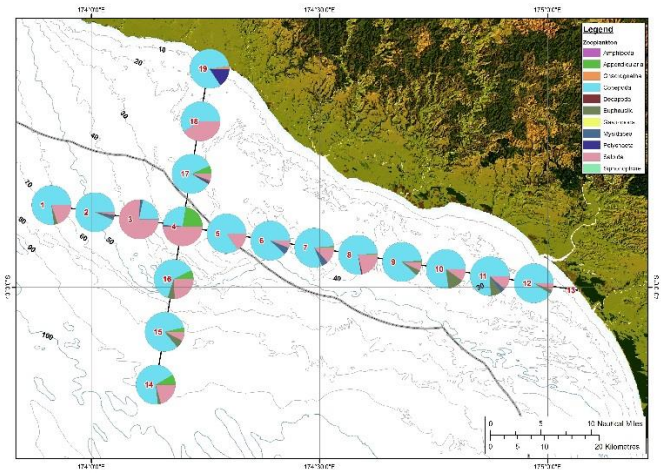
NIWA
Taihoro Nukurangi

Zooplankton communities and surface water quality in the South Taranaki Bight February 2015

Prepared for Trans-Tasman Resources Ltd

May 2015



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Cover image: Plot of the percentage numerical composition of the zooplankton at stations sampled in February 2015 showing the dominance of copepods (turquoise) at most stations other than those few dominated by salps (pink).

NIWA CLIENT REPORT No: WLG2015-25
Report date: May 2015
NIWA Project: TTR15301

Quality Assurance Statement		
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Executive summary

Trans-Tasman Resources Ltd (TTR) are considering reapplying for a consent to annually mine up to 50 M t of iron sands in the South Taranaki Bight (STB). The proposed mining activities will cause a plume of suspended particles to be carried down-current of the mining area and may affect zooplankton communities. Zooplankton communities in the STB were well assessed in the 1970s and 1980s though not near shore and no recent data are available. Here we report on the results of a snap-shot survey of zooplankton and surface water quality in the STB carried out in mid-February 2015.

The wet weight of zooplankton varied forty fold among stations from 229 to 9,380 mg m^{-3}, while the dry weights varied almost 50 fold from 7 to 341 mg m^{-3}. There was no obvious inshore-offshore spatial pattern in biomass distribution but the highest biomasses occurred over the Patea Shoals in the vicinity of the proposed mining site, as well as further east towards Whanganui. The largest biomasses were associated with high catches of salps, particularly *Thalia democratica,* and with juvenile euphausiids. At all other stations copepods dominated numerically, comprising on average 77.5 $\pm$ 2.5 % (SE) of the zooplankton. Over all stations, 18 species of copepods were sampled with omnivorous species comprising 81% of the copepod fauna (range 60-92%). Of these omnivorous copepods, two genera dominated; *Oithona* spp. especially offshore, and *Paracalanus* spp. particularly inshore. Other notable elements of the zooplankton community were the occurrence of appendicularia at offshore stations, mysids at stations in 30m water depth, and polychaete larvae close inshore.

The zooplankton community sampled in the STB in February 2015 is typical of the nearshore zooplankton communities found around the North Island, New Zealand. Its specific composition closely resembles Zooplankton Geographic Group III that occurred in the same area in the 1980s. This group was comprised 17 species of copepods, and was also dominated by *Paracalanus* spp and *Oithona* spp with the omnivorous copepods comprising 75% of the copepod fauna. Interestingly on at least one previous occasion in the 1980s, a huge biomass of the fast growing, gelatinous salp *Thalia democratica* species was present in the north eastern STB.

Surface optical water quality (colour and clarity) and the concentrations of the optically active components (Chlorophyll a (*Chl.a*), Total Suspended Solids (TSS), and Coloured Dissolved organic Material (CDOM)) varied spatially among stations, with a general onshore-offshore pattern, especially along the north-south transect. Lower concentrations of *Chl.a* and TSS were associated with clearer bluer waters, and higher concentrations with less clear, greener waters. *Chl.a*, TSS and CDOM are expected to co-vary in oceanic, offshore waters, due to their interdependence and local biological origin. *Chl.a*, TSS and CDOM may vary independently in waters closer to shore due to input from other sources such as river plumes and seabed transport. The highest *Chl.a* concentrations (> 1 mg m^{-3}) occurred immediately east of the proposed mining site, indicating the occurrence of a localised phytoplankton bloom.

The mid-February (late summer) sampling occurred over two days under calm conditions and provides a brief snapshot of this seasonal period for 2015. Climatic factors such as storm events, river flows and/or calm periods prior to sampling can influence the optical water quality experienced during a survey. In the week prior to the survey there was no rainfall recorded at Whanganui and the winds averaged less than 10 knots, predominately from the south-east (NIWA Climate Database). These benign conditions are reflected in the water quality data with relatively low TSS concentrations and CDOM levels nearshore indicating a lack of major river input or re-suspension of seafloor sediments by wave activity.

1 Introduction

Trans-Tasman Resources Ltd (TTR) are considering reapplying for a consent to annually mine up to 50 M t of iron sands in the South Taranaki Bight (STB) from an area of 65.76 square kilometres lying 22 to 36 kilometres offshore of Patea, in water depths ranging from 19 to 42 metres. The mining activities will cause a plume of suspended particles to be carried down-current of the mining area (Hadfield and Macdonald 2015).

Suspended sediments may affect zooplankton communities by shading phytoplankton thus reducing primary production and the amount of food available to zooplankton grazers. High concentrations of fine sediment can clog zooplankton respiratory surfaces and/or feeding apparatus as well as visually impair the ability of some predatory zooplankton to find prey (Arendt et al. 2011).

Zooplankton communities in the STB were well assessed in the 1970s and 1980s with 90 stations sampled over a period of 13 years (Battaerd 1983, Bradford 1977, 1978, 1980, Bradford and Roberts 1978, Bradford et al. 1993) but have not been sampled since, calling into question the relevance of the older data to a modern assessment of mining impacts. Moreover, most of the sampling stations (83%) were in depths > 50 m offshore of the mining stations, with just a few were from the areas likely to be affected by sediment plumes from the proposed mining activities.

In mid-January 2015 TTR contracted NIWA to sample zooplankton communities from the sea surface to the sea floor, and if possible take and analyse surface water samples for components affecting water clarity, at 16-20 stations along the length and across the width of the area potentially affected by the sediment plume. Weather conditions allowed this sampling to take place in mid-February 2015. Here we provide the details of the methods and results of this sampling programme, and briefly discuss the results in relation to previous sampling carried out in the region.

2 Methods

2.1 Zooplankton

2.1.1 Zooplankton field sampling

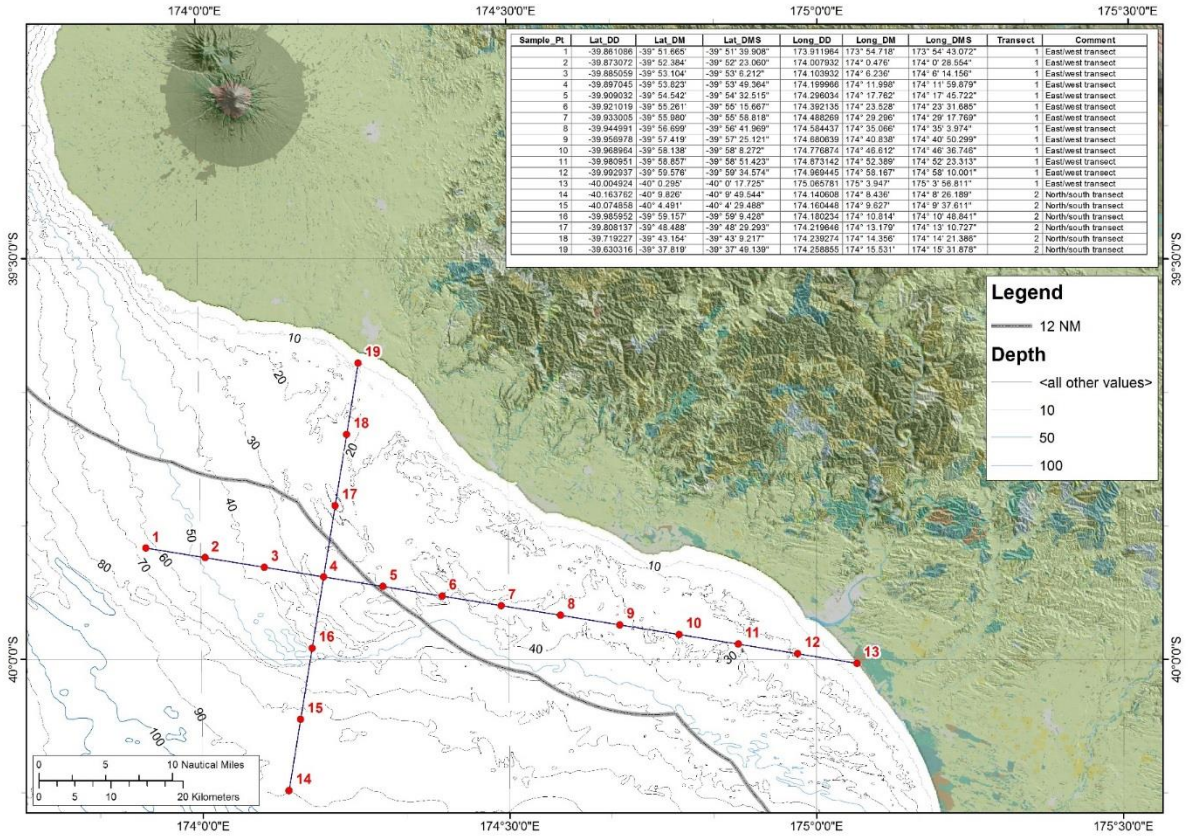
Zooplankton was sampled on 17-18 February 2015 from the sea surface to just above the sea floor using a 57 cm conical net with 200 micron mesh known as “The Heron” net (similar to the nets used by Bradford et al. 1993) at 19 stations along two transects which ran approximately east-west and north-south through the centre of the proposed mining area (Figure 2-1). Station 4 sits approximately over the proposed mining site.

The PVC cod-end had a removable lower section with two window meshes to enhance water filtration through the net. The net ring had three 1 kg dive weights secured 120^{o} apart around its perimeter to provide extra weight and stability during the deployment (Left panel in Figure 2-2). This proved to be an effective set-up for a controlled descent rate and manageable handling when hauled by hand.

At each station the water depth was noted and the appropriate length (approximately 2 to 3 m short of the seafloor depth) of hauling rope was flaked onto the deck. This was to ensure the net did not make contact with the seafloor at the full extent of its vertical drop.

Prior to each deployment once the vessel was stationary, the net choking rope was fully eased to ensure the mouth of the net was not restricted. The net was cast by hand off the stern and continued to free-fall to the desired depth with no restriction on the hauling rope (right panel in Figure 2-2). Once the depth was reached the hauling rope became taut closing off the choking rope to secure and prevent any more sampling. At this point the net was hand-hauled to the surface via an overhead block secured to a make-shift scaffolding frame over the vessels transom.

On the vessel deck the net was held vertically by a crew member and then rinsed with filtered seawater (30 micron) towards the cod-end to ensure any zooplankton trapped on the upper net was forced to the cod-end. Contents of the cod-end were then tipped into a bucket and then transferred to a one litre sample via a 200 micron filter funnel to remove excess water (Figure 2-3). Approximately 100 ml of concentrated formaldehyde was added to each sample jar with label and topped up with filtered seawater to ensure a preservative of a 4% Formalin solution.



Sample_Pt	Lat_DD	Lat_DM	Lat_DMS	Long_DD	Long_DM	Long_DMS	Transect	Comment
1	-39.861086	-39° 51.665'	-39° 51' 39.908"	173.911964	173° 54.718'	173° 54' 43.072"	1	East/west transect
2	-39.873072	-39° 52.384'	-39° 52' 23.060"	174.007932	174° 0.476'	174° 0' 28.554"	1	East/west transect
3	-39.885059	-39° 53.104'	-39° 53' 6.212"	174.103932	174° 6.236'	174° 6' 14.156"	1	East/west transect
4	-39.897045	-39° 53.823'	-39° 53' 49.364"	174.199866	174° 11.998'	174° 11' 59.879"	1	East/west transect
5	-39.909032	-39° 54.542'	-39° 54' 32.515"	174.296034	174° 17.762'	174° 17' 45.722"	1	East/west transect
6	-39.921019	-39° 55.261'	-39° 55' 15.667"	174.392135	174° 23.528'	174° 23' 31.685"	1	East/west transect
7	-39.933005	-39° 55.980'	-39° 55' 58.818"	174.488269	174° 29.296'	174° 29' 17.769"	1	East/west transect
8	-39.944991	-39° 56.699'	-39° 56' 41.969"	174.584437	174° 35.066'	174° 35' 3.974"	1	East/west transect
9	-39.956978	-39° 57.419'	-39° 57' 25.121"	174.680639	174° 40.838'	174° 40' 50.299"	1	East/west transect
10	-39.968964	-39° 58.138'	-39° 58' 8.272"	174.776874	174° 46.612'	174° 46' 36.746"	1	East/west transect
11	-39.980951	-39° 58.857'	-39° 58' 51.423"	174.873142	174° 52.389'	174° 52' 23.313"	1	East/west transect
12	-39.992937	-39° 59.576'	-39° 59' 34.574"	174.969445	174° 58.167'	174° 58' 10.001"	1	East/west transect
13	-40.004924	-40° 0.295'	-40° 0' 17.725"	175.065781	175° 3.947'	175° 3' 56.811"	1	East/west transect
14	-40.163782	-40° 9.826'	-40° 9' 49.544"	174.140608	174° 8.436'	174° 8' 26.189"	2	North/south transect
15	-40.074858	-40° 4.491'	-40° 4' 29.488"	174.160448	174° 9.627'	174° 9' 37.611"	2	North/south transect
16	-39.985952	-39° 59.157'	-39° 59' 9.428"	174.180234	174° 10.814'	174° 10' 48.841"	2	North/south transect
17	-39.808137	-39° 48.488'	-39° 48' 29.293"	174.219946	174° 13.179'	174° 13' 10.727"	2	North/south transect
18	-39.719227	-39° 43.154'	-39° 43' 9.217"	174.239274	174° 14.356'	174° 14' 21.386"	2	North/south transect
19	-39.630316	-39° 37.819'	-39° 37' 49.139"	174.258855	174° 15.531'	174° 15' 31.878"	2	North/south transect

Figure 2-1: Stations in the northern South Taranaki Bight where meso-zooplankton and surface water sampling was conducted on the 17-18 February 2015. Note that due to time constraints station 13 was not sampled.

Figure 2-2: Zooplankton sampling in the northern STB. Left panel: Heron net on deck of *MV Tardis* depicting PVC cod-end and make-shift gantry. Right panel: Heron net deployed off the stern of the *MV Tardis* in vertical free-fall mode, note the cod-end about to submerge below the surface.

Figure 2-3: Zooplankton captured at station 14 in the STB, 18 February 2015.

2.1.2 Zooplankton laboratory analysis

Each preserved zooplankton sample was split in two by volume using a standard plankton splitter.

One half of the original sample was retained at NIWA Wellington for a fractionated biomass analysis by pouring the sample through a tower of stacked pre-weighed filters. These consisted of three mesh sizes; 1000 um, 500 um and 200 um and each pre-weighed filter measured 70 mm in diameter and ranged from 4 to 5 grams in weight. Fractionated wet weights were determined by blotting the samples and weighing with the filters to four decimal places on a Mettler AG245 balance. Dry weights were derived after drying samples on filters in an ESCO Isotherm Forced Convection laboratory oven for 24 hours at 60^{o}C to a constant four decimal weight.

The second half of each zooplankton sample was sent to NIWA Christchurch for identification and enumeration by an experienced zooplankton researcher. Prior to counting, each sample container was opened and left to air in an externally vented fume-hood to get reduce formaldehyde fumes. The sample was then drained through a 100µm sieve to remove the formalin in seawater. This was retained to re-preserve the sample after use. The sample was then washed in tap water to remove any remaining traces of formalin, and then re-suspended in tap water. This re-suspended sample was then split, using a plankton splitter in order to get a manageable sized sample for counting. The split was recorded and the unused sample was placed back into the original container with the retained formalin. The sub-sample for analysis was placed into a sorting tray, and individuals were identified and counted.

2.2 Optical water quality (colour and clarity) and optically active component concentrations

2.2.1 Water colour and clarity

At each sampling station one staff member determined the surface water colour by matching it to standard Munsell colour cards (Davies-Colley 1997). This was always done on the shaded side of the vessel to exclude glare.

At each station one staff member determined the water visibility in the vertical direction by deploying a Secchi disc on a measured tape. The point at which the disc disappeared from view was the value recorded.

2.2.2 Optically active component concentrations

At each of the 18 stations sampled, a five litre plastic container was filled with surface water off the stern duck-board. This was after the container had been well rinsed on three occasions with smaller amounts of seawater from the same location. Each container was then placed in a chilly bin and crushed ice was heaped around it to keep the sample cool prior to shipment to the NIWA Water Quality Laboratory in Hamilton for analysis. Just prior to off-loading the water samples from the vessel, the chilli bins were packed with freezer bricks to maintain their chilled state.

Within 24 hrs the water samples were processed at the laboratory for the determination of: Turbidity (Method APHA 2130B - Standard Methods for the Examination of Water and Wastewater, 21st Edition, 2005); Total Suspended Solids (TSS), and its inorganic (ISS) and organic (OSS) fractions (Method APHA 2540D); Chlorophyll *a* (*Chl.a*) concentration (Method APHA 10200H); and Coloured Dissolved Organic Matter (CDOM) by its absorption at 340 and 440 nm (Davies-Colley, RJ 1992).

3 Results

3.1 Zooplankton

The wet weight of zooplankton samples varied forty fold from 229 to 9,380 mg m^{-3} (top panel in Figure 3-1) while the dry weights varied almost 50 fold from 7 to 341 mg m^{-3} (bottom panel in Figure 3-1). There was no obvious inshore-offshore spatial pattern in biomass but the highest biomasses occurred over the Patea Shoals in the vicinity of the proposed mining site, as well as further east towards Whanganui. The largest biomasses were associated with high catches of salps, particularly *Thalia democratica* at stations 3, 4 and 16, and with juvenile euphausiids at stations 10 and 11 (Figure 3-2). At all other stations copepods dominated comprising on average 77.5 $\pm$ 2.5 % (SE) of the zooplankton. Other notable elements were appendicularia at stations 14-17, mysids at stations 6 and 7 and polychaetes close inshore at station 19 (Figure 3-2).

Over all stations 18 species of copepods were sampled (Figure 3-3). The copepod fauna tended to be dominated by two omnivorous genera (as defined in Table 1 of Bradford -Grieve et al. 1993), *Oithona* spp. offshore and *Paracalanus* spp. inshore (Figure 3-3). For instance, along the north-south transect the proportional contribution of *Oithona* spp fell from 45% of copepods offshore in 90 m of water to just 5% inshore in 13 m of water, while for *Paracalanus* spp the pattern was reversed making up 26% of the copepods offshore and 35% inshore. Similarly, along the east-west transect the proportional contribution of *Oithona* spp fell from 61% of copepods offshore in 63 m of water to just 3% inshore in 19 m of water, while for *Paracalanus* spp the proportion increased from 24% offshore to 85% inshore (Figure 3-3).

Other notable features were the presence of other omnivorous copepods at some stations. *Acartia* sp occurred at the shallow northern station 19 where it comprised 40% numerically of the copepods (Figure 3-3). At all other stations *Acartia* sp comprised <3.5% of copepods. In the east where the water depth was less than 30m, *Temora turbinata* occurred, comprising 1.5-13.7 % of the copepods. Over all stations the omnivorous copepods on average numerically comprised 81% (range 60-92%) of the copepod fauna.

Strictly herbivorous copepods such as *Euterpina acutifrons, Calanus australis*, and *Ctenocalanus* sp. were less abundant than the omnivorous copepods, comprising numerically on average 6.7% (range 0-19%) of the copepods. Similarly, strictly carnivorous copepods such as *Corycaeus acutifrons, Oncaea* spp, and *Candacia* spp. were uncommon, on average comprising 5.5% (range 0.5-13.7%) of the copepods (Figure 3-3).

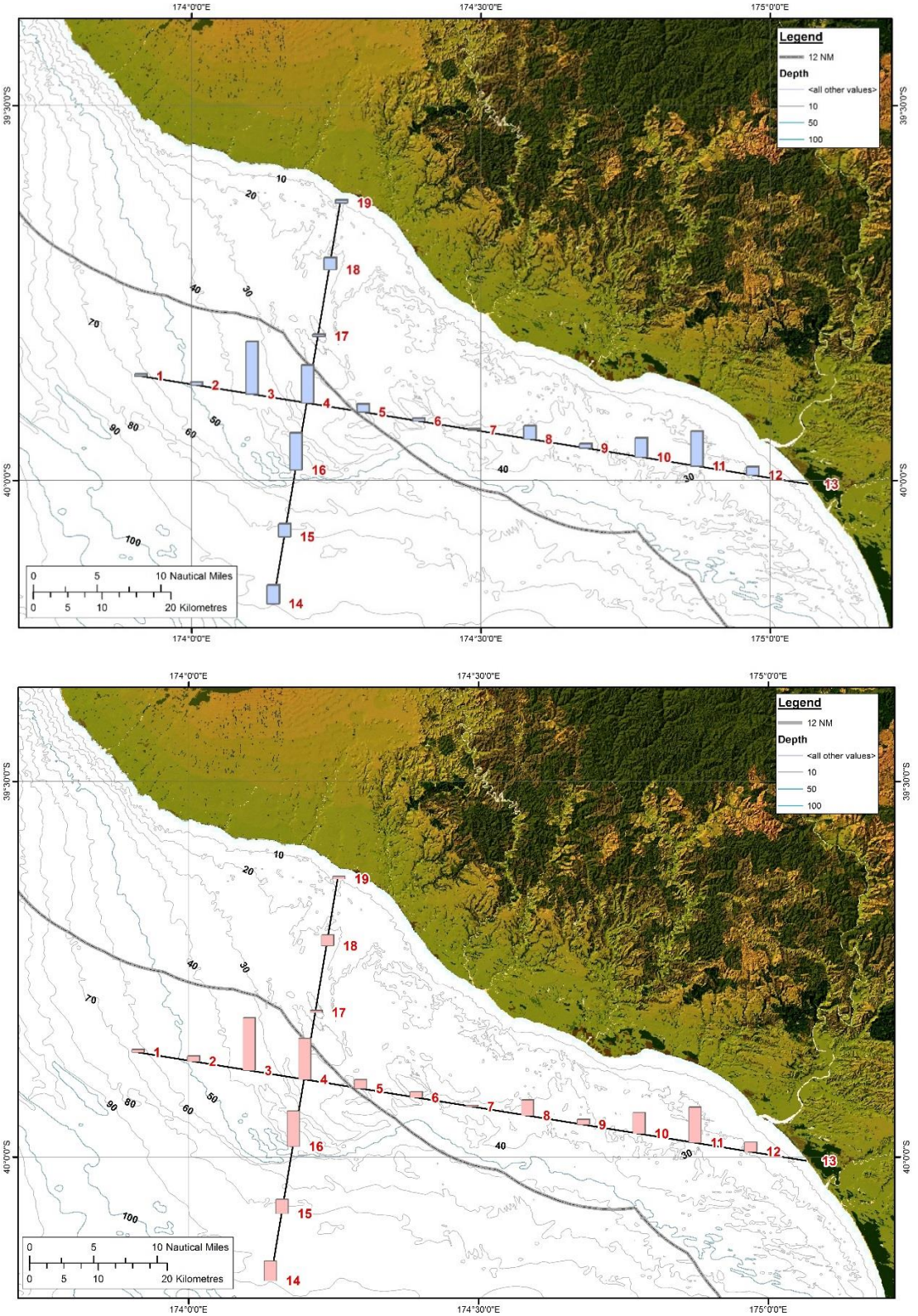


Figure 3-1: Integrated (from surface to near seafloor) zooplankton biomass (mg m^{-3}) in the northern STB, 17-18 February 2015. Upper panel: wet weights where the tallest column (station 3) is 9,380 mg m^{-3} and the shortest column (station 7) is 229 mg m^{-3}. Lower panel: dry weights where the tallest column is 341 mg m^{-3} and the shortest column is 7 mg m^{-3}.

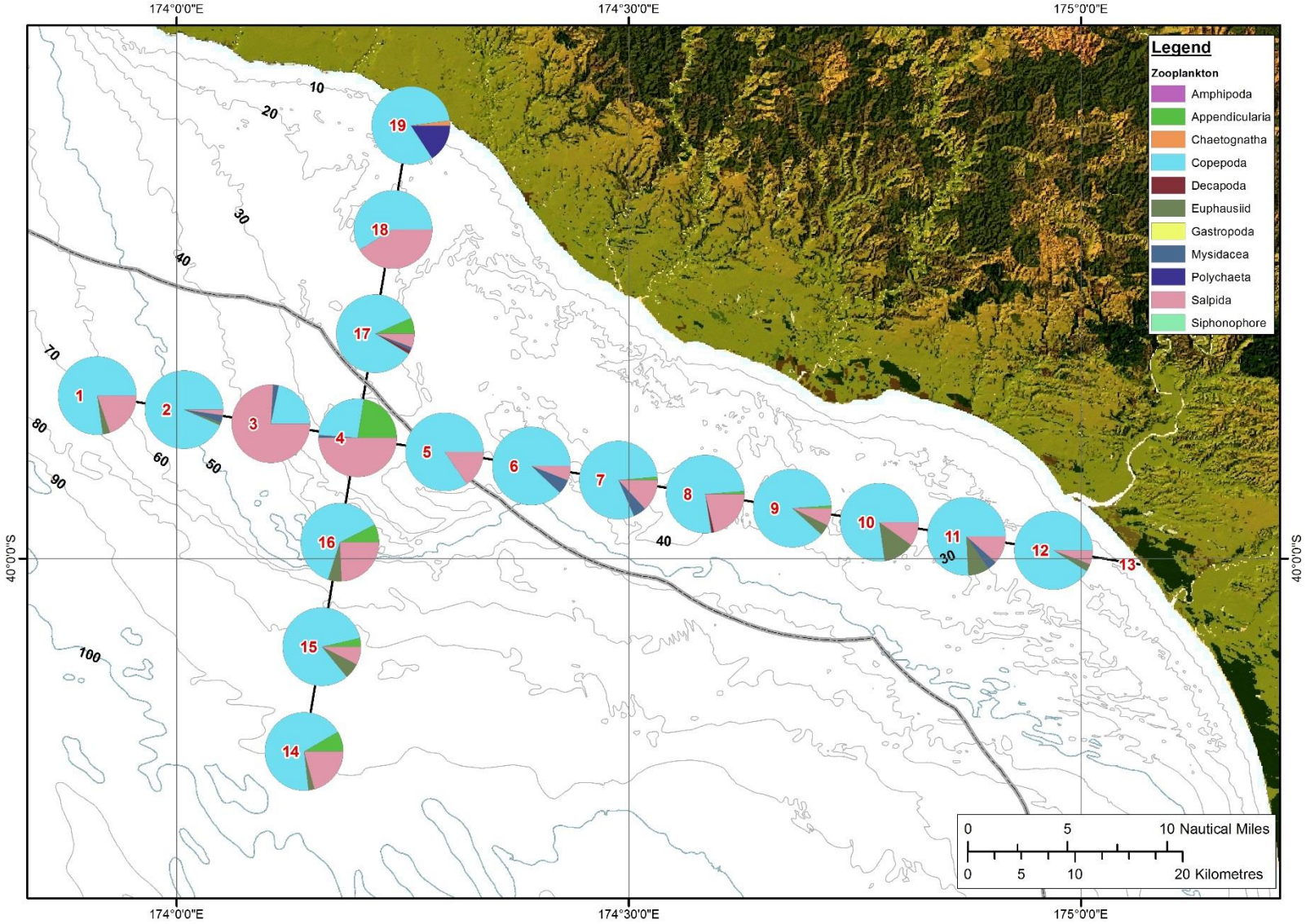


Figure 3-2: The broad taxonomic numerical composition of zooplankton samples taken in the northern STB, 17-18 February 2015.

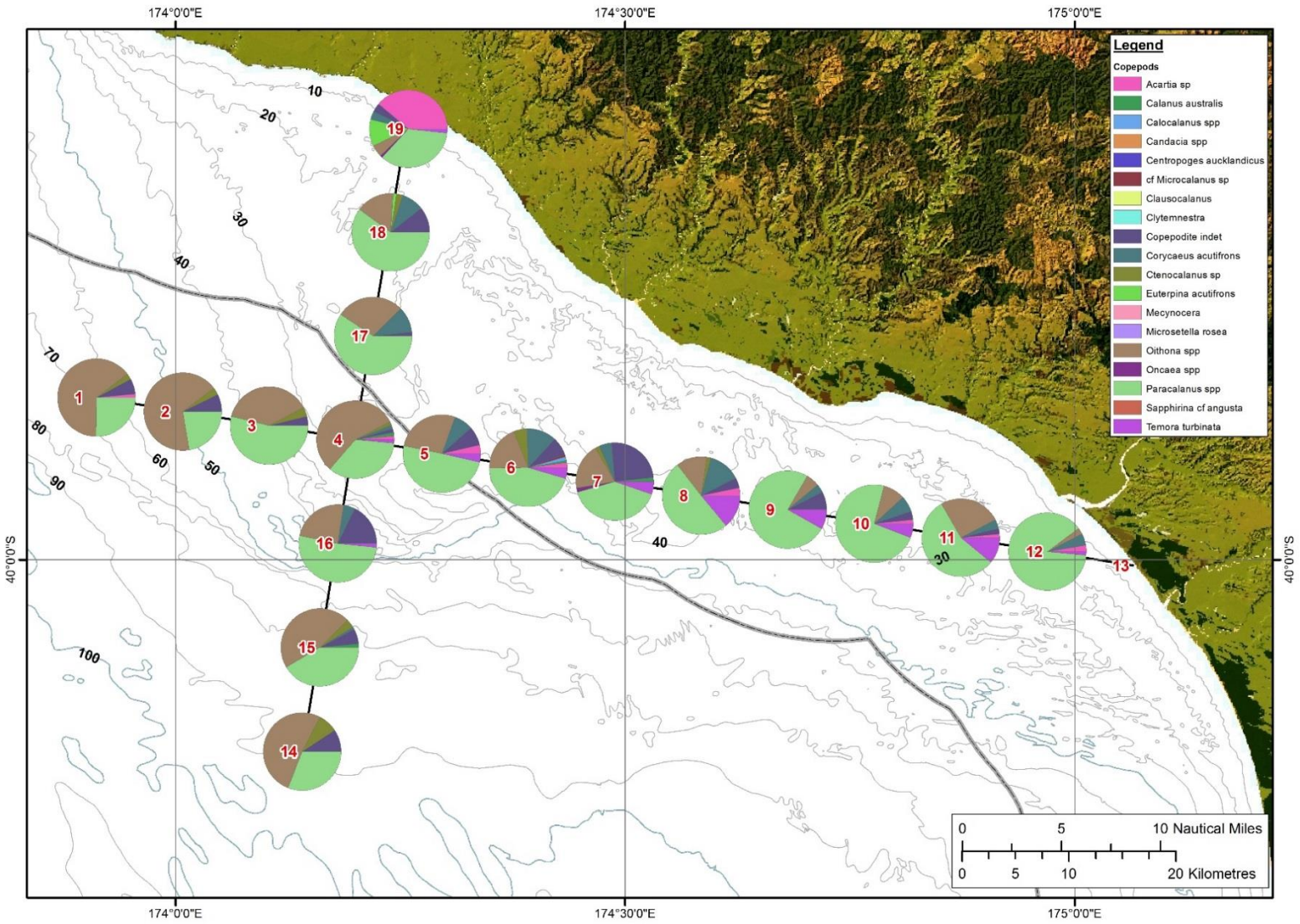


Figure 3-3: The numerical taxonomic composition of copepods sampled in the northern STB 17-18 February 2015.

3.2 Optical water quality and optically active component concentrations

A summary of parameters at each station is provided in Table 3-1.

Table 3-1: Water quality parameters measured for each station sampled in the northern STB, February 2015. Note: zSD – Secchi Disk (SD) visibility depth (z). Munsell Hue Value/Chroma (H V/C) scale measured (m) and corrected (c) to even lighting conditions (5/6). Tn – Turbidity NTU (Nephelometric Turbidity Units). ag - the absorption of gilvin (yellow substance) at wavelength in nm. TTS - Total Suspended Sediments, Organic (OSS) and Inorganic (ISS) concentrations. OSSp – percentage. *Chl.a* – Chlorophyll a.

Station	zSD	Munsellm	Munsellc	Tn	ag340	ag440	TSS	OSS	ISS	OSSp	*Chl.a*
Units	m	HV/C	HV/C	NTU	m^{-1}	m^{-1}	$g\ m^{-3}$	$g\ m^{-3}$	$g\ m^{-3}$	%	$mg\ m^{-3}$
1	11.0	5B 4/2	5B 5/6	1.0	0.46	0.17	1.46	0.74	0.72	51	0.50
2	9.5	2.5B 4/2	2.5B 5/6	0.5	0.17	0.00	0.64	0.34	0.30	53	0.48
3	12.0	5BG 4/2	5BG 5/6	0.5	0.17	0.00	1.15	0.53	0.62	46	0.52
4	11.5	10BG 4/2	10BG 5/6	0.8	0.23	0.06	1.17	0.49	0.68	42	0.58
5	7.1	5BG 5/6	5BG 5/6	1.2	0.23	0.06	1.25	0.75	0.50	60	1.38
6	8.4	7.5BG 5/6	7.5BG 5/6	0.8	0.23	0.06	0.66	0.26	0.40	39	0.83
7	7.3	5B 7/6	5B 5/6	0.8	0.23	0.06	1.03	0.22	0.81	21	0.77
8	7.1	5BG 8/2	5BG 5/6	0.6	0.35	0.06	1.08	0.82	0.26	76	0.63
9	8.6	2.5BG 5/6	2.5BG 5/6	0.6	0.29	0.06	0.50	0.20	0.30	40	0.45
10	10.0	5BG 5/6	5BG 5/6	0.8	0.23	0.06	0.74	0.21	0.53	28	0.32
11	10.0	2.5BG 5/6	2.5BG 5/6	0.5	0.23	0.06	0.68	0.19	0.49	28	0.42
12	6.3	2.5BG 5/6	2.5BG 5/6	1.1	0.58	0.12	1.09	0.21	0.88	19	0.50
14	12.9	5B 4/2	5B 5/6	0.6	0.17	0.06	0.50	0.15	0.35	30	0.17
15	11.8	5B 5/2	5B 5/6	0.5	0.17	0.06	0.84	0.21	0.63	25	0.19
16	14.1	2.5B 4/2	2.5B 5/6	0.6	0.17	0.06	1.03	0.49	0.54	48	0.19
17	11.0	10BG 5/6	10BG 5/6	0.5	0.17	0.06	0.61	0.20	0.41	33	0.37
18	14.2	5B 5/6	5B 5/6	0.4	0.17	0.00	0.43	0.13	0.30	30	0.24
19	4.9	7.5BG 5/6	7.5BG 5/6	1.0	0.40	0.12	1.87	0.42	1.45	22	0.81

3.2.1 Optical water quality

Surface water colours varied from blue-green to blue hues (H) on the Munsell scale (Figure 3-4). Values (V – Brightness) and Chroma (C – Chroma or colourfulness) where standardised to 5/6 from that measured, to compensate for the range sunlight conditions experienced across sampling (from early morning to mid-afternoon). Waters closer to the shore tend to be greener (blue-green) that blue waters furthest from the shore (outside and inside the 12 NM limit). However, some stations within the 12 NM limit had blue waters.

The vertical visibility of a black and white Secchi disk was generally least inshore (4.9 -6.3 m) and greatest offshore (11.0 - 12.9 m). However, as above for water colour, some stations within the 12 NM contained clearer (bluer) waters (10 – 14 m) visibility at the time of sampling (Figure 3-5).

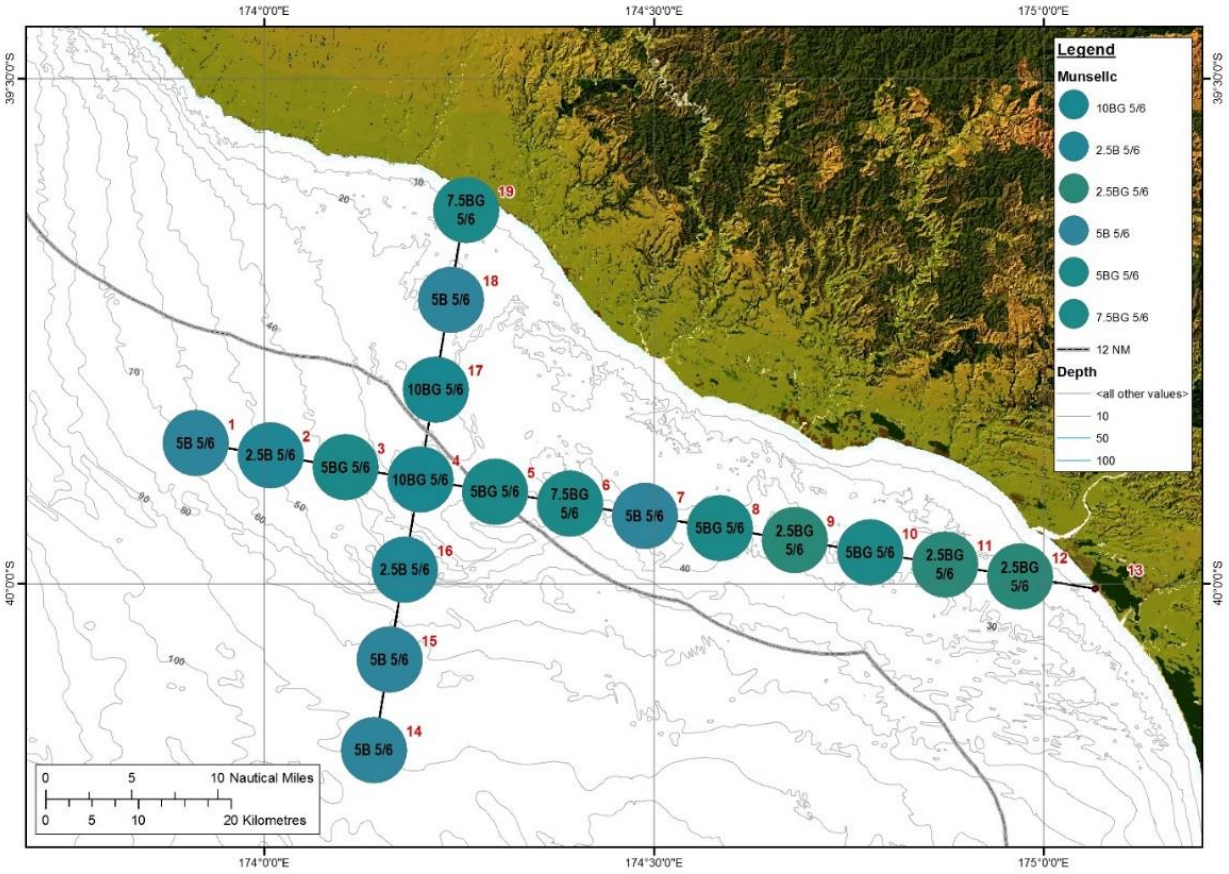


Figure 3-4: Munsell scale surface water colour at stations sampled in the northern STB, February 2015. The dominant colour wavelength is the Munsell Hue (H) with colour descriptions (purple (P), blue (B), green (G), yellow (Y) and red (R) – and their combinations PB, BG, GY an YR)) in steps (2.5, 5, 7.5 and 10) across the Hue scale (0-100); Brightness is represented as Munsell Value (V) from black to white (0-10); Colour purity (saturation) is the Munsell Chroma (C), ranging from neutral grey to fully colour (0-20). Notes: Screens and printers do not accurately represent natural colour. Station 13 was not sampled.

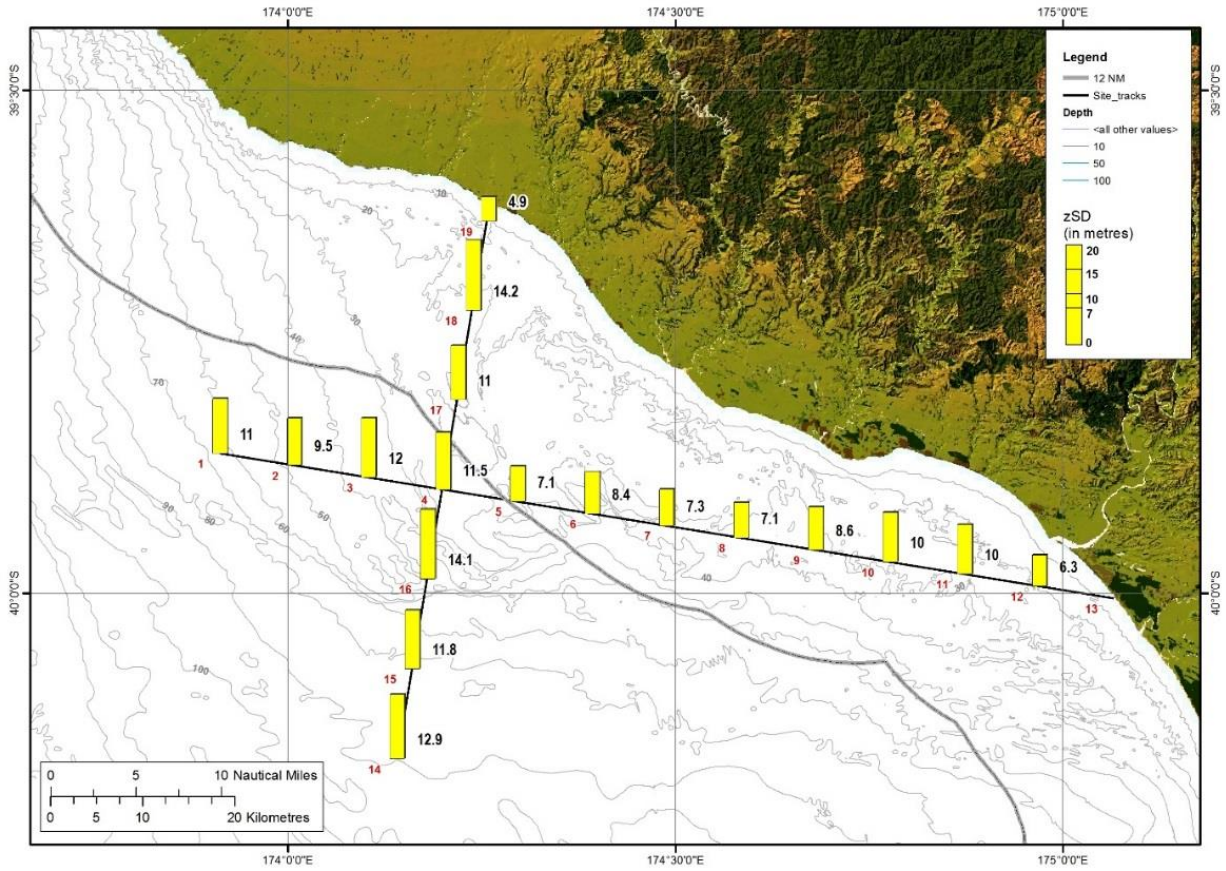


Figure 3-5: Water clarity measure in the vertical direction at stations sampled in the northern STB, February 2015. Secchi depth (zSD – m). Note: Station 13 was not sampled.

3.2.2 Surface water optically active component concentrations

Chlorophyll *a* (*Chl.a*) concentrations varied from 0.2 – 1.4 mg m^{-3} (Figure 3-6). Along the north-south transect *Chl.a* concentrations were generally highest nearshore and lower further offshore. Along the east-west transect the highest *Chl.a* concentrations occurred at stations immediately to the east of the proposed mining area (stations 5-7).

In general, Total Suspended Sediment (TSS) concentrations were low and did not form a clear spatial pattern. Along the north-south transect the highest TSS concentration occurred nearshore and the lowest TSS concentration occurred offshore but TSS concentration varied two-fold among the intermediate stations (Figure 3-7). Along the east-west transect there was no clear pattern in TSS concentration (Figure 3-7).

Coloured Dissolved Organic Matter (CDOM), expressed as the absorption of gilvin (yellow substance) at 340 nm (ag340) was generally higher inshore (near river mouths) than offshore – apart from station 1 (Figure 3-8).

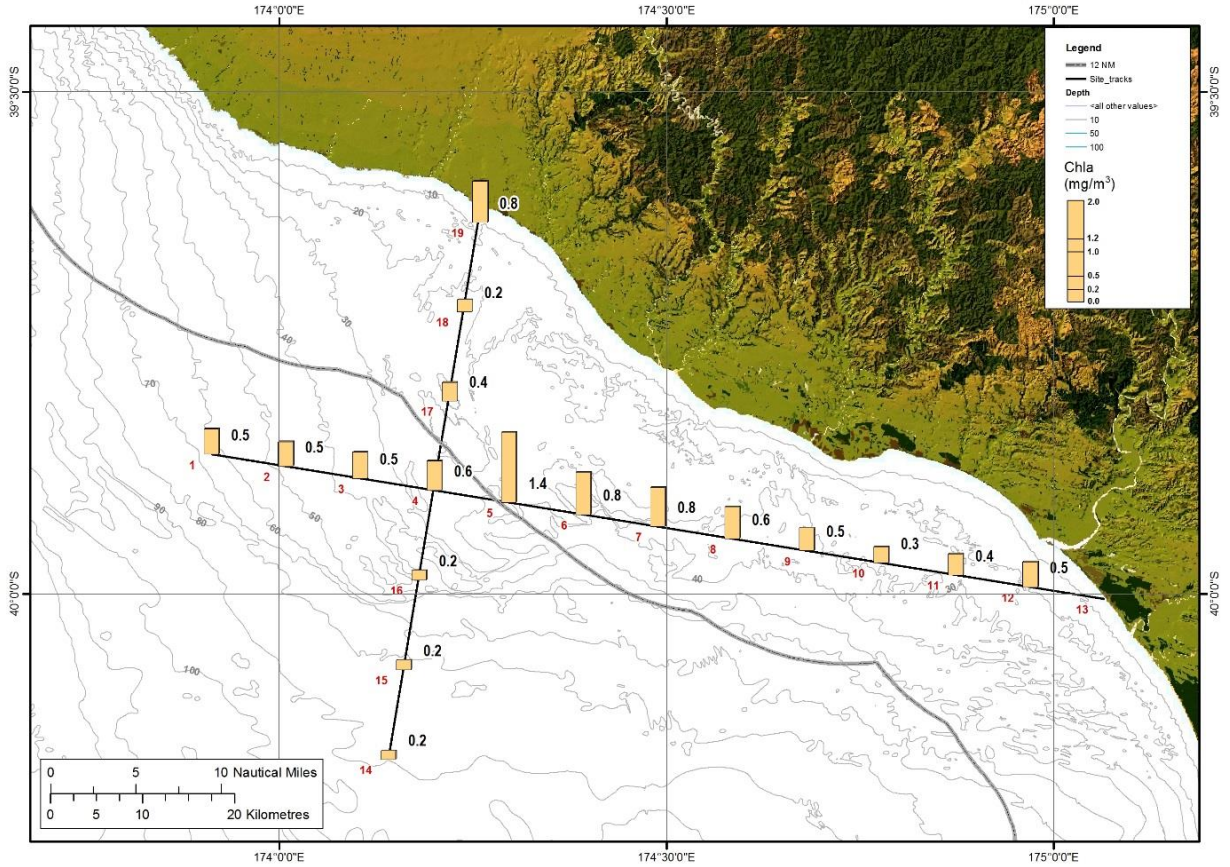


Figure 3-6: Chlorophyll a (*Chl.a*) concentration at stations sampled in the northern STB, February 2015.
Note: Station 13 was not sampled.

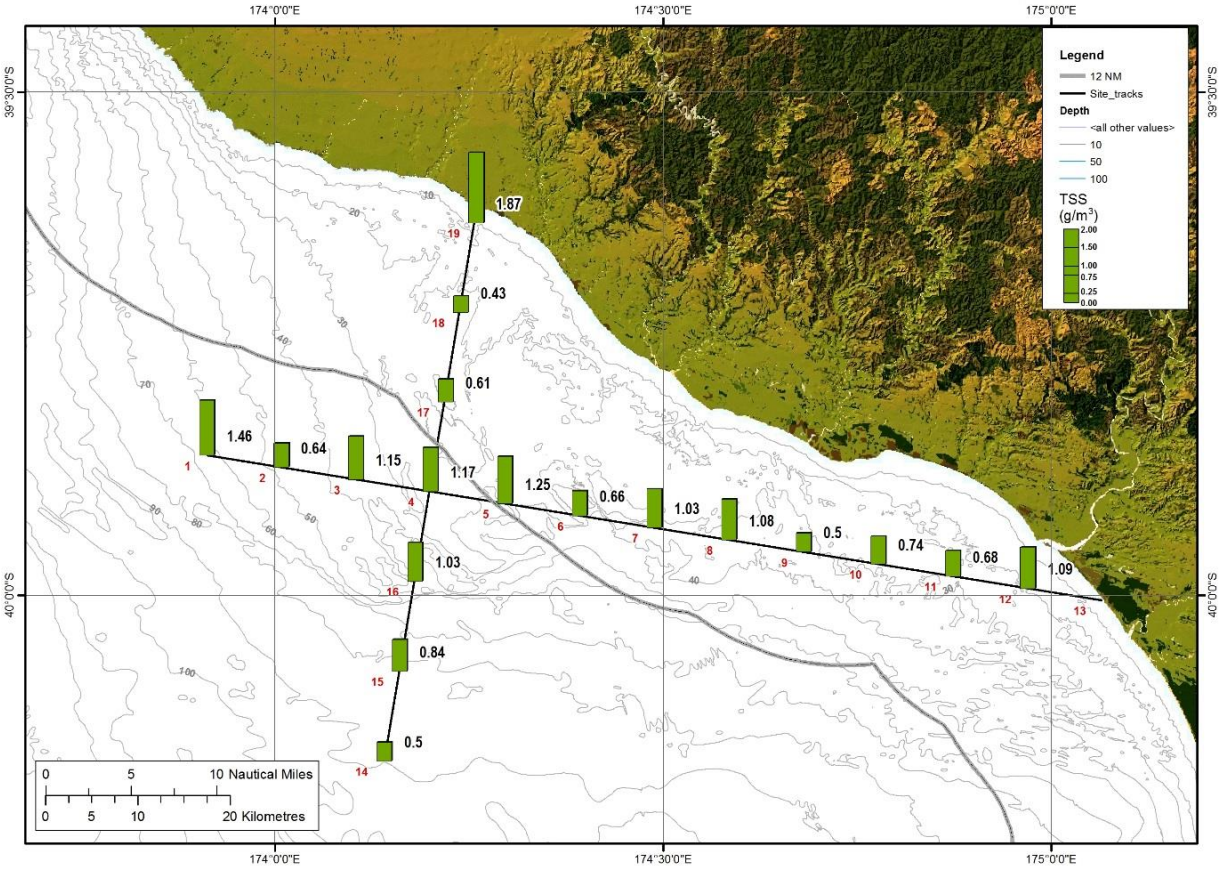


Figure 3-7: Total Suspended Sediment (TSS) concentration at stations sampled in the northern STB, February 2015. Note: Station 13 was not sampled.

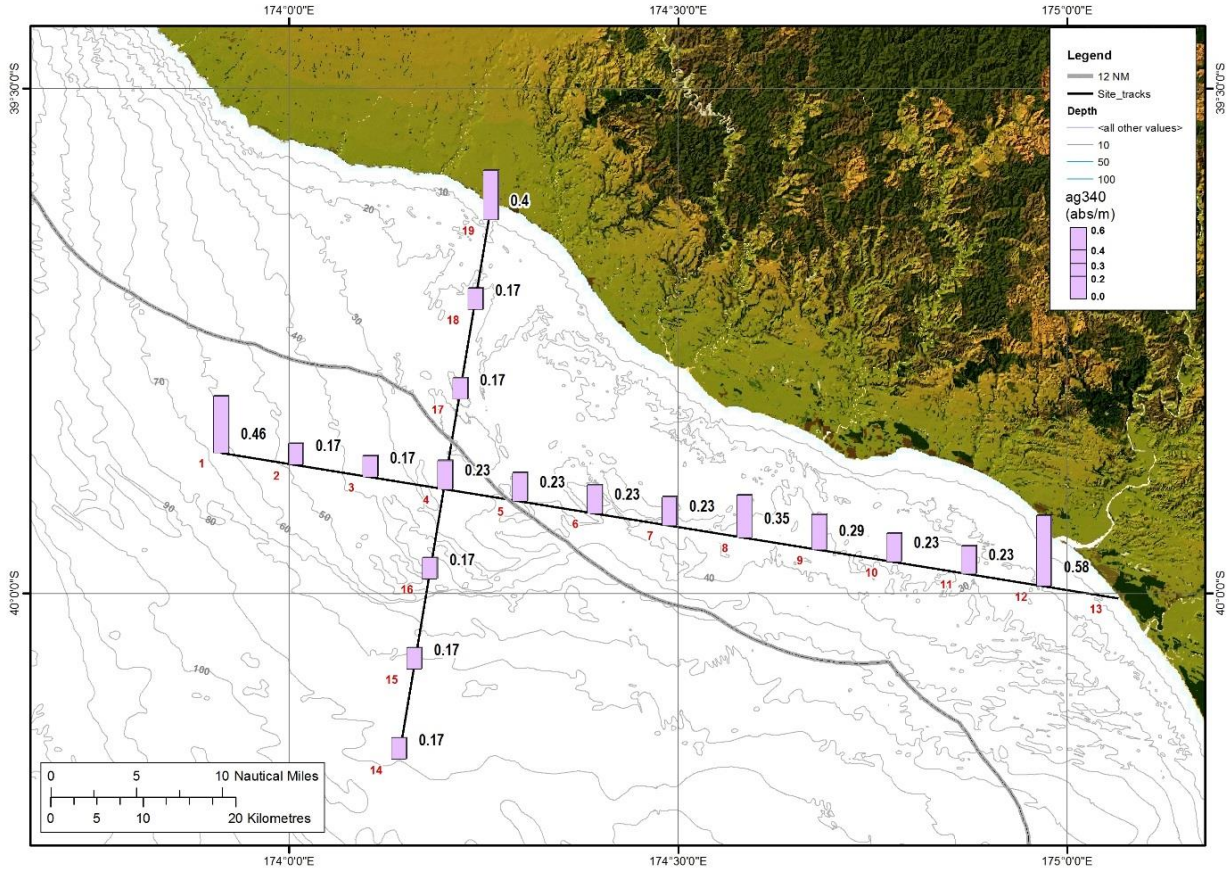


Figure 3-8: Coloured Dissolved Organic Matter (CDOM) at stations sampled in the northern STB, February 2015. CDOM is quantified by its absorption at 340 nm (ag340 – g represents gilvin, or yellow substance). Note: Station 13 was not sampled.

4 Discussion

The zooplankton community sampled in the STB in February 2015, which dominated by omnivorous copepods, particularly *Oithona* spp., and *Paracalanus* spp., is typical of the nearshore zooplankton communities found around the North Island, New Zealand (Bradford 1980), including the STB stations sampled in the 1970s and 1980s (Maui-A platform, STB proper and Port Taranaki) (Battaerd 1983; Foster and Battaerd 1985; Bradford-Grieve et al. 1993). In its specific composition the 2015 samples most closely resembles Zooplankton Geographic Group III identified by Bradford-Grieve et al. (1993). This group was located in the eastern STB at the eastern end of the mature upwelling system originating off the north-west coast of the South Island, comprised 17 copepod species, and was dominated by *Paracalanus* spp and *Oithona* spp with the omnivorous copepods comprising 75% of the copepods.

Interestingly on at least one previous occasion, a huge biomass of the fast growing, gelatinous salps (*Thalia democratica*) were present in the north eastern STB where it was thought it might have been responsible for the low chlorophyll a measured on that occasion (Bradford et al. 1986). However there was no relationship between chlorophyll a concentration and salp density in the 2015 sampling (r^2= 0.11).

4.1 Optical water quality and optically active component concentrations

Surface optical water quality (colour and clarity) and the concentrations of the optically active components (*Chl.a*, TSS and CDOM) varied spatially among stations, with a general onshore-offshore pattern, especially along the north-south transect. Lower concentrations of *Chl.a* and TSS were associated with clearer bluer waters, and higher concentrations with less clear, greener waters. *Chl.a*, TSS and CDOM are expected to co-vary in oceanic, offshore waters, due to their interdependence and local biological (autochthonous) origin. *Chl.a*, TSS and CDOM may vary independently in waters closer to shore due to input from other sources such as river plumes and seabed transport (allochthonous origin).

The mid-February (late summer) sampling occurred over two days under calm conditions and provides a brief snapshot of this seasonal period for 2015. Climatic factors such as storm events, river flows and/or calm periods prior to sampling can influence the optical water quality experienced during a survey. In the week prior to the survey there was no rainfall recorded at Whanganui and the winds averaged less than 10 knots, predominately from the south-east (NIWA Climate Database). These benign conditions are reflected in the water quality data with relatively low TSS concentrations and CDOM levels nearshore indicating a lack of major river input or re-suspension of seafloor sediments by wave activity.

The highest *Chl.a* concentrations (> 1 mg m^{-3}) occurred immediately east of the proposed mining area (stations 5, 6, and 7). *Chl.a* concentrations this high are unusual for oceanic waters at this time of year, indicating the occurrence of a localised phytoplankton bloom (Murphy et al. 2001, Gall and Zeldis 2011). Further spatial and temporal (seasonal) context to this late summer 2015 survey are provided by Pinkerton and Gall (2015) who report on the likely optical effects of the proposed mining activities.

5 Acknowledgements

We thank Peter Geering for his help in accessing alternative vessels when the RV *Ikatere* became unavailable. We thank the skipper of FV *Tardis* for his flexibility in planning and undertaking the sampling trip. Many thanks to Janet Grieve for reviewing the report and suggesting a number of useful changes.

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