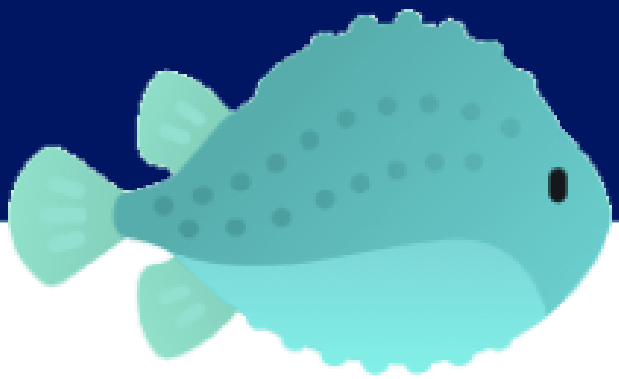

Lumpfish Welfare Watcher

Web interface user manual

Acknowledgements

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- MOWI Scotland
- The Cleaner Fish Company
- Ocean Matters
- Three Sixty Aquaculture
- Organic Sea Harvest.

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What Does This Guide Contain?

INTRODUCTION

The Lumpfish Welfare Watcher is a web & desktop interface designed to help fish farmers assess and improve the welfare of Lumpfish based on the validated operational welfare score index known as the Lumpfish Operational Welfare Score Index or LOWSI.

The aim of this guide is to explain what the tools within the web-interface are designed to do. All while pinpointing and guiding you on their two main features, and how to use them.

BMI Calculator:

The purpose of the Body Mass Index (BMI) calculator is to calculate the BMI of a given sample of Lumpfish based on wet weight (measured in grams) and total length (measured in millimetres). The tool calculates the proportion of fish that are emaciated, underweight, normal-weight or above normal weight, and estimates the body height, the fineness ratio and the maximum mesh size that is required to prevent lumpfish from escaping. This calculator also provides summary statistics and recommendations for action based on the BMI outcome for the sampled population.

Rapid Welfare Assessment Tool:

The purpose of the Rapid Welfare Assessment Tool is to calculate the Lumpfish Operational Welfare Score Index (LOWSI) based on the BMI data (as stated above) and four additional welfare metrics:

1. Body damage score
2. Tail or Caudal fin damage score
3. Eye condition score
4. Sucker deformity score

This tool determines the proportion of fish that have good welfare, moderately compromised welfare and severely compromised welfare. The RWAT provides the same summary statistics as the BMI calculator in addition to all individual scores and overall LOWSI. The information is displayed with summary statistics and recommendations for action.

Additional Information

Lumpfish are monitored at the hatchery and also at salmon farms. There are four distinct life stages that are assessed: three in the hatchery (S1 through S3) and one in the salmon cages (S4) as shown in Table 1;

Table 1. The four Lumpfish life-stages. (± SE) for farmed lumpfish at different stages of development (log10 Ws = a + b·(log10 TL), where Ws = standard weight (g) and TL = total length (mm), adapted from Rabadan et al. (2020).

Site	Life Stage	Weight Range (g)
Hatchery	S1 Larvae	0-1
	S2 Pre-deployment	1-10
	S3 Pre-deployment	>10
Salmon Cages	S4 Post-deployment	>10

WEB INTERFACE GUIDE

How to access the web interface:

You can access the web interface via; https://bsciweb.swan.ac.uk/lumpfish/public/

What To Expect & Functionality:

The home screen has three tools available (*Figure 1*):

- Lumpfish Welfare e-learning
- BMI Calculator
- Rapid Welfare Assessment Tool

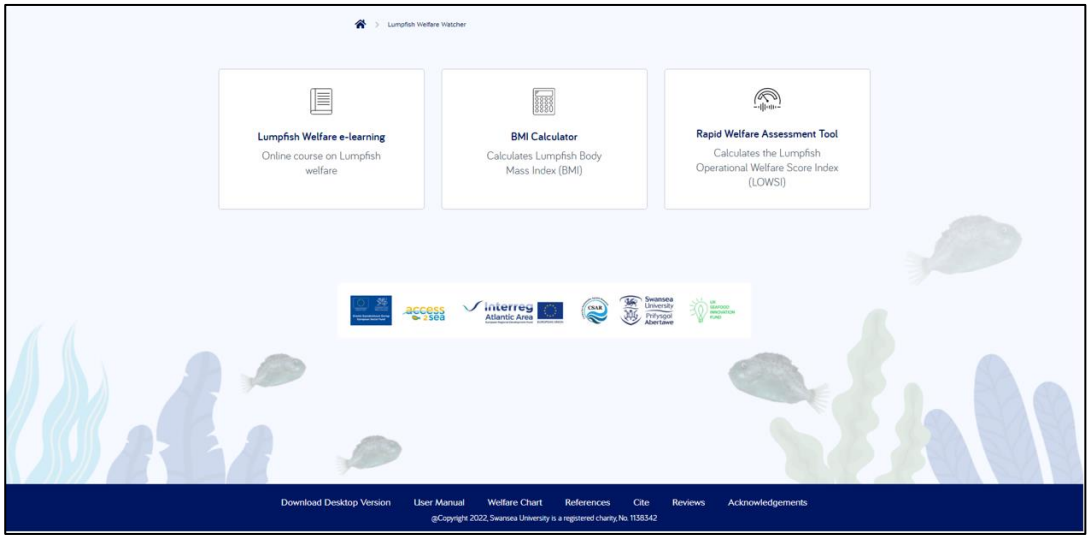


Figure 1: Screenshot displaying the web interface home-screen and the three tools

LUMPFISH WELFARE E-LEARNING

Clicking on the Lumpfish Welfare E-learning tool will open the free course in Lumpfish welfare. (You do not need to sign in to partake in this course)

This short online course provides essential information for both professionals and students on Lumpfish welfare. It also shows how to score the lumpish visual indicators which is essential to use the Rapid Welfare Assessment Tool. *Figure 2* shows the course content.

(Network connectivity is required to access this page)

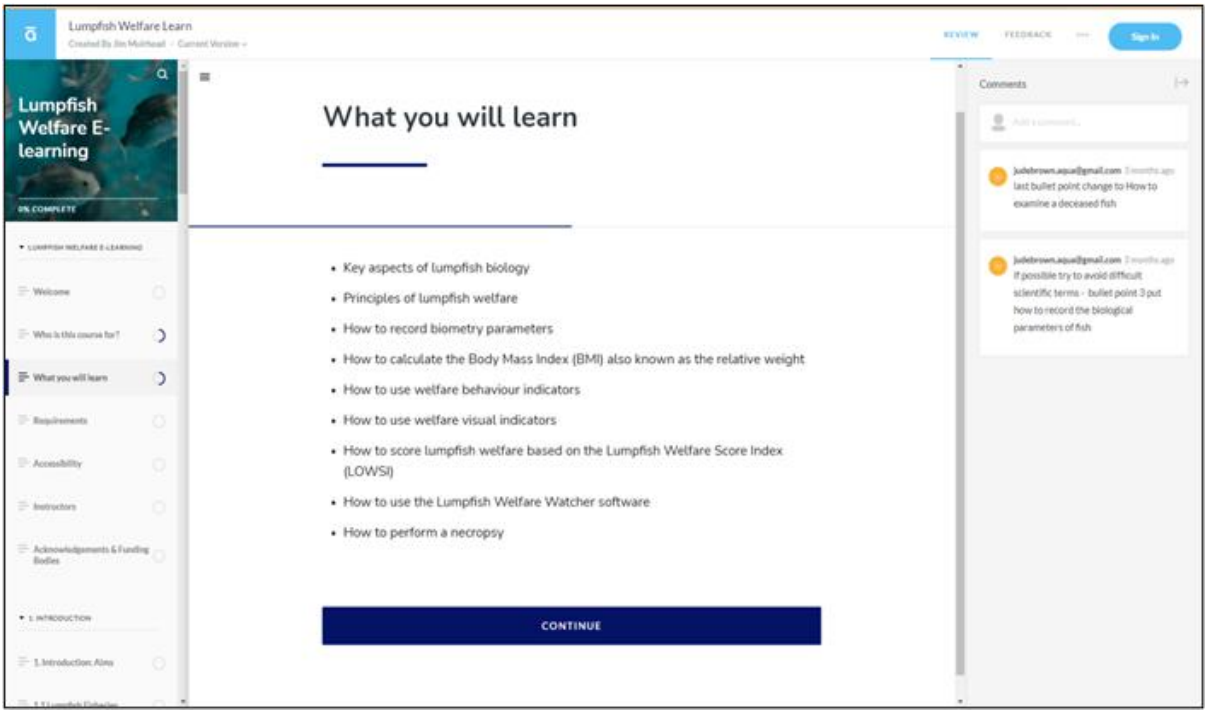


Figure 2: Screenshot displaying what is covered in the e-learning course

BMI CALCULATOR

Accessing this tool will open the BMI calculator home page, where you will be required to input the following basic information (*Figure 3*):

- Company/Site Name
- Environment *(hatchery or salmon cages)*
- Tank Number/Cage Number *(based on hatchery or salmon cages)*
- Date *(the date you are uploading the data)*

(*The basic information is for your reference only: the tool will not store the data provided*)

As for the "Environment" you have two options, either "Hatchery" or "Salmon Cages". It is imperative that you select the correct environment as the calculations vary between the two. Below is a table which will assist in identifying which environment you will need to select based on the data you have.

Site	Life Stage	Weight Range (g)
Hatchery	S1 Larvae	0-1
	S2 Pre-deployment	1-10
	S3 Pre-deployment	>10
Salmon Cages	S4 Post-deployment	>10

To calculate the BMI the software uses different length-weight regression coefficients based on the four life stages. For more information about the calculations and regression lines used, please go to page *#29*.

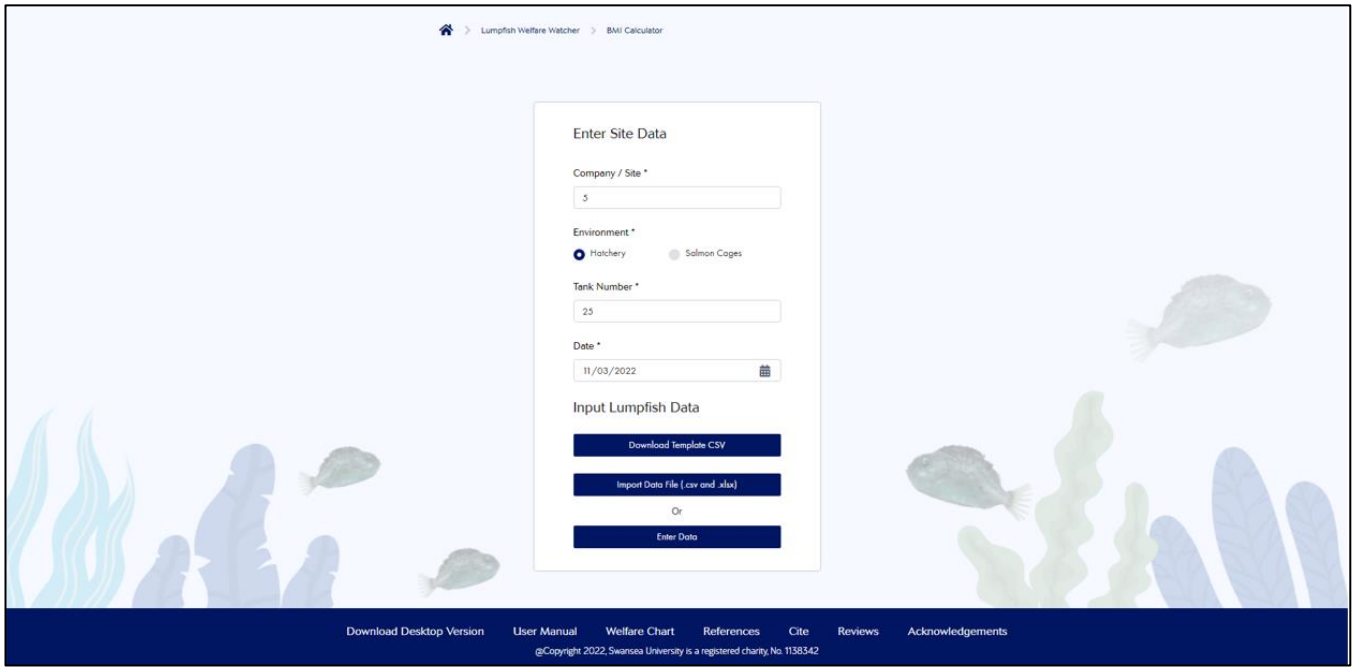


Figure 3: Screenshot displaying the basic input information required by the BMI calculator

Downloading A Template .CSV

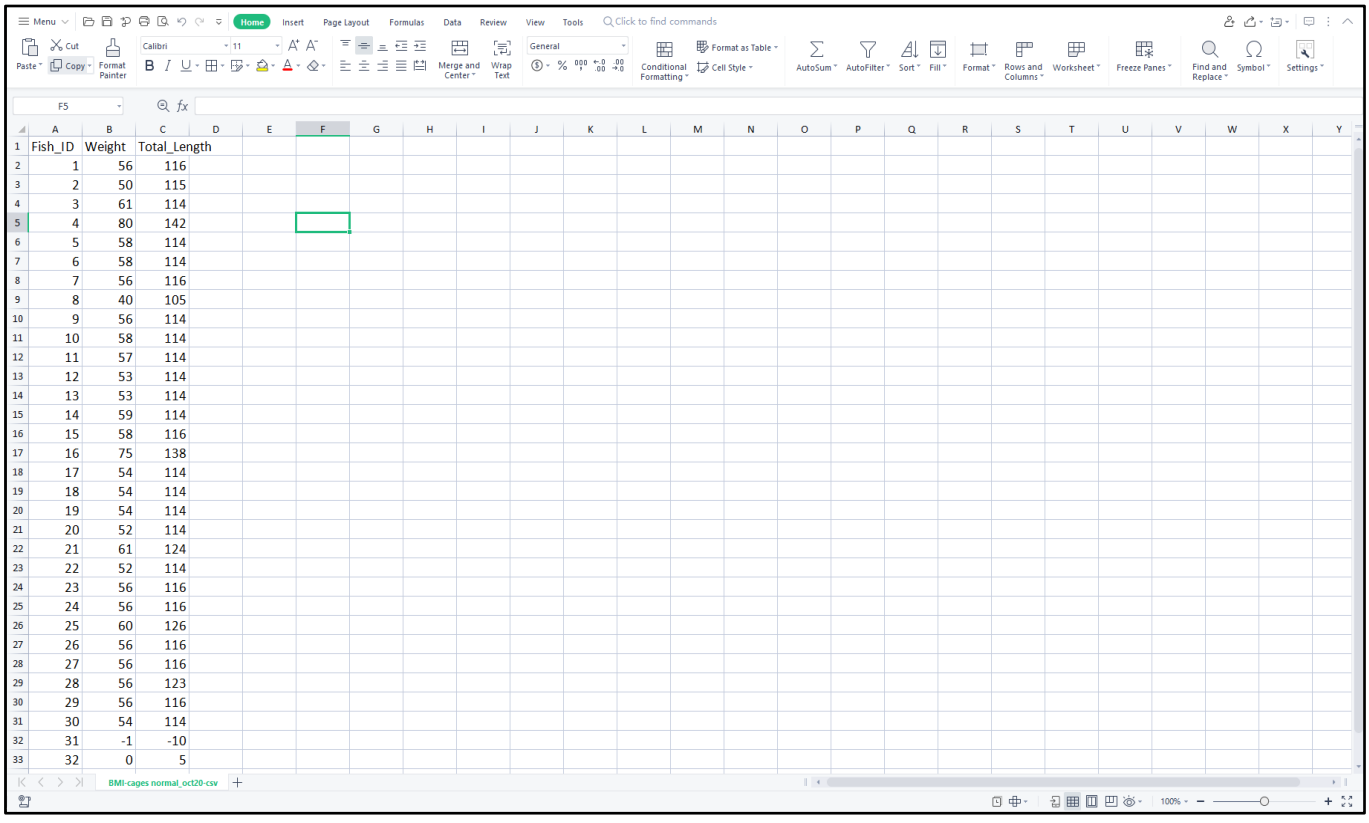
Upon entering the required data and selecting the appropriate “Environment”, you have three options (*Figure 3)*;

- Download Template .CSV
- Import Data File (.csv or .xlsx)
- Enter Data (*manual data entry)*

The first option is “Download Template .CSV” this feature will download a set template

This template contains all of the necessary information for the BMI calculator to carry out its main function, all you need to do is input your data in the respective columns and fields, then save the file as a .CSV or .XLSX file format (*Figure 4*).

Data in “Weight” column is measured in grams “g” and the “Total Length” data is measured in millimetres “mm”



Fish_ID	Weight	Total_Length
1	56	116
2	50	115
3	61	114
4	80	142
5	58	114
6	58	114
7	56	116
8	40	105
9	56	114
10	58	114
11	57	114
12	53	114
13	53	114
14	59	114
15	58	116
16	75	138
17	54	114
18	54	114
19	54	114
20	52	114
21	61	124
22	52	114
23	56	116
24	56	116
25	60	126
26	56	116
27	56	116
28	56	123
29	56	116
30	54	114
31	-1	-10
32	0	5

Figure 4: Screenshot displaying the template.csv for the BMI Calculator with sample data

(Please make sure that the data you input is in the correct units, example from row 2: A2 = 1; B2 = 56; C2 = 116. This means that lumpfish 1, weighs 56 g and has a total length of 116 mm.)

Importing Data Files

If your data is already within either a .CSV or .XLSX file or you have put your data into the template you can move straight onto the second option “Import Data File (.csv or .xlsx)” which will open a new window (*Figure 5*)

There are several options on this screen, starting with how to import a file, simply select “Choose File” this will enable you to locate a file for importing, do ensure that it is either .CSV or .XLSX format. Once the file is selected you will be able to “Import File”

Once your data is imported it will fill the table on the right side of the window (*Figure 6)*.

(It is also worth noting that the data you entered prior to this window, company name, site name and environment type are all displayed on this screen and will remain throughout the entire process.)

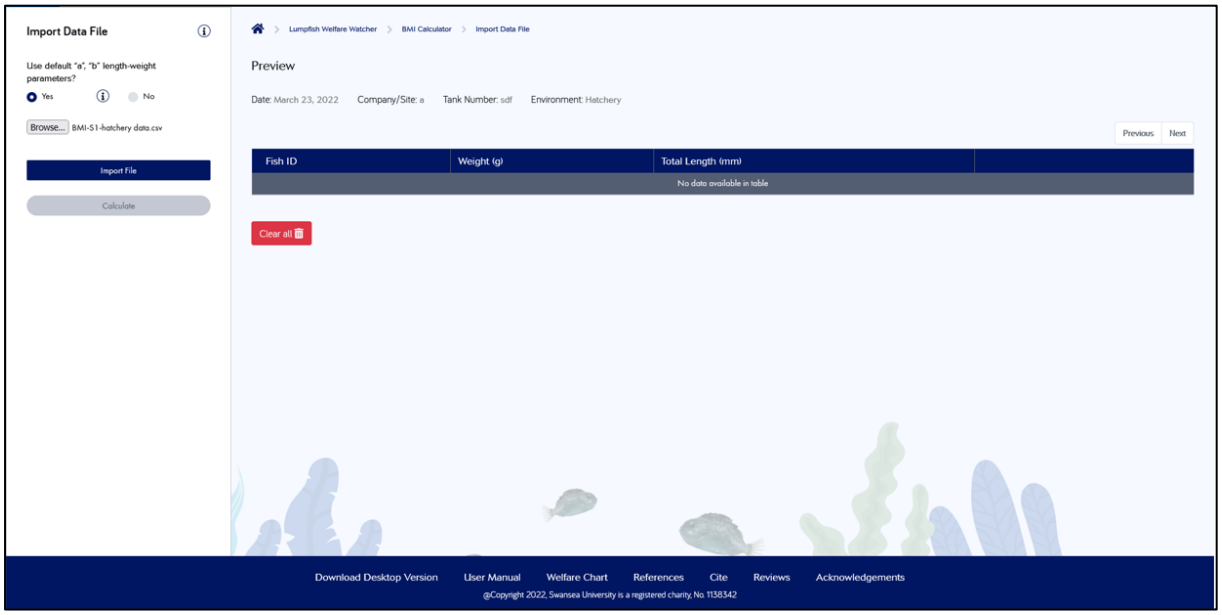


Figure 5: Screenshot displaying the “Import Data File (.csv or .xlsx)” for the BMI Calculator

Editing & Deleting Existing Records

Once you have your data imported you can edit the data values of an individual record by using the tools located on the far right of each record, bringing up the following “Edit Entry” window found below;

These tools in the far right will also allow you to clear an individual record or delete every record imported by clicking "Clear All" (*Figure 7*).

Figure 6: Screenshot displaying the “Imported Data File (.csv or .xlsx)” of the BMI Calculator with data

(It is worth noting that you may receive the message stating “*Estimates may be unreliable due to small sample size*” the best and recommended sample size is 30+.)

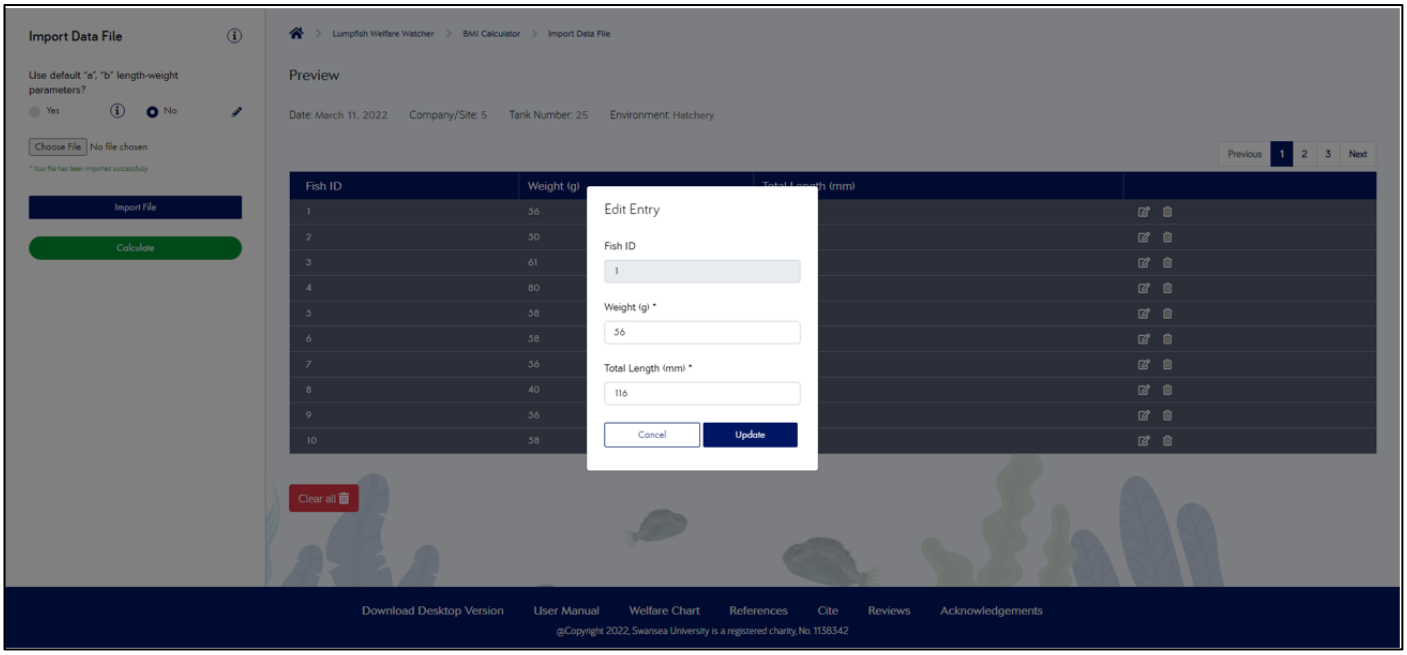


Figure 7: Screenshot displaying the “Edit Entry” section with data for the BMI Calculator

Changing Default Parameters

You can also change the “a” and b” length-weight parameters, by selecting “No” (*Figure 8)*. The table will display the default values of the “a” and “b” parameters which can be overwritten. For a better understanding of the parameters currently used please go to page *#29*.

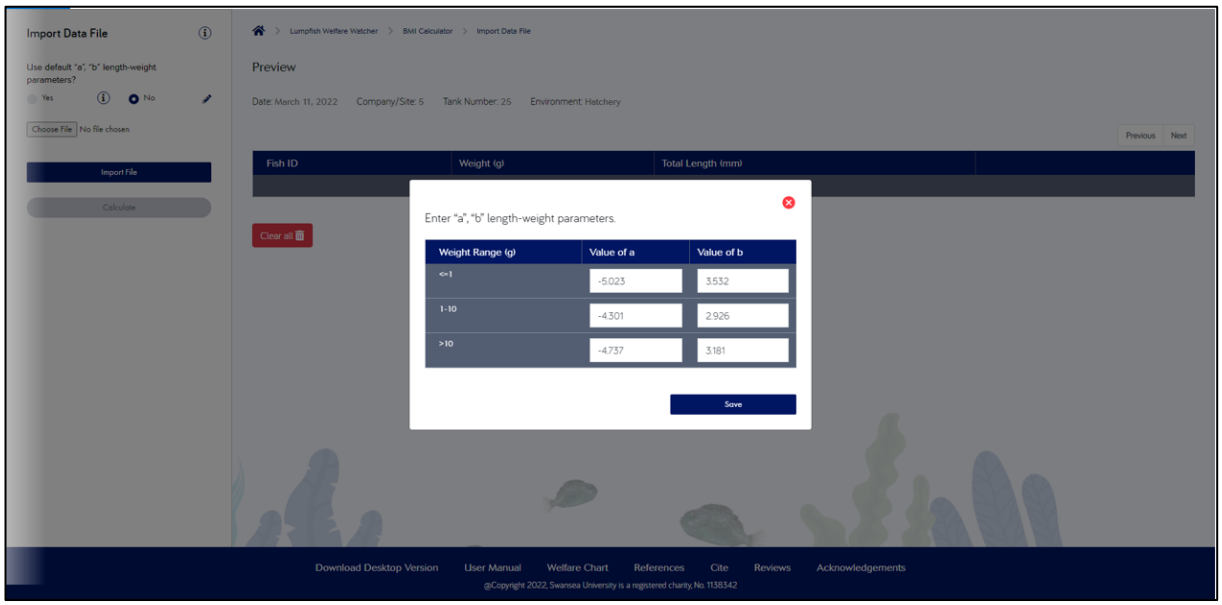


Figure 8: Screenshot displaying the “Changing default parameters” section with data for the BMI Calculator

The “a” and “b” parameters are used in the calculation of Lumpfish BMI. If the default values are overwritten (*which you can do by following the process above*), then the new values of “a” and “b” parameters are used in the BMI Calculations.

Manually Entering Data

It is possible to choose to manually enter the data into the BMI calculator, you only need to select "Enter Data" (*Figure 3*) and it will bring up the page for entering data (*Figure 9*). Here you are able to enter in the "Fish ID", "Weight and "Total Length" manually, an example of this has been shown below.

(*Do note that you cannot enter negative values and the value must be between 0 and 10000*)

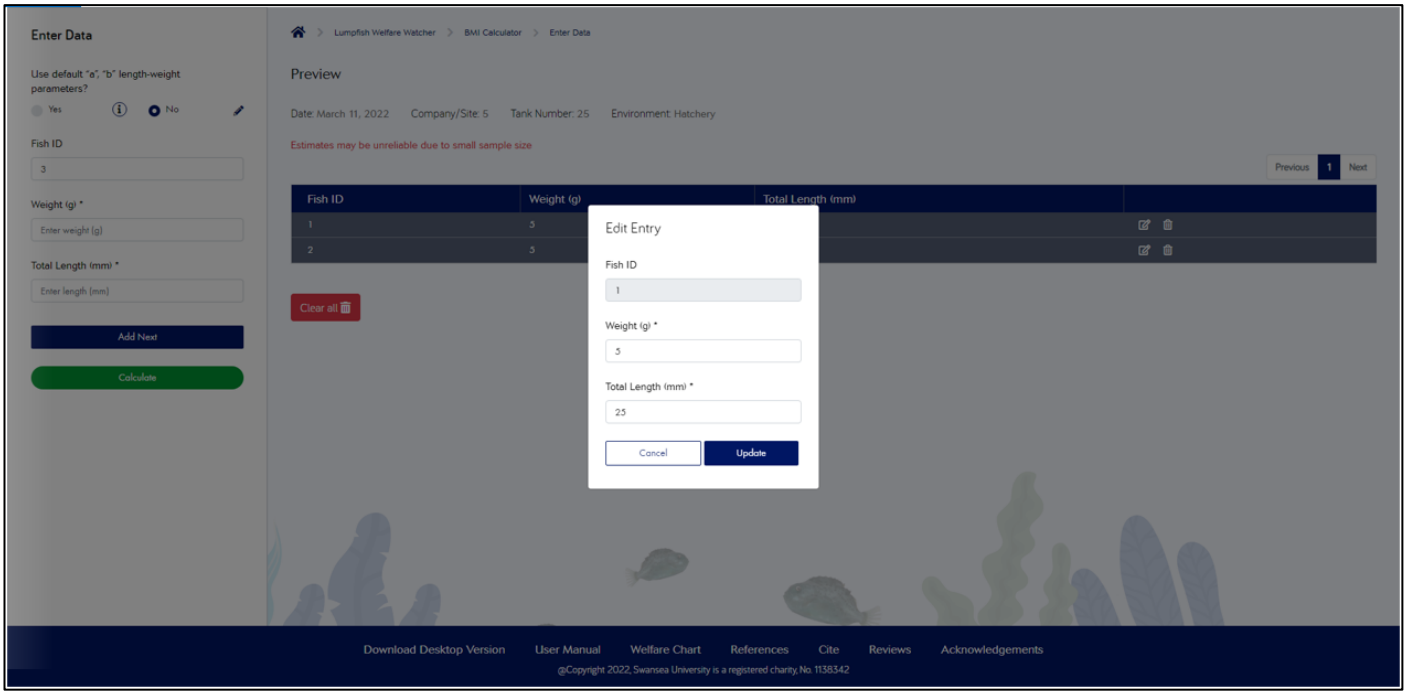


Figure 9: Screenshot displaying the "Enter Data" with example data for the BMI Calculator

You are able to edit the default "a" and "b" parameters the same way as shown under "Changing Default Parameters" by selecting "No" in the top left of the screen.

You are also able to edit individual records and delete them following the same process as shown in "Editing & Deleting Existing Records" by either selecting "Clear all" or by using the tools on the far right of each record which would bring up this screen as shown on the right.

What The Calculated Data Looks Like

Output Data

Once ready and all of your data has either entered manually or imported using a .CSV or .XLSX file you can click “Calculate” as seen in *Figure 6* this will lead you to the first of four sections of data representation below is a screenshot of the “Output Data Section” (*Figure 10*)

This section contains the data previously entered, the “Fish ID”, “Weight” and “Total Length” and the extra data calculated by the BMI calculator

- Expected Weight
- BMI
- Class
- Height
- Fineness
- Max Mesh Size

The “Class” is used to sort the fish into 4 weight classes, Emaciated, Underweight, Normal and Above normal (check the appendix section page *#30* for the criteria used to classify the BMI).

The max mesh size is used to identify the maximum mesh size needed to prevent the fish from escaping based on their estimated height.

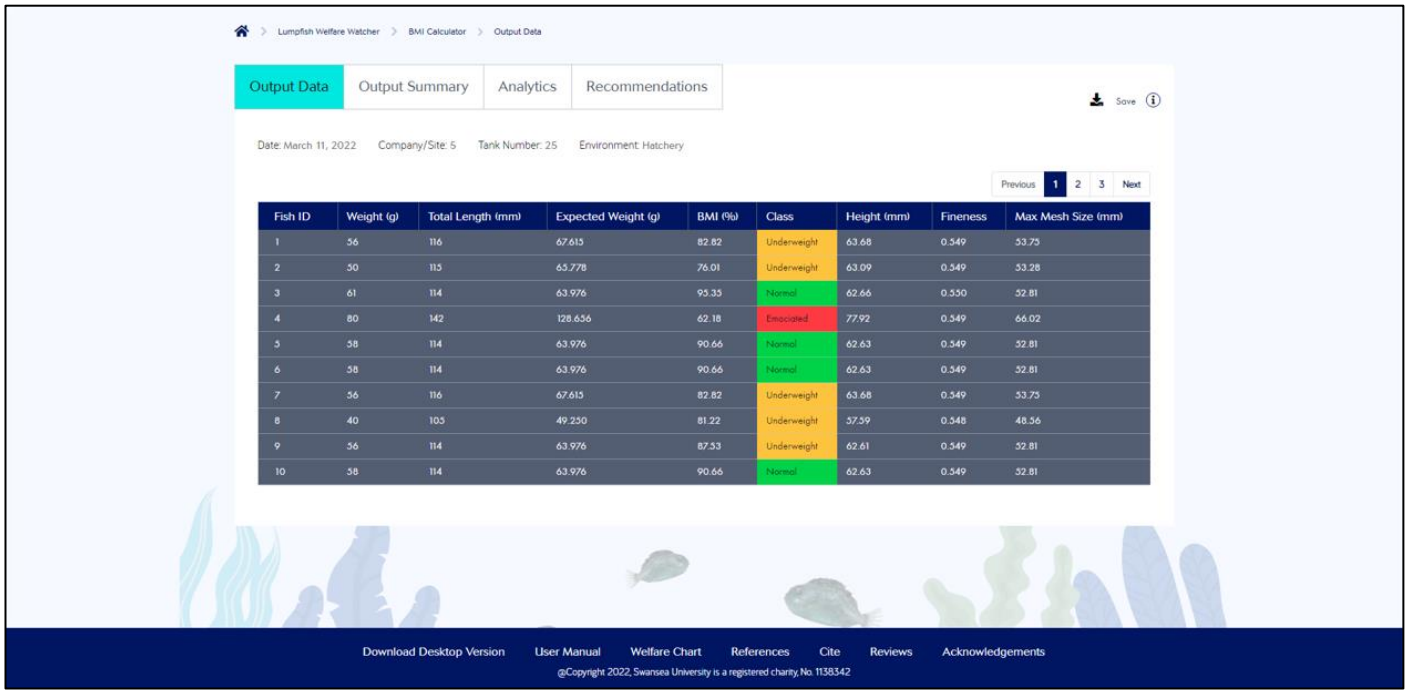


Figure 10: Screenshot displaying the “Output Data” section of the BMI Calculator

Output Summary

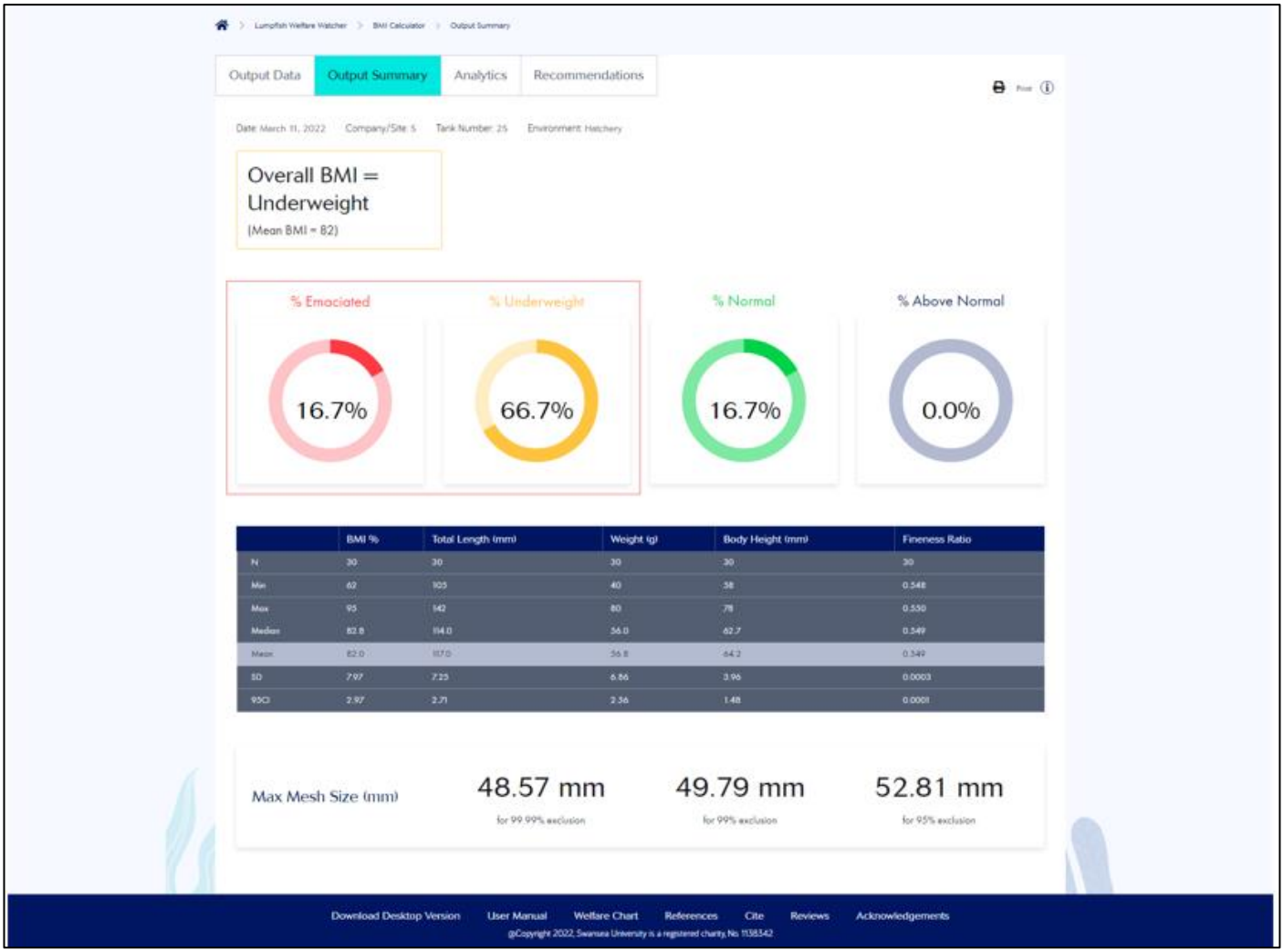


Figure 11: Screenshot displaying the "Output Summary" section of the BMI Calculator

This section provides an infographic showing the overall mean BMI but also the proportion of the sampled fish which are emaciated, underweight, normal or have above normal weights. In the example below 16.7% of the Lumpfish sampled are emaciated, 66.7% are underweight, 16.7% are normal and 0% are above normal (*Figure 11*). A summary statistic table is also shown

The table provides a quick summary of the data. Hovering over the table will show you what it contains and what each row of data means. The table provides the following information;

- N - Sample size
- Min - Minimum value
- Max - Maximum value
- Median - Median
- Mean - Mean
- SD - Standard Deviation showing the variation or dispersion
- 95CI - 95% confidence value around the mean

Figure 12 shows the mesh sizes required to prevent fish from escaping;

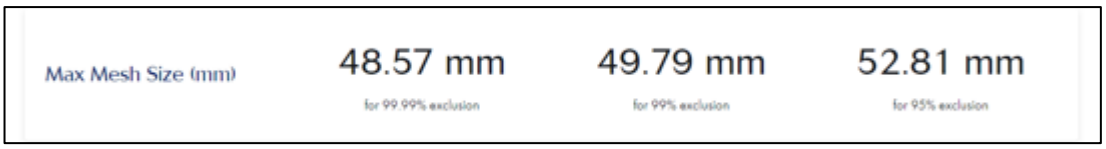


Figure 12: Screenshot showing the required mesh sizes to prevent the fish from escaping

Analytics

The "Analytics" shows the BMI cumulative frequency graph (*Figure 13*). The value on the left-hand side of the horizontal axis, is the minimum BMI value. The right hand-side along the bottom shows the maximum BMI value. The density colours show the % of fish in each BMI class – emaciated, underweight, normal or above normal.

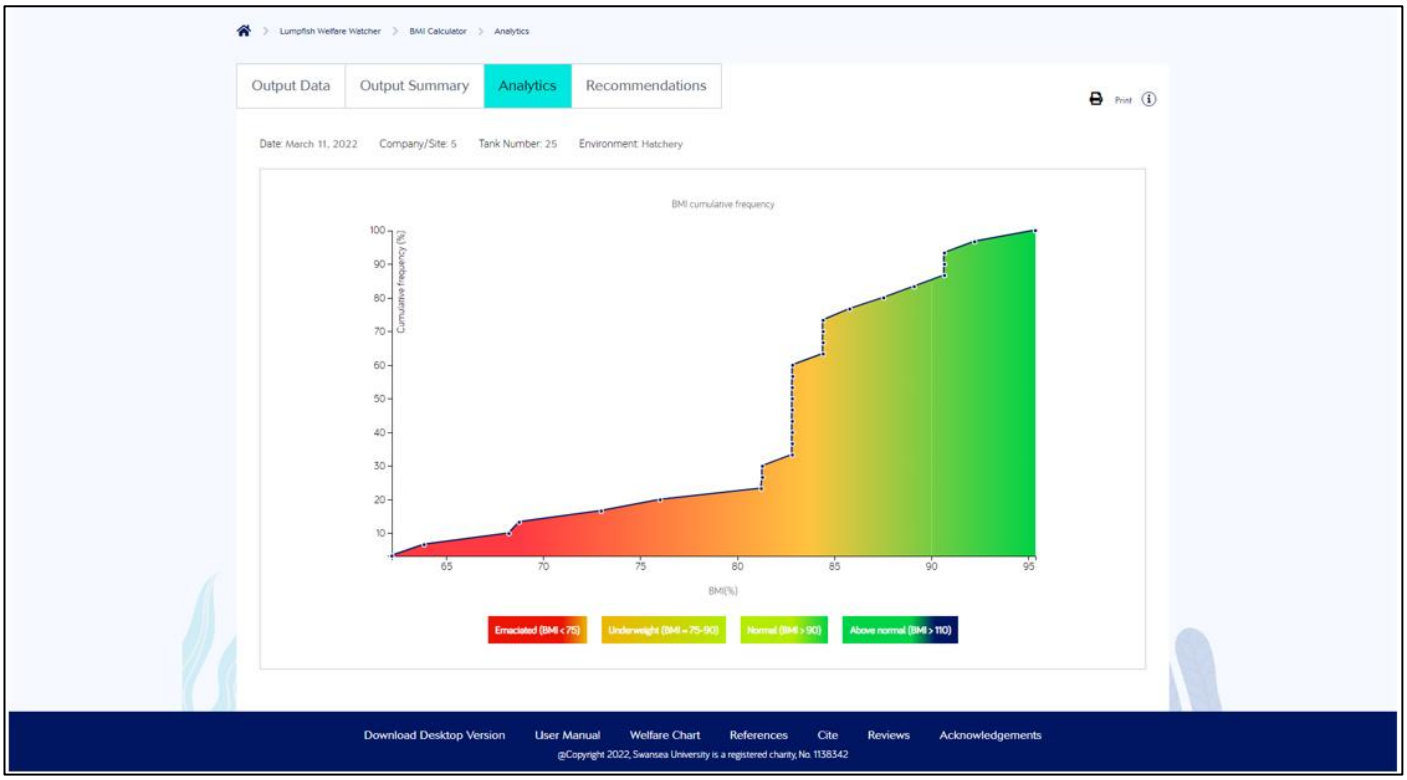


Figure 13: Screenshot displaying the "Analytics" section of the BMI Calculator

There are no fish with above normal weight in this sample, but 16.7% are emaciated (degrade of red), 66.7% are underweight (degrade of yellow), and 16.7% have a normal weight (degrade of green)

(*This graph displays data better with a larger sample size.*)
(*You can save the output summary as PDF document or simply print it using the icons in the top right.*)

To calculate the cumulative frequency table in Excel, use this instructional video.
https://www.statisticshowto.com/cumulative-frequency-table-excel-easy-steps/

Recommendations

This section provides recommended actions based on the calculated mean BMI and the proportion of fish which are emaciated, underweight, normal and above normal (please check recommendation criteria in the appendix section page #35) For the data set in this example, there is a serious cause for concern and the recommendations provided address those (*Figure 14*).

(Do note that at any point you can save these pages as PDF documents or simply print them using the icons in the top right)

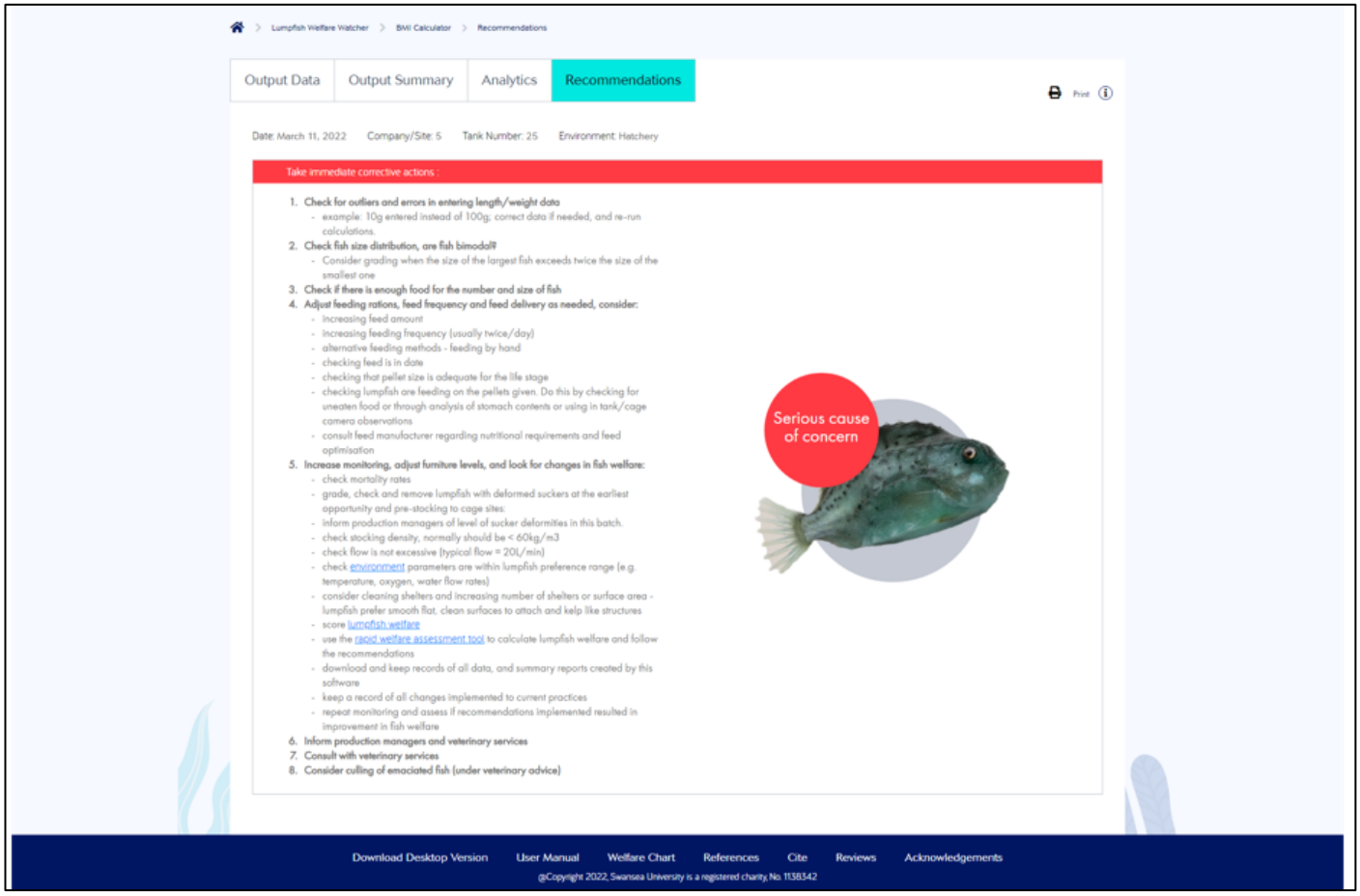


Figure 14: Screenshot displaying the "Recommendations" section of the BMI Calculator

RAPID WELFARE ASSESSMENT TOOL

On the home page, by clicking on “Rapid Welfare Assessment Tool” another window will open (*Figure 15)*. This tool will calculate the Lumpfish Operational Welfare Score Index (LOWSI) based on the BMI value and four additional operational welfare indicators scored from 0 to 2, these are:

1. Body damage score
2. Tail or Caudal fin damage
3. Eye condition score
4. Sucker deformity score

It will also produce summary statistics, infographics and recommendations for action based on each of the operational welfare metrics and the calculated the proportion of fish that have good welfare, moderately compromised welfare or severely compromised welfare.

The tool will request basic information:

- Company /Site Name
- Environment *(hatchery or salmon cages)*
- Tank Number/Cage Number *(based on hatchery or salmon cages)*
- Date *(the date you are uploading the data)*

(*The basic information is for your reference only; the tool will not store the data provided*)

As for the “Environment” you have two options, either “Hatchery” or “Salmon Cages”. It is imperative that you select the correct environment as the calculations vary for each environment, for more information about the calculations and regression lines used, please go to page *#29*.

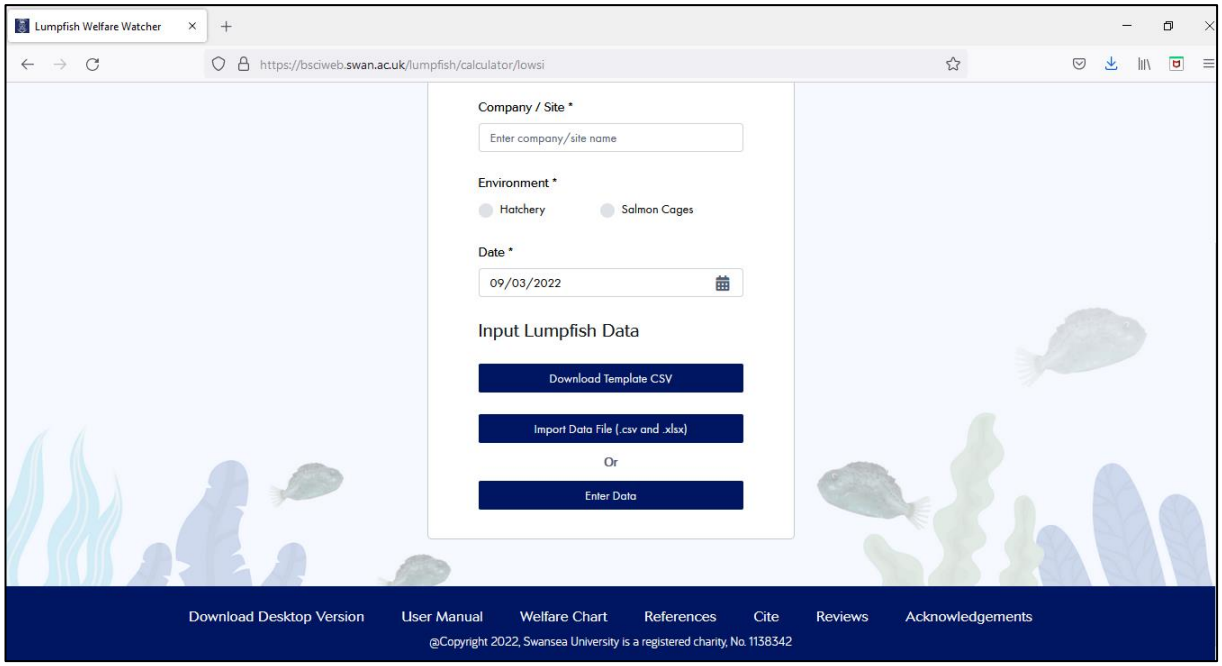


Figure 15: Screenshot displaying the basic input information required by the Rapid Welfare Assessment Tool

Downloading A Template .CSV

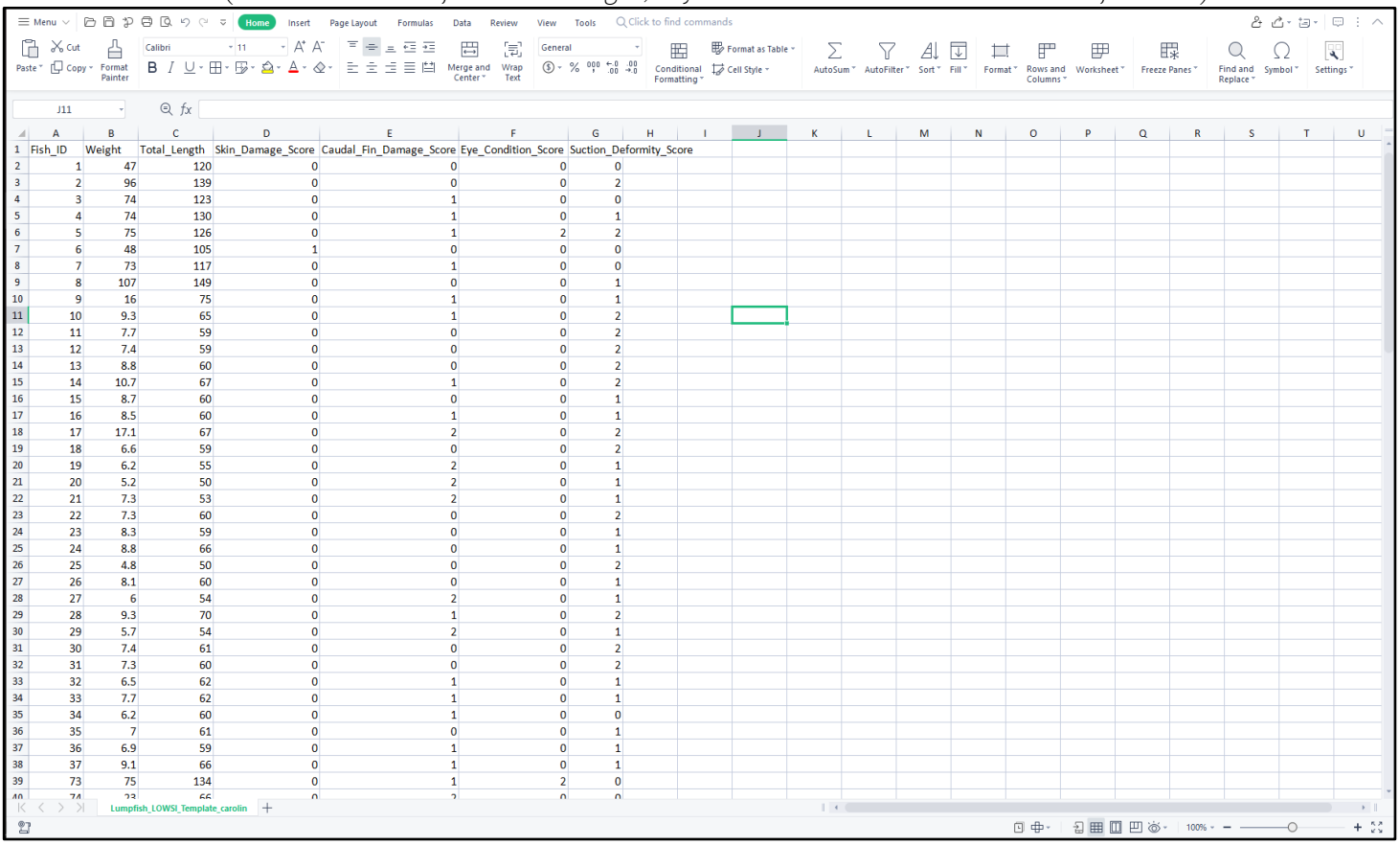
Like in the BMI calculator, upon entering the required data and selecting the appropriate "Environment", you are presented with three options (*Figure 15*)

- Download Template .CSV
- Import Data File (.csv or .xlsx)
- Enter Data (manual data entry)

The first option available is "Download Template .CSV" this feature will download a template, similar to the BMI calculator template file with all the required data fields needed for the Rapid Welfare Assessment Tool to calculate the LOWSI (*Figure 16*). All you need to do is input your data in the respective columns and fields, then save the file as a .CSV or .XLSX file format.

(Please ensure that the data you input is in the correct units, example from row 2: A2 = 1; B2 = 47; C2 = 120; D2 = 0; E2 = 0; F2 = 0; G2 = 0. This means that lumpfish 1, weighs 47 g and has a total length of 120 mm, and all visual indicator scores were 0.)

(Data in "Weight" column is measured in grams "g" and the "Total Length" data is measured in millimetres "mm")
(The Score columns for "Skin Damage", "Eye Condition" etc. are scored in values from 0-2.)



Fish_ID	Weight	Total_Length	Skin_Damage_Score	Caudal_Fin_Damage_Score	Eye_Condition_Score	Suction_Deformity_Score
1	47	120	0	0	0	0
2	96	139	0	0	0	2
3	74	123	0	1	0	0
4	74	130	0	1	0	1
5	75	126	0	1	2	2
6	48	105	1	0	0	0
7	73	117	0	1	0	0
8	107	149	0	0	0	1
9	16	75	0	1	0	1
10	9.3	65	0	1	0	2
11	7.7	59	0	0	0	2
12	7.4	59	0	0	0	2
13	8.8	60	0	0	0	2
14	10.7	67	0	1	0	2
15	8.7	60	0	0	0	1
16	8.5	60	0	1	0	1
17	17.1	67	0	2	0	2
18	6.6	59	0	0	0	2
19	6.2	55	0	2	0	1
20	5.2	50	0	2	0	1
21	7.3	53	0	2	0	1
22	7.3	60	0	0	0	2
23	8.3	59	0	0	0	1
24	8.8	66	0	0	0	1
25	4.8	50	0	0	0	2
26	8.1	60	0	0	0	1
27	6	54	0	2	0	1
28	9.3	70	0	1	0	2
29	5.7	54	0	2	0	1
30	7.4	61	0	0	0	2
31	7.3	60	0	0	0	2
32	6.5	62	0	1	0	1
33	7.7	62	0	1	0	1
34	6.2	60	0	1	0	0
35	7	61	0	0	0	1
36	6.9	59	0	1	0	1
37	9.1	66	0	1	0	1
38	75	134	0	1	2	0

Figure 16: Screenshot displaying the template .csv for the Rapid Welfare Assessment Tool with sample data

Importing A Data File

If your data is already in the correct format a .CSV or .XLSX file or you have put your data into the template you can move straight onto the second option “Import Data File (.csv or .xlsx)” which will open the Import Data File window (*Figure 17)*.

There are several options on this screen, starting with how to import a file, simply select “Choose File” this will enable you to locate a file for importing, do ensure that it is either .CSV or .XLSX format, once the file is selected you will be able to “Import File”.

Once your data is imported it will fill the table on the right side of the window as seen in *Figure 18*.

(It is also worth noting that the data you entered prior to this window, company name, site name and environment type are all displayed on this screen and will remain throughout the entire process.)

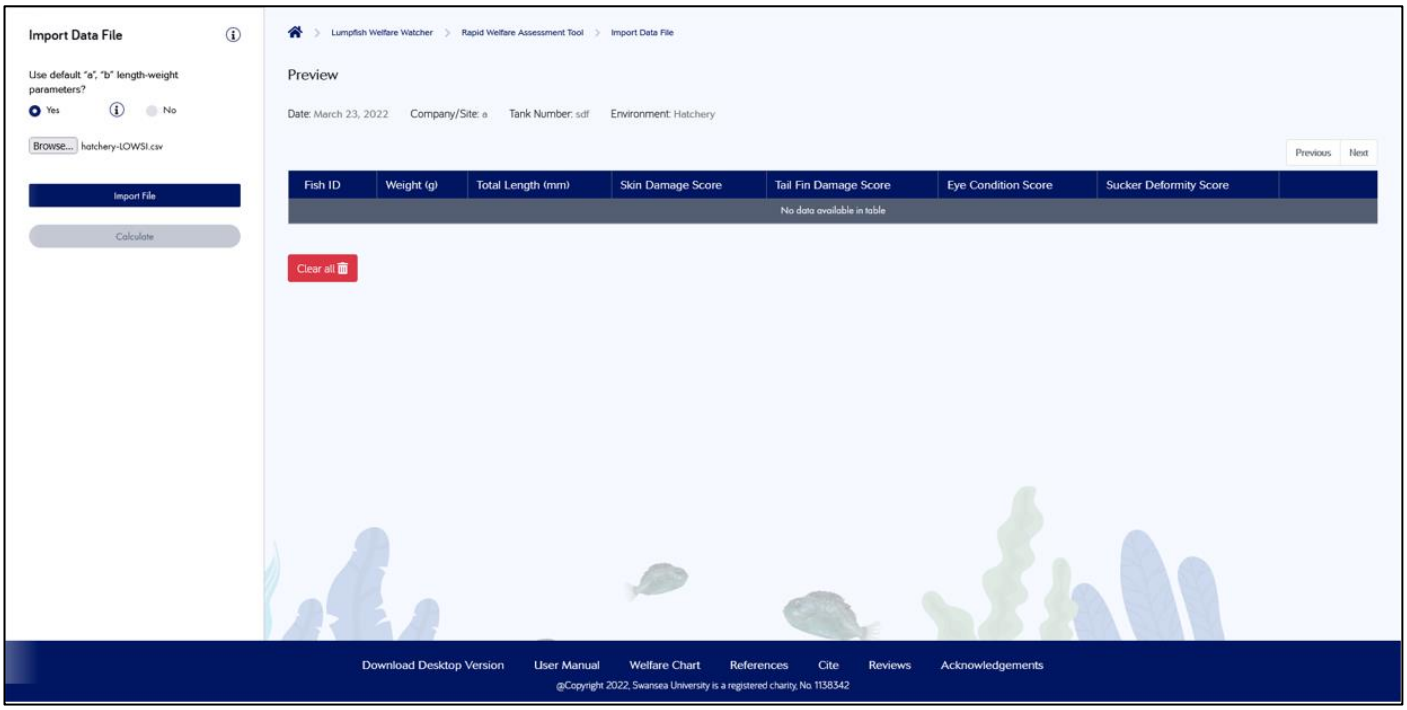


Figure 17: Screenshot displaying the “Import Data File (.csv or .xlsx)” section of the Rapid Welfare Assessment Tool

Editing & Deleting Existing Records

From the image below the data was successfully imported. However, you can see that there appears to be an error, stating that “Some of the rows are not imported due to some invalid data” this can be due to any negative data values, review the data and make sure that it is all valid before proceeding.

Once you have done this, you can edit the data values of an individual record by using the tools located on the far right of each record, bringing up the following “Edit Entry” window shown below;

These tools in the far right will also allow you to: clear an individual record or delete every record imported by clicking "Clear All" as found in *Figure 19*.

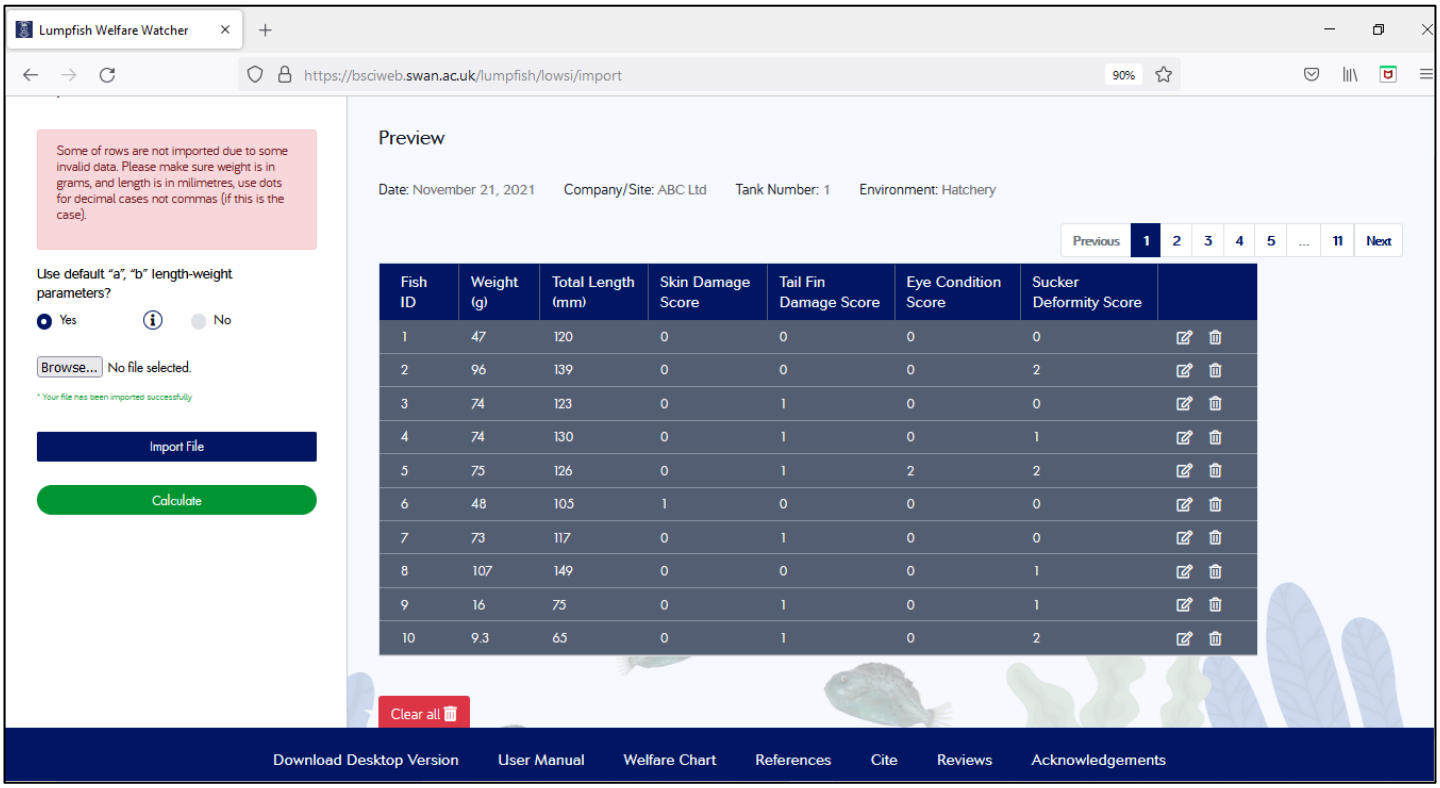


Figure 18: Screenshot displaying the “Imported Data File (.csv or .xlsx)” of the Rapid Welfare Assessment Tool with data

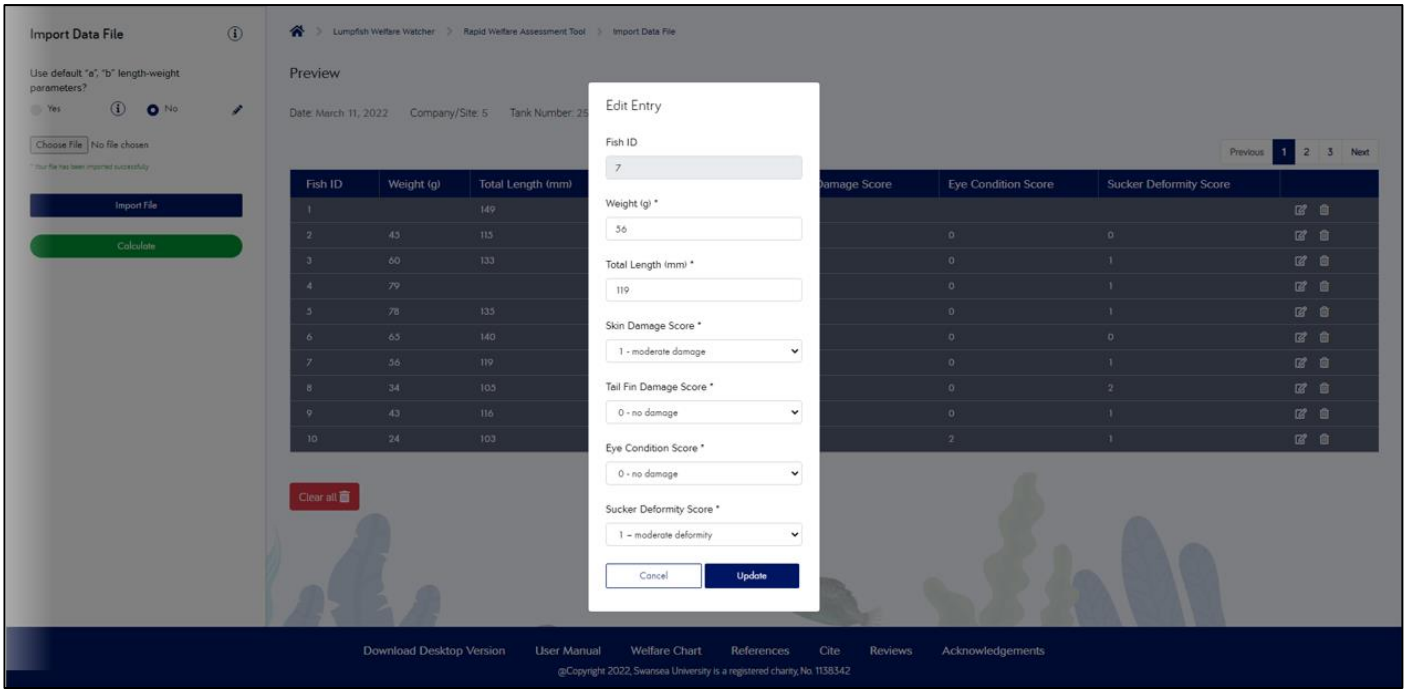


Figure 19: Screenshot displaying the "Edit Entry" section with data for the Rapid Welfare Assessment Tool

Changing Default Parameters

You can also change the “a” and b” length-weight parameters, by selecting “No” as shown in the top left of *Figure 20*. The table will display the default values of the “a” and “b” parameters which can be overwritten. For a better understanding of the parameters currently used please go to page *#29*.

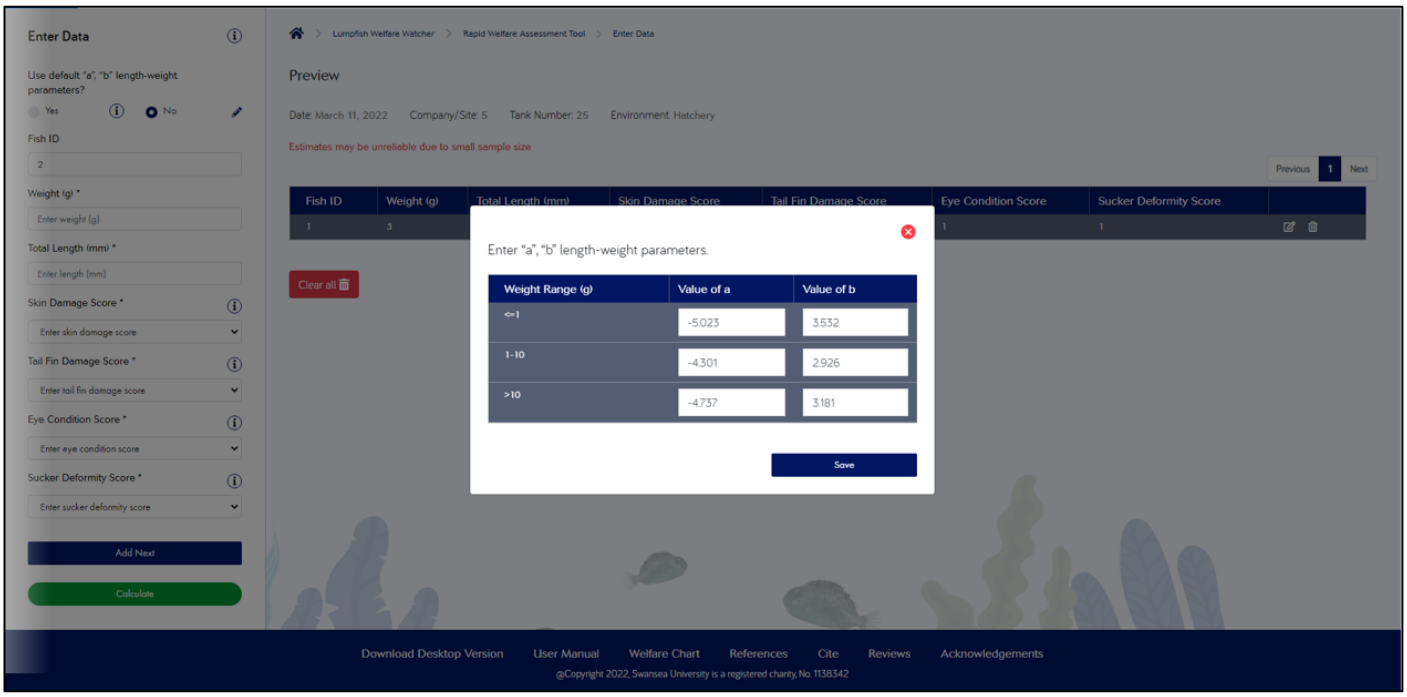


Figure 20: Screenshot displaying the “Changing default parameters” section with data for the Rapid Welfare Assessment Tool

The “a” and “b” parameters are used in the calculation of Lumpfish BMI. If the default values are overwritten (*which you can do by following the process above*), then the new values of “a” and “b” parameters are used in the BMI Calculations.

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Manually Entering Data

It is possible to opt into manually entering the data into the tool, you only need to select “Enter Data” as shown in *Figure 21* and it will bring up the page shown below;

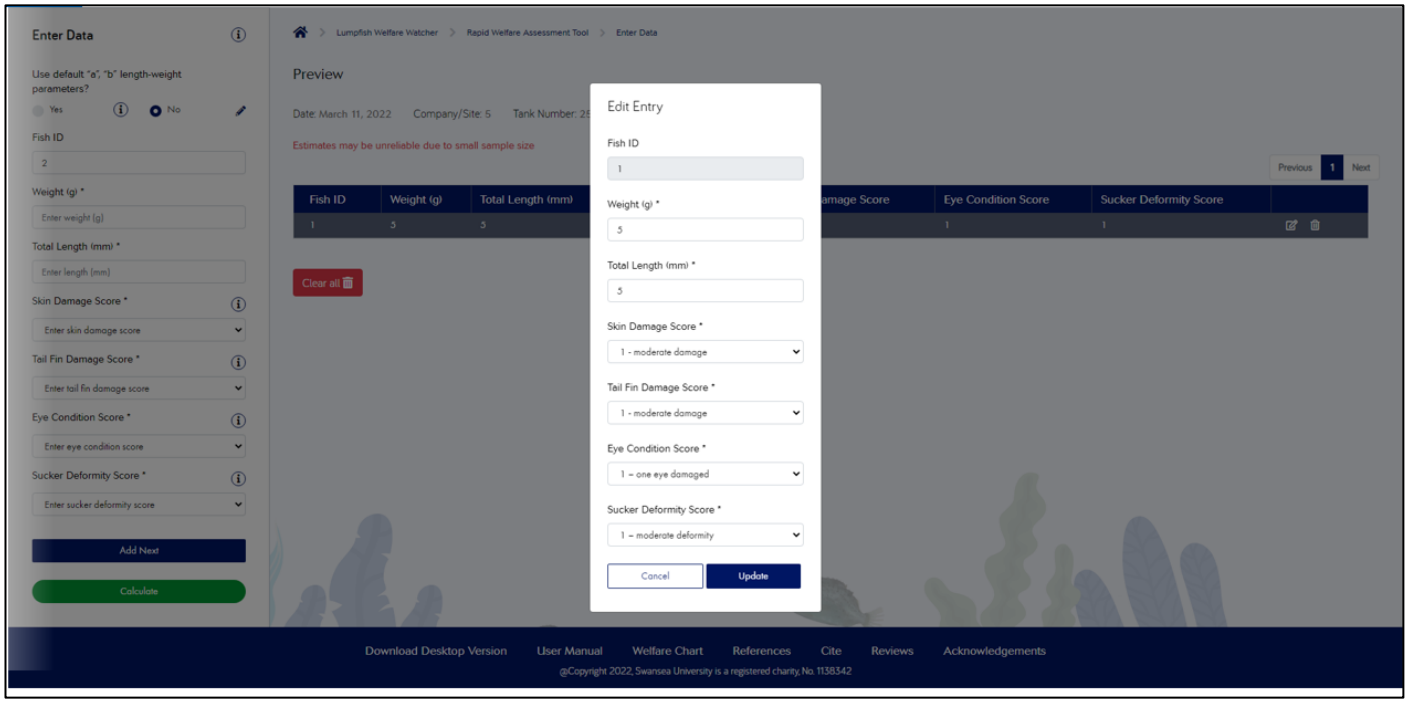

Figure 21: Screenshot displaying the “Enter Data” with example data for the Rapid Welfare Assessment Tool

You are able to edit the default “a” and “b” parameters the same way as shown under “Changing Default Parameters” by selecting “No” in the top left of the screen.

You are also able to edit individual records and delete them following the same process as shown in “Editing & Deleting Existing Records” by either selecting “Clear all” or by using the tools on the far right of each record which would bring up this screen as shown on the right.

What The Calculated Data Looks Like

Output Data

Once ready and all of your data is either entered manually or imported using a .CSV or .XLSX file you can click “Calculate” as seen in *Figure 20* this will lead you to the first of four sections of data below is a screenshot of the “Output Data” (*Figure 22*)

This section contains similar data to the BMI calculator showing the data previously entered; Fish ID, Weight and Total Length values, but also displays the extra data calculated.:

- Expected Weight
- BMI
- BMI Class
- Height
- Fineness (3 decimal places)
- Max Mesh Size
- BMI score
- Skin damage score
- Tail fin damage score
- Eye condition score
- Sucker deformity score
- LOWSI
- Welfare Class

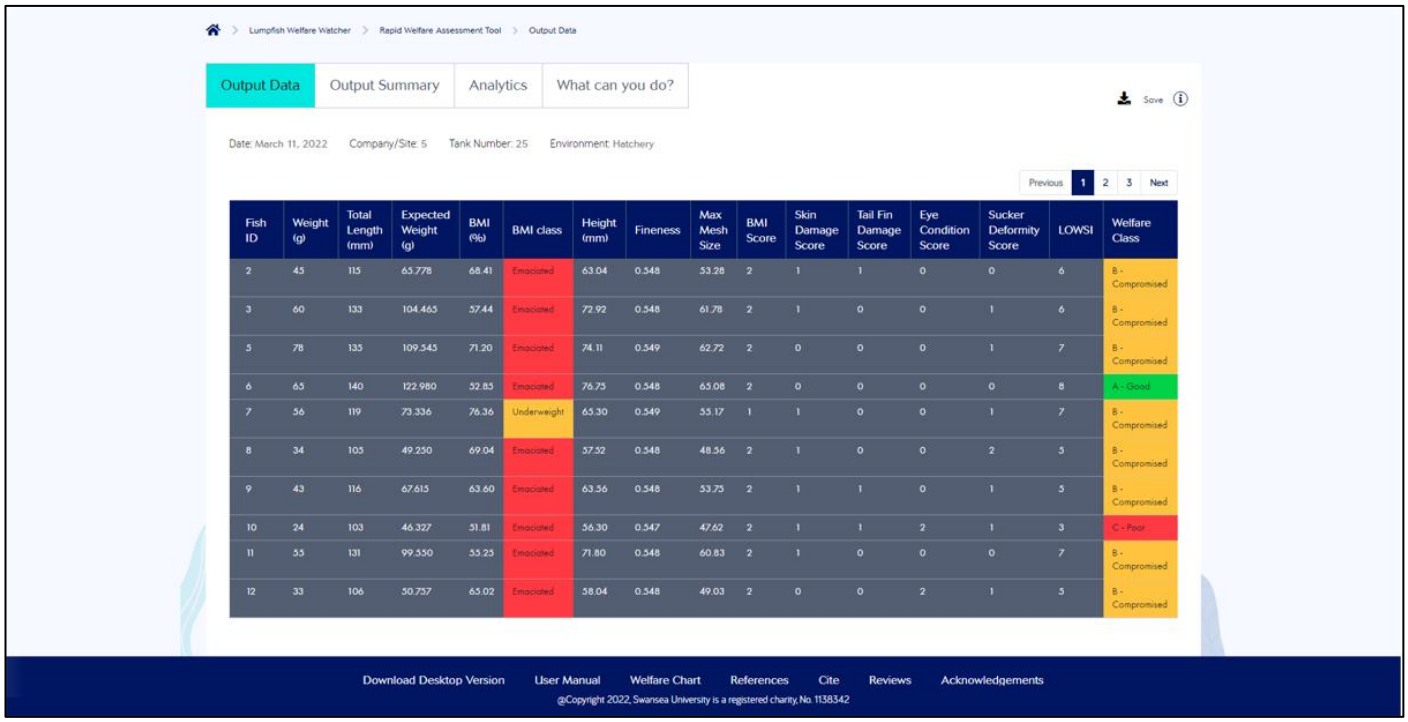

Figure 22: Screenshot displaying the “Output Data” section of the Rapid Welfare Assessment Tool

(You can hover over each column so see an explanation of what the data means, giving context to the data they hold. You can save the data on this screen as a .CSV or directly print it using the features on the top right of the page.)

Similar to the BMI calculator the BMI is still calculated, as is the maximum mesh size, however you are also given a LOWSIscore which is calculated by subtracting the five operational welfare metric scores from 10, giving a final score that corresponds to a welfare class as seen below;

- Good welfare – Green (LOWSI score above 8)
- Compromised welfare– Amber (LOWSI score between 5 and 7)
- Poor welfare– Red (LOWSI score between 0 and 4)

Output Summary

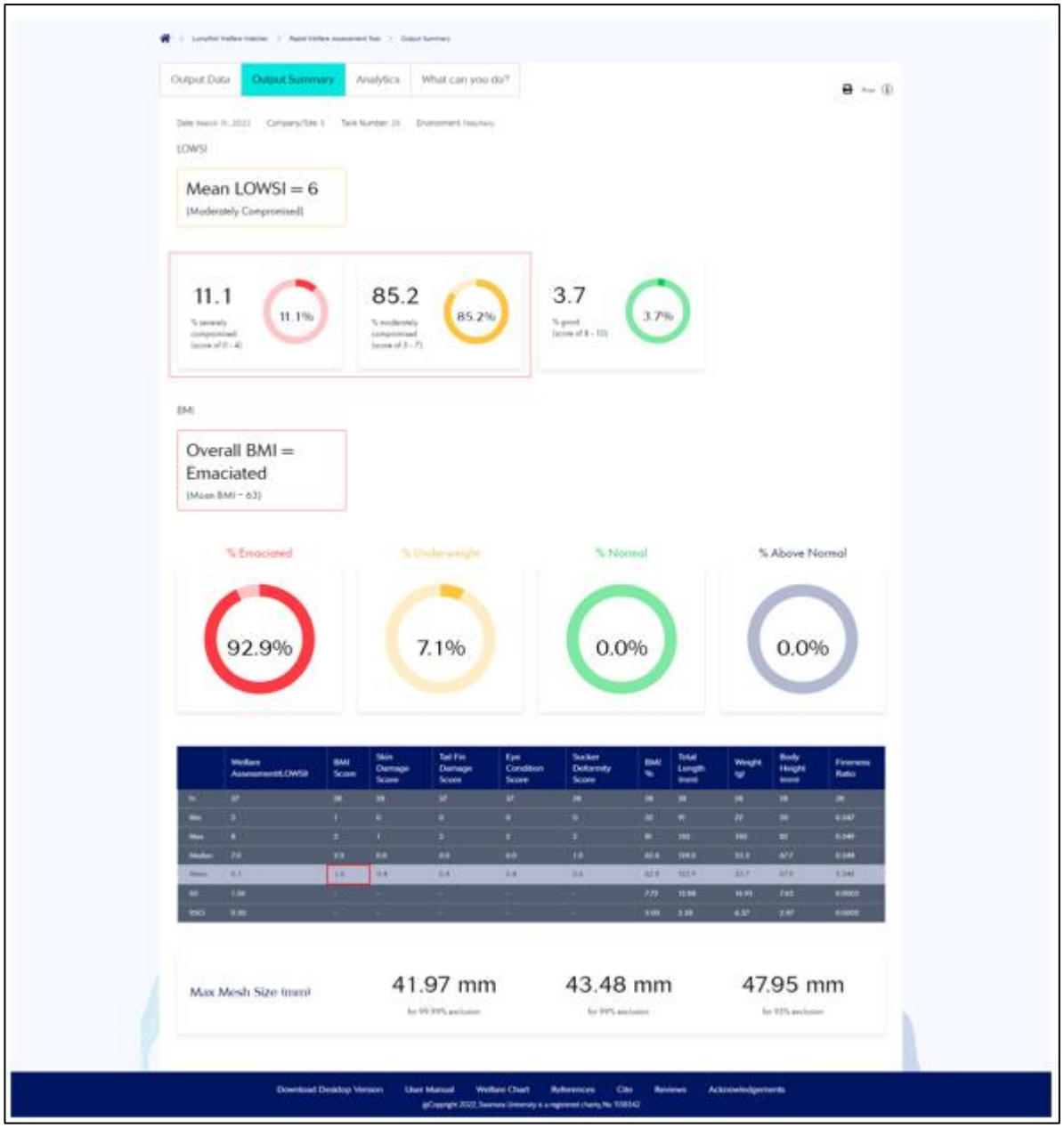

Figure 23: Screenshot displaying the "Output Summary" section of the Rapid Welfare Assessment Tool

The "Output Summary" section (*Figure 23*) shows an infographic with the mean LOWSI score, which in this case is 6, the higher this score, the better is the welfare. It also illustrates the percentages of the sampled lumpfish with a good welfare, a moderately compromised welfare or a severely compromised welfare, based on their LOWSI score. In this example, 3.7% of the sampled lumpfish, achieved a good score, 85.2% achieved moderately compromised score and only 11.1% had a severely compromised welfare score.

Below the LOWSI data, is the same type of infographic displayed in the BMI calculator with the mean BMI and the BMI class (*Figure 11*). The "BMI Class" is used to sort the fish into 4 weight classes, Emaciated, Underweight, Normal and Above Normal (*Figure 24*).

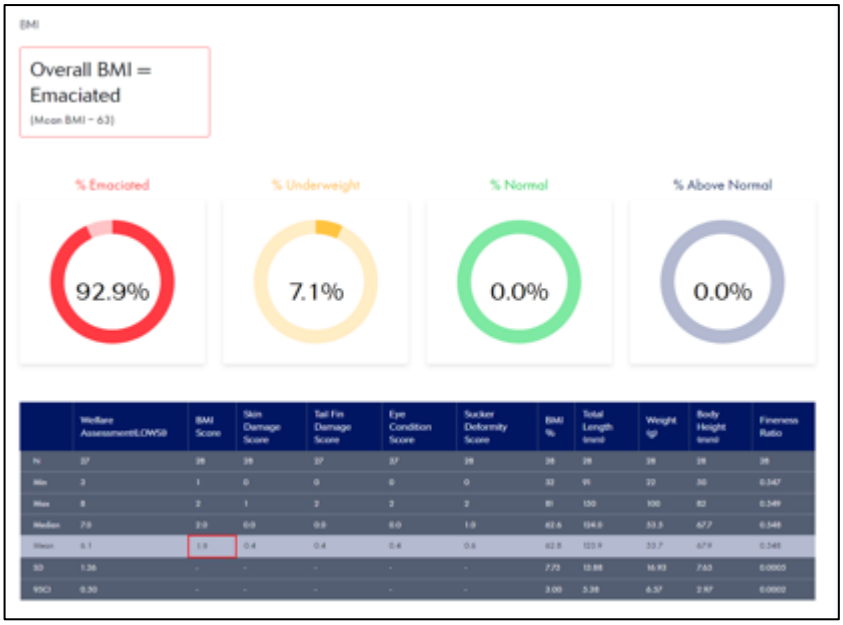

Figure 24: Screenshot displaying the "Output Summary"- BMI section only of the Rapid Welfare Assessment Tool

In this case, 92.9% of this Lumpfish sample are emaciated, 7.1% are underweight, 0% are normal and 0% are above normal.
This is the same information the BMI calculator would provide for this sample population

The table provides a quick summary of the data. Hovering over the table will show you what it contains and what each row of data means. The table provides the following information (*Figure 25*):

- N - Sample size
- Min - Minimum value
- Max - Maximum value
- Median - Median
- Mean - Mean
- SD - Standard Deviation showing the variation or dispersion
- 95CI - 95% confidence value around the mean.

At the bottom of the page, the "Max Mesh Size" shows the maximum mesh size needed to prevent the fish escaping.

Figure 25: Screenshot displaying the "Output Summary" section of the Rapid Welfare Assessment tool

(You can save these pages as PDF documents or simply print them using the icons in the top right.)

Analytics

Figure 26: Screenshot displaying the "Analytics" section of the Rapid Welfare Assessment Tool

The "Analytics" section includes a graph of the LOWSI cumulative frequency, showing how many of the fish in this sample fall to the specific welfare class. Each class is colour coded to a density colour (*Figure 26*). In this case, a large volume of fish have a "Good Welfare" score (green degrade) and a very small number have a "Severely Compromised" welfare (red degrade). The greater the green area the better is the welfare.

The "Analytics" also shows the BMI cumulative frequency graph. The value on the left-hand side of the horizontal axis, is the minimum BMI value. The right hand-side along the bottom shows the maximum BMI value. The density colours show the % of fish in each BMI class – emaciated, underweight, normal or above normal. In this example, 0% of the fish are above normal (blue degrade), around 7.1% are underweight (yellow degrade) and 0% are normal (green degrade).

(*This graph displays data better with a larger sample size*)
(*You can save these pages as PDF documents or simply print them using the icons in the top right.*)

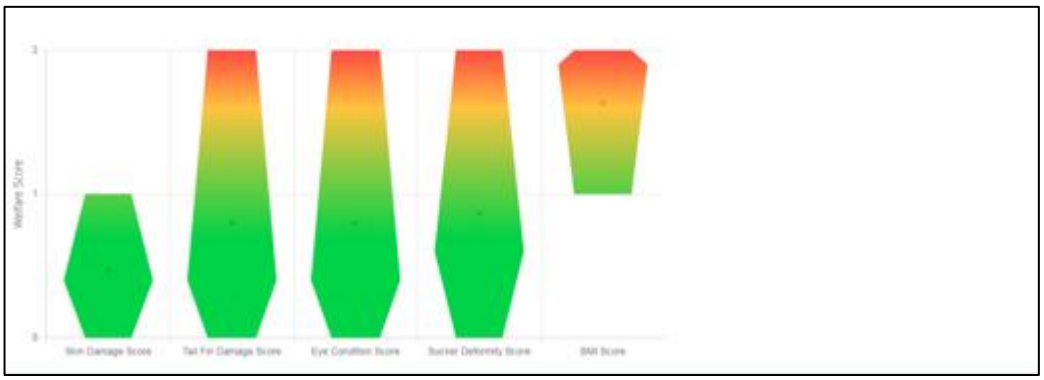

Figure 27: Screenshot displaying the "Welfare score of the fish using the five operation welfare metrics" section of the Rapid Welfare Assessment Tool

This graph shown in *Figure 27* is located at the bottom of the "Analytics" page and shows the welfare score of the fish using the five operation welfare metrics scoring them on a scale of 0 – 2 (where higher scores correspond to a poor welfare). The small dot located on the graph represents the mean value of each score, the lower this dot is on the graph the better.

The individual indicators are scored from 0 – no damage (for the visual indicators) OR normal (for the BMI) to 2 -severely damaged (for the visual indicators) OR emaciated (for the BMI). In this case the BMI is the indicators which has higher scores, with a wider red area closer to the top. Indicators with higher scores (i.e.closer to 2), can skew the overall welfare towards a compromised overall score.

(*You can save these pages as PDF documents or simply print them using the icons in the top right.*)

Recommendation

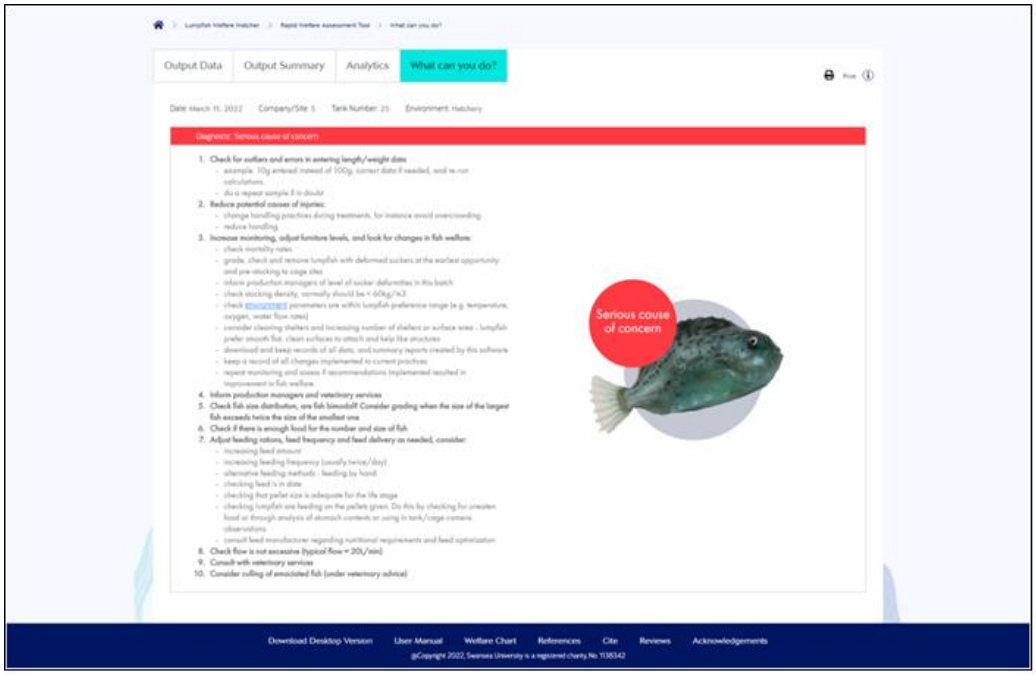

Figure 28: Screenshot displaying the "Recommendations" section of the Rapid Welfare Assessment Tool

The "Recommendations" these are recommended actions based on the calculated overall welfare, including the five indicators (*Figure 28*). For the data set in this example, there is a serious cause for concern and the recommendations provided address those (please check recommendation criteria in the appendix section page #45).

(You can save these pages as PDF documents or simply print them using the icons in the top right.)

APPENDIX

BMI calculations for individual lumpfish

The BI calculator uses the Length-weight regression coefficients based on lumpfish life stages (S1 to S4) from Rabadan *et al*. 2021(Table 1).

Table 1. Length-weight regression coefficients (± SE) for farmed lumpfish at different stages of development (log10 Ws = a + b·(log10 TL), where Ws = standard weight (g) and TL = total length (mm), adapted from Rabadan et al. (2020).

Life Stage		Weight range (g)	a	b
Hatchery	S1 Larvae	0–1	−5.023	3.532
	S2 Pre-deployment	1–10	−4.301	2.926
	S3 Pre-deployment	>10	−4.737	3.181
Salmon cages	S4 Post-deployment	>10	−3.516	2.559

The software uses the equations in Table 2 to calculate the BMI. Based on the calculated BMI the software then classifies each lumpfish as emaciated, underweight, normal weight or above normal weight.

Table 2 Equations used to calculate the BMI

Estimates	Excel formula
Expected weight (g) Two decimal places	= 10^(-***a***)*Total Length^(***b***)
BMI (%) Two decimal places	= (Observed Weight/Expected Weight) × 100

NOTE on terms used:

- **Expected Weight (g) from regression**
  this is also called Standard Weight coded as Ws
- **Observed Weight (g)** can also be coded as WT
- **BMI (%) from equation BMI** = (WT/WS) x 100
  this is also called Relative Weight – Wr we will use the term BMI to avoid any confusion with observed and expected weights)

The BMI calculator uses the following logic to **classify individual lumpfish BMI and colour code each category as follows:**

- **Emaciated** (BMI <75) – RED, fish weighing 25% or less below their expected value
- **Underweight** (75-90) – ORANGE, fish weighing between 10% and 25% below their expected value
- **Normal** (>90-110) – GREEN fish weighing their expected weight
- Above Normal (>=110) – coded BLUE in the cumulative graph or grey in the data table, fish weighing 10% or more their expected value

NOTE: Please check poster entitled Lumpfish Welfare Chart for individual BMI classes

Estimates from individual BMI data

From the calculated individual BMI values, the BMI calculator estimates the following parameters summarized in Table 2:

- **Body Height**
- **Finesse**"
- **Maximum Mesh Size**
- From the Maximum Mesh Size the mesh opening (mm) that excludes 99.99%, 99%, and 95% of fish is calculated

Table 3 Equations used to calculate Body Height in mm, Fineness and Maximum Mesh Size (slack) in mm. ***TL – Total Length in mm.***

Estimates	Excel formula
Body Height* Individual lumpfish height (mm) Two decimal places	-0.9606783 + (BMI*0.00648) + (**TL***0.5526598)
Fineness* A measure of how elongated a fish is relative to its length Three decimal places	Body Height**/TL** The fineness ratio of a lumpfish of normal weight is about 0.1
Max Mesh Size** Integer	-1.0 + 0.472***TL**
Exclusion 99.99% Max Mesh Size to prevent 99.99% of fish from escaping Integer	PERCENTILE ('Max mesh size data range",0.0001)
Exclusion 99% Max Mesh Size to prevent 99% of fish from escaping Integer	PERCENTILE ('Max mesh size data range",0.01)
Exclusion 95% Max Mesh Size to prevent 95% of fish from escaping Integer	PERCENTILE ('Max mesh size data range",0.05)

*Body Height and Fineness equations are based on data from suppl. data in Johannesen et al 2018. PeerJ 6, e4837.

** Maximum Mesh Size estimated based on the Data from Herrmann, B., Sistiaga, M. & Jorgensen, T. (2021). Size-dependent escape risk of lumpfish (*Cyclopterus lumpus*) from salmonid farm nets. Mar Pollut Bull 162, 111904.

Output Data Section – individual lumpfish data

The BMI calculator provides the following data to be downloaded in an Excel file in the section entitled Output Data (Table 4 and *Figure i*).

Table 4 Type of data provided (input or calculated) by the BMI calculator in the section entitled Output Data.

Columns name	Type of data: Input/Calculated Excel format
Fish ID	Input data given by the user
Weight (g)	Input Wet weight measured by the user
Total Length (mm)	Input data Total length measured by the user
Expected Weight (g) Two decimal places	Output data, calculated by the software 10^(-a)*Total Length^(b)
BMI (%) Two decimal places	Output data, calculated by the software = (Observed Weight/Expected Weight) × 100
BMI Class	• **Emaciated (BMI <75)** • **Underweight (BMI = 75-90)** • **Normal (BMI >90-110)** • **Above Normal (BMI >=110)**
Body Height (mm) Individual lumpfish height (mm) Two decimal places	Output data, calculated by the software = -0.9606783 + (BMI*0.00648)+(TL*0.5526598)
Fineness* A measure of how elongated a fish is relative to its length Three decimal places	Output data, calculated by the software = Body Height/TL
Maximum Mesh Size (mm) Integer	Output data, calculated by the software = -1.0 + 0.472*TL

*The fineness ratio of a lumpfish of normal weight is about 0.1

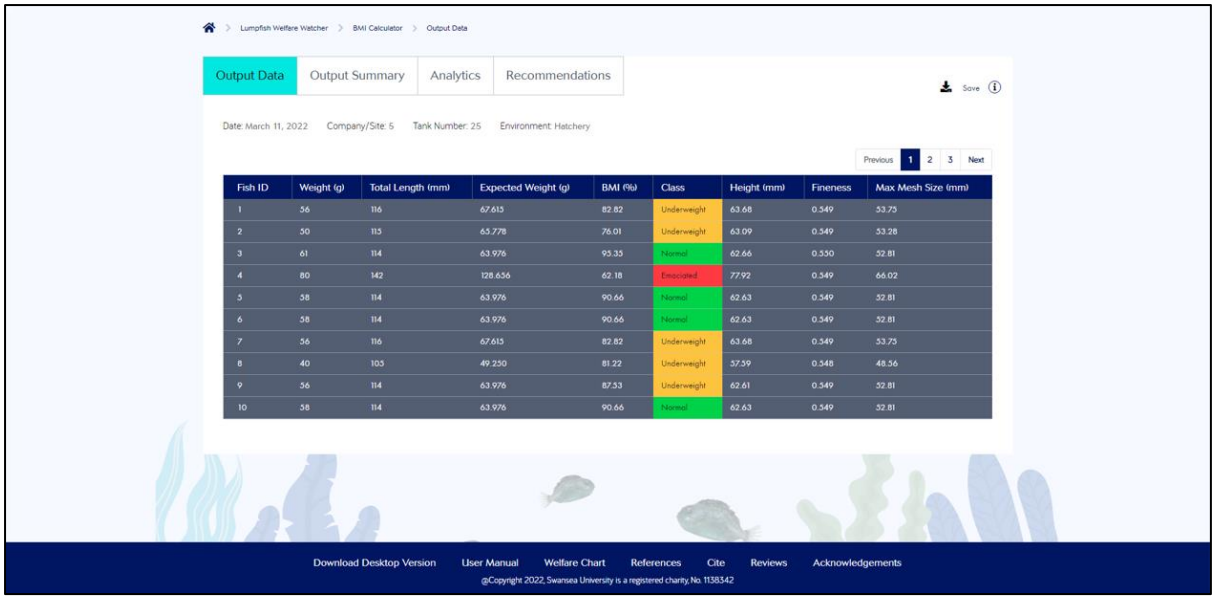

Figure i: BMI calculator screenshot from Output Data section, the data can be downloaded and saved as Excel file.

BMI estimates at the population level

Output summary section – summary statistics for BMI

The BMI calculator also provides information concerning the population of the lumpfish sampled. For instance, if you have measured the length and weight of a total of 30 lumpfish, the BMI calculator will provide the sample size (in this case 30 lumpfish), but also the statistics shown in Table 5 below, for the following parameters shown in *Figure ii*:

- BMI (%)
- Total Length (mm)
- Weight (g)
- Body Height (mm)
- Fineness Ratio

Table 5 Summary table with the statistics calculated by the BMI calculator and the equivalent formulas in Excel. The statistics are provided for the BMI

Statistic	Excel formula
Overall BMI class Emaciated, Underweight, Normal or Above Normal	"AVERAGE"
% emaciated % of the total fish sampled (N) weighing 25% below their expected value	("COUNTIF(range,"<75")/COUNT*100)
% normal % of the total fish sampled (N) weighing their expected value	("COUNTIF(range,">90", range, "<110")/COUNT*100)
% fish underweight % of the total fish sampled (N) weighing between 10% and 25% below their expected value	("COUNTIFS(range,">=75",range,"<=90")/COUNT*100))

% fish above normal fish weighing 10% or more their expected value	(“COUNTIF(range,">=110")/COUNT*100)
N Sample size	“COUNT”
Min Minimum value	“MIN”
Median Value that splits the data into equal halves	“MEDIAN”
Mean Arithmetic Mean	“AVERAGE”
SD Standard Deviation	“STDEV.S”
95CI 95% confidence interval around the mean	“CONFIDENCE.T” with alpha = 0.05, and SD and N

In this Output Summary section, the Maximum Mesh Size, i.e. the mesh opening (mm) that excludes 99.99%, 99%, and 95% of fish is also provided (*Figure ii*).

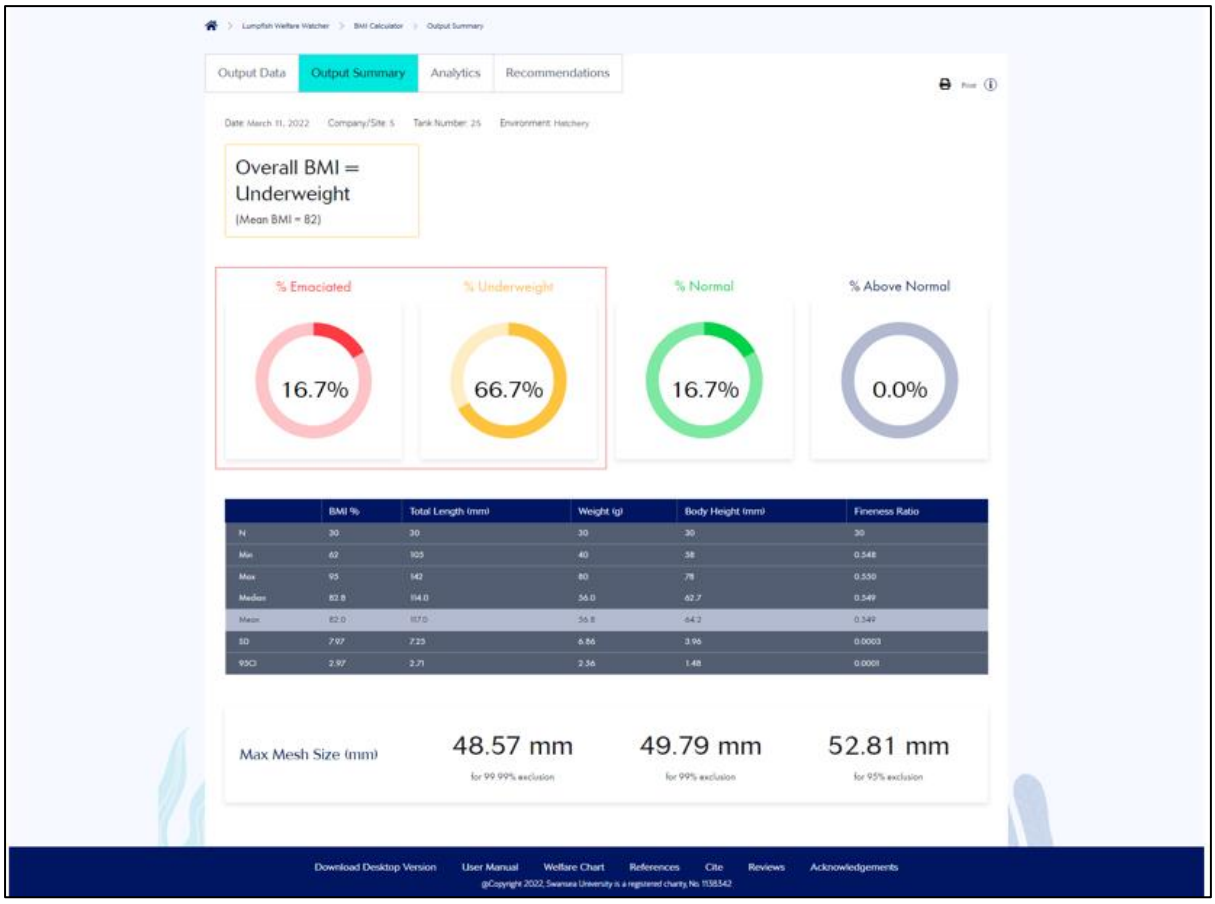

Figure ii: BMI calculator screenshot of Output Summary section showing all the information listed in Table 5, in an infographic.

Analytics section - Cumulative frequency plot

The graph shows the proportion of fish in each of the four BMI categories.

The area under the curve of each BMI class is coloured coded and shows the percentage of lumpfish that are:

- Emaciated **(BMI <75)**
- Underweight **(BMI = 75-90)**
- Normal **(BMI > 90-110)**
- Above Normal **(BMI >=110)**

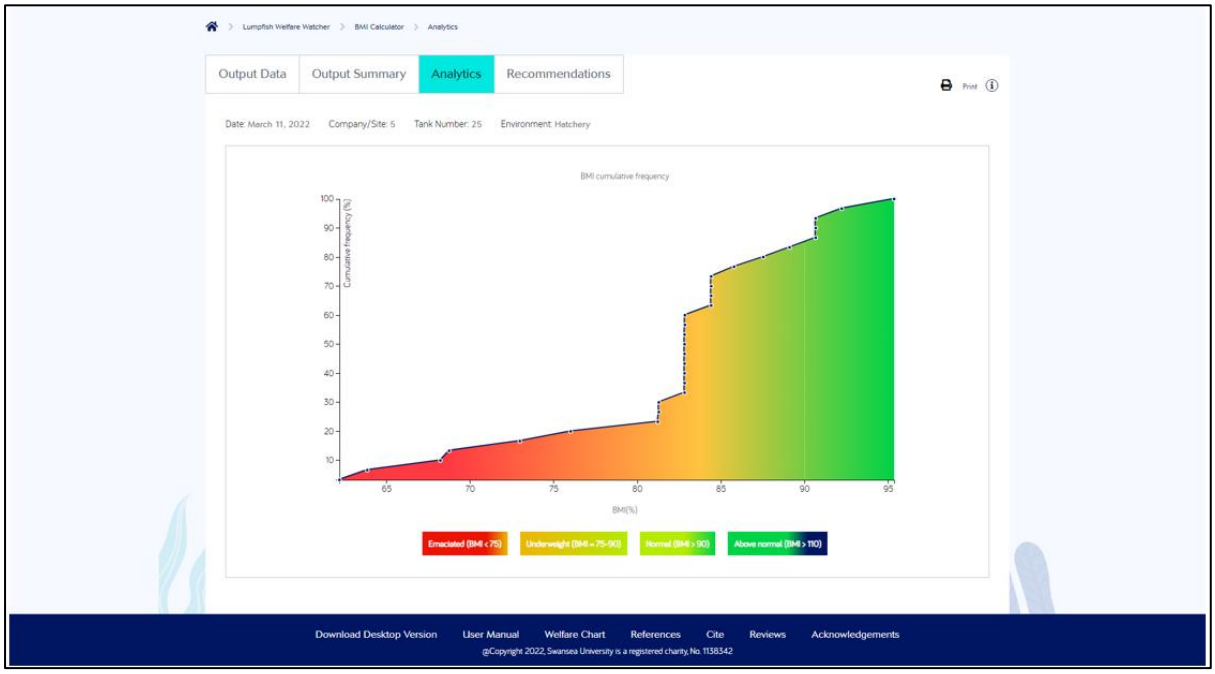

Figure iii: BMI calculator screenshot of the Analytics section showing the cumulative frequency graph.

Note: to calculate the cumulative frequency table in Excel, use this instructional video https://www.statisticshowto.com/cumulative-frequency-table-excel-easy-steps/

Recommendation Section - overall BMI classification and recommendation

The BMI calculator will determine the recommendation level which ranges from "*No cause of Concern"* to "*Severe cause of concern"* based on the criteria summarized in the table below.

Table 6 BMI calculator recommendation level criteria

BMI Criteria			
Mean BMI	**% of fish emaciated (BMI<75)**	**% of fish underweight (BMI 75-90)**	
>95	**AND** No fish with BMI<75	**AND** <15% fish with BMI<90	**GREEN No cause of concern**
90-95	**OR** Up to 10% with BMI <75	**OR** 15-30% fish with BMI <90	**AMBER Moderate cause of concern**
< 90	**OR** More than 10% with BMI<75	**OR** More than 30% fish with BMI <90	**RED Serious cause of concern**

The BMI calculator lists the recommendations for each level of concern and is specific to lumpfish sampled in hatcheries or lumpfish sampled from salmon cages (*Figure iv*).

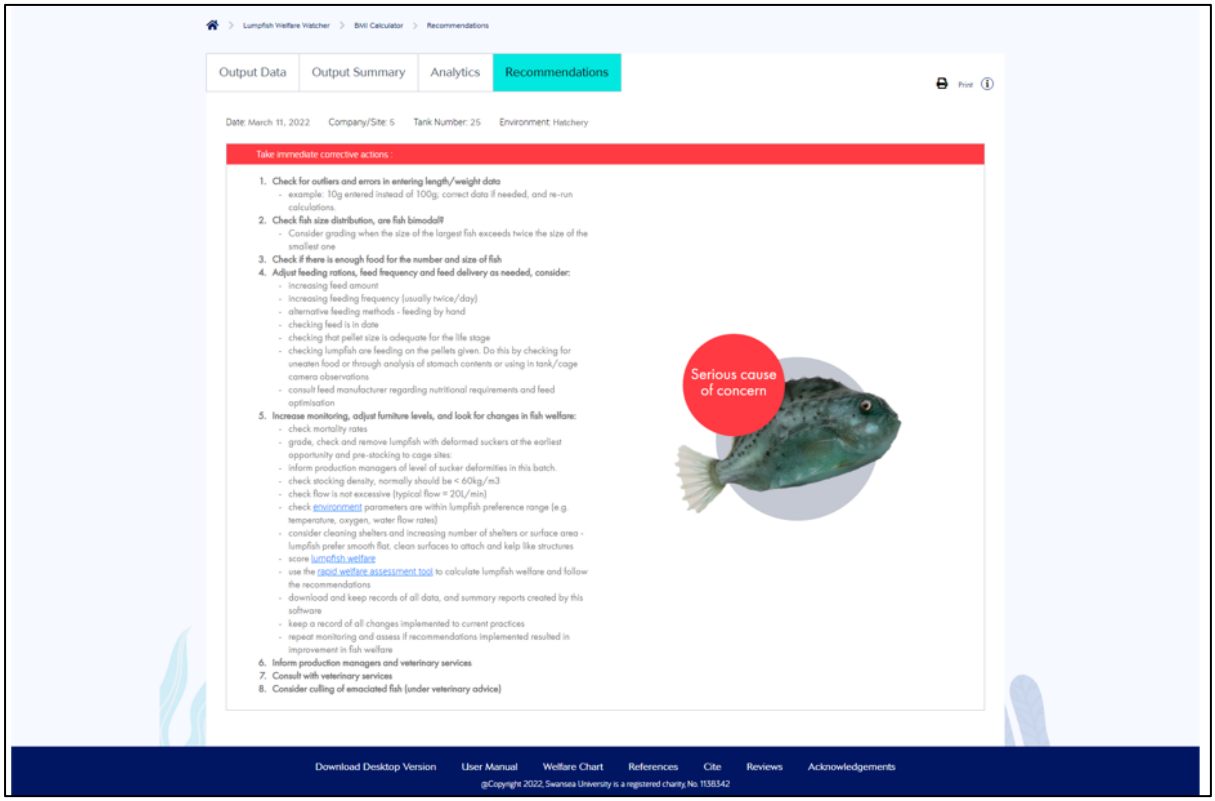

Figure iv: BMI calculator screenshot of the Recommendation section.

Hatchery Recommendations list

GREEN - No cause of concern

if mean BMI >95 AND No fish with BMI<75 AND <15% fish with BMI<90

Maintain current feeding regime and feeding conditions (*Figure v*)

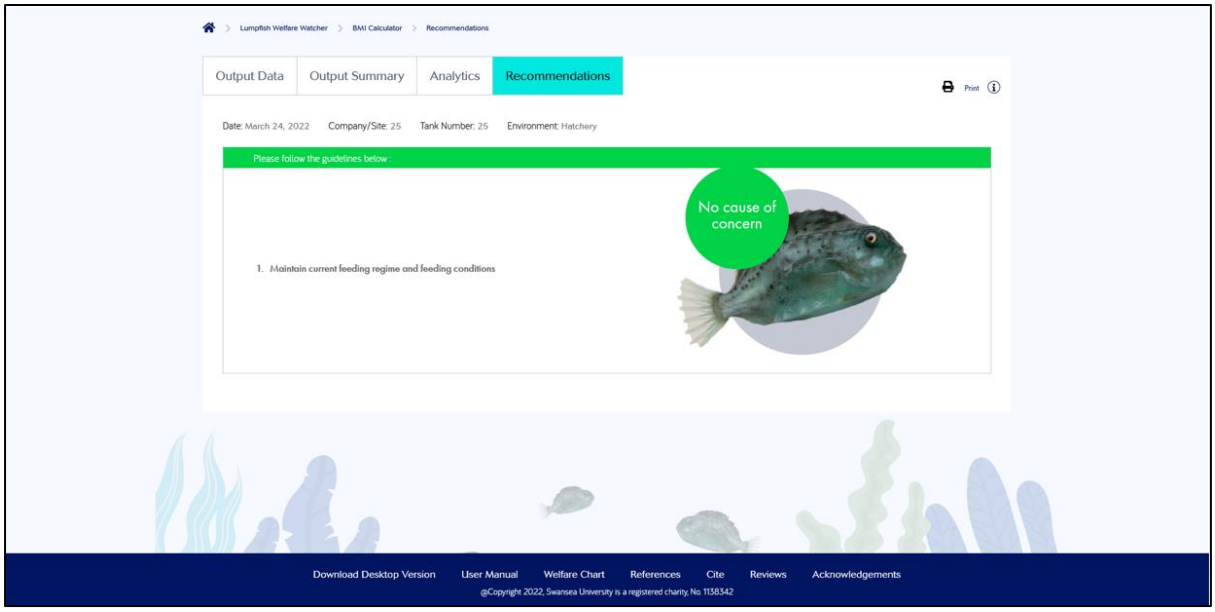

Figure v: BMI calculator screenshot of Recommendation section.

AMBER - Moderately compromised

if mean BMI 90-95 OR Up to 10% with BMI <75 OR 15-30% fish with BMI <90

1. **Check for outliers and errors in entering length/weight data**
   - example: 10g entered instead of 100g; correct data if needed, and re-run calculations.
   - do a repeat sample if in doubt
2. **Check fish size distribution, are fish bimodal?** Consider grading when the size of the largest fish exceeds twice the size of the smallest one
3. **Check if there is enough food for the number and size of fish**
4. **Adjust feeding rations, feed frequency and feed delivery as needed, consider:**
   - increasing feed amount
   - increasing feeding frequency (usually twice/day)
   - alternative feeding methods - feeding by hand
   - checking feed is in date
   - checking that pellet size is adequate for the life stage
   - checking lumpfish are feeding on the pellets given. Do this by checking for uneaten food or through analysis of stomach contents or using in tank/cage camera observations
   - consult feed manufacturer regarding nutritional requirements and feed optimisation
5. **Increase monitoring, adjust furniture levels, and look for changes in fish welfare:**
   - check mortality rates
   - grade, check and remove lumpfish with deformed suckers at the earliest opportunity and pre-stocking to cage sites
   - inform production managers of level of sucker deformities in this batch
   - check stocking density, normally should be <60kg/m^3
   - check flow is not excessive (typical flow = 20L/min)
   - check environment parameters are within lumpfish preference range (e.g. temperature, oxygen, water flow rates) #Show the text in blue as hyperlink and Convert table water quality lumpfish document in pdf and open this pdf
   - consider cleaning shelters and increasing number of shelters or surface area - lumpfish prefer smooth flat, clean surfaces to attach and kelp like structures
   - score lumpfish welfare #Add the link to the e-learning section to be provided
   - use the rapid welfare assessment tool to calculate lumpfish welfare and follow the recommendations #Add the link to the Rapid Welfare assessment tool to the text in blue
   - download and keep records of all data, and summary reports created by this software
   - keep a record of all changes implemented to current practices
   - repeat monitoring and assess if recommendations implemented resulted in improvement in fish welfare
6. **Inform production managers and veterinary services**

RED - Serious cause of concern

if mean BMI Less than 90 OR More than 10% with BMI<75) OR More than 30% fish with BMI <90

Same list as AMBER plus the following recommendations.

7. **Consult with veterinary services**

8. **Consider culling of emaciated fish (under veterinary advice)**

GREY – Investigate

if mean BMI >110

1. **Check for outliers and errors in entering length/weight data**
   - example: 1000g entered instead of 100g; correct data if needed, and re-run calculations.
   - do a repeat sample if in doubt
2. **Adjust feeding rations, frequency and amount**
3. **Consider increasing flow -** typical flow 20l/min #Show the text in blue as hyperlink and Convert table water quality lumpfish document in pdf and open this pdf
4. **Monitor often and look for changes in fish welfare:**
   - check mortality rates
   - score lumpfish welfare #Add the link to the welfare chart
   - use the rapid welfare assessment tool to calculate lumpfish welfare and follow the recommendations #Add the link to the Rapid Welfare assessment tool to the text in blue
   - download and keep records of all data, and summary reports created by this software
   - keep a record of all changes implemented to current practices
   - repeat monitoring and assess if recommendations implemented resulted in improvement in fish welfare
5. **Inform production managers and veterinary services**

Salmon cages recommendations list

GREEN - No cause of concern

if mean BMI >95 AND No fish with BMI<75 AND <15% fish with BMI<90

Maintain current feeding regime and feeding conditions

AMBER - Moderately compromised

if mean BMI 90-95 OR Up to 10% with BMI <75 OR 15-30% fish with BMI <90

1. **Check for outliers and errors in entering length/weight data**
   - example: 10g entered instead of 100g; correct data if needed, and re-run calculations.
   - do a repeat sample if in doubt
2. **Request hatchery to provided evidence that lumpfish supplied are of similar sizes and in good welfare using this software.**
3. **Ensure deployed fish are of similar sizes, largest fish should be less than twice the size of the smallest fish and aim to reduce size difference with wrasse (if present).**
4. **Check if there is enough food for the number and size of fish**
5. **Adjust feeding rations, feed frequency and feed delivery as needed, consider:**
   - increasing feed amount
   - increasing feeding stations near the hides
   - increasing feeding frequency (usually twice/day)
   - alternative feeding methods - feeding by hand, feed blocks
   - checking feed is in date
   - checking that pellet size is adequate for the life stage
   - checking lumpfish are feeding on the pellets given. Do this by checking for uneaten food or through analysis of stomach contents or using in tank/cage camera observations
   - consult feed manufacturer regarding nutritional requirements and feed optimisation
6. **Increase monitoring, adjust furniture levels, and look for changes in fish welfare:**
   - check mortality rates
   - grade, check and remove lumpfish with deformed suckers at the earliest opportunity (for instance if lumpfish are to be re-deployed)
   - inform hatchery and production managers of level of sucker deformities in this batch
   - check environment parameters are within lumpfish preference range (e.g. temperature, oxygen, water flow rates) #Show the text in blue as hyperlink and Convert table water quality lumpfish document in pdf and open this pdf
   - consider cleaning shelters and increasing number of shelters or surface area - lumpfish prefer smooth flat, clean surfaces to attach and kelp like structures
   - score lumpfish welfare #Add the link to the e-learning section- to be provided
   - use the rapid welfare assessment tool to calculate lumpfish welfare and follow the recommendations #Add the link to the Rapid Welfare assessment tool to the text in blue
   - download and keep records of all data, and summary reports created by this software
   - keep a record of all changes implemented to current practices
   - repeat monitoring and assess if recommendations implemented resulted in improvement in fish welfare

7. **Consider avoiding the use of lumpfish at sites characterised by excessively high energy and water flow rates.**
8. **Inform supplier and production managers**
9. **Inform veterinary services**

RED - Serious cause of concern

if mean BMI Less than 90 OR More than 10% with BMI<75) OR More than 30% fish with BMI <90

Same list as AMBER plus the following recommendations.

10. **Consult with veterinary services**
11. **Consider culling of emaciated fish (under veterinary advice)**

GREY – Investigate

if mean BMI >110

1. **Check for outliers and errors in entering length/weight data**
   - Example: 1000g entered instead of 100g); correct data if needed, and re-run calculations.
   - do a repeat sample if in doubt
2. **Adjust feeding rations, frequency and amount**
3. **Monitor often and look for changes in fish welfare:**
   - check mortality rates
   - score lumpfish welfare #Add the link to the e-learning section- to be provided
   - use the rapid welfare assessment tool to calculate lumpfish welfare and follow the recommendations #Add the link to the Rapid Welfare assessment tool to the text in blue
   - download and keep records of all data, and summary reports created by this software
   - keep a record of all changes implemented to current practices
   - repeat monitoring and assess if recommendations implemented resulted in improvement in fish welfare
4. **Inform veterinary services**

Lumpfish Operational Welfare Score Index (LOWSI) calculations for individual lumpfish

The Rapid Welfare Assessment Tool (RWAT) calculates the LOWSI score using the data entered for the four visual indicators (Skin, Eyes, Tail fin and Suction disc) and the calculated BMI.

BMI score

Based on the calculated BMI value for each individual fish the BMI score is as follows:

BMI score:

- **Score 0: Normal (>90)**
- **Score 1: Underweight (75-90)**
- **Score 2: Emaciated (BMI <=75)**

Visual indicators score

For the individual visual indicators: Skin damage, Tail or caudal fin damage, Eye condition and Suction disc the scores are as follows:

- Score 0: **No damage**
- Score 1: **Moderate damage** (in the case of the eye condition – one eye damaged)
- Score 2: **Severe damage** (in the case of the eye condition – two eyes damaged)

NOTE: Please check poster entitled Lumpfish Welfare Chart for individual scores

Calculations for overall LOWSI at the individual level

- The LOWSI ranges from 0 (worst) to 10 (best), a higher score indicates better welfare.
- The LOWSI is calculated by subtracting 10 to the sum of the five indicator scores.
- Lumpfish are classified into three welfare classes based on the LOWSI
    - ***Good welfare = 8-10***
    - ***Moderately compromised = 5-7***
    - ***Severely compromised =0-4***

In the example below the LOWSI is 6, and the welfare of this individual lumpfish is moderately compromised (class B)

Skin damage score = 0
Caudal fin damage score = 2
Eye condition score = 0
Suction disc score = 1
BMI score = 1
SUM = 4
LOWSI = 10 – 4 = 6 **Moderately compromised**

LOWSI estimates at the population level

Output summary section - summary statistics for LOWSI

The RWAT provides the same summary statistics as the BMI calculator in addition to all individual scores and overall LOWSI (*Figure vi*)

Table 7 Summary table with the statistics calculated by the RWAT and the equivalent formulas in Excel.

Statistic	Excel formula
N Sample size	"COUNT"
Min Minimum value	"MIN"
Median Value that splits the data into equal halves	"MEDIAN"
Mean Arithmetic Mean	"AVERAGE"
SD Standard Deviation	"STDEV.S"
95CI 95% confidence interval around the mean	"CONFIDENCE.T" with alpha = 0.05, and SD and N
% fish with good welfare class A % of the total fish sampled (N) with LOWSI score 8 to 10	("COUNTIF(range,">=8")/COUNT*100))
% fish with moderately compromised welfare class B % of the total fish sampled (N) with LOWSI score 5 to 7	("COUNTIF(range,">=5", range,"<=7")/COUNT*100))
% fish with severely compromised welfare Class C % of the total fish sampled (N) with LOWSI score 0 to 4	("COUNTIFS(range,"<5")/COUNT*100))

Note: SD and 95CI are calculated here as total LOWSI scores can span 10 points

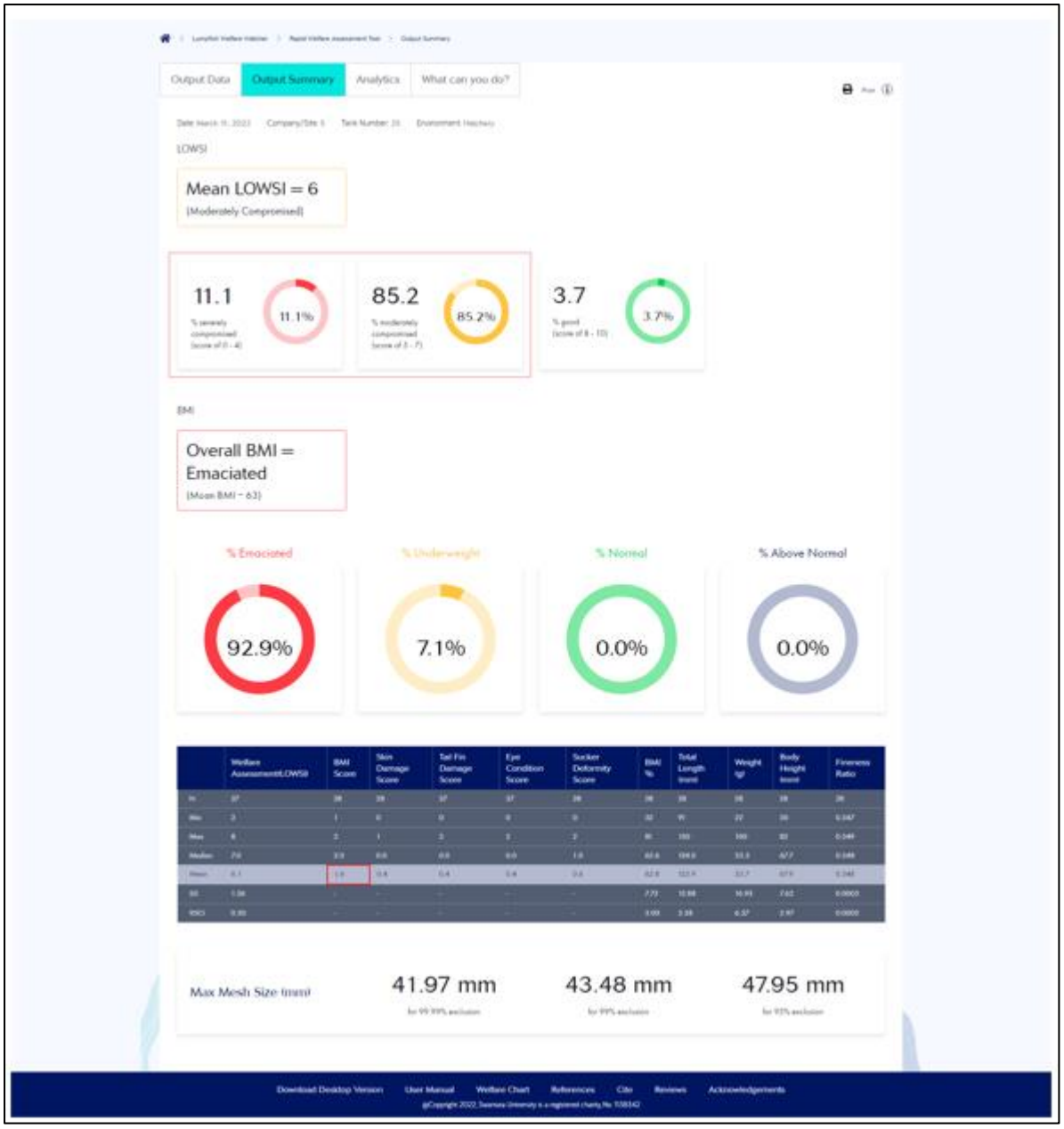

Figure vi: RWAT screenshot of the Output Summary section showing all the information listed in Table 5, in an infographic.

Analytics section - Cumulative frequency plot and violin chart

This section shows the cumulative frequency for both Lumpfish Operational Welfare Index Score (LOWSI on the left) and BMI (on the right). The LOWSI cumulative frequency graph shows the proportion of fish in each of the three LOWSI categories:

- Good = 8-10
- Moderately compromised = 5-7
- Severely compromised = 0-4

The last graph in this section is a violin chart showing the welfare score for each of the five indicators scored on a scale of 0 – 2 (where higher scores correspond to a poor welfare). The small dot located on the graph represents the mean value of each score, the lower this dot is located on the graph the better.

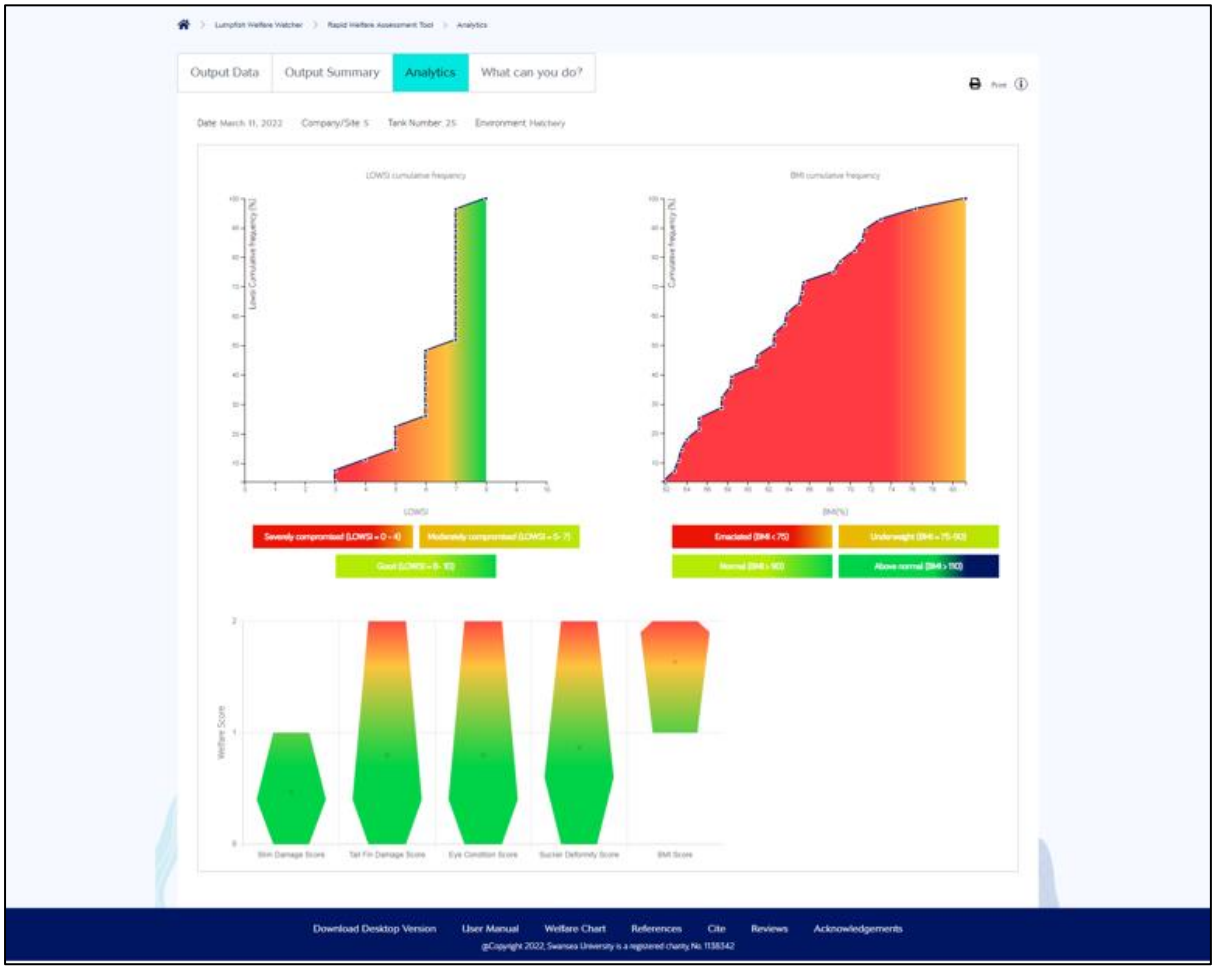

Figure vii: RWAT screenshot of the Analytics section showing the cumulative frequency graphs for both LOWSI and BMI. In this example the tail damage is the indicators which has a higher score, with a wider red area closer to the top, and the BMI has the lowest score with a wider green area loser to the bottom.

Recommendation section - overall LOWSI classification and recommendation

The RWAT will determine the recommendation level which ranges from “No cause of Concern” to “Serious cause of concern” based on the criteria summarized below.

The LOWSI is green – No cause of concern

If < 15% fish in class B (i.e. moderately compromised welfare LOWSI=5-7 points) **AND** No fish in class C (i.e. severely compromised welfare LOWSI<=4)

The LOWSI is amber - Moderate cause of concern

If 15-30% fish in class B (i.e. moderately compromised welfare LOWSI=5-7 points) **OR** Up to 10% in class C (i.e. severely compromised welfare LOWSI<=4)

The LOWSI is red - Serious cause of concern

If more than 30% fish in class B (i.e. moderately compromised welfare LOWSI=5-7 points) **OR** more than 10% fish in class C (i.e. severely compromised welfare LOWSI<=4)

LOWSI Criteria matrix		
% of fish with moderately compromised welfare **Class B = 5-7 points**	% of fish with severely compromised welfare **Class C <4 points**	
AND < 15% fish in class B	**AND** No fish in class C	**GREEN** **Good welfare**
OR 15-30% fish in class B	**OR** Up to 10% in class C	**AMBER** Moderate cause of concern
OR More than 30% in class B	OR More than 10% fish in class C	RED Serious cause of concern

LOWSI recommendations

Hatchery Recommendations list

GREEN – Good Welfare

If < 15% fish moderately compromised welfare (LOWSI=5-7 points) **AND** No fish severely compromised welfare (LOWSI<=4 points)

1. **Maintain current conditions**

AMBER - Moderate cause of concern

If 15-30% fish moderately compromised welfare (LOWSI=5-7 points) **OR** Up to 10% in class severely compromised welfare (LOWSI<=4).

The first four points below will be common recommendations. But there will be specific additional recommendations if one or more indicators (e.g. BMI, skin damage, etc.) have a mean LOWSI score >=1.

1. **Check for outliers and errors in entering length/weight data**
    - example: 10g entered instead of 100g; correct data if needed, and re-run calculations.
    - do a repeat sample if in doubt
2. **Reduce potential causes of injuries:**
    - change handling practices during treatments, for instance avoid overcrowding
    - reduce handling
3. **Increase monitoring, adjust furniture levels, and look for changes in fish welfare:**
    - check mortality rates
    - grade, check and remove lumpfish with deformed suckers at the earliest opportunity and pre-stocking to cage sites
    - inform production managers of level of sucker deformities in this batch
    - check stocking density, normally should be <60kg/m^3
    - check environment parameters are within lumpfish preference range (e.g. temperature, oxygen, water flow rates) #Show the text in blue as hyperlink and Convert table water quality lumpfish document in pdf and open this pdf
    - consider cleaning shelters and increasing number of shelters or surface area - lumpfish prefer smooth flat, clean surfaces to attach and kelp like structures
    - download and keep records of all data, and summary reports created by this software
    - keep a record of all changes implemented to current practices
    - repeat monitoring and assess if recommendations implemented resulted in improvement in fish welfare
4. **Inform production managers and veterinary services**

If the mean BMI score>=1 then the following list will be added to the previous four points above:

- Check fish size distribution, are fish bimodal? Consider grading when the size of the largest fish exceeds twice the size of the smallest one
- Check if there is enough food for the number and size of fish
- Adjust feeding rations, feed frequency and feed delivery as needed, consider:
    - increasing feed amount
    - increasing feeding frequency (usually twice/day)
    - alternative feeding methods - feeding by hand
    - checking feed is in date
    - checking that pellet size is adequate for the life stage
    - checking lumpfish are feeding on the pellets given. Do this by checking for uneaten food or through analysis of stomach contents or using in tank/cage camera observations
    - consult feed manufacturer regarding nutritional requirements and feed optimisation
- Check flow is not excessive (typical flow = 20L/min)

If the mean Skin damage score>=1 then the following list will be added to the previous points above:

- Check for underlying skin pathologies

If the mean Tail fin damage score>=1 then the following list will be added to the previous points above:

- Check stocking density is within optimal level (<60kg/m3)

If the mean Eye damage score>=1 then the following list will be added to the previous points above:

- Check feed meets all nutritional requirements
- Check recent temperature shock events
- Check for underlying pathologies

If the mean Suction disk score>=1 then the following list will be added to the previous points above:

- Reduce developmental stress during egg incubation:
  - Consider using light 420 nm (blue)
  - Maintain water temperature: 2–17ºC for egg development
  - Avoid mechanical shocks
- Consider culling of fish with heavily deformed suckers (under veterinary advice)

Red - Serious cause of concern

If more than 30% fish moderately compromised welfare (LOWSI=5-7 points) OR more than 10% fish severely compromised welfare (LOWSI<=4)

In this case, the same list used for the Moderately compromised fish (amber colour) will be displayed followed by the following 2 extra recommendations:

- Consult with veterinary services
- Consider culling of emaciated fish (under veterinary advice)

Salmon cages recommendations list

GREEN – Good Welfare

If < 15% fish moderately compromised welfare (LOWSI=5-7 points) **AND** No fish severely compromised welfare (LOWSI<=4 points)

1. **Maintain current conditions**

AMBER - Moderate cause of concern

If 15-30% fish moderately compromised welfare (LOWSI=5-7 points) **OR** Up to 10% in class severely compromised welfare (LOWSI<=4).

The first four points below will be common recommendations. But there will be specific additional recommendations if one or more indicators (e.g. BMI, skin damage, etc.) have a mean LOWSI score >=1.

1. **Check for outliers and errors in entering length/weight data**
    - example: 10g entered instead of 100g; correct data if needed, and re-run calculations.
    - do a repeat sample if in doubt
2. **Reduce potential causes of injuries:**
    - change handling practices during treatments, for instance avoid overcrowding
    - reduce handling
3. **Increase monitoring, adjust furniture levels, and look for changes in fish welfare:**
    - check mortality rates
    - grade, check and remove lumpfish with deformed suckers at the earliest opportunity (for instance if lumpfish are to be re-deployed)
    - inform hatchery and production managers of level of sucker deformities in this batch.
    - check environment parameters are within lumpfish preference range (e.g. temperature, oxygen, water flow rates) #Show the text in blue as hyperlink and Convert table water quality lumpfish document in pdf and open this pdf
    - consider cleaning shelters and increasing number of shelters or surface area - lumpfish prefer smooth flat, clean surfaces to attach and kelp like structures
    - download and keep records of all data, and summary reports created by this software
    - keep a record of all changes implemented to current practices
    - repeat monitoring and assess if recommendations implemented resulted in improvement in fish welfare
4. **Inform production managers and veterinary services**

If the mean BMI score>=1 then the following list will be added to the previous four points above:

- Request hatchery to provided evidence that lumpfish supplied are of similar sizes and in good welfare using this software.
- Ensure deployed fish are of similar sizes, largest fish should be less than twice the size of the smallest fish and aim to reduce size difference with wrasse (if present).
- Check if there is enough food for the number and size of fish
- Adjust feeding rations, feed frequency and feed delivery as needed, consider:
    - increasing feed amount
    - increasing feeding stations near the hides
    - increasing feeding frequency (usually twice/day)
    - alternative feeding methods - feeding by hand, feed blocks
    - checking feed is in date
    - checking that pellet size is adequate for the life stage

    - checking lumpfish are feeding on the pellets given. Do this by checking for uneaten food or through analysis of stomach contents or using in tank/cage camera observations
    - consult feed manufacturer regarding nutritional requirements and feed optimisation
- Consider avoiding the use of lumpfish at sites characterised by excessively high energy and water flow rates.

If the mean Skin damage score>=1 then the following list will be added to the previous points above:

- Check for underlying skin pathologies

If the mean Tail fin damage score>=1 then the following list will be added to the previous points above:

- Exclude predators

If the mean Eye damage score>=1 then the following list will be added to the previous points above

- Check feed meets all nutritional requirements
- Check recent temperature shock events
- Check for underlying pathologies

If the mean Suction disk score>=1 then the following list will be added to the previous points above:

- Consider culling of fish with heavily deformed suckers (under veterinary advice)
- Inform supplier

Red - Serious cause of concern

If more than 30% fish moderately compromised welfare (LOWSI=5-7 points) OR more than 10% fish severely compromised welfare (LOWSI<=4)

In this case, the same list used for the Moderately compromised fish (amber colour) will be displayed followed by the following 2 extra recommendations:

- Consult with veterinary services
- Consider culling of severely deformed and badly injured fish (under veterinary advice)