How the new “Derived Consideration Reference Levels” compare with other data

Description of underlying data and comparison of other lab and field data with DCRLs

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INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION
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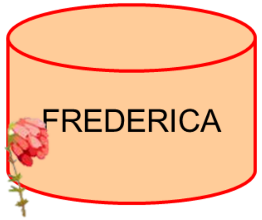
Primary source of biological data

Chap 4.1 to 4.4

Select QC data for each test [series of data pairs for (species, endpoint, exposure conditions)]



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Copplestone et al., JER 2013
Garnier-Laplace et al., JER 2010

- **Most recent update of FREDERICA database (version 2010) :**
  - References cover **biological effects** to a range of non-human species following exposure to **ionising radiation** (including papers used for ICRP Publication 108)
  - > 1500 references; 26 000 data entries
  - **~ 2/3 of references deal with acute exposure** (~1/3 chronic, some transitory)
  - Mainly for **external gamma irradiation**
  - More **laboratory** than field studies (field or controlled field studies)

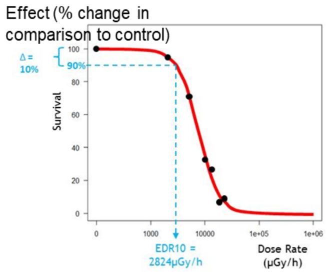
Description of data and electronic annexes

ICRP *Chap 4.1 to 4.4*

Reconstruct dose(rate)-effect relationship for each test

Chronic lab test – Observed EDR_{10}

Acute lab test -- Observed ED_{50}



Develop the Acute-to-Chronic Transformation of Radiation effects (ACTR) model

Observed ED_{50} → ACTR → Predicted EDR_{10}

- Based on FREDERICA **gamma or X ray external irradiation laboratory test data sets*** only; **a data set is a series of [dose(rate)-effect] for a given species and a given effect, examined under defined exposure conditions*
- **Population-relevant endpoints (reproduction, morbidity, mortality)**
- For each effect data set, if selection criteria (see logic diagram in Annex B) were satisfied, a **dose response curve was constructed to estimate EDR_{10} (chronic exposure) and ED_{50} (acute exposure)**
- 10 models used to construct the dose (rate) response curve (best-fit primarily obtained using log-logistic patterns)
- Use of **ACTR (Acute-to-Chronic Transformation of Radiation effects) model**
  - transformation of observed data of acute radiotoxicity (ED_{50}) into predicted data of chronic radiotoxicity (EDR_{10}) ; enables the expansion of chronic radiation effect datasets predicting chronic radiotoxicity values (EDR_{10}) for (species and endpoint) where only acute effect data (ED_{50}) exist
- Use of **Endpoint Sensitivity Distribution (ESD) model**
  - statistical model to summarise the variation of radiosensitivity of population-relevant endpoints for all species within a given taxonomic level

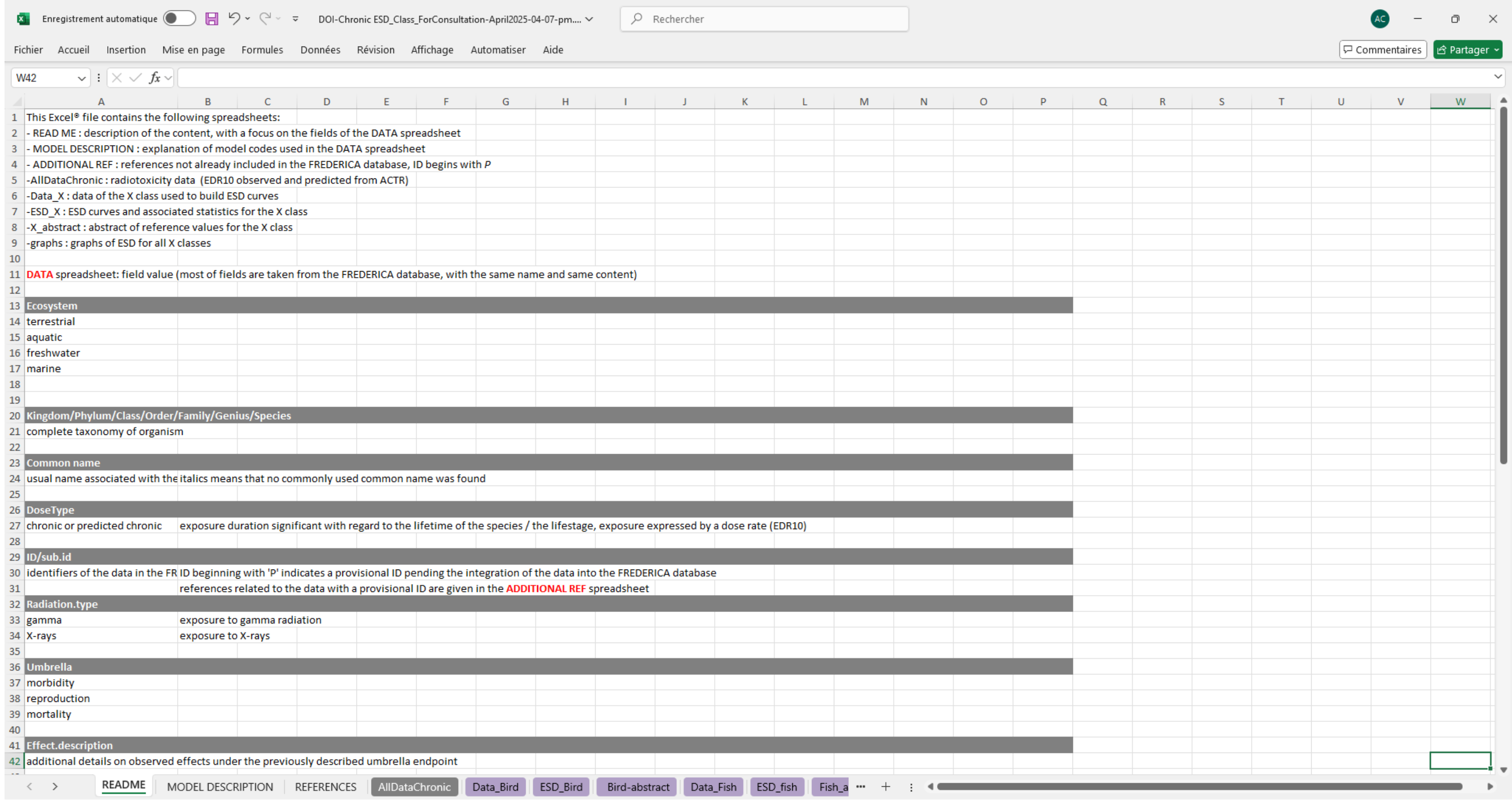
Electronic annexes with the used data sets and references

4 files (Chronic ESD BroadGroups ; Chronic ESD Class ; Acute ESD BroadGroups ; Acute ESD Class) are available on demand (Christelle.adam-Guillermin@asnr.fr)

File organisation

(example for ChronicESD_class)

ReadMe Spreadsheet (file explanation)


DOI-Chronic ESD_Class_ForConsultation-April2025-04-07-pm....

This Excel® file contains the following spreadsheets:
- READ ME : description of the content, with a focus on the fields of the DATA spreadsheet
- MODEL DESCRIPTION : explanation of model codes used in the DATA spreadsheet
- ADDITIONAL REF : references not already included in the FREDERICA database, ID begins with *P*
-AllDataChronic : radiotoxicity data (EDR10 observed and predicted from ACTR)
-Data_X : data of the X class used to build ESD curves
-ESD_X : ESD curves and associated statistics for the X class
-X_abstract : abstract of reference values for the X class
-graphs : graphs of ESD for all X classes

DATA spreadsheet: field value (most of fields are taken from the FREDERICA database, with the same name and same content)

Ecosystem	
terrestrial	
aquatic	
freshwater	
marine	
Kingdom/Phylum/Class/Order/Family/Genius/Species	
complete taxonomy of organism	
Common name	
usual name associated with the	italics means that no commonly used common name was found
DoseType	
chronic or predicted chronic	exposure duration significant with regard to the lifetime of the species / the lifestage, exposure expressed by a dose rate (EDR10)
ID/sub.id	
identifiers of the data in the FR	ID beginning with 'P' indicates a provisional ID pending the integration of the data into the FREDERICA database
	references related to the data with a provisional ID are given in the ADDITIONAL REF spreadsheet
Radiation.type	
gamma	exposure to gamma radiation
X-rays	exposure to X-rays
Umbrella	
morbidity	
reproduction	
mortality	
Effect.description	
additional details on observed effects under the previously described umbrella endpoint	

README | MODEL DESCRIPTION | REFERENCES | AllDataChronic | Data_Bird | ESD_Bird | Bird-abstract | Data_Fish | ESD_fish | Fish_a

Electronic annexes with the used data sets and references

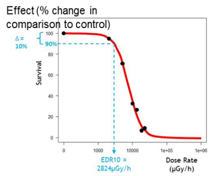
File organisation (example for ChronicESD_class)

Model description

Reconstruct dose(rate)-effect relationship for each test

Chronic lab test – Observed EDR_{10}

Acute lab test -- Observed ED_{50}



Develop the Acute-to-Chronic Transformation of Radiation effects (ACTR) model

Observed ED_{50} → ACTR → Predicted EDR_{10}

	A	B	C	D	E	F	G
1	Code	Model	lower limit	upper limit	alpha	ber of parameters	
2	BC.4	Brain-Cousens (hormesis)	0	free	N.D.	4	
3	CRS.4a	Cedergreen-Ritz-Streibig	0	free	1	4	
4	CRS.4b	Cedergreen-Ritz-Streibig	0	free	0,5	4	
5	CRS.4c	Cedergreen-Ritz-Streibig	0	free	0,25	4	
6	LL.2	Log-logistic	0	1	N.D.	2	
7	LL.3	Log-logistic	0	free	N.D.	3	
8	LL.3u	Log-logistic	free	1	N.D.	3	
9	LL.4	Log-logistic	0	free	N.D.	4	
10	LL.5	Log-logistic	0	free	N.D.	5	
11	UCRS.4a	U-shaped Cedergreen-Ritz-Streibig	free	1	1	4	

$$y(x) = c + \frac{d - c + fx}{1 + \exp[b(\log(x) - \log(e))]}$$

$$y(x) = c + \frac{d - c + f\exp(-1/x^{\alpha})}{1 + \exp\{b[\log(x) - \log(e)]\}}$$

$$y(x) = c + \frac{d - c}{1 + \exp[b(\log(x) - \log(e))]}$$

For more details

Garnier-Laplace, J., Della-Vedova, C., Andersson, P., et al., 2010. A multi-criteria weight of evidence approach for deriving ecological benchmarks for radioactive substances. J. Radic

Sheets: README | MODEL DESCRIPTION | REFERENCES | AllDataChronic | Data_Bird | ESD_Bird | Bird-abstract | Data_Fish | ESD_fish | Fish_a

Electronic annexes with the used data sets and references

File organisation (example for ChronicESD_class)

References

DOI-Chronic ESD_Class_ForConsultation-April2025-04-07-pm... • Enregistré dans ce PC

ID	Author	Title	Year	Journal	Volume	PartNumber	PageNumbers
16	Egami, N., Shimada, A., and Hama-Furukawa, A.	Dominant lethal mutation rate after y-irradiation of the fish, Oryzias latipes.	-1983	Mutation Re	107		265-277.
17	Chakrabarti, S., Streisinger, G., Singer, F., and Wal	Frequency of y-ray induced specific locus and recessive lethal mutations in mature germ cells of the zebrafish, Bra	-1983	Genetics.	103		109-123.
18	Walker, C., and Streisinger, G.	Induction of mutations by y-rays in pregonial germ cells of zebrafish embryos.	-1983	Genetics.	103		125-136.
21	Hyodo-Taguchi, Y., and Egami, N.	Change in dose-survival time relationship after x-irradiation during embryonic development in the fish, Oryzias lat	-1969	Journal of R	10	(3-4),	121-125.
28	Ward, E., Beach, S.A., and Dyson, E.D	The effect of acute X-irradiation on the development of the eggs of the plaice, Pleuronectes platessa.	-1970	United Kingdom Atomic Energy PG Re			1-10.
29	Wadley, G.W., and Welander, A.D.	X-rays and temperature: Combined effects on mortality and growth of salmon embryos.	-1971	Transaction	100	(2),	267-275.
30	McGregor, J.F., and Newcombe, H.B.	Major malformations in trout embryos irradiated prior to active organogenesis.	-1968	Radiation R	35	(2),	282-300.
31	Konno, K., Kikuchi, T., Osakabe, I., and Okada, I.	On the influence of gamma-ray radiation on the aquatic animals. I. On the influence in the early development of go	-1955	Journal of th	41	(2),	163-168.
33	Templeton, W.L.	Resistance of fish eggs to acute and chronic irradiation.		Unknown.			847-860.
36	Ghoneum, M.M.H., Ijiri, K-I., and Egami, N.	Effects of gamma-rays on morphology of the thymus of the adult fish of Oryzias latipes.	-1982	Journal of R	23		253-259.
39	Aoki, K., Egami, N., and Arai, R.	Histological changes in internal tissue of the goldfish, Carassius auratus,following X-irradiation.	-1966	Journal of R	7	(2),	83-90.
41	Engel, D.W., Angelovic, J.W., and Davis, E.M.	Effects of acute gamma irradiation on the blood constituents of Pinfish, Lagodon rhomboides.	-1966	Chesapeake	7	(2),	90-94.
45	Ghoneum, M.M.H., Ijiri, K-I., and Egami, N.	A note on gamma-ray effects on the thymus in the adult fish of Oryzias latipes.	-1979	Journal of th	14	(3),	299-304.
47	Hama, A., and Egami, N.	The dose-rate effect of gamma-irradiation on the initiation of mitosis in the regenerating tail fin of the fish, Oryzias	-1977	Journal of th	14	(1),	47-60.
61	Newcombe, H.B., and McGregor, J.F.	Increased embryo production following low doses of radation to trout spermatozoa.	-1972	Radiation R	51		402-409.
65	Bonham, K., Donaldson, L.R., Foster R.F., Welande	The effect of X-ray on mortality, weight, length and counts of erythrocytes and hematopoietic cells in fingerling chi	-1948	Growth.	12		107-121.
68	Brown, V.M., and Templeton, W.L.	Resistance of fish embryos to chronic irradiation.	-1964	Nature.			1257-1259.
69	Blaylock, B.G., and Griffith, N.A.	Effects of acute beta and gamma radiation on developing embryos of carp (Cyprinus carpio).	-1971	Radiation R	46	(1),	99-104.
74	Woodhead, D.S.	The effects of chronic irradiation on the breeding performance of the guppy, Poecilia reticulata (Osteichthyes : Tele	-1977	Internationa	32	(1),	1-22.
76	Hyodo-Taguchi, Y., and Etoh, H.	Vertebral malformations in Medaka (Teleost Fish) after exposure to tritiated water in the embyonic stage.	-1993	Radiation R	135		400-404.
88	Blaylock, B.G., and Mitchell, T.J.	The effect of temperature on the dose response of Gambusia affinis affinis from two natural populations.	-1969	Radiation R	40	(3),	503-511.
95	Hyodo-Taguchi, Y., and Etoh, H.	Effects of Tritiated water on germ cells in Medaka II. Diminished reprodutive capacity following embryonic exposur	-1986	Radiation R	106		321-330.
97	Etoh, H., and Hyodo-Taguchi, Y.	Effects of tritiated water on germ cells in medaka embryos.	-1983	Radiation R	93		332-339.
101	Michibata, H.	The role of spermatogonia in the recovery process from temporary sterility induced by gamma-ray irradiation in th	-1976	Journal of R	17		142-153.
107	Egami, N., and Hyodo, Y.	Inhibitory effect of X-irradiation on the development of the ovaries of the fish, oryzias latipes, in sexually inactive s	-1965	Annotatione	38	(1),	8-11.
112	Egami, N., and Hyodo-Taguchi, Y.	Hermaphroditic gonads produced in oryzias latipes by X-radiation during embryonic stages.	-1969	Copeia.	1		195-196.
113	Kulikov, N.V., Timofeeva, N.A., and Al'shits, L.K.	Decrease in the radiosensitivity of tench embryos (Tinca tinca L.) as a result of preliminary irradiation.	-1969	Radiobiolog	9		637-639.
118	Shimada, Y., and Egami, N.	An electron microscopic study of radiation damage and their recovery in the germ cells in the early development of	-1982	Journal of th	15	(2),	255-272.
150	Foster, R.F., Donaldson, L.R., Welander, A.D., Bonl	The effect on embryos and young of rainbow trout from exposing the parent fish to X-rays.	-1949	Growth.	13		119-142.
170	Bonham, K., and Donaldson, L.R.	Sex ratios and retardation of gonadal development in chronically gamma-irradiated chinook salmon smolts.	-1972	Transaction	101	(3),	428-434.
174	Bakulina, E.D., Pokrovskaya, G.L., and Romashov,	On radio-sensitivity of loach (Misgurnus fossilis l.) spermatozoa.	-1962	Radiobiolog	2		135-147.
178	Egami, N., and Hyodo, Y.	Effect of X-irradiation on the oviposition of the teleost, Oryzias latipes.	-1965	Annotatione	38	(4),	171-181.
184	Baldwin, W.F.	Increased yield of gamma-induced eye colour mutations from chronic versus acute exposures in Dahlbominus.	-1968	Isotopes and Radiation in Entomolog			365-375.
199	Menhinick, E.F., and Crossley, D.A.	Radiation sensitivity of twelve species of arthropods.	-1969	Annals of th	62	(4),	711-717.
204	Egami, N., and Hama-Furukawa, A.	Late effects of continuous gamma irradiation of the developmental stage on the gonads in Oryzias latipes.	-1980	Radiation Effects on Aquatic Organis			105-117.
207	Knowles, J.F.	Long-term irradiation of the marine fish, the plaice Pleuronectes platessa: an assessment of the effects on size an	-1999	Internationa	75	(6),	773-782.
213	Welander, A.D., Donaldson, L.R., Foster, R.F., Bonl	The effects of roentgen rays on the embryos and larvae of the chinook salmon.	-1948	Growth.	12		203-242.
247	Hingston, J.L., Knowles, J.F., Walker, P.J., Wood, M	Effects of ionising radiation on soil fauna.	-2004	Environment Agency R&D Technical Report P3-101/SP7			
286	Bonham, K., and Palumbo, R.F.	Effects of X-rays on snails, crustacea and algae.	-1951	Growth.	15		155-188.
292	Ballardin, E., and Metalli, P.	Estimates of some components of fitness in diploid parthenogenetic Artemia salina irradiated over several genera	-1968	Atti. Ass. Ge	13		342-345.
296	Baptist, J.P., Wolfe, D.A., and Colby, D.R.	Effects of chronic gamma radiation on the growth and survival of juvenile clams (Mercenaria mercenaria) and sca	-1976	Health phys	30		79-83.

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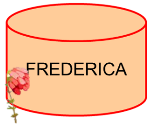
Select QC data for each test [series of data pairs for (species, endpoint, exposure conditions)]



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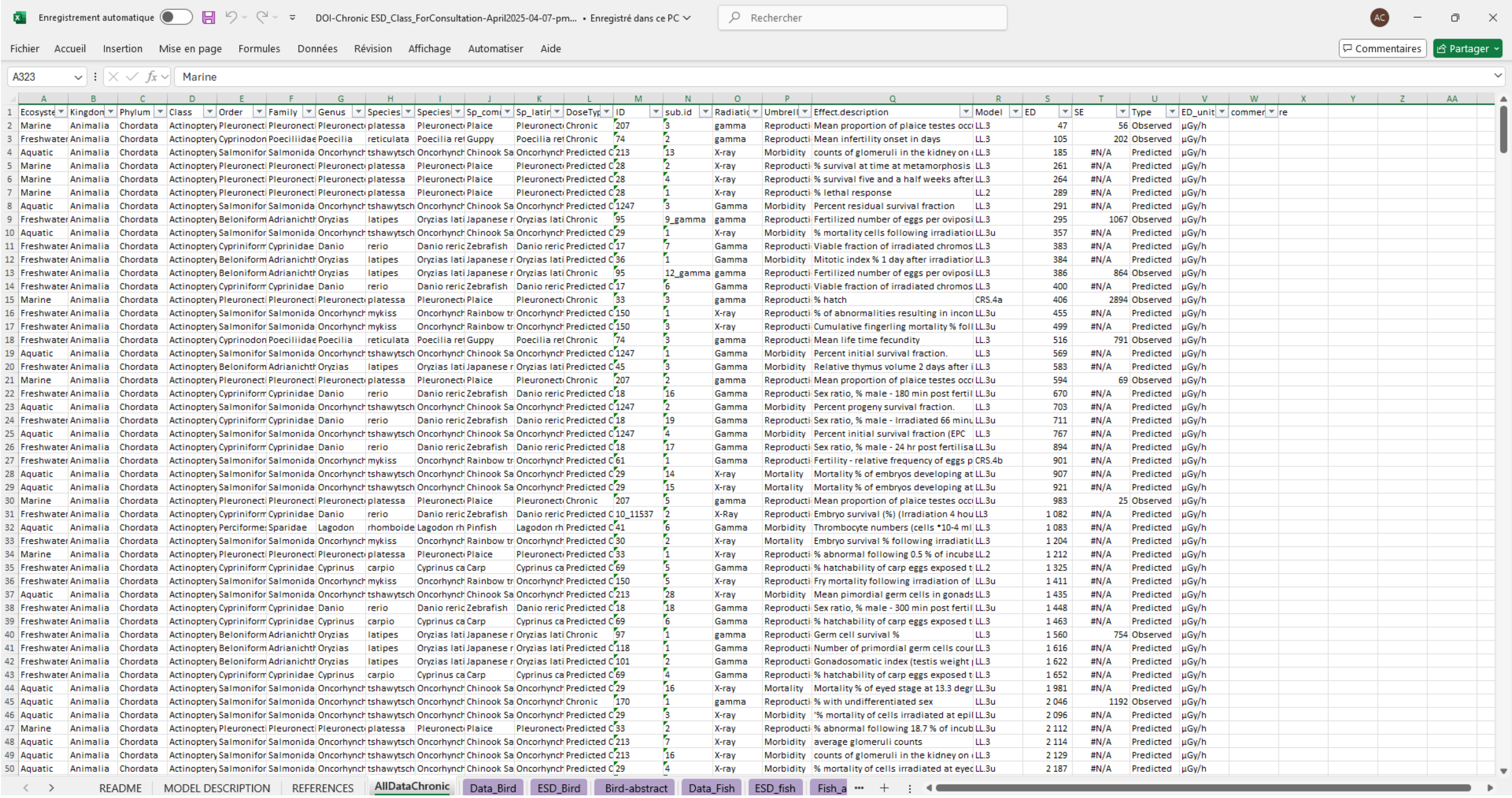
Electronic annexes with the used data sets and references

File organisation (example for ChronicESD_class)

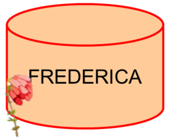
AllDataChronic



	Ecosyste	Kingdon	Phylum	Class	Order	Family	Genus	Species	Species	Sp_comi	Sp_latir	DoseTyp	ID	sub.id	Radiatic	Umbrell	Effect.description	Model	ED	SE	Type	ED_unit	commer	re
2	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Chronic	207	3	gamma	Reproducti	Mean proportion of plaice testes occ	LL.3	47	56	Observed	µGy/h		
3	Freshwater	Animalia	Chordata	Actinoptery	Cyprinodon	Poeciliidae	Poecilia	reticulata	Poecilia ret	Guppy	Poecilia ret	Chronic	74	2	gamma	Reproducti	Mean infertility onset in days	LL.3	105	202	Observed	µGy/h		
4	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	213	13	X-ray	Morbidity	counts of glomeruli in the kidney on	LL.3	185	#N/A	Predicted	µGy/h		
5	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Predicted C	28	2	X-ray	Reproducti	% survival at time at metamorphosis	LL.3	261	#N/A	Predicted	µGy/h		
6	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Predicted C	28	4	X-ray	Reproducti	% survival five and a half weeks after	LL.3	264	#N/A	Predicted	µGy/h		
7	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Predicted C	28	1	X-ray	Reproducti	% lethal response	LL.2	289	#N/A	Predicted	µGy/h		
8	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	1247	3	Gamma	Morbidity	Percent residual survival fraction	LL.3	291	#N/A	Predicted	µGy/h		
9	Freshwater	Animalia	Chordata	Actinoptery	Beloniform	Adrianichth	Oryzias	latipes	Oryzias lati	Japanese r	Oryzias lati	Chronic	95	9_gamma	gamma	Reproducti	Fertilized number of eggs per oviposi	LL.3	295	1067	Observed	µGy/h		
10	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	29	1	X-ray	Morbidity	% mortality cells following irradiatio	LL.3u	357	#N/A	Predicted	µGy/h		
11	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Danio	rerio	Danio reric	Zebrafish	Danio reric	Predicted C	17	7	Gamma	Reproducti	Viable fraction of irradiated chromos	LL.3	383	#N/A	Predicted	µGy/h		
12	Freshwater	Animalia	Chordata	Actinoptery	Beloniform	Adrianichth	Oryzias	latipes	Oryzias lati	Japanese r	Oryzias lati	Predicted C	36	1	Gamma	Morbidity	Mitotic index % 1 day after irradiatior	LL.3	384	#N/A	Predicted	µGy/h		
13	Freshwater	Animalia	Chordata	Actinoptery	Beloniform	Adrianichth	Oryzias	latipes	Oryzias lati	Japanese r	Oryzias lati	Chronic	95	12_gamma	gamma	Reproducti	Fertilized number of eggs per oviposi	LL.3	386	864	Observed	µGy/h		
14	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Danio	rerio	Danio reric	Zebrafish	Danio reric	Predicted C	17	6	Gamma	Reproducti	Viable fraction of irradiated chromos	LL.3	400	#N/A	Predicted	µGy/h		
15	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Chronic	33	3	gamma	Reproducti	% hatch	CRS.4a	406	2894	Observed	µGy/h		
16	Freshwater	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	mykiss	Oncorhynch	Rainbow tr	Oncorhynch	Predicted C	150	1	X-ray	Reproducti	% of abnormalities resulting in incon	LL.3u	455	#N/A	Predicted	µGy/h		
17	Freshwater	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	mykiss	Oncorhynch	Rainbow tr	Oncorhynch	Predicted C	150	3	X-ray	Reproducti	Cumulative fingerling mortality % foll	LL.3u	499	#N/A	Predicted	µGy/h		
18	Freshwater	Animalia	Chordata	Actinoptery	Cyprinodon	Poeciliidae	Poecilia	reticulata	Poecilia ret	Guppy	Poecilia ret	Chronic	74	3	gamma	Reproducti	Mean life time fecundity	LL.3	516	791	Observed	µGy/h		
19	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	1247	1	Gamma	Morbidity	Percent initial survival fraction.	LL.3	569	#N/A	Predicted	µGy/h		
20	Freshwater	Animalia	Chordata	Actinoptery	Beloniform	Adrianichth	Oryzias	latipes	Oryzias lati	Japanese r	Oryzias lati	Predicted C	45	3	Gamma	Morbidity	Relative thymus volume 2 days after i	LL.3	583	#N/A	Predicted	µGy/h		
21	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Chronic	207	2	gamma	Reproducti	Mean proportion of plaice testes occ	LL.3u	594	69	Observed	µGy/h		
22	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Danio	rerio	Danio reric	Zebrafish	Danio reric	Predicted C	18	16	Gamma	Reproducti	Sex ratio, % male - 180 min post fertil	LL.3u	670	#N/A	Predicted	µGy/h		
23	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	1247	2	Gamma	Morbidity	Percent progeny survival fraction.	LL.3	703	#N/A	Predicted	µGy/h		
24	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Danio	rerio	Danio reric	Zebrafish	Danio reric	Predicted C	18	19	Gamma	Reproducti	Sex ratio, % male - Irradiated 66 minu	LL.3u	711	#N/A	Predicted	µGy/h		
25	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	1247	4	Gamma	Morbidity	Percent initial survival fraction (EPC	LL.3	767	#N/A	Predicted	µGy/h		
26	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Danio	rerio	Danio reric	Zebrafish	Danio reric	Predicted C	18	17	Gamma	Reproducti	Sex ratio, % male - 24 hr post fertilisa	LL.3u	894	#N/A	Predicted	µGy/h		
27	Freshwater	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	mykiss	Oncorhynch	Rainbow tr	Oncorhynch	Predicted C	61	1	Gamma	Reproducti	Fertility - relative frequency of eggs p	CRS.4b	901	#N/A	Predicted	µGy/h		
28	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	29	14	X-ray	Mortality	Mortality % of embryos developing at	LL.3u	907	#N/A	Predicted	µGy/h		
29	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	29	15	X-ray	Mortality	Mortality % of embryos developing at	LL.3u	921	#N/A	Predicted	µGy/h		
30	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Chronic	207	5	gamma	Reproducti	Mean proportion of plaice testes occ	LL.3u	983	25	Observed	µGy/h		
31	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Danio	rerio	Danio reric	Zebrafish	Danio reric	Predicted C	10_11537	2	X-Ray	Reproducti	Embryo survival (%) (Irradiation 4 hou	LL3	1 082	#N/A	Predicted	µGy/h		
32	Aquatic	Animalia	Chordata	Actinoptery	Perciformes	Sparidae	Lagodon	rhomboide	Lagodon rh	Pinfish	Lagodon rh	Predicted C	41	6	Gamma	Morbidity	Thrombocyte numbers (cells *10-4 ml	LL.3	1 083	#N/A	Predicted	µGy/h		
33	Freshwater	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	mykiss	Oncorhynch	Rainbow tr	Oncorhynch	Predicted C	30	2	X-ray	Mortality	Embryo survival % following irradiatic	LL.3	1 204	#N/A	Predicted	µGy/h		
34	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Predicted C	33	1	X-ray	Reproducti	% abnormal following 0.5 % of incuba	LL.2	1 212	#N/A	Predicted	µGy/h		
35	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Cyprinus	carpio	Cyprinus ca	Carp	Cyprinus ca	Predicted C	69	5	Gamma	Reproducti	% hatchability of carp eggs exposed t	LL.2	1 325	#N/A	Predicted	µGy/h		
36	Freshwater	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	mykiss	Oncorhynch	Rainbow tr	Oncorhynch	Predicted C	150	5	X-ray	Reproducti	Fry mortality following irradiation of	LL.3u	1 411	#N/A	Predicted	µGy/h		
37	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	213	28	X-ray	Morbidity	Mean pimordial germ cells in gonads	LL.3	1 435	#N/A	Predicted	µGy/h		
38	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Danio	rerio	Danio reric	Zebrafish	Danio reric	Predicted C	18	18	Gamma	Reproducti	Sex ratio, % male - 300 min post fertil	LL.3u	1 448	#N/A	Predicted	µGy/h		
39	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Cyprinus	carpio	Cyprinus ca	Carp	Cyprinus ca	Predicted C	69	6	Gamma	Reproducti	% hatchability of carp eggs exposed t	LL.3	1 463	#N/A	Predicted	µGy/h		
40	Freshwater	Animalia	Chordata	Actinoptery	Beloniform	Adrianichth	Oryzias	latipes	Oryzias lati	Japanese r	Oryzias lati	Chronic	97	1	gamma	Reproducti	Germ cell survival %	LL.3	1 560	754	Observed	µGy/h		
41	Freshwater	Animalia	Chordata	Actinoptery	Beloniform	Adrianichth	Oryzias	latipes	Oryzias lati	Japanese r	Oryzias lati	Predicted C	118	1	Gamma	Reproducti	Number of primordial germ cells cour	LL.3	1 616	#N/A	Predicted	µGy/h		
42	Freshwater	Animalia	Chordata	Actinoptery	Beloniform	Adrianichth	Oryzias	latipes	Oryzias lati	Japanese r	Oryzias lati	Predicted C	101	2	Gamma	Reproducti	Gonadosomatic index (testis weight	LL.3	1 622	#N/A	Predicted	µGy/h		
43	Freshwater	Animalia	Chordata	Actinoptery	Cypriniform	Cyprinidae	Cyprinus	carpio	Cyprinus ca	Carp	Cyprinus ca	Predicted C	69	4	Gamma	Reproducti	% hatchability of carp eggs exposed t	LL.3	1 652	#N/A	Predicted	µGy/h		
44	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	29	16	X-ray	Mortality	Mortality % of eyed stage at 13.3 degr	LL.3u	1 981	#N/A	Predicted	µGy/h		
45	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Chronic	170	1	gamma	Reproducti	% with undifferentiated sex	LL.3u	2 046	1192	Observed	µGy/h		
46	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	29	3	X-ray	Morbidity	'% mortality of cells irradiated at epil	LL.3u	2 096	#N/A	Predicted	µGy/h		
47	Marine	Animalia	Chordata	Actinoptery	Pleuronecti	Pleuronecti	Pleuronect	platessa	Pleuronect	Plaice	Pleuronect	Predicted C	33	2	X-ray	Reproducti	% abnormal following 18.7 % of incub	LL.3u	2 112	#N/A	Predicted	µGy/h		
48	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	213	7	X-ray	Morbidity	average glomeruli counts	LL.3	2 114	#N/A	Predicted	µGy/h		
49	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	213	16	X-ray	Morbidity	counts of glomeruli in the kidney on	LL.3	2 129	#N/A	Predicted	µGy/h		
50	Aquatic	Animalia	Chordata	Actinoptery	Salmonifor	Salmonida	Oncorhynch	tshawytsch	Oncorhynch	Chinook Sa	Oncorhynch	Predicted C	29	4	X-ray	Morbidity	% mortality of cells irradiated at eyec	LL.3u	2 187	#N/A	Predicted	µGy/h		

README | MODEL DESCRIPTION | REFERENCES | AllDataChronic | Data_Bird | ESD_Bird | Bird-abstract | Data_Fish | ESD_fish | Fish_a

Select QC data for each test [series of data pairs for (species, endpoint, exposure conditions)]

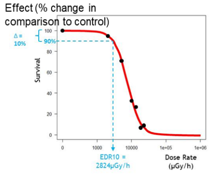


www.frederica-online.org

Copplestone et al., JER 2013
Garnier-Laplace et al., JER 2010

Reconstruct dose(rate)-effect relationship for each test

Chronic lab test – Observed EDR_{10}
Acute lab test -- Observed ED_{50}



Develop the Acute-to-Chronic Transformation of Radiation effects (ACTR) model

Electronic annexes with the used data sets and references

Establish Endpoint Sensitivity Distribution (ESD) per taxonomic group

Chronic ESD *[EDR_{10} observed and predicted]*

Acute ESD [ED_{50} observed]

ESD Generator

Endpoint Sensitivity Distribution

An ASNR software

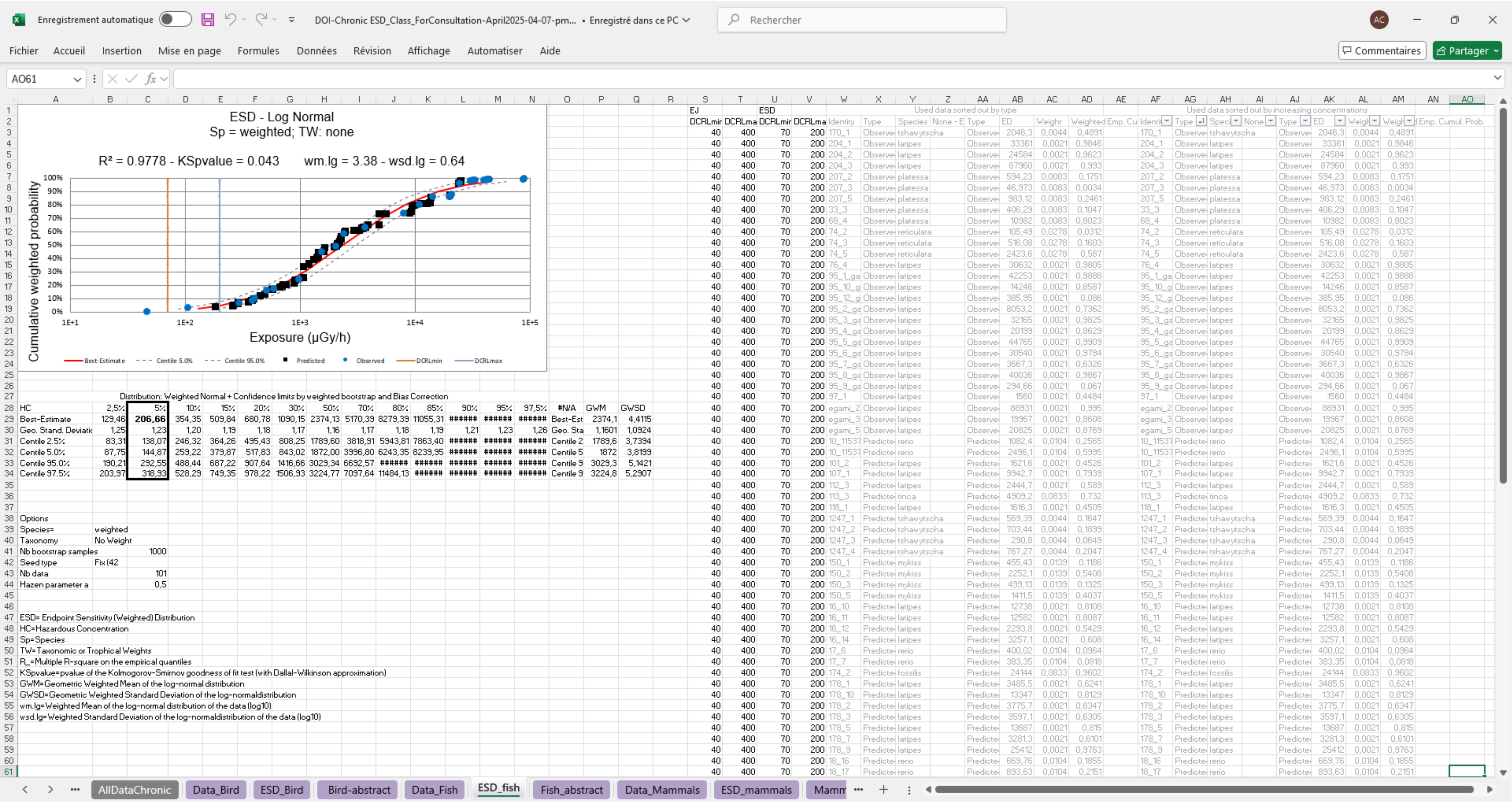
File organisation (example for ChronicESD_class)

Endpoint

Sensitivity

Distributions

(ESD)



Electronic annexes with the used data sets and references

File organisation (example for ChronicESD_class)

Abstract

n	min	max	HDR5	IC95% de HDR5	HDR50	IC95% de HDR50	Observed data proportion	Reproductive endpoints proportion	Nb data below 5th	Number of species
101	46,97	88931,00	206,66	[139 ; 319]	2374,13	[1790 ; 3225]	0,28	0,63	3	12

Data_Fish | ESD_fish

Needed for the Extrapolation Factor

Table 4.1

Criterion\level of uncertainty	low uncertainty	intermediate uncertainty	high uncertainty
Individual score per criterion	3	2	1
#1. Total number of data	>100	50-100	0-50
#2. Proportion of observed data in data set	0.7 to 1	0.3-0.7	0-0.3
#3. Proportion of reproductive endpoints	0.7 to 1	0.3-0.7	0-0.3
#4. Number of observed data below 5th out of total data	0.7 to 1	0.3-0.7	0-0.3
#5. Number of species	>10	from 5 to 10	<5
TOTAL SCORE RANGE	15	10	5
EF RANGE*	1	3	5

Table 4.3

$RAP_{\text{Class or Phylum}}$*	5th percentile	EF	$DCRL_{\text{Class or Phylum}}$†	RAP_{Family}‡	$DCRL_{\text{Family}}$‡
Birds	313	3	100-300	duck	4-40
Fish	207	3	70-200	trout; flat fish	40-400
Mammals	60	3	20-60	deer; rat	4-40
Crustaceans*	456	4	100-400	crab	400-4000
Worms*	580	3	100-500	earthworm	400-4000
Conifers	379	5	70-300	pine tree	4-40
Grasses and Monocots	1020	4	200-1000	wild grass	40-400
Shrubs, Trees not coniferous, Dicots	664	3	200-600	none	none

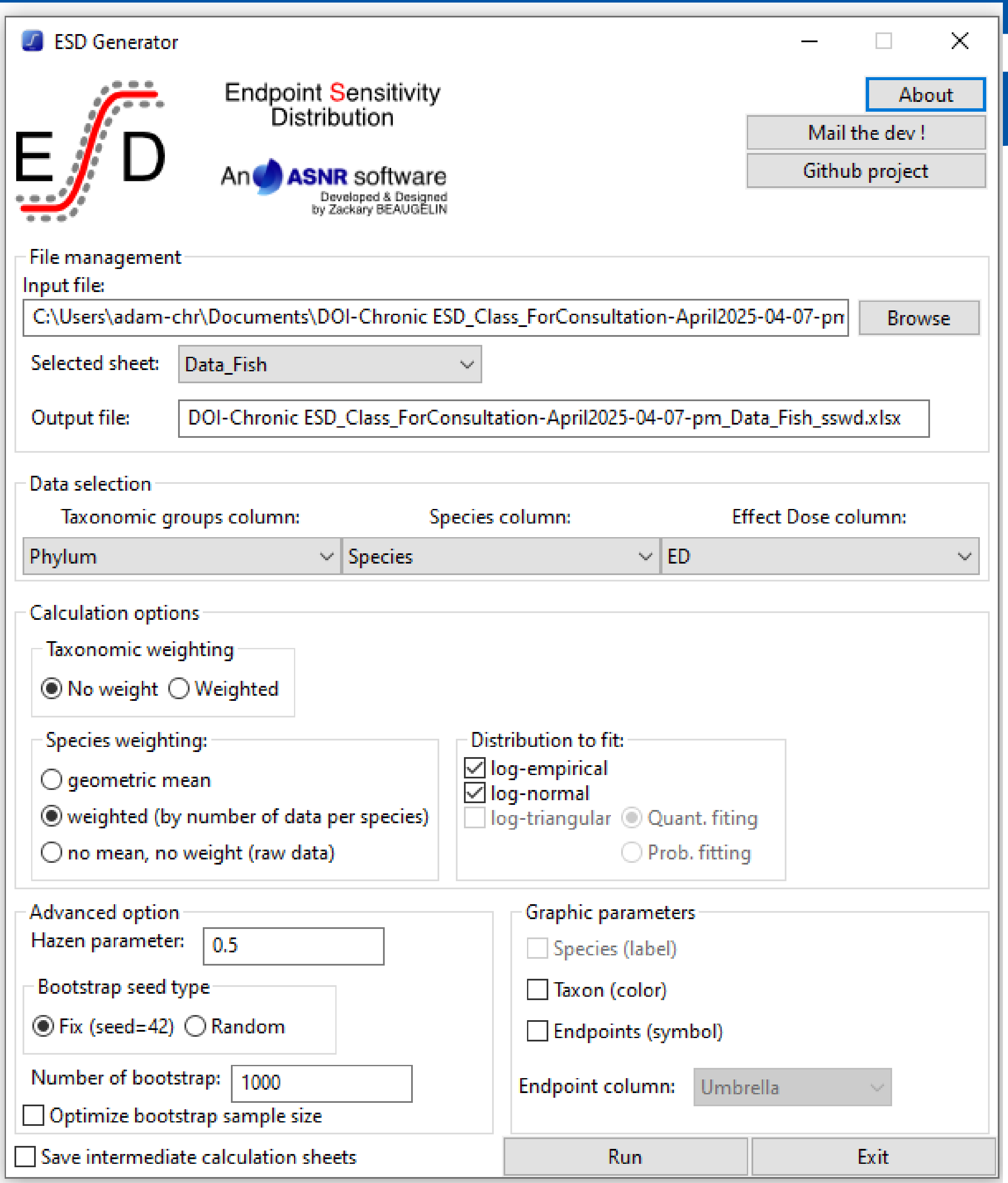
Data processing – dev r

Establish Endpoint Sensitivity Distribution (ESD) per taxonomic group

Chronic ESD *[EDR$_{10}$ observed and predicted]*

Acute ESD [ED$_{50}$ observed]

Tools developed for Windows are available on demand to Christelle Adam-Guillermin (christelle.adam-guillermin@asnr.fr)



Data processing – developed Tools : ESD Generator

Enregistrement automatique DOI-Chronic ESD_Class_ForConsultation-April2025-04-07-pm... • Enregistré dans ce PC

Fichier Accueil Insertion Mise en page Formules Données Révision Affichage Automatiser Aide

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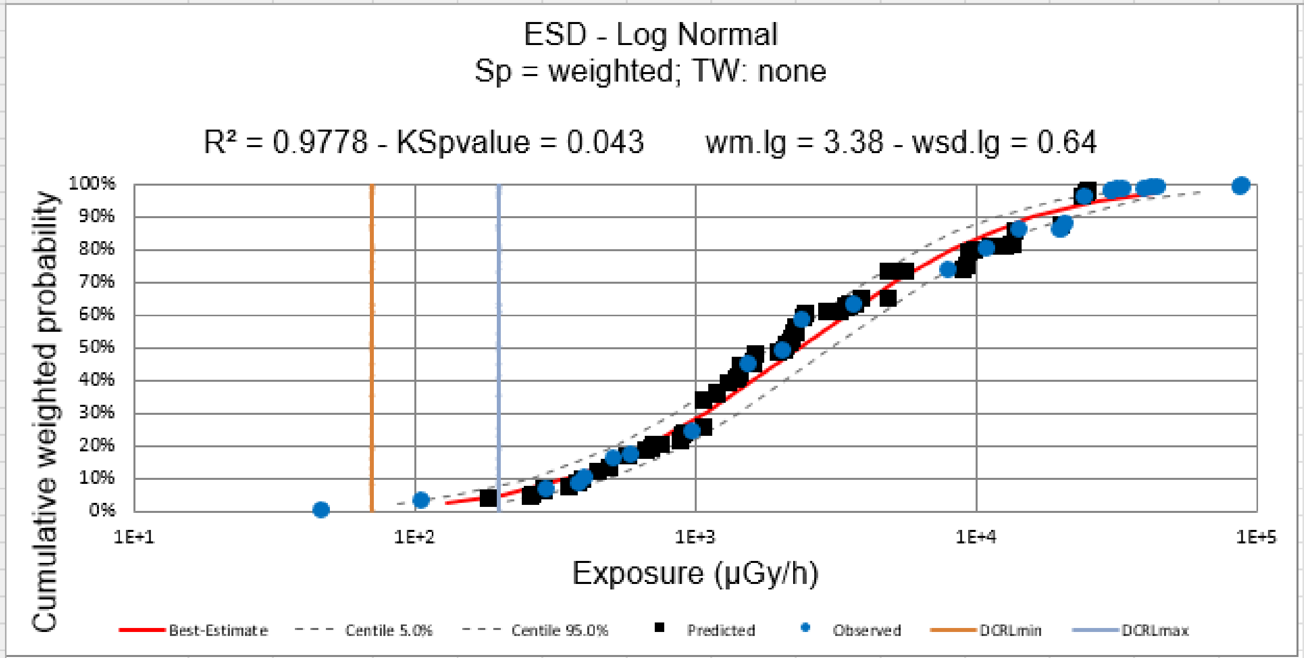


Distribution: Weighted Normal + Confidence limits by weighted bootstrap and Bias Correction

HC	2,5%	5%	10%	15%	20%	30%	50%	70%	80%	85%	90%	95%	97,5%	#N/A	GWM	GWSD
Best-Estimate	129,46	**206,66**	354,35	509,84	680,78	1090,15	2374,13	5170,39	8279,39	11055,31	######	######	######	Best-Est	2374,1	4,4115
Geo. Stand. Deviatic	1,25	1,23	1,20	1,19	1,18	1,17	1,16	1,17	1,18	1,19	1,21	1,23	1,26	Geo. Sta	1,1601	1,0924
Centile 2.5%	83,31	138,07	246,32	364,26	495,43	808,25	1789,60	3818,91	5943,81	7863,40	######	######	######	Centile 2	1789,6	3,7394
Centile 5.0%	87,75	144,87	259,22	379,87	517,83	843,02	1872,00	3996,80	6243,35	8239,95	######	######	######	Centile 5	1872	3,8199
Centile 95.0%	190,21	292,55	488,44	687,22	907,64	1416,66	3029,34	6692,57	######	######	######	######	######	Centile 9	3029,3	5,1421
Centile 97.5%	203,97	318,93	528,29	749,35	978,22	1506,93	3224,77	7097,64	11484,13	######	######	######	######	Centile 9	3224,8	5,2907

Establish Endpoint Sensitivity Distribution (ESD) per taxonomic group

Chronic ESD [EDR_{10} observed and predicted]

Acute ESD [ED_{50} observed]

ESD Generator

Endpoint Sensitivity Distribution

An ASNR software

Data processing – developed tools : ESD Viewer

Establish Endpoint Sensitivity Distribution (ESD) per taxonomic group

Chronic ESD *[EDR$_{10}$ observed and predicted]*

Acute ESD [ED$_{50}$ observed]

ESD Generator

Endpoint Sensitivity Distribution

An ASNR software

Developed & Designed by Zackary BEAUGELIN

1) RAP$_{\text{Class or Phylum}}$ selection

2) Exposure regime selection (acute or chronic)

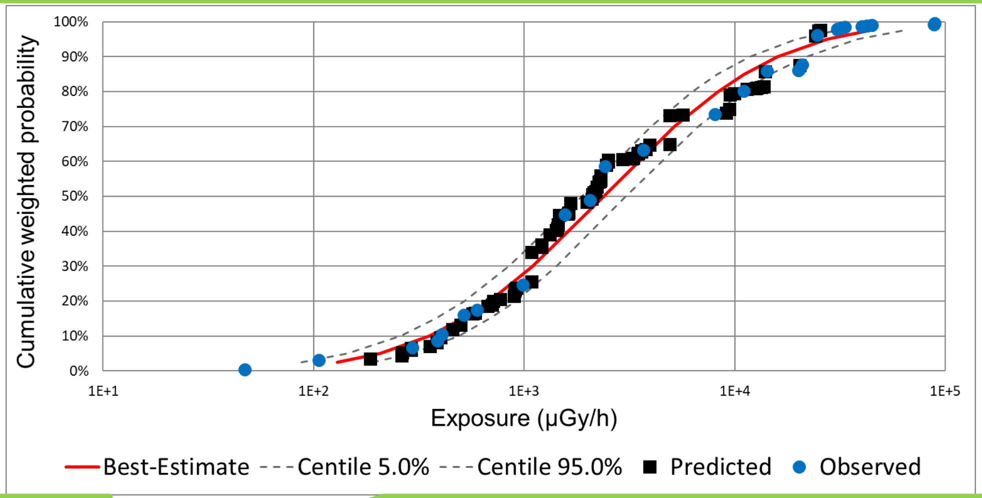
3) Confidence interval selection (90 or 95% around the fitted model)

=> Summary of the ESD parameters

Data selection: Fish

Radiation type: Chronic

Confidence interval: 90%



5th and 50th percentiles

	5%	50%
Best-Estimate	206.66	2374.13
Centile 5.0%	144.87	1872.00
Centile 95.0%	292.55	3029.34

Data sorted by Effect dose (rate)

Phylum	SpeciesComp	Umbrella	ED
Chordata	Pleuronectes platessa	Reproductioı	47
Chordata	Poecilia reticulata	Reproductioı	105
Chordata	Oncorhynchus tshawytscha	Morbidity	185
Chordata	Pleuronectes platessa	Reproductioı	261
Chordata	Pleuronectes platessa	Reproductioı	264
Chordata	Pleuronectes platessa	Reproductioı	289
Chordata	Oncorhynchus tshawytscha	Morbidity	291
Chordata	Oryzias latipes	Reproductioı	295
Chordata	Oncorhynchus tshawytscha	Morbidity	357
Chordata	Danio rerio	Reproductioı	383
Chordata	Oryzias latipes	Morbidity	384
Chordata	Oryzias latipes	Reproductioı	386

=> Resulting Endpoint Sensitivity Distribution (ESD)

Criteria : fish, chronic, 90%

Distinction between observed (round blue symbols) and predicted (from acute) data (**black square symbols**)

Data processing – developed tools : ESD Viewer

Establish Endpoint Sensitivity Distribution (ESD) per taxonomic group

Chronic ESD *[EDR_{10} observed and predicted]*

Acute ESD [ED_{50} observed]

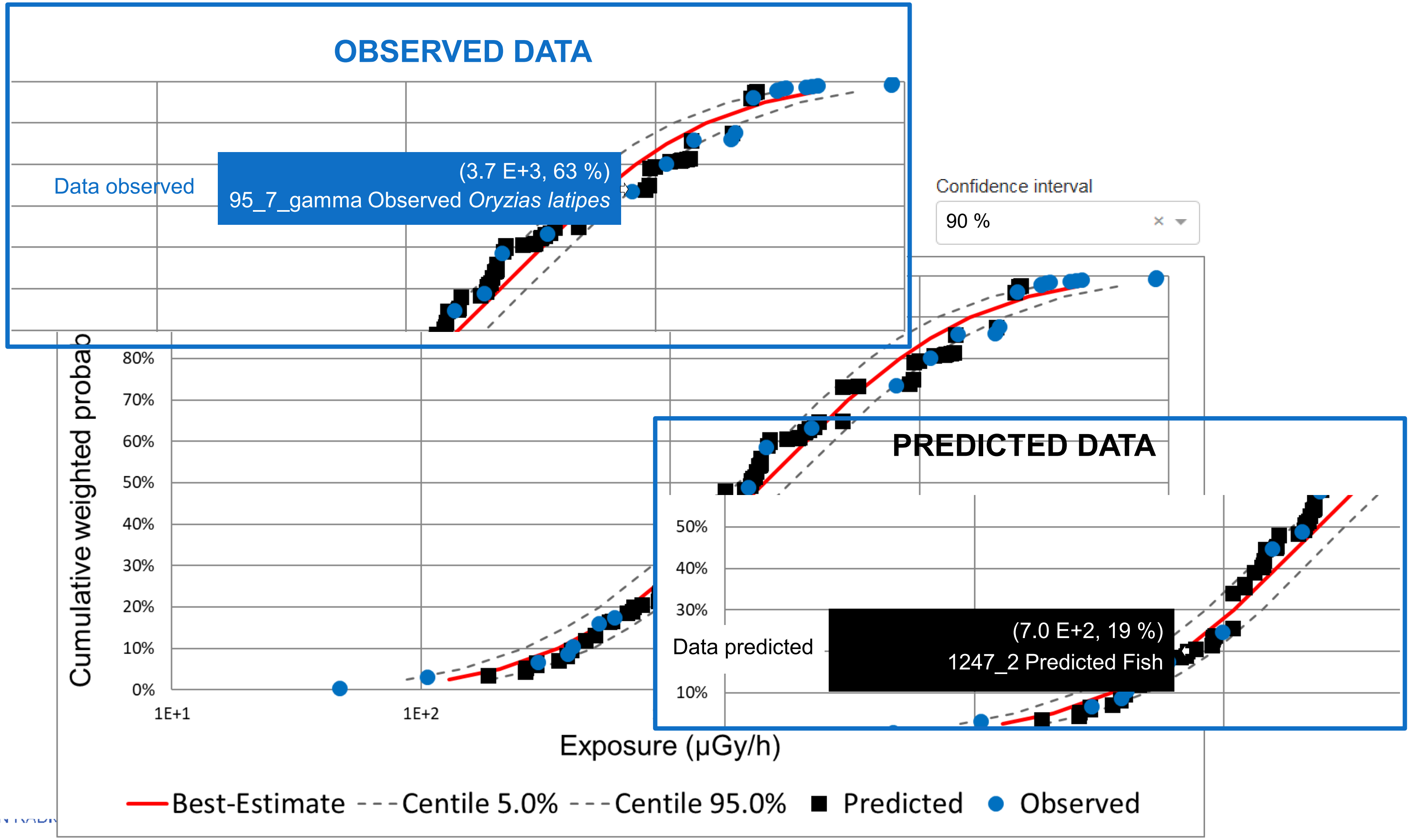
ESD Generator

Endpoint Sensitivity Distribution

An ASNR software

Developed & Designed by Zackary BEAUGELIN

- By pointing on one symbol of the ESD => summary of the corresponding data (value, percentile, FREDERICA reference, predicted/observed, species)



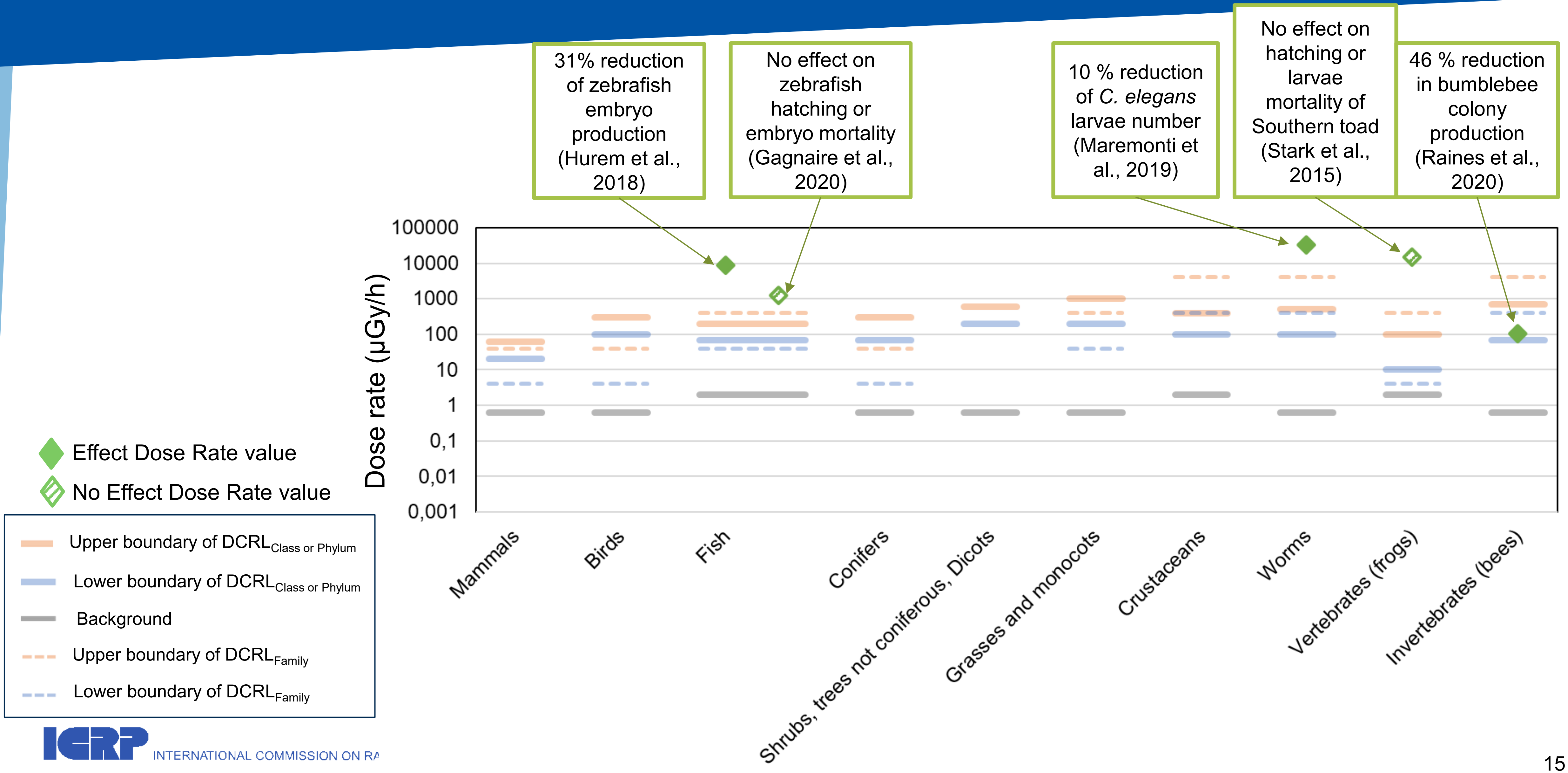
How do lab data compare with DCRLs

Chap 5

The data set used for $DCRL_{Class\ or\ Phylum}$ derivation was extracted from the most recent (2010) version of the quality checked FREDERICA database. Since that date, several papers have been published

- Meta-analysis of peer reviewed papers on laboratory experiments and field studies on sites contaminated by radionuclides
- For the laboratory studies : focus on the effects of exposure to external X-ray or gamma irradiation that comply with the selection rules of data for reconstruction of Dose(rate) - Effect relationship (quality check)
- Due to a shift to novel molecular tools during the last decades, most of papers were only dealing with mechanistic understanding of radiation-induced effects. Even if they are generally more sensitive than the population-relevant endpoints used to derive DCRLs, the long-term consequences of such molecular responses are still difficult to causally link to population level changes.
- ~150 full-paper screening : some of them met the quality criteria for reconstruction of Dose(rate) - Effect relationship but not all were usable because the studied endpoints were not linked to population dynamics
- Finally, a few papers only could be directly used to compare these data with appropriate DCRLs

How do lab data compare with DCRLs



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How do lab and field data compare with DCRLs

- These recent lab studies show that most of effect values are well above the $DCRL_{Class\ or\ Phylum}$ and hence do not substantively challenge them
- For bumblebees, the effect value falls within the corresponding range for invertebrates $DCRL_{Class\ or\ Phylum}$ of 70-700 µGy h^{-1}, and support this more conservative (lower) range than the one for bee where $DCRL_{Family}$ is 400 to 4000 µGy h^{-1}

- For the field studies : difficult to use these data to compare to DCRLs
  - Molecular endpoints are often used to shed light on toxicity mechanisms or as early warning biomarkers of adverse effects.
  - Several confounding factors such as dosimetry assessment, indirect effects, multiple exposure

Conclusions and research needs

Several research needs to better address some uncertainty sources (e.g. dose assessment, impact of the life stages, transgenerational effects (see ICRP TG121))

More studies are also needed to link radiation effects at the molecular (e.g. DNA damage) and cellular (e.g. oxidative stress) levels, with potential effects at higher levels of organisation (individual, population, community or ecosystem) and to link individual responses to population ones.

Toward this, the application of Adverse Outcome Pathway (AOP) is a promising tool, which helps to identify gaps of knowledge by organising the scientific data in a systematic way, and to link toxic pathways at the subcellular level to a macroscopic endpoint such as reproduction

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