Interactive Excel Tool for Computing, Assessing, and Using

EmP Ws Equations

Tool Philosophy

Rather than "input data here", and "get Ws equation there", this tool was designed to allow the researcher to participate (by observing or intervening) in the process of setting up the data for equation estimation. In this way, it is hoped that the resulting equation will have less of a "black box" feel, and feel more like a sequence of understandable steps. Excel was chosen as the platform for the tool since it is ubiquitous, and it has graphical and interactive capabilities that most other software packages don't (in combination, at least) have.

Tool Elements (each element has its own worksheet)

Raw data: Simply, a place to organize the length-weight data in a manner that facilitates data quality assurance and analysis.

Data quality: The data from a selected sampled population is graphed so that unusual values and other data quality issues can be detected. This sheet is kept hidden unless the user invokes it from the data sheet.

Collation: Mean weights for fish in each length class from each study population are recorded. In addition, the number of populations with fish in each length class is noted.

"Number of fish": This sheet, hidden unless invoked by the user from the collation worksheet, tallies the number of fish in each length class from each study population.

Summarized: This sheet sets up the data for estimation of quartiles (1^{st}, 2^{nd}, and 3^{rd}) and means of mean weights for each length class.

EmP-Ws: On this sheet, the summarized data is organized for estimation of Ws equations (in particular, length classes with insufficient data) are removed from consideration, and the resulting Ws equations are displayed.

Ws graphs: Plots of the resulting equations are done on the log-log and original scales.

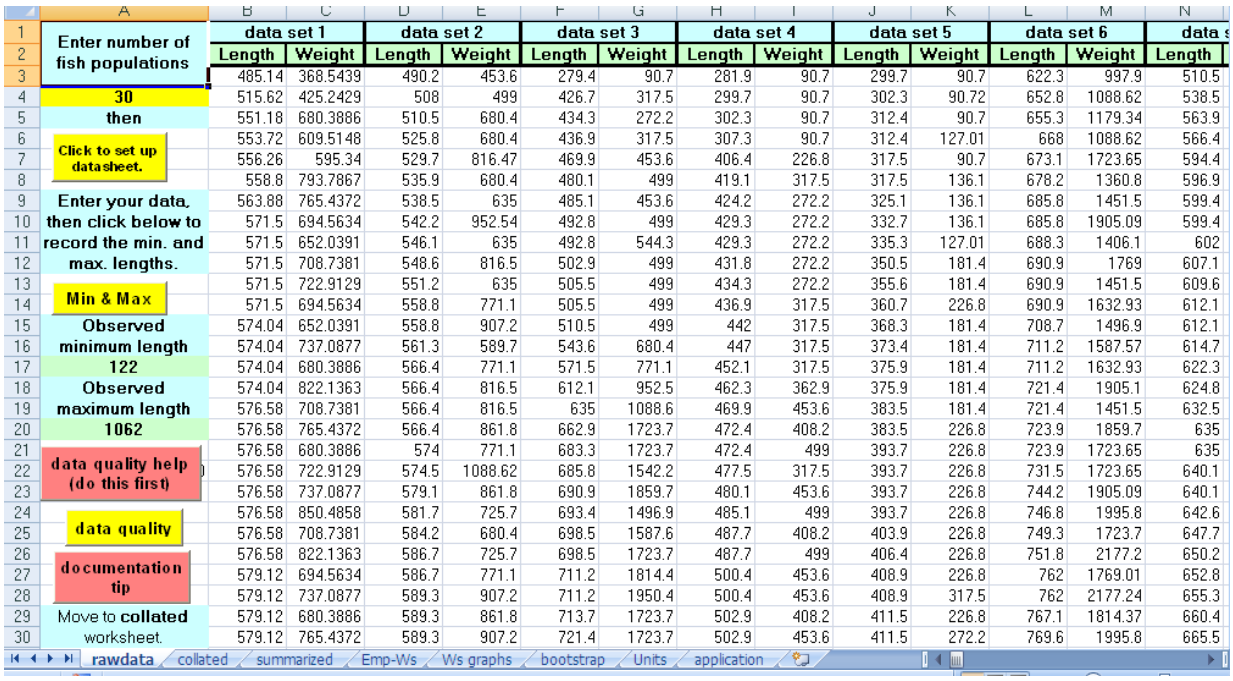
Bootstrap: A bootstrap study is done to assess precision of the median Ws equations.

Units: this sheet allows the user to change measurement units; updated Ws equations and estimates of Ws are then provided.

Application: For a chosen study population, scatter plots are drawn of Wr for individual fish, and for means from selected length categories.

Instructions for Use:

Raw data:

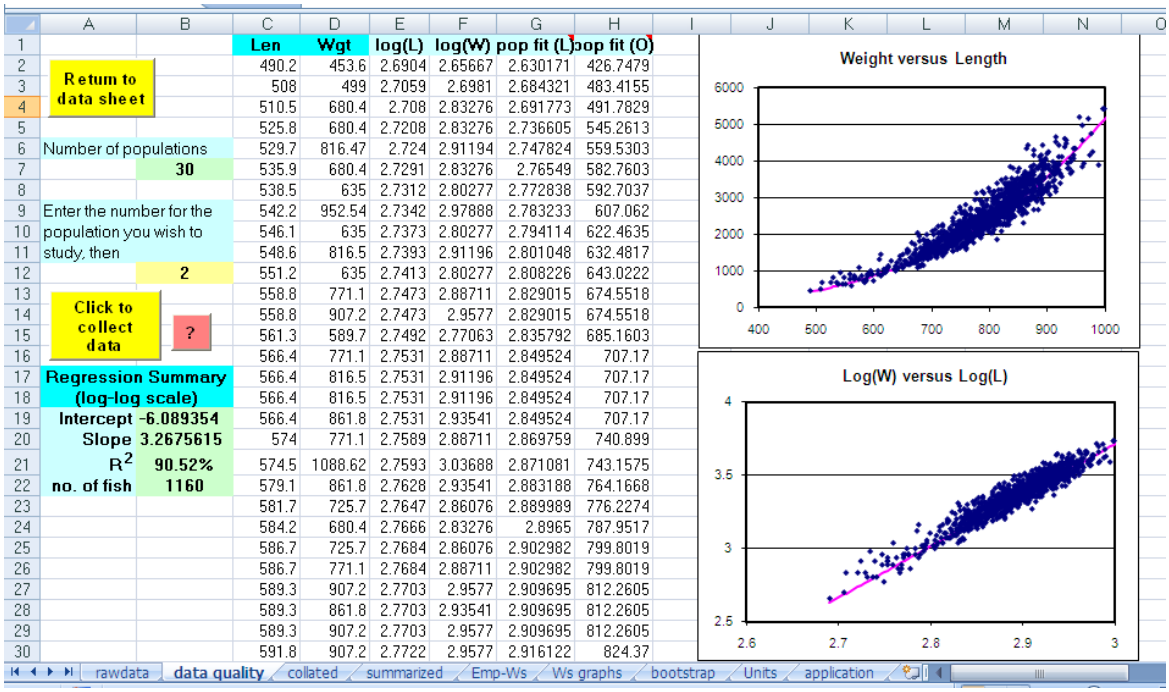


	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Enter number of fish populations	data set 1		data set 2		data set 3		data set 4		data set 5		data set 6		data s
2		Length	Weight	Length	Weight	Length	Weight	Length	Weight	Length	Weight	Length	Weight	Length
3		485.14	368.5439	490.2	453.6	279.4	90.7	281.9	90.7	299.7	90.7	622.3	997.9	510.5
4	30	515.62	425.2429	508	499	426.7	317.5	299.7	90.7	302.3	90.72	652.8	1088.62	538.5
5	then	551.18	680.3886	510.5	680.4	434.3	272.2	302.3	90.7	312.4	90.7	655.3	1179.34	563.9
6	Click to set up datasheet.	553.72	609.5148	525.8	680.4	436.9	317.5	307.3	90.7	312.4	127.01	668	1088.62	566.4
7		556.26	595.34	529.7	816.47	469.9	453.6	406.4	226.8	317.5	90.7	673.1	1723.65	594.4
8		558.8	793.7867	535.9	680.4	480.1	499	419.1	317.5	317.5	136.1	678.2	1360.8	596.9
9	Enter your data,	563.88	765.4372	538.5	635	485.1	453.6	424.2	272.2	325.1	136.1	685.8	1451.5	599.4
10	then click below to	571.5	694.5634	542.2	952.54	492.8	499	429.3	272.2	332.7	136.1	685.8	1905.09	599.4
11	record the min. and	571.5	652.0391	546.1	635	492.8	544.3	429.3	272.2	335.3	127.01	688.3	1406.1	602
12	max. lengths.	571.5	708.7381	548.6	816.5	502.9	499	431.8	272.2	350.5	181.4	690.9	1769	607.1
13		571.5	722.9129	551.2	635	505.5	499	434.3	272.2	355.6	181.4	690.9	1451.5	609.6
14	Min & Max	571.5	694.5634	558.8	771.1	505.5	499	436.9	317.5	360.7	226.8	690.9	1632.93	612.1
15	Observed	574.04	652.0391	558.8	907.2	510.5	499	442	317.5	368.3	181.4	708.7	1496.9	612.1
16	minimum length	574.04	737.0877	561.3	589.7	543.6	680.4	447	317.5	373.4	181.4	711.2	1587.57	614.7
17	122	574.04	680.3886	566.4	771.1	571.5	771.1	452.1	317.5	375.9	181.4	711.2	1632.93	622.3
18	Observed	574.04	822.1363	566.4	816.5	612.1	952.5	462.3	362.9	375.9	181.4	721.4	1905.1	624.8
19	maximum length	576.58	708.7381	566.4	816.5	635	1088.6	469.9	453.6	383.5	181.4	721.4	1451.5	632.5
20	1062	576.58	765.4372	566.4	861.8	662.9	1723.7	472.4	408.2	383.5	226.8	723.9	1859.7	635
21	data quality help (do this first)	576.58	680.3886	574	771.1	683.3	1723.7	472.4	499	393.7	226.8	723.9	1723.65	635
22		576.58	722.9129	574.5	1088.62	685.8	1542.2	477.5	317.5	393.7	226.8	731.5	1723.65	640.1
23		576.58	737.0877	579.1	861.8	690.9	1859.7	480.1	453.6	393.7	226.8	744.2	1905.09	640.1
24	data quality	576.58	850.4858	581.7	725.7	693.4	1496.9	485.1	499	393.7	226.8	746.8	1995.8	642.6
25		576.58	708.7381	584.2	680.4	698.5	1587.6	487.7	408.2	403.9	226.8	749.3	1723.7	647.7
26	documentation tip	576.58	822.1363	586.7	725.7	698.5	1723.7	487.7	499	406.4	226.8	751.8	2177.2	650.2
27		579.12	694.5634	586.7	771.1	711.2	1814.4	500.4	453.6	408.9	226.8	762	1769.01	652.8
28		579.12	737.0877	589.3	907.2	711.2	1950.4	500.4	453.6	408.9	317.5	762	2177.24	655.3
29	Move to collated	579.12	680.3886	589.3	861.8	713.7	1723.7	502.9	408.2	411.5	226.8	767.1	1814.37	660.4
30	worksheet.	579.12	765.4372	589.3	907.2	721.4	1723.7	502.9	453.6	411.5	272.2	769.6	1995.8	665.5

rawdata | collated | summarized | Emp-Ws | Ws graphs | bootstrap | Units | application

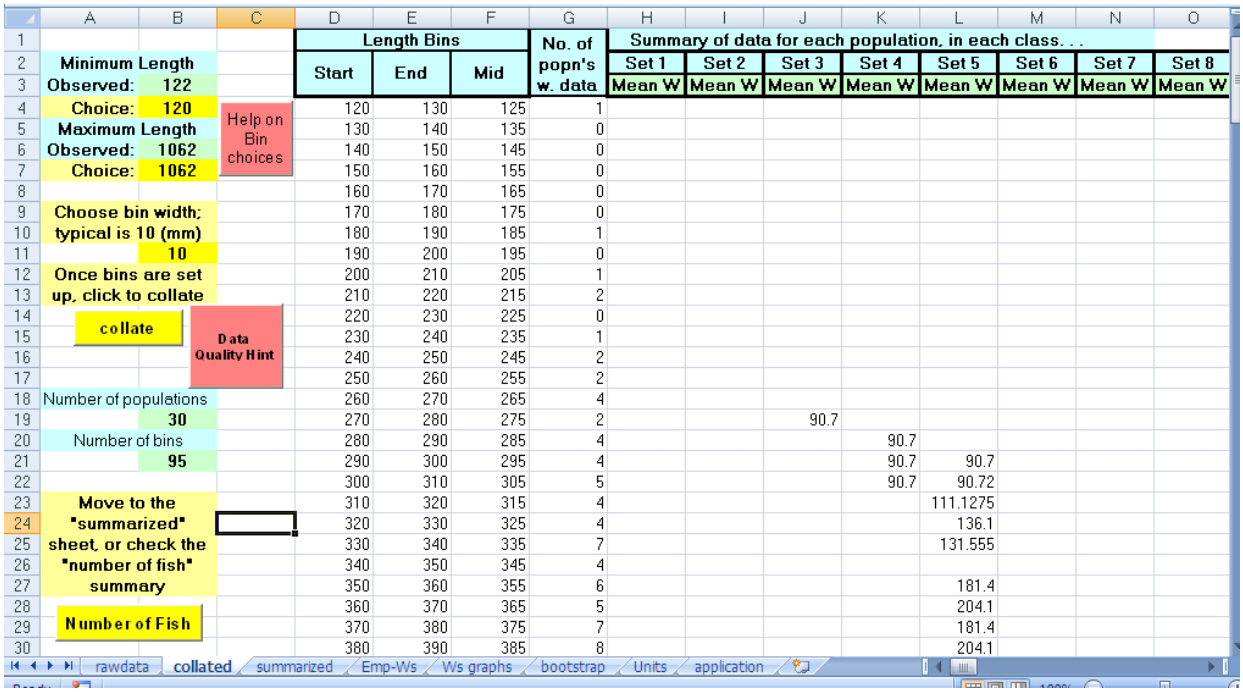
1. Enter the number of fish populations for which you have length-weight data; the **set up datasheet** button will organize the requisite number of data entry columns.
2. Enter your data (hopefully, you can cut & paste it from another file).
3. **Click** the **Min & Max** button to find the smallest and largest observed lengths in your entire data set. This will be useful in establishing an initial set of length classes to consider.
4. Prior to proceeding with the analysis, we recommend you spending some time with the **data quality** sheet so that you can be very confident in the validity of the raw data.

Data quality:



1. Enter the number (numbers are those assigned on the raw data sheet) for the population you want to look at.
2. **Click** to collect the data.
3. A numerical summary of the log(W)-log(L) regression for that population is given in the table on the left of the screen.
4. The data values are plotted in scatter plots with the log-log regression from the entire data set drawn on them to provide a reference point. Example: If the majority of the points for one population fall below (or above) the population regression line, that might be due to length having been measured by a different protocol for that population. At any rate, you can detect such things as well as individual gross data entry errors using this sheet.

Collation:

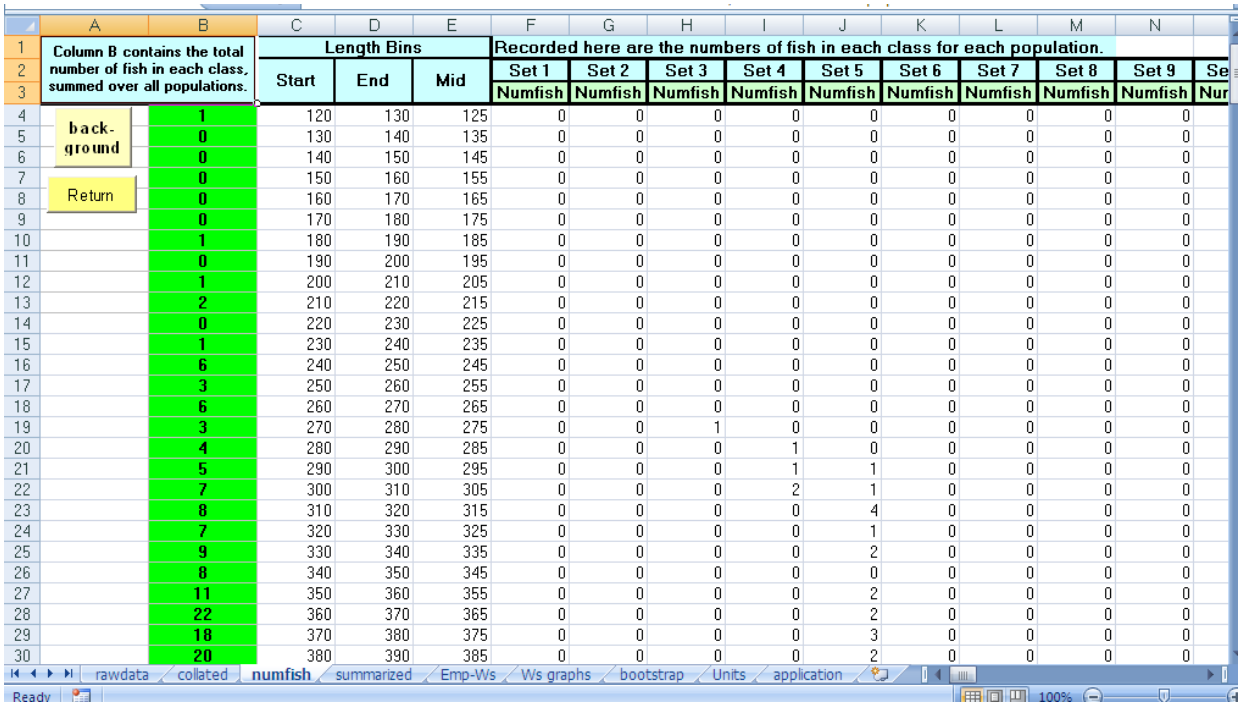


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1				Length Bins			No. of	Summary of data for each population, in each class. . .							
2	Minimum Length			Start	End	Mid	popn's	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8
3	Observed:	122					w. data	Mean W	Mean W	Mean W	Mean W	Mean W	Mean W	Mean W	Mean W
4	Choice:	120	Help on Bin choices	120	130	125	1								
5	Maximum Length			130	140	135	0								
6	Observed:	1062		140	150	145	0								
7	Choice:	1062		150	160	155	0								
8				160	170	165	0								
9	Choose bin width;			170	180	175	0								
10	typical is 10 (mm)			180	190	185	1								
11		10		190	200	195	0								
12	Once bins are set			200	210	205	1								
13	up, click to collate			210	220	215	2								
14	collate		Data Quality Hint	220	230	225	0								
15				230	240	235	1								
16				240	250	245	2								
17				250	260	255	2								
18	Number of populations			260	270	265	4								
19		30		270	280	275	2			90.7					
20	Number of bins			280	290	285	4				90.7				
21		95		290	300	295	4				90.7	90.7			
22				300	310	305	5				90.7	90.72			
23	Move to the			310	320	315	4					111.1275			
24	"summarized"			320	330	325	4					136.1			
25	sheet, or check the			330	340	335	7					131.555			
26	"number of fish"			340	350	345	4								
27	summary			350	360	355	6					181.4			
28				360	370	365	5					204.1			
29	Number of Fish			370	380	375	7					181.4			
30				380	390	385	8					204.1			

rawdata | collated | summarized | Emp-Ws | Ws graphs | bootstrap | Units | application

1. Enter a value for the lower limit of the lowest length class, and a choice for the longest length that you want to consider (here, with 1062 mm selected, the largest length class is from 1060 mm to 1070 mm). Also indicate the bin width (10 mm is usual for most studies; some researchers working with juvenile fish have used 5 mm).
2. **Click** the **collate** button. The mean weight for fish in each length class, from each population, will be recorded.
3. Note for this illustration that the length classes for lengths less than 250 mm are represented by very few populations. We'll return to this when we discuss the bootstrapping sheet.
4. To take the sample size examination, a little deeper, **click** the **Number of fish** button.

“Number of fish”:



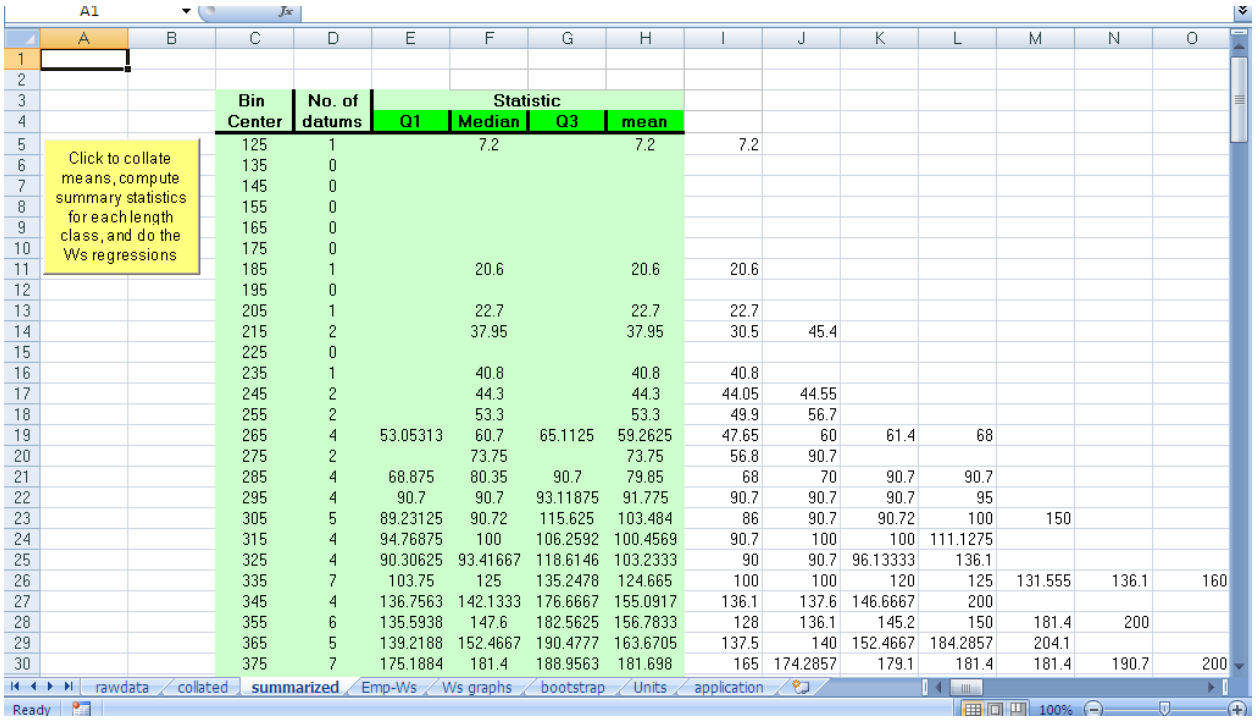
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Column B contains the total number of fish in each class, summed over all populations.		Length Bins			Recorded here are the numbers of fish in each class for each population.								
2			Start	End	Mid	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9
3						Numfish	Numfish	Numfish	Numfish	Numfish	Numfish	Numfish	Numfish	Numfish
4	back-ground	1	120	130	125	0	0	0	0	0	0	0	0	0
5		0	130	140	135	0	0	0	0	0	0	0	0	0
6		0	140	150	145	0	0	0	0	0	0	0	0	0
7	Return	0	150	160	155	0	0	0	0	0	0	0	0	0
8		0	160	170	165	0	0	0	0	0	0	0	0	0
9		0	170	180	175	0	0	0	0	0	0	0	0	0
10		1	180	190	185	0	0	0	0	0	0	0	0	0
11		0	190	200	195	0	0	0	0	0	0	0	0	0
12		1	200	210	205	0	0	0	0	0	0	0	0	0
13		2	210	220	215	0	0	0	0	0	0	0	0	0
14		0	220	230	225	0	0	0	0	0	0	0	0	0
15		1	230	240	235	0	0	0	0	0	0	0	0	0
16		6	240	250	245	0	0	0	0	0	0	0	0	0
17		3	250	260	255	0	0	0	0	0	0	0	0	0
18		6	260	270	265	0	0	0	0	0	0	0	0	0
19		3	270	280	275	0	0	1	0	0	0	0	0	0
20		4	280	290	285	0	0	0	1	0	0	0	0	0
21		5	290	300	295	0	0	0	1	1	0	0	0	0
22		7	300	310	305	0	0	0	2	1	0	0	0	0
23		8	310	320	315	0	0	0	0	4	0	0	0	0
24		7	320	330	325	0	0	0	0	1	0	0	0	0
25		9	330	340	335	0	0	0	0	2	0	0	0	0
26		8	340	350	345	0	0	0	0	0	0	0	0	0
27		11	350	360	355	0	0	0	0	2	0	0	0	0
28		22	360	370	365	0	0	0	0	2	0	0	0	0
29		18	370	380	375	0	0	0	0	3	0	0	0	0
30		20	380	390	385	0	0	0	0	2	0	0	0	0

rawdata | collated | numfish | summarized | Emp-Ws | Ws graphs | bootstrap | Units | application

Ready 100%

This sheet, hidden unless invoked by the user from the collation worksheet, tallies the number of fish in each length class from each study population. On the left of the sheet is the total number of fish in each length class, summed over all the study populations. Note, in this illustration, the paucity of data for the smaller length classes.

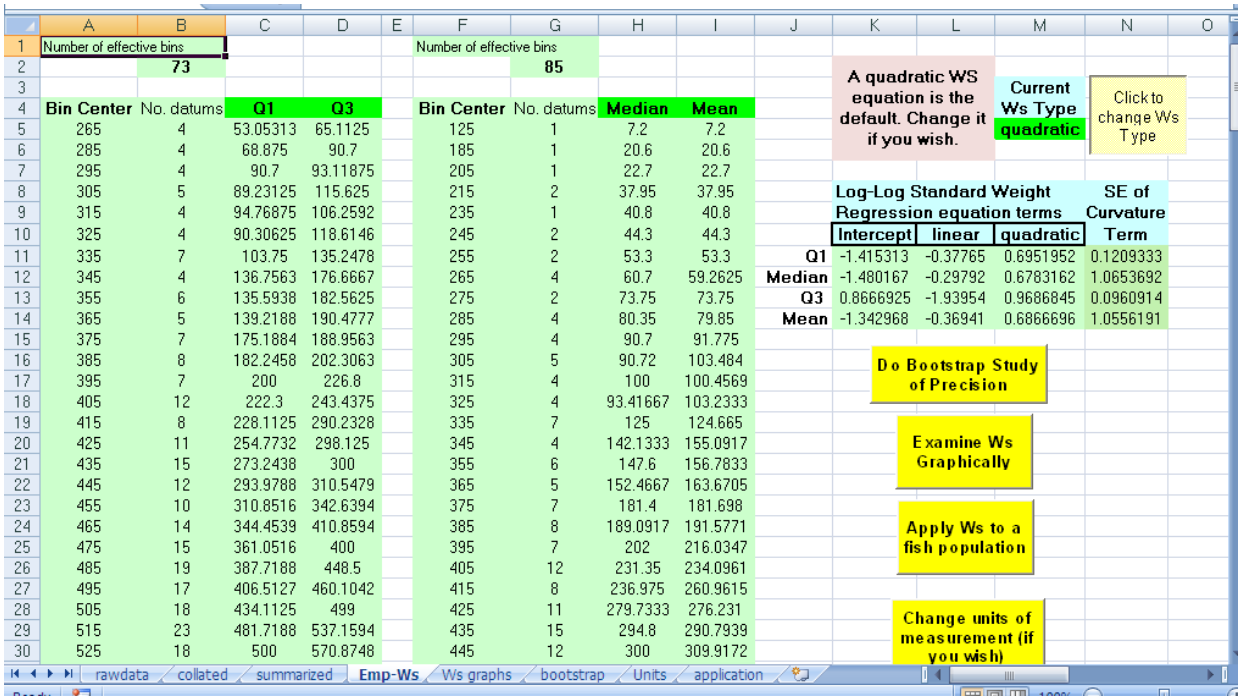
Summarized:



Bin Center	No. of datums	Statistic Q1	Median	Q3	mean							
125	1		7.2		7.2	7.2						
135	0											
145	0											
155	0											
165	0											
175	0											
185	1		20.6		20.6	20.6						
195	0											
205	1		22.7		22.7	22.7						
215	2		37.95		37.95	30.5	45.4					
225	0											
235	1		40.8		40.8	40.8						
245	2		44.3		44.3	44.05	44.55					
255	2		53.3		53.3	49.9	56.7					
265	4	53.05313	60.7	65.1125	59.2625	47.65	60	61.4	68			
275	2		73.75		73.75	56.8	90.7					
285	4	68.875	80.35	90.7	79.85	68	70	90.7	90.7			
295	4	90.7	90.7	93.11875	91.775	90.7	90.7	90.7	95			
305	5	89.23125	90.72	115.625	103.484	86	90.7	90.72	100	150		
315	4	94.76875	100	106.2592	100.4569	90.7	100	100	111.1275			
325	4	90.30625	93.41667	118.6146	103.2333	90	90.7	96.13333	136.1			
335	7	103.75	125	135.2478	124.665	100	100	120	125	131.555	136.1	160
345	4	136.7563	142.1333	176.6667	155.0917	136.1	137.6	146.6667	200			
355	6	135.5938	147.6	182.5625	156.7833	128	136.1	145.2	150	181.4	200	
365	5	139.2188	152.4667	190.4777	163.6705	137.5	140	152.4667	184.2857	204.1		
375	7	175.1884	181.4	188.9563	181.698	165	174.2857	179.1	181.4	181.4	190.7	200

1. **Click** to have the data re-organized for computation of summary statistics.
2. This sheet sets up the data for estimation of quartiles (1st, 2nd, and 3rd) and means of mean weights for each length class. The available means for each length class are sorted, and laid out in the relevant row (at this point, connection to specific study populations is not retained).
3. The mean and median are computed for all length classes with at least one mean, and the 1st and 3rd quartiles are computed for length classes with three or more means.
4. You are likely tired, by now, of our noting the paucity of data for shorter length classes, so we won't bother doing that again.
5. Turn to the **EmP-Ws** sheet for results.

EmP-Ws:



Number of effective bins					Number of effective bins			
	73					85		
Bin Center	No. datums	**Q1**	**Q3**		**Bin Center**	No. datums	**Median**	**Mean**
265	4	53.05313	65.1125		125	1	7.2	7.2
285	4	68.875	90.7		185	1	20.6	20.6
295	4	90.7	93.11875		205	1	22.7	22.7
305	5	89.23125	115.625		215	2	37.95	37.95
315	4	94.76875	106.2592		235	1	40.8	40.8
325	4	90.30625	118.6146		245	2	44.3	44.3
335	7	103.75	135.2478		255	2	53.3	53.3
345	4	136.7563	176.6667		265	4	60.7	59.2625
355	6	135.5938	182.5625		275	2	73.75	73.75
365	5	139.2188	190.4777		285	4	80.35	79.85
375	7	175.1884	188.9563		295	4	90.7	91.775
385	8	182.2458	202.3063		305	5	90.72	103.484
395	7	200	226.8		315	4	100	100.4569
405	12	222.3	243.4375		325	4	93.41667	103.2333
415	8	228.1125	290.2328		335	7	125	124.665
425	11	254.7732	298.125		345	4	142.1333	155.0917
435	15	273.2438	300		355	6	147.6	156.7833
445	12	293.9788	310.5479		365	5	152.4667	163.6705
455	10	310.8516	342.6394		375	7	181.4	181.698
465	14	344.4539	410.8594		385	8	189.0917	191.5771
475	15	361.0516	400		395	7	202	216.0347
485	19	387.7188	448.5		405	12	231.35	234.0961
495	17	406.5127	460.1042		415	8	236.975	260.9615
505	18	434.1125	499		425	11	279.7333	276.231
515	23	481.7188	537.1594		435	15	294.8	290.7939
525	18	500	570.8748		445	12	300	309.9172

A quadratic WS equation is the default. Change it if you wish.

Current Ws Type: quadratic

Click to change Ws Type

	Log-Log Standard Weight Regression equation terms			SE of Curvature Term
	Intercept	linear	quadratic	
Q1	-1.415313	-0.37765	0.6951952	0.1209333
Median	-1.480167	-0.29792	0.6783162	1.0653692
Q3	0.8666925	-1.93954	0.9686845	0.0960914
Mean	-1.342968	-0.36941	0.6866696	1.0556191

Do Bootstrap Study of Precision

Examine Ws Graphically

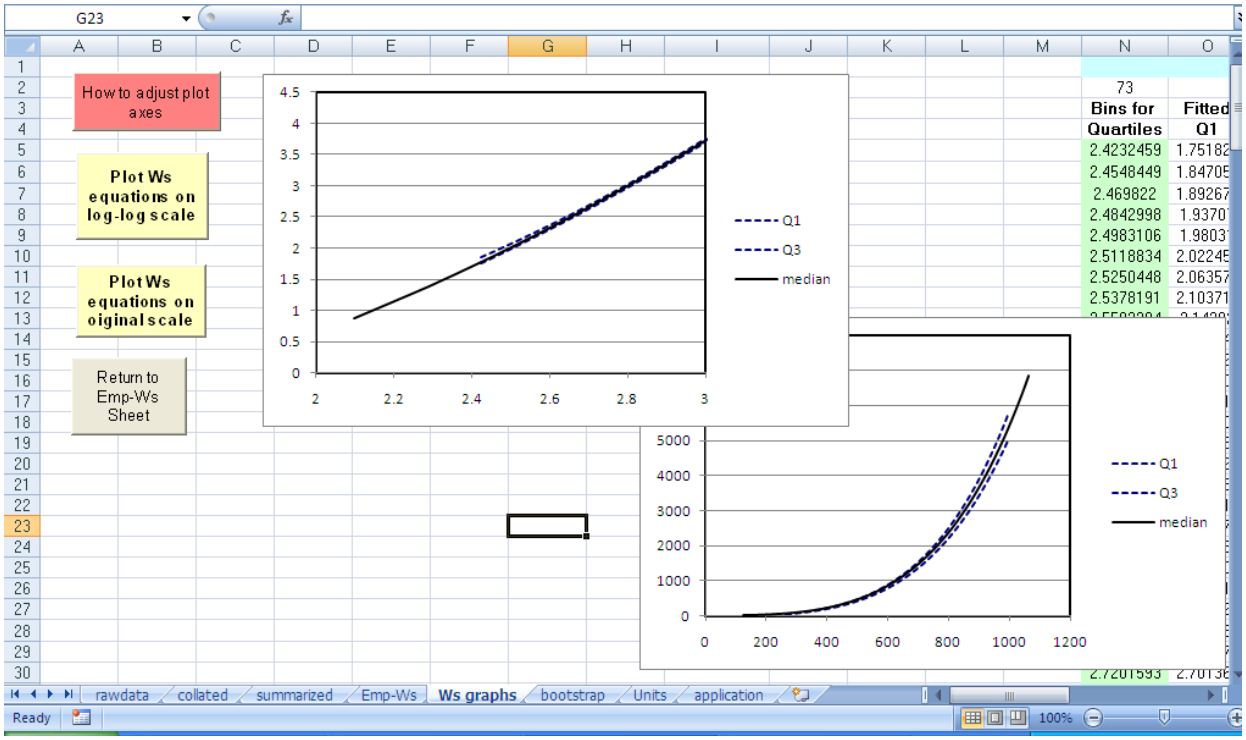
Apply Ws to a fish population

Change units of measurement (if you wish)

rawdata | collated | summarized | Emp-Ws | Ws graphs | bootstrap | Units | application

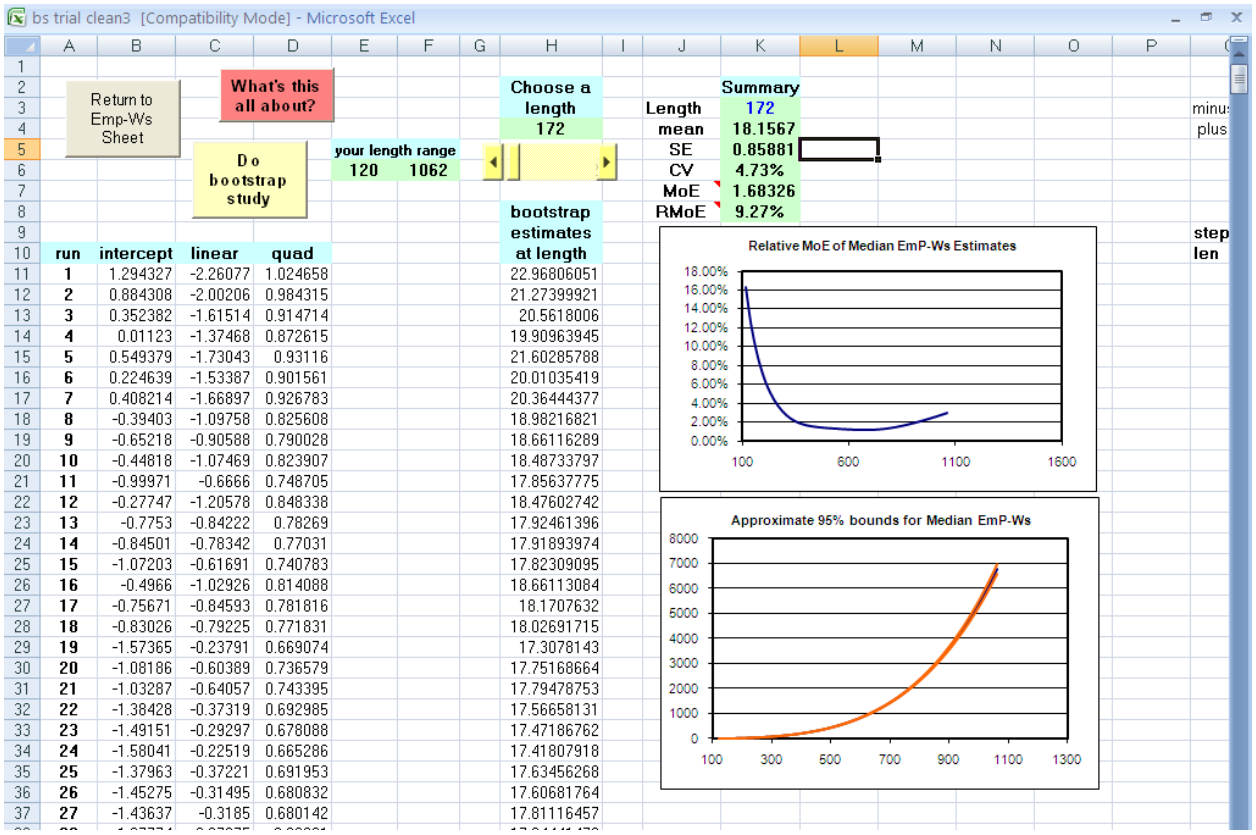
1. For sake of keeping neatly organized, one more data summary is done, namely to organize the relevant data (excluding length classes with too little or no data) for each of the target summary statistics.
2. Once done, the regression equations are computed for each summary statistic (all three quartiles and the mean). The choice of using a linear regression or a quadratic is given (one of us, at least, is inclined to always use a quadratic, but that choice properly belongs to the researcher). As an aid to assessing the utility of a quadratic, the standard error of the quadratic term is displayed.
3. The yellow buttons that take you to other worksheets are self-explanatory.

Ws graphs:



Plots of the resulting equations are done on the log-log and original scales. Michael and Kate: I'm not sure if this sheet is all that useful, so I'm not going to elaborate on this one just now…

Bootstrap:



Notes to M & K:

1. **The bootstrapping currently does only 100 replicates. Formerly, that took many many hours; now it takes only a few minutes. It would be easy to give the user the option of how many to do. Your thoughts?**
2. **The graph showing the approximate 95% bounds for the median Emp-Ws is not very useful I think (by necessity of scale, the three lines (median Ws, and upper and lower bounds) are going to be hard to distinguish. Kill it?**
3. **I'm not sure whether the ability to get a numerical summary of the bootstrap results for individual lengths adds much utility. The relevant information is visible on the graph. If you think it is useful (or at least, interesting), we can keep it. Otherwise, its removal would make the page cleaner.**

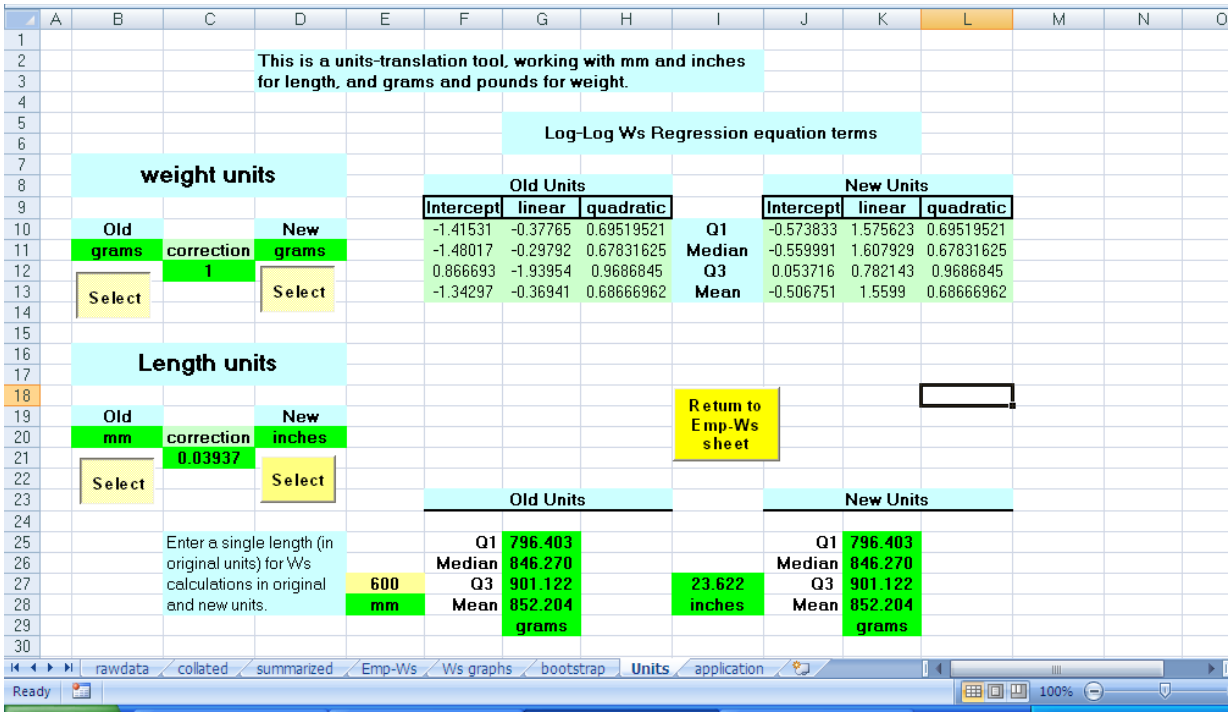
1. Each bootstrap replicate consists of the following steps:
    a. Randomly select, with replacement, *n* integers from 1 to *n*, where *n* is the number of populations being used to form the Ws equation. This represents the act of

randomly selecting *n* populations from the conceptual collection of all such populations.

b. For each selected population, randomly select, with replacement n_i pairs of lengths and weights, where n_i is the number of fish in the i^{th} sampled population. This represents the act of randomly sampling from that particular population.
c. Collate, organize, and compute the EmP-median Ws equation for that replicate.

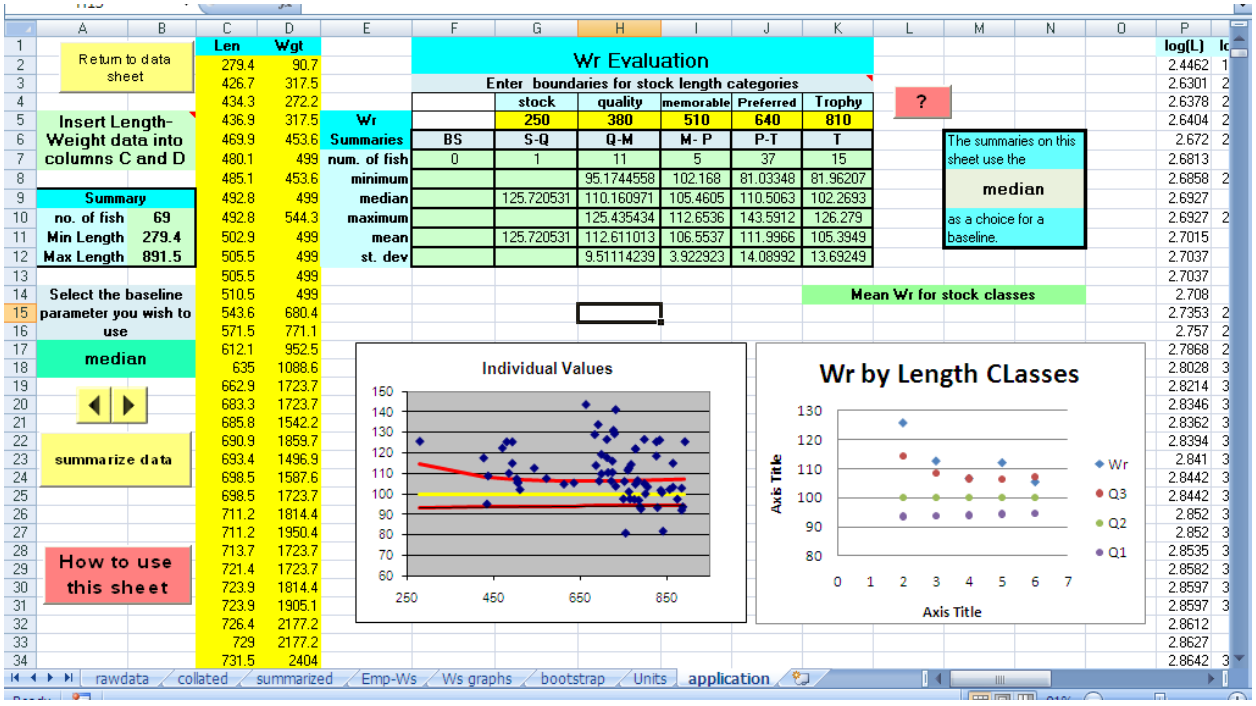
2. Repeat Step 1 a large number of times.
3. For each length class, compute a relative margin of error (RMoE) as follows. Let $SE_i = SD_i \Big/ \sqrt{n_i}$ be the standard error of the mean of the estimated Ws for that length class. Then $2 \times SE_i$ is the approximate margin of error (MoE) for a classical 95% confidence interval (the MoE is the plus/minus part of the C.I. calculation. Then MoE divided by the mean for that length class reports the precision of the mean on a relative scale.
4. In the illustration, notice that the RMoE is quite large for the smaller length classes, due to the paucity of data therein. This observation might impel the researcher to re-do the Ws computations using a larger lower limit.

Units:



On occasion, one might wish to present standard weight in units other than those used to generate the Ws in the first place. We assume here that researchers are likely to use for length and weight millimeters and grams, or inches and pounds. This sheet lets you choose which of those units you want to consider.

Application:



1. Enter length-weight data for a population whose relative weight you are interested in studying.
2. **Click** the **summarize data** button.
3. Scatter plots are drawn of Wr for individual fish, and for means from selected length categories. For the illustrated "test" population, the **Individual values** graph shows that most of the fish are above the median; on average, the means in each length category are near or above the third quartile.