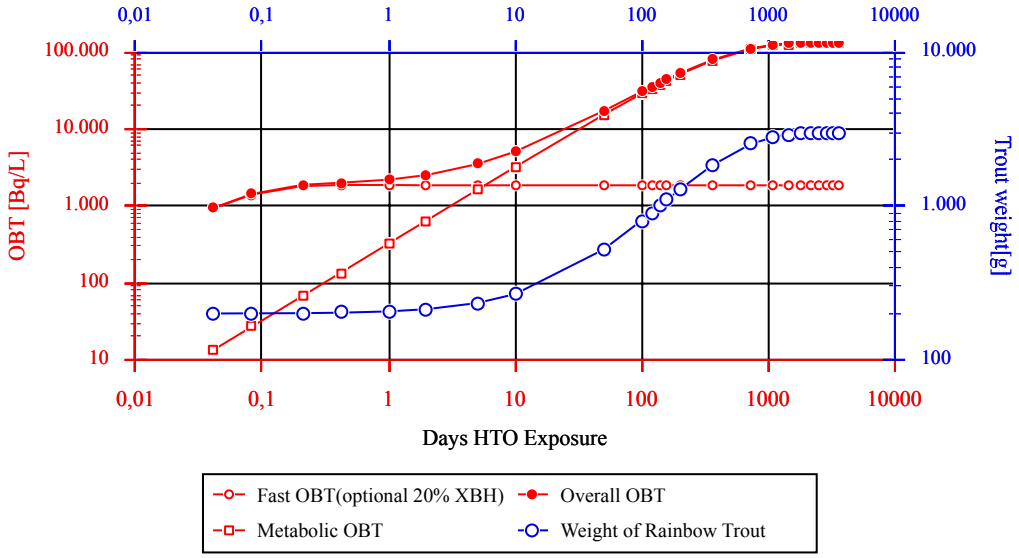

Table 1. Estimated data of weight and OBT.

hours	days	Weight [g]	Overall OBT [Bq/L]	Fast OBT [Bq/L]	Metabolic OBT [Bq/L]
1	0,04	200	953	939	14
2	0,08	201	1.435	1.408	27
5	0,21	201	1.887	1.819	68
10	0,42	203	2.011	1.876	135
24	1	207	2.202	1.877	325
	2	213	2.526	1.877	649
	5	234	3.494	1.877	1.617
	10	267	5.090	1.877	3.213
	50	523	17.177	1.877	15.300
	100	819	30.696	1.877	28.819
	120	930	35.652	1.877	33.775
	140	1.037	40.368	1.877	38.491
	160	1.141	44.857	1.877	42.980
	200	1.337	53.195	1.877	51.318
	365	2.014	80.055	1.877	78.178

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NO OBT after OBT food

Previous
BIOCHEM Model
EXERCISE II fish, WG 9-EMRAS II.
Weight increase 800 g
20% Protein 160 g
Calculation of gXBT:
protein-mass*182,56H_{exch}/1089$_{protein}$ = 160*0,016765 = 1,84 gXBH
XBH + HTO ⇄ XBT + HOH
YBH + HTO ⇄ YBT + HOH

. α_{XBT} = 2.0 α_{YBT} = 1.4
Estimation according to traditional OBT analysis
XBT 80% buried,
YBT 30% buried
Phase 1.

In the range of 10, 15, 18oC the results are within error of HTO source term. Equal protein content in edible part and main organs is assumed. Therefore, there is no difference beyond the experimental error in the calculated OBT at the temperatures and organs asked for.

Traditional OBT[Bq/L] = (0,8*2 + 0,3*1,4) * HTO * X/YBT ~ 2 * 7000 * 1.84 ~ 26 000 Bq/L

Phase 2.
BIOCHEM assumes chief part of OBT is X/YBT. Therefore, there is no difference between HTO source term and OBT dry mass of feed within experimental error of both source terms. Therefore, the same OBT results in all points of questions as in phase 1: ~ 26 000Bq/L

My interpretation on BIOCHEM
No distinction between HTO and OBT intake
Final value close to 40 000 Bq/L

EDF
OBT in fish is assumed to be incorporated from plankton OBT or OBT coming from food. Plakton OBT is in equilibrium with water HTO

$$\frac{dA_{fish}^{OBT}(t)}{dt} = -k_{ing} A_{fish}^{OBT}(t) + k_{ing}.DF_{phyto}.\frac{H_{phyto}}{H_{fish}}.A_{eau}^{HTO}(t)$$

with

$$k_{ing} = \frac{I \cdot D}{W}$$

and

A_{fish}^{OBT} : OBT specific activity in fish (Bq/L combustion water)
A_{water}^{HTO} : HTO specific activity in water (Bq/L)
k_{ing} : relative ingestion rate in day $^{-1}$
I : food intake in Kg (dry weight)day $^{-1}$
D : digestibility (unitless)
W : animal dry weight in Kg
DF_{phyto} : 'discrimination' factor , ratio between OBT in phytoplankton (Bq/L combustion water) and HTO in water (Bq/L)
H_{phyto} : average phyto OBH in g/kg dry matter
H_{fish} : average fish OBH in g/kg dry matter

Now F=1
H substrate (g/kg of dry matter) 0.6 from phyto or food
Water equivalent factor 0.48 L/kgdm

results
For phase 1 (HTO 7000 Bq/l)
Uniform growth of OBT, at day 140
OBT in fish : 1450 Bq/L

For phase 2 OBT in food 7000 Bq/kgdm , at day 140
OBT in Fish 15200 Bq/L

Both participant use combustion water for the scenario

QUESTION What composition of fish OBT food

provisional value for food fish rainbow trout Intensive farming and laboratory (AECL?)

high Energy intensive DM 94 %, Crude protein 47 %, crude fat 21 %, Gross Energyy 22.8 MJ/kg

Low energy DM 94 % CP 40 % CF 7 % GE 19 MJ/kg
~ 20 % minerals, vitamine, very low carbohydrates

Bound hydrogen content Cf Diabate&Strack , and others

	free H	non exchangeable bound H	exch and nonexch org H
water	0.11	0	
carbohyd	0.02	0.044	0.064
protein	0.017	0.051	0.068
fat	0.003	0.117	0.12

Consider crude protein 44 % and crude fat 20 %>> 0.057 kgH/kgdm of bound H , GE ~ 20 MJ/kgdm

Food contain ~ 57 g OBH per kgDM

Fish composition (internet search) protein ~ 15 %, lipids ~10 % , water ~70 % >. ~ 0.022 kgH/kgfw
0.073 kgH/kgdm

WHAT CAN BE THE OBT loss rate ?

MUST BE HIGHER THAN THE RELATIVE GROWTH RATE

140 day from 0.2 to 1 kg, average relative growth rate 0.8/140/0.6

9.52E-03 d^{-1}

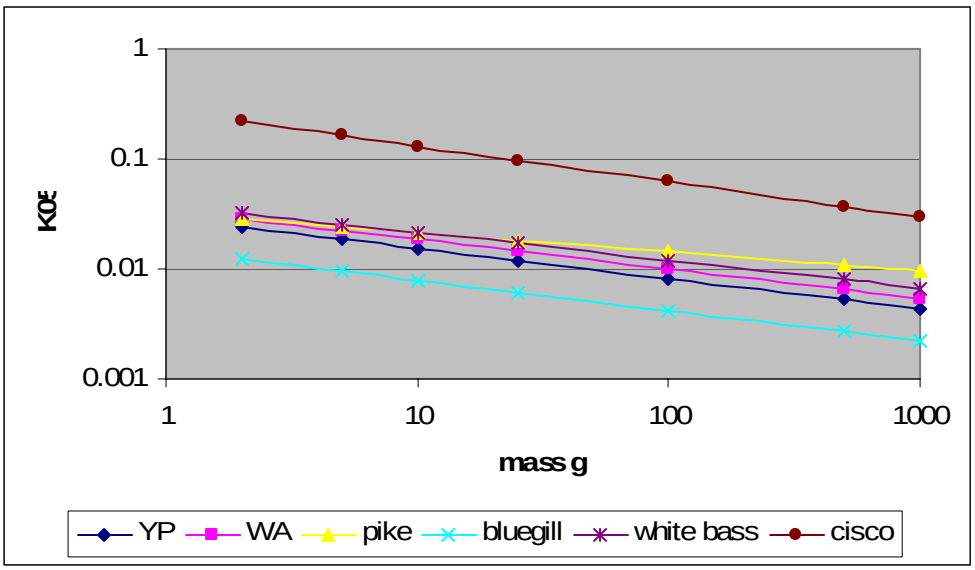
HIGHER THAT EDF

In equilibrium condition, the recent IAEA quidance recommend a value
600 Bq/kgfw of fish when water have 7000 Bq/L
The standard fish have 78 % water and the standard water equivalent factor is 0.5
In the condition of phase 1 (7000 Bq/L in water) IAEA gives ~4600 BQ/L for the combustion water. This is higher than EDF and lower than Franz Baumgarner..

THE IFIN model AQUATRIT have some generic and specific fish but no rainbow trout.

We use CISCO (coregonus artedii) as it is in the same family of salmonides.

CISCO in AQUATRIT at 15 C relatively close
OBT loss rate



We slightly adapt the parameters to correspond with the growth in the scenario

Phase 1 AQUATRIT predict 275 Bq/kgfw of fish (~1700 Bq/L water of combustion)

Phase 2 AQUATRIT predict 2024 Bq/kgfw (~ 12450 Bq/L water of combustion)

In absence of experimental data we can not select the best model