MEMO

TO: Jackie Wells
FROM: Rob Willis
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SUBJECT: Technical Memo – Supplemental Human Health Risk Assessment (HHRA) of 2022 Fish and Seal Mercury Data
OUR FILE: 22-4223

Supplemental Human Health Risk Assessment (HHRA) of 2022 Fish and Seal Mercury Data

1.0 Introduction

As part of ongoing efforts to continually update predictions regarding the potential for methylmercury (MeHg) levels to increase in Muskrat Falls study area aquatic biota, and the potential for increased MeHg exposure among human consumers of locally harvested aquatic country foods, this report presents the outcomes of human health risk assessment (HHRA) of 2022 aquatic EEM program data on MeHg concentrations in harvested fish and seal species.

Previous HHRA work conducted within the Muskrat Falls HHRA Program (i.e., Dillon, 2016a,b; 2018) focused on the assessment and characterization of baseline and predicted future MeHg exposure and risk. The prediction of MeHg exposure and human health risk in relation to the 2022 aquatic EEM data builds upon the modelling framework developed within the comprehensive 2016 final baseline HHRA (i.e., Dillon, 2016b), and also incorporates and/or builds upon the outcomes of the various modelling studies, field programs, EEM data evaluations, and other studies that were conducted by independent technical experts throughout 2017 and 2018, and that are described in Dillon (2018) and various other documents posted to the Muskrat Falls Project websites: (https://muskratfalls.nalcorenergy.com/environment/generation/; https://muskratfalls.nalcorenergy.com/environment/generation/methylmercury-monitoring/)

The Muskrat Falls Human Health Program was initiated in 2013 and has been ongoing since that time. Key elements and milestones of the Human Health Program have been described in previous documentation (in particular, Dillon (2018; 2016b)) and in other documents posted to the above websites. This memo does not elaborate on information that is covered in detail within previous HHRA program documents.

It is acknowledged that while all Muskrat Falls study area HHRA studies to date focus on MeHg exposures, and the potential human health risks of such exposures, Muskrat Falls study area fish and seal mercury concentration data are primarily measured and expressed as total mercury (THg) concentrations, rather than MeHg concentrations. It is very common (for reasons relating to practicality and efficiency) to measure THg rather than MeHg in comprehensive mercury environmental monitoring programs. In the baseline HHRA (Dillon, 2016b), and the Dillon (2018) assessment of potential future

MeHg exposures and risks, it was conservatively assumed that the THg present in fish and seal muscle tissue (meat) was comprised of 100% MeHg, and that the THg present in seal liver was comprised of 40% MeHg (based on literature review conducted during the baseline HHRA program and on empirical study area ringed seal tissue THg and MeHg data that were collected in support of the baseline HHRA). These assumptions continue to apply herein. For the sake of simplicity and consistency, this memo mainly refers to MeHg concentrations in fish and seal (even though the mercury concentrations are reported as THg), and MeHg exposures and risks, unless specifically referring directly to the fish and seal aquatic EEM datasets, which report THg.

2.0 Potential MeHg Exposures and Risks Within the Muskrat Falls Study Area – 2022 Aquatic EEM Data

This section addresses potential MeHg exposures that may be incurred by study area community members due to the harvesting and consumption of fish and seal, and the potential health risks that may be anticipated as a result of such exposures. Assessment of potential MeHg exposures and risks, based on the 2022 aquatic EEM program data, is supplemental to the final baseline HHRA (Dillon, 2016b), and the prediction of potential future MeHg exposures and risks that were presented in Dillon (2018). The 2022 potential MeHg exposures and risks were estimated using the same exposure and risk model developed for the final baseline HHRA, which was also applied for the estimation of potential future MeHg exposures and risks.

Because the evaluation presented herein is based on MeHg concentrations in key fish and seal species from the study area in 2022, the predicted peak MeHg increase factors reported in Table 2-3 of Wood (2018a) for Goose Bay and West Lake Melville were not necessary to apply. Nonetheless, these increase factors continue to represent the current best available estimates of potential future increases in MeHg concentrations within the edible tissues of locally harvested fish species and ringed seal. As previously noted in Dillon (2018), the peak MeHg increase factors were derived in a manner that is believed to be highly conservative, such that their application likely substantially overestimates future dietary MeHg exposures and risks within the study area communities. Also, the peak MeHg increase factors are temporary and are expected to occur within 2 to 3 years following reservoir impoundment. The various studies conducted in 2017 and 2018 (all of which are posted at: https://muskratfalls.nalcorenergy.com/environment/generation/methylmercury-monitoring/) collectively indicate that MeHg concentrations in study area aquatic biota are anticipated to gradually increase such that they would peak by post-reservoir impoundment years 2 or 3, persist for potentially 1 year, and then gradually decline thereafter back towards baseline levels.

As previously noted in Dillon (2018) and Wood (2018a,b), brook trout, rainbow smelt and ringed seal (meat and liver) are focused on with respect to the assessment of potential MeHg exposure and risk. These species are the most commonly consumed (as reported in HHRA program diet surveys), are among the most abundant harvested species within the study area, and are the only harvested and consumed species likely to be affected by the Project (i.e., these species are most likely to experience increases in MeHg accumulation within their tissues as a result of the Project). The outcomes of Wood (2018b) and the HHRA Program diet surveys demonstrated that other fish species known to occur within the study area are either not harvested/consumed (based on diet survey results), or, if they are harvested and consumed, are unlikely to be influenced by the Project, given their habitat preferences, distribution, foraging preferences, life history, and prevalence and abundance within study area water

bodies. Thus, brook trout, rainbow smelt and ringed seal are the only species that merit consideration at this time.

Of the study area communities considered in the baseline HHRA (Dillon, 2016b), all but Churchill Falls (CF) merit consideration with respect to current MeHg exposures and risks. CF is excluded from the current HHRA as the fish harvested and consumed by CF residents are extremely unlikely to come from the Muskrat Falls reservoir, areas downstream of the reservoir, Goose Bay or Western Lake Melville (given that the distance between CF and these water bodies is >250 km), and CF residents did not report the consumption of ringed seal meat or liver. Thus, for CF community members, current and future MeHg exposures and risks as a result of the Muskrat Falls Project are expected to equal baseline MeHg exposures and risks.

The HHRA of the 2022 aquatic EEM program MeHg data for brook trout, rainbow smelt and ringed seal meat and liver tissues was conducted using the same model that was developed for the baseline HHRA, and that was also utilized in the Dillon (2018) assessment of potential future MeHg exposures and risks. For the HHRA of the 2022 data, MeHg exposure point concentrations (EPCs) were calculated from the 2022 brook trout, rainbow smelt, and ringed seal meat and liver MeHg (reported as THg) concentration datasets. These 2022 data were provided to Dillon by WSP. Statistical data summaries for the 2022 brook trout, rainbow smelt, and ringed seal meat and liver THg datasets are provided in **Attachment A** to this memo.

All EPCs (which are upper 95% confidence limits on the arithmetic mean, or UCLM95) were calculated using the latest version of the U.S. EPA's ProUCL software. EPC calculation was conducted in the same manner as described in Dillon (2016b), and the EPC units are expressed in mg/kg wet weight (ww) of fish (or seal) tissue. EPC calculation output is provided in **Attachment A**. As previously noted, it was conservatively assumed herein, and throughout the HHRA Program to date, that the THg concentrations measured in fish and seal muscle tissue (meat) were comprised of 100% MeHg, and that the THg concentrations in seal liver were comprised of 40% MeHg.

For the calculation of 2022 MeHg exposures and risks, all other sources and rates of MeHg exposure that were evaluated in the baseline HHRA (i.e., other locally harvested country foods that are not influenced by the Muskrat Falls Project, and grocery store foods) remained constant or unchanged from what was assumed for baseline conditions. This was also the approach taken for the estimation of predicted future peak MeHg exposures and risks in Dillon (2018). For these "other" country food items and grocery store food items, it is considered very likely that current and future MeHg exposures would be no different from baseline MeHg exposures.

Table 1 provides a summary of MeHg EPCs for brook trout, rainbow smelt, and ringed seal meat and liver, for the baseline period, for the future predicted peak MeHg condition, for 2021 (calculated from measured 2021 aquatic EEM program THg data), and for 2022 (calculated from measured 2022 aquatic EEM program THg data). In **Table 1**, ringed seal meat and liver THg data are provided separately for pups and non-pups, as well as for all seals (pups and non-pups) combined. At this time, these data are provided to illustrate the differences in THg (and MeHg) concentrations in pups versus non-pups. However, there is no basis at this time to separate seals into pups and non-pups for HHRA purposes, as it is commonly reported that both pups and non-pups can be harvested and consumed, though pups are often reported to be harvested preferentially. The need for separating seal THg data into pups and non-

pups will continue to be reviewed, and planned study area diet survey updates may provide useful information towards determining the appropriateness and representativeness of potentially conducting separate exposure and risk assessments for Hg in seal pups and non-pups.

Table 1: Summary of MeHg EPCs: Baseline, Potential Future Peak Conditions, 2021, and 2022; mg/kg ww

Key Species	Baseline MeHg EPC	Future Peak Predicted MeHg EPC (Peak Increase Factor X Baseline EPC)	2021 MeHg EPC	2022 MeHg EPC
brook trout	0.07; N=340 [max=0.44]	0.11; N=340	0.074; N=81 [max=0.24]	0.034; N=84 [max=0.08]
rainbow smelt	0.12; N=142 [max=0.31]	0.22; N=142	0.054; N=73 [max=0.12]	0.062; N=64 [max=0.16]
ringed seal meat (all seals; pups and non-pups)	0.34; N=159 [max=6.3]	0.43; N=159	0.031; N=30 [max=0.08]	0.058; N=30 [max=0.12]
ringed seal liver (all seals; pups and non-pups)	9.1; N=145 [max=110]	11.5; N=145	0.30; N=30 [max=0.57]	4.9; N=30 [max=20.5]
Ringed Seal Meat and Liver Data – Separated into Pups Versus Non-Pups				
ringed seal meat (pups only)	0.08; N=133 [max=0.35]	0.1; N=133	As above (0.031); only pups were harvested in 2021.	0.052; N=27 [max=0.10]
ringed seal meat (non-pups only)	1.5; N=26 [max=6.3]	1.9; N=26	Not calculable as only pups were harvested in 2021.	EPC not calculable; N=3 [range: 0.01 – 0.12]
ringed seal liver (pups only)	0.41; N=124 [max=1.8]	0.52; N=124	As above (0.30); only pups were harvested in 2021.	0.48; N=27 [max=1.1]
ringed seal liver (non-pups only)	41; N=21 [max=110]	51; N=21	Not calculable as only pups were harvested in 2021.	EPC not calculable; N=3 [range: 0.13 – 20.5]

Notes:
N=sample size (# of samples); max=maximum MeHg concentration.
All EPC units are in mg/kg ww and all EPCS are UCLM95 statistics determined using USEPA ProUCL v5.2 statistical software.
All fish and seal mercury data were measured as THg concentrations (which, in the table, are referred to as MeHg concentrations). For HHRA purposes, it was conservatively assumed that THg measured in fish and seal muscle tissue (meat) was comprised of 100% MeHg, and that THg in seal liver was comprised of 40% MeHg.

It is noted that all brook trout and rainbow smelt Hg EPCs for the baseline, future peak predicted, 2021 and 2022 conditions are below the Health Canada maximum level for mercury in fish of 0.5 mg THg/kg ww fish (https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/maximum-levels-chemical-contaminants-foods.html#a2). The measured baseline, 2021

and 2022 maximum concentrations of THg in brook trout and rainbow smelt are also below this Health Canada maximum level.

For brook trout, the THg EPCs and maximum concentrations presented in **Table 1** appear to suggest a decreasing trend from the baseline period through to 2021 and 2022. For rainbow smelt, there is less of an apparent decreasing trend for THg EPCs and maxima, but both the 2021 and 2022 measured THg EPCs and maximum concentrations in smelt are lower than the measured THg EPC and maximum concentrations for the baseline period.

Table 1 indicates that the 2022 seal meat and seal liver Hg EPCs have increased from 2021, but still remain well below the baseline and future peak Hg EPCs for seal meat and liver. The increase for 2022 is due to the presence of some older seals (non-pups) in the 2022 EEM seal dataset, whereas the 2021 dataset comprised only pups. As has been noted in a number of previous HHRA Program reports (e.g., Dillon, 2016a,b; 2018), older seals tend to have higher Hg levels in both their muscle and liver tissues, but especially in their liver tissue.

2.1 HHRA Outcomes: Evaluation of 2022 MeHg Data

Outcomes of the HHRA of the 2022 MeHg data for brook trout, rainbow smelt, and ringed seal meat and liver showed either no change in MeHg hazard quotients relative to the baseline MeHg hazard quotients (the hazard quotient is the primary indicator of potential human health risk in a HHRA), or decreased MeHg hazard quotients relative to the baseline MeHg hazard quotients. Model-predicted hair and blood MeHg concentrations for the assessed human receptors and study area communities followed the same pattern as the MeHg hazard quotients. **Tables 2 to 5** summarize the changes in these key HHRA outcomes based on the assessment of 2022 brook trout, rainbow smelt and ringed seal meat and liver MeHg data, relative to baseline, predicted future peak conditions, and 2021 HHRA outcomes.

The HHRA of the 2022 MeHg data does not alter any of the conclusions made within the previous baseline HHRA, and the results presented in **Tables 2 to 5** should be considered in the same context and perspective that was provided in the final baseline HHRA report (i.e., Dillon, 2016b).

Specifically, the HHRA outcomes suggest a low to negligible potential for human health risk resulting from current MeHg exposures, and the calculated MeHg exposures and risks are similar to what would be expected in numerous communities in North America where food consumption patterns comprise the ingestion of both store-bought foods and country food items that are of aquatic origin. HHRA outcomes also do not indicate a need for corrective action or risk management (such as specific consumption advisories) at this time. However, standard precautionary recommendations as per those made in Dillon (2016b) and Dillon (2018) continue to be considered prudent to apply. For example, despite the conservatism and the high likelihood that the HHRA substantially overestimates MeHg exposures and risks to nursing mothers, breast-feeding infants, females of child-bearing age and the developing fetus, standard universal advice that pregnant women, nursing mothers and women of child-bearing age avoid, restrict or temporarily cease their consumption of certain country and store-bought food items that tend to be elevated in MeHg, is prudent, and should apply within the study area communities. It must be recognized that this well-established precautionary advice applies to pregnant women, nursing mothers and women of child-bearing age anywhere, and is not made for the study area

communities because of baseline HHRA, future predicted peak HHRA, 2021 HHRA or 2022 HHRA outcomes.

It must also be recognized that there are numerous and universally well-established benefits (to both the infant and mother) of breast-feeding, and HHRA outcomes indicate no reason whatsoever for there to be concerns regarding breast-feeding in relation to the levels of MeHg exposure within study area communities. In general, breast-feeding should never be stopped due to fears over chemical exposure unless specifically recommended by a physician. The benefits of breast-feeding far outweigh the potential health risks from chemical exposure in the overwhelmingly vast majority of cases. Given the HHRA outcomes, and recognizing the inherent conservatism and tendency for the HHRA approaches to overestimate exposure and risk, there is no cause for concern in relation to potential infant MeHg exposures that may be incurred via breast-feeding. Thus, any new or soon-to-be mothers within the study area communities should continue to be encouraged to breast-feed their infants and young toddlers, if they are able to. Following the standard universal precautionary measures for MeHg will further reduce what is an already low to negligible potential for significant MeHg exposure and risk.

In addition (as noted previously in Dillon, 2016a,b and Dillon, 2018), it may be prudent to recommend to those study area residents that consume ringed seal meat and organs, that only younger ringed seals (i.e., pups) be harvested for human consumption (as older seals tend to have higher THg and MeHg concentrations in both their muscle and liver tissue). Typically, it is the younger seals that are preferentially harvested (based on information from a number of study area residents who engage in seal harvesting), but encouraging this practice would likely reduce the Hg exposures that may be incurred from seal meat and liver consumption.

MEMO

TABLE 2a: SUMMARY OF METHYLMERCURY (MeHg) HAZARD QUOTIENTS (HQs) FOR MUSKRAT FALLS STUDY AREA EXPOSURE/CONSUMPTION SCENARIOS (COMMUNITIES) – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: HAPPY VALLEY-GOOSE BAY (HVGB)

Human Receptor Type	HQ Type	Baseline HVGB	Potential Future Peak HVGB	2021 HVGB	2022 HVGB
M Toddler	HQ1	**1.3**	**1.39**	**1.1**	**1.1**
	HQ2	NA	NA	NA	NA
	HQ3	0.64	0.69	0.53	0.53
M Child	HQ1	**1.5**	**1.6**	**1.5**	**1.5**
	HQ2	NA	NA	NA	NA
	HQ3	0.77	0.8	0.73	0.74
M Teen	HQ1	**1.2**	**1.2**	0.99	1.0
	HQ2	0.25	0.26	0.21	0.21
	HQ3	NA	NA	NA	NA
M Adult	HQ1	**2.5**	**2.6**	**2.1**	**2.3**
	HQ2	0.53	0.55	0.45	0.48
	HQ3	NA	NA	NA	NA
F Toddler	HQ1	**1.4**	**1.5**	**1.1**	**1.1**
	HQ2	NA	NA	NA	NA
	HQ3	0.68	0.74	0.57	0.56
F Child	HQ1	**1.6**	**1.7**	**1.5**	**1.5**
	HQ2	NA	NA	NA	NA
	HQ3	0.79	0.83	0.75	0.76
F Teen	HQ1	**1.3**	**1.4**	**1.1**	**1.1**
	HQ2	0.28	0.29	0.24	0.24
	HQ3	0.65	0.69	0.56	0.57
F Adult	HQ1	**3.0**	**3.1**	**2.6**	**2.7**
	HQ2	0.63	0.66	0.54	0.57

Human Receptor Type	HQ Type	Baseline HVGB	Potential Future Peak HVGB	2021 HVGB	2022 HVGB
	HQ3	**1.5**	**1.6**	**1.3**	**1.3**
Infant with F Teen Mother	HQ1	**2.6**	**2.7**	**2.2**	**2.2**
	HQ3	**1.3**	**1.4**	**1.1**	**1.1**
Infant with F Adult Mother	HQ1	**5.8**	**6.1**	**5.0**	**5.3**
	HQ3	**2.9**	**3.1**	**2.5**	**2.6**

Notes:
M=Male; F=Female.
HQ values are rounded to two significant figures. HQ values are unitless.
Bolded values indicate exceedance of target HQ value of 1.0.
HQ1 refers to HQ based on use of the U.S. EPA (2001a,b) and NRC (2000) TRV (See Dillon, 2016b).
HQ2 refers to HQ based on use of the Health Canada (2010c; 2007) TRV for the general adult population (See Dillon, 2016b). This TRV was also applied to M and F teen receptors (>12 to <20 years).
HQ3 refers to HQ based on use of the Health Canada (2010c; 2007) TRV for women of child-bearing age (considered to be both teen and adult life stages) and children <12 years of age (See Dillon, 2016b).
NA=not applicable for a given receptor; due to application of the gender and age-specific TRVs for MeHg from Health Canada.

TABLE 2b: SUMMARY OF METHYLMERCURY (MeHg) HAZARD QUOTIENTS (HQs) FOR MUSKRAT FALLS STUDY AREA EXPOSURE/CONSUMPTION SCENARIOS (COMMUNITIES) – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: SHESHATSHIU (SH)

Human Receptor Type	HQ Type	Baseline SH	Potential Future Peak SH	2021 SH	2022 SH
M Toddler	HQ1	1.0	**1.1**	1.0	0.97
	HQ2	NA	NA	NA	NA
	HQ3	0.50	0.53	0.50	0.48
M Child	HQ1	**1.4**	**1.5**	**1.4**	**1.4**
	HQ2	NA	NA	NA	NA
	HQ3	0.71	0.73	0.70	0.70
M Teen	HQ1	0.95	0.97	0.94	0.93
	HQ2	0.20	0.21	0.20	0.20
	HQ3	NA	NA	NA	NA
M Adult	HQ1	**2.1**	**2.1**	**2.1**	**2.1**
	HQ2	0.44	0.45	0.44	0.44
	HQ3	NA	NA	NA	NA
F Toddler	HQ1	**1.1**	**1.1**	**1.1**	1.0
	HQ2	NA	NA	NA	NA
	HQ3	0.54	0.56	0.53	0.52
F Child	HQ1	**1.5**	**1.5**	**1.4**	**1.4**
	HQ2	NA	NA	NA	NA
	HQ3	0.73	0.76	0.72	0.72
F Teen	HQ1	**1.1**	**1.1**	**1.1**	**1.1**
	HQ2	0.23	0.23	0.23	0.23
	HQ3	0.54	0.55	0.53	0.53
F Adult	HQ1	**2.5**	**2.5**	**2.5**	**2.5**
	HQ2	0.53	0.54	0.52	0.52
	HQ3	**1.2**	**1.3**	**1.2**	**1.2**
Infant with F Teen Mother	HQ1	**2.1**	**2.1**	**2.1**	**2.1**
	HQ3	**1.1**	**1.1**	1.0	1.0

Human Receptor Type	HQ Type	Baseline SH	Potential Future Peak SH	2021 SH	2022 SH
Infant with F Adult Mother	HQ1	**4.9**	**5.0**	**4.8**	**4.8**
	HQ3	**2.4**	**2.5**	**2.4**	**2.4**

Notes:
M=Male; F=Female.
HQ values are rounded to two significant figures. HQ values are unitless.
Bolded values indicate exceedance of target HQ value of 1.0.
HQ1 refers to HQ based on use of the U.S. EPA (2001a,b) and NRC (2000) TRV (See Dillon, 2016b).
HQ2 refers to HQ based on use of the Health Canada (2010c; 2007) TRV for the general adult population (See Dillon, 2016b). This TRV was also applied to M and F teen receptors (>12 to <20 years).
HQ3 refers to HQ based on use of the Health Canada (2010c; 2007) TRV for women of child-bearing age (considered to be both teen and adult life stages) and children <12 years of age (See Dillon, 2016b).
NA=not applicable for a given receptor; due to application of the gender and age-specific TRVs for MeHg from Health Canada.

TABLE 2c: SUMMARY OF METHYLMERCURY (MeHg) HAZARD QUOTIENTS (HQs) FOR MUSKRAT FALLS STUDY AREA EXPOSURE/CONSUMPTION SCENARIOS (COMMUNITIES) – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: NORTHWEST RIVER (NWR) AND MUD LAKE (ML)

Human Receptor Type	HQ Type	Baseline NWR and ML	Potential Future NWR and ML	2021 NWR and ML	2022 NWR and ML
M Toddler	HQ1	**1.5**	**1.7**	**1.3**	**1.3**
	HQ2	NA	NA	NA	NA
	HQ3	0.77	0.82	0.66	0.66
M Child	HQ1	**1.6**	**1.7**	**1.5**	**1.5**
	HQ2	NA	NA	NA	NA
	HQ3	0.80	0.83	0.76	0.77
M Teen	HQ1	**1.2**	**1.3**	1.0	1.0
	HQ2	0.25	0.27	0.22	0.22
	HQ3	NA	NA	NA	NA
M Adult	HQ1	**2.5**	**2.7**	**2.2**	**2.3**
	HQ2	0.54	0.57	0.46	0.49
	HQ3	NA	NA	NA	NA
F Toddler	HQ1	**1.6**	**1.8**	**1.4**	**1.4**
	HQ2	NA	NA	NA	NA
	HQ3	0.82	0.88	0.71	0.70
F Child	HQ1	**1.7**	**1.7**	**1.6**	**1.6**
	HQ2	NA	NA	NA	NA
	HQ3	0.83	0.86	0.78	0.79
F Teen	HQ1	**1.4**	**1.4**	**1.2**	**1.2**
	HQ2	0.29	0.30	0.25	0.25
	HQ3	0.68	0.71	0.58	0.60
F Adult	HQ1	**3.0**	**3.2**	**2.6**	**2.7**
	HQ2	0.64	0.68	0.55	0.58
	HQ3	**1.5**	**1.6**	**1.3**	**1.4**
Infant with F Teen Mother	HQ1	**2.6**	**2.8**	**2.3**	**2.3**

Human Receptor Type	HQ Type	Baseline NWR and ML	Potential Future NWR and ML	2021 NWR and ML	2022 NWR and ML
	HQ3	**1.3**	**1.4**	**1.1**	**1.2**
Infant with F Adult Mother	HQ1	**5.9**	**6.2**	**5.1**	**5.4**
	HQ3	**2.9**	**3.1**	**2.5**	**2.7**

Notes:
M=Male; F=Female.
HQ values are rounded to two significant figures. HQ values are unitless.
Bolded values indicate exceedance of target HQ value of 1.0.
HQ1 refers to HQ based on use of the U.S. EPA (2001a,b) and NRC (2000) TRV (See Dillon, 2016b).
HQ2 refers to HQ based on use of the Health Canada (2010c; 2007) TRV for the general adult population (See Dillon, 2016b). This TRV was also applied to M and F teen receptors (>12 to <20 years).
HQ3 refers to HQ based on use of the Health Canada (2010c; 2007) TRV for women of child-bearing age (considered to be both teen and adult life stages) and children <12 years of age (See Dillon, 2016b).
NA=not applicable for a given receptor; due to application of the gender and age-specific TRVs for MeHg from Health Canada.

TABLE 3a: SUMMARY OF PREDICTED HAIR MeHg CONCENTRATIONS (mg/kg ww) FOR HUMAN RECEPTORS ASSESSED IN THE HHRA – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: HAPPY VALLEY-GOOSE BAY (HVGB)

Receptor	Baseline HVGB	Potential Future HVGB	2021 HVGB	2022 HVGB
M Toddler	1.4	1.6	1.2	1.2
M Child	1.7	1.8	1.6	1.7
M Teen	1.3	1.4	1.1	1.1
M Adult	2.8	3.0	2.4	2.6
F Toddler	1.5	1.7	1.3	1.3
F Child	1.8	1.9	1.7	1.7
F Teen	1.5	1.6	1.3	1.3
F Adult	**3.4**	**3.5**	**2.9**	**3.0**
Pregnant F Teen	1.0	1.1	0.9	0.9
Pregnant F Adult	**2.3**	**2.5**	2.0	**2.1**

Notes:
F=female; M=male; ww =wet weight.
Bolded values denote an exceedance over the applicable "no action" Health Canada hair guidance value(s) for THg/MeHg (2 mg/kg ww for pregnant F; F 0-49 yrs; M≤18 yrs; and, 5 mg/kg ww for F≥50 yrs; M >18 yrs).

TABLE 3b: SUMMARY OF PREDICTED HAIR MeHg CONCENTRATIONS (mg/kg ww) FOR HUMAN RECEPTORS ASSESSED IN THE HHRA – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: SHESHATSHIU (SH)

Receptor	Baseline SH	Potential Future SH	2021 SH	2022 SH
M Toddler	1.1	1.2	1.1	1.1
M Child	1.6	1.7	1.6	1.6
M Teen	1.1	1.1	1.1	1.1
M Adult	2.4	2.4	2.3	2.3
F Toddler	1.2	1.3	1.2	1.2
F Child	1.7	1.7	1.6	1.6
F Teen	1.2	1.2	1.2	1.2
F Adult	**2.8**	**2.9**	**2.8**	**2.8**
Pregnant F Teen	0.8	0.8	0.8	0.8
Pregnant F Adult	2.0	2.0	1.9	1.9

Notes:
F=female; M=male; ww =wet weight.
Bolded values denote an exceedance over the applicable "no action" Health Canada hair guidance value(s) for THg/MeHg (2 mg/kg ww for pregnant F; F 0-49 yrs; M≤18 yrs; and, 5 mg/kg ww for F≥50 yrs; M >18 yrs).

TABLE 3c: SUMMARY OF PREDICTED HAIR MeHg CONCENTRATIONS (mg/kg ww) FOR HUMAN RECEPTORS ASSESSED IN THE HHRA – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: NORTHWEST RIVER (NWR) AND MUD LAKE (ML)

Receptor	Baseline NWR and ML	Potential Future NWR and ML	2021 NWR and ML	2022 NWR and ML
M Toddler	1.7	1.9	1.5	1.5
M Child	1.8	1.9	1.7	1.7
M Teen	1.3	1.4	1.2	1.2
M Adult	2.9	3.0	2.5	2.6
F Toddler	1.9	2.0	1.6	1.6
F Child	1.9	1.9	1.8	1.8
F Teen	1.5	1.6	1.3	1.3
F Adult	**3.4**	**3.6**	**2.9**	**3.1**
Pregnant F Teen	1.0	1.1	0.9	0.9
Pregnant F Adult	**2.4**	**2.5**	**2.1**	**2.2**

Notes:
F=female; M=male; ww =wet weight.
Bolded values denote an exceedance over the applicable "no action" Health Canada hair guidance value(s) for THg/MeHg (2 mg/kg ww for pregnant F; F 0-49 yrs; M≤18 yrs; and, 5 mg/kg ww for F≥50 yrs; M >18 yrs).

TABLE 4a: SUMMARY OF PREDICTED BLOOD MeHg CONCENTRATIONS (µg/L) FOR HUMAN RECEPTORS ASSESSED IN THE HHRA – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: HAPPY VALLEY-GOOSE BAY (HVGB)

Receptor	Baseline HVGB	Potential Future HVGB	2021 HVGB	2022 HVGB
M Toddler	5.8	6.3	4.8	4.8
M Child	7.0	7.3	6.6	6.7
M Teen	5.2	5.5	4.5	4.6
M Adult	11.2	11.8	9.7	10.2
F Toddler	6.2	6.7	5.1	5.1
F Child	7.2	7.5	6.8	6.9
F Teen	5.9	6.3	5.1	5.2
F Adult	**13.4**	**14.1**	**11.5**	**12.2**
Pregnant F Teen	4.0	4.3	3.5	3.5
Pregnant F Adult	**9.4**	**9.9**	**8.1**	**8.5**

Notes:
F=female; M=male.
Bolded values denote an exceedance over the applicable "no action" Health Canada blood guidance value(s) for MeHg (8 µg/L for pregnant F; F 0-49 yrs; M≤18 yrs; and, 20 µg/L for F≥50 yrs; M>18 yrs).

TABLE 4b: SUMMARY OF PREDICTED BLOOD MeHg CONCENTRATIONS (µg/L) FOR HUMAN RECEPTORS ASSESSED IN THE HHRA – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: SHESHATSHIU (SH)

Receptor	Baseline SH	Potential Future SH	2021 SH	2022 SH
M Toddler	4.6	4.8	4.5	4.4
M Child	6.5	6.6	6.4	6.3
M Teen	4.3	4.4	4.3	4.2
M Adult	9.4	9.6	9.4	9.3
F Toddler	4.9	5.1	4.8	4.7
F Child	6.6	6.8	6.5	6.5
F Teen	4.9	5.0	4.8	4.8
F Adult	**11.3**	**11.5**	**11.2**	**11.1**
Pregnant F Teen	3.3	3.4	3.3	3.3
Pregnant F Adult	7.9	8.0	7.8	7.8

Notes:
F=female; M=male.
Bolded values denote an exceedance over the applicable "no action" Health Canada blood guidance value(s) for MeHg (8 µg/L for pregnant F; F 0-49 yrs; M≤18 yrs; and, 20 µg/L for F≥50 yrs; M>18 yrs).

TABLE 4c: SUMMARY OF PREDICTED BLOOD MeHg CONCENTRATIONS (µg/L) FOR HUMAN RECEPTORS ASSESSED IN THE HHRA – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022: NORTHWEST RIVER (NWR) AND MUD LAKE (ML)

Receptor	Baseline NWR and ML	Potential Future NWR and ML	2021 NWR and ML	2022 NWR and ML
M Toddler	7.0	7.5	6.0	5.9
M Child	7.3	7.6	6.9	7.0
M Teen	5.4	5.7	4.7	4.7
M Adult	11.4	12	9.9	10.4
F Toddler	7.5	8.0	6.4	6.3
F Child	7.5	7.8	7.1	7.2
F Teen	6.1	6.5	5.3	5.4
F Adult	**13.6**	**14.4**	**11.8**	**12.4**
Pregnant F Teen	4.2	4.4	3.6	3.7
Pregnant F Adult	**9.5**	**10**	**8.2**	**8.7**

Notes:
F=female; M=male.
Bolded values denote an exceedance over the applicable "no action" Health Canada blood guidance value(s) for MeHg (8 µg/L for pregnant F; F 0-49 yrs; M≤18 yrs; and, 20 µg/L for F≥50 yrs; M>18 yrs).

TABLE 5: SUMMARY OF PREDICTED FETAL BLOOD MeHg CONCENTRATIONS (µg/L) – BASELINE, POTENTIAL FUTURE PEAK CONDITIONS, 2021, 2022

Community	Predicted Fetal Blood Concentration (µg/L) Based on Pregnant Female Teen	Predicted Fetal Blood Concentration (µg/L) Based on Pregnant Female Adult
Baseline HVGB	6.9	**15.9**
Potential Future HVGB	7.2	**16.8**
2021 HVGB	5.9	**13.7**
2022 HVGB	6.0	**14.4**
Baseline SH	5.6	**13.4**
Potential Future SH	5.8	**13.6**
2021 SH	5.6	**13.2**
2022 SH	5.5	**13.2**
Baseline NWR and ML	7.1	**16.2**
Potential Future NWR and ML	7.5	**17**
2021 NWR and ML	6.1	**13.9**
2022 NWR and ML	6.2	**14.7**

Notes:
Bolded concentrations exceed the Health Canada (Legrand et al., 2010) “no action” blood guidance value of 8 µg/L. Health Canada considers that <8 µg/L of MeHg in maternal blood is protective of the developing fetus as well as infants and young and older children (up to adolescence).

MEMO

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Attachment A: 2022 Brook Trout, Rainbow Smelt and Ringed Seal (Meat and Liver) Data Summaries and Statistical Output

Fish species codes	Area codes	Section codes - refers to the initial river section codes used in early baseline reports
AS - atlantic salmon	AM - Above Muskrat Falls in area of reservoir	0 - Goose Bay and Lake Melville (downstream of the river)
BK - brook trout	BM - Below Muskrat Falls but upriver of Goose Bay	1 - River between Goose Bay and Muskrat Falls
LF - lake whitefish	GB - Goose Bay	2 - River between Muskrat Falls and Grizzle Rapids (the reservoir area)
LS - longnose sucker	LM - west Lake Melville	3 - River between Grizzle Rapids and outflow of Winokapau Lake
NP - northern pike	OM - outer Lake Melville	4 - Winokapau Lake
RS - rainbow smelt	SL - above reservoir	5 River between Winokapau Lake and Churchill Falls tailrace
TC - tomcod		
WS - white sucker		

year	section	area	species	length	st_length	thg
2022	1	BM	BK	279	250	0.06
2022	1	BM	BK	361	250	0.05
2022	1	BM	BK	302	250	0.06
2022	1	BM	BK	309	250	0.08
2022	1	BM	BK	345	250	0.07
2022	1	BM	BK	220	250	0.06
2022	1	BM	BK	283	250	0.07
2022	1	BM	BK	244	250	0.05
2022	1	BM	BK	204	250	0.04
2022	1	BM	BK	212	250	0.05
2022	1	BM	BK	327	250	0.05
2022	1	BM	BK	192	250	0.02
2022	1	BM	BK	164	250	0.04
2022	1	BM	BK	185	250	0.02
2022	1	BM	BK	250	250	0.04
2022	1	BM	BK	277	250	0.05
2022	1	BM	BK	254	250	0.05
2022	1	BM	BK	175	250	0.02
2022	1	BM	BK	282	250	0.07
2022	1	BM	BK	274	250	0.04
2022	1	BM	BK	252	250	0.04
2022	1	BM	BK	270	250	0.04
2022	1	BM	BK	178	250	0.02
2022	1	BM	BK	262	250	0.04
2022	1	BM	BK	246	250	0.05
2022	1	BM	BK	255	250	0.05
2022	1	BM	BK	164	250	0.04
2022	1	BM	BK	252	250	0.08
2022	1	BM	BK	225	250	0.02
2022	1	BM	BK	217	250	0.04
2022	0	OM	BK	240	250	0.01
2022	0	OM	BK	245	250	0.02
2022	0	OM	BK	225	250	0.01
2022	0	OM	BK	205	250	0.01
2022	0	OM	BK	150	250	0.01
2022	0	OM	BK	200	250	0.04
2022	0	OM	BK	220	250	0.01
2022	0	OM	BK	205	250	0.01
2022	0	OM	BK	200	250	0.01
2022	0	OM	BK	175	250	0.01
2022	0	OM	BK	135	250	0.02
2022	0	OM	BK	185	250	0.01
2022	0	OM	BK	200	250	0.02
2022	0	OM	BK	140	250	0.01
2022	0	OM	BK	135	250	0.02
2022	0	OM	BK	360	250	0.04
2022	0	OM	BK	380	250	0.05
2022	0	OM	BK	335	250	0.07
2022	0	OM	BK	126	250	0.05
2022	0	OM	BK	200	250	0.01
2022	0	GB	BK	257	250	0.02
2022	0	GB	BK	270	250	0.02
2022	0	GB	BK	293	250	0.02
2022	0	GB	BK	287	250	0.03
2022	0	GB	BK	243	250	0.02
2022	0	GB	BK	215	250	0.02
2022	0	GB	BK	235	250	0.02
2022	0	GB	BK	245	250	0.02
2022	0	GB	BK	337	250	0.04
2022	0	GB	BK	197	250	0.02
2022	0	LM	BK	310	250	0.02

2022 BROOK TROUT THg DATA

Summary Statistics (Excel)

N	84	
min	0.01	(<0.01)
max	0.08	
arithmean	0.03	
median	0.02	
# nd	4	
freq. nd (%)	4.761905	

Correlation Coefficient (length vs THg)

0.332508

ProUCL 5.2 Summary Statistics

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 5/9/2023 9:25:04 AM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67!	Skewness	CV
C0	84	0	0.01	0.08	0.029881	0.024289	0.019169	0.002092	0.014826	0.868896	0.641517

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
C0	84	0	0.01	0.01	0.0175	0.02	0.04	0.05	0.057	0.07	0.08

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 5/9/2023 9:29:53 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics	
Number of Valid Observations	84
Number of Distinct Observations	8
Minimum	0.01
Maximum	0.08
Mean of Raw Data	0.029881
Standard Deviation of Raw Data	0.019169
Khat	2.567376
Theta hat	0.011639
Kstar	2.483621
Theta star	0.012031
Mean of Log Transformed Data	-3.71775
Standard Deviation of Log Transformed Data	0.658226

Normal GOF Test Results

Correlation Coefficient R	0.931946
Approximate Shapiro Wilk Test Statistic	0.8476
Approximate Shapiro Wilk P Value	4.18E-12

2022	0	LM	BK	327	250	0.03	Lilliefors Test Statistic 0.268313
2022	0	LM	BK	290	250	0.03	Lilliefors Critical (0.0500000) Value 0.096802
2022	0	LM	BK	321	250	0.02	Data not Normal at (0.0500000) Significance Level
2022	0	LM	BK	311	250	0.01	
2022	0	LM	BK	260	250	0.02	Gamma GOF Test Results
2022	0	LM	BK	249	250	0.02	
2022	0	LM	BK	245	250	0.01	Correlation Coefficient R 0.970163
2022	0	LM	BK	241	250	0.02	A-D Test Statistic 3.244881
2022	0	LM	BK	278	250	0.02	A-D Critical (0.0500000) Value 0.761126
2022	0	LM	BK	276	250	0.01	K-S Test Statistic 0.222174
2022	0	LM	BK	231	250	0.01	K-S Critical(0.0500000) Value 0.098497
2022	0	LM	BK	420	250	0.04	Data not Gamma Distributed at (0.0500000) Significance Level
2022	0	LM	BK	345	250	0.02	
2022	0	LM	BK	407	250	0.03	Lognormal GOF Test Results
2022	0	LM	BK	321	250	0.02	
2022	0	LM	BK	308	250	0.02	Correlation Coefficient R 0.949937
2022	0	LM	BK	300	250	0.01	Approximate Shapiro Wilk Test Statistic 0.872477
2022	0	LM	BK	247	250	0.01	Approximate Shapiro Wilk P Value 8.33E-10
2022	0	LM	BK	245	250	0.01	Lilliefors Test Statistic 0.187489
2022	0	LM	BK	252	250	0.02	Lilliefors Critical (0.0500000) Value 0.096802
2022	0	LM	BK	240	250	0.01	Data not Lognormal at (0.0500000) Significance Level
2022	0	LM	BK	225	250	0.01	
2022	0	LM	BK	240	250	0.01	Non-parametric GOF Test Results

Data do not follow a discernible distribution at (0.0500000) Level of Significance

UCL Statistics for Uncensored Full Data Sets

User Selected Options

Date/Time of Computation	ProUCL 5.2 5/9/2023 9:31:23 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	84	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	0.01	Mean	0.029881
Maximum	0.08	Median	0.02
SD	0.019169	Std. Error of Mean	0.002092
Coefficient of Variation	0.641517	Skewness	0.868896

Normal GOF Test

Shapiro Wilk Test Statistic	0.8476	Shapiro Wilk GOF Test
1% Shapiro Wilk P Value	4.18E-12	Data Not Normal at 1% Significance Level
Lilliefors Test Statistic	0.268313	Lilliefors GOF Test
1% Lilliefors Critical Value	0.111944	Data Not Normal at 1% Significance Level
Data Not Normal at 1% Significance Level		

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.03336	95% Adjusted-CLT UCL (Chen-1995)	0.033533
		95% Modified-t UCL (Johnson-1978)	0.033393

Gamma GOF Test

A-D Test Statistic	3.244881	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.761126	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.222174	Kolmogorov-Smirnov Gamma GOF Test

5% K-S Critical Value	0.098497	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	2.567376	k star (bias corrected MLE)	2.483621
Theta hat (MLE)	0.011639	Theta star (bias corrected MLE)	0.012031
nu hat (MLE)	431.3192	nu star (bias corrected)	417.2483
MLE Mean (bias corrected)	0.029881	MLE Sd (bias corrected)	0.018961
		Approximate Chi Square Value (0.05)	370.8962
Adjusted Level of Significance	0.047143	Adjusted Chi Square Value	370.1396
Assuming Gamma Distribution			
95% Approximate Gamma UCL	0.033615	95% Adjusted Gamma UCL	0.033684
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.872477	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk P Value	8.33E-10	Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.187489	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.088582	Data Not Lognormal at 10% Significance Level	
Data Not Lognormal at 10% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-4.60517	Mean of logged Data	-3.71775
Maximum of Logged Data	-2.52573	SD of logged Data	0.658226
Assuming Lognormal Distribution			
95% H-UCL	0.034751	90% Chebyshev (MVUE) UCL	0.037142
95% Chebyshev (MVUE) UCL	0.040345	97.5% Chebyshev (MVUE) UCL	0.044791
99% Chebyshev (MVUE) UCL	0.053525		
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.033321	95% BCA Bootstrap UCL	0.033214
95% Standard Bootstrap UCL	0.033248	95% Bootstrap-t UCL	0.033608
95% Hall's Bootstrap UCL	0.03353	95% Percentile Bootstrap UCL	0.033333
90% Chebyshev(Mean, Sd) UCL	0.036156	95% Chebyshev(Mean, Sd) UCL	0.038998
97.5% Chebyshev(Mean, Sd) UCL	0.042943	99% Chebyshev(Mean, Sd) UCL	0.050691
Suggested UCL to Use			
95% Student's-t UCL	0.03336	(rejected as data distribution is non-parametric and student's-t ucl assumes normality)	

Selected UCL is arithmetic mean of non-parametric UCL estimates, where alpha=0.05:

0.034179

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

year	section	area	species	length	st_length	thg
2022	0	OM	RS	210	150	0.03
2022	0	OM	RS	160	150	0.02
2022	0	OM	RS	165	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	155	150	0.01
2022	0	OM	RS	160	150	0.02
2022	0	OM	RS	175	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	150	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	160	150	0.02
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	165	150	0.02
2022	0	OM	RS	180	150	0.03
2022	0	OM	RS	145	150	0.01
2022	0	OM	RS	170	150	0.02
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	170	150	0.02
2022	0	OM	RS	155	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	190	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	155	150	0.01
2022	0	OM	RS	165	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	160	150	0.01
2022	0	OM	RS	170	150	0.01
2022	0	OM	RS	150	150	0.03
2022	0	LM	RS	143	150	0.01
2022	0	LM	RS	113	150	0.01
2022	0	LM	RS	119	150	0.01
2022	0	LM	RS	114	150	0.01
*2022		GB	RS	145	150	0.12
*2022		GB	RS	162	150	0.03
*2022		GB	RS	208	150	0.09
*2022		GB	RS	191	150	0.08
*2022		GB	RS	191	150	0.13
*2022		GB	RS	161	150	0.04
*2022		GB	RS	175	150	0.02
*2022		GB	RS	186	150	0.14
*2022		GB	RS	217	150	0.09
*2022		GB	RS	191	150	0.11
*2022		GB	RS	196	150	0.07
*2022		GB	RS	192	150	0.15
*2022		GB	RS	187	150	0.16
*2022		GB	RS	150	150	0.03
*2022		GB	RS	193	150	0.09
*2022		GB	RS	173	150	0.05
*2022		GB	RS		150	0.14
*2022		GB	RS	190	150	0.12
*2022		GB	RS	210	150	0.06
*2022		GB	RS	199	150	0.06
*2022		GB	RS	185	150	0.1
*2022		GB	RS	167	150	0.1
*2022		GB	RS	180	150	0.05
*2022		GB	RS	183	150	0.08
*2022		GB	RS	177	150	0.13
*2022		GB	RS	151	150	0.08
*2022		GB	RS	175	150	0.14

2022 RAINBOW SMELT THg DATA

Summary Statistics (Excel)

N	64	**Correlation Coefficient (length vs THg)**
min	0.01 (<0.01)	0.54598
max	0.16	
arithmean	0.05	
median	0.03	
# nd	16	
freq. nd (%)	25	

ProUCL 5.2 Summary Statistics

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 8/22/2023 10:17:37 AM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67!	Skewness	CV
C0	64	0	0.01	0.16	0.05	0.030092	0.047107	0.005888	0.022239	0.846431	0.942135

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
C0	64	0	0.01	0.01	0.01	0.025	0.09	0.094	0.127	0.14	0.1537

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/22/2023 10:20:01 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics	
Number of Valid Observations	64
Number of Distinct Observations	16
Minimum	0.01
Maximum	0.16
Mean of Raw Data	0.05
Standard Deviation of Raw Data	0.047107
Khat	1.122033
Theta hat	0.044562
Kstar	1.079855
Theta star	0.046303
Mean of Log Transformed Data	-3.50349
Standard Deviation of Log Transformed Data	1.048206
Normal GOF Test Results	
Correlation Coefficient R	0.903022
Approximate Shapiro Wilk Test Statistic	0.792807
Approximate Shapiro Wilk P Value	5.28E-12

*2022	GB	RS	197	150	0.1
*2022	GB	RS	180	150	0.09
*2022	GB	RS	170	150	0.09

* denotes smelt collected in Winter 2023; these fish are considered 2022 fish as their Hg exposures primarily occurred during 2022

Lilliefors Test Statistic	0.242549
Lilliefors Critical (0.0500000) Value	0.110579
Data not Normal at (0.0500000) Significance Level	

Gamma GOF Test Results

Correlation Coefficient R	0.945948
A-D Test Statistic	4.121497
A-D Critical (0.0500000) Value	0.777044
K-S Test Statistic	0.23332
K-S Critical(0.0500000) Value	0.11433
Data not Gamma Distributed at (0.0500000) Significance Level	

Lognormal GOF Test Results

Correlation Coefficient R	0.91681
Approximate Shapiro Wilk Test Statistic	0.808261
Approximate Shapiro Wilk P Value	4.22E-11
Lilliefors Test Statistic	0.243998
Lilliefors Critical (0.0500000) Value	0.110579
Data not Lognormal at (0.0500000) Significance Level	

Non-parametric GOF Test Results

Data do not follow a discernible distribution at (0.0500000) Level of Significance

UCL Statistics for Uncensored Full Data Sets

User Selected Options

Date/Time of Computation	ProUCL 5.2 8/22/2023 10:21:42 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	64	Number of Distinct Observations	16
		Number of Missing Observations	0
Minimum	0.01	Mean	0.05
Maximum	0.16	Median	0.025
SD	0.0471068	Std. Error of Mean	0.005888
Coefficient of Variation	0.9421354	Skewness	0.846431

Normal GOF Test

Shapiro Wilk Test Statistic	0.7928068	Shapiro Wilk GOF Test
1% Shapiro Wilk P Value	5.28E-12	Data Not Normal at 1% Significance Level
Lilliefors Test Statistic	0.242549	Lilliefors GOF Test
1% Lilliefors Critical Value	0.1278764	Data Not Normal at 1% Significance Level
Data Not Normal at 1% Significance Level		

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.05983	95% Adjusted-CLT UCL (Chen-1995)	0.060351
		95% Modified-t UCL (Johnson-1978)	0.059934

Gamma GOF Test

A-D Test Statistic	4.1214966	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.777044	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.2333202	Kolmogorov-Smirnov Gamma GOF Test

5% K-S Critical Value	0.1143303	Data Not Gamma Distributed at 5% Significance Level		
Data Not Gamma Distributed at 5% Significance Level				
Gamma Statistics				
k hat (MLE)	1.1220331	k star (bias corrected MLE)	1.079855	
Theta hat (MLE)	0.044562	Theta star (bias corrected MLE)	0.046303	
nu hat (MLE)	143.62024	nu star (bias corrected)	138.2214	
MLE Mean (bias corrected)	0.05	MLE Sd (bias corrected)	0.048116	
		Approximate Chi Square Value (0.05)	112.0564	
Adjusted Level of Significance	0.04625	Adjusted Chi Square Value	111.5156	
Assuming Gamma Distribution				
95% Approximate Gamma UCL	0.0616749	95% Adjusted Gamma UCL	0.061974	
Lognormal GOF Test				
Shapiro Wilk Test Statistic	0.8082606	Shapiro Wilk Lognormal GOF Test		
10% Shapiro Wilk P Value	4.22E-11	Data Not Lognormal at 10% Significance Level		
Lilliefors Test Statistic	0.2439984	Lilliefors Lognormal GOF Test		
10% Lilliefors Critical Value	0.1011892	Data Not Lognormal at 10% Significance Level		
Data Not Lognormal at 10% Significance Level				
Lognormal Statistics				
Minimum of Logged Data	-4.60517	Mean of logged Data	-3.50349	
Maximum of Logged Data	-1.832581	SD of logged Data	1.048206	
Assuming Lognormal Distribution				
95% H-UCL	0.0703204	90% Chebyshev (MVUE) UCL	0.075748	
95% Chebyshev (MVUE) UCL	0.0867537	97.5% Chebyshev (MVUE) UCL	0.102029	
99% Chebyshev (MVUE) UCL	0.1320343			
Nonparametric Distribution Free UCL Statistics				
Data do not follow a Discernible Distribution				
Nonparametric Distribution Free UCLs				
95% CLT UCL	0.0596855	95% BCA Bootstrap UCL	0.060156	Selected UCL is arithmetic mean of calculable non-parametric UCL estimates, where alpha=0.05:
95% Standard Bootstrap UCL	0.0595564	95% Bootstrap-t UCL	0.060478	0.062154
95% Hall's Bootstrap UCL	0.0600029	95% Percentile Bootstrap UCL	0.059531	
90% Chebyshev(Mean, Sd) UCL	0.067665	95% Chebyshev(Mean, Sd) UCL	0.075667	
97.5% Chebyshev(Mean, Sd) UCL	0.0867727	99% Chebyshev(Mean, Sd) UCL	0.108588	
Suggested UCL to Use				
95% Student's-t UCL	0.05983	(rejected as data distribution is non-parametric and student's-t ucl assumes normality)		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Year	Life Stage	Length (est cm)	Muscle THg
2022	Pup	88	0.02
2022	Pup	80	0.04
2022	Pup	74	0.07
2022	Pup	60	0.04
2022	Pup	81	0.05
2022	Pup	73	0.04
2022	Pup	79	0.03
2022	Pup	89	0.05
2022	Non Pup	97	0.01
2022	Pup	90	0.02
2022	Pup	84	0.04
2022	Pup	86	0.02
2022	Pup	86	0.07
2022	Pup	67	0.10
2022	Pup	72	0.04
2022	Pup	88	0.03
2022	Pup	84	0.07
2022	Pup	80	0.05
2022	Pup	66	0.03
2022	Pup	84	0.05
2022	Pup	80	0.06
2022	Pup	72	0.05
2022	Pup	60	0.05
2022	Non Pup	110	0.12
2022	Pup	80	0.05
2022	Non Pup	119	0.10
2022	Pup	62	0.08
2022	Pup	62	0.03
2022	Pup	74	0.02
2022	Pup	70	0.03

2022 RINGED SEAL MUSCLE THg DATA (pups and non-pups)

Summary Stats

N	30
min	0.01
max	0.12
arithmean	0.05
median	0.05
# nd	0
freq. nd (%)	0

Correlation Coefficient (length vs THg)

0.266398

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 5/8/2023 3:35:30 PM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67	Skewness	CV
C0	30	0	0.01	0.12	0.048667	0.042295	0.026094	0.004764	0.022239	1.054336	0.536187

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
C0	30	0	0.02	0.03	0.03	0.045	0.0575	0.07	0.082	0.1	0.1142

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 5/8/2023 3:37:14 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics

Number of Valid Observations	30
Number of Distinct Observations	10
Minimum	0.01
Maximum	0.12
Mean of Raw Data	0.0486667
Standard Deviation of Raw Data	0.0260944
Khat	3.721331
Theta hat	0.0130778
Kstar	3.3714201
Theta star	0.0144351
Mean of Log Transformed Data	-3.163097
Standard Deviation of Log Transformed Data	0.5565637

Normal GOF Test Results

Correlation Coefficient R	0.953529
Shapiro Wilk Test Statistic	0.9097388
Shapiro Wilk Critical (0.0500000) Value	0.927
Approximate Shapiro Wilk P Value	0.0158656
Lilliefors Test Statistic	0.2129577
Lilliefors Critical (0.0500000) Value	0.159

Data not Normal at (0.0500000) Significance Level

Gamma GOF Test Results

Correlation Coefficient R	0.9868214
A-D Test Statistic	0.4169145
A-D Critical (0.0500000) Value	0.7503365
K-S Test Statistic	0.1440266
K-S Critical(0.0500000) Value	0.160811

Data appear Gamma Distributed at (0.0500000) Significance Level

Lognormal GOF Test Results

Correlation Coefficient R	0.9812497
Shapiro Wilk Test Statistic	0.9657793

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.2 5/8/2023 3:38:46 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	30	Number of Distinct Observations	10
		Number of Missing Observations	0
Minimum	0.01	Mean	0.048667
Maximum	0.12	Median	0.045
SD	0.026094	Std. Error of Mean	0.004764
Coefficient of Variation	0.536187	Skewness	1.054336

Normal GOF Test

Shapiro Wilk Test Statistic	0.909739	Shapiro Wilk GOF Test
1% Shapiro Wilk Critical Value	0.9	Data appear Normal at 1% Significance Level
Lilliefors Test Statistic	0.212958	Lilliefors GOF Test
1% Lilliefors Critical Value	0.1848	Data Not Normal at 1% Significance Level

Data appear Approximate Normal at 1% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.056762	95% Adjusted-CLT UCL (Chen-1995)	0.057483
		95% Modified-t UCL (Johnson-1978)	0.056914

Gamma GOF Test

A-D Test Statistic	0.416915	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.750337	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.144027	Kolmogorov-Smirnov Gamma GOF Test
5% K-S Critical Value	0.160811	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.721331	k star (bias corrected MLE)	3.37142
Theta hat (MLE)	0.013078	Theta star (bias corrected MLE)	0.014435
nu hat (MLE)	223.2799	nu star (bias corrected)	202.2852
MLE Mean (bias corrected)	0.048667	MLE Sd (bias corrected)	0.026505
		Approximate Chi Square Value (0.05)	170.3761
Adjusted Level of Significance	0.041	Adjusted Chi Square Value	168.6903

Shapiro Wilk Critical (0.0500000) Value	0.927
Approximate Shapiro Wilk P Value	0.4785567
Lilliefors Test Statistic	0.1267515
Lilliefors Critical (0.0500000) Value	0.159
Data appear Lognormal at (0.0500000) Significance Level	

Assuming Gamma Distribution

Selected UCL is the avg of the gamma UCLs (as two GOF tests support an underlying gamma data distribution at alpha of 0.05)

95% Approximate Gamma UCL	0.057781	95% Adjusted Gamma UCL	0.058359

0.05807

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.965779	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk Critical Value	0.939	Data appear Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.126752	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.146	Data appear Lognormal at 10% Significance Level	
Data appear Lognormal at 10% Significance Level			

Lognormal Statistics

Minimum of Logged Data	-4.60517	Mean of logged Data	-3.1631
Maximum of Logged Data	-2.12026	SD of logged Data	0.556564

Assuming Lognormal Distribution

95% H-UCL	0.060714	90% Chebyshev (MVUE) UCL	0.06486
95% Chebyshev (MVUE) UCL	0.072003	97.5% Chebyshev (MVUE) UCL	0.081917
99% Chebyshev (MVUE) UCL	0.101391		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	0.056503	95% BCA Bootstrap UCL	0.056667
95% Standard Bootstrap UCL	0.056359	95% Bootstrap-t UCL	0.058887
95% Hall's Bootstrap UCL	0.058793	95% Percentile Bootstrap UCL	0.056667
90% Chebyshev(Mean, Sd) UCL	0.062959	95% Chebyshev(Mean, Sd) UCL	0.069433
97.5% Chebyshev(Mean, Sd) UCL	0.078419	99% Chebyshev(Mean, Sd) UCL	0.09607

Suggested UCL to Use

95% Student's-t UCL	0.056762	(rejected, as gamma GOF tests suggest the data has more of a gamma distribution than a normal or lognormal distribution)

When a data set follows an approximate distribution passing only one of the GOF tests,
it is suggested to use a UCL based upon a distribution passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Year	Life Stage	Length (est cm)	Muscle THg
2022	Pup	88	0.02
2022	Pup	80	0.04
2022	Pup	74	0.07
2022	Pup	60	0.04
2022	Pup	81	0.05
2022	Pup	73	0.04
2022	Pup	79	0.03
2022	Pup	89	0.05
2022	Pup	90	0.02
2022	Pup	84	0.04
2022	Pup	86	0.02
2022	Pup	86	0.07
2022	Pup	67	0.10
2022	Pup	72	0.04
2022	Pup	88	0.03
2022	Pup	84	0.07
2022	Pup	80	0.05
2022	Pup	66	0.03
2022	Pup	84	0.05
2022	Pup	80	0.06
2022	Pup	72	0.05
2022	Pup	60	0.05
2022	Pup	80	0.05
2022	Pup	62	0.08
2022	Pup	62	0.03
2022	Pup	74	0.02
2022	Pup	70	0.03

2022 RINGED SEAL MUSCLE THg DATA (Pups only)

Summary Stats

N	27
min	0.02
max	0.10
arithmean	0.05
median	0.04
# nd	0
freq. nd (%)	0

Correlation Coefficient (length vs THg)

-0.21312

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 8/22/2023 11:48:37 AM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67	Skewness	CV
C0	27	0	0.02	0.1	0.045556	0.041578	0.019871	0.003824	0.014826	0.864259	0.436201

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
C0	27	0	0.02	0.03	0.03	0.04	0.05	0.058	0.07	0.077	0.0948

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/22/2023 11:49:44 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics

Number of Valid Observations	27
Number of Distinct Observations	8
Minimum	0.02
Maximum	0.1
Mean of Raw Data	0.0455556
Standard Deviation of Raw Data	0.0198714
Khat	5.6343373
Theta hat	0.0080853
Kstar	5.0329912
Theta star	0.0090514
Mean of Log Transformed Data	-3.180181
Standard Deviation of Log Transformed Data	0.4414876

Normal GOF Test Results

Correlation Coefficient R	0.9596013
Shapiro Wilk Test Statistic	0.9192598
Shapiro Wilk Critical (0.0500000) Value	0.923
Approximate Shapiro Wilk P Value	0.0404358
Lilliefors Test Statistic	0.1892885
Lilliefors Critical (0.0500000) Value	0.1665

Data not Normal at (0.0500000) Significance Level

Gamma GOF Test Results

Correlation Coefficient R	0.9838832
A-D Test Statistic	0.5250239
A-D Critical (0.0500000) Value	0.7469166
K-S Test Statistic	0.1355799
K-S Critical(0.0500000) Value	0.1684904

Data appear Gamma Distributed at (0.0500000) Significance Level

Lognormal GOF Test Results

Correlation Coefficient R	0.976685
Shapiro Wilk Test Statistic	0.9436113
Shapiro Wilk Critical (0.0500000) Value	0.923
Approximate Shapiro Wilk P Value	0.1634336
Lilliefors Test Statistic	0.1434309
Lilliefors Critical (0.0500000) Value	0.1665

Data appear Lognormal at (0.0500000) Significance Level

UCL Statistics for Uncensored Full Data Sets

User Selected Options

Date/Time of Computation	ProUCL 5.2 8/22/2023 11:51:15 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	27	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	0.02	Mean	0.045556
Maximum	0.1	Median	0.04
SD	0.0198714	Std. Error of Mean	0.003824
Coefficient of Variation	0.4362011	Skewness	0.864259

Normal GOF Test

Shapiro Wilk Test Statistic	0.9192598	Shapiro Wilk GOF Test	
1% Shapiro Wilk Critical Value	0.894	Data appear Normal at 1% Significance Level	
Lilliefors Test Statistic	0.1892885	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.1941	Data appear Normal at 1% Significance Level	

Data appear Normal at 1% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.0520783	95% Adjusted-CLT UCL (Chen-1995)	0.052526
		95% Modified-t UCL (Johnson-1978)	0.052184

Gamma GOF Test

A-D Test Statistic	0.5250239	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.7469166	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.1355799	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.1684904	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	5.6343373	k star (bias corrected MLE)	5.032991
Theta hat (MLE)	0.0080853	Theta star (bias corrected MLE)	0.009051
nu hat (MLE)	304.25421	nu star (bias corrected)	271.7815
MLE Mean (bias corrected)	0.0455556	MLE Sd (bias corrected)	0.020306
		Approximate Chi Square Value (0.05)	234.6029
Adjusted Level of Significance	0.0401	Adjusted Chi Square Value	232.3984

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.052775	95% Adjusted Gamma UCL	0.053276

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.9436113	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk Critical Value	0.935	Data appear Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.1434309	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.1533	Data appear Lognormal at 10% Significance Level	

Data appear Lognormal at 10% Significance Level

Lognormal Statistics

Minimum of Logged Data	-3.912023	Mean of logged Data	-3.18018
Maximum of Logged Data	-2.302585	SD of logged Data	0.441488

Assuming Lognormal Distribution

95% H-UCL	0.0541343	90% Chebyshev (MVUE) UCL	0.057681
95% Chebyshev (MVUE) UCL	0.0631289	97.5% Chebyshev (MVUE) UCL	0.07069
99% Chebyshev (MVUE) UCL	0.0855421		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	0.0518459	95% BCA Bootstrap UCL	0.052963
95% Standard Bootstrap UCL	0.0517273	95% Bootstrap-t UCL	0.053301
95% Hall's Bootstrap UCL	0.0538272	95% Percentile Bootstrap UCL	0.051482
90% Chebyshev(Mean, Sd) UCL	0.0570283	95% Chebyshev(Mean, Sd) UCL	0.062225
97.5% Chebyshev(Mean, Sd) UCL	0.069438	99% Chebyshev(Mean, Sd) UCL	0.083606

Suggested UCL to Use
95% Student's-t UCL 0.0520783

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Year	Life Stage	Length (est cm)	Liver THg
2022	Pup	88	0.11
2022	Pup	80	0.69
2022	Pup	74	0.74
2022	Pup	60	0.17
2022	Pup	81	0.44
2022	Pup	73	0.40
2022	Pup	79	0.30
2022	Pup	89	0.79
2022	Non Pup	97	0.13
2022	Pup	90	0.21
2022	Pup	84	0.18
2022	Pup	86	0.34
2022	Pup	86	0.36
2022	Pup	67	1.10
2022	Pup	72	0.30
2022	Pup	88	0.20
2022	Pup	84	0.83
2022	Pup	80	0.34
2022	Pup	66	0.31
2022	Pup	84	0.47
2022	Pup	80	0.36
2022	Pup	72	0.21
2022	Pup	60	0.35
2022	Non Pup	110	1.90
2022	Pup	80	0.33
2022	Non Pup	119	20.50
2022	Pup	62	0.48
2022	Pup	62	0.25
2022	Pup	74	0.23
2022	Pup	70	0.22

2022 RINGED SEAL LIVER THg DATA (pups and non-pups)

Summary Stats

N	30
min	0.11
max	20.50
arithmean	1.11
median	0.34
# nd	0
freq. nd (%)	0

Correlation Coefficient (length vs THg)

0.572983

General Statistics on Uncensored Full Data
ProUCL 5.2 5/8/2023 3:16:42 PM

Date/Time of Computation
User Selected Options — WorkSheet.xls
From File — ON
Full Precision

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67	Skewness	CV
Variable	30	0	0.11	20.5	1.108	0.402035	3.680151	0.671901	0.192735	5.396005	3.321436
C0											

Percentiles for Uncensored Dataset

	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
Variable	30	0	0.179	0.21	0.2225	0.34	0.4775	0.7	0.857	1.54	15.106
C0											

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options
Date/Time of Computation — ProUCL 5.2 5/8/2023 3:18:57 PM
From File — WorkSheet.xls
Full Precision — ON
Confidence Coefficient — 0.95

C0

Raw Statistics

Number of Valid Observations	30
Number of Distinct Observations	26
Minimum	0.11
Maximum	20.5
Mean of Raw Data	1.108
Standard Deviation of Raw Data	3.6801512
Khat	0.6082564
Theta hat	1.8216003
Kstar	0.569653
Theta star	1.9450439
Mean of Log Transformed Data	-0.911217
Standard Deviation of Log Transformed Data	0.9745657

Normal GOF Test Results

Correlation Coefficient R	0.4661792
Shapiro Wilk Test Statistic	0.2503494
Shapiro Wilk Critical (0.0500000) Value	0.927
Approximate Shapiro Wilk P Value	4.89E-14
Lilliefors Test Statistic	0.4342006
Lilliefors Critical (0.0500000) Value	0.159

Data not Normal at (0.0500000) Significance Level

Gamma GOF Test Results

Correlation Coefficient R	0.7318605
A-D Test Statistic	5.0177513
A-D Critical (0.0500000) Value	0.7999006
K-S Test Statistic	0.3156579
K-S Critical(0.0500000) Value	0.1679286

Data not Gamma Distributed at (0.0500000) Significance Level

Lognormal GOF Test Results

UCL Statistics for Uncensored Full Data Sets

User Selected Options
Date/Time of Computation — ProUCL 5.2 5/8/2023 3:20:38 PM
From File — WorkSheet.xls
Full Precision — ON
Confidence Coefficient — 95%
Number of Bootstrap Operations — 2000

C0

General Statistics

Total Number of Observations	30	Number of Distinct Observations	26
		Number of Missing Observations	0
Minimum	0.11	Mean	1.108
Maximum	20.5	Median	0.34
SD	3.680151	Std. Error of Mean	0.671901
Coefficient of Variation	3.321436	Skewness	5.396005

Normal GOF Test

Shapiro Wilk Test Statistic	0.250349	Shapiro Wilk GOF Test	
1% Shapiro Wilk Critical Value	0.9	Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.434201	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.1848	Data Not Normal at 1% Significance Level	

Data Not Normal at 1% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	2.249644	95% Adjusted-CLT UCL (Chen-1995)	2.920468
		95% Modified-t UCL (Johnson-1978)	2.359967

Gamma GOF Test

A-D Test Statistic	5.017751	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.799901	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.315658	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.167929	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.608256	k star (bias corrected MLE)	0.569653
Theta hat (MLE)	1.8216	Theta star (bias corrected MLE)	1.945044
nu hat (MLE)	36.49538	nu star (bias corrected)	34.17918
MLE Mean (bias corrected)	1.108	MLE Sd (bias corrected)	1.468029
		Approximate Chi Square Value (0.05)	21.80764

Correlation Coefficient R	0.8792013
Shapiro Wilk Test Statistic	0.7990805
Shapiro Wilk Critical (0.0500000) Value	0.927
Approximate Shapiro Wilk P Value	2.86E-05
Lilliefors Test Statistic	0.1945076
Lilliefors Critical (0.0500000) Value	0.159
Data not Lognormal at (0.0500000) Significance Level	

Non-parametric GOF Test Results

Data do not follow a discernible distribution at (0.0500000) Level of Significance

Adjusted Level of Significance	0.041	Adjusted Chi Square Value	21.23718

Assuming Gamma Distribution

95% Approximate Gamma UCL	1.736571	95% Adjusted Gamma UCL	1.783218

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.799081	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk Critical Value	0.939	Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.194508	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.146	Data Not Lognormal at 10% Significance Level	
Data Not Lognormal at 10% Significance Level			

Lognormal Statistics

Minimum of Logged Data	-2.20728	Mean of logged Data	-0.91122
Maximum of Logged Data	3.020425	SD of logged Data	0.974566

Assuming Lognormal Distribution

95% H-UCL	1.006337	90% Chebyshev (MVUE) UCL	1.017722
95% Chebyshev (MVUE) UCL	1.192398	97.5% Chebyshev (MVUE) UCL	1.434841
99% Chebyshev (MVUE) UCL	1.911075		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	2.213178	95% BCA Bootstrap UCL	3.164	Selected UCL is arithmetic mean of non-parametric UCL estimates where alpha=0.05
95% Standard Bootstrap UCL	2.197656	95% Bootstrap-t UCL	13.45802	4.908975
95% Hall's Bootstrap UCL	6.856217	95% Percentile Bootstrap UCL	2.437	
90% Chebyshev(Mean, Sd) UCL	3.123702	95% Chebyshev(Mean, Sd) UCL	4.036747	
97.5% Chebyshev(Mean, Sd) UCL	5.304018	99% Chebyshev(Mean, Sd) UCL	7.793327	

Suggested UCL to Use

95% Student's-t UCL 2.249644 (rejected as data distribution is non-parametric and use of student's-t ucl assumes normality)

The calculated UCLs are based on assumptions that the data were collected in a random and unbiased manner.
Please verify the data were collected from random locations.
If the data were collected using judgmental or other non-random methods,
then contact a statistician to correctly calculate UCLs.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Year	Life Stage	Length (est cm)	Liver THg
2022	Pup	88	0.11
2022	Pup	80	0.69
2022	Pup	74	0.74
2022	Pup	60	0.17
2022	Pup	81	0.44
2022	Pup	73	0.40
2022	Pup	79	0.30
2022	Pup	89	0.79
2022	Pup	90	0.21
2022	Pup	84	0.18
2022	Pup	86	0.34
2022	Pup	86	0.36
2022	Pup	67	1.10
2022	Pup	72	0.30
2022	Pup	88	0.20
2022	Pup	84	0.83
2022	Pup	80	0.34
2022	Pup	66	0.31
2022	Pup	84	0.47
2022	Pup	80	0.36
2022	Pup	72	0.21
2022	Pup	60	0.35
2022	Pup	80	0.33
2022	Pup	62	0.48
2022	Pup	62	0.25
2022	Pup	74	0.23
2022	Pup	70	0.22

2022 RINGED SEAL LIVER THg DATA (pups only)

Summary Stats

N	27
min	0.11
max	1.10
arithmean	0.40
median	0.34
# nd	0
freq. nd (%)	0

Correlation Coefficient (length vs THg)

0.002985

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 8/22/2023 1:34:21 PM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67!	Skewness	CV
C0	27	0	0.11	1.1	0.396667	0.342139	0.237503	0.045708	0.17791	1.470624	0.598747

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1]	50%ile(Q2)	75%ile(Q3]	80%ile	90%ile	95%ile	99%ile
C0	27	0	0.192	0.212	0.225	0.34	0.455	0.478	0.76	0.818	1.0298

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/22/2023 1:38:40 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics	
Number of Valid Observations	27
Number of Distinct Observations	23
Minimum	0.11
Maximum	1.1
Mean of Raw Data	0.3966667
Standard Deviation of Raw Data	0.237503
Khat	3.5391042
Theta hat	0.1120811
Kstar	3.1705618
Theta star	0.1251093
Mean of Log Transformed Data	-1.07254
Standard Deviation of Log Transformed Data	0.5440733

Normal GOF Test Results

Correlation Coefficient R	0.9169366
Shapiro Wilk Test Statistic	0.8451773
Shapiro Wilk Critical (0.0500000) Value	0.923
Approximate Shapiro Wilk P Value	6.90E-04

Lilliefors Test Statistic	2.28E-01
Lilliefors Critical (0.0500000) Value	0.1665
Data not Normal at (0.0500000) Significance Level	

Gamma GOF Test Results

Correlation Coefficient R	0.9758759
A-D Test Statistic	0.644787
A-D Critical (0.0500000) Value	0.7502298
K-S Test Statistic	0.1666609
K-S Critical(0.0500000) Value	0.1691289
Data appear Gamma Distributed at (0.0500000) Significance Level	

Lognormal GOF Test Results

Correlation Coefficient R	0.9861093
Shapiro Wilk Test Statistic	0.9725739
Shapiro Wilk Critical (0.0500000) Value	0.923
Approximate Shapiro Wilk P Value	0.6867106
Lilliefors Test Statistic	1.29E-01
Lilliefors Critical (0.0500000) Value	0.1665
Data appear Lognormal at (0.0500000) Significance Level	

UCL Statistics for Uncensored Full Data Sets

User Selected Options

Date/Time of Computation	ProUCL 5.2 8/22/2023 1:40:06 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	27	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	0.11	Mean	0.396667
Maximum	1.1	Median	0.34
SD	0.237503	Std. Error of Mean	0.045708
Coefficient of Variation	0.5987472	Skewness	1.470624

Normal GOF Test

Shapiro Wilk Test Statistic	0.8451773	Shapiro Wilk GOF Test	
1% Shapiro Wilk Critical Value	0.894	Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.2280132	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.1941	Data Not Normal at 1% Significance Level	
Data Not Normal at 1% Significance Level			

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.4746262	95% Adjusted-CLT UCL (Chen-1995)	0.485671
		95% Modified-t UCL (Johnson-1978)	0.476782

Gamma GOF Test

A-D Test Statistic	0.644787	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.7502298	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.1666609	Kolmogorov-Smirnov Gamma GOF Test
5% K-S Critical Value	0.1691289	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics			
k hat (MLE)	3.5391042	k star (bias corrected MLE)	3.170562
Theta hat (MLE)	0.1120811	Theta star (bias corrected MLE)	0.125109
nu hat (MLE)	191.11163	nu star (bias corrected)	171.2103
MLE Mean (bias corrected)	0.3966667	MLE Sd (bias corrected)	0.222771
		Approximate Chi Square Value (0.05)	141.9517
Adjusted Level of Significance	0.0401	Adjusted Chi Square Value	140.2503
Assuming Gamma Distribution			
95% Approximate Gamma UCL	0.4784265	95% Adjusted Gamma UCL	0.48423
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.9725739	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk Critical Value	0.935	Data appear Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.129407	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.1533	Data appear Lognormal at 10% Significance Level	
Data appear Lognormal at 10% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-2.207275	Mean of logged Data	-1.07254
Maximum of Logged Data	0.0953102	SD of logged Data	0.544073
Assuming Lognormal Distribution			
95% H-UCL	0.491577	90% Chebyshev (MVUE) UCL	0.524249
95% Chebyshev (MVUE) UCL	0.5831269	97.5% Chebyshev (MVUE) UCL	0.664847
99% Chebyshev (MVUE) UCL	0.825371		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.4718488	95% BCA Bootstrap UCL	0.488519
95% Standard Bootstrap UCL	0.4687785	95% Bootstrap-t UCL	0.49968
95% Hall's Bootstrap UCL	0.496524	95% Percentile Bootstrap UCL	0.47
90% Chebyshev(Mean, Sd) UCL	0.5337891	95% Chebyshev(Mean, Sd) UCL	0.595901
97.5% Chebyshev(Mean, Sd) UCL	0.6821098	99% Chebyshev(Mean, Sd) UCL	0.85145
Suggested UCL to Use			
95% Adjusted Gamma UCL	0.4842303		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Baseline Seal THg Data and Statistics - Separated into Pups vs Non-pups

ALL SEALS

Sample Year	species	sample area	Weight (kg)	Length (cm)	Mercury (muscle)	Mercury (liver)	Age	Age Estimate	life_stage	#nonpups/year
2011	Ringed Seal	LM	68.2	122	0.19		8		Non Pup	5
2011	Ringed Seal	LM	27.3	84	0.09		1		Non Pup	
2011	Ringed Seal	LM	18.2	76	0.1		0		Pup	
2011	Ringed Seal	LM	22.7	76	0.09		0		Pup	
2011	Ringed Seal	LM	50	122	0.39		2		Non Pup	
2011	Ringed Seal	LM	27.3	86	0.05		0		Pup	
2011	Ringed Seal	LM	45.5	102	0.35		0		Pup	
2011	Ringed Seal	LM	27.3	97	0.13		0		Pup	
2011	Ringed Seal	LM	27.3	91	0.23		1		Non Pup	
2011	Ringed Seal	LM	31.8	91	0.06		0		Pup	
2011	Ringed Seal	LM	36.4	102	0.11		0		Pup	
2011	Ringed Seal	LM	40.9	112	0.19		0		Pup	
2011	Ringed Seal	LM	59.1	122	0.32		1		Non Pup	
2011	Ringed Seal	LM	27.3	91	0.16		0		Pup	
2012	Ringed Seal	LM	63.5	91	0.16	0.98	1		Non Pup	6
2012	Ringed Seal	LM	27.2	61	0.01	0.18	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.07	0.4	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.07	0.75	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.02	0.16	0		Pup	
2012	Ringed Seal	LM	90.7	114	0.18	13	6		Non Pup	
2012	Ringed Seal	LM	27.2	61	0.04	0.17	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.01	0.21	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.05	0.18	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.07	0.28	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.02	0.58	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.02	0.11	0		Pup	
2012	Ringed Seal	LM	81.6	102	0.21	14	6		Non Pup	
2012	Ringed Seal	LM	27.2	61	0.08	0.35	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.01	0.22	0		Pup	
2012	Ringed Seal	LM	90.7	114	0.21	38	7		Non Pup	
2012	Ringed Seal	LM	54.4	91	0.03	0.18	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.02	0.17	0		Pup	
2012	Ringed Seal	LM			0.03	0.34	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.04	0.17	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.07	0.43	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.05	0.37	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.03	0.04	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.02	0.2	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.03	0.29	0		Pup	
2012	Ringed Seal	LM	27.2	61	0.03	0.12	0		Pup	
2012	Ringed Seal	LM	68	91	0.38	62	6		Non Pup	
2012	Ringed Seal	LM	113.4	122	6.3	110	10		Non Pup	
2012	Ringed Seal	LM	27.2	61	0.04	0.18	0		Pup	
2012	Ringed Seal	LM	27.2	64	0.16	1.7	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.25	0		Pup	3
2013	Ringed Seal	LM	22.7	66	0.08	0.9	0		Pup	
2013	Ringed Seal	LM	22.7	66	0.05	0.05	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.42	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.27	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.5	0		Pup	
2013	Ringed Seal	LM	22.7	66	0.05	0.15	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.35	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.44	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.49	0		Pup	
2013	Ringed Seal	LM	22.7	66	0.05	0.11	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.11	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.24	0		Pup	
2013	Ringed Seal	LM	31.8	86	0.05	0.46	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.42	0		Pup	
2013	Ringed Seal	LM	90.7	112	0.18	2.5	9		Non Pup	
2013	Ringed Seal	LM	22.7	66	0.05	0.17	0		Pup	
2013	Ringed Seal	LM	113.4	122	0.11	24.1	6		Non Pup	
2013	Ringed Seal	LM	68	91	0.2	26.4	9		Non Pup	
2013	Ringed Seal	LM	27.2	76	0.13	0.82	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.29	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.26	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.16	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.36	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.07	0.53	0		Pup	
2013	Ringed Seal	LM	22.7	66	0.05	0.18	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.2	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.2	0		Pup	
2013	Ringed Seal	LM	27.2	76	0.05	0.21	0		Pup	
2013	Ringed Seal	LM	18.1	66	0.05	0.05	0		Pup	
2014	Ringed Seal	LM	27.3	76	0.05	0.14	0		Pup	4
2014	Ringed Seal	LM	27.3	74	0.08	0.57	0		Pup	
2014	Ringed Seal	LM	22.7	67	0.05	0.25	0		Pup	
2014	Ringed Seal	LM	22.7	72	0.06	0.38	0		Pup	
2014	Ringed Seal	LM	27.3	74	0.05	0.33	0		Pup	
2014	Ringed Seal	LM	36.4	86	0.05	0.14	0		Pup	
2014	Ringed Seal	LM	27.3	78	0.05	0.17	0		Pup	
2014	Ringed Seal	LM	27.3	77	0.05	0.19	0		Pup	
2014	Ringed Seal	LM	31.8	83	0.22	1.51	0		Pup	
2014	Ringed Seal	LM	27.3	76	0.05	0.38	0		Pup	
2014	Ringed Seal	LM	22.7	64	0.05	0.64	0		Pup	
2014	Ringed Seal	LM	27.3	78	0.05	0.37	0		Pup	
2014	Ringed Seal	LM	27.3	76	0.3	1.52	0		Pup	
2014	Ringed Seal	LM	31.8	88	0.05	0.09	0		Pup	
2014	Ringed Seal	LM	31.8	86	0.05	0.1	0		Pup	
2014	Ringed Seal	LM	90.9	134	0.19	8.09	5		Non Pup	
2014	Ringed Seal	LM	31.8	76	0.05	0.35	0		Pup	
2014	Ringed Seal	LM	68.2	114	0.25	7.76	4		Non Pup	
2014	Ringed Seal	LM	27.3	70	0.11	0.7	0		Pup	
2014	Ringed Seal	LM	31.8	84	0.06	0.49	0		Pup	
2014	Ringed Seal	LM	22.7	66	0.05	0.36	0		Pup	
2014	Ringed Seal	LM	31.8	80	0.05	0.21	0		Pup	
2014	Ringed Seal	LM	90.9	126	1.43	18.2	14		Non Pup	
2014	Ringed Seal	LM	27.3	80	0.25	1.81	0		Pup	
2014	Ringed Seal	LM	113.6	138	1.38	17.6	22		Non Pup	
2014	Ringed Seal	LM	27.3	78	0.08	1.07	0		Pup	
2014	Ringed Seal	LM	22.7	68	0.05	0.31	0		Pup	
2014	Ringed Seal	LM	27.3	78	0.08	0.95	0		Pup	
2015	Ringed Seal	LM	113.6	128	0.27	11.2	9		Non Pup	3
2015	Ringed Seal	LM	22.7	78	0.05	0.19	0		Pup	
2015	Ringed Seal	LM	22.7	80	0.05	0.18	0		Pup	
2015	Ringed Seal	LM	27.3	82	0.1	0.26	0		Pup	
2015	Ringed Seal	LM	18.2	68	0.08	0.26	0		Pup	
2015	Ringed Seal	LM	18.2	72	0.05	0.14	0		Pup	
2015	Ringed Seal	LM	136.4	140	0.87	12.3	11		Non Pup	
2015	Ringed Seal	LM	22.7	76	0.15	0.33	0		Pup	
2015	Ringed Seal	LM	27.3	80	0.05	0.19	0		Pup	
2015	Ringed Seal	LM	54.5	98	0.42	9.07	4		Non Pup	
2015	Ringed Seal	LM	27.3	84	0.05	0.13	0		Pup	
2015	Ringed Seal	LM	22.7	78	0.05	0.36	0		Pup	

Muscle (Meat) THg Data - Non-pups only

N	26	**length vs THg**
min	0.09	0.259786
max	6.3	
arithmean	0.623077	
median	0.24	
#nd	0	
Freq nd	0	

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 8/24/2023 11:37:05 AM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67	Skewness	CV
C0	26	0	0.09	6.3	0.623077	0.326506	1.219786	0.23922	0.103781	4.364349	1.957681

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1	50%ile(Q2	75%ile(Q3	80%ile	90%ile	95%ile	99%ile
C0	26	0	0.165	0.18	0.19	0.24	0.3875	0.42	1.315	1.4175	5.0825

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/24/2023 11:38:05 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics	
Number of Valid Observations	26
Number of Distinct Observations	23
Minimum	0.09
Maximum	6.3
Mean of Raw Data	0.623077
Standard Deviation of Raw Data	1.219786
Khat	0.904143
Theta hat	0.689136
Kstar	0.82546
Theta star	0.754824
Mean of Log Transformed Data	-1.11931
Standard Deviation of Log Transformed Data	0.938253

Normal GOF Test Results

Correlation Coefficient R	0.617341
Shapiro Wilk Test Statistic	0.411764
Shapiro Wilk Critical (0.0500000) Value	0.92
Approximate Shapiro Wilk P Value	1.08E-10
Lilliefors Test Statistic	0.373805
Lilliefors Critical (0.0500000) Value	0.1699
Data not Normal at (0.0500000) Significance Level	

Gamma GOF Test Results

Correlation Coefficient R	0.839014
A-D Test Statistic	2.945522
A-D Critical (0.0500000) Value	0.777575
K-S Test Statistic	0.302992
K-S Critical(0.0500000) Value	0.176998
Data not Gamma Distributed at (0.0500000) Significance Level	

Lognormal GOF Test Results

Correlation Coefficient R	0.912093
Shapiro Wilk Test Statistic	0.843624
Shapiro Wilk Critical (0.0500000) Value	0.92
Approximate Shapiro Wilk P Value	8.06E-04
Lilliefors Test Statistic	0.201897
Lilliefors Critical (0.0500000) Value	0.1699
Data not Lognormal at (0.0500000) Significance Level	

Non-parametric GOF Test Results

Data do not follow a discernible distribution at (0.0500000) Level of Significance

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/24/2023 11:39:37 AM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	26	Number of Distinct Observations	23
		Number of Missing Observations	0
Minimum	0.09	Mean	0.623077
Maximum	6.3	Median	0.24
SD	1.219786	Std. Error of Mean	0.23922
Coefficient of Variation	1.957681	Skewness	4.364349

Normal GOF Test

Shapiro Wilk Test Statistic	0.411764	Shapiro Wilk GOF Test	
1% Shapiro Wilk Critical Value	0.891	Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.373805	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.1985	Data Not Normal at 1% Significance Level	

Data Not Normal at 1% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	1.031698	95% Adjusted-CLT UCL (Chen-1995)	1.23534
		95% Modified-t UCL (Johnson-1978)	1.065823

Gamma GOF Test

A-D Test Statistic	2.945522	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.777575	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.302992	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.176998	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.904143	k star (bias corrected MLE)	0.82546
Theta hat (MLE)	0.689136	Theta star (bias corrected MLE)	0.754824
nu hat (MLE)	47.01543	nu star (bias corrected)	42.92391
MLE Mean (bias corrected)	0.623077	MLE Sd (bias corrected)	0.685794
		Approximate Chi Square Value (0.05)	28.90226
Adjusted Level of Significance	0.0398	Adjusted Chi Square Value	28.14183

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.925357	95% Adjusted Gamma UCL	0.950361

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.843624	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk Critical Value	0.933	Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.201897	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.1562	Data Not Lognormal at 10% Significance Level	

Data Not Lognormal at 10% Significance Level

Lognormal Statistics

Minimum of Logged Data	-2.40795	Mean of logged Data	-1.11931
Maximum of Logged Data	1.84055	SD of logged Data	0.938253

Assuming Lognormal Distribution

95% H-UCL	0.799902	90% Chebyshev (MVUE) UCL	0.803256
95% Chebyshev (MVUE) UCL	0.942721	97.5% Chebyshev (MVUE) UCL	1.136293
99% Chebyshev (MVUE) UCL	1.516529		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	1.016558	95% BCA Bootstrap UCL	1.350769	UCL to use: arithmean of non-parametric UCL estimates at alpha of 0.05
95% Standard Bootstrap UCL	1.014391	95% Bootstrap-t UCL	1.957973	1.476317
95% Hall's Bootstrap UCL	2.261024	95% Percentile Bootstrap UCL	1.067692	
90% Chebyshev(Mean, Sd) UCL	1.340736	95% Chebyshev(Mean, Sd) UCL	1.665812	
97.5% Chebyshev(Mean, Sd) UCL	2.117004	99% Chebyshev(Mean, Sd) UCL	3.003283	

Suggested UCL to Use

95% Student's-t UCL	1.031698	(rejected as data distribution is non-parametric)

The calculated UCLs are based on assumptions that the data were collected in a random and unbiased manner.
Please verify the data were collected from random locations.
If the data were collected using judgmental or other non-random methods,
then contact a statistician to correctly calculate UCLs.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.

2015	Ringed Seal	LM	45.5	104	0.08	0.32	0	Pup	
2015	Ringed Seal	LM	27.3	78	0.06	0.27	0	Pup	
2015	Ringed Seal	LM	22.7	74	0.05	0.41	0	Pup	
2015	Ringed Seal	LM	27.3	78	0.05	0.28	0	Pup	
2015	Ringed Seal	LM	15.9	60	0.1	0.2	0	Pup	
2015	Ringed Seal	LM	22.7	66	0.05	0.18	0	Pup	
2015	Ringed Seal	LM	27.3	78	0.12	0.44	0	Pup	
2015	Ringed Seal	LM	27.3	76	0.07	0.21	0	Pup	
2015	Ringed Seal	LM	27.3	80	0.06	0.26	0	Pup	
2015	Ringed Seal	LM	15.9	60	0.05	0.15	0	Pup	
2015	Ringed Seal	LM	31.8	80	0.05	0.27	0	Pup	
2015	Ringed Seal	LM	27.3	76	0.05	0.29	0	Pup	
2015	Ringed Seal	LM	22.7	72	0.05	0.19	0	Pup	
2015	Ringed Seal	LM	27.3	80	0.05	0.27	0	Pup	
2015	Ringed Seal	LM	27.3	76	0.05	0.05	0	Pup	
2016	Ringed Seal	LM	22.7	78	0.05	0.09	0	Pup	5
2016	Ringed Seal	LM	22.7	80	0.05	0.2	0	Pup	
2016	Ringed Seal	LM	22.7	76	0.05	0.23	0	Pup	
2016	Ringed Seal	LM	27.2	80	0.05	0.13	0	Pup	
2016	Ringed Seal	LM	18.1	74	0.06	0.26	0	Pup	
2016	Ringed Seal	LM	27.2	82	0.05	0.15	0	Pup	
2016	Ringed Seal	LM	22.7	78	0.05	0.21	0	Pup	
2016	Ringed Seal	LM	18.1	74	0.05	0.11	0	Pup	
2016	Ringed Seal	LM	15.9	68	0.05	0.15	0	Pup	
2016	Ringed Seal	LM	18.1	74	0.05	0.15	0	Pup	
2016	Ringed Seal	LM	13.6	70	0.05	0.25	0	Pup	
2016	Ringed Seal	LM	18.1	66	0.06	0.26	0	Pup	
2016	Ringed Seal	LM	27.2	78	0.05	0.09	0	Pup	
2016	Ringed Seal	LM	13.6	62	0.05	0.22	0	Pup	
2016	Ringed Seal	LM	27.2	80	0.07	0.23	0	Pup	
2016	Ringed Seal	LM	27.2	78	0.05	0.26	0	Pup	
2016	Ringed Seal	LM	15.9	64	0.06	0.18	0	Pup	
2016	Ringed Seal	LM	63.5	120	0.17	15.7	2	Non Pup	
2016	Ringed Seal	LM	29.5	80	0.07	0.44	0	Pup	
2016	Ringed Seal	LM	79.4	133	1.25	78.3	11	Non Pup	
2016	Ringed Seal	LM	29.5	80	0.05	0.31	0	Pup	
2016	Ringed Seal	LM	30.4	81	0.05	0.14	0	Pup	
2016	Ringed Seal	LM	56.7	114	0.29	47.1	15	Non Pup	
2016	Ringed Seal	LM	18.1	72	0.06	0.29	0	Pup	
2016	Ringed Seal	LM	30.8	79	0.07	0.55	0	Pup	
2016	Ringed Seal	LM	32.7	85	0.11	1.03	0	Pup	
2016	Ringed Seal	LM	20.4	72	0.05	0.26	0	Pup	
2016	Ringed Seal	LM	56.7	119	0.31	33.1	5	Non Pup	
2016	Ringed Seal	LM	49.9	107	0.22	6.76	3	Non Pup	
2016	Ringed Seal	LM	30.8	79	0.1	1.23	0	Pup	
									26

total # seals 159
#non-pups of total 26
% non-pups of total 16.3522

NON-PUPS (estimated age range: 1 to 22 years)

Sample Year	species	sample area	Weight (kg)	Length (cm)	Mercury (muscle)	Mercury (liver)	Age	Age Estimate	life_stage
2011	Ringed Seal	LM	68.2	122	0.19		8		Non Pup
2011	Ringed Seal	LM	27.3	84	0.09		1		Non Pup
2011	Ringed Seal	LM	50	122	0.39		2		Non Pup
2011	Ringed Seal	LM	27.3	91	0.23		1		Non Pup
2011	Ringed Seal	LM	59.1	122	0.32		1		Non Pup
2012	Ringed Seal	LM	63.5	91	0.16	0.98	1		Non Pup
2012	Ringed Seal	LM	90.7	114	0.18	13	6		Non Pup
2012	Ringed Seal	LM	81.6	102	0.21	14	6		Non Pup
2012	Ringed Seal	LM	90.7	114	0.21	38	7		Non Pup
2012	Ringed Seal	LM	68	91	0.38	62	6		Non Pup
2012	Ringed Seal	LM	113.4	122	6.3	110	10		Non Pup
2013	Ringed Seal	LM	90.7	112	0.18	2.5	9		Non Pup
2013	Ringed Seal	LM	113.4	122	0.11	24.1	6		Non Pup
2013	Ringed Seal	LM	68	91	0.2	26.4	9		Non Pup
2014	Ringed Seal	LM	90.9	134	0.19	8.09	5		Non Pup
2014	Ringed Seal	LM	68.2	114	0.25	7.76	4		Non Pup
2014	Ringed Seal	LM	90.9	126	1.43	18.2	14		Non Pup
2014	Ringed Seal	LM	113.6	138	1.38	17.6	22		Non Pup
2015	Ringed Seal	LM	113.6	128	0.27	11.2	9		Non Pup
2015	Ringed Seal	LM	136.4	140	0.87	12.3	11		Non Pup
2015	Ringed Seal	LM	54.5	98	0.42	9.07	4		Non Pup
2016	Ringed Seal	LM	63.5	120	0.17	15.7	2		Non Pup
2016	Ringed Seal	LM	79.4	133	1.25	78.3	11		Non Pup
2016	Ringed Seal	LM	56.7	114	0.29	47.1	15		Non Pup
2016	Ringed Seal	LM	56.7	119	0.31	33.1	5		Non Pup
2016	Ringed Seal	LM	49.9	107	0.22	6.76	3		Non Pup

PUPS (<1 year)

Sample Year	species	sample area	Weight (kg)	Length (cm)	Mercury (muscle)	Mercury (liver)	Age	Age Estimate	life_stage
2011	Ringed Seal	LM	18.2	76	0.1		0		Pup
2011	Ringed Seal	LM	22.7	76	0.09		0		Pup
2011	Ringed Seal	LM	27.3	86	0.05		0		Pup
2011	Ringed Seal	LM	45.5	102	0.35		0		Pup
2011	Ringed Seal	LM	27.3	97	0.13		0		Pup
2011	Ringed Seal	LM	31.8	91	0.06		0		Pup
2011	Ringed Seal	LM	36.4	102	0.11		0		Pup
2011	Ringed Seal	LM	40.9	112	0.19		0		Pup
2011	Ringed Seal	LM	27.3	91	0.16		0		Pup
2012	Ringed Seal	LM	27.2	61	0.01	0.18	0		Pup
2012	Ringed Seal	LM	27.2	61	0.07	0.4	0		Pup
2012	Ringed Seal	LM	27.2	61	0.07	0.75	0		Pup
2012	Ringed Seal	LM	27.2	61	0.02	0.16	0		Pup
2012	Ringed Seal	LM	27.2	61	0.04	0.17	0		Pup
2012	Ringed Seal	LM	27.2	61	0.01	0.21	0		Pup
2012	Ringed Seal	LM	27.2	61	0.05	0.18	0		Pup
2012	Ringed Seal	LM	27.2	61	0.07	0.28	0		Pup
2012	Ringed Seal	LM	27.2	61	0.02	0.58	0		Pup
2012	Ringed Seal	LM	27.2	61	0.02	0.11	0		Pup
2012	Ringed Seal	LM	27.2	61	0.08	0.35	0		Pup
2012	Ringed Seal	LM	27.2	61	0.01	0.22	0		Pup
2012	Ringed Seal	LM	54.4	91	0.03	0.18	0		Pup
2012	Ringed Seal	LM	27.2	61	0.02	0.17	0		Pup
2012	Ringed Seal	LM			0.03	0.34	0		Pup
2012	Ringed Seal	LM	27.2	61	0.04	0.17	0		Pup
2012	Ringed Seal	LM	27.2	61	0.07	0.43	0		Pup
2012	Ringed Seal	LM	27.2	61	0.05	0.37	0		Pup
2012	Ringed Seal	LM	27.2	61	0.03	0.04	0		Pup
2012	Ringed Seal	LM	27.2	61	0.02	0.2	0		Pup
2012	Ringed Seal	LM	27.2	61	0.03	0.29	0		Pup
2012	Ringed Seal	LM	27.2	61	0.03	0.12	0		Pup
2012	Ringed Seal	LM	27.2	61	0.04	0.18	0		Pup
2012	Ringed Seal	LM	27.2	64	0.16	1.7	0		Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.25	0		Pup
2013	Ringed Seal	LM	22.7	66	0.08	0.9	0		Pup
2013	Ringed Seal	LM	22.7	66	0.05	0.05	0		Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.42	0		Pup

Liver THg Data - Non-pups only

N	21
min	0.98
max	110
arithmean	26.48381
median	15.7
#nd	0
Freq nd	0

length vs THg
0.087523

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 8/24/2023 1:32:50 PM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.67	Skewness	CV
C0	21	0	0.98	110	26.48381	16.16308	27.54224	6.01021	12.45367	1.871494	1.039965

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
C0	21	0	6.76	8.09	9.07	15.7	33.1	38	62	78.3	103.66

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/24/2023 1:40:03 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics	
Number of Valid Observations	21
Number of Distinct Observations	21
Minimum	0.98
Maximum	110
Mean of Raw Data	26.48381
Standard Deviation of Raw Data	27.54224
Khat	1.150599
Theta hat	23.01742
Kstar	1.017974
Theta star	26.01621
Mean of Log Transformed Data	2.78273
Standard Deviation of Log Transformed Data	1.107114

Normal GOF Test Results

Correlation Coefficient R	0.879909
Shapiro Wilk Test Statistic	0.781251
Shapiro Wilk Critical (0.0500000) Value	0.908
Approximate Shapiro Wilk P Value	1.89E-04
Lilliefors Test Statistic	0.237252
Lilliefors Critical (0.0500000) Value	0.1881

Data not Normal at (0.0500000) Significance Level

Gamma GOF Test Results

Correlation Coefficient R	0.99118
A-D Test Statistic	0.315384
A-D Critical (0.0500000) Value	0.76618
K-S Test Statistic	0.141558
K-S Critical(0.0500000) Value	0.194248

Data appear Gamma Distributed at (0.0500000) Significance Level

Lognormal GOF Test Results

Correlation Coefficient R	0.979259
Shapiro Wilk Test Statistic	0.964888
Shapiro Wilk Critical (0.0500000) Value	0.908
Approximate Shapiro Wilk P Value	0.606015
Lilliefors Test Statistic	0.120295
Lilliefors Critical (0.0500000) Value	0.1881

Data appear Lognormal at (0.0500000) Significance Level

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/24/2023 1:41:20 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	21	Number of Distinct Observations	21
		Number of Missing Observations	0
Minimum	0.98	Mean	26.48381
Maximum	110	Median	15.7
SD	27.54224	Std. Error of Mean	6.01021
Coefficient of Variation	1.039965	Skewness	1.871494

Normal GOF Test

Shapiro Wilk Test Statistic	0.781251	Shapiro Wilk GOF Test	
1% Shapiro Wilk Critical Value	0.873	Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.237252	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.219	Data Not Normal at 1% Significance Level	

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	36.84973	95% Adjusted-CLT UCL (Chen-1995)	38.99243
		95% Modified-t UCL (Johnson-1978)	37.25882

Gamma GOF Test

A-D Test Statistic	0.315384	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.76618	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.141558	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.194248	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.150599	k star (bias corrected MLE)	1.017974
Theta hat (MLE)	23.01742	Theta star (bias corrected MLE)	26.01621
nu hat (MLE)	48.32515	nu star (bias corrected)	42.75489
MLE Mean (bias corrected)	26.48381	MLE Sd (bias corrected)	26.24897
		Approximate Chi Square Value (0.05)	28.76343
Adjusted Level of Significance	0.0383	Adjusted Chi Square Value	27.88181

Assuming Gamma Distribution

95% Approximate Gamma UCL	39.36639	95% Adjusted Gamma UCL	40.61114

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.964888	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk Critical Value	0.923	Data appear Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.120295	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.1726	Data appear Lognormal at 10% Significance Level	

Data appear Lognormal at 10% Significance Level

Lognormal Statistics

Minimum of Logged Data	-0.0202	Mean of logged Data	2.78273
Maximum of Logged Data	4.70048	SD of logged Data	1.107114

Assuming Lognormal Distribution

95% H-UCL	58.38984	90% Chebyshev (MVUE) UCL	52.19528
95% Chebyshev (MVUE) UCL	62.90346	97.5% Chebyshev (MVUE) UCL	77.76599
99% Chebyshev (MVUE) UCL	106.9606		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	36.36973	95% BCA Bootstrap UCL	38.4081
95% Standard Bootstrap UCL	36.0376	95% Bootstrap-t UCL	40.93658
95% Hall's Bootstrap UCL	41.43692	95% Percentile Bootstrap UCL	36.89952
90% Chebyshev(Mean, Sd) UCL	44.51444	95% Chebyshev(Mean, Sd) UCL	52.68171
97.5% Chebyshev(Mean, Sd) UCL	64.01756	99% Chebyshev(Mean, Sd) UCL	86.28465

Suggested UCL to Use
95% Adjusted Gamma UCL 40.61114

The calculated UCLs are based on assumptions that the data were collected in a random and unbiased manner.
Please verify the data were collected from random locations.
If the data were collected using judgmental or other non-random methods,
then contact a statistician to correctly calculate UCLs.

2013	Ringed Seal	LM	27.2	76	0.05	0.27	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.5	0	Pup
2013	Ringed Seal	LM	22.7	66	0.05	0.15	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.35	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.44	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.49	0	Pup
2013	Ringed Seal	LM	22.7	66	0.05	0.11	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.11	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.24	0	Pup
2013	Ringed Seal	LM	31.8	86	0.05	0.46	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.42	0	Pup
2013	Ringed Seal	LM	22.7	66	0.05	0.17	0	Pup
2013	Ringed Seal	LM	27.2	76	0.13	0.82	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.29	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.26	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.16	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.36	0	Pup
2013	Ringed Seal	LM	27.2	76	0.07	0.53	0	Pup
2013	Ringed Seal	LM	22.7	66	0.05	0.18	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.2	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.2	0	Pup
2013	Ringed Seal	LM	27.2	76	0.05	0.21	0	Pup
2013	Ringed Seal	LM	18.1	66	0.05	0.05	0	Pup
2014	Ringed Seal	LM	27.3	76	0.05	0.14	0	Pup
2014	Ringed Seal	LM	27.3	74	0.08	0.57	0	Pup
2014	Ringed Seal	LM	22.7	67	0.05	0.25	0	Pup
2014	Ringed Seal	LM	22.7	72	0.06	0.38	0	Pup
2014	Ringed Seal	LM	27.3	74	0.05	0.33	0	Pup
2014	Ringed Seal	LM	36.4	86	0.05	0.14	0	Pup
2014	Ringed Seal	LM	27.3	78	0.05	0.17	0	Pup
2014	Ringed Seal	LM	27.3	77	0.05	0.19	0	Pup
2014	Ringed Seal	LM	31.8	83	0.22	1.51	0	Pup
2014	Ringed Seal	LM	27.3	76	0.05	0.38	0	Pup
2014	Ringed Seal	LM	22.7	64	0.05	0.64	0	Pup
2014	Ringed Seal	LM	27.3	78	0.05	0.37	0	Pup
2014	Ringed Seal	LM	27.3	76	0.3	1.52	0	Pup
2014	Ringed Seal	LM	31.8	88	0.05	0.09	0	Pup
2014	Ringed Seal	LM	31.8	86	0.05	0.1	0	Pup
2014	Ringed Seal	LM	31.8	76	0.05	0.35	0	Pup
2014	Ringed Seal	LM	27.3	70	0.11	0.7	0	Pup
2014	Ringed Seal	LM	31.8	84	0.06	0.49	0	Pup
2014	Ringed Seal	LM	22.7	66	0.05	0.36	0	Pup
2014	Ringed Seal	LM	31.8	80	0.05	0.21	0	Pup
2014	Ringed Seal	LM	27.3	80	0.25	1.81	0	Pup
2014	Ringed Seal	LM	27.3	78	0.08	1.07	0	Pup
2014	Ringed Seal	LM	22.7	68	0.05	0.31	0	Pup
2014	Ringed Seal	LM	27.3	78	0.08	0.95	0	Pup
2015	Ringed Seal	LM	22.7	78	0.05	0.19	0	Pup
2015	Ringed Seal	LM	22.7	80	0.05	0.18	0	Pup
2015	Ringed Seal	LM	27.3	82	0.1	0.26	0	Pup
2015	Ringed Seal	LM	18.2	68	0.08	0.26	0	Pup
2015	Ringed Seal	LM	18.2	72	0.05	0.14	0	Pup
2015	Ringed Seal	LM	22.7	76	0.15	0.33	0	Pup
2015	Ringed Seal	LM	27.3	80	0.05	0.19	0	Pup
2015	Ringed Seal	LM	27.3	84	0.05	0.13	0	Pup
2015	Ringed Seal	LM	22.7	78	0.05	0.36	0	Pup
2015	Ringed Seal	LM	45.5	104	0.08	0.32	0	Pup
2015	Ringed Seal	LM	27.3	78	0.06	0.27	0	Pup
2015	Ringed Seal	LM	22.7	74	0.05	0.41	0	Pup
2015	Ringed Seal	LM	27.3	78	0.05	0.28	0	Pup
2015	Ringed Seal	LM	15.9	60	0.1	0.2	0	Pup
2015	Ringed Seal	LM	22.7	66	0.05	0.18	0	Pup
2015	Ringed Seal	LM	27.3	78	0.12	0.44	0	Pup
2015	Ringed Seal	LM	27.3	76	0.07	0.21	0	Pup
2015	Ringed Seal	LM	27.3	80	0.06	0.26	0	Pup
2015	Ringed Seal	LM	15.9	60	0.05	0.15	0	Pup
2015	Ringed Seal	LM	31.8	80	0.05	0.27	0	Pup
2015	Ringed Seal	LM	27.3	76	0.05	0.29	0	Pup
2015	Ringed Seal	LM	22.7	72	0.05	0.19	0	Pup
2015	Ringed Seal	LM	27.3	80	0.05	0.27	0	Pup
2015	Ringed Seal	LM	27.3	76	0.05	0.05	0	Pup
2016	Ringed Seal	LM	22.7	78	0.05	0.09	0	Pup
2016	Ringed Seal	LM	22.7	80	0.05	0.2	0	Pup
2016	Ringed Seal	LM	22.7	76	0.05	0.23	0	Pup
2016	Ringed Seal	LM	27.2	80	0.05	0.13	0	Pup
2016	Ringed Seal	LM	18.1	74	0.06	0.26	0	Pup
2016	Ringed Seal	LM	27.2	82	0.05	0.15	0	Pup
2016	Ringed Seal	LM	22.7	78	0.05	0.21	0	Pup
2016	Ringed Seal	LM	18.1	74	0.05	0.11	0	Pup
2016	Ringed Seal	LM	15.9	68	0.05	0.15	0	Pup
2016	Ringed Seal	LM	18.1	74	0.05	0.15	0	Pup
2016	Ringed Seal	LM	13.6	70	0.05	0.25	0	Pup
2016	Ringed Seal	LM	18.1	66	0.06	0.26	0	Pup
2016	Ringed Seal	LM	27.2	78	0.05	0.09	0	Pup
2016	Ringed Seal	LM	13.6	62	0.05	0.22	0	Pup
2016	Ringed Seal	LM	27.2	80	0.07	0.23	0	Pup
2016	Ringed Seal	LM	27.2	78	0.05	0.26	0	Pup
2016	Ringed Seal	LM	15.9	64	0.06	0.18	0	Pup
2016	Ringed Seal	LM	29.5	80	0.07	0.44	0	Pup
2016	Ringed Seal	LM	29.5	80	0.05	0.31	0	Pup
2016	Ringed Seal	LM	30.4	81	0.05	0.14	0	Pup
2016	Ringed Seal	LM	18.1	72	0.06	0.29	0	Pup
2016	Ringed Seal	LM	30.8	79	0.07	0.55	0	Pup
2016	Ringed Seal	LM	32.7	85	0.11	1.03	0	Pup
2016	Ringed Seal	LM	20.4	72	0.05	0.26	0	Pup
2016	Ringed Seal	LM	30.8	79	0.1	1.23	0	Pup

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Muscle (Meat) THg Data - pups only

N	133		**length vs THg**
min	0.01	(<0.01)	0.415453858
max	0.35		
arithmean	0.06586466		
median	0.05		
#nd	66		
Freq nd	49.6240602		

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 8/24/2023 3:09:22 PM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.675	Skewness	CV
C0	133	0	0.01	0.35	0.065865	0.0561492	0.0480077	0.0041628	0	3.434881	0.728884

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
C0	133	0	0.04	0.05	0.05	0.05	0.07	0.07	0.108	0.154	0.284

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options

Date/Time of Computation	ProUCL 5.2 8/24/2023 3:12:58 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics

Number of Valid Observations	133
Number of Distinct Observations	20
Minimum	0.01
Maximum	0.35
Mean of Raw Data	0.0658647
Standard Deviation of Raw Data	0.0480077
Khat	3.2903454
Theta hat	0.0200176
Kstar	3.2211396
Theta star	0.0204476
Mean of Log Transformed Data	-2.879742
Standard Deviation of Log Transformed Data	0.5414637

Normal GOF Test Results

Correlation Coefficient R	0.765884
Approximate Shapiro Wilk Test Statistic	0.6116145
Approximate Shapiro Wilk P Value	0
Lilliefors Test Statistic	0.298647
Lilliefors Critical (0.0500000) Value	0.0771916

Data not Normal at (0.0500000) Significance Level

Gamma GOF Test Results

Correlation Coefficient R	0.8742429
A-D Test Statistic	12.278386
A-D Critical (0.0500000) Value	0.7583471
K-S Test Statistic	0.2829605
K-S Critical(0.0500000) Value	0.0814159

Data not Gamma Distributed at (0.0500000) Significance Level

Lognormal GOF Test Results

Correlation Coefficient R	0.9056195
Approximate Shapiro Wilk Test Statistic	0.8334371
Approximate Shapiro Wilk P Value	0
Lilliefors Test Statistic	0.2948885
Lilliefors Critical (0.0500000) Value	0.0771916

Data not Lognormal at (0.0500000) Significance Level

Non-parametric GOF Test Results

Data do not follow a discernible distribution at (0.0500000) Level of Significance

UCL Statistics for Uncensored Full Data Sets

User Selected Options

Date/Time of Computation	ProUCL 5.2 8/24/2023 3:14:20 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics

Total Number of Observations	133	Number of Distinct Observations	20
		Number of Missing Observations	0
Minimum	0.01	Mean	0.065865
Maximum	0.35	Median	0.05
SD	0.048008	Std. Error of Mean	0.004163
Coefficient of Variation	0.728884	Skewness	3.434881

Normal GOF Test

Shapiro Wilk Test Statistic	0.611615	Shapiro Wilk GOF Test	
1% Shapiro Wilk P Value	0	Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.298647	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.089266	Data Not Normal at 1% Significance Level	

Data Not Normal at 1% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	0.07276	95% Adjusted-CLT UCL (Chen-1995)	0.074037
		95% Modified-t UCL (Johnson-1978)	0.072967

Gamma GOF Test

A-D Test Statistic	12.27839	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.758347	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.282961	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.081416	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.290345	k star (bias corrected MLE)	3.22114
Theta hat (MLE)	0.020018	Theta star (bias corrected MLE)	0.020448
nu hat (MLE)	875.2319	nu star (bias corrected)	856.8231
MLE Mean (bias corrected)	0.065865	MLE Sd (bias corrected)	0.036698
		Approximate Chi Square Value (0.05)	789.8883
Adjusted Level of Significance	0.048196	Adjusted Chi Square Value	789.1924

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.071446	95% Adjusted Gamma UCL	0.071509

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.833437	Shapiro Wilk Lognormal GOF Test	
10% Shapiro Wilk P Value	0	Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.294889	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.070637	Data Not Lognormal at 10% Significance Level	

Data Not Lognormal at 10% Significance Level

Lognormal Statistics

Minimum of Logged Data	-4.60517	Mean of logged Data	-2.87974
Maximum of Logged Data	-1.04982	SD of logged Data	0.541464

Assuming Lognormal Distribution

95% H-UCL	0.070936	90% Chebyshev (MVUE) UCL	0.074682
95% Chebyshev (MVUE) UCL	0.079098	97.5% Chebyshev (MVUE) UCL	0.085228
99% Chebyshev (MVUE) UCL	0.097268		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution

Nonparametric Distribution Free UCLs

95% CLT UCL	0.072712	95% BCA Bootstrap UCL	0.074887
95% Standard Bootstrap UCL	0.072716	95% Bootstrap-t UCL	0.074558
95% Hall's Bootstrap UCL	0.074406	95% Percentile Bootstrap UCL	0.072932
90% Chebyshev(Mean, Sd) UCL	0.078353	95% Chebyshev(Mean, Sd) UCL	0.08401
97.5% Chebyshev(Mean, Sd) UCL	0.091861	99% Chebyshev(Mean, Sd) UCL	0.107284

Suggested UCL to Use

95% Student's-t UCL	0.07276	(rejected as data distribution is non-parametric)

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

UCL to use: arithmean of UCL estimates for non-parametric data distribution at alpha of 0.05

0.075174

Liver THg Data - pups only

N	124	**length vs THg**	
min	0.04	(but 3 samples <0.05)	0.110260687
max	1.81		
arithmean	0.34395161		
median	0.26		
#nd	3		
Freq nd	2.41935484		

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 8/25/2023 2:04:34 PM
User Selected Options	
From File	WorkSheet.xls
Full Precision	ON

From File: WorkSheet.xls

General Statistics for Uncensored Dataset

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.675	Skewness	CV

C0	124	0	0.04	1.81	0.343952	0.2619671	0.3169566	0.0284635	0.1408451	2.725038	0.921515

Percentiles for Uncensored Dataset

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
C0	124	0	0.123	0.16	0.1775	0.26	0.3725	0.424	0.622	1.018	1.6586

Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/25/2023 2:08:41 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	0.95

C0

Raw Statistics	
Number of Valid Observations	124
Number of Distinct Observations	56
Minimum	0.04
Maximum	1.81
Mean of Raw Data	0.3439516
Standard Deviation of Raw Data	0.3169566
Khat	1.9868507
Theta hat	0.173114
Kstar	1.9441581
Theta star	0.1769155
Mean of Log Transformed Data	-1.339536
Standard Deviation of Log Transformed Data	0.7076189

Normal GOF Test Results

Correlation Coefficient R	0.8226948
Approximate Shapiro Wilk Test Statistic	0.6846303
Approximate Shapiro Wilk P Value	0
Lilliefors Test Statistic	0.2208538
Lilliefors Critical (0.0500000) Value	0.0799103
Data not Normal at (0.0500000) Significance Level	

Gamma GOF Test Results

Correlation Coefficient R	0.94346
A-D Test Statistic	3.4166496
A-D Critical (0.0500000) Value	0.7654873
K-S Test Statistic	0.1339854
K-S Critical(0.0500000) Value	0.0843733
Data not Gamma Distributed at (0.0500000) Significance Level	

Lognormal GOF Test Results

Correlation Coefficient R	0.9857829
Approximate Shapiro Wilk Test Statistic	0.965678
Approximate Shapiro Wilk P Value	0.0342446
Lilliefors Test Statistic	0.0799782
Lilliefors Critical (0.0500000) Value	0.0799103
Data not Lognormal at (0.0500000) Significance Level	

Non-parametric GOF Test Results

Data do not follow a discernible distribution at (0.0500000) Level of Significance

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.2 8/25/2023 2:35:35 PM
From File	WorkSheet.xls
Full Precision	ON
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

C0

General Statistics			
Total Number of Observations	124	Number of Distinct Observations	56
		Number of Missing Observations	0
Minimum	0.04	Mean	0.343952
Maximum	1.81	Median	0.26
SD	0.3169566	Std. Error of Mean	0.028464
Coefficient of Variation	0.9215151	Skewness	2.725038
Normal GOF Test			
Shapiro Wilk Test Statistic	0.6846303	Shapiro Wilk GOF Test	
1% Shapiro Wilk P Value	0	Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.2208538	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.0924102	Data Not Normal at 1% Significance Level	
Data Not Normal at 1% Significance Level			
Assuming Normal Distribution			
		95% UCLs (Adjusted for Skewness)	
95% Normal UCL			
95% Student's-t UCL	0.3911253	95% Adjusted-CLT UCL (Chen-1995)	0.398213
		95% Modified-t UCL (Johnson-1978)	0.392286
Gamma GOF Test			
A-D Test Statistic	3.4166496	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.7654873	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.1339854	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.0843733	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.9868507	k star (bias corrected MLE)	1.944158
Theta hat (MLE)	0.173114	Theta star (bias corrected MLE)	0.176916
nu hat (MLE)	492.73898	nu star (bias corrected)	482.1512
MLE Mean (bias corrected)	0.3439516	MLE Sd (bias corrected)	0.246679
		Approximate Chi Square Value (0.05)	432.2353
Adjusted Level of Significance	0.0480645	Adjusted Chi Square Value	431.6852
Assuming Gamma Distribution			
95% Approximate Gamma UCL	0.3836723	95% Adjusted Gamma UCL	0.384161
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.965678	Shapiro Wilk Lognormal GOF Test	

10% Shapiro Wilk P Value	0.0342446	Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.0799782	Lilliefors Lognormal GOF Test	
10% Lilliefors Critical Value	0.0731246	Data Not Lognormal at 10% Significance Level	
Data Not Lognormal at 10% Significance Level			

Lognormal Statistics			
Minimum of Logged Data	-3.218876	Mean of logged Data	-1.33954
Maximum of Logged Data	0.5933268	SD of logged Data	0.707619

Assuming Lognormal Distribution			
95% H-UCL	0.3811635	90% Chebyshev (MVUE) UCL	0.40661
95% Chebyshev (MVUE) UCL	0.4387516	97.5% Chebyshev (MVUE) UCL	0.483363
99% Chebyshev (MVUE) UCL	0.5709946		

Nonparametric Distribution Free UCL Statistics
Data do not follow a Discernible Distribution

Nonparametric Distribution Free UCLs				UCL to use: arithmean of non-parametric UCL estimates at alpha of 0.05
95% CLT UCL	0.39077	95% BCA Bootstrap UCL	0.400887	0.407542
95% Standard Bootstrap UCL	0.3911191	95% Bootstrap-t UCL	0.405286	
95% Hall's Bootstrap UCL	0.4033218	95% Percentile Bootstrap UCL	0.393387	
90% Chebyshev(Mean, Sd) UCL	0.4293422	95% Chebyshev(Mean, Sd) UCL	0.468021	
97.5% Chebyshev(Mean, Sd) UCL	0.5217064	99% Chebyshev(Mean, Sd) UCL	0.62716	

Suggested UCL to Use		
95% Student's-t UCL	0.3911253	(rejected as data distribution is non-parametric)

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.