BEFORE THE ENVIRONMENTAL PROTECTION AUTHORITY

AT WELLINGTON

IN THE MATTER	of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
AND	
IN THE MATTER	of a decision-making committee appointed to hear a marine consent application by Trans Tasman Resources to undertake iron ore extraction and processing operations offshore in the South Taranaki Bight

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EXPERT SUPPLEMENTARY EVIDENCE OF ALISON MACDIARMID ON BEHALF OF TRANS TASMAN RESOURCES LIMITED

1 MAY 2017

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INTRODUCTION

1. My name is Alison Bronwyn MacDiarmid.

2. I prepared Expert Evidence dated 15 December 2016 (First Statement), and Rebuttal Evidence dated 9 February 2017 with respect to these proceedings on behalf of Trans-Tasman Resources Limited.

3. My qualifications and experience as a marine ecologist are set out in paragraphs 1 and 2 of my First Statement.

4. I repeat the confirmation given at paragraph 4 of my First Statement that I have read the Code of Conduct for Expert Witnesses and agree to comply with it.

5. The purpose of this Supplementary Evidence is to respond to respond to several questions posed by the DMC in minute 41 Appendix 1 and three question posed in Appendix 2.

REPOSNSES TO QUESTIONS POSED IN APPENDIX 1

6. The appended NIWA report provides responses to questions 5, 6, 8, 12 and 13 in Appendix 1.

REPOSNSES TO QUESTIONS POSED IN APPENDIX 2

QUESTION 1

When, where, and to what extent will elevated SSC levels cause environmentally significant changes (for benthos, primary production, fish) arising from light received. Decreased primary production is an example. What comprises a "significant" change should be specifically addressed.

7. Effects of elevated SSC on primary production are dealt with in supplementary evidence of Professor Cahoon. He concludes that those effects will be minor overall; spatially limited in terms of local, more intense effects,; and rapidly mitigated by physical and biological processes typical of continental shelf ecosystems.

8. Consequent effects on secondary production by groups such as krill, fish, seabirds and cetaceans will be negligible according to standard evaluation criteria (see Table 2-2 in MacDiarmid et al. 2015)[1] as they will be spread across wide areas due to the mixing of phytoplankton and zooplankton in currents and the movement of mobile fauna.

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[1] Report 17_NIWA Assessment of the scale of marine effects Report FINAL September 2015.pdf.

9. Reductions in light available for visual predators to hunt and for prey species to avoid predation is another potential effect of reduced light levels in the water column and on the seafloor. I consider these effects along with potential physical effects of elevated SSC in the section below.

QUESTION 2

When, where, and to what extent will elevated SSC levels cause environmentally significant changes (for benthos, primary production, fish) related to physical effects. Smothering of algae or filter feeders is an example. What comprises a "significant" change should be specifically addressed.

10. The direct effects of elevated SSC are discussed in paragraphs 65-74 in my First Statement. In summary, to determine ecologically consequential concentrations of suspended sediment recent reviews of species responses to SSC were examined by MacDiarmid et al. (2015).

11. They identified 2 mg /litre as a conservative minimum threshold of effects for all pelagic species of fish and invertebrates, sea birds, and marine mammals, and 3 mg/litre as a conservative threshold of effects for all demersal and benthic species of fish and invertebrates.

12. The effects taken into account were clogging of respiratory surfaces and feeding structures of marine organisms, avoidance of the discharge area by mobile species, and reduced availability of prey due to either reduced underwater visibility or a reduction in prey numbers or biomass.

13. These effects will occur whenever mining takes place and will be highest in a relatively small area immediately surrounding the area of active mining. For pelagic species the affected area (60.5 km^2) was estimated based on the average of surface and near bottom median SSC values when mining at Site A and Site B. For benthic and demersal species the area (47.5 km^2) was based on the average near bottom median value when mining at Site A and Site B.

14. For all zooplankton, and marine mammal species, and most fish species, there should be negligible effects of mining 50 Mt per annum according to standard evaluation criteria (Table 2-2 in MacDiarmid et al. 2015) This is principally because the scale of the mined area and the areas of elevated SSC are small compared to the area used by the populations of these species. Consequently they are likely to be displaced from, or experience a decrease in prey abundance or availability over a very small part of their distribution.

15. For coastal kaimoana species, the proposed mining activity should not add significantly to the levels of suspended sediments currently experienced inshore in frequently turbid waters.

16. One species, eagle ray, may be affected to a moderate extent (p. 24 in MacDiarmid et al. 2015).

QUESTION 3

What issues of materiality, in terms of ecological effects, do you perceive between the original modelling and the HR Wallingford 17 March 2017 modelling.

17. With regard to my evidence, the principal effect of the 17 March 2017 modelling was to increase the area of median SSC elevated above the 2 and 3 mg/L thresholds used to assess impacts on pelagic species of fish and invertebrates, seabirds and marine mammals, and demersal and benthic species of fish respectively. These increases are summarised in the table below.

Table 1: Area where the proposed iron sand mining activities are estimated to elevate suspended sediment concentration (SSC) above 2 and 3 mg/litre. The original scenario estimates were based on the average area of elevated SSC stemming from proposed mining at site A and at site B using the median SSC estimated by Hadfield and Macdonald (2015). The March 2017 scenario estimates are based on the model runs conducted in March 2017.

Height in water column	Area with SSC elevated above 2 mg/l (km^2)		Area with SSC elevated above 3 mg/l (km^2)	
	Original scenario	March 2017 scenario	Original scenario	March 2017 scenario
Surface	45.3	57.3	20.5	28.1
Near-bottom	75.7	99.8	47.5	61.7

18. Despite the increases the impacted areas remain small (<1%) compared to the areas occupied by each species evaluated and do not lift any species into a higher consequence level according to the criteria outlined in Table 2-2 of MacDiarmid et al. (2015).

EFFECT ON EVIDENCE

19. The additional modelling does not change any of the conclusions in my primary evidence.

Alison MacDiarmid

1 May 2017

APPENDIX 1 – NIWA REPORT RESPONDING TO QUESTIONS 5, 6, 8 12, AND 13 OF MINUTE 41 APPENDIX 1

Responses to questions raised in Appendix 1 of DMC Minute 41

Prepared for Trans-Tasman Resources Ltd

May 2017

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Quality Assurance Statement		
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Executive summary

On the 10th April 2017 the EPA Decision Making Committee (DMC) sitting to hear the application by Trans-Tasman Resources Ltd for a consent to mine iron sands in the South Taranaki Bight issued Minute 41 (M41) which outlined the need for additional information. Appendix 1 of M41 lists 14 questions from the DMC regarding sediment plume modelling, the ecological impacts of suspended sediments, and some other issues. This report provides NIWAs responses to questions 5, 6, 8, 12 and 13.

1 Background

On the 10th April 2017 the EPA Decision Making Committee (DMC) sitting to hear the application by Trans-Tasman Resources Ltd (TTR) for a consent to mine iron sands in the South Taranaki Bight (STB) issued Minute 41 (M41) which outlined the need for additional information. Appendix 1 of M41 lists 14 questions from the DMC regarding sediment plume modelling, the ecological impacts of suspended sediments, and some other issues. NIWA has been requested to address questions 5, 6, 8, 12 and 13, and our responses are provided in the sections below.

2 Responses to questions

2.1 Question 5.

This question asks "*Provide the suspended sediment concentration (SSC) statistics (25%, 50%, 95%, and maximum) for the ten locations assessed in the worst case modelling report. This should be presented both in tabular form and visually (bell curves) for the 'background'(no-mining), 'mining derived', and 'background plus mining' datasets. Both surface water and near-bottom water datasets should be presented*"

With the exception of Project Reef (whose position is sensitive), the locations of interest are provided below.

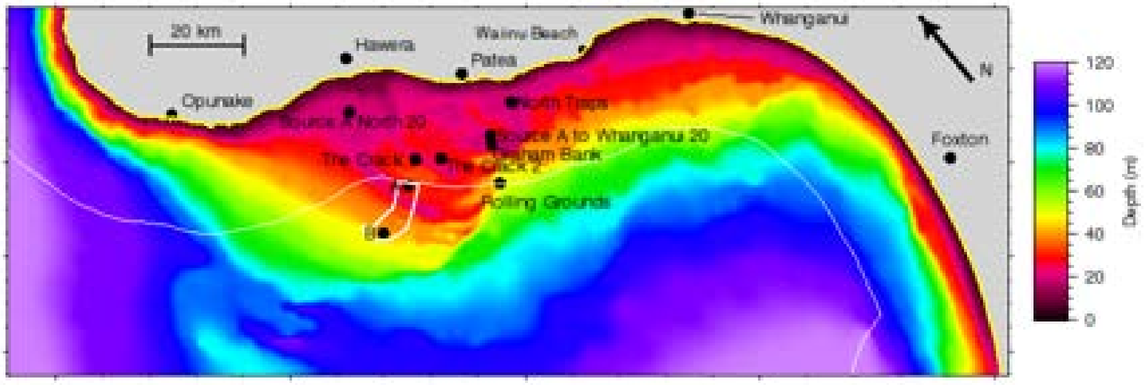

Figure 2-1: Locations of interest. The locations at which time series are taken, key rivers, mining source A and mining source B are indicated. The mining region is outlined in white. Colour shows bathymetry. From Figure 3.1 of Macdonald and Hadfield (2017).

These tables and figures below address question 5 for each of the ten locations. The figures show the frequency distribution for both surface and near-bottom for background, mining derived, and background plus mining when mining at source A which has the largest impact on all ten locations of interest. To enable an easier comparison between background and mining-derived sources the frequency has not been normalised. The total number of data points used in each subplot is 1460. The 99th percentile was indicated on the time-series presented for these locations in Macdonald and Hadfield (2017) and it is also included here for completeness.

For most of these time series the mining SSC is much lower than the background and background plus mining SSC. As such, to enable the statistics to be displayed the data-ranges for the mining plume SSC need to be different to the background and background plus mining. Hence, note that the background and the background plus mining panels use the same axis limits but the mining panel is on a different axis limit.

As with the time series presented in Macdonald and Hadfield (2017), the differences in the distributions between the background and the background plus mining tend to be small for most cases. The absolute differences are more noticeable in the extreme events (95thpercentile, 99th percentile and the maximum). The largest differences can be seen at the locations: Source A to Whanganui (20), Graham Bank and at The Crack.

Table 2-1: The suspended sediment concentration (SSC) statistics (25th, 50th, 95th and 99th percentiles, and maximum) for the ten locations assessed in the worst case modelling report. This is for surface concentrations sourced from background sediments.

Location	25th percentile (mg/L)	Median (mg/L)	95th percentile (mg/L)	99th percentile (mg/L)	Maximum (mg/L)
Patea	9.15	18.45	92.81	144.33	241.85
South Traps	1.61	3.05	11.03	17.23	34.97
North Traps	1.89	3.60	12.37	18.90	51.38
Rolling Grounds	0.01	0.06	1.12	3.16	7.46
Graham Bank	0.24	0.60	4.49	8.62	15.09
Source A to Whanganui 20	0.35	0.88	5.91	10.56	17.05
Source A North 20 km	2.09	4.29	15.70	28.01	44.33
The Crack 1	0.24	0.72	4.72	8.66	16.40
The Crack 2	0.20	0.56	4.08	8.06	15.21
Project reef	0.67	1.63	8.27	12.31	20.60

Table 2-2: The suspended sediment concentration (SSC) statistics (25th, 50th, 95th and 99th percentiles, and maximum) for the ten locations assessed in the worst case modelling report. This is for surface concentrations sourced from mining sediments from mining site A.

Location	25th percentile (mg/L)	Median (mg/L)	95th percentile (mg/L)	99th percentile (mg/L)	Maximum (mg/L)
Patea	0.04	0.13	0.64	1.04	1.76
South Traps	0.08	0.21	1.15	1.82	2.81
North Traps	0.06	0.19	0.98	1.60	2.75
Rolling Grounds	0.00	0.02	0.23	0.47	1.75
Graham Bank	0.17	0.40	2.23	4.06	7.25
Source A to Whanganui 20	0.17	0.40	2.13	4.19	8.03
Source A North 20 km	0.01	0.03	0.32	0.49	0.73
The Crack 1	0.17	0.43	2.63	4.04	6.25
The Crack 2	0.25	0.64	3.17	4.90	9.29
Project reef	0.09	0.27	1.63	2.89	4.83

Table 2-3: The suspended sediment concentration (SSC) statistics (25th, 50th, 95th and 99th percentiles, and maximum) for the ten locations assessed in the worst case modelling report. This is for surface concentrations sourced from background plus mining sediments from mining site A.

Location	25th percentile (mg/L)	Median (mg/L)	95th percentile (mg/L)	99th percentile (mg/L)	Maximum (mg/L)
Patea	8.66	18.29	92.23	150.60	270.31
South Traps	1.69	3.22	10.66	16.70	34.29
North Traps	1.90	3.64	12.14	18.55	51.35
Rolling Grounds	0.03	0.10	1.20	3.22	7.67
Graham Bank	0.62	1.19	5.06	9.33	15.47
Source A to Whanganui 20	0.74	1.49	6.01	10.78	17.91
Source A North 20 km	1.71	3.91	15.36	27.51	43.30
The Crack 1	0.71	1.56	5.40	8.69	15.76
The Crack 2	0.74	1.48	5.43	8.46	14.97
Project reef	0.92	2.17	7.63	11.74	20.08

Table 2-4: The suspended sediment concentration (SSC) statistics (25th, 50th, 95th and 99th percentiles, and maximum) for the ten locations assessed in the worst case modelling report. This is for near-bottom concentrations sourced from background sediments.

Location	25th percentile (mg/L)	Median (mg/L)	95th percentile (mg/L)	99th percentile (mg/L)	Maximum (mg/L)
Patea	105.88	220.89	1016.48	1647.69	2359.34
South Traps	6.79	15.86	96.05	168.47	226.53
North Traps	9.36	20.76	114.33	191.33	259.71
Rolling Grounds	0.09	0.57	15.34	42.05	68.61
Graham Bank	4.12	12.44	83.93	164.15	222.80
Source A to Whanganui 20	3.84	11.16	76.45	149.55	206.43
Source A North 20 km	14.06	29.18	138.78	249.39	366.67
The Crack 1	2.62	8.66	61.24	123.46	180.28
The Crack 2	2.44	7.53	54.09	113.80	164.36
Project reef	4.50	11.56	71.94	139.22	195.04

Table 2-5: The suspended sediment concentration (SSC) statistics (25th, 50th, 95th and 99th percentiles, and maximum) for the ten locations assessed in the worst case modelling report. This is for near-bottom concentrations sourced from mining sediments from mining site A.

Location	25th percentile (mg/L)	Median (mg/L)	95th percentile (mg/L)	99th percentile (mg/L)	Maximum (mg/L)
Patea	0.08	0.25	1.03	1.48	2.63
South Traps	0.15	0.30	1.47	2.42	3.67
North Traps	0.11	0.27	1.30	1.98	3.35
Rolling Grounds	0.01	0.03	0.28	0.69	1.49
Graham Bank	0.28	0.60	2.46	4.52	8.20
Source A to Whanganui 20	0.28	0.59	2.44	4.81	9.14
Source A North 20 km	0.01	0.04	0.42	0.64	0.88
The Crack 1	0.34	0.77	3.30	5.29	8.00
The Crack 2	0.47	1.00	3.88	5.97	10.20
Project reef	0.18	0.38	1.85	3.39	5.57

Table 2-6: The suspended sediment concentration (SSC) statistics (25th, 50th, 95th and 99th percentiles, and maximum) for the ten locations assessed in the worst case modelling report. The suspended sediment concentration (SSC) statistics (25th, 50th, 95th and 99th percentiles, and maximum) for the ten locations assessed in the worst case modelling report. This is for near-bottom concentrations sourced from background plus mining sediments from mining site A.

Location	25th percentile (mg/L)	Median (mg/L)	95th percentile (mg/L)	99th percentile (mg/L)	Maximum (mg/L)
Patea	105.49	222.53	1022.89	1685.74	2389.98
South Traps	6.83	16.34	94.93	166.42	226.91
North Traps	9.38	20.61	111.91	188.96	258.98
Rolling Grounds	0.14	0.65	15.34	41.63	68.50
Graham Bank	4.67	12.93	84.16	162.97	223.22
Source A to Whanganui 20	4.35	11.64	75.87	148.94	207.63
Source A North 20 km	13.19	28.45	137.88	247.38	363.00
The Crack 1	3.71	9.54	62.08	124.25	178.57
The Crack 2	3.73	8.68	56.19	114.56	165.29
Project reef	4.83	12.02	71.14	138.15	195.72

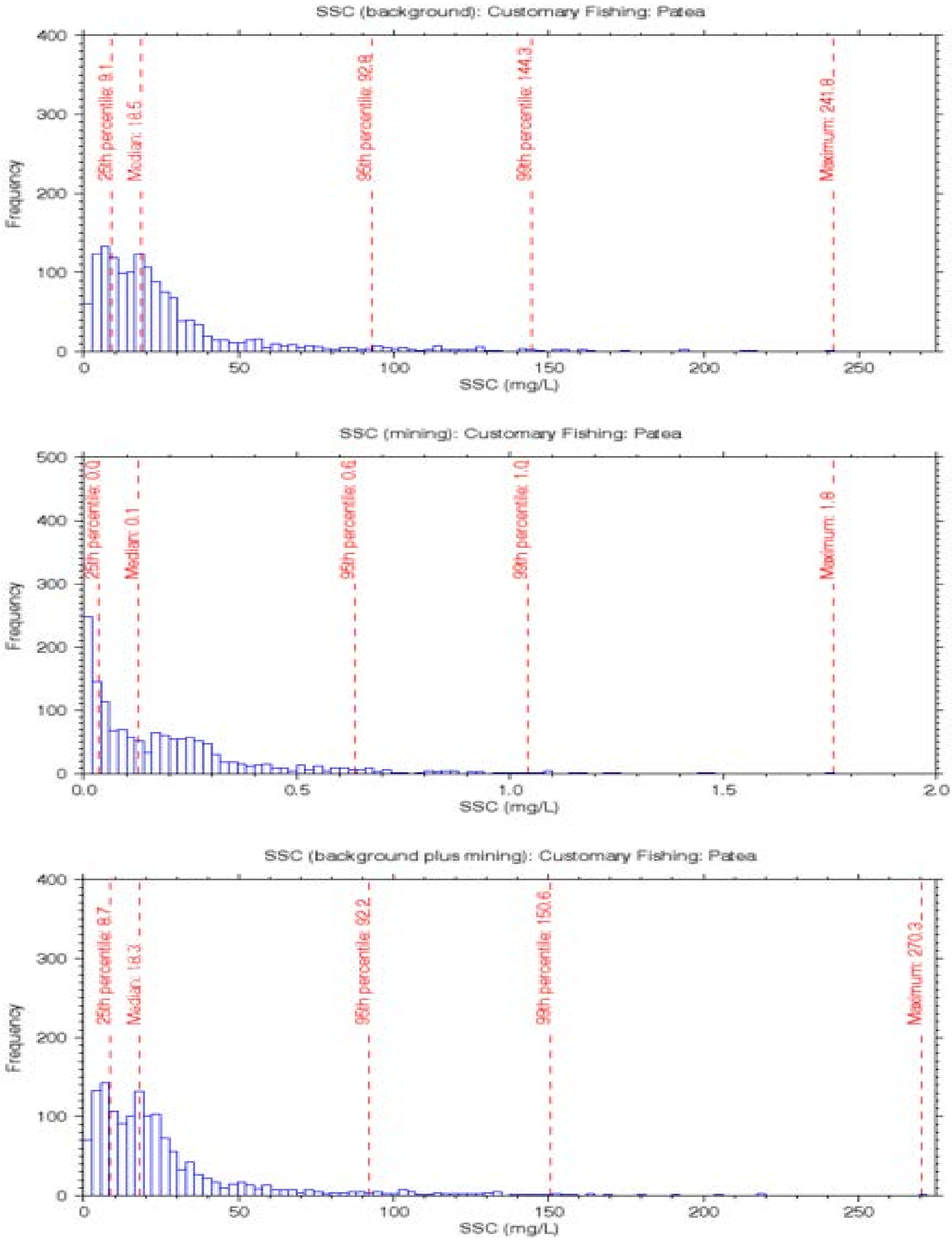

Figure 2-2: Frequency distribution of the surface suspended sediment concentration (SSC) at Patea for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

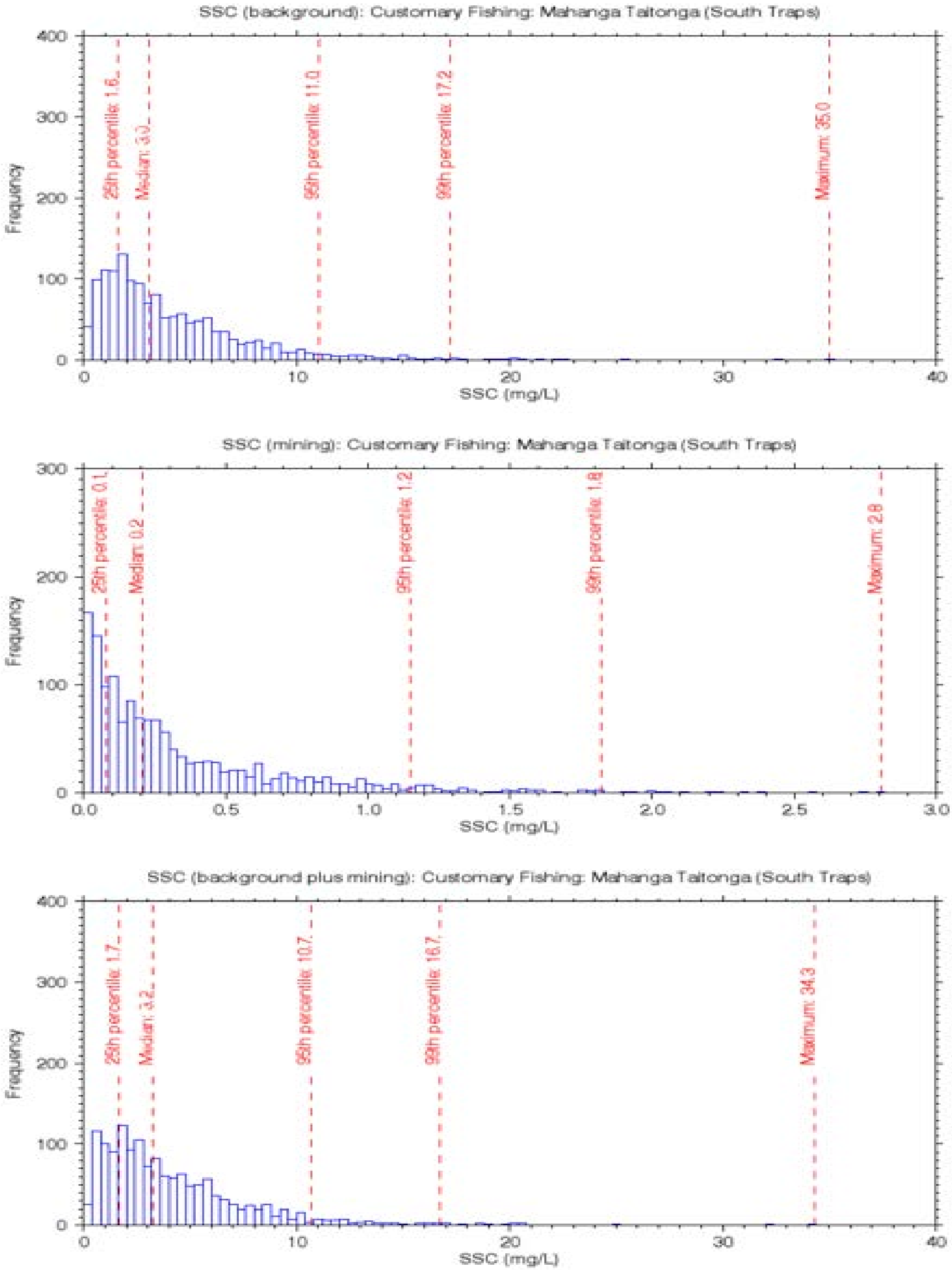

Figure 2-3: Frequency distribution of the surface suspended sediment concentration (SSC) at South Traps for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

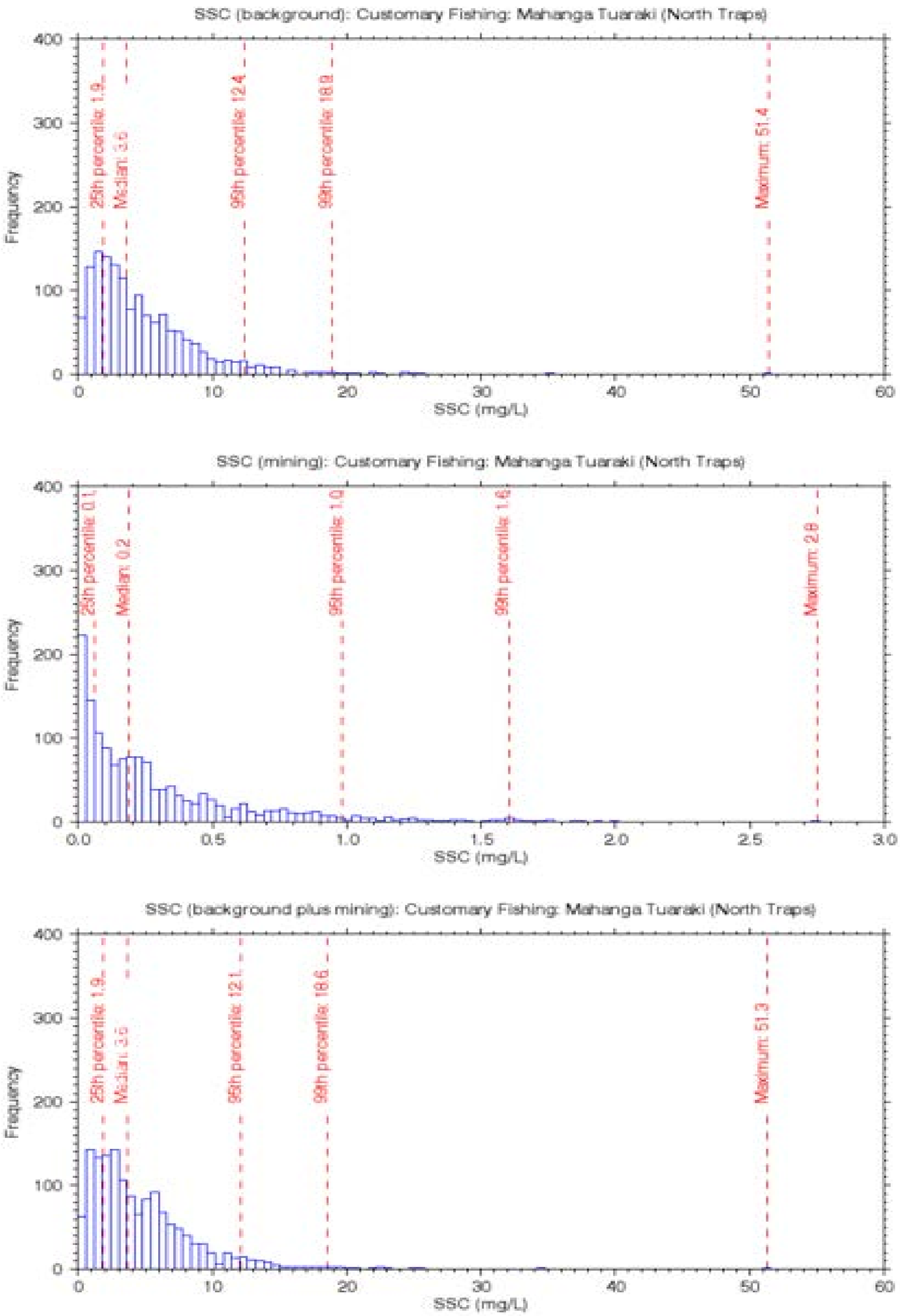

Figure 2-4: Frequency distribution of the surface suspended sediment concentration (SSC) at North Traps for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

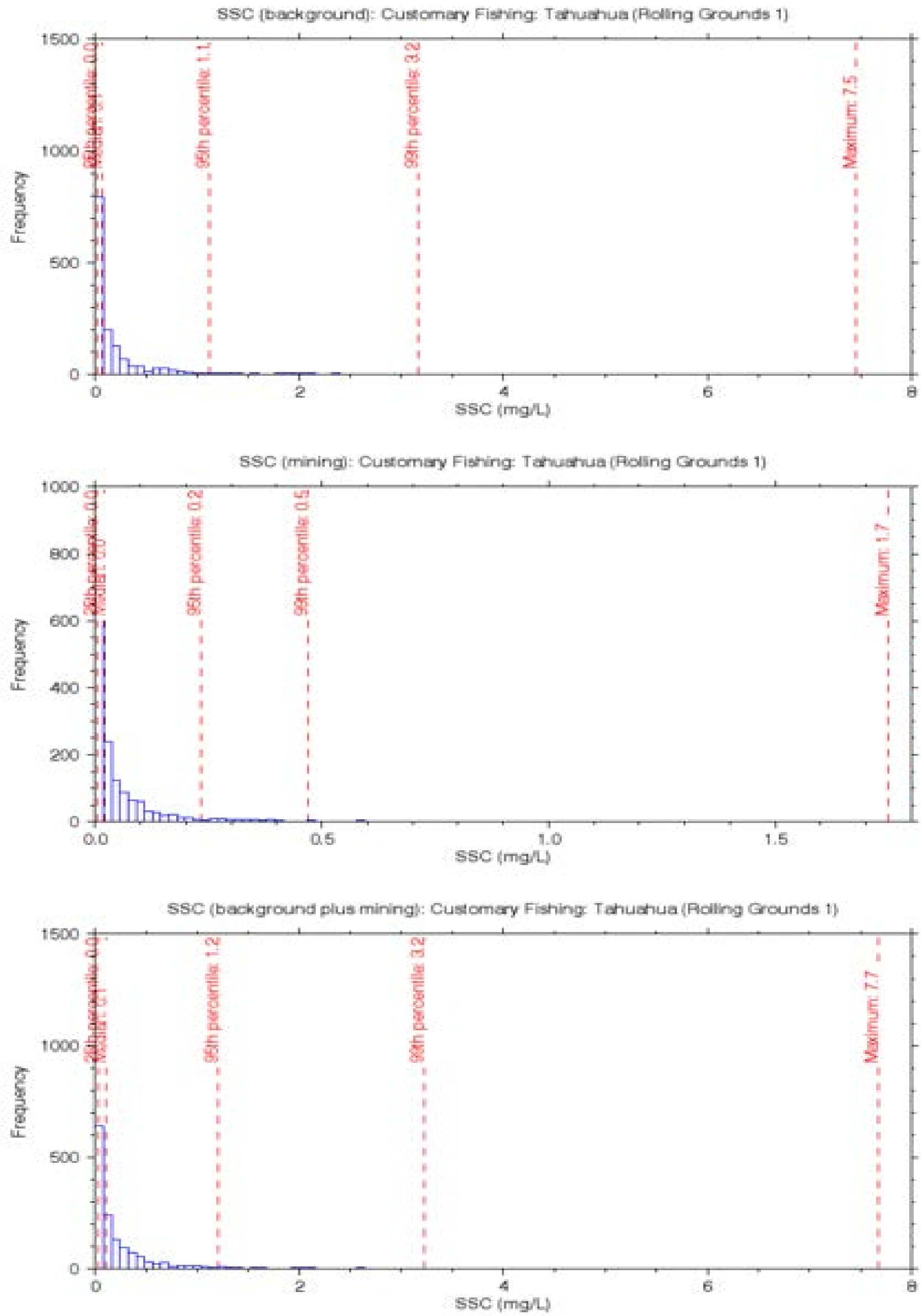

Figure 2-5: Frequency distribution of the surface suspended sediment concentration (SSC) at Rolling Grounds for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels. The background median (25th percentile) is 0.06 (0.01) mg/L and the background plus mining median (25th percentile) is 0.1 (0.03).

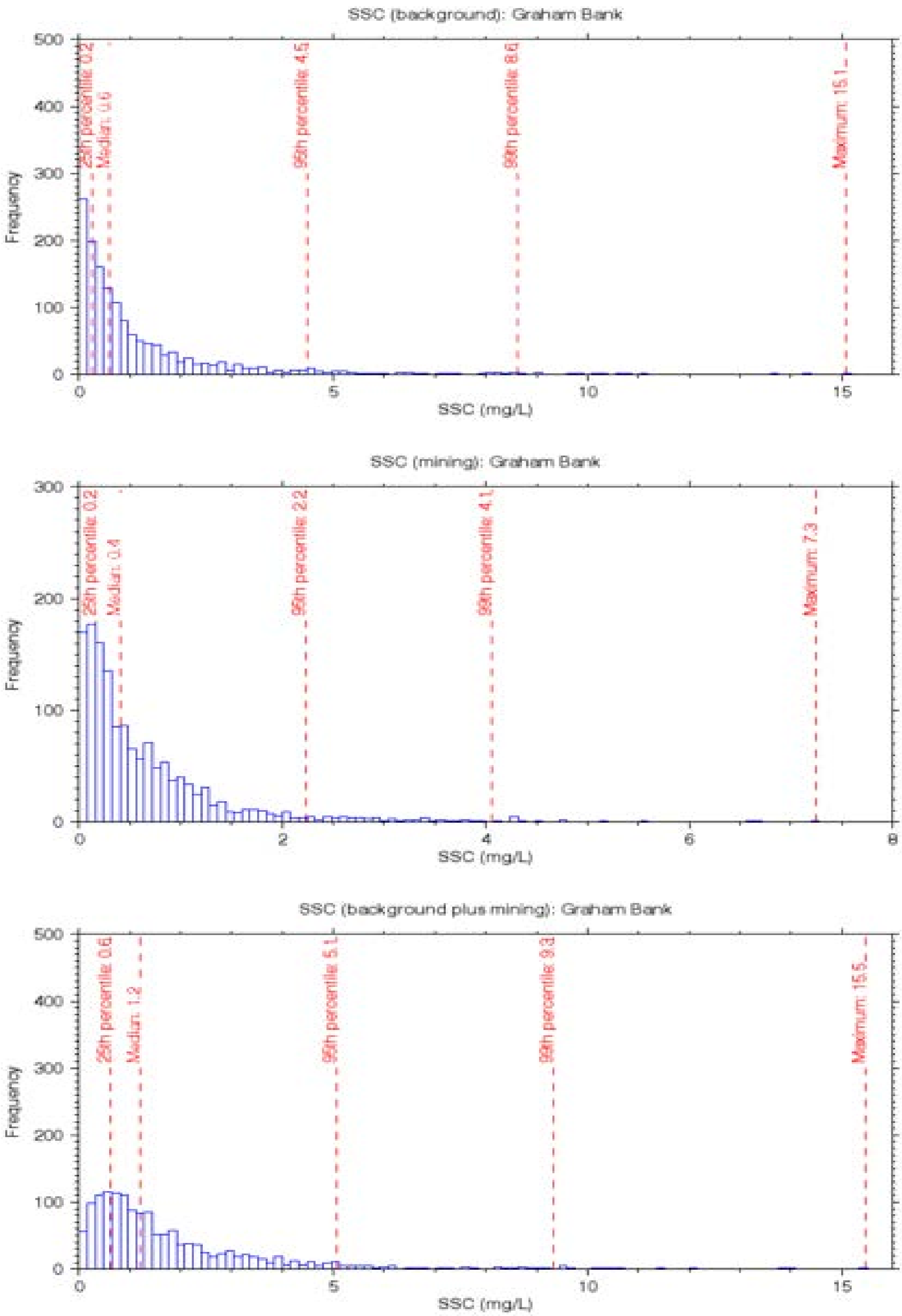

Figure 2-6: Frequency distribution of the surface suspended sediment concentration (SSC) at Graham Bank for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

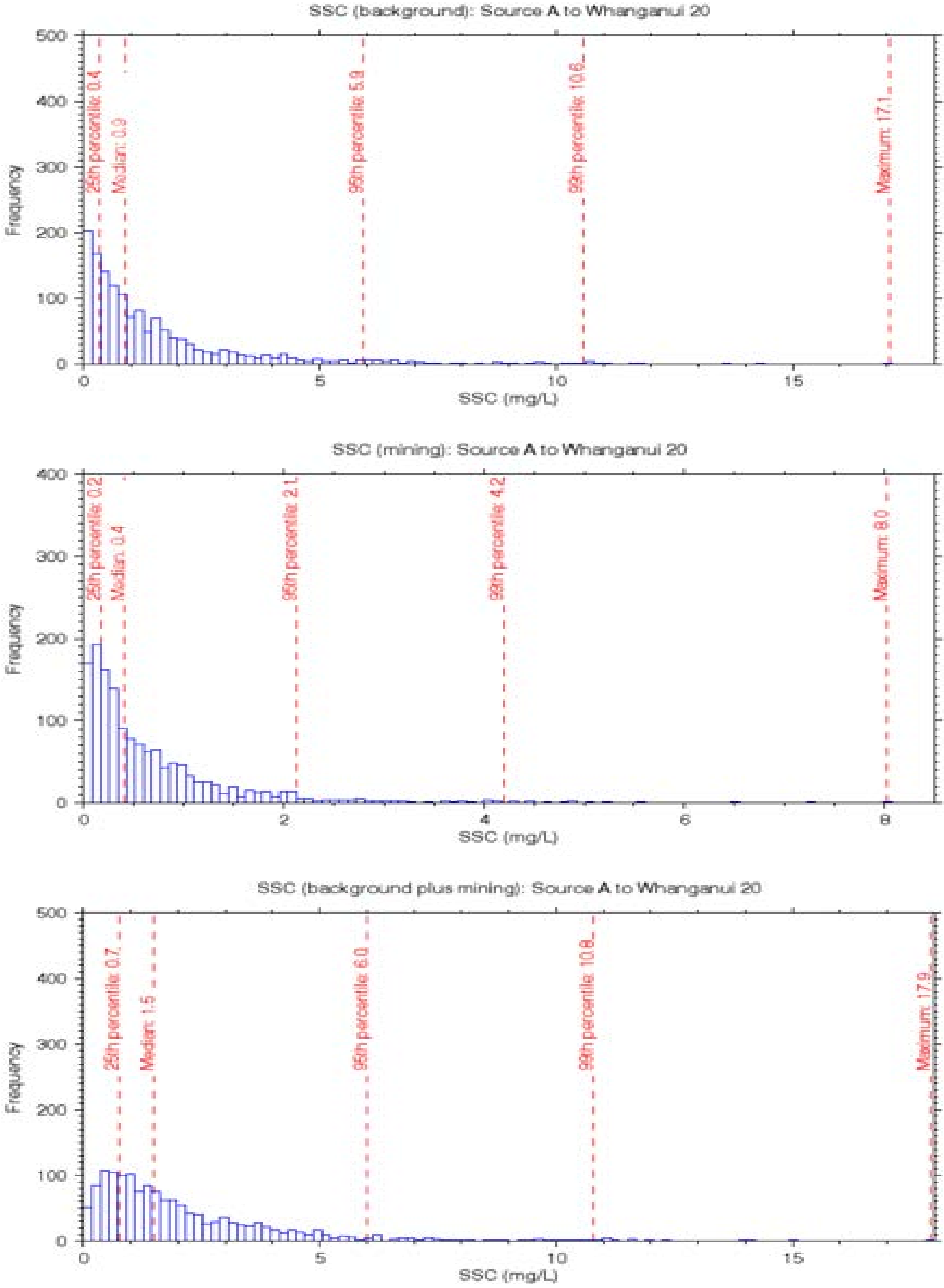

Figure 2-7: Frequency distribution of the surface suspended sediment concentration (SSC) at a location 20km in the direction of the main plume from mining site A for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

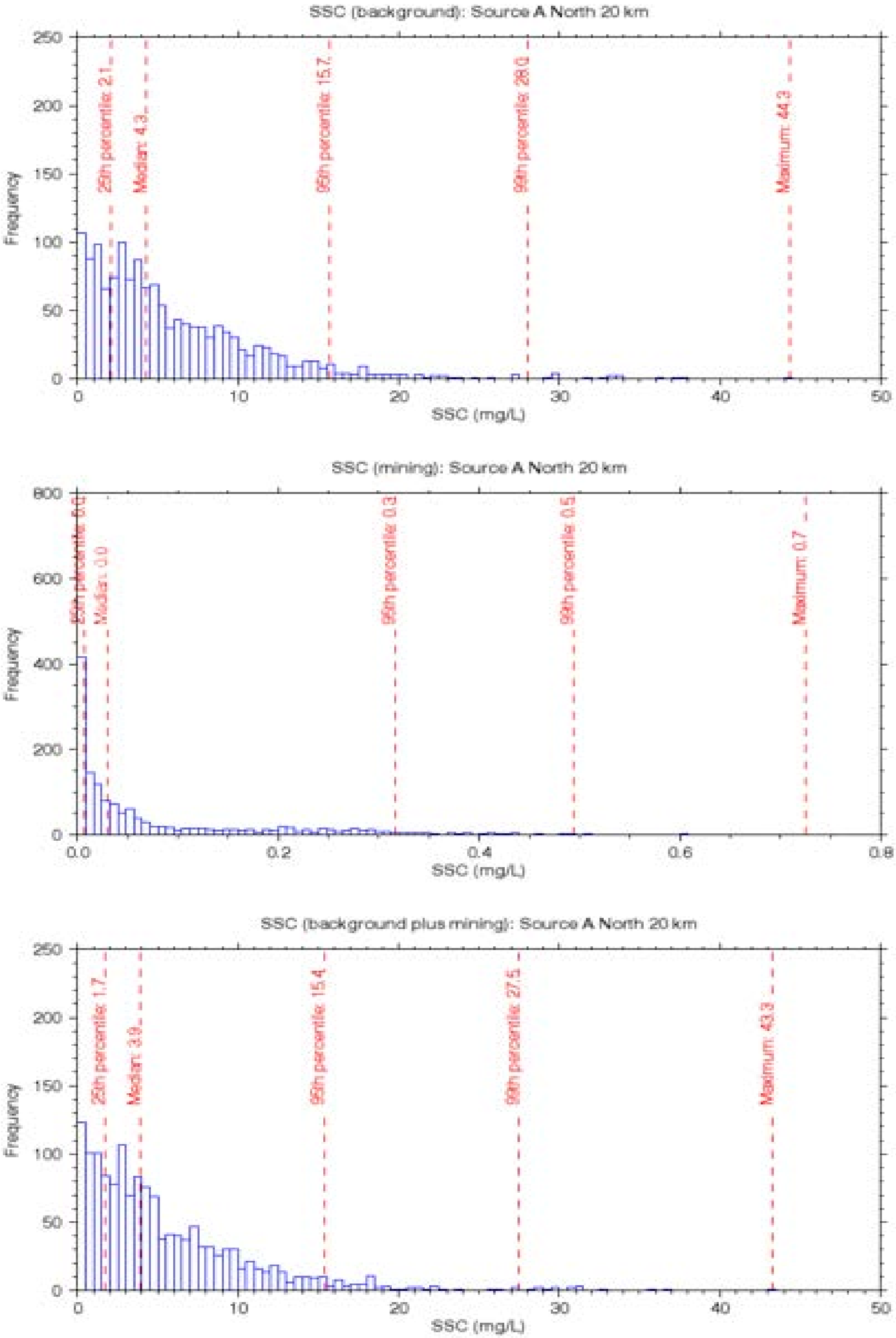

Figure 2-8: Frequency distribution of the surface suspended sediment concentration (SSC) at a point 20km north of mining site A for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

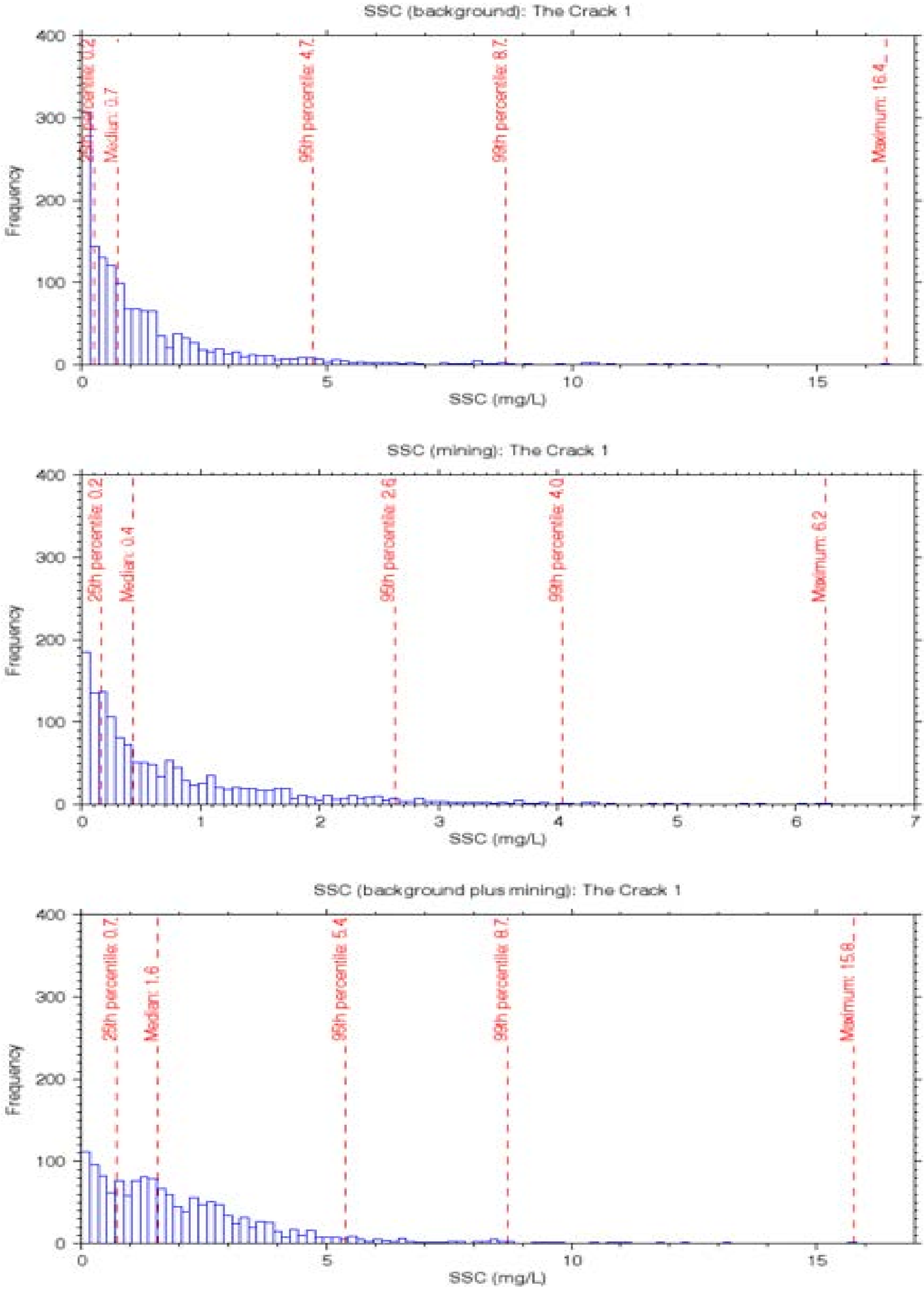

Figure 2-9: Frequency distribution of the surface suspended sediment concentration (SSC) at The Crack (1) for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

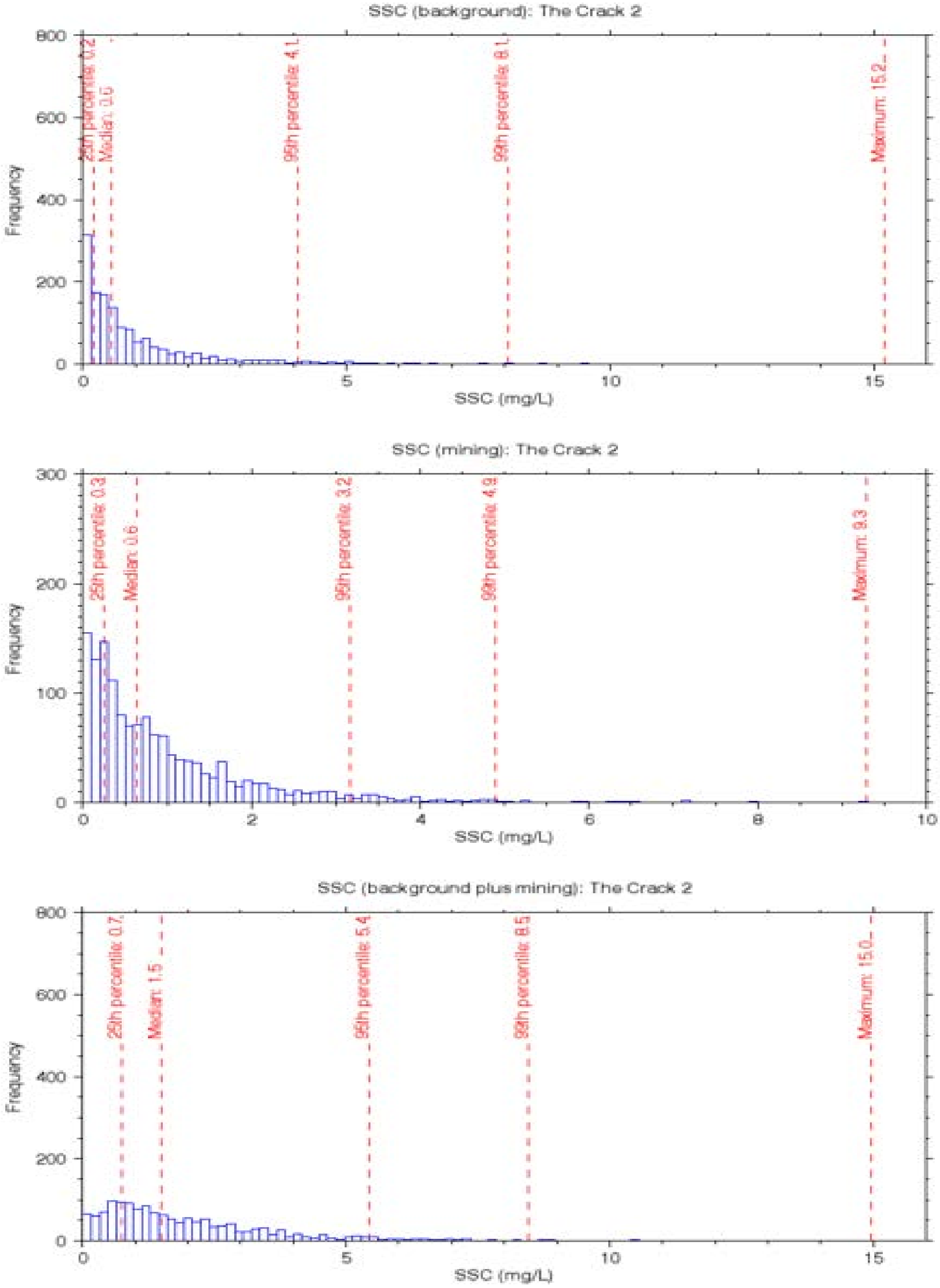

Figure 2-10: Frequency distribution of the surface suspended sediment concentration (SSC) at The Crack (2) for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

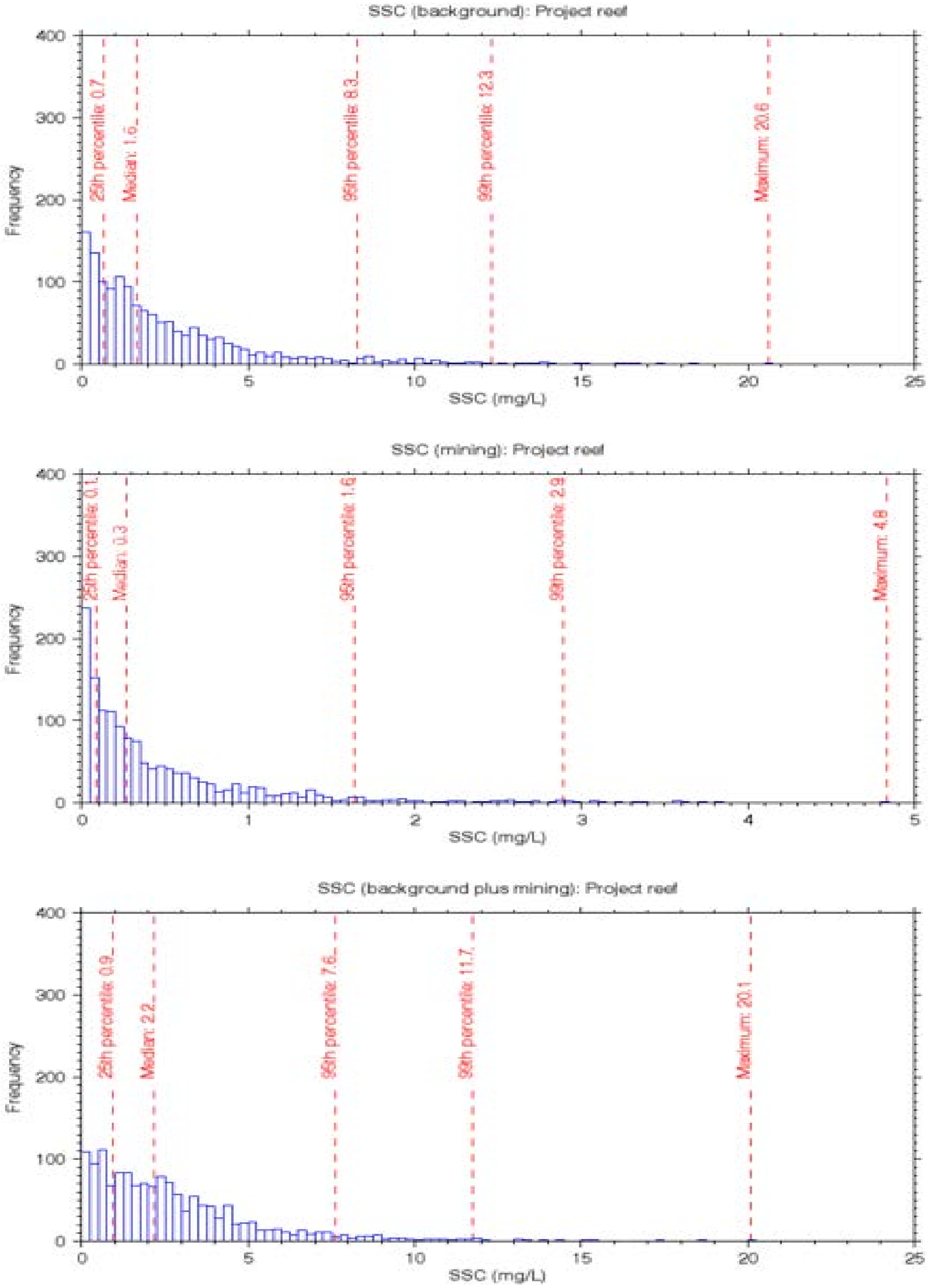

Figure 2-11: Frequency distribution of the surface suspended sediment concentration (SSC) at Project Reef for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

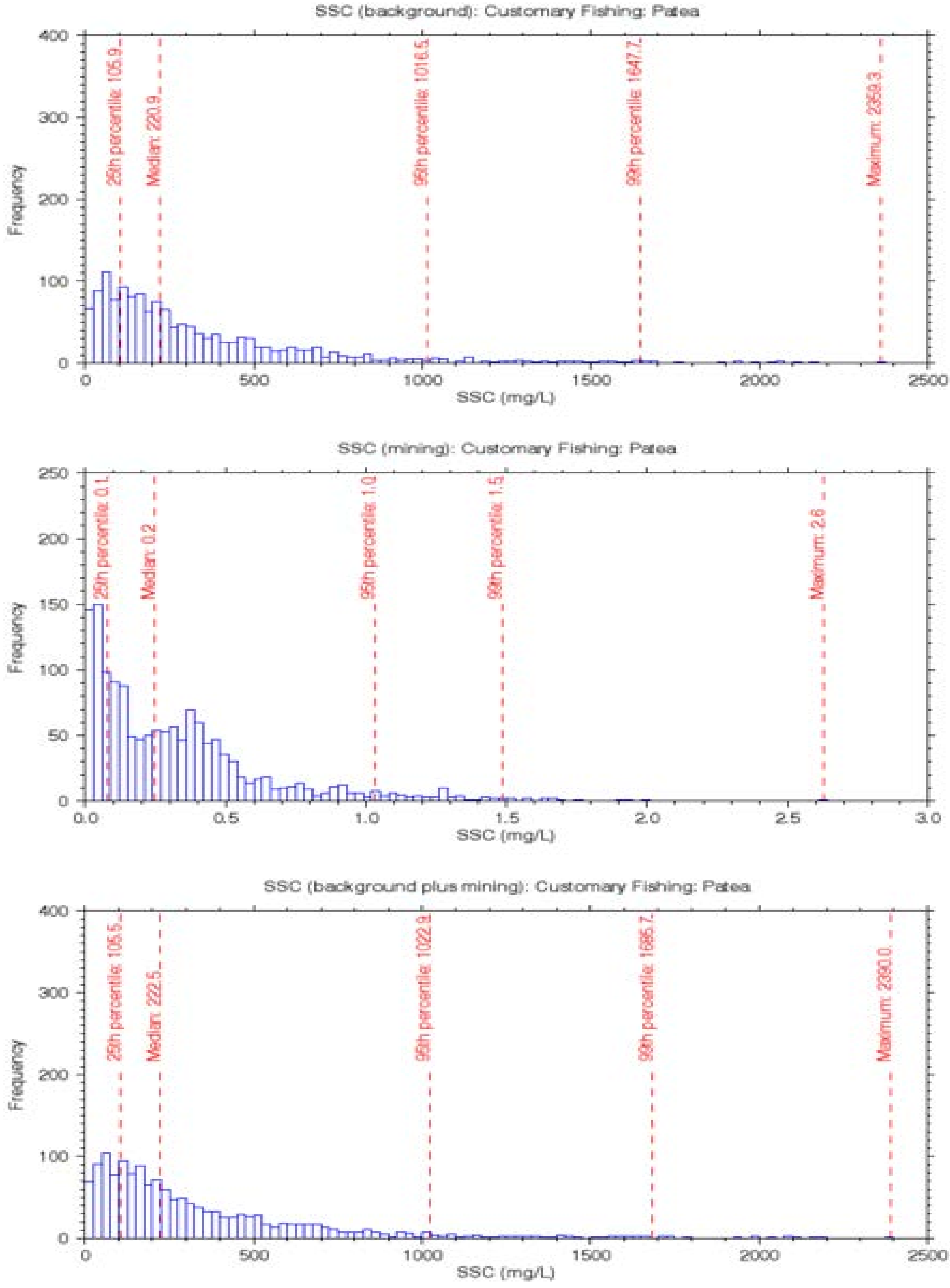

Figure 2-12: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at Patea for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

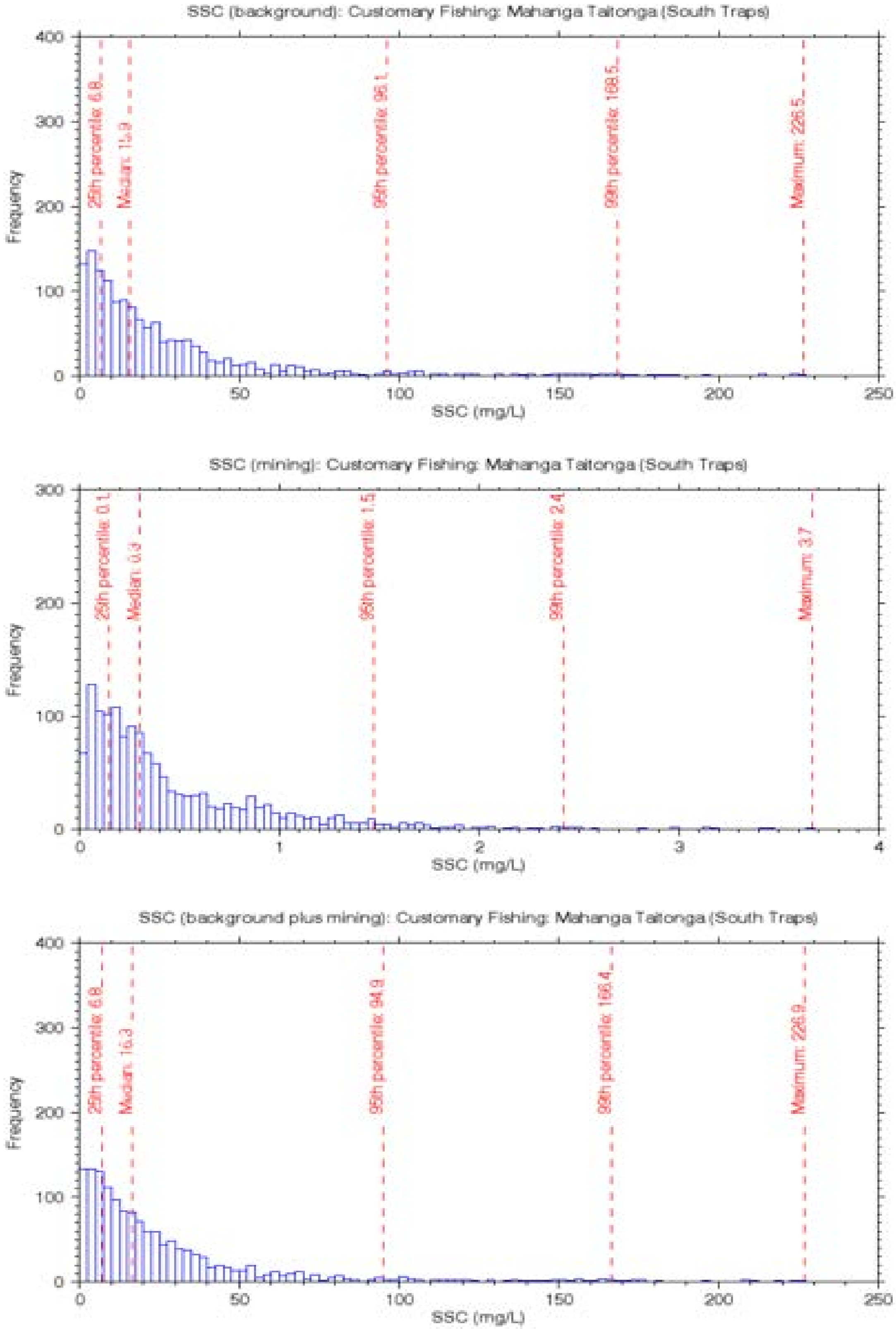

Figure 2-13: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at South Traps for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

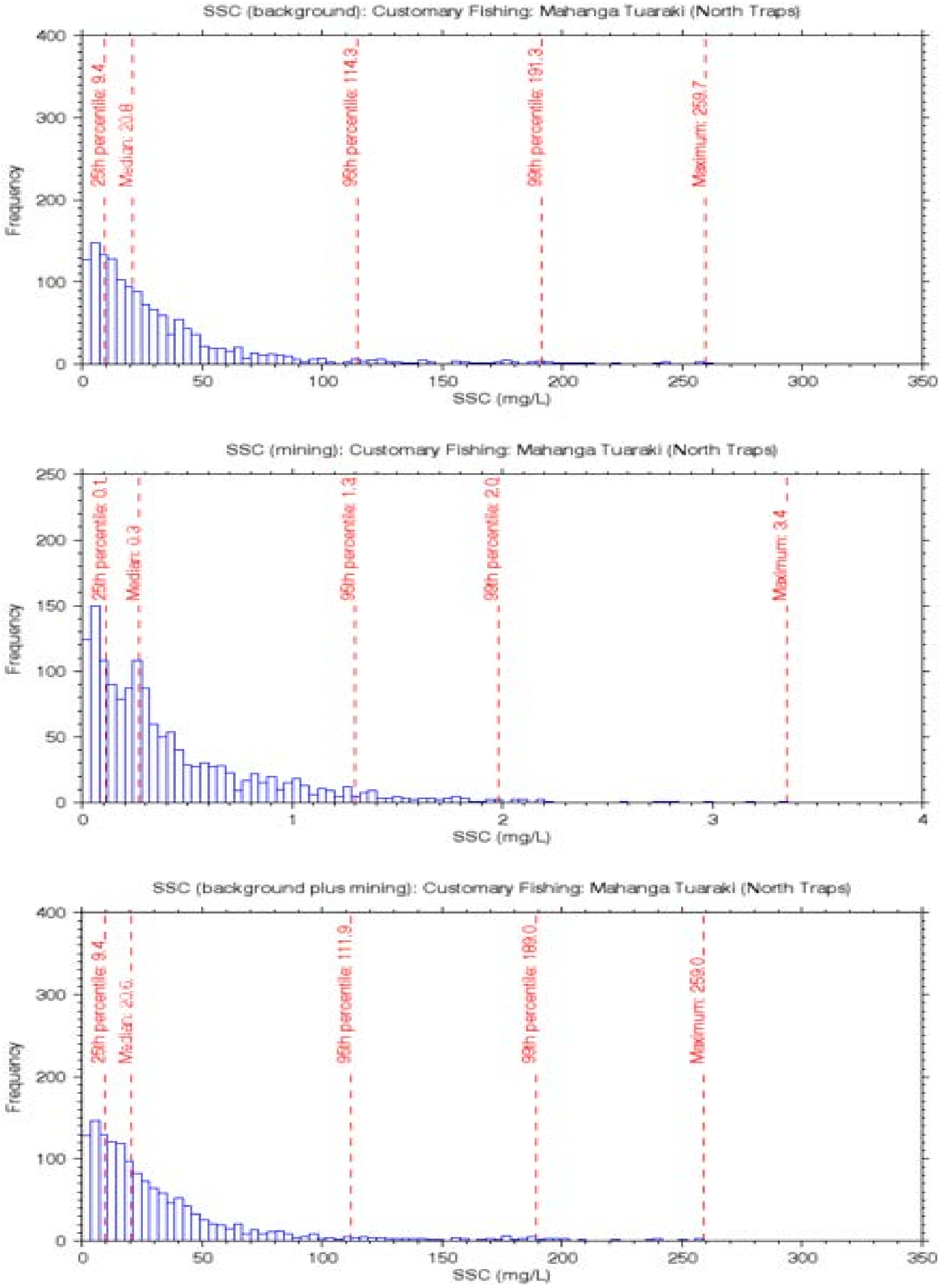

Figure 2-14: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at North Traps for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

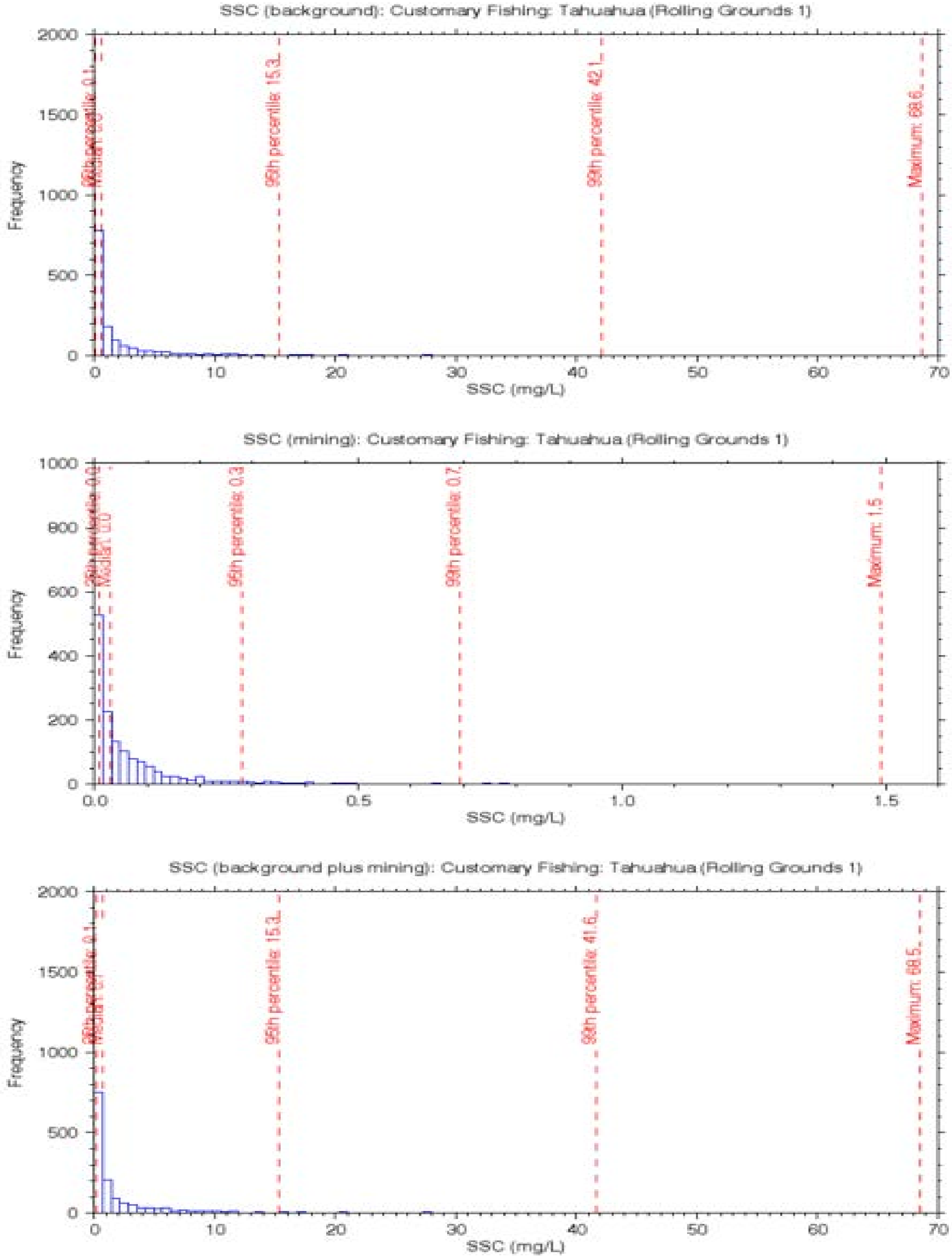

Figure 2-15: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at Rolling Grounds for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels. The background median (25th percentile) is 0.57 (0.09) mg/L and the background plus mining median (25th percentile) is 0.65 (0.14).

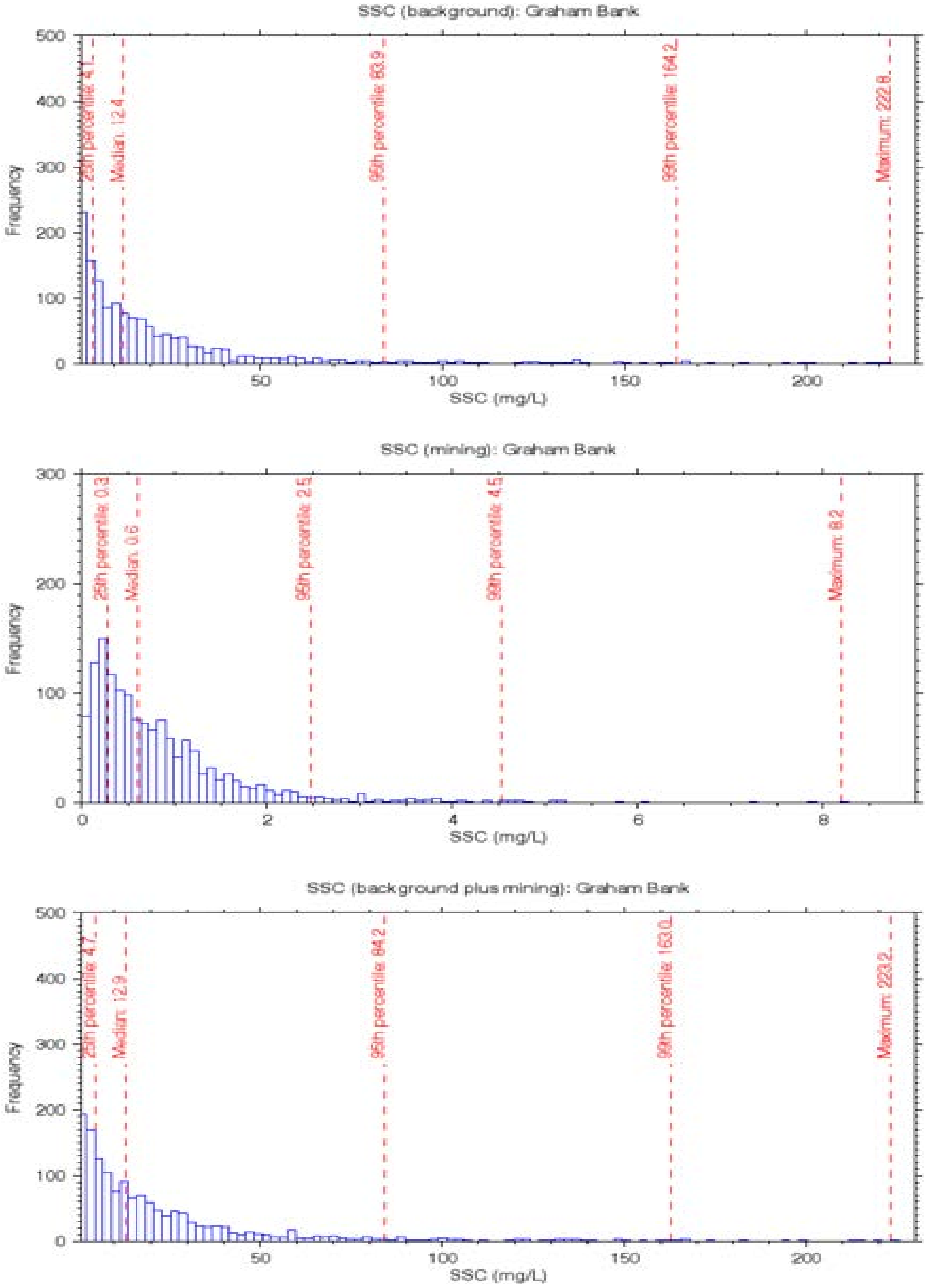

Figure 2-16: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at Graham Bank for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

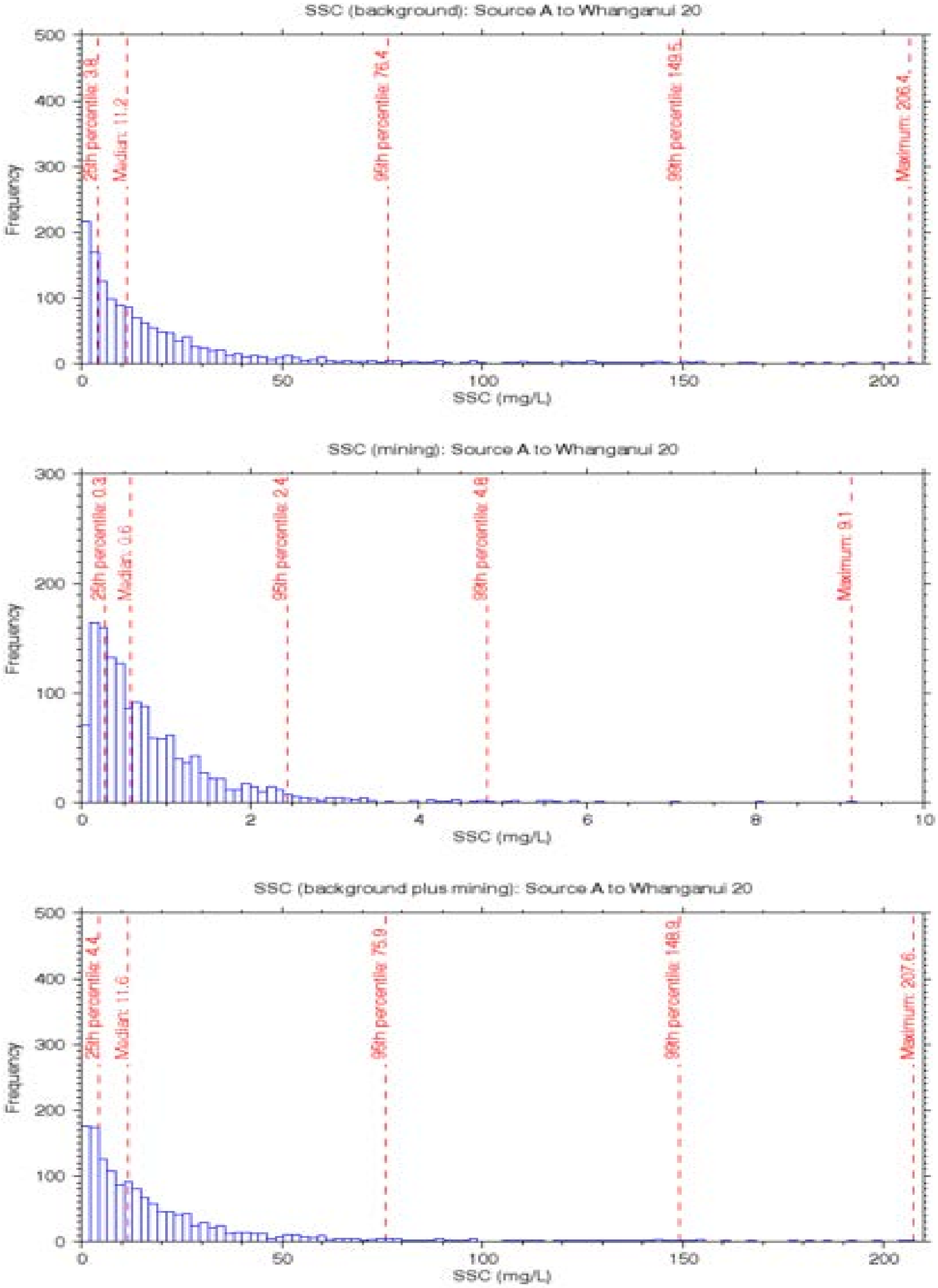

Figure 2-17: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at a location 20km in the direction of the main plume from mining site A for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

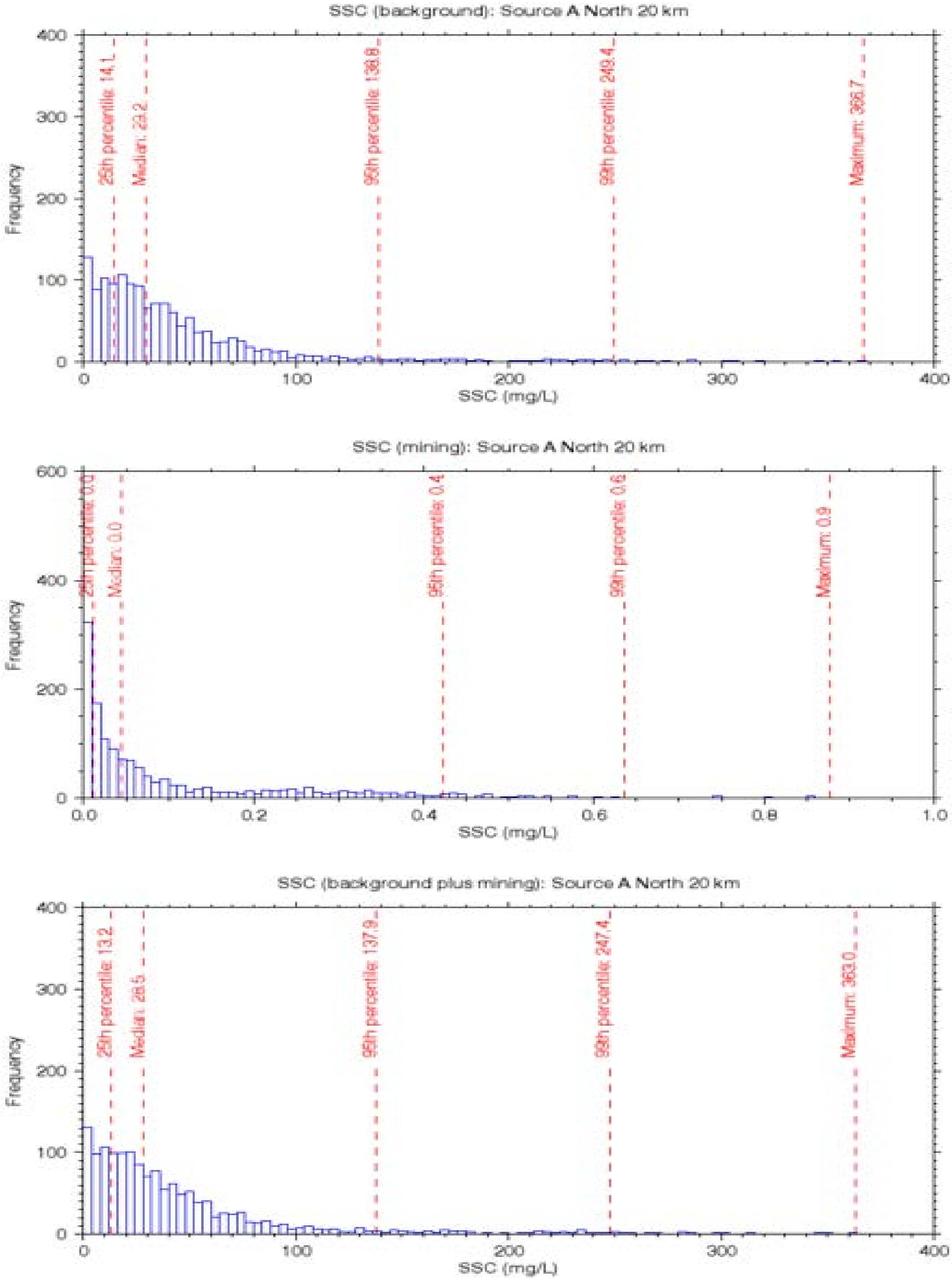

Figure 2-18: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at a location 20km north from mining site A for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

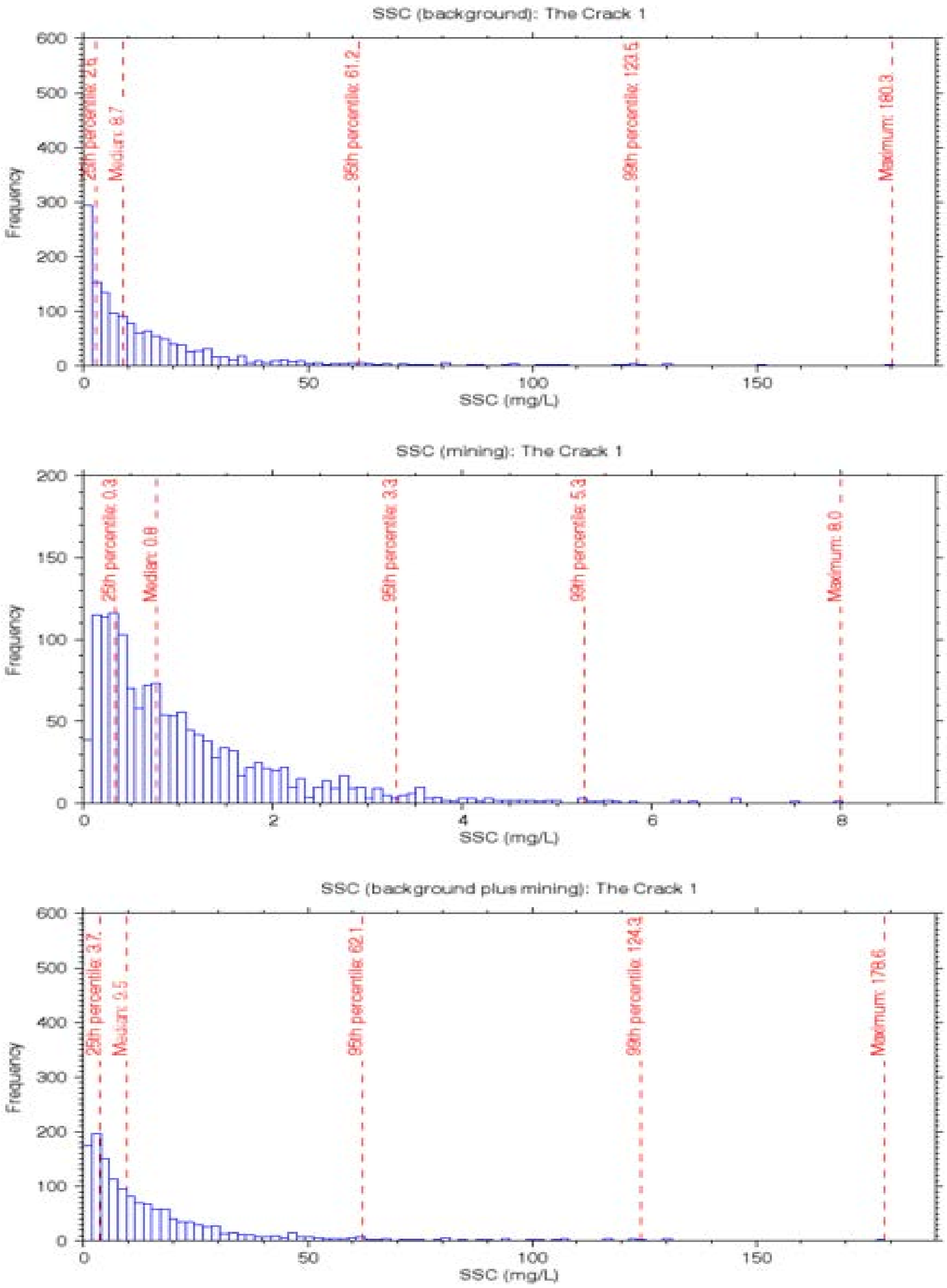

Figure 2-19: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at The Crack (1) for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

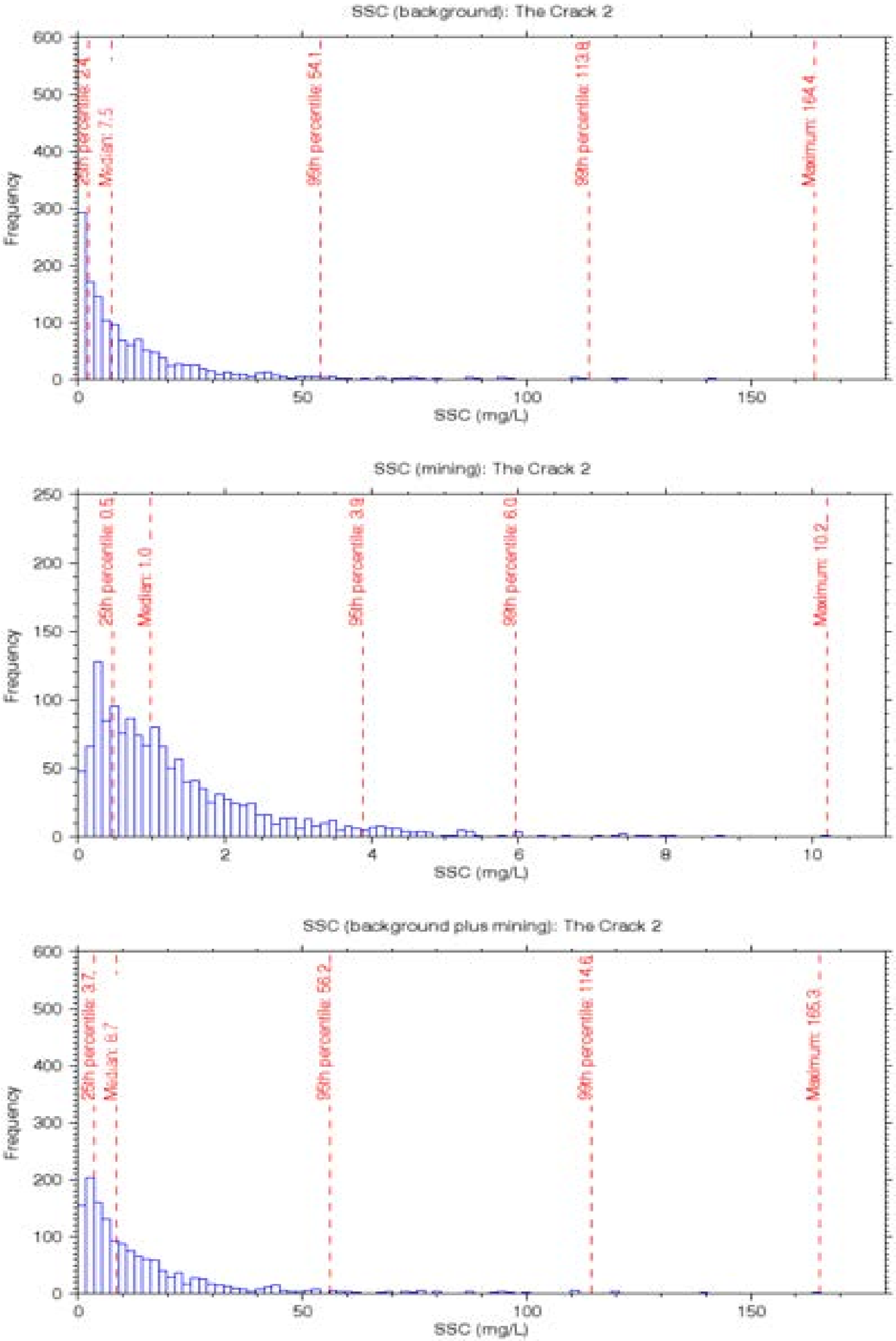

Figure 2-20: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at The Crack (2) for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

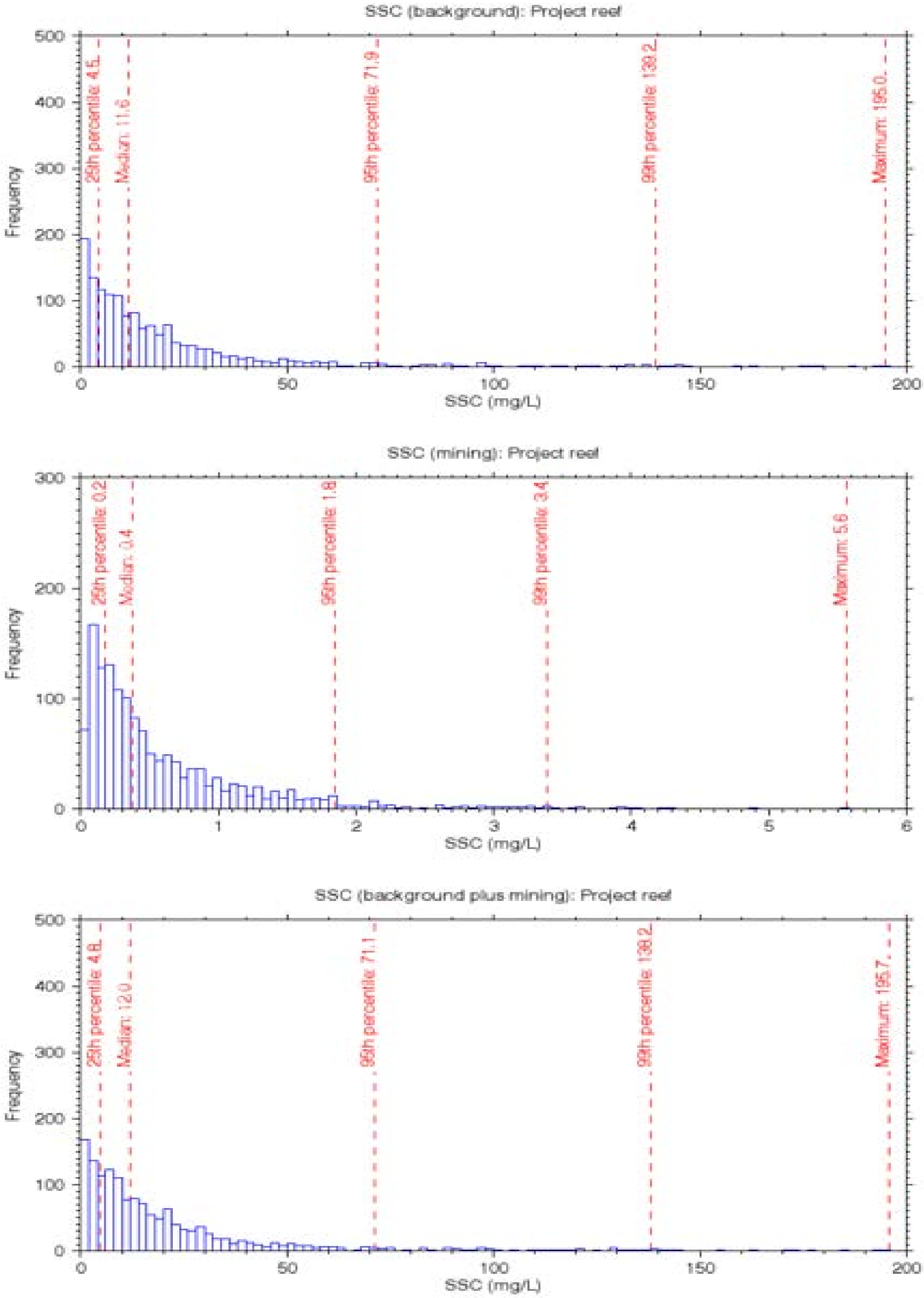

Figure 2-21: Frequency distribution of the near-bottom suspended sediment concentration (SSC) at Project Reef for the worst case scenario modelling. The 25%, 50%, 95% and 99th percentile are indicated along with the maximum. Top is for background only, middle is for mining only and bottom is for background and mining. Note that the middle panel has a different scale to the top and bottom panels.

2.2 Question 6.

This question asks, "*Including the Project Reef, provide the predicted sedimentation rates, both the 5-day and 365-day rates, for the same ten locations which were assessed for SSC in the worst case scenario modelling. Like the SSC tables, this should include 'background' (no-mining), 'mining derived', and 'background plus mining' for both the 5-day and 365-day deposition rates*."

The tables for the maximum 5-day and 365-day deposition are presented below for the locations that were presented in the worst case scenario report. Background, mining and background with mining are all presented for mine site A (the site that produces the largest effect). Spatial variability of the deposition rates can be seen in Figures 3-20 to 3-23 of the Worst Case Scenario sediment report (found here: http://www.epa.govt.nz/EEZ/EEZ000011/Appendix_to_HRW_Report_updated.pdf)

Note that the background sediments can also undergo erosion and there are regions where the background sediments tend to erode rather than deposit sediments. This erosion is noticeable in the 365-day deposition and is presented as a negative number in the tables.

Recall that the results from background with mining deposition does not equal the sum of the background and mining deposition as the presence of the mining sediments slightly alters the erosion and deposition of the background sediments.

Table 2-7: The Maximum 5-day increment in sediment bed thickness for suspended sediment from mining source A. The values for the 10 study locations are shown.

Location	Background (mm)	Mining (mm)	Mining with background (mm)
Patea	4.21	0.01	3.69
South Traps	0.32	0.01	0.40
North Traps	0.27	0.01	0.27
Rolling Grounds	0.56	0.01	0.54
Graham Bank	0.40	0.02	0.42
Source A to Whanganui 20	1.09	0.03	1.11
Source A North 20 km	0.52	0.00	0.48
The Crack 1	0.62	0.03	0.56
The Crack 2	0.36	0.04	0.37
Project reef	0.21	0.02	0.20

Table 2-8: The Maximum 365-day increment in sediment bed thickness for suspended sediment from mining source A. The values for the 10 study locations are shown.

Location	Background (mm)	Mining (mm)	Mining with background (mm)
Patea	0.38	0.02	-0.09
South Traps	-1.31	0.02	-0.43
North Traps	-6.50	0.02	-5.97
Rolling Grounds	2.61	0.01	2.61
Graham Bank	-7.07	0.04	-6.20
Source A to Whanganui 20	5.26	0.03	5.30
Source A North 20 km	-0.42	0.01	-0.67
The Crack 1	-0.52	0.05	-0.57
The Crack 2	0.78	0.05	1.12
Project reef	-2.03	0.03	-1.90

2.3 Question 8.

This question asks, "*If there is information available on river-borne particle size distribution (PSD), provide that data for the material that enters the coastal marine area (CMA) from rivers during average April 2017 and flood flows. Rivers of interest to the DMC include the Tangahoe, Manawapou, Patea, Waitotara, Whanganui and Whangaehu*."

There is some limited information on suspended sediment concentration from the rivers that was included in the original submission in section 2.5 of Hadfield and Macdonald (2015). This is reproduced below. To the best of our knowledge no further information is available.

Table 2-9: Rivers represented in the sediment plume model, with mean freshwater and sediment input rates from WRENZ. From Hadfield and Macdonald (2015).

Name	Flow rate (m3/s)	Sediment rate (kg/s)
Whanganui River	229.0	149.03
Manawatu River	129.5	118.46
Rangitikei River	76.4	35.04
Whangaehu River	47.2	21.82
Patea River	30.4	9.85
Waitotara River	23.3	15.08
Otaki River	30.1	5.46
Whenuakura River	9.9	8.75
Kaupokonui Stream	8.6	0.31
Turakina River	8.4	9.54
Tangahoe	4.2	1.39
Total	593	373

2.4 Question 12

This question asks, "*Define the extent of sediment plume derived changes in PSD within the SSC of the receiving environment, both near shore and closer to the project area.*"

The model uses distinct size classes rather than a particle spectrum but the extent of the plume can be shown for the different size classes. When setting up the model the size classes were chosen to best represent the given material rather than to enable a direct comparison between background and mining. As such, the background sediment classes are not the same size as the mining sediment classes. To perform a comparison between background and mining sediment classes, the mining classes that were the closest match to individual background classes were chosen. This resulted in two different classes to compare. Here we call these classes "fine" sediments and "finest" sediments. The finest sediments include the seabed-derived sediment class with a median size of 0.008 mm, the riverine class with a median size of 0.008mm, the mining class with a median size of 0.004 mm and the mining class with a median size of 0.011 mm. The fine sediments include the seabed-derived sediment class with a median size of 0.031 mm, the riverine input class with a median size of 0.031 mm and the mining input class with a median size of 0.025 mm.

The background sediments do have three further size classes that are larger than the mining sediment classes. As the mining doesn't directly inject sediments into these classes, the mining-derived changes in these classes will be very small to non-existent across the domain.

The figures shown are for the worst case scenario presented in Macdonald and Hadfield (2017). For the fine and finest sediment classes, the extent of sediment plume derived changes in the SSC are shown for the 99th percentile. Mining site A for the 99th percentile has been chosen as this is where the largest mining-plume derived changes in SSC can be seen. When interpreting the figures, it should be noted the analysis done here is not a direct comparison of identical size classes and the resultant should be taken as indicative rather than an exact measure of the changes.

The sediment plume derived changes in PSD will extend as far as the mining plume extends but the magnitude of the change will differ between sediment classes. The extent of the changes in the mining derived sediments for each class mirrors the total SSC mining-derived changes in sediments. That is, the plume frequently extends to the east-southeast from the source location towards the coast at Whanganui.

Coarser sediments sink relatively quickly and, hence, in the background and mining-derived sediments more of the SSC is derived from the finest sediments. As such, the largest mining-derived changes occur in the finest sediments. This is reflected in the changes in each of the size classes due to the mining plume.

In the surface plume for the fine sediments (Figure 2-22), the mining plume is small and the resultant changes in SSC are not discernible in the "background plus mining" figure. Near the bottom (Figure 2-23), the resultant changes in SSC can be seen at the source location but are not discernible throughout the rest of the domain.

For the finest sediments changes are more discernible (Figures 2-24 and 2-25). In the near surface the mining plume increases the finest sediments in the vicinity of the mining location with the region less than 10 mg/L SSC (dark blue in Figure 2-24) moving further offshore, over the mining site.

Similarly, in the near-bottom 99th percentiles, the finest sediments are increased more. This also results in higher sediment concentrations further offshore.

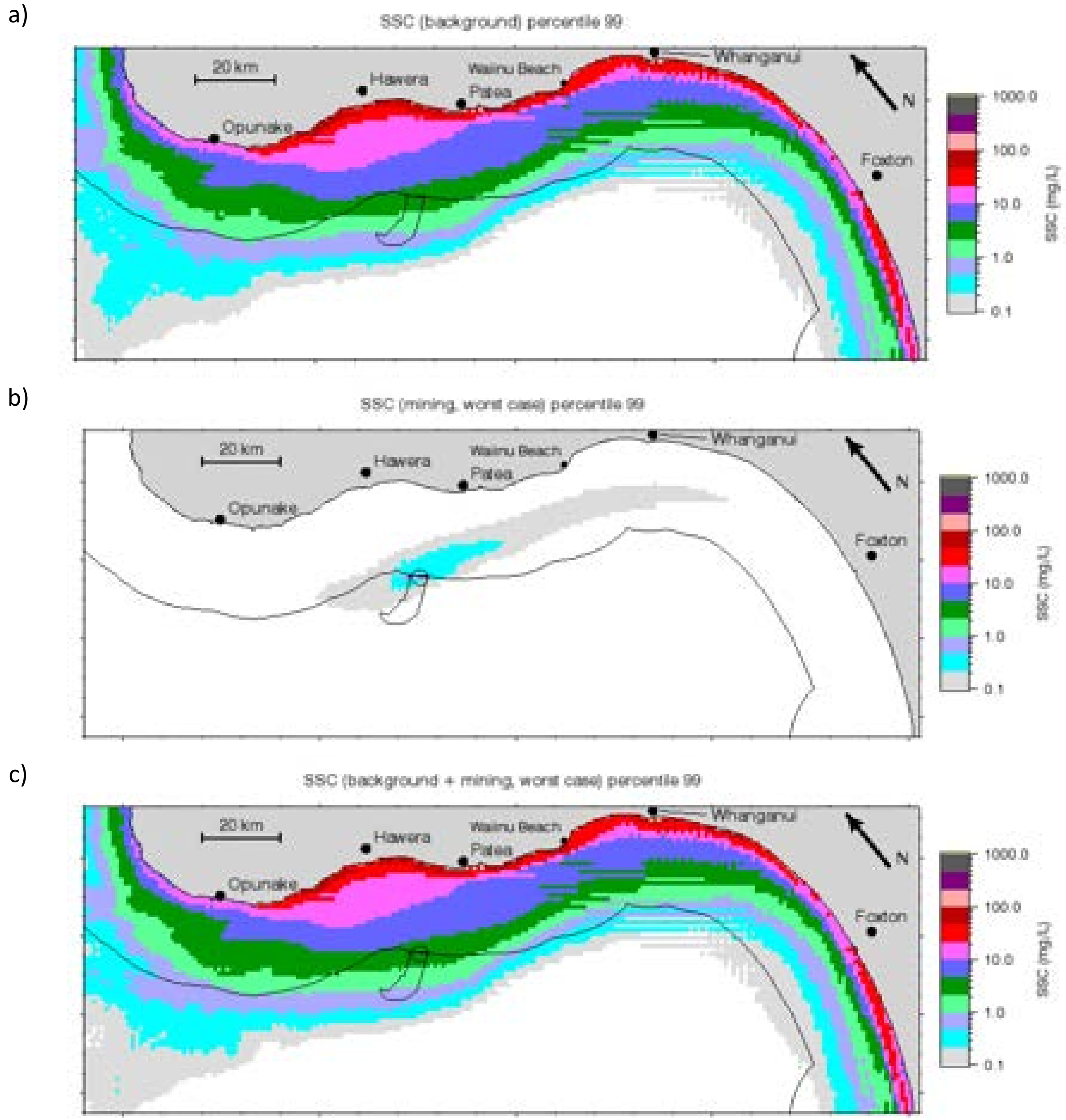

Figure 2-22: 99th percentile near-surface concentration of suspended sediment due to the fine sediments classes from worst case scenario at source location A. a) Background SSC; b) mining-derived SSC; c) background plus mining-derived SSC.

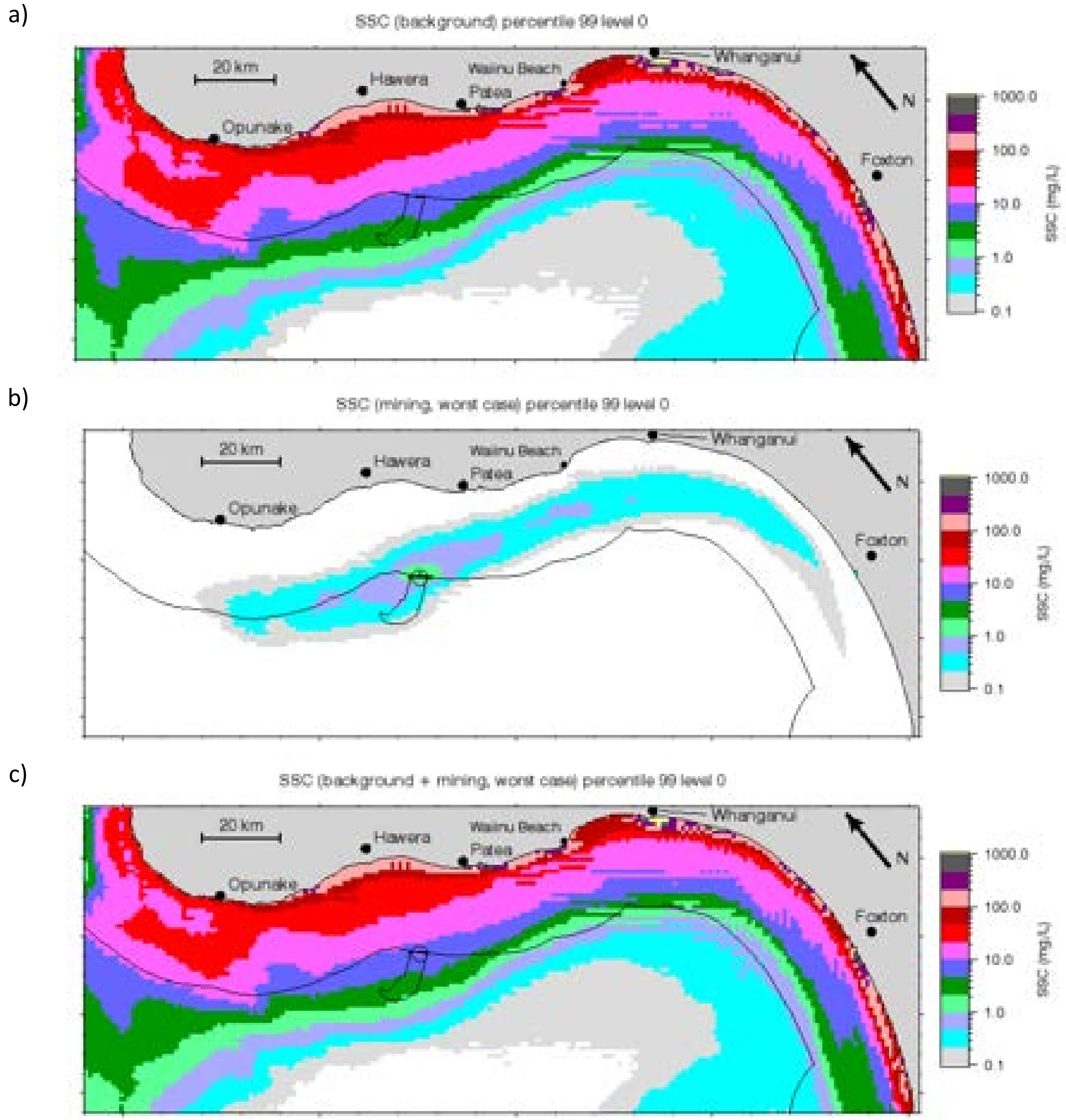

Figure 2-23: 99th percentile near-bottom concentration of suspended sediment due to the fine sediments classes from worst case scenario at source location A. a) Background SSC; b) mining-derived SSC; c) background plus mining-derived SSC.

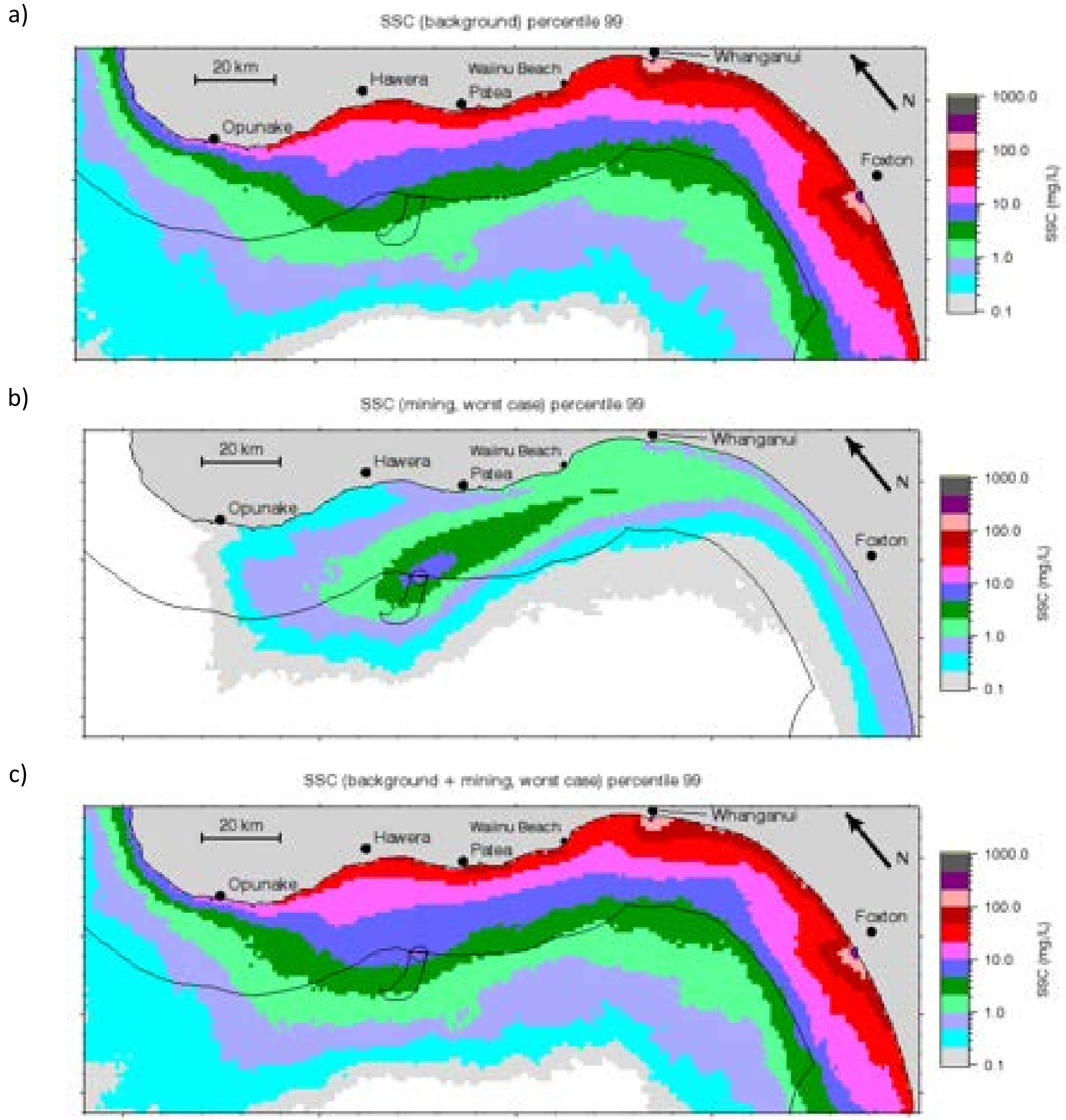

Figure 2-24: 99th percentile near-surface concentration of suspended sediment due to the finest sediments classes from worst case scenario at source location A. a) Background SSC; b) mining-derived SSC; c) background plus mining-derived SSC.

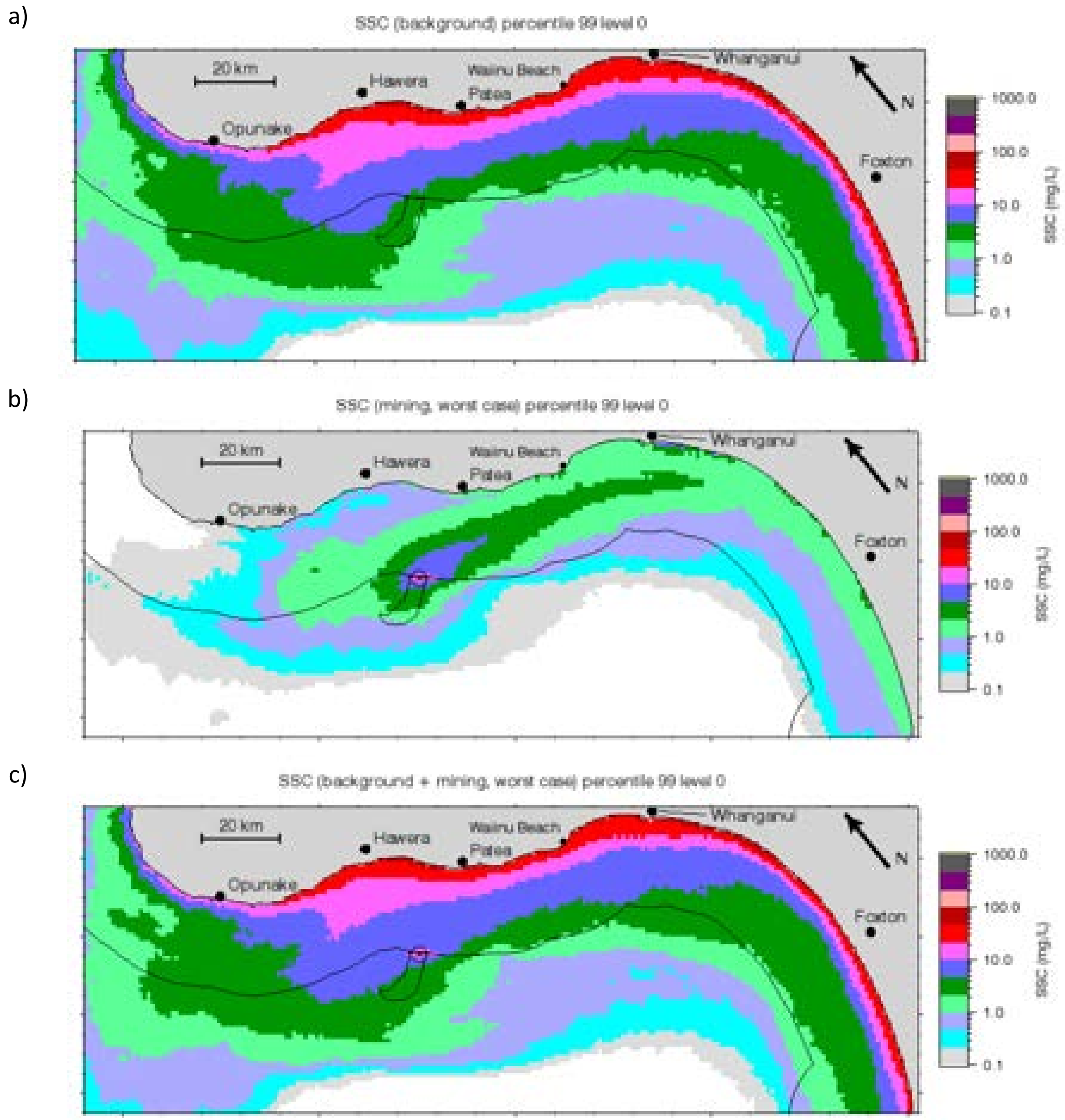

Figure 2-25: 99th percentile near-bottom concentration of suspended sediment due to the finest sediments classes from worst case scenario at source location A. a) Background SSC; b) mining-derived SSC; c) background plus mining-derived SSC.

2.5 Question 13.

This question asks, "*If there is more recent information available regarding krill aggregations in the STB, map these to improve on Figure 6-1 from Report 17. Advise whether any other areas of NZ have similar or greater recorded levels of krill aggregations*".

There are no more recent STB wide data on krill (*Nyctiphanes australis*) distribution available to improve on the information previously available. In New Zealand waters this species occurs around both North and South Islands, and as far south as the Snares Islands (48°S). It also occurs around southern Australia (O'Brian 1988). Dense aggregations of *Nyctiphanes australis* have also been observed in other areas of New Zealand (Bary 1956, Bradford 1972 and 1979, Fenwick 1978, McClatchie et al. 1991). The STB is noted the for the widespread distribution of this species largely driven by production driven by upwelling of nutrient rich water off Kahurangi Point (NW South Island) which is transported into the Bight as the krill populations develop (Foster and Battaerd 1985, Bradford and Chapman 1988, James and Wilkinson 1988).

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