Characterisation of the Evans Bay *Adamsiella* algal bed

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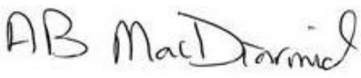	Reviewed by:	Alison MacDiarmid
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Cover image: A masking crab (*Notomithrax* sp.) in the Evans Bay *Adamsiella* bed. [Peter Marriott, NIWA]

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Executive summary

A survey of the *Adamsiella* bed in Evans Bay, Wellington Harbour, was conducted in May/June 2021, and in February 2022 to document its extent, associated biodiversity (both macroalgae and large invertebrates), as well as identifying anthropogenic and climate change threats to this red algal meadow. The *Adamsiella* bed is in the southwest corner of Evans Bay between depths of ca. 4-8 m and is adjacent to a marina, Evans Bay Parade and Cobham Drive (State Highway One).

In winter, May 2021, the *Adamsiella* bed was delimited and mapped using towed video transects. Diver surveys were conducted shortly after, in June 2021, using a stratified sampling design in areas of dense, sparse and no *Adamsiella*, enabling the extent of the bed to be further evaluated, along with an assessment of the associated diversity and biomass of the *Adamsiella*.

In summer, February 2022, the *Adamsiella* bed was further delimited using the towed camera focusing on the edge of the bed close to Evans Bay Marina, the northern limit, as well as along transects placed between the winter transects to create a grid with smaller gaps and to verify the areas with dense and sparse *Adamsiella.* Diver surveys were repeated at the same winter sites to compare biomass and associated flora and fauna. Sites where *Adamsiella* had been previously recorded, Burnham wharf, Roseneath and Greta Point, were surveyed with the towed camera to check its occurrence. At these sites, however *Adamsiella* was not observed.

The total area of the *Adamsiella* bed as estimated with data from winter and summer surveys was 112,749 m^2 (11.2749 ha), consisting of 81,684 m^2 of dense beds and 31,065 m^2 with less dense coverage of *Adamsiella*. The accumulations of *Adamsiella* in dense regions ranged from ca 10-15 cm in thickness. The estimates of the biomass in wet weight per square metre in the dense and sparse *Adamsiella* bed were respectively 2,582 g and 515 g in winter and 666.63 g and 164.67 in summer. The total estimated biomass in wet weight were 193,840.393 kg in winter and 220,627.446 kg in summer.

Collections from dive transects in June 2021 resulted in a total of 60 taxa compared to a total of 54 taxa in February 2022. These included 1 fish, 39 invertebrates and 20 algae in June, and 42 invertebrates and 12 algae in February. At both sampling times, species richness was lowest in the areas of lower *Adamsiella* percentage cover (e.g., either transect 3 or 4). Overall, invertebrate richness was higher, and algae richness lower in February compared to the previous June. Invertebrate abundance was dominated by molluscs at both sampling times, and there were different patterns of abundance observed between and within transects in June and February.

1 Introduction

Macroalgae contribute important structural and functional components of marine ecosystems, contributing primary productivity, the provision of three-dimensional structure and habitat, as well as through the stabilisation of sediments.

While most macroalgae are found attached to rocky substrates, macroalgae are also found forming extensive meadows on the surface of the soft sediments or on coarser sediments (e.g., shell fragments, cobbles, coarse gravels). Depending on the species, the macroalgae can grow anchored in the sediment, attached to small cobbles, and shell fragments, or unattached on the surface of the seafloor forming meadows (Anderson et al. 2019).

Red algal meadows on soft sediments are examples of small natural features (SNFs), ecological assemblages that have been defined as "sites with ecological importance that is disproportionate to size; sometimes because they provide resources that limit key populations or processes that influence a much larger area; sometimes because they support unusual diversity, abundance, or productivity" (Hunter 2017; Lundquist et al. 2017). While some marine SNFs are well recognised and studied (e.g., tropical coral reefs, seagrass meadows and mangrove forests, sponge gardens, hydrothermal vents), other marine SNFs, such as rhodolith beds and red algal meadows on soft sediment, are relatively unknown, poorly mapped, and their ecological roles are largely under-estimated (Foster 2001; Nelson et al. 2015; Schmidt et al. 2021). As noted by Hunter (2017) "the recognition and management of small natural features as distinct entities is primarily a means to facilitate pragmatic conservation of their associated biodiversity and ecosystem services.".

Meadows of the red alga *Adamsiella angustifolia* (Harv.) L.E.Phillips & W.A.Nelson attached to small shells or pebbles have been reported to occur over substantial areas of muddy sediment at the southern end of Evans Bay, Wellington Harbour. These meadows were discovered during routine biosecurity surveys of the Evans Bay marina and adjacent area (Inglis et al. 2006). Algal assemblages on soft sediments are rare regionally, probably only occurring in Wellington and Te Awarua-o-Porirua Harbours but there is a lack of systematic data on regional and national distribution of soft sediment macroalgae, and at a national scale, these have been largely overlooked (Neill et al. 2012).

As summarised by Nelson et al. (2020), in other parts of New Zealand *Adamsiella* beds are known to support a range of associated species (Rainer 1981; Hare 1992; Anderson et al. 2019). Roper et al. (1988) concluded that the *Adamsiella* meadows in Big Glory Bay "probably play an important role in stabilising the muddy bottom and provide a refuge for animals". In the Marlborough Sounds *Adamsiella* beds and have been reported to be associated with bivalves, including horse mussels (*Atrina zelandica*) and scallops (*Pecten novaezelandiae*), holothurians, tube worm colonies, and fish (Davidson et al. 2010, 2015; Anderson et al. 2019, 2020).

As part of investigations to evaluate the potential ecological impact of metropolitan Wellington's proposed water supply pipeline to be constructed on the bed of Wellington Harbour, during a survey carried out by Cawthron Institute, the position of the red-algal bed was recorded but not the area occupied (Morrisey et al. 2019). No previous investigations of the Wellington Harbour *Adamsiella* bed have been conducted to analyse their biodiversity or ecological functioning.

1.1 Scope & nature of the Services:

This report details a survey of the red algal meadow, also known as the *Adamsiella* bed, in Evans Bay, Wellington Harbour, conducted to document its extent and the density of the meadow (with the production of relevant maps), evaluation of the biodiversity values of the meadow (including production of species lists for macroalgae and large invertebrates associated with the *Adamsiella* meadow), and a consideration of the anthropogenic and climate change threats to the meadow as well as the ecosystem services it provides. These surveys (winter and summer) were undertaken to provide background information with a view to supporting the addition of the *Adamsiella* bed as a site of significance in the Proposed Natural Resources Plan (PNRP), recognising that red algal meadows are a rare and highly vulnerable biogenic habitat that supports diverse communities of organisms. In addition, underwater video transects were used to survey other areas in Evans Bay where *Adamsiella* had been reported previously.

2 Methods

2.1 Video transects

A total of 21 towed video transects were surveyed at the southern end of Evans Bay, Wellington (Figure 1). Nine transects (EB01-EB09) were surveyed on 26/05/2021, and three additional transects (EB10-EB12) on 27/05/21 during the winter survey. The summer survey on the 25/02/2022 consisted of nine transects (EB13-EB21) and six additional transects surveyed in other areas of Evans Bay to check if *Adamsiella* was present and forming large assemblages. The extra sites were located at entrance of Evans Bay, Roseneath (RN01-RN02), two transects at Greta Point (GP01-GP02) and two transects at Burnham wharf (BW01-BW02). These extra transects were at sites where *Adamsiella* had been observed previously during the High-Risk Marine Site Surveillance (MHRSS) conducted by NIWA for the Ministry of Primary industries

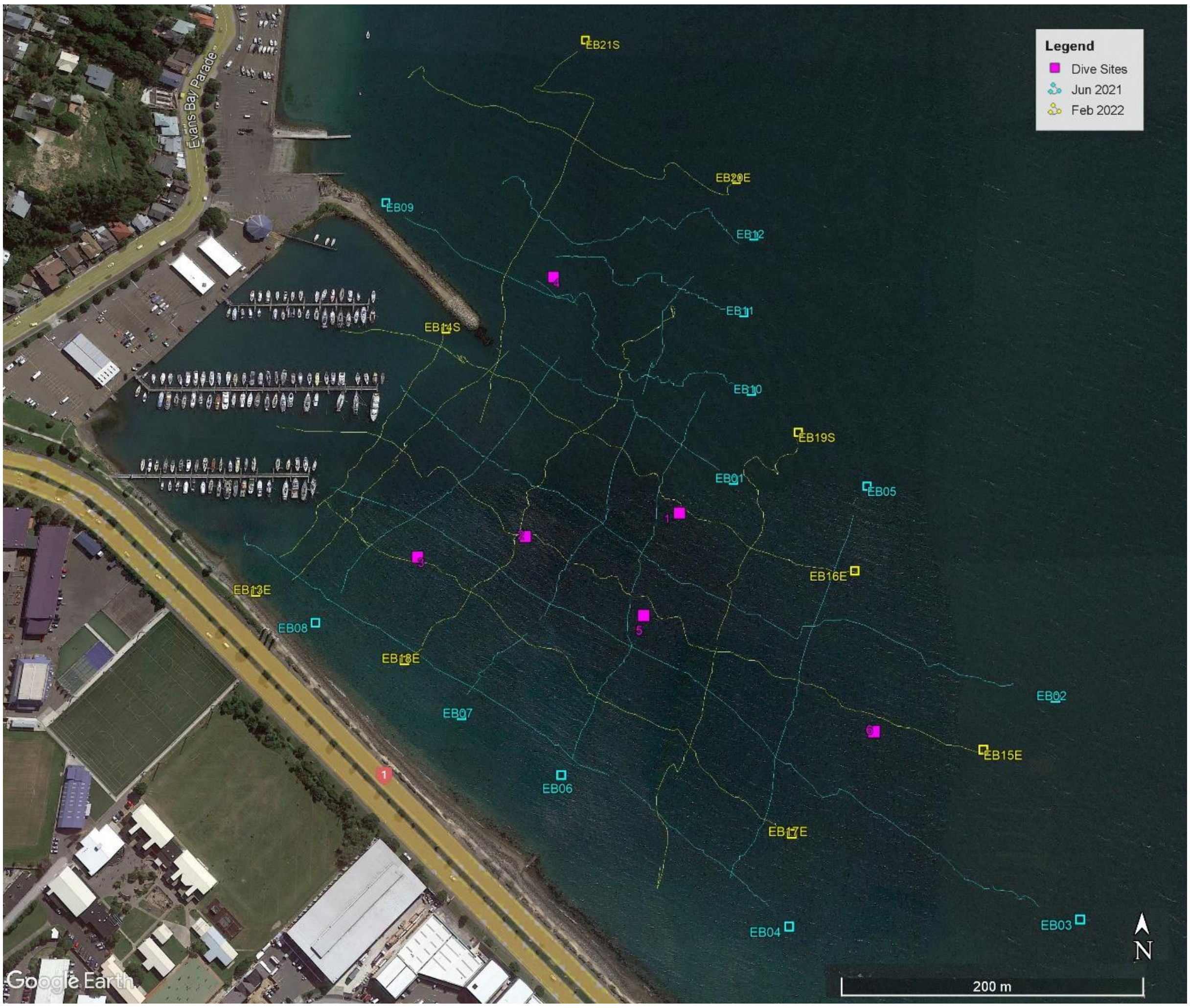

Figure 1: Boat tracks of the towed video transects, winter (yellow), summer (blue) and dive sites (pink squares).

NIWA's Seaweed-Cam, a small, towed video camera system (Figure 2) and methodology were used for the survey. The tow frame was fitted with a high-definition forward-facing video camera (Splashcam Deep-Blue HD-1080p) to see both the seabed and oncoming objects, with real-time video feed via a coaxial cable to the surface vessel. The high-resolution (1080p) video footage was viewed and recorded on a topside video monitor/recorder (HDMI Atomos Ninja Blade 5" fitted with a 240GB

Solid State Disk Drive). The system received a GPS fix from a GPS antenna affixed to the vessel, collecting satellite-referenced position every 1–3 seconds. The videos were stamped with the GPS position (latitude and longitude in decimal degrees), site or transect number (manually entered), and local date and time (Figure 3) which ensured that the video imagery and the corresponding metadata (GPS position and time) were permanently synchronized. The Seaweed-Cam was deployed by hand off the side of NIWA's RV *Rukuwai* and was towed approximately 1 m above the seabed at a speed of approximately 0.5 to 1 knot. Video transects were conducted parallel and perpendicular to the coast creating a grid at the south-western end of Evans Bay.

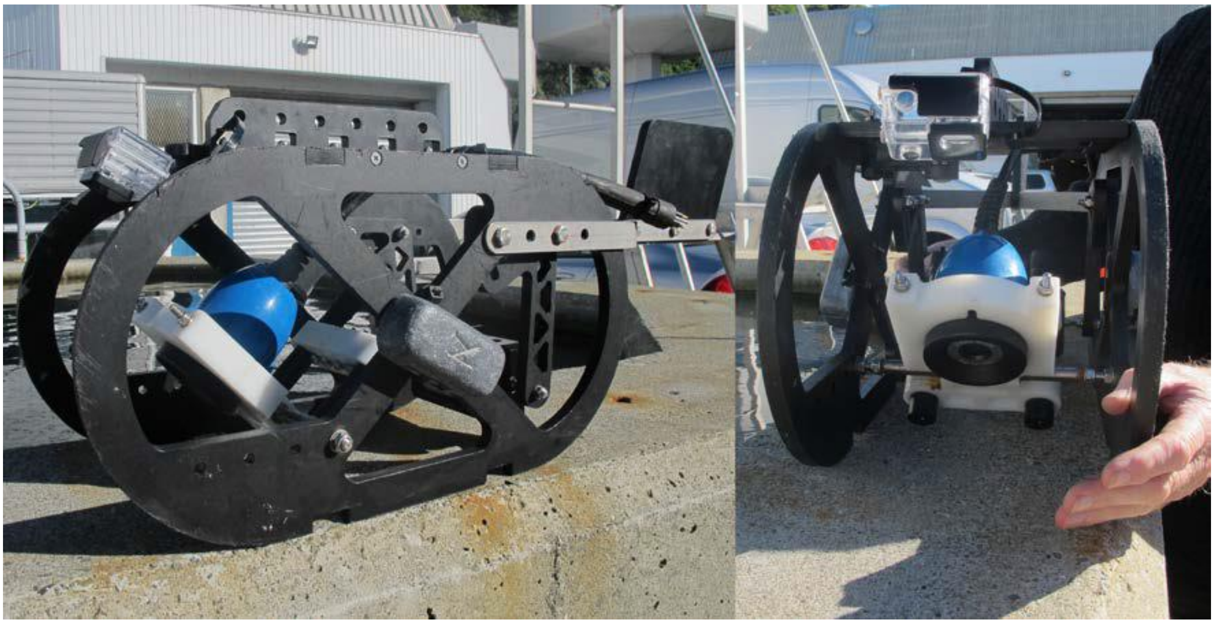

Figure 2: Towed camera system incorporating a splash cam.

Figure 3: Examples of metadata overlaid at the top of the video footage.

Underwater videos were acquired at depths between 3 m and 9 m. The length of the transects ranged from 50 m to 330 m. The underwater visibility was about 2 m, and the video imagery was of adequate quality to distinguish macroalgae and large invertebrates. All video footage was backed up to NIWA's archive drive upon completion of the day's field survey.

A Python algorithm developed by D'Archino et al. (2019, 2021) was used to automatically read the metadata overlaid on the videos, (see detailed description in Appendix 8 of D'Archino et al. 2019) and to extract video frames for the video analysis. These extracted data were then exported in comma-delimited files, along with relevant information, including the source video filename, corresponding frame number in the video, and time since the beginning of the video (e.g., Figure 4;

also see appendix 8 of D'Archino et al. (2019) for a detailed description of this method). Video analysis was performed visualising the video frames (one each second) and annotating: 1) *Adamsiella* dense, 2) *Adamsiella* sparse, 3) substrate (when visible e.g. clear from *Adamsiella*), 4) horse mussels, 5) motile invertebrates, 6) sessile invertebrates, 7) other algae, and 8) 'bad' frames (i.e. camera on the boat or too far from the bottom). A total of 23,077 frames were analysed and the data exported from excel (Figure 4) were used to create a multi layered map in GIS.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	No	date	time	video_time	latitude	longitude	prefix	frame	Bad frame	Sediment	Adamsiella	Horse mussel	motile inver	sessile invert	other algae
11111	677	26/05/2021	13:18:22	0:11:17	-41.312060	174.800700	EvansBay_08	20310			dense		y		
11112	678	26/05/2021	13:18:23	0:11:18	-41.312060	174.800700	EvansBay_08	20340			dense		y		
11113	679	26/05/2021	13:18:24	0:11:19	-41.312060	174.800700	EvansBay_08	20370			dense			y	
11114	680	26/05/2021	13:18:25	0:11:20	-41.312060	174.800700	EvansBay_08	20400		muddy sand, shell gravel	sparse			y	y
11115	681	26/05/2021	13:18:26	0:11:21	-41.312060	174.800700	EvansBay_08	20430		muddy sand, shell gravel	sparse			y	
11116	682	26/05/2021	13:18:27	0:11:22	-41.312050	174.800700	EvansBay_08	20460		muddy sand, shell gravel	sparse			y	
11117	683	26/05/2021	13:18:28	0:11:23	-41.312050	174.800700	EvansBay_08	20490		muddy sand, shell gravel	sparse			y	
11118	684	26/05/2021	13:18:29	0:11:24	-41.312050	174.800700	EvansBay_08	20520		muddy sand, shell gravel	sparse			y	
11119	685	26/05/2021	13:18:30	0:11:25	-41.312040	174.800700	EvansBay_08	20550		muddy sand, shell gravel	sparse				
11120	686	26/05/2021	13:18:31	0:11:26	-41.312040	174.800700	EvansBay_08	20580		muddy sand, shell gravel	sparse	y		y	
11121	687	26/05/2021	13:18:32	0:11:27	-41.312040	174.800700	EvansBay_08	20610		muddy sand, shell gravel	sparse		y		
11122	688	26/05/2021	13:18:33	0:11:28	-41.312040	174.800700	EvansBay_08	20640		muddy sand, shell gravel	sparse				
11123	689	26/05/2021	13:18:34	0:11:29	-41.312040	174.800700	EvansBay_08	20670		muddy sand, shell gravel	sparse				
11124	690	26/05/2021	13:18:35	0:11:30	-41.312030	174.800700	EvansBay_08	20700		muddy sand, shell gravel	sparse		y		
11125	691	26/05/2021	13:18:36	0:11:31	-41.312030	174.800700	EvansBay_08	20730		muddy sand, shell gravel	sparse		y		

Figure 4: Example video frames data analysis.

2.2 Mapping

All GIS and mapping for this report was done using ESRI ArcPro (vers. 2.8.1). The GIS project and maps are in New Zealand Transverse Mercator (NZTM; EPSG2193). Tracks were built from the positions recorded on the video frames. To adjust for the lower accuracy of navigation under water (positions with 10s of metres accuracy) and to allow for the point observations to represent a wider area outside of the camera view, a buffer of 50m was built around these track lines reflecting the natural extent of the point observations. This buffer is displayed with a fading outside edge to depict the fact that the likelihood of observations being a true reflection of the seafloor cover decreases with distance from the recorded position.

2.3 Dive transects

Six sites (Figure 5) were surveyed by divers to assess the biomass of *Adamsiella* and fauna associated with the bed in winter 2021 and summer 2022. The sites were chosen in areas where *Adamsiella* was observed to be dense (4 transects), sparse (1 transect) or absent (1 transect) based on the towed camera video survey. Priority was given to sites with dense *Adamsiella* to obtain data about its biomass and characterise the bed. The transects were oriented parallel to the shoreline in the southwest corner of Evans Bay, running northwest to southeast. At each site a 30 m transect was deployed on the substrate and a video was recorded before the bottom was disturbed. Five quadrats, 50 cm x 50 cm, were placed at 5 m intervals along the transect lines. The percentage cover of *Adamsiella* and the thickness of the *Adamsiella* layer were recorded before removing all the seaweed and associated invertebrates from the quadrat. Large invertebrates (e.g., horse mussels, kina (*Evechinus chloroticus*) and sponges) were counted along the entire transect (Appendix B).

Figure 5: Location of the start of each dive transect. T1 (WP 53), T2 (WP 54), T3 (WP 55), T4 (WP56), T5 (WP 57), T6 (WP 58).

2.4 Sorting and identifications

In June and February in the field laboratory, the contents of each quadrat were tipped into trays and sorted. All *Adamsiella* material was picked through by hand, and other algae and invertebrates removed (Figures 6, 7). Wet weights were recorded for the total amount of A*damsiella* for each quadrat, and, where possible, weights of other algae were recorded too, although in most cases they were too small to weigh. Invertebrates were sorted into taxa or morphotypes and counted. Once weighed and quantified the flora and fauna were returned to the bed, representative voucher specimens retained in the invertebrate and algal collections at NIWA and registered into our Specify databases, *niwainvert* and *niwaalgae*. Invertebrate vouchers were retained from the June collections only and are held in the NIWA Invertebrate collection with accession numbers of 157483-157616 and 157696-157698. Vouchers of algae were pressed (algae sample numbers ASV246-ASV262 and ASW050-ASW055), and silica gel subsamples taken. Both are currently retained at NIWA, and pressed material may be accessioned into the Te Papa herbarium in the future. The identity of *Adamsiella* and three common species associated with the bed were confirmed by *rbc*L sequence data following methods in D'Archino et al. (2018).

Figure 6: Sorting samples in field laboratory.

Figure 7: Sorting samples in field laboratory.

2.5 Biomass estimation

The biomass of *Adamsiella* was calculated by averaging the wet weight of *Adamsiella* collected from the quadrats that had 100 % coverage (dense) and for those with less than 100% coverage (sparse). The average weight per m^2 was multiplied by the area covered by the bed with the proportions of dense and sparse *Adamsiella* growth as estimated through the mapping of the bed.

Two samples of *Adamsiella* with a wet weight of 100 g, were dried at 60˚C until they reached a constant weight to determine the conversion from wet to dry weight. The contribution to the biomass from other algae was minimal as no other species collected from the quadrats reached 100 g wet weight in winter and summer surveys.

3 Results

The combined data (winter and summer) from the video analysis enabled the production of a map (Figure 8) delimiting the bed and differentiating the areas with dense and sparse coverage, as well as providing an estimation of the area occupied by *Adamsiella* (Table 1). The total area estimated was 112,749 m^2 (11.2749 ha) consisting of 81,684m^2 of dense *Adamsiella* growth and 31,065m^2 of sparse coverage of *Adamsiella* (Figure 8). In winter, the area was 114,735 m^2 (11.4735 ha), consisting of 65,192m^2 of dense beds (100% cover) (Figure 9,10) and 49,543m^2 with less dense coverage of *Adamsiella* (Figures 11, 12). Areas without *Adamsiella* were detected along the video transects (Figure 13).

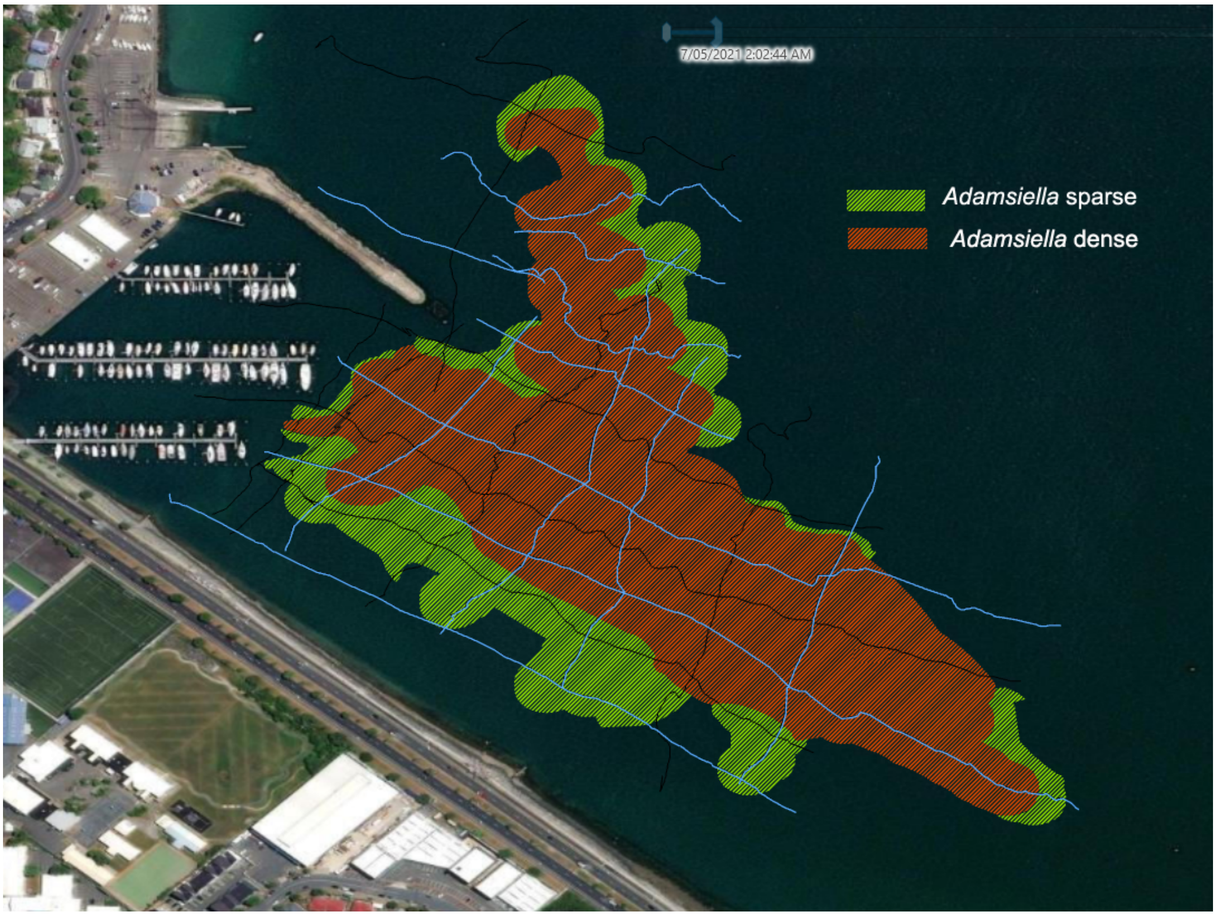

Figure 8: Map of the *Adamsiella* bed (winter and summer data) at the south end of Evans Bay.

Table 1: Area covered by *Adamsiella* estimated through video analysis.

Winter			Winter and summer combined data		
Dense	Sparse	Total area	Dense	Sparse	Total
65,192 m^2 (6.5192 ha)	49,543 m^2 (4.9543 ha)	114,735 m^2 (11.435 ha)	81,684 m^2 (8.1684 ha)	31,65 m^2 (3.1065 ha)	112,749 m^2 (11.2749 ha)

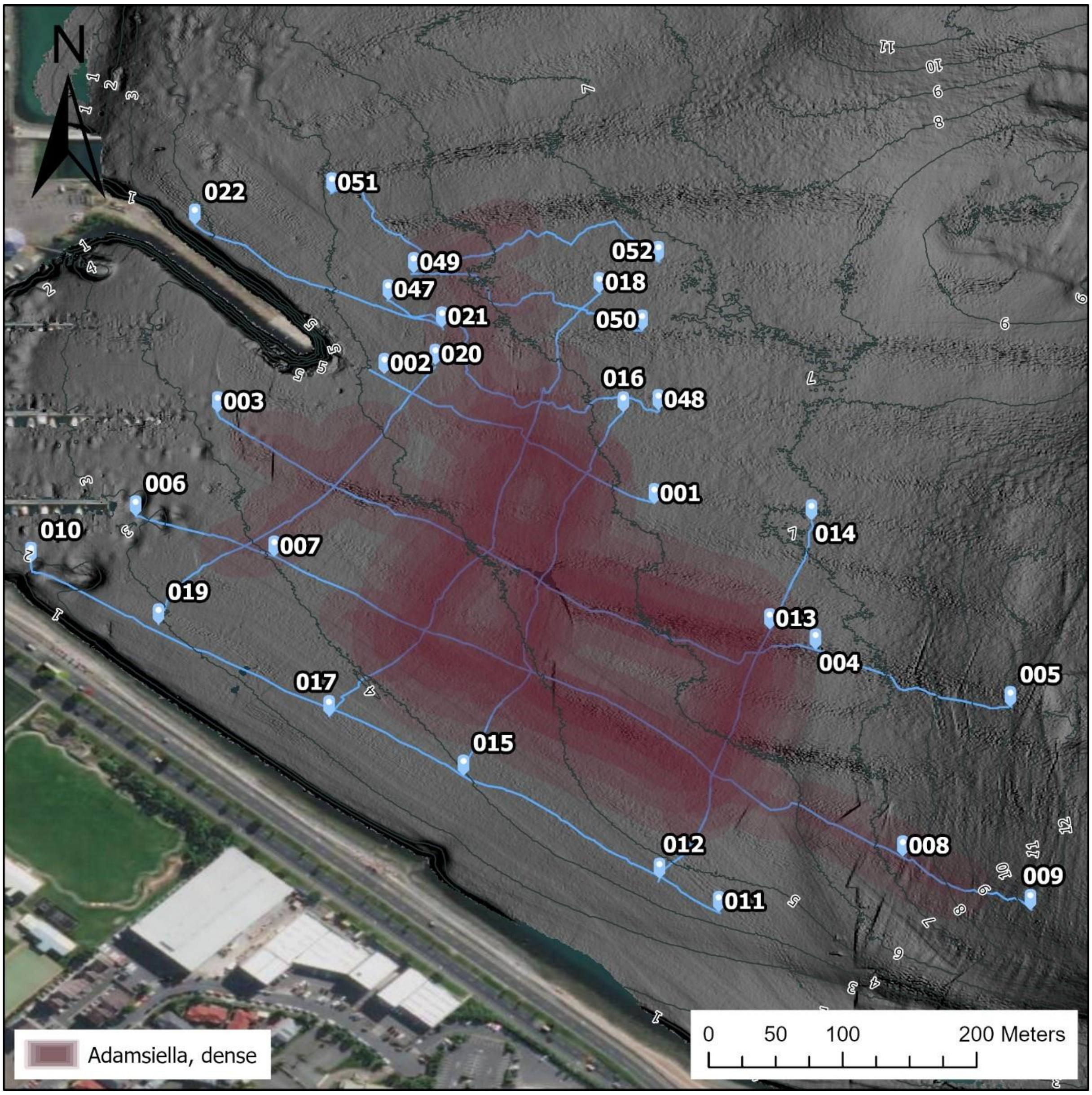

Figure 9: **Map of the *Adamsiella* bed showing areas with dense coverage (winter).**

Figure 10: Examples of video frames showing dense *Adamsiella* and associated organisms. A. kina. B. spotty (*Notolabrus celidotus*). C. *Coscinasterias muricata*. D. elephant fish (*Callorhinchus milii*) egg case. E. sponge. F. horse mussel.

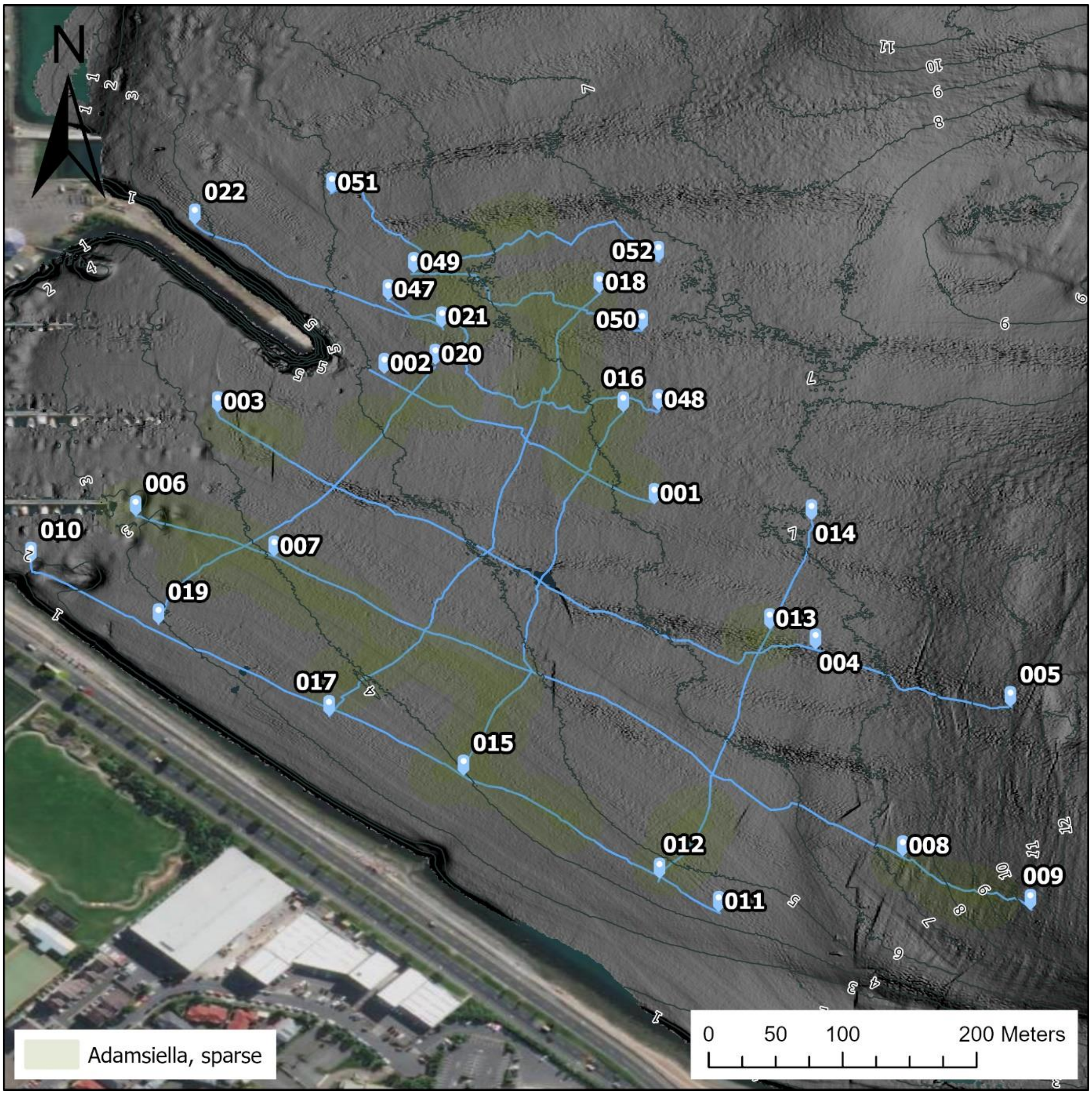

Figure 11: **Map of the *Adamsiella* bed showing areas with sparse coverage (winter).**

Figure 12: Examples of video frames showing sparse *Adamsiell*a and associated organisms. A. kina. B. sponge. C. horse mussel. D. puffer fish (*Tragulichthys jaculiferus*). E. Elephant fish egg case and sea stars. *F Coscinasterias* and *Patiriella*/*Meridiastra* sp.

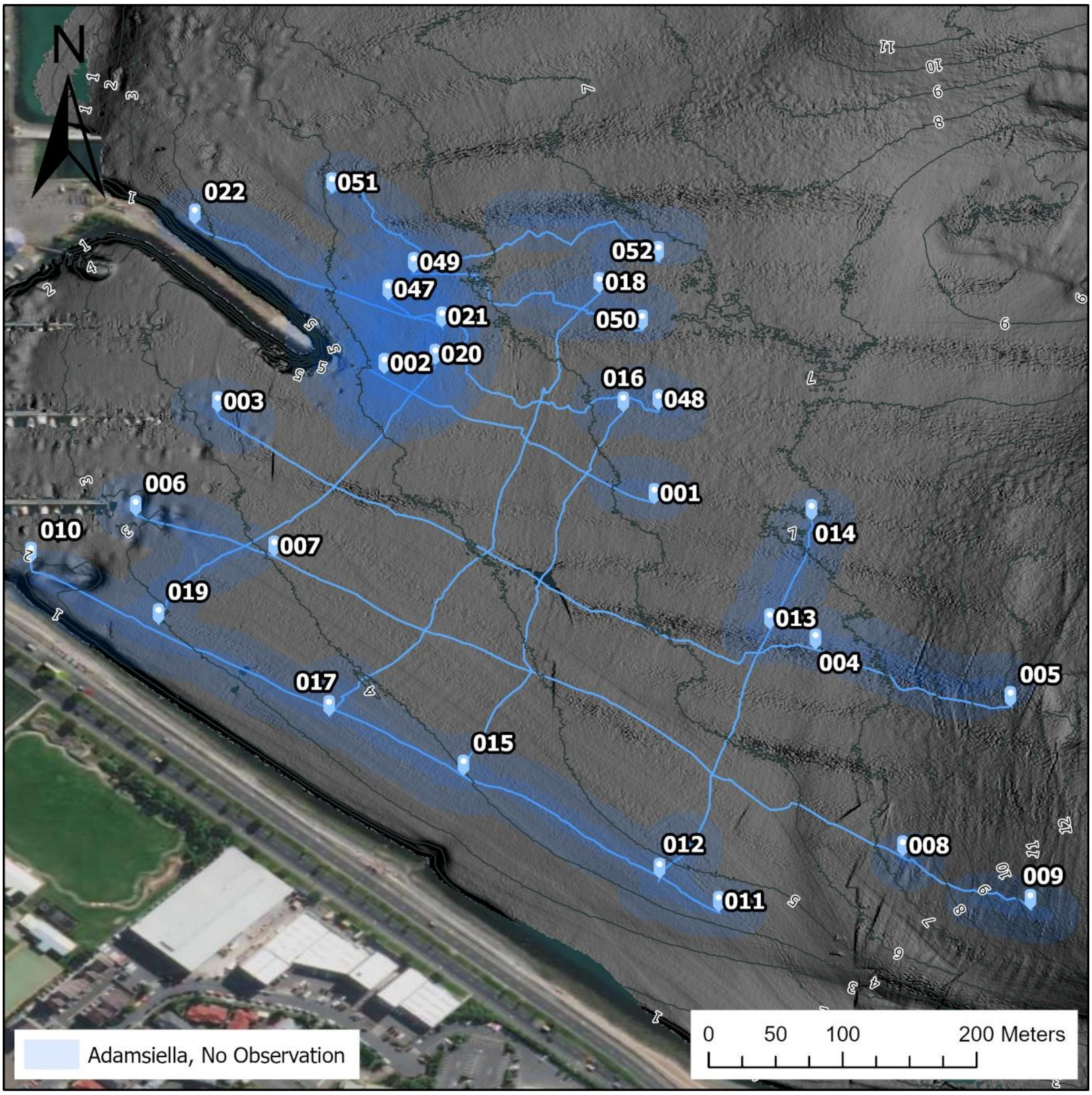

Figure 13: Map showing areas without *Adamsiella* detected through video analysis (winter).

The data obtained from the underwater video analysis made it possible to produce maps showing the presence of large invertebrates (Figure 14), differentiated into horse mussels (Figure 15), mobile invertebrates (Figure 16) and sessile invertebrates (Figure 17).

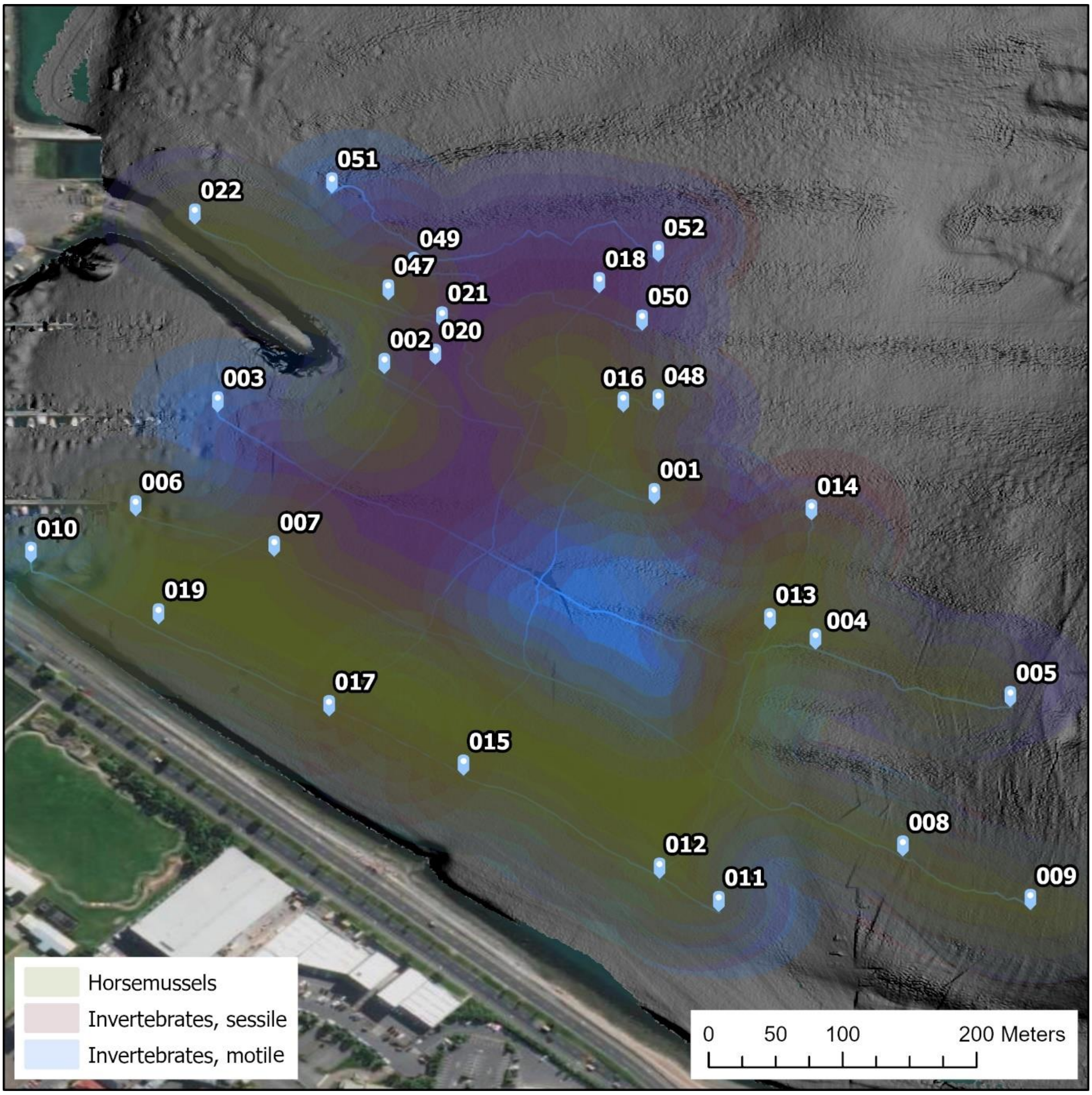

Figure 14: **Map showing the distribution of large invertebrates in Evans Bay (winter).**

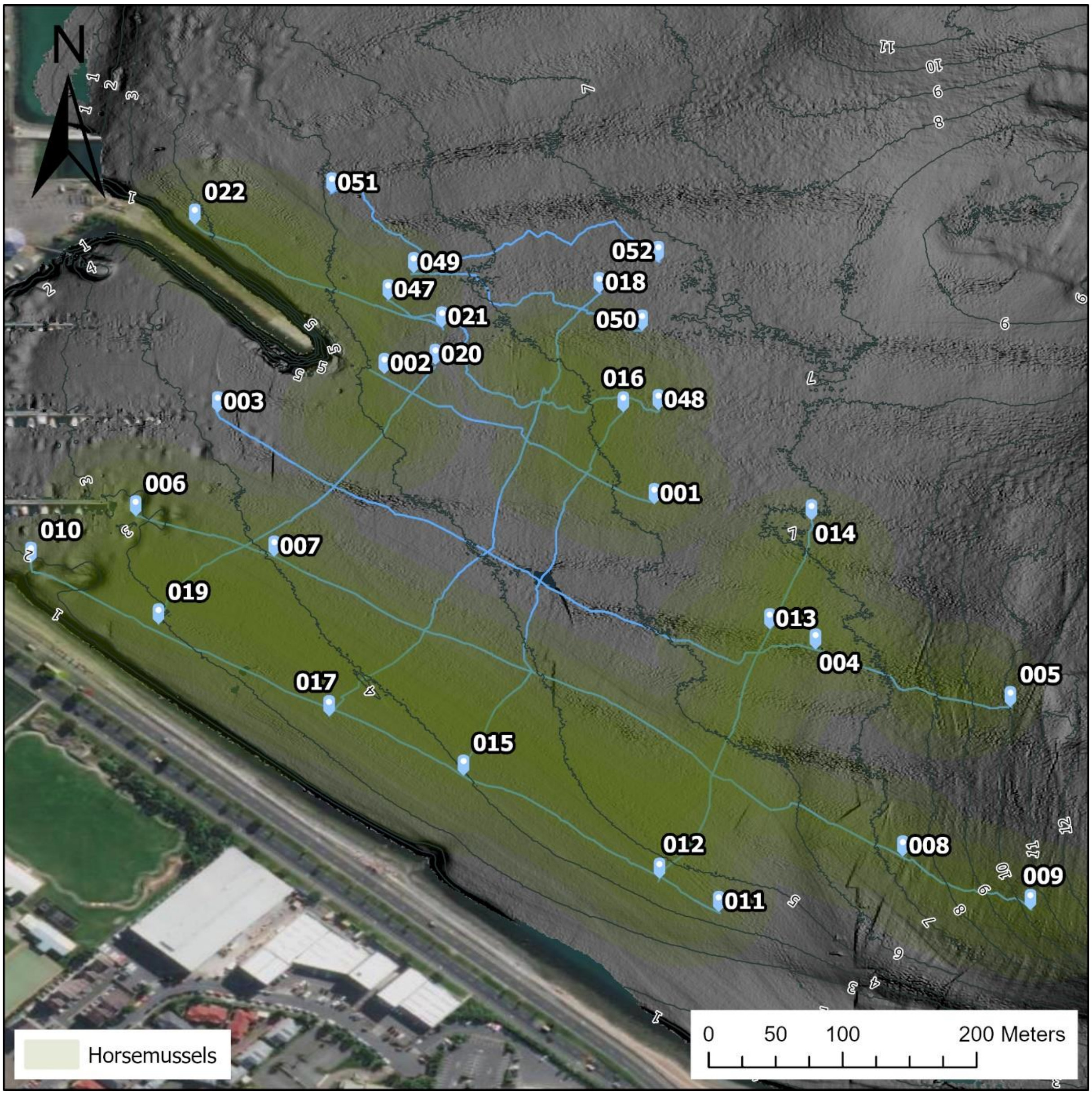

Figure 15: Map showing the distribution of horse mussels in Evans Bay (winter).

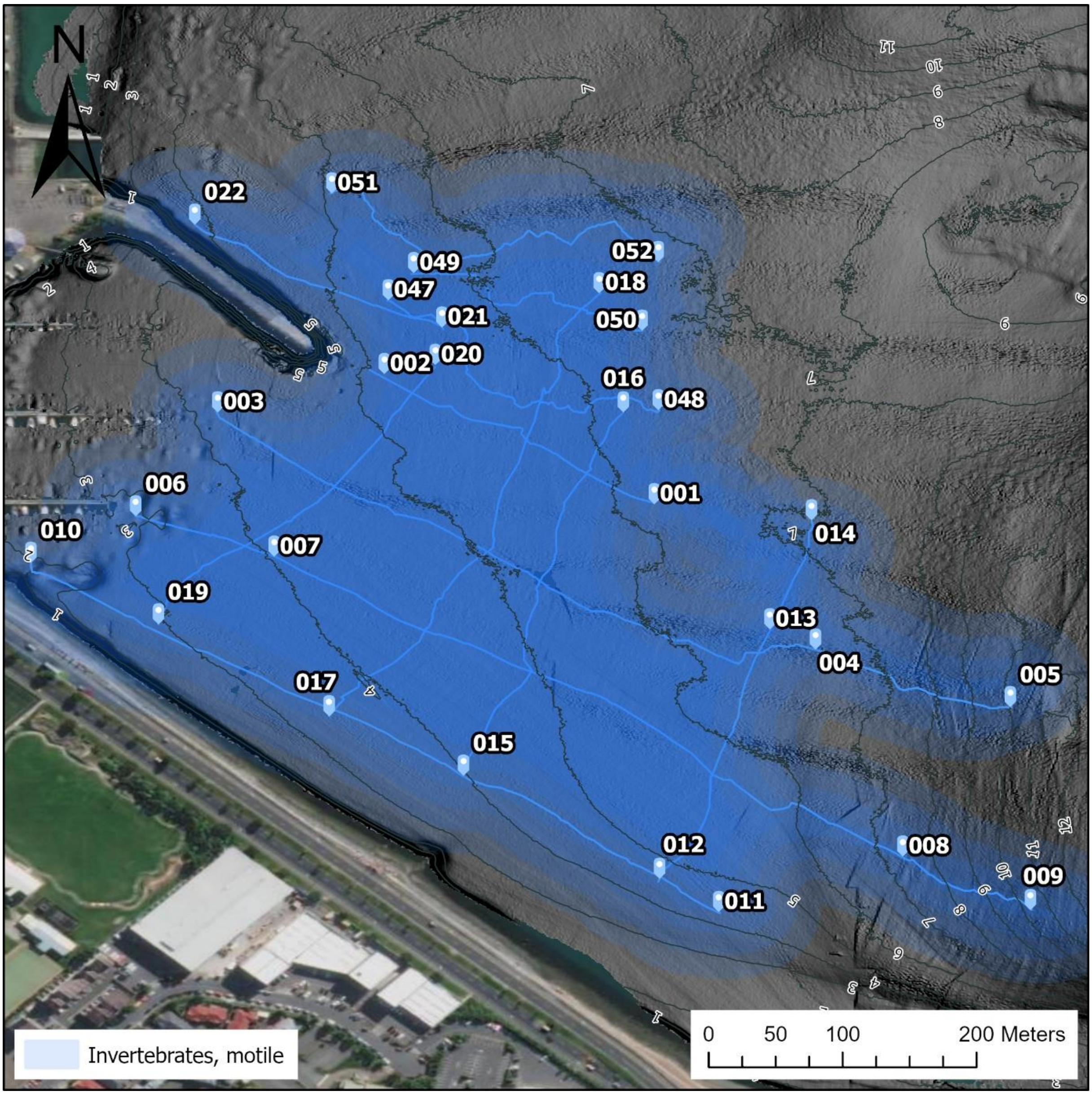

Figure 16: **Map showing the distribution of motile invertebrates in Evans Bay (winter).**

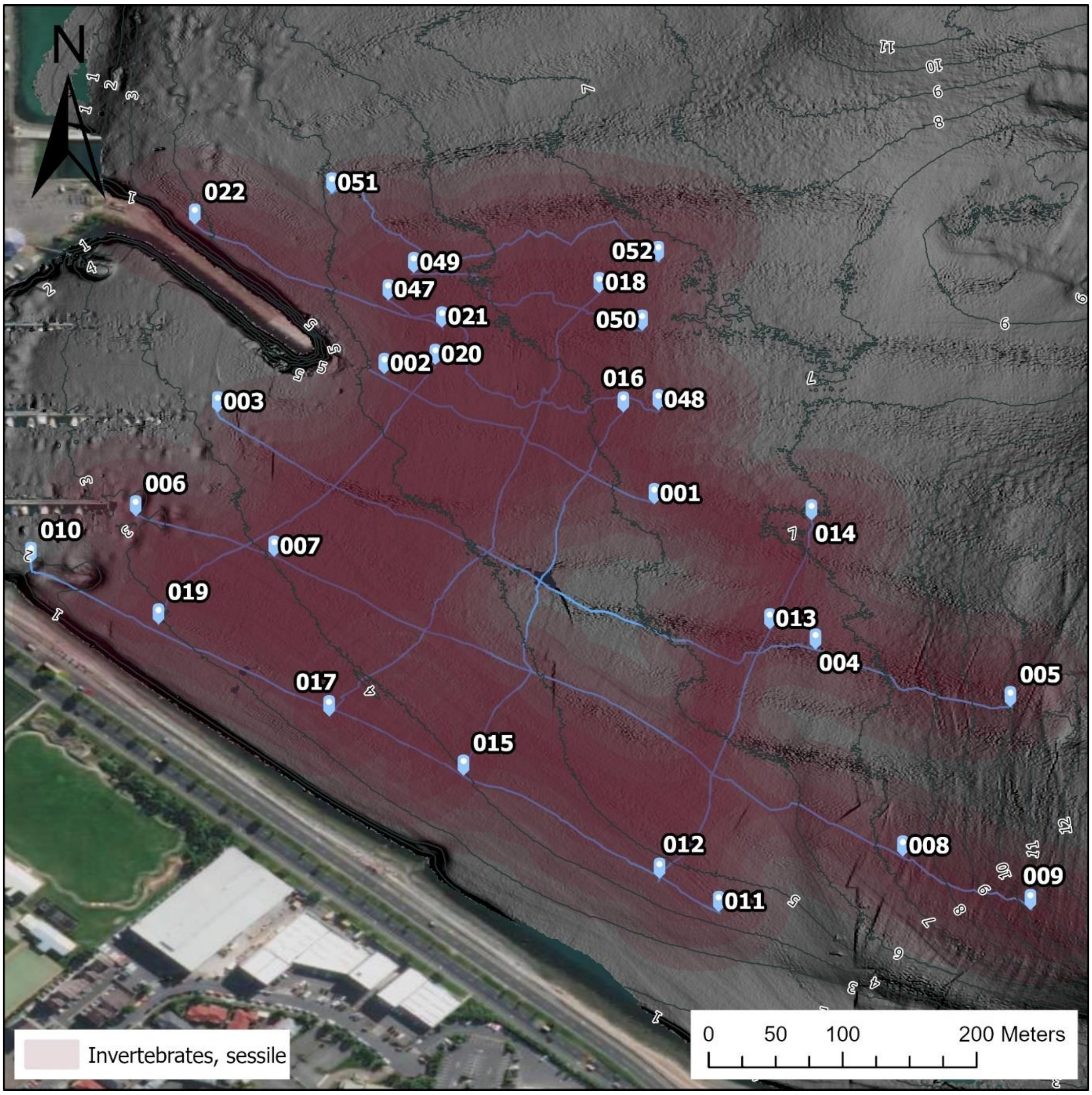

Figure 17: Map showing the distribution of sessile invertebrates in Evans Bay (winter).

3.1 Dive transects

In winter, dive transect T1 (depth 6.3-6.6 m) was characterized by a dense coverage of *Adamsiella* along the entire 30 m transect (Figure 18). The five quadrats had 100% coverage, and the thickness of the bed varied between 10 and 15 cm. The wet weight found in the quadrats ranged between 531 g and 961 g. Other algae were almost absent and only 1 g of *Callophyllis angustifrons* and *Griffithsia* sp. was recorded from a quadrat. In summer, the five quadrats in T1 (depth 6.8-6.9) had 100% coverage, the thickness of the bed varied between 8 and 11 cm, and the wet weight ranged 385 and 959 g. Other algae present were *Pterosiphonia* sp. *Aphanocladia delicatula*, *Leptosiphonia brodiei* and a fragment of *Carpophyllum flexuosum*. The total biomass of these species was less than 1 g. Large mobile invertebrates were observed along the transects (e.g., kina, *Coscinasterias muricata*) in winter and summer survey (see Appendix B). Anoxic sediment underneath *Adamsiella* was not observed.

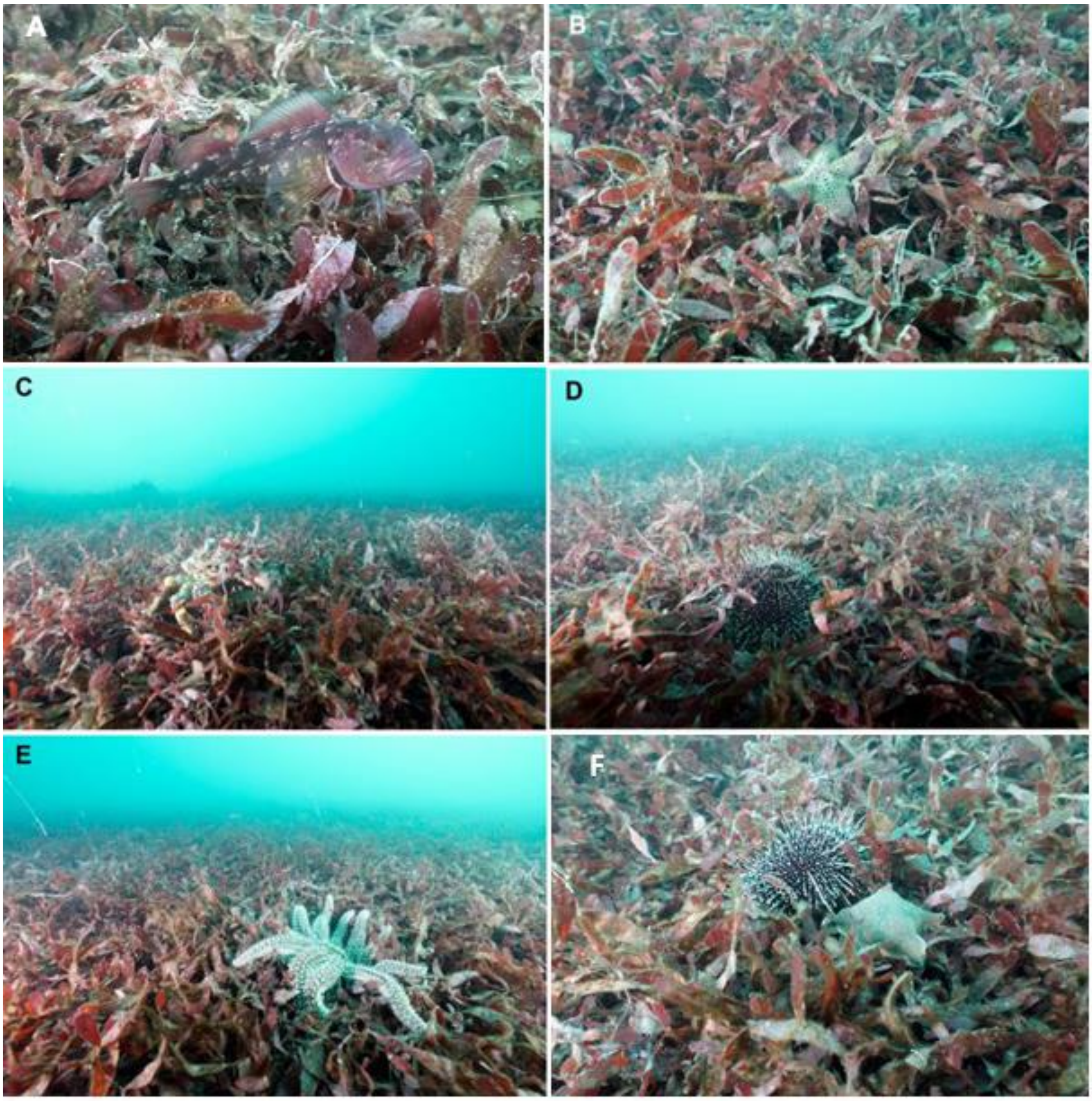

Figure 18: Dive transect T1, characterised by a dense coverage of *Adamsiella*.A. Triple fin (*Forsterygion varium*) B. *Pentagonaster pulchellus.* C. Masking crab (*Notomithrax* sp.*).* D. kina. E. *Coscinasterias muricata*. F. *Patiriella/Meridiastra* and kina.

In winter, transect T2 (depth 5.3-5.4 m) was characterized by a dense coverage of *Adamsiella* along the entire 30 m transect (Figure 19). The five quadrats had 100% coverage, the thickness of the bed varied between 2 and 13 cm, and the wet weight among the quadrats ranged between 554 g and 875 g. Other algae (*Callophyllis angustifrons* and *Sarcothalia livida*) were recorded in small quantities. In summer, the five quadrats (depth 6.1-6.2) had a coverage of 100 %, thickness ranging between 10 and 12 cm, and wet weight varied 576 and 853 g. *Ceramium* sp. was collected in negligible amounts, less than 1 g. Large mobile invertebrates were observed along the transects e.g., *Australostichopus mollis*, kina (see Appendix B). Anoxic sediment underneath *Adamsiella* was not observed.

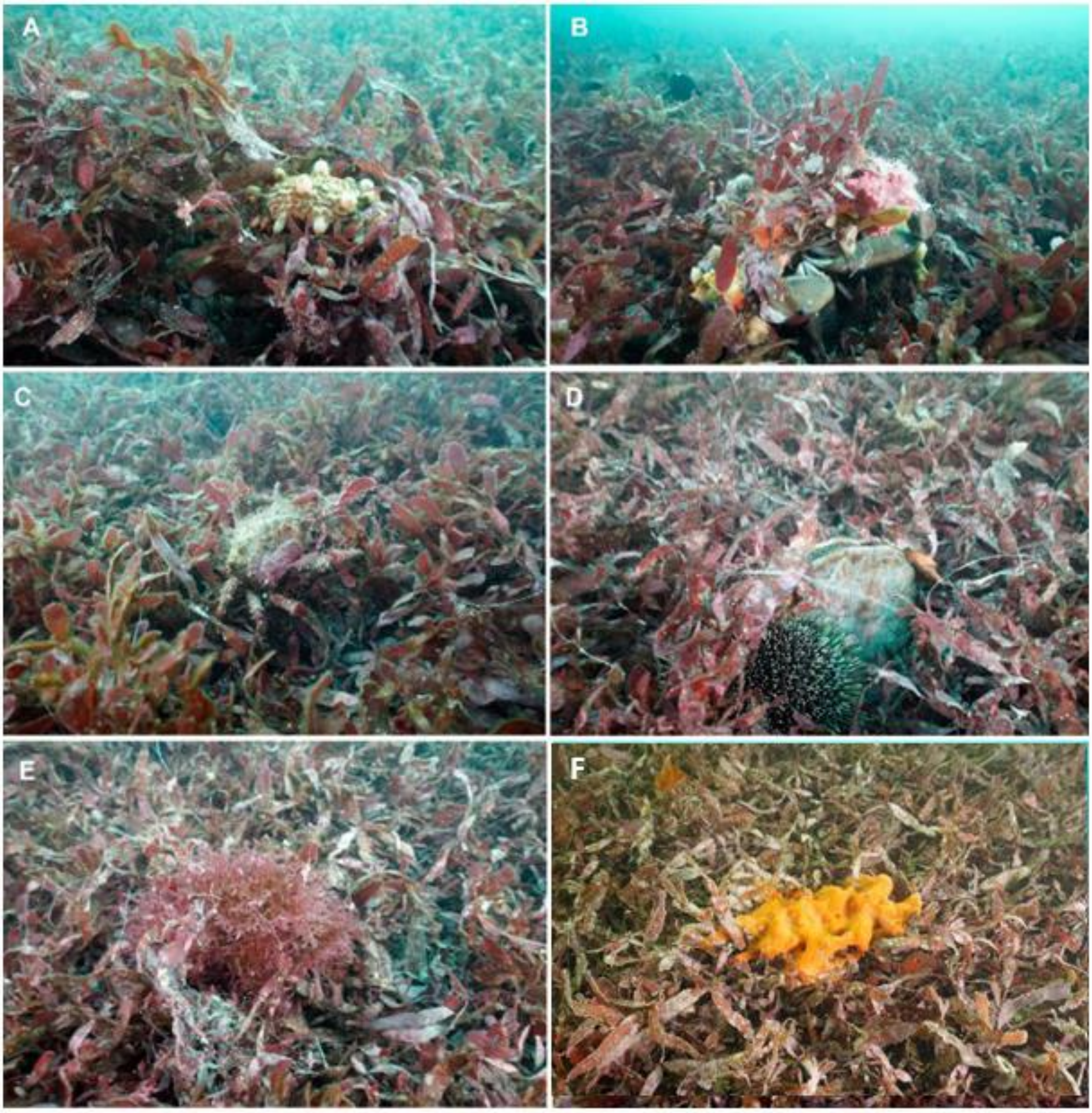

Figure 19: Dive transect T2, characterised by a dense coverage of *Adamsiella* A. Holothurian (*Australostichopus mollis*). B-C Masking crab (*Notomithrax* sp.). D. Kina and horse mussel. E. *Callophyllis angustifrons*. F. Orange colonial ascidian (*Didemnum lambitum*).

In winter, dive transect T3 (depth 4.3-4.7 m) was characterized by a sparse coverage of *Adamsiella* along the entire 30 m transect (Figure 20). *Adamsiella* coverage in the quadrats varied from 20 to 80 %, the thickness of the bed between 1 and 3 cm and the wet weight among the quadrats ranged between 40 g and 176 g. Other algae (16 taxa) were recorded for a total weight of 197 g. In summer (depth 5.4-5.5 m) *Adamsiella* coverage was sparse, ranging between 20 and 70 %, thickness 1 cm and wet weight varied 33-183 g. Eight algal taxa were recorded, although in small quantities. Large invertebrates e.g., horse mussels, kina, were observed in winter and summer (see Appendix B). Anoxic sediment underneath *Adamsiella* was not observed.

Figure 20: Dive transect T3, characterised by a sparse coverage of *Adamsiella*.A. Hermit crab (Paguridae) B. Horse mussels (*Atrina zelandica*). C. Nudibranch (*Doris wellingtonensis*). D. Scallop (*Pecten novaezelandiae)*. E. *Polysiphonia* sp. and colonial ascidian. F. Gastropods.

In winter, dive transect T4 (depth 6.8-6.9 m) was characterized by a substrate of muddy sand with shell gravel and the absence of *Adamsiella* (Figure 21). Invertebrates kina, *Coscinasterias* and *Patiriella*/*Meridiastra* sp. were found commonly along the transect. Other macroalgae were scarce. In summer (depth 6.7 m) *Adamsiella* fragments were recorded but with less than 1 g in biomass.

Figure 21: Dive transect T4, characterised by absence of *Adamsiella.* A. Sandy mud with shell gravel. B. Yellow sponge. C. *Coscinasterias muricata*. D. Kina

In winter, dive transect T5 (depth 6.3-6.5 m) was characterized by a dense coverage of *Adamsiella* along the entire 30 m transect (Figure 22). The five quadrats had 100% coverage, the thickness of the bed varied between 11 and 13 cm and the wet weight among the quadrats ranged between 584 g and 853 g. Similarly, in summer (depth 6.1 m) *Adamsiella* coverage was 100%, the thickness of the bed ranged between 5 and 15 cm, and the wet weight between 596 and 820 g. Anoxic sediment underneath *Adamsiella* was not observed.

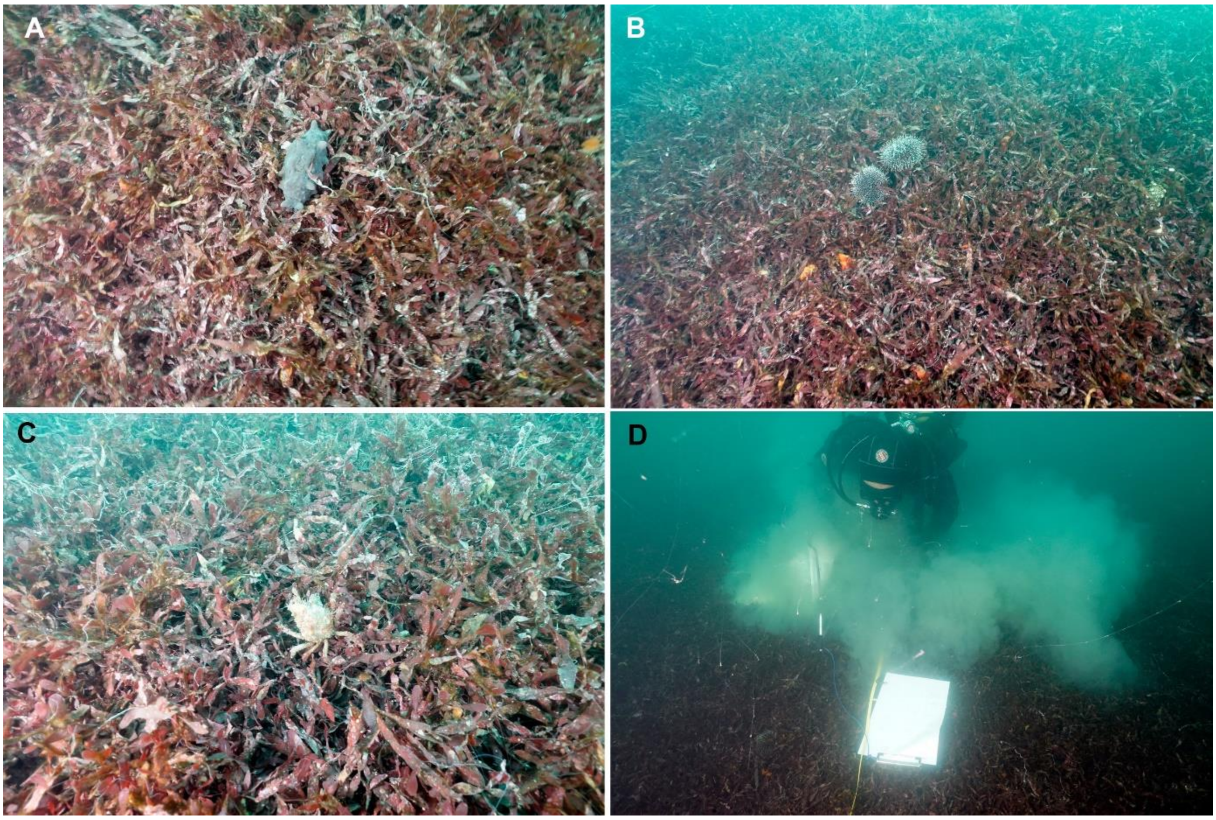

Figure 22: Dive transect T5, characterised by a dense coverage of *Adamsiella*. A. Holothurian (*Australostichopus mollis).* B. Kina. C. Masking crab (*Notomithrax* sp.). D. fine sediment cloud resulting from disturbance of the substrate.

In winter, dive transect T6 (depth 6.3-6.5 m) was characterized by a dense coverage of *Adamsiella* along the entire 30 m transect (Figure 23). Three quadrats had 100% coverage, the other two quadrats had 90 and 70 % coverage, the thickness of the bed varied between 3 and 10 cm, and the wet weight among the quadrats ranged between 139 g and 510 g. In summer (depth 8.2 m), four quadrats had a coverage of 100% and one of 80 %, thickness was 5 cm in all the quadrats and the wet weight between 274 and 461 g. Other algae recorded were *Callophyllis angustifrons* and *Leptosiphonia brodiei*. Anoxic sediment underneath *Adamsiella* was not observed.

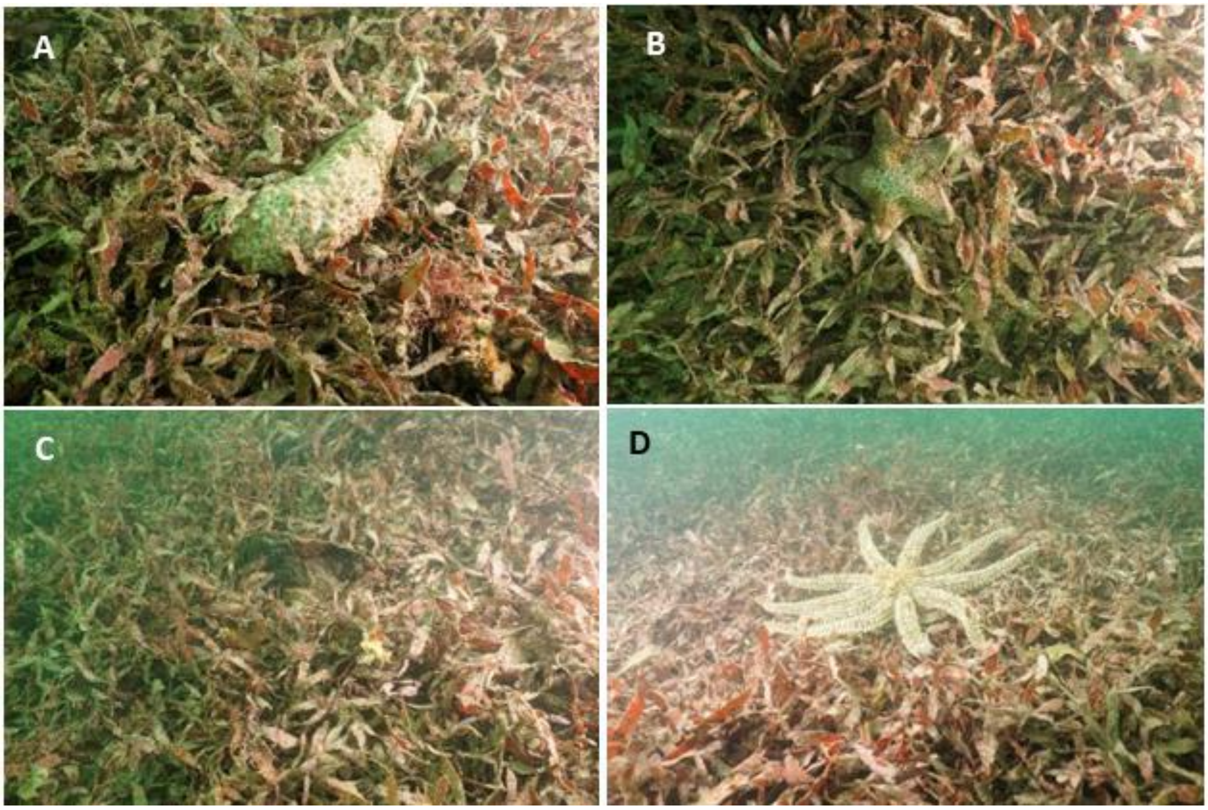

Figure 23: Dive transect T6, characterised by a dense coverage of *Adamsiella.* A. Holothurian (*Australostichopus mollis*). B. *Pentagonaster pulchellus.* C. Horse mussel. D. *Coscinasterias muricata.*

3.2 Biomass estimation

Winter survey

The estimates of the biomass per square metre in the dense and sparse regions of the *Adamsiella* bed were respectively 2,582 g and 515 g wet weight. The estimate of the biomass for the areas of dense (65,192 m^2) and sparse (49,543 m^2) coverage were respectively 168,325.743 kg and 25,514.65 kg. The total biomass estimate of the bed in Evans Bay was 193,840.38 kg.

The conversion from wet to dry weight was calculated to be 0.27. The dry weight per square metre was therefore calculated as 697.14 and 139.05 g in dense and sparse areas respectively. The average dry weight was 456.3 g per square metre.

Summer survey

The estimates of the biomass per square metre in the dense and sparse regions of the *Adamsiella* bed were respectively 2,469 g and 610 g wet weight. The estimate of the biomass for the areas of dense (81,684m^2) and sparse (31,065 m^2) were respectively 201,677.796 kg and 18,949.65 kg. The total biomass estimate of the bed in Evans Bay was 220,627.446 kg.

The conversion from wet to dry weight was calculated to be 0.27. The dry weight per square metre was therefore calculated as 666.63 g and 164.7 g in dense and sparse areas respectively. The average dry weight was 415.6 g per square metre.

Table 2: Estimated biomass of the Adamsiella bed in Evans Bay.

Adamsiella	Wet Weight per m^2		Dry Weight per m^2		Total wet weight estimated for area covered by Adamsiella	
	Winter 2021	Summer 2022	Winter 2021	Summer 2022	Winter 2021	Summer 2022
Dense	2,582 g	2,469.2 g	697.14 g	666.63 g	168,325.743 kg	201,677.796 kg
Sparse	515 g	610 g	139.05 g	164.7 g	25,514.65 kg	18,949.65 kg
Total					193,840.393 kg	220,627.446 kg

3.3 Diversity and abundance

A total of 60 taxa were collected from quadrats in June 2021, including 20 algal taxa, one fish and 39 invertebrate taxa. In comparison, 12 algae taxa and 42 invertebrate taxa (a total of 54 taxa) were collected in February 2022. At both times red algae predominated (18 reds in June, seven in February). In June two invasive algal species were collected (the invasive kelp, *Undaria pinnatifida*) and the red alga *Leptosiphonia brodiei.* Although *Leptosiphonia* was collected again in February, *Undaria* was not, but was seen occasionally in the underwater videos. In June the green alga *Codium fragile* was collected but samples would require gene sequencing to determine if it was the native or invasive subspecies. Twelve taxa were identified to species level from June collections, and seven from February collections. The identity of *Adamsiella angustifolia* was confirmed by *rbc*L analysis (see Appendix E). *Callophyllis angustifrons, Melanothamnus strictissimus,* and *Leptosiphonia brodiei* were also confirmed by *rbc*L sequence data. The remainder require more work to identify further as the material was often fragmentary or would require sequencing to confirm identities.

In June, the 39 invertebrate taxa collected from quadrats included 13 molluscs, eight echinoderms, nine crustaceans, three polychaetes, and several other taxa. In February there were more mollusc taxa found (17) but similar numbers of echinoderm and crustacean taxa (seven and nine respectively), and other taxa (see Appendix A). Average taxon richness per transect and average *Adamsiella* percentage cover are shown in Figure 24 A&B. Total diversity was greater in February than in June across most transects, and in both cases total diversity was generally highest in the transects with the highest *Adamsiella* % cover (T1, T2, T5 & T6). However, there were other changes in diversity between T3 and T4 (Figure 24 A&B).

Molluscs dominated abundance counts from the four transects with the highest level of *Adamsiella* percentage cover in June (T1, T2, T5 & T6) (Figure 25A), and all transects in February (Figure 25B). Crustaceans were also more abundant across transects in February than June. At both times abundance was lowest in the two transects with the lowest levels of *Adamsiella* cover (T3 and T4), however other shifts in abundance were also noticeable, for example, between T1 and T6 which had the highest average abundance in February (Figure 25C&D). At both times the most abundant invertebrate species was the screw shell, *Maoricolpus roseus* (Appendix A).

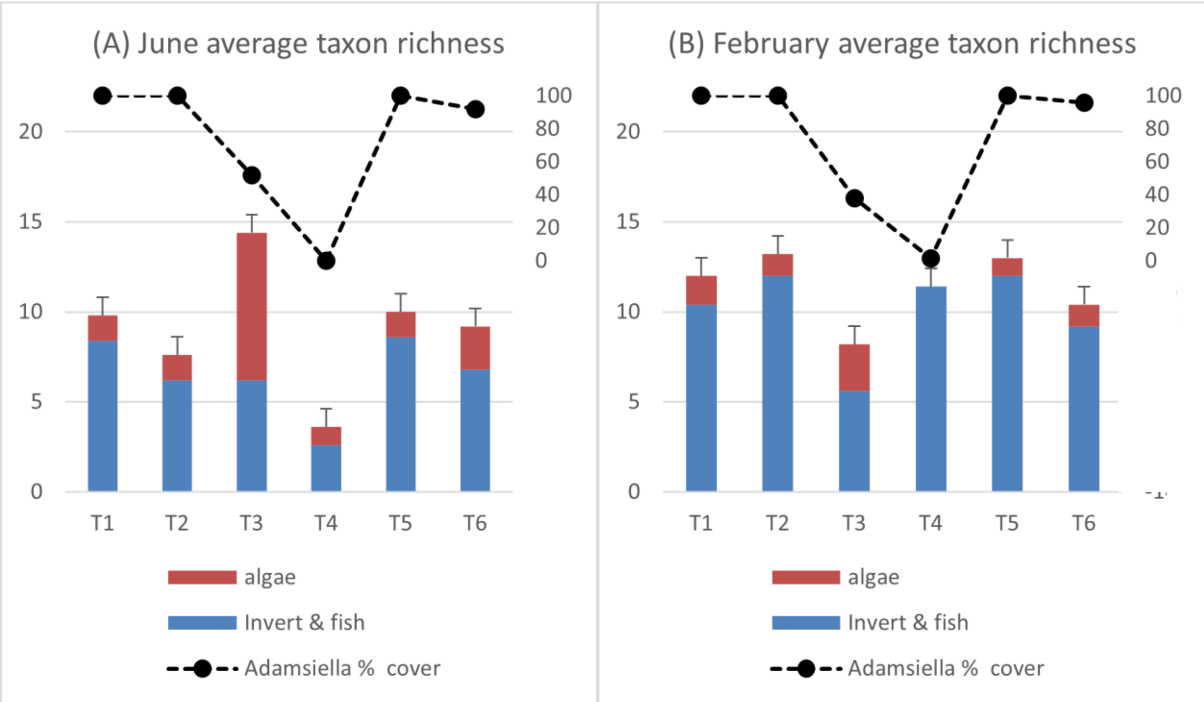

Figure 24: **Average taxon richness (+ SD) and *Adamsiella* percentage cover recorded from transects by divers in the Evans Bay *Adamsiella* bed in June 2021 (A) and February 2022 (B).**

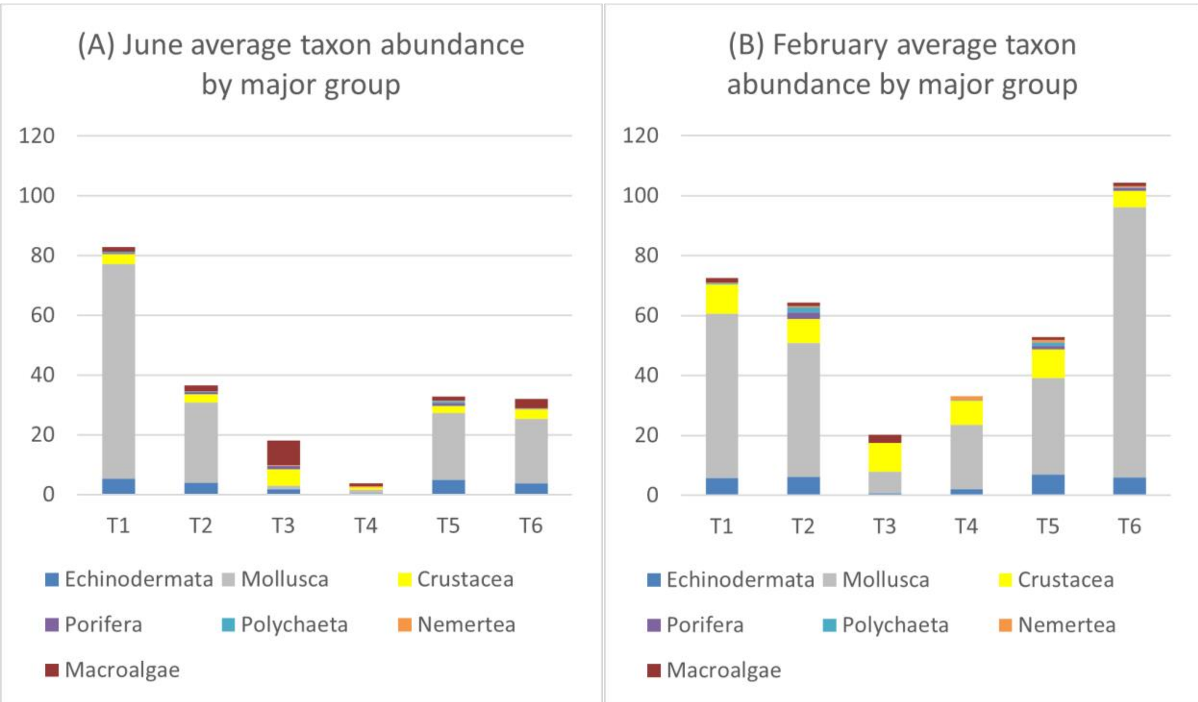

Figure 25: **Average taxon abundance recorded from transects by divers in the Evans Bay Adamsiella bed in June 2021 (A) and February 2022 (B).**

3.4 Other sites surveyed with the towed camera

3.4.1 Burnham Wharf

Adamsiella was not observed along the two transects surveyed with the towed camera at Burnham wharf (Figure 26). Transect BW01 started at the northern end of Burnham wharf in shallow water 1.3 m depth characterised by a belt of *Carpophyllum flexuosum* and *Cystophora retroflexa* intermixed with cobbles with crustose and geniculate coralline algae, which extend up to 4-5 m depth. After a brief transition to an area with larger cobbles in deeper water at 6-7.2 m depth, the substrate became sandy mud with fine or coarse shell hash, occasionally with filamentous macroalgae (e.g., *Leptosiphonia brodiei*) or sparse *Codium fragile*. Common invertebrates observed included *Coscinasterias muricata*, *Patiriella/Meridiastra* and tubeworms. In slightly shallower water (6-5 m) the sediment became pebblier with shell gravel and sparse plants of *Carpophyllum flexuosum*, orange ascidians and sparse sea urchins. Fish (spotty and juvenile leather jackets (*Meuschenia scaber*)) were observed along the video tow. Transect BW02 was at depths of 8-12 m. The substrate was characterised by sandy mud with tubeworms and filamentous macroalgae alternating with areas with shell gravels covered by fine sediment (Figure 27).

Figure 26: Boat tracks of the towed video transects at Burnham wharf (BW01S- BW02S).

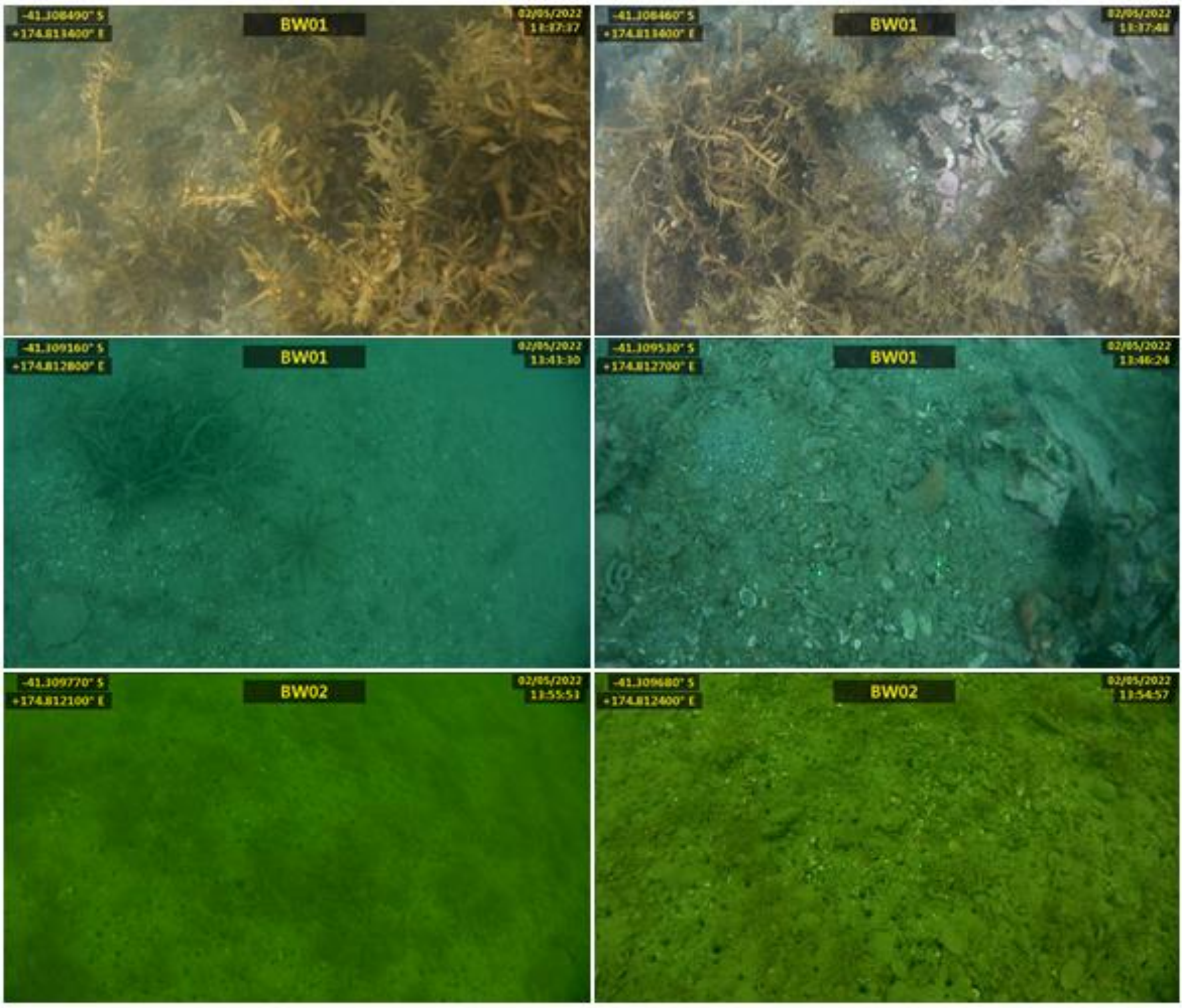

Figure 27: Examples of video frames showing subtidal habitats at Burnham wharf.

3.4.2 Roseneath

Adamsiella was not observed along the two transects surveyed at the northern end of Roseneath (Figure 28). Transect RN01 (Figure 29) ran perpendicular to the shoreline from 4 to 12 m. The shallow water section was characterised by bed rock, followed by large cobbles with crustose coralline algae, orange solitary ascidians, encrusting tubeworms, sparse *Coscinasterias muricata*, kina and *Australostichopus mollis*. In deeper water the substrate became characterised by shell gravel and cobbles with frequent red algal assemblages, mostly *Callophyllis angustifrons*, *Stenogramma* sp. and filamentous red algae. If some sparse plants of *Adamsiella* were present in the assemblage it was not obvious as seen at the southern end of Evans Bay. At the deeper end of the transect 9–12 m, large sponges were observed intermixed with patchy algal assemblages. Transects RN02 (Figure 30) ran mostly parallel to the shoreline from 4 to 9 m, characterised by cobbles and shell gravel with encrusting, coralline algae, calcareous tubeworms, solitary orange ascidians (*Cnemidocarpa bicornuta)*, and sparse kina. Filamentous macroalgae were observed slightly deeper at 8-9 m. Horse mussels and scallops were also observed along the transect.

Figure 28: Boat tracks of the towed video transects at Roseneath (RN01E-RN02S)

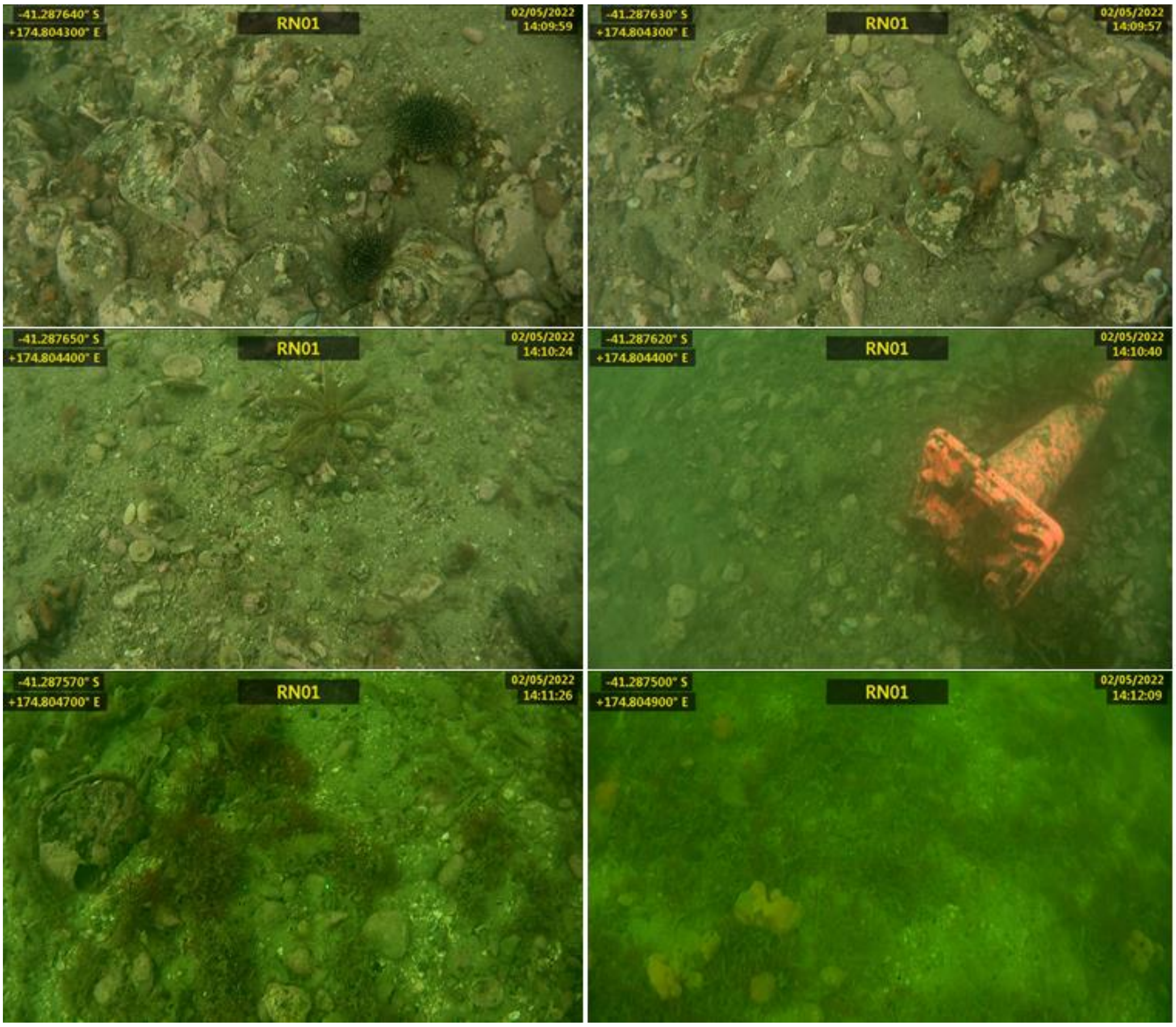

Figure 27: Examples of video frames showing subtidal habitats at Roseneath (transect RN01).

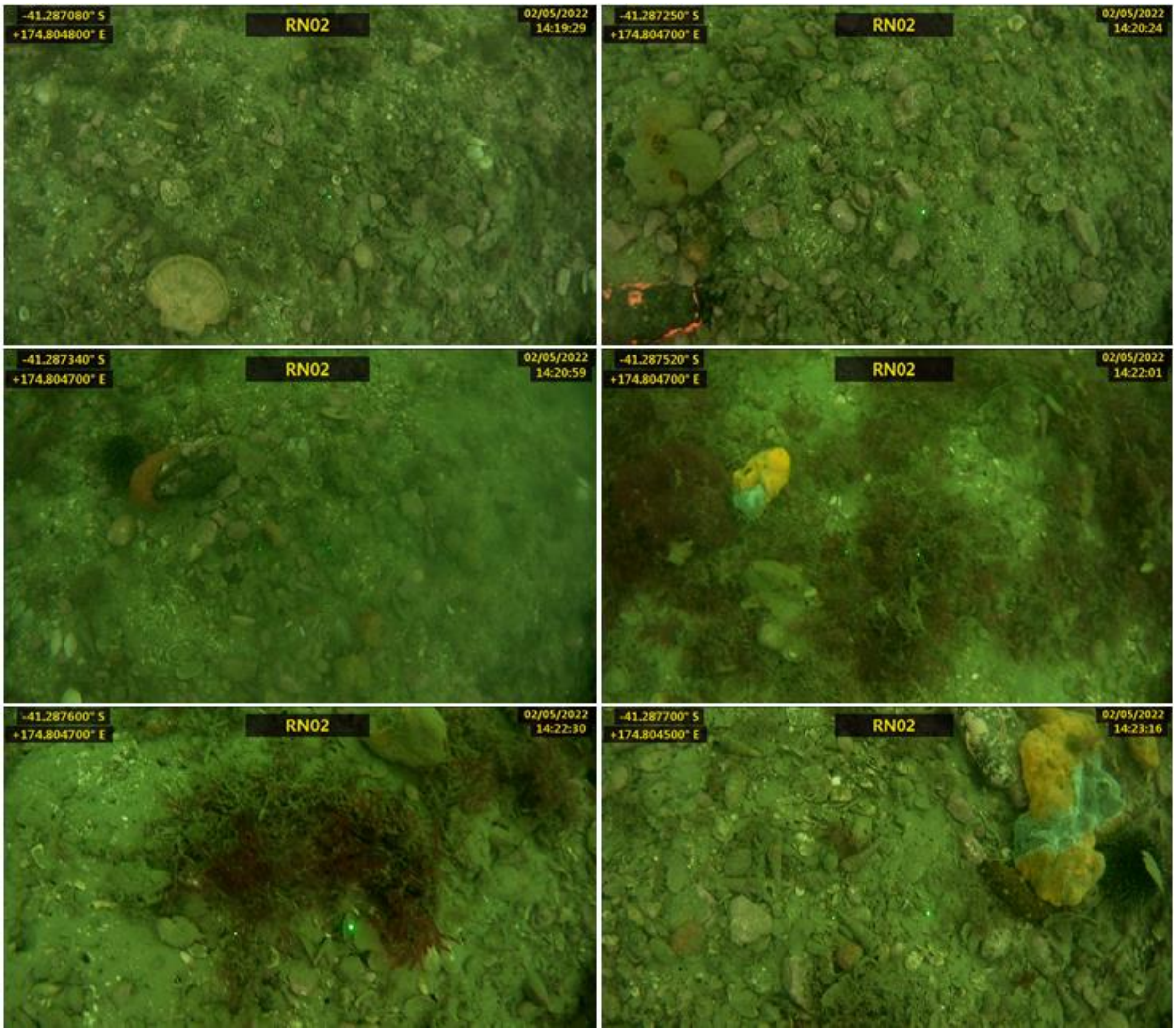

Figure 28: Examples of video frames showing subtidal habitats at Roseneath (transect RN01).

3.4.3 Greta Point

Adamsiella was not observed along the two transects at Greta Point (Figure 31). The two transects ran parallel to the shoreline (Figure 31). In shallow water 3.6–5 m, both transects were characterised by bed rock and large cobbles encrusted with coralline algae, calcareous tubeworms, colonial orange ascidians (*Aplidium benhami*), solitary ascidians, and encrusting sponges. Slightly deeper the substrate consisted of small cobbles, becoming sandy mud with shell and gravel at 8-10m with patchy seaweed assemblages and large sponges. Sparse horse mussels and scallops were observed along the transects (Figures 32 and 33) and the brittle star *Ophiopsammus maculata.*

Figure 29: Boat tracks of the towed video transects at Greta Point (GP01E- GP02E).

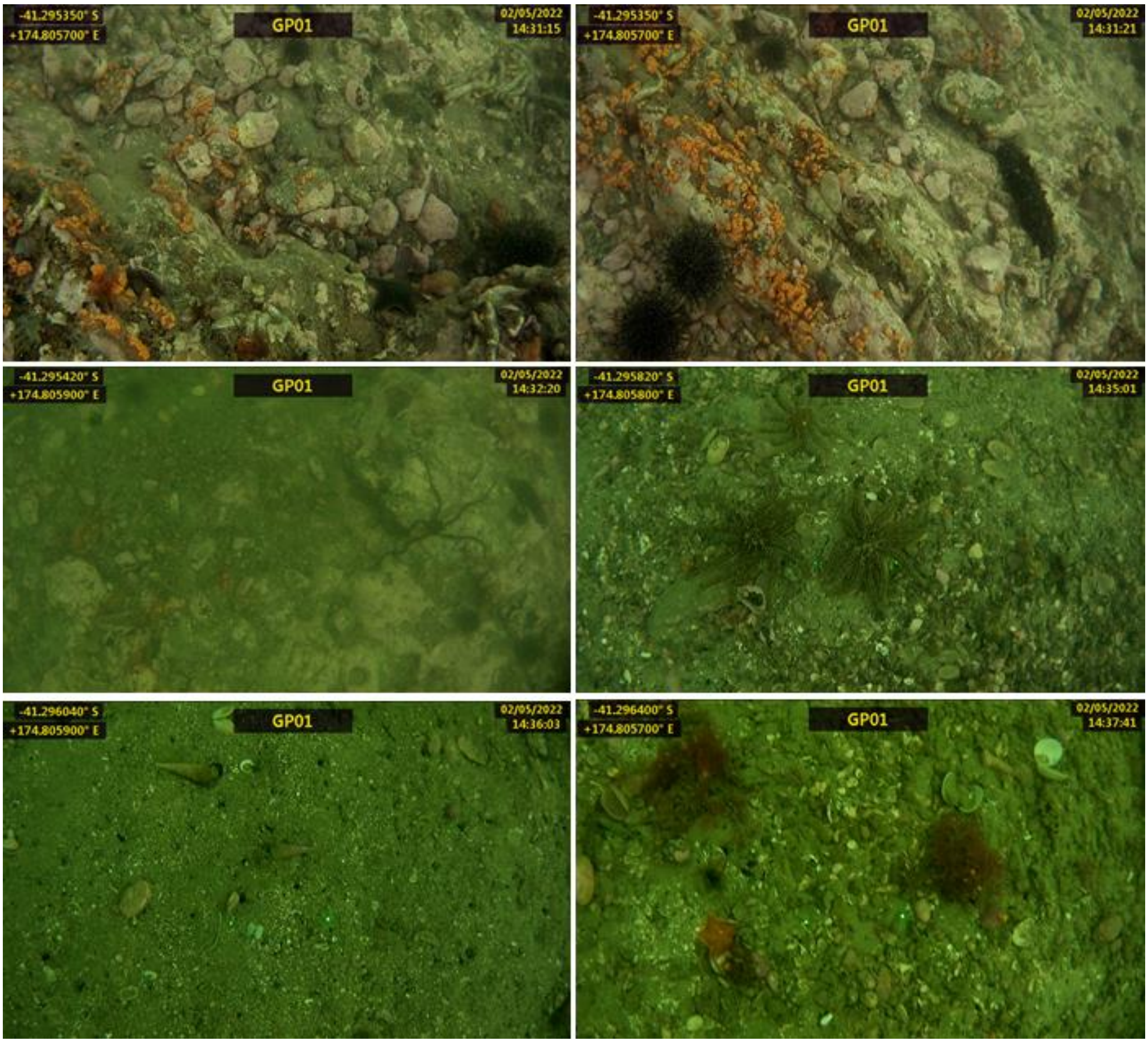

Figure 30: Examples of video frames showing subtidal habitats at Roseneath (transect GP01E).

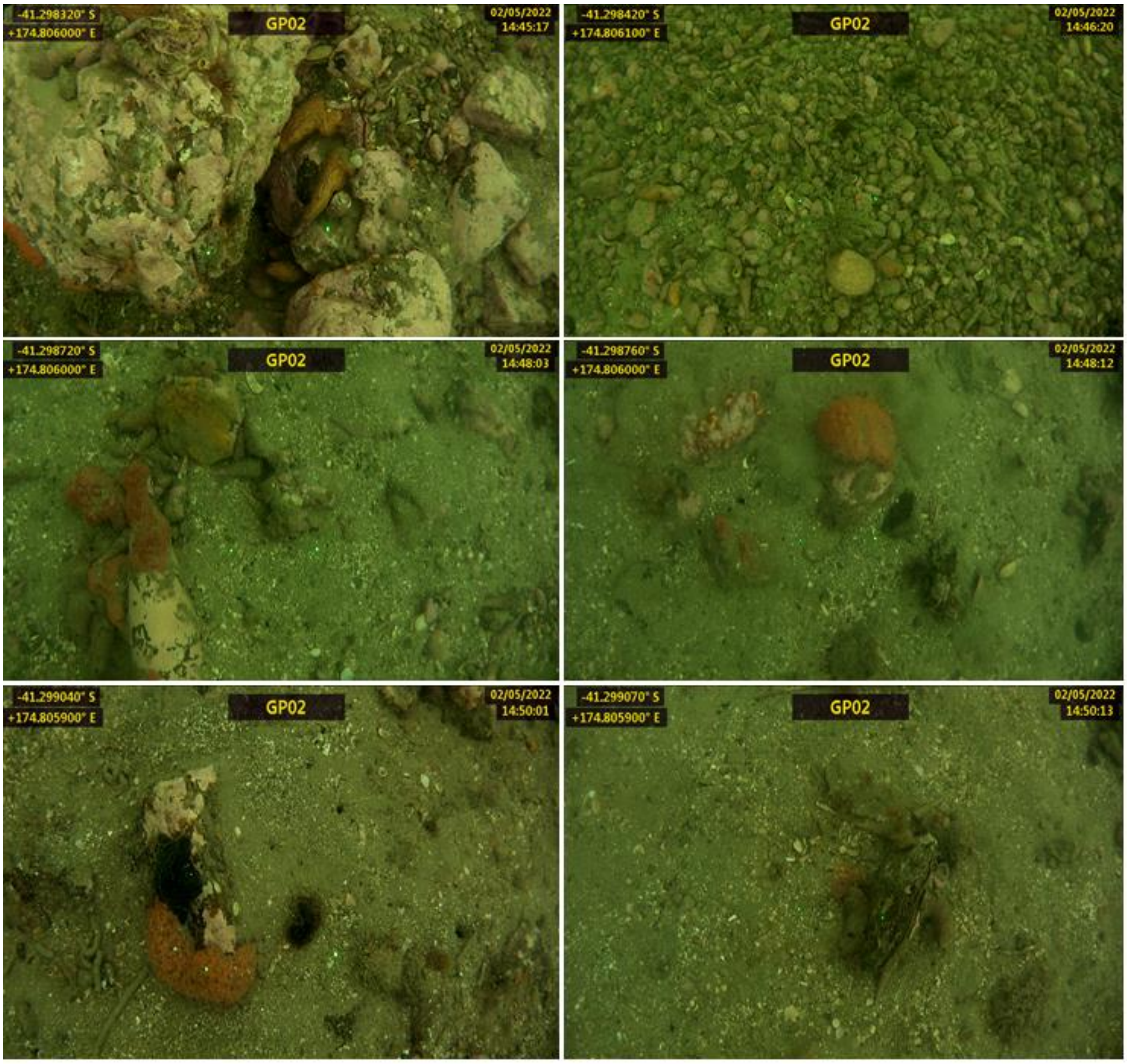

Figure 31: Examples of video frames showing subtidal habitats at Greta Point (transect GP02E).

4 Discussion and conclusions

4.1 Winter and summer surveys

The towed video transects acquired in summer have complemented the data acquired in the winter survey and further delimited *Adamsiella* bed, confirming the northern limit and the western edge in proximity of the Evans Bay Marina. The summer transects have contributed new data about the areas of sparse and dense *Adamsiella* and two polygons have been drawn on the map to highlight these areas. The area covered by dense *Adamsiella* is 81,684 m^2 and the area of sparse *Adamsiella* is 31,065 m^2 for a total of 112,749 m^2. The total area of the combined data winter and summer was slightly smaller than the area estimated in winter (114,735 m^2) however the total biomass for the summer survey – calculated on the total area (winter and summer surveys) was higher - possibly because during the summers survey more areas of dense *Adamsiella* were confirmed through the underwater video analysis.

At both sampling times, species richness was lowest in the areas of lower *Adamsiella* percentage cover (e.g., either transect 3 or 4). Overall, invertebrate richness was higher, and algae richness lower in February compared to the previous June. Invertebrate abundance was dominated by molluscs at both sampling times, and there were different patterns of abundance observed between and within transects in June and February.

The biomass was very similar with a slight increase in summer in both sparse and dense areas showing that the bed is stable and doesn't have seasonal fluctuations. Our observations agree with Kregting et al. (2008a, b) who observed no evidence of nitrogen limited growth in summer as observed for temperate species growing on hard substrate (Hepburn & Hurd 2005). *Adamsiella* was not observed in the other sites surveyed with the towed camera (Burnham wharf, Roseneath and Greta Point). *Adamsiella* was recorded at these sites in 2009-2011. It is unknown how abundant it was at the time and why has not been recorded since then. At Roseneath there were some sparse red algal assemblages, and if *Adamsiella* was present, it was not obvious from the video. Potentially this could be a site that could support *Adamsiella* in case transplanting the bed from the south end of Evans Bay is attempted. However, a site assessment would be necessary to understand if the hydrodynamic environment, light, nutrient and sediment conditions are suitable for *Adamsiella*.

4.2 Ecosystem services

The role of macroalgae in ecosystem functioning in soft sediment ecosystems has received little attention both globally and in New Zealand, not only with respect to their contributions to productivity but also to system complexity (Neill et al. 2012; Anderson et al. 2019; Schmidt et al. 2021). While investigations of the ecosystem functions and services provided by the *Adamsiella* bed in Evans Bay have not been conducted, based on research elsewhere, it is possible to generalise about the contributions of algal meadows ecosystem services.

Red algal meadows are known to alter the local water flow regime primarily by reducing the speed of water flow within the canopy), as well as influencing the local dynamics of sediment, including stabilising sediments (e.g., Cornelisen & Thomas 2004; Schmidt et al. 2021). They may also function as coastal filters in eutrophic coastal bays and embayments (McGlathery et al. 2007; Anderson et al. 2019). In studies on a macroalga in Italy with similar physical properties to *Adamsiella*, Schmidt et al. (2021) noted "despite reaching heights of only about 15 cm, this red alga therefore acts as a small-scale ecosystem engineer", by influencing the key environmental factors such as water movement and light intensity, and by providing resources for associated organisms by retaining sediment, providing food, and creating habitat.

The primary production by red algal meadows has been estimated to be an important source of carbon for near shore food webs (Kregting et al. 2008a) particularly in areas sheltered from wave action and where there are no large rocky reefs. Red algal beds may also be sites of long-term burial of carbon (Gattusso et al. 1998). They also provide three-dimensional habitat and low-lying canopy cover for a range of invertebrates and fishes, as well as surfaces for settlement of larval stages, and sites for reproduction for marine fauna (Lenihan & Micheli 2001; Anderson et al. 2019). Investigations of the beds of the red alga *Phyllophora* in the Mediterranean have revealed high diversity of associated invertebrates including bryozoa, serpulid polychaetes, and potentially serving as 'biodiversity reservoirs' for sessile invertebrates under changing ocean conditions (Rossbach et al. 2021, 2022; Schmidt et al. 2021; El-Khaled et al. 2022).

4.3 Anthropogenic and climate change threats

Anderson et al. (2019) summarised the key stressors and threats influencing algal meadows at a national scale. The threats of greatest relevance to the *Adamsiella* bed in Evans Bay include the impacts of sedimentation, boat anchoring, pollution, marina expansion, reclamation, invasive species, and general effects of climate change. As the *Adamsiella* bed is adjacent to a marina, and also neighbours Evans Bay Parade and Cobham Drive (State Highway One), the habitat has been influenced by impacts of urbanisation and anthropogenic change over time which are likely to have reduced local biodiversity (Scherner et al. 2013). Oliver (2014) noted that Wellington Harbour is affected by urban stormwater containing significant concentrations of copper, lead and zinc "likely sourced from amongst other things, vehicle brake and tyre wear, galvanised roofs and historical inputs of road dust and soils contaminated by leaded petrol and lead based paints". Recent extensive roadworks and changes to the coastal margin, have resulted in visible sedimentation of the southern end of Evans Bay and resuspension of sediments under strong wind conditions. Nelson et al. (2020) assessed six known categories of impacts of climate change (after Foley & Carbines 2019) on the Evans Bay *Adamsiella* beds, based on expert knowledge and a previous expert assessment (MacDiarmid et al. 2012). The most significant were considered to be rising sea water temperatures (both long term and also associated with heat waves), sedimentation and nutrients, with extreme rainfall, ocean acidification and sea level rise all evaluated as having moderate impact.

Although there are long term sediment sampling sites in Wellington Harbour (Oliver 2014; Hewitt 2019; Cummings et al. 2022), none of the sites are within the *Adamsiella* bed. The nearest sites (EB1 and EB2 – Oliver 2014; Cummings et al. 2022) differ from other sites in Wellington Harbour with sand dominating rather than finer sediments. The sediments directly under the bed have not been analysed, and it is not clear if the sediments measured at EB1 (now discontinued as a monitoring site) and EB2 are representative of the sediments in the *Adamsiella* bed.

In Europe extensive red algal meadows were reported by Zernov in the 1950s in the NW shelf of the Black Sea, with an area of approximately 11,000km^2, and an estimated biomass of between 5 and 10 tonnes (Berov et al. 2018), referred to a 'Zernov's field'. The extent of this field was greatly affected by eutrophication, and by the 1980s was reduced in size by an order of magnitude. Recovery was recorded by the early 2000s, but there is evidence of secondary eutrophication resulting from leaching of nutrients from the sediments (Berov et al. 2018). Stevens et al. (2019) summarised the collapse and partial recovery of the Black Sea *Phyllophora* beds. Near the Ukraine coast in NW Black Sea there are two *Phyllophora* beds, the largest of which was declared the first offshore, fully marine

MPA in the Black Sea by the President of Ukraine (Presidential order, 1064/2008; Kostylev et al., 2010). Kostylev et al. (2012) report on the designation of the smaller bed as a nature reserve of national importance, based on its role as habitat for fish and invertebrate species, with the intention of enabling both protection and continuing restoration of the ecosystem values of these beds.

Loose-lying mats of *Phyllophora crispa* have also been reported from the United Kingdom and evaluated as a unique biotope for the Marine Life Information Network, Marine Biological Association of the United Kingdom (Tyler-Walters 2016). Tyler-Walters (2016) notes that little direct research has been undertaken on this biotope in the UK, and thus the sensitivity analyses had to be based on more general information. It is noted that the removal of the *Phyllophora* mat would “result in a significant change in the biological character of, and loss of, the biotope”.

4.4 General Discussion

The survey reported here to delimit the *Adamsiella* bed in Evans Bay and describe the associated biodiversity provides new information, revealing it to be a site with high biomass when compared to both soft sediment algal assemblages and other marine algal habitats in New Zealand (e.g., Desmond et al. 2015; Neill & Nelson 2016). In Otago Harbour maximum growth of the meadow-forming *Adamsiella chauvinii* (Harv.) L.E. Phillips & W.A. Nelson occurred between January and March (Kregting et al. 2008a, b). After examining the nutrient status of this alga and the prevailing nutrient environment within the harbour, Kregting et al. (2008a, b) proposed that macroalgae growing on soft sediments may have little reliance on external nutrients but rather obtain sufficient nutrients from localised sources from sediments beneath the macroalgal canopy. In this study of *Adamsiella* in Wellington, there is little difference between winter and summer in the biomass and associated biota.

The recent research on Mediterranean red algal meadows has revealed high associated biodiversity of invertebrates (Rossbach et al 2021, 2022, El-Khaled et al. 2022). Rossbach et al. (2021) recommending that these habitats “should be included in conservation strategies”. Schmidt et al. (2021) note the need to further investigate how red algal mats may be moderating local environmental conditions, and to evaluate the potential of red algal mats to serve as refuge habitat for organisms “which may suffer habitat loss from anthropogenic pressure and climate change”. El-Khaled et al. (2022) suggest that fleshy red algal mats can act as “alternative habitats and temporary sessile invertebrate biodiversity reservoirs in times of environmental change”.

As noted by Anderson et al. (2019), algal meadows on soft sediments are poorly protected in New Zealand with few occurring within existing marine reserves. In addition, little is known about the vulnerability or recovery rates of algal meadows relative to stressors and disturbances.

If attempts are to be made to enhance, restore or transplant *Adamsiella* to protect the productivity and associated biodiversity of these meadows, more information is required to understand the hydrodynamic environment that enables the stability of this loose-lying assemblage, as well as a greater understanding of the light, nutrient and sediment conditions. At present there is a lack of habitat-specific information about environmental drivers, as well as fundamental biological data (e.g., the growth and reproduction of *Adamsiella* within the beds - is the maintenance of the population through largely vegetative growth or as a result of sexual reproduction-?) as well as ecological information (e.g., the impact of structural complexity on ecosystem functioning).

The exploration of other sites within Evans Bay did not reveal any additional sites where *Adamsiella* is currently forming beds. Sparse algal assemblages were recorded at the northern entrance of Evans

Bay, Roseneath and at Greta Point. These sites could be assessed to see if they could support *Adamsiella*.

Restoration of marine vegetation has largely focused on sea grass and on kelp forests, with little attention on biodiverse red algal meadows (e.g., Cebrian et al. 2021). In seagrass meadow restoration, it has been demonstrated that scale and feasibility are positively correlated (van Katwijk et al. 2016), with more specimens providing a critical mass, ameliorating stress for the founding population and enhancing survival. There is also evidence that transplanting different species simultaneously may improve their overall survival and growth and enable habitat restoration.

4.5 Conclusions

The *Adamsiella angustifolia* bed in Evans Bay was found to occupy ca. 112,749 m^2 (11.2749 ha) at depths between ca. 4-8 m depth. Approximately 72% of the bed consisted of dense accumulations ca. 10-15 cm thick with 100% *Adamsiella* cover.

The dense areas of *Adamsiella* surveyed by divers had 2 to 3 times the number of species present than the adjacent area with no *Adamsiella* cover.

In terms of the Wellington region, algal assemblages on soft sediments are rare regionally, and no red algal meadows occur within existing marine reserves.

5 Acknowledgements

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Appendix A Diversity counts of invertebrates, fish and algae in each transect and quadrat in June 2021 and February 2022.

	Transect	T1		T2		T3		T4		T5		T6	
	Quadrat	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22
Echinodermata	*Australostichopus mollis*	7	13	11	8	1				13	12	4	7
	Holothuroidea sp. 1 gelatinous	2		2	1						1	6	1
	Holothuroidea sp. 2 red, shield	1		1	4						1		
	Holothuroidea sp. 3 nesting			1									
	Evechinus chloroticus	5	2	2	3				1	3	7		1
	Ophiuroidea								1				
	Coscinasterias muricata	1		3				2	3				
	Patiriella/Meridiastra	11	14	3	12	8	4		5	8	14	9	21
	Pentagonaster pulchellus									1			
Mollusca	*Maoricolpus roseus*	347	215	129	192	2	23	3	39	99	121	28	379
	Buccinulum	1	1		2	1	2		3		2	1	1
	Cominella	1				1							
	Gastropoda sp. 1 (small biege)		5	1		1							1
	Gastropoda sp. 2 (curved base)		1		8						2		
	Gastropoda sp. 3 (triangular)		1		2		2		1		3		
	Gastropoda sp. 4 (tall skinny)								5				
	Gastropoda sp. 5 (flattened)						1		1				
	Lunella smaragda			1	1		3	3	1	2	1		1
	Zeatrophon ambiguus									1	1		
	Corbula zelandica	7	30			1			17	4	21	74	67
	Linucula hartvigiana	1	17	2	17		2		25	3	6	3	2
	Limaria orientalis								3			1	
	Talochlamys (fan scallop?)	1	2		1					2	1		
	Bivalvia sp. 1 (Flat white)						2		1				
	Bivalvia sp. 2 (Smooth rounded)		1				1		3		1		
	Bivalvia sp. 3 (Oblong)								1				
	Bivalvia sp. 4 (Cockle)		1						8		2		
	Chiton (orange)	1					1				1	1	
	Chiton (brown)		4	1					7		1		3
	Cryptoconchus porosus									1			

	Transect	T1		T2		T3		T4		T5		T6	
	Quadrat	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**
Crustacea	Amphipoda					2		1				1	1
	Austrohelice crassa		14		11		11		2	1	16	1	10
	Halicarcinus	9	14	12	24	19	34		14	5	17	10	11
	Notomithrax			1	1	2	1				1		
	Nectocarcinus								1				1
	Paguridae (hermit)	1	19		3	1	2	3	22	3	14	4	3
	Petrolisthes					2			1				
	Shrimp' 1 clear	2	2	1									
	Shrimp' 2 red	4								1			
	Shrimp' 3 thick bodied	1			1	1				1			1
Porifera	Sponge (dark orange pitted)			3	10	1				2	3		1
	Sponge (biege holey)	2		1		1				1	3		4
	Sponge (yellow smooth)				1	4				2			
Fish	Fish	1											
Polychaeta	Polychaete (mud tube worm)	1	1		5					1		1	
	Polychaete (scaleworm)			1	4					1	5		1
	Polychaete (Hesionidae)	1	1						1	1			
Nemertea	Nemertea (black)		1		2	1		2	7	1	4	1	2
Ascidiacea	Ascidacea (solitary)					1		1					
	Ascidacea (colonial)												
Chlorophyta	*Chaetomorpha* sp.						1						
	Codium fragile					2		1					
Ochrophyta	*Carpophyllum flexuosum*		1										
	Colpomenia sp.						1						
	Undaria pinnatifida					3							

	Transect	T1		T2		T3		T4		T5		T6	
	Quadrat	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**	**Jun-21**	**Feb-22**
Rhodophyta	*Acrosorium ciliolatum*					2							
	Adamisella angustifolia	5	5	5	5	5	5	3		5	5	5	4
	Antithamnion					1							
	Aphanocladia delicatula		1			3							
	Apoglossum montagneanum					1							
	Callithamnion					1							
	Callophyllis angustifrons	1		1		5	1			1		3	1
	Caulacanthus ustulatus						2						
	Ceramium (corticated)				1	5						1	1
	Dipterosiphonia							1					
	Griffithsia sp. 1	1				1							
	Griffithsia sp. 2 (fat)					1						1	
	Haraldiophyllum crispatum					3	1						
	Heterosiphonia squarrossa					2							
	Leptosiphonia brodiei						1					1	
	Non-geniculate coralline algae					1	1						
	Phycodrys novae-zelandiae					4				1		1	
	Pterosiphonia sp.		1										
	Rhodymenia					2							
	Sarcothalia livida			4									

Appendix B Diver tallies of large invertebrates and algae on transects In June 2021 and February 2022

Diver tallies	T1		T2		T3		T4		T5		T6	
	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22	Jun-21	Feb-22
Australostichopus mollis				2		1			1	2		
Kina (*Evechinus chloroticus*)	5	4		8			14	4	16	8	4	1
Coscinasterias muricata		1	2	7	3	6	6	5			1	
Pentagonaster pulchellus							1					1
Patiriella/Meridiastra		10		24		11	7	3	4	17	1	1
Notomithrax		1	1						2			
Horse mussels (*Atrina zelandica*)					14	11		1		1	2	1
Lunella smaragda (was *Turbo smaragdus*)							3	2				2
Shark eggs					4							
Undaria pinnatifida (juveniles)					3	2		1				
Sponges							2		1		3	
Clear holothurian							2					
Scallop								1				

Appendix C Location of the start of dive transects

Transect		Depth	latitude	longitude
T1	WP053	6.3-6.6m	-41.312833	174.802133
T2	WP054	5.3-5.4m	-41.312983	174.800833
T3	WP055	4.3-4.7m	-41.313117	174.799917
T4	WP056	6.8-6.9m	-41.311183	174.80095
T5	WP057	6.3-6.6m	-41.3135	174.801867
T6	WP058	6.3-6.5m	-41.314233	174.8038

Appendix D Location and depth of the video transects (winter and summer surveys

Transect	Date	Start			End		
		depth	latitude	longitude	depth	latitude	longitude
EB01	26/05/21	5.3 m	-41.3116	174.8007	6.4 m	-41.3125	174.8026
EB02	26/05/21	4.4 m	-41.3119	174.7996	10.0 m	-41.3138	174.8049
EB03	26/05/21	3.1 m	-41.3126	174.7991	10.4 m	-41.3153	174.8052
EB04	26/05/21	2.2 m	-41.3131	174.7985	4.9 m	-41.3153	174.8031
EB05	26/05/21	5.1 m	-41.3151	174.8026	7.8 m	-41.3146	174.8029
EB06	26/05/21	4.8 m	-41.3143	174.8013	7.1 m	-41.3127	174.8037
EB07	26/05/21	4.3 m	-41.3138	174.8004	7.4 m	-41.3111	174.8022
EB08	26/05/21	4.0 m	-41.3133	174.7992	6.5 m	-41.3116	174.8010
EB09	26/05/21	6.6 m	-41.3113	174.8011	5.3 m	-41.3106	174.7995
EB10	27/05/21	6.4 m	-41.3112	174.801	8.0 m	-41.3120	174.8027
EB11	27/05/21	6.3 m	-41.311	174.8011	7.6 m	-41.3113	174.8025
EB12	25/02/22	5.8 m	-41.3105	174.8005	8.8 m	-41.3108	174.8027
EB13	25/02/22	5.7 m	-41.3118	174.8005	3.8 m	-41.3132	174.7990
EB14	25/02/22	5.6 m	-41.3116	174.8001	2.8 m	-41.3131	174.7988
EB15	25/02/22	4.2 m	-41.3123	174.7988	10.5 m	-41.3145	174.8048
EB16	25/02/22	5.3 m	-41.3116	174.7993	8.0 m	-41.3132	174.8037
EB17	25/02/22	4.2 m	-41.3127	174.7992	6.7 m	-41.3149	174.8032
EB18	25/02/22	7.5 m	-41.3114	174.8021	4.4 m	-41.3137	174.7999
EB19	25/02/22	8.1 m	-41.3123	174.8032	5.0 m	-41.3151	174.8021
EB20	25/02/22	5.3 m	-41.3097	174.7996	8.1 m	-41.3105	174.8026
EB21	25/02/22	7.2 m	-41.3096	174.8009	5.4 m	-41.3122	174.8005
BW01	25/02/22	1.3 m	-41.3085	174.8133	6.8 m	-41.3101	174.8123
BW02	25/02/22	8.0 m	-41.3098	174.8125	12.0 m	-41.3098	174.8120
RN01	25/02/22	4.0 m	-41.2875	174.8043	12.4 m	-41.2874	174.8050
RN02	25/02/22	4.0 m	-41.2865	174.8045	9.0 m	-41.2879	174.8046
GP01	25/02/22	3.6 m	-41.2954	174.8058	6.9 m	-41.2971	174.8055
GP02	25/02/22	5.9 m	-41.2983	174.8061	8.2 m	-41.3008	174.8059

Appendix E Phylogenetic tree - *Adamsiella*

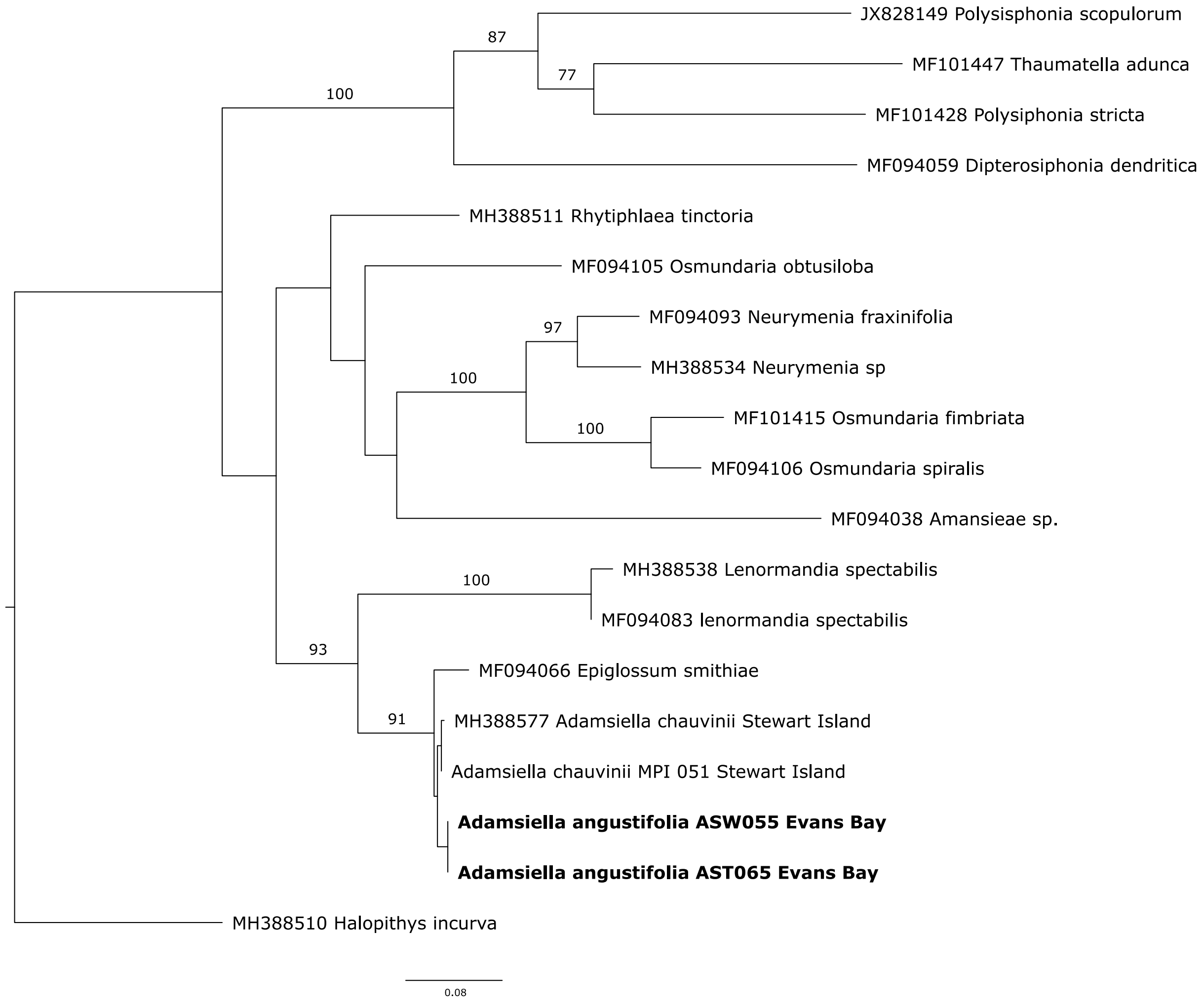

Figure E1: Maximum-likelihood phylogeny (−log Ln = -6014.0872) of *rbc*L sequences of *Adamsiella angustifolia* from Evans Bay and related sequences from GenBank or unpublished. Model used for codons (TIM+F+I+G4:part1, F81+F+I+G4:part2, TIM+F+G4:part3). *Halopithys incurva* used as outgroup.